SYNTHESIS OF RATING METHODOLOGIES FOR CONCRETE BRIDGES WITHOUT PLANS

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Abstract

In response to Federal Highway Administration requirements, many states are confronted with assigning load ratings to large numbers of concrete bridges that do not have plans. The AASHTO Manual for Bridge Evaluation does not specify which methodologies should be used to establish load ratings for concrete bridges without plans, nor does it clearly state how extensive the evaluation of such structures should be. To inform engineers responsible for load rating structures without plans, this report highlights available non-destructive evaluation methods that are able, to varying extents, to locate and determine the size of concrete reinforcing bars. It also provides a survey of current and emergent methodologies for establishing load ratings for concrete bridges without plans. Finally, to characterize the state-of-the-practice, results are reported from a survey distributed to state bridge engineers. There are large differences among states in terms of the specificity of established procedures and overall methodologies employed to assign load ratings to the more than 25,000 bridges without plans located in the 24 states that responded to the survey. Recommendations for approaching this problem in a rational and cost-effective manner are made after considering both published evidence and ease of implementation across large inventories of structures.

Acknowledgments

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Chapter 1: Introduction

The Kansas Department of Transportation (KDOT) is in the process of load rating all bridges in the state inventory, with an estimated completion date in 2024. This is being done in response to a Federal Highway Administration (FHWA) mandate. The scope of the task includes all bridges on the Kansas Local System, a network of nearly 20,000 structures owned and operated by counties, cities, and other local municipalities. For many of these structures there are no existing design or as-built plans. It is estimated there are 6,000 reinforced and prestressed concrete bridges in the Kansas Local System without plans.

Load rating these bridges is difficult because of the lack of information on member dimensions, material properties, and the size and location of reinforcing bars and/or prestressing strands. Although there are effective and established methods for load rating these structures, such as static proof load testing, they are impractical for implementation across the entire inventory. Consultants have been contracted by KDOT to determine many of the load ratings, but the work cannot be performed without a clear framework for how to cost-effectively assess these structures.

1.1 Problem Statement

There is a need to identify the most time- and cost-efficient methods for load rating in-service reinforced and prestressed concrete bridges without plans. These methods need to be applicable to the large inventory of structures in the Kansas Local System at reasonable cost.

1.2 Objectives

- Identify existing and emergent technologies that can be used to identify the size and spacing of reinforcement in concrete bridges,
- Identify methodologies for load rating concrete bridges without plans,
- Determine which methodologies are most widely used by load-rating practitioners in the United States through literature reviews and surveys, and
- Comparatively evaluate the methodologies for load rating concrete bridges without plans and provide recommendations.

1.3 Methodology

A literature review was conducted to identify methods for non-destructive evaluation of bridges without plans and methodologies for establishing load ratings for those bridges. In addition, an effort was made to identify advantages and potential limitations of each existing method. Emergent methods that are being developed but are not yet in use were also identified.

A survey was developed and distributed to state bridge engineers in an effort to document the scope of this problem in other states and identify commonly used methodologies for load rating concrete bridges without plans. The responses have been synthesized and are summarized in this report.

Chapter 2: Literature Review: Non-Destructive Evaluation Methods for Identifying Reinforcement Details in Concrete Bridges

2.1 Summary of Non-Destructive Evaluation Methods

Non-destructive evaluation (NDE) methods listed in Table 2.1 can be used to locate and estimate the size of steel reinforcement in concrete. The methods are subdivided into three categories: *Primary*, *Secondary*, and *Emergent*. NDE methods are categorized as *Primary* if they are currently used in practice and the results are relatively accurate. NDE methods in the *Secondary* category are either not commonly used for the stated purpose or the results tend to be less accurate than other available methods. Finally, NDE methods categorized as *Emergent* are not commercially available, but may become relevant with further refinement and development.

Table 1: Summary of NDE methods for locating and identifying reinforcement

Application	Category	Method
Reinforcement Location	Primary	Covermeter
		Ground penetrating radar (GPR)
		Visual inspection (where spalling exposes reinforcement)
	Secondary	Visual inspection (where cracking provides some indication of reinforcement location)
		Radiography
	Emergent	Electrical resistance tomography
Reinforcing Bar Size	Primary	Covermeter
		Intrusive probing
	Secondary	Radiography
	Emergent	Electrical resistance tomography

2.2 Description of Pertinent NDE Methods

NDE methods in Table 2.1 can be used to identify the location and/or size of reinforcing bars. These methods are described in some detail in this section. For each method, the mechanism of action is described briefly followed by a list of advantages and limitations.

Much of the information in this section is drawn from the ACI Committee 228.2R-13 report titled *Report on Nondestructive Test Methods for Evaluation of Concrete in Structures* [1]. That report includes additional details on the methods described herein and descriptions of several other NDE methods that are useful for structural evaluation but are not suited for identifying the location or size of reinforcing bars.

2.2.1 Visual Surveys and Intensive Probing

Bridge evaluations should include a detailed visual survey. Visual surveys should identify the structural layout and member dimensions, which may give some indication as to the type of reinforcement that may have been used (prestressing strands versus mild-steel reinforcement, etc.). Visual surveys should also document the condition of the bridge, identifying areas of spalling or pronounced cracking as well as surface staining and other evidence of corrosion.

Sometimes spalled concrete cover will expose reinforcement, allowing for measurement of cover, spacing, and bar diameter (Figure 1). Ultra-sonic thickness gauges can be helpful in estimating bar diameter if only a small portion of the bar is exposed. These instruments provide accurate estimation of reinforcement diameter by measuring the time required for ultra-sonic pulses to reflect off the far side of the bar and back to the instrument. Ultra-sonic thickness gauges are, however, sensitive to poor contact with the reinforcement surface and may therefore need lubricant and/or multiple measurements to obtain an accurate and repeatable result.

In areas where spalling is not present, it is possible to expose reinforcement by chipping away the cover concrete or drilling down to the reinforcement. Such intrusive probing can be effective, but requires careful execution to avoid damaging the reinforcement. Appropriate patching is also required to protect the exposed reinforcement.

Concrete cracking can also provide some indication of the location of reinforcement, as cracking often occurs first at reinforcement locations. This is true in bridge decks, where cracking commonly occurs directly over the bars in the top mat of reinforcement due to settlement when the concrete is still plastic (Figure 2). This is also true in beams, where flexural cracks commonly occur first where there is transverse reinforcement. Such observations can be informative, especially when cracks are observed to occur at a regular spacing. However, estimates of reinforcement location based on observed cracking should only be used as secondary evidence to corroborate results obtained using other methods and never as the sole source of information.

Figure 1. Reinforcing bars exposed by spalled concrete [2]

Figure 2. Bridge deck cracking (M. O'Reilly, personal communication, January 2019)

2.2.2 Covermeter

The most common tool for locating reinforcing bars is a covermeter, which is commercially available, affordable, and accurate in many circumstances. Depending on the design of the instrument, commercially available covermeters locate reinforcing bars using either magnetic reluctance or eddy currents. Magnetic reluctance covermeters measure changes in flux between a pair of coils. The measured flux is affected by the presence of reinforcement, with measured values correlating with both reinforcing bar size and depth. Covermeters that operate based on eddy currents can operate with eddy currents that are either continuously or intermittently induced as a series of pulses. Changes in eddy currents correlate with reinforcing bar size and depth.

Advantages:

- Affordable, lightweight, and relatively easy to use,
- The presence and location of reinforcing steel can be readily identified, and cover depth can be estimated, and
- Depending on the instrument, application, and the experience of the operator, covermeters can be used to estimate bar size.

Limitations:

- Estimates of bar size are not very precise. In good conditions, bar size estimates can be within one bar size of the correct value,
- Reinforcing bar spacing affects the accuracy of covermeters, so estimating cover depth and bar size in beams with unknown reinforcement that is closely spaced is not always possible, and
- Covermeters cannot typically identify the presence of multiple reinforcement layers. The signal from the layer closest to the member surface is much stronger than the signal from deeper layers.

Notes:

- Covermeters work best when reinforcement is widely spaced and in a single layer, as is typical in bridge decks and culverts.

2.2.3 Ground-penetrating radar

Ground-penetrating radar (GPR) is an effective tool for scanning concrete and soil to identify the depths of distinct layers, voids, and embedded objects [3]. It operates by emitting short-wavelength electromagnetic waves (microwaves) that reflect off embedded objects and interfaces between materials with different dielectric properties (Figure 3). The time elapsed between emission of the waves and the instant the reflected waves are received by the instrument is recorded; the elapsed time is proportional to the depth of the surface that reflected the waves.

GPR is an effective means of identifying the location of reinforcing steel and other embedded metal. There have been efforts to adapt the method or use it in combination with advanced image processing and other techniques to permit identification of reinforcing bar size [4]. These efforts, however, need further development as current technology should not be expected to produce accurate estimates of reinforcing bar diameter.

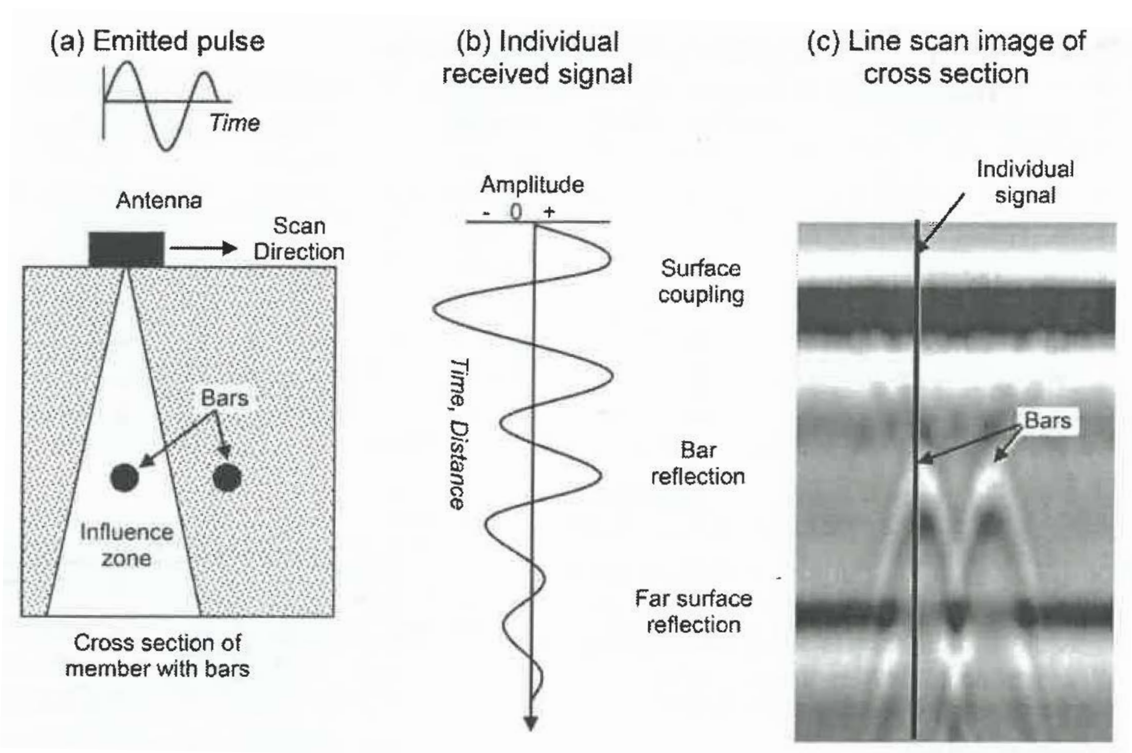

Figure 3. Ground-penetrating radar schematic (a) scanned concrete with embedded steel bars, (b) received signal waveform, and (c) display of output as antenna moves across surface (Fig. 3.8.4b in Ref [1])

Advantages:

- Identifies the depth and spacing of reinforcement, and
- Can be used to scan a large area using instruments mounted to vehicles.

Limitations:

- An experienced technician is required,
- Cannot be used to identify the size of reinforcing bars,
- Cannot distinguish individual bars that are closely spaced. Although the minimum spacing is a function of the instrument type, bar size, and cover depth, difficulties generally arise for bars with a spacing smaller than 8 in.,
- Cannot consistently identify multiple layers of reinforcement, especially when the deeper layers are aligned with the layer nearest the instrument, and
- Influenced by concrete moisture and salt contents, which must be considered when interpreting results.

2.2.4 Radiography

Tools are available for conducting both X-ray and Gamma-ray radiography of concrete members. Although radiographic methods are most commonly used to perform measurements of soil and concrete density, they can also be used to identify the size and location of reinforcing bars. Through-transmission radiography is the most suitable for identifying embedded reinforcement. In this method, a radiation source is placed on one face of the member in question and an image plate or photographic film is placed on the opposite face. The image that results has dark areas where reinforcement is located and lighter areas where there is only concrete (Figure 4). Scaled measurements of the image therefore provide detailed information about the location and diameter of reinforcement.

Advantages:

- Reinforcing bar size and location can be accurately determined in some circumstances.

Limitations:

- Expensive compared to other methods,
- An experienced and licensed technician is required,
- Safety issues associated with field use of radiographic equipment may be prohibitive,
- Access to both sides of a member is necessary, and
- Most instruments are limited to members with thicknesses less than 12 in.

Notes:

- Although this method is effective and commercially available, the writers consider it a secondary method because of cost and safety concerns.

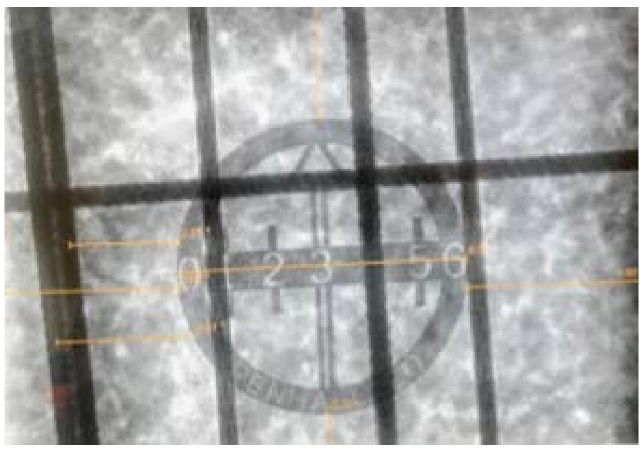

Figure 4. Image of reinforcement within a concrete element obtained with X-ray radiography [5]

2.2.5 Electrical Resistance Tomography

This method is emergent, as it will require substantial development before it can be commercialized. In its current form, the method requires an array of electrodes to be connected to the perimeter of a concrete element. The electrodes apply alternating current to the concrete and measure potential differences along the surface. The distribution of resistivity within the element is then estimated based on the measured potentials. The location and size of reinforcing bars within the element can then be estimated through solution of a nonlinear minimization problem that uses the estimated distribution of resistivity as an input. The method and solution procedure have been shown effective when applied to cylinders of concrete with one reinforcing bar, as shown in Figure 5 and Figure 6 [6, 7].

Before the method can be useful in practice it will need to be developed further to allow use of electrodes on a single surface of the concrete element (instead of around its perimeter) and automation of the process of solving the minimization problem.

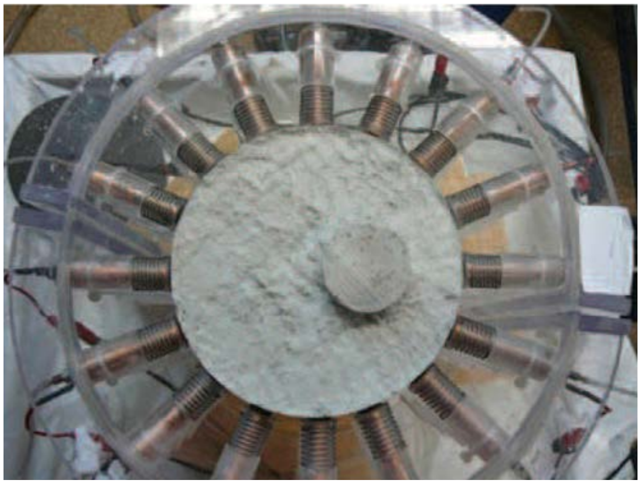

Figure 5. Concrete specimen with embedded reinforcement and electrodes installed around its perimeter [6]

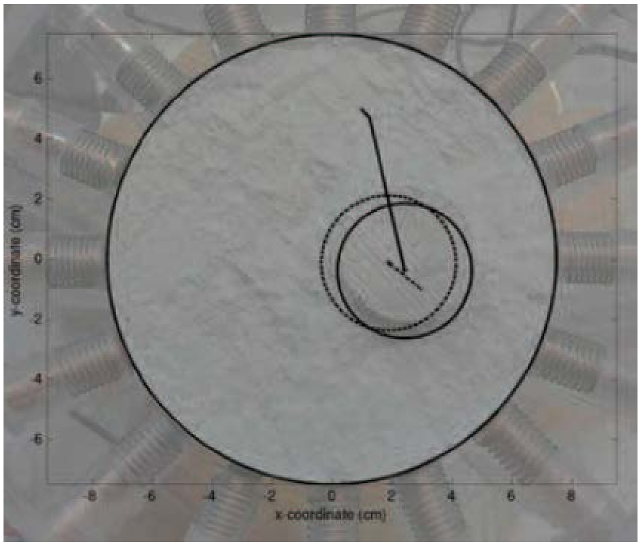

Figure 6. Specimen with estimated location of the reinforcing bar shown with a dotted line and the actual location shown with a solid line [6]

Chapter 3: Literature Review: Methodologies for Load Rating Reinforced Concrete Bridges without Plans

The third edition of the AASHTO Manual for Bridge Evaluation (MBE3) [8] provides detailed procedures for load rating bridges. The procedures are designed to account for in situ conditions, including actual material properties, boundary conditions, and deterioration. The intended result is a load rating that has a reliability similar to a newly designed bridge.

Ratings that are too conservative cause bridge owners and the public to incur large costs because of disruptions to freight transfer routes and bridge retrofits or replacement. The danger of undue conservatism is illustrated in reference [9], wherein 16 existing concrete bridges without plans were analyzed using very conservative assumptions. The results indicated that 80% of the bridges considered failed to pass design checks for standard truck loads despite their decades-long record of acceptable performance. Such conservatism in bridge load rating is not acceptable.

For concrete bridges where important information, such as amount and detailing of reinforcement, is not available, the MBE3 [8] gives considerable leeway to engineers and owners tasked with establishing a load rating. It states "a physical inspection of the bridge by a qualified inspector and evaluation by a qualified engineer may be sufficient to establish an approximate load rating based on rational criteria. Load tests may be helpful in establishing the safe load capacity for such structures." Furthermore, MBE3 [8] indicates that "a concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period and shows no distress." Regardless of the methodologies used, load ratings are to be determined based on standardized procedures that are implemented by Bridge Owners (per Section 6.1 of MBE3 [8]).

Several methodologies for establishing load ratings of bridges without plans are described in this chapter. Some are currently in use whereas others might be considered emergent. The emergent methodologies have been the subject of some research but need further development before use in practice is appropriate.

3.1 Rating Based on Bridge Age and Traffic Loads

Several states assign load ratings based on engineering judgement, with or without supporting calculations. Regardless of whether it is explicit, such ratings rely on the assumption that a bridge that has been in service for years and remains in good condition is able to remain in service under similar conditions and traffic loads. In effect, the time-in-service is treated as a proof load test. Although there is a sound basis for this approach, as discussed below, there are some limitations. Unless additional physical testing, simulation, or reliability studies are undertaken, this approach should not be used as the sole basis for establishing a load rating when a bridge:

- Is being evaluated for an expected increase in traffic loads,
- Has details that are susceptible to fatigue-related failures., and
- Has evidence of serious deterioration.

Because most prestressed and reinforced concrete bridges do not fail in a manner related to fatigue, this approach is applicable to most concrete bridges.

There is a sound basis in the literature for use of bridge condition surveys and knowledge of existing traffic loads to inform bridge assessments. Reliability studies have shown that when bridge age and existing traffic loads are considered, the calculated annual reliability of an in-service structure significantly increases [10, 11]. In other words, whatever the annual reliability of the bridge was when it started carrying current traffic loads, its annual reliability at the time of reevaluation is larger if it remains in good condition. Wang and Ellingwood [11] explain that "surviving a service load history that is stochastic in nature provides evidence of structural reliability that may be comparable to what might be learned from a proof load test." They also provide a brief example of how time-in-service affects the calculated reliability and probability of failure of a well-maintained concrete T-beam bridge. In their example, they show that the probability of failure decreases from approximately 0.006 at the time of construction to 0.001 after 50 years of service. The improvements in reliability occur because the distribution assumed for the bridge resistance (shear, flexure, etc.) can be truncated after accounting for the serviceable behavior of the structure under traffic loads. To establish a load rating based on acceptable service under existing traffic loads, traffic data can be assumed based on published data [12] or measured near the structure using weigh-in-motion measurement technology.

Similar reliability methods can be used for detailed evaluation of an individual structure [13, 14] when additional information about the structure is available, including condition assessment, structural layout, boundary conditions, dimensions, material properties, and reinforcement amounts and detailing. This can be advantageous because it prevents overly conservative ratings that can be very costly. Such methods have been standardized in the Danish guideline titled "Reliability Based Classification of the Load Carrying Capacity of Existing Bridges" [15, 16]. However, the effort involved makes these reliability-based assessment approaches practical only for special structures.

3.2 Rating Based on Association with Similar Bridges with Known Load Ratings

Load ratings can be assigned to bridges without plans based on knowledge of other bridges in the Bridge Owner's inventory or the National Bridge Inventory maintained by the Federal Highway Administration (NBI) [17]. In practice, this approach has been adopted by some Bridge Owners who know with some certainty that standard bridge plans were used throughout the state for design of bridges constructed within known time-frames. Under these circumstances, a qualified engineer establishes the load rating for one bridge that has detailed information available about design loads, structural configuration and proportions, reinforcement, and material properties. Engineers then assign the same load rating to all similar bridges within its inventory that were built in the same time period and have similar condition ratings.

Some researchers have endeavored to adapt this approach so it can be applied more broadly. Catbas, Ciloglu, and Aktan [18] proposed using assessments of a statistically representative sample of bridges to make assessment and management decisions about larger populations of bridges. Their study focused on a population of 1,650 reinforced concrete T-beam bridges in Pennsylvania. An analysis of the database indicated that the load resisting mechanisms and critical failure modes of the bridges were governed by two independent variables (span length and skew) as long as unusual conditions such as foundation problems were ruled out by inspections. A small but representative sample of bridges was then randomly sampled from the larger population. The researchers showed that findings from detailed assessments of the representative sample of bridges could be applied to the entire population with high enough confidence to inform resource allocation decisions by the Bridge Owner. The researchers did not discuss using this probabilistic approach to establish bridge load ratings. It is important to note that the T-beam bridges considered in this study were believed to all be designed using similar procedures.

There have since been attempts to use a similar approach to develop load ratings based on large populations of bridges that were not designed using the same plans or procedures [19, 20, 21]. The researchers propose to use analytical procedures including multivariate regression, advanced neural networks, and machine learning to examine populations of bridges like the NBI [17], identify bridge characteristics that correlate with established load ratings, and produce estimates of load ratings for bridges that do not have plans. The results show there is potential for this approach as a screening tool used to prioritize allocation of resources to potentially vulnerable bridges within an inventory. There are, however, limitations. Although populations of bridge structures share many attributes, each structure is unique and can have unique vulnerabilities that are not common among bridges in the NBI [17]. Furthermore, it is difficult for the average engineer to dedicate the time required to fully understand the advanced analytical tools adopted in these studies. Engineers are therefore at the mercy of the models and not well positioned to apply judgement. It is the opinion of the writers that this type of approach may be a valuable screening tool but should not be used to assign load ratings – particularly to bridges with unusual details, construction defects, or other relatively unique features.

Bridges should only be assigned ratings based on association with similar structures when there is a high level of confidence that similar details were used in construction and after careful inspection to rule out anomalous features. Aside from that purpose, there is potential for using associations among bridges as a screening tool to prioritize investigation of bridges without plans.

3.3 Rating Based on Measurements Taken When Bridge is Under Load

Section 8 of the MBE3 [8] summarizes approved static and dynamic non-destructive load testing procedures. Static load testing procedures are sub-categorized into proof or diagnostic load tests. Static proof load tests may be used to establish load ratings for bridges without plans, among other applications. Static diagnostic load tests, as embodied in the MBE3 [8], cannot be used to determine load ratings for bridges without plans. They do, however, have other applications that are discussed below. Dynamic loading procedures are sub-categorized into weigh-in-motion, dynamic response, and vibration tests. None of these can be used to establish load ratings for bridges without plans, although there are efforts to develop methods for doing so.

3.3.1 Static Proof Load Tests

The MBE3 [8] states that bridges without plans are potential candidates and beneficiaries of static proof load testing. Perhaps no other method for establishing a load rating results in higher confidence in the assigned rating. Furthermore, detailed knowledge of the bridge is not required when conducting a static proof load test.

A static proof load test consists of incrementally applying a static load to a bridge while closely monitoring the structure for signs of distress or non-linear behavior (see Ref. 22 for an example). The imposed load must exceed, by some margin, the live load the bridge is expected to carry. The load rating for the bridge is determined from the proof load after accounting for the impact factor, live load factor, and other features such as non-redundancy of the bridge design, observed deterioration, extent of knowledge of the bridge condition and reinforcement, and observations during testing. Slightly different analysis procedures are recommended when static proof load tests are used for permit load decisions.

Static proof load tests might be considered the gold standard for rating bridges without plans, but there are difficulties associated with implementing static proof load tests across a large inventory of bridges. Static proof load tests are expensive, as they require instrumenting the structure, mobilization of heavy loads, diversion of traffic, and can be time consuming. There are also important safety concerns associated with static proof load tests of bridges without plans. To ensure safe execution, they must be conducted methodically by experienced engineers.

There is also considerable evidence that deterministic methods for establishing load ratings, embodied in the MBE3 [8], tend to be conservative. Several researchers have argued [11, 23, 24, 25, 26] there is a need to migrate to more reliability-based methods, which tend to produce a more controlled level of conservatism. Reliability theory can also be used to determine an appropriate proof load magnitude based on age, condition, and actual traffic loads that will result in a load rating with the desired reliability [24, 27]. Regardless, these reliability-based methods continue to need research and standardization before they can be broadly implemented easily.

3.3.2 Static Diagnostic Load Tests

Static diagnostic load tests described in the MBE3 [8] are used to validate or refine models of a bridge created based on known information about the structure. The imposed loads tend to be less than the rated capacity of the structure, although the closer the applied load is to the unfactored gross rating, the more certain it is that the bridge can sustain factored loads. To conduct a static diagnostic load test according to the MBE3 [8], the prescribed load is positioned on the structure and then measurements of deformation are recorded. These measurements may include changes in strain, deflection, or rotation that occur in response to application of the load. Typically multiple tests with the load positioned in different locations are required to maximize load effects on critical bridge components. Recorded deformations are then compared against the results of engineering calculations for that structure under the prescribed load. If, for instance, the measured strains are less than estimated, the load rating determined analytically may be increased as a function of the ratio between estimated and measured strains using prescribed procedures. This increase must account for the magnitude of the applied load, observations during testing, and the linearity of the measured response.

Static diagnostic load tests are expensive, as they require instrumenting the structure, mobilization of heavy loads, and diversion of traffic. Furthermore, engineers must be cautious when using models based on measurements taken under small loads to determine load ratings because the behavior of a structure under small loads does not necessarily represent its behavior at its rated capacity [28]. This is because some mechanisms such as support stiffness and degree of composite action do not necessarily scale up like other mechanisms. Nevertheless, static diagnostic load tests have been used in many circumstances. These include for the purpose of establishing bridge load ratings [23, 29, 30, 31], assessing damaged and deteriorated structures [32], and examining a structure prior to permitting for superloads [33].

Static diagnostic load tests conducted in accordance with the MBE3 [8] are not readily applicable to the problem of bridges without plans because they are generally used when detailed information about the structure is known. There have been some efforts by researchers to apply this method to bridges without plans. Shenton III, Chajes, and Huang [34] evaluated methods proposed in Ref. [35] that were developed to estimate the amount of flexural reinforcement in a bridge using mechanics and either strain or deflection measurements obtained when the bridge is loaded. Their methods are, however, problematic. For instance, to relate reinforcement area to deflections, the researchers assume that cracked section properties calculated neglecting the concrete in tension apply throughout the span length. Because beam sections between cracks are uncracked, this assumption is not true for a member under uniform moment and even more incorrect for members with varying internal moments, where some regions of the member may be uncracked. Their methods for relating measured strains to reinforcement area must also be considered carefully. While some have argued that strain measurements are unreliable relative to global measures like deflection [23], even correctly measured strains are problematic. For example, how is the engineer to know the relative stiffness/fixity of the supports? This would be a prerequisite for application of their methods, which depend on accurate knowledge of the internal moment at the section where measurements were taken. This discussion is provided not to diminish their efforts, which are thought-provoking, but to highlight the difficulties associated with reliably load rating bridges based on static diagnostic load tests.

3.3.3 Dynamic Load Tests

Three types of dynamic data collection or testing are described in the MBE3 [8]. These methods may provide useful information about traffic loads and in-situ bridge behavior.

The first is weigh-in-motion testing, wherein sensors are used to collect traffic data. These data may include vehicle arrivals, axle loads, gross loads, axle configurations, and vehicle speed. These data can be paired with dynamic data collection to assess features of the bridge response or used to inform load rating decisions based on existing traffic loads (Section 3.1). Data from this type of testing may be an improvement over generic traffic load data derived such that they are applicable to a broad population of bridges (such as that provided in Ref. 12).

Dynamic response tests are also described in the MBE3 [8]. In these tests, either normal traffic or controlled test vehicles crossing the bridge at speed are used to excite the bridge. Data are typically collected using strain gauges, although there is evidence that accelerometers can also be used [36]. Data collected under dynamic excitation are compared against data collected under static loading. These comparisons can be used to obtain estimates of the dynamic load allowance of an existing bridge. Data collected from dynamic response tests can also provide evidence of the live-load stress ranges experienced by bridge components. These results are insufficient to determine a load rating, but they can inform load rating and fatigue evaluation calculations.

Vibration tests are the last type of dynamic test described in the MBE3 [8]. These tests are used to determine dynamic characteristics of the structure such as frequencies of vibration, mode shapes, and damping. While normal traffic loads might be useable as a means of exciting the structure, it is also common to use portable shakers, sudden release of applied deflections, and other means of exciting the structure. Accelerometers are typically used to collect data during these tests, although some forms of non-contact data collection may be useful. For instance, high-definition video footage of the structure can sometimes be used to collect data about frequencies of vibration and mode shapes.

Each of these dynamic tests provide somewhat different information about the demands on and condition of a bridge. Many studies have shown that localized strain data and global modal structural properties, collected from dynamic tests (and sometimes also static diagnostic load tests), can be used to update and refine detailed models of a bridge developed based on plans of the bridge. This has been done for steel bridges [37, 38], concrete arch bridges [39], and reinforced concrete bridges [31, 40].

When conducted as described in the MBE3 [8], none of these dynamic tests provide information that can be readily converted into a load rating for a bridge without plans. However, each dynamic test may provide information that is useful to an engineer tasked with establishing a load rating for a bridge without plans. For example, information about traffic loads, dynamic load allowance, or modes of vibration may be used to reduce some of the uncertainties associated with the necessary assumptions made in such an evaluation.

There have also been attempts to extrapolate from data collected during dynamic tests to establish load ratings for concrete bridges without plans. For instance, methods have been proposed for estimating reinforcement area based on modal properties determined from dynamic tests [41]. This approach has numerous inherent limitations. It requires the engineer to accurately assess the in-situ stiffness of supports, the extent and distribution of cracking throughout the structure, the shear stiffness of structural members, the extent of load sharing between structural members, the extent of composite action, effects of degradation and concrete creep, temperature [42], and other factors. There have been recent attempts to overcome these limitations by combining data collected from numerous tests conducted on a single structure without plans [43]. The approach requires the use of:

- Non-destructive testing to determine structural member dimensions and concrete material properties (compressive strength and stiffness),
- Static diagnostic load tests to determine deflections and strains under load, which are then used to infer reinforcement quantities, and
- Dynamic vibration testing used to determine modal properties of the structure.

Results from these tests are then used to refine finite element models with the help of advanced analytical tools such as artificial neural networks and other optimization approaches. In this particular study, the research team was able to establish load ratings without access to bridge plans that closely matched the rating assigned to the structure by engineers with access to the bridge plans. However, this approach is expensive and clearly requires expert knowledge of instrumentation, field testing, finite element modeling, and mathematical optimization tools. Further development is necessary to streamline this approach before it can be implemented widely.

Chapter 4: Survey of Load Rating Practitioners: Summary of Responses

A survey was developed by the research team, with input from KDOT engineers, to gather information on the state of the practice of load rating concrete bridges with no plans. Targeted survey respondents were state department of transportation (DOT) engineers responsible for rating bridges within their inventories. The purpose of the survey was two-fold: to quantify the number of bridges in each state with no plans and to identify the approaches currently being used to deal with this issue. Chapter 4 includes an overview of the survey and results received from respondents.

Forty-nine state DOTs (excluding KDOT) were contacted about load rating concrete bridges with no plans and to identify the appropriate contact person for the survey. However, engineers at only 24 states returned the survey. Engineers at two state DOTs, although providing information through email and/or phone, did not return the survey. Information from these two engineers is included with the survey responses as appropriate. It should also be noted that not all returned surveys were complete, as there was a wide range in the degree of detail in the responses. DOT engineers at the following states, listed alphabetically, are acknowledged for their participation with this survey in some manner: Alaska, Arizona, California, Delaware, Florida, Illinois, Indiana, Kentucky, Louisiana, Maine, Maryland, Michigan, Nevada, North Carolina, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming.

The survey was divided into three sections. The first section gathered respondent contact information. The second section asked questions regarding how states deal with the issue of rating concrete bridges with no plans. The third and final section asked questions aimed at quantifying the scope of the issue within each state. The survey, as sent to each DOT, is included in Appendix A. Although contact information was gathered from each respondent, presented results are not associated with respondents, as some states asked that their responses remain anonymous. As applicable, results of the survey are presented graphically in Appendix B. Also included in Appendix B are detailed responses to open-ended survey questions.

4.1 Survey Questions on Methods for Rating Concrete Bridges with No Plans

Question 2.1 asked "What approaches has your state taken to load-rate concrete bridges with no plans?" The options provided were:

- Load testing,
- Destructive testing,
- Nondestructive testing,
- Rate based on known traffic loads and condition, and
- Use of 'engineering judgement'.

The percent of respondents using each of the five options is shown in Figure 7. Responses indicate that load testing has been used by 29% (7 of 24) states, with destructive and nondestructive testing used by 13% (3 of 24) and 21% (5 of 24), respectively. Known traffic loads have been used to rate concrete bridges with no plans in 42% (10 of 24) of the responding states, while 92% (22 of 24) use some form of engineering judgement in their assessments. The question also asked respondents for additional details related to the specifics of each option and a preferred method. Most of the respondents simply provided 'yes' or 'no' answers for each option with no additional details.

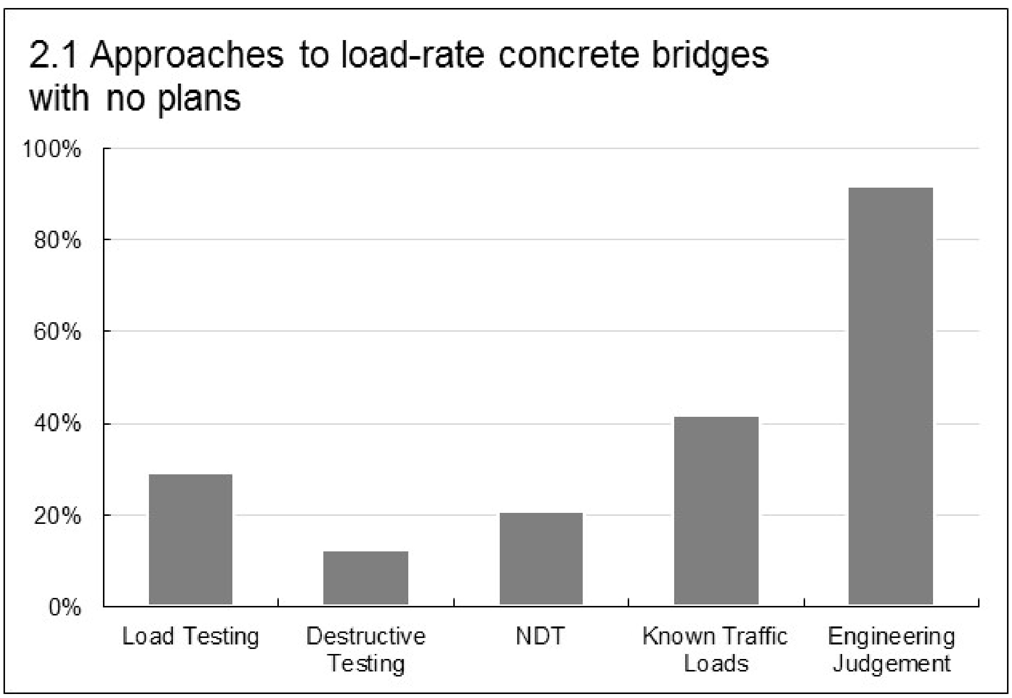

Figure 7. Respondent approaches to load-rate concrete bridges with no plans

Question 2.2 asked “Does your state have a formalized process for rating concrete bridges with no plans?” If so, respondents were also asked to provide a written overview of the process. Of the responding states, 71% (17 of 24) reported they have a formalized process. Detailed responses for this question are presented in Appendix B and included in the Chapter 5 discussion.

Question 2.3 asked “Does your state publish its own bridge evaluation manual?” This was followed by question 2.4 which asked “If you responded ‘Yes’ to 2.3, is the rating process for concrete bridges with no plans addressed in this manual?” Half (12 of 24) of the responding state DOTs reported that they publish their own version of the manual for bridge evaluation. Of these states, 92% (11 of 12) reported that their MBE specifically addresses rating concrete bridges with no plans. Corresponding documentation can be found in Appendix C.

Question 2.5 asked “Does your approach to rating concrete bridges with no plans follow the procedures recommended in the Manual for Bridge Evaluation?” The vast majority of respondents (92%) indicated that their approach was in compliance with the procedures of the MBE. Only 2 of the 24 states responding indicated that rating procedures do not follow the MBE. In both cases no further information was provided to clarify the intent of the response.

Question 2.6 asked whether any specific technologies are used to aid in the process of rating concrete bridges with no plans. If so, respondents were also asked to list which technologies have been used, what information it has provided, and how it is used in the rating process. Only 25% of respondents (6 of 24) indicated that a specific technology was regularly used in this process. Detailed responses are in Appendix B. Specific technologies listed by respondents are:

- NDE rebar locator,
- Destructive testing to verify reinforcing location,
- “Scanning” equipment to identify reinforcing location,
- Pachometer,
- X-ray to identify and count prestressing strand,
- Ground-penetrating radar to identify reinforcing location,
- Strain gages during load testing,
- Concrete core samples, and
- Database of similar structures with existing plans.

4.2 Survey Questions on Quantifying the Scope of the Issue

Question 3.1 asked respondents for the number of bridges in each state for which there are no available plans (including bridges made from any material). Responses varied widely from state to state, with totals ranging from 7 to 6,000. The 18 respondents (6 survey respondents did not provide the number of bridges in their state for which no plans exist) reported a total of approximately 25,000 bridges with no plans (note that while some states provided very detailed responses, others gave approximate values). Each respondent was categorized based on the number of bridges for which they have no plans into groups of states with fewer than 100, 101 to 500, 501 to 1000, or more than 1000 bridges without plans (Figure 8). At least seven other states are in a situation similar to Kansas, with reportedly more than 1000 bridges without plans.

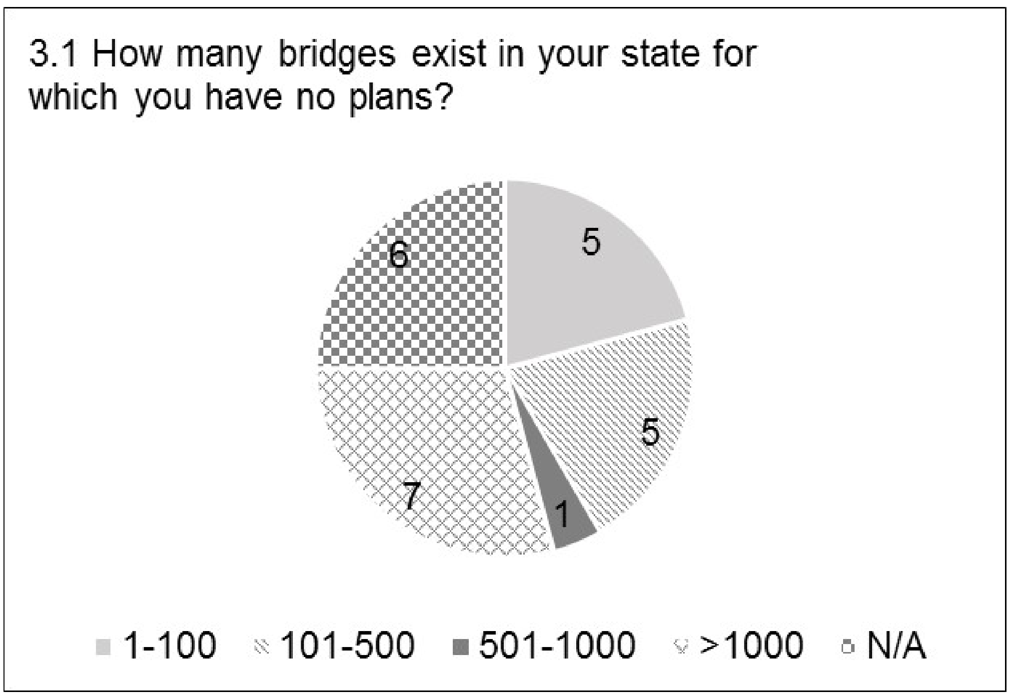

Figure 8. Quantity of bridges with no plans

Question 3.2 asked for the quantity of no-plan bridges in each of the following categories:

- Rolled steel girders,
- Built-up (welded/riveted/bolted) steel plate girders,
- Railroad flatcar structures,
- Other steel structures,

- Timber structures,
- Reinforced concrete girders,
- Prestressed concrete girders,
- Reinforced concrete culverts,
- Reinforced concrete slabs, and
- Other concrete structures.

Detailed responses to this question were not consistently provided. For example, some states reported a certain quantity of rolled steel girder bridges, but noted that this number also included built-up and/or railroad flatcar bridges. Many states also grouped quantities for reinforced concrete girders, concrete slabs, and prestressed concrete girders. Therefore, results are grouped into five categories: steel, timber, concrete, reinforced concrete culverts, and other. The majority of bridges with no plans are concrete structures, representing 48% of responses. Steel and reinforced concrete culverts both account for 23% of the total responses, while timber structures and 'other' account for 5% and 1%, respectively. These results are presented in Figure 9.

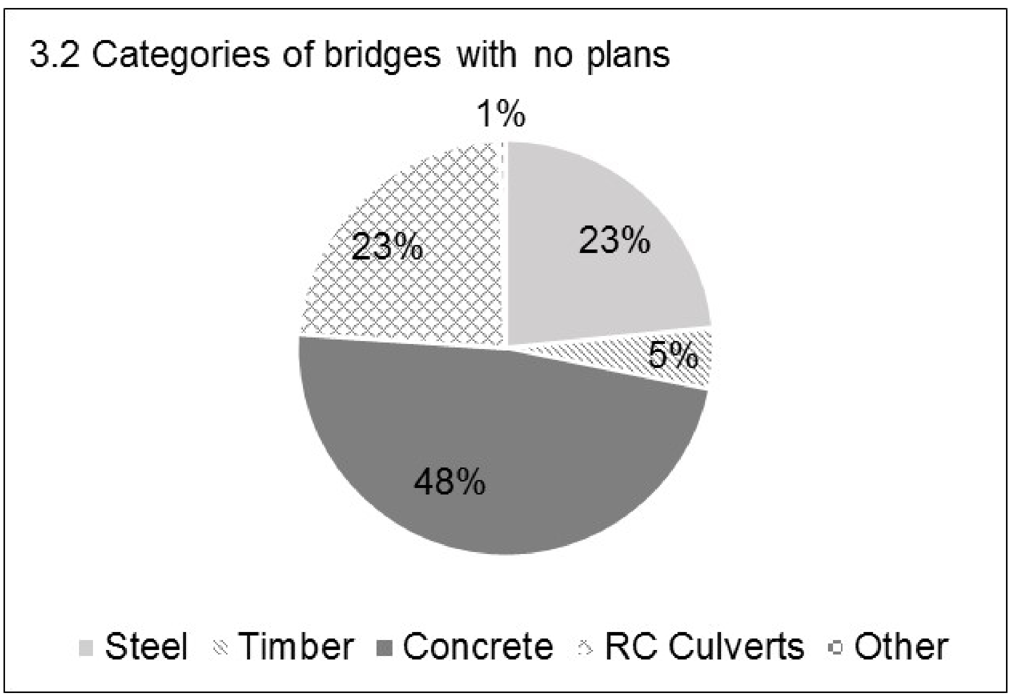

Figure 9. Categories of bridges with no plans

Regarding these bridges for which states have no plans, question 3.3 asked whether they are currently load rated. More than half of respondents (13 of 24) indicated that the bridges without plans are all load rated. One third of respondents (8 of 24) indicated that they were in the process of rating the bridges without plans, two did not respond, and one indicated that the bridges without plans are not currently rated but not whether they are in the process of load rating them.

Survey question 3.4 asked about the signage associated with Special Haul Vehicles (SHVs). Detailed responses are provided in Appendix B.

Question 3.5 asked who was responsible for rating bridges owned by counties/localities. The vast majority of respondents (19 of 25) indicated that states are ultimately responsible for rating bridges, regardless of ownership. Localities are responsible for load rating in 20% of responding states (5 of 25), while one respondent did not provide any information. It should be noted that these totals include information from a phone conversation in addition to the survey response, resulting in 25 respondents.

Questions 3.6 and 3.7 asked about federal requirements for load rating. States indicated whether they had ever been required to develop a Plan of Corrective Action for bridge load rating in question 3.6, and 3.7 asked whether this PCA included bridges for which there were no plans. Two-thirds of respondents (16 of 24) indicated their state has been required to develop a PCA. Of those, 88% (14 of 16) indicated that the required PCA included bridges for which there were no plans. Some survey respondents noted no PCAs have been recently required. It is possible that PCAs have been required in these states prior to the employment of the survey respondent.

Questions 3.8 and 3.9 asked whether their FHWA Division Bridge Engineer had ever approved or disallowed specific methods for load rating bridges with no plans. Responses were even with 12 ‘Yes’ and 12 ‘No’ responses, indicating FHWA Division Bridge Engineer involvement with this issue varies widely from state to state. Detailed responses regarding the methods are presented in Appendix B. Similarly, questions 3.10 and 3.11 asked whether their FHWA Division Bridge Engineer had ever requested additional information regarding the rating of bridges with no plans. Only 17% of survey respondents (4 of 24) indicated the FHWA has requested additional information. Two requests dealt with the development of PCAs, one requested load testing, and the fourth related specifically to the rating of reinforced concrete culverts.

In question 3.12, survey respondents were asked to provide any other relevant information related to this issue. Only three states provided substantive responses, the details of which are presented in Appendix B.

Chapter 5: State-of-the-Practice: Description and Discussion

There are a wide variety of methodologies used by state DOTs to rate concrete bridges with no plans. They range from vague references to the allowance of engineering judgement in the MBE, to very detailed procedures and specified calculations, to a mandatory annual number of load tests statewide. Documentation provided by state DOT survey respondents regarding methodologies for rating concrete bridges without plans can be found in Appendix C. Examination of the documents reveal that approaches to rating concrete bridges with no plans can roughly be divided into the following four categories:

- Applying assigned rating factors,
- Rating with historic design loads,
- Performing calculations with assumed/measured properties., and
- Load testing.

These four categories are not considered to be mutually exclusive as some DOTs use multiple approaches while others employ rating practices combining methodologies from different categories. There is also inherent category overlap in the application of these rating methodologies. Each category is discussed below, referencing documents found in Appendix C as appropriate. Identifying information has been redacted in the corresponding documents, so reference is made to randomly-assigned letter designations.

5.1 Assigned Rating Factors

5.1.1 State-of-the-Practice

Several DOTs allow for the assigning of both Inventory and Operating Rating Factors without supporting calculations. In many cases reference is made to MBE3 [8] where it states that "a concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period" [8]. Inherent in this method is a reliance on historic traffic loads and a recognition that the annual reliability is currently larger than it was when the structure was first built [11]. In several states, it is policy to only allow this method to be applied to structures with a condition rating of 5 or better. In some cases state procedures provide little guidance beyond referencing engineering judgement for load rating bridges with condition ratings less than 5 (State U), while other states require some form of mandatory testing (NDE, destructive testing, load testing, etc.) (States E and D).

Other DOTs employ a sliding scale, whereby load rating factors are diminished based on condition ratings (States F, L, and O). This method either directly applies rating factors based on condition, or provides a condition reduction factor to be used in assigning load ratings. In some instances these scales are structure-specific (only applying to certain structure types), while in others the rating factors apply to all concrete bridges with no plans. An example of assigned rating factors based on condition assessment is shown in Figure 10, while Figure 11 shows the condition factors presented by State O.

	LFR Design Load Rating Factors		Load Postings (Tons)		
Condition Rating	Inventory	Operating	Single Unit	3 or 4 Axle Combinations	5 or More Axle Combinations
Good to Excellent - No signs of structural deterioration or distress.	1.00	1.66	No Posting Required		
Fair - Initial evidence of structural deterioration or distress. (No restrictions required)	0.75	1.25	No Posting Required		
Poor - Some structural deterioration or distress. (Legal Loads Only restriction)	0.60	1.00	No Posting Required		
Serious - Advanced structural deterioration or distress evident. (Load posting required) *(See Note 1)*	0.39	0.65	15	20	25
	0.21	0.35	8	12	14
Critical - Severe structural deterioration or distress evident.	0.13	0.22	5		

Figure 10. State F rating factors and load postings based on condition

NBI Item 59 (or 60), Superstructure (or Substructure) Condition Rating	Condition Factor (CF)
5 “Fair Condition” or better	1.00
4 “Poor Condition”	0.50
3 “Serious Condition” *	0.25
2 “Critical Condition” *	0.12

Figure 11. State O condition factors used in load rating

5.1.2 Discussion

As described in Section 3.1, acceptable performance of a bridge under known traffic loads over time is a reasonable basis for establishing load ratings. This is because “surviving a service load history that is stochastic in nature provides evidence of structural reliability that may be comparable to what might be learned from a proof load test” [11]. The approach provides better evidence that existing reinforcement details in a particular structure are adequate for sustaining current loads than methods based on assumptions or comparisons with other structures of the same age. This approach has the added benefit of being cost effective relative to other methodologies, particularly for structures in fair or better condition.

For structures assigned condition ratings less than 5 (i.e. poor, serious, or critical condition), the writers find it reasonable to assign to bridges without plans a condition factor (CF) rating correlated with the condition rating. This should be done systematically and in a manner consistent with condition factors applied to bridges with plans.

This approach may be both robust and cost-effective for many structures without plans, but there are limitations. This approach does not provide evidence that can be easily extrapolated beyond normal traffic loads. For bridges being evaluated for overweight vehicles or changes in traffic loads, as well as for damaged bridges (e.g. due to impact), additional evidence may be required to support engineering decisions.

5.2 Historic Design Loads

5.2.1 State-of-the-Practice

Although inherent in the previous method, the use of historic design live loads can directly be used in calculations to determine rating factors. This method also assumes that annual reliability of a structure increases over time and that structures remain in good condition. The approach can be implemented in a variety of ways with some DOTs tabulating historic live load moments and/or capacities based on span length (States C, E, L, and V) and others simply presenting historic live loads to be used in calculations (States D and U). Still other DOTs simply state historic design live loads should be used as part of an engineering judgement rating process (State T). An example of era-specific design live loads is presented in Figure 12.

Table 1 – Estimated Design Live Load Based on Year of Design and Design Agency

Design Year	State Design	Local Agency Design
Before 1944	H15	H10
1944 to 1949	H20-S16-44	H10
1950 to 1956	H20-S16-44	H15
1957 to 1964	H20-S16-44 and Alt	H15
1965 to 1972	HS20-44	H15
1973 to present*	HS20-44, Alt and Permit	HS20-44

Figure 12. State C era-specific design live loads to be used in rating

State V uses a historic design live load approach based on parametric analyses and groupings of similar structures. Load ratings are based on capacity tables that were developed through a parametric study that examined a variety of reinforced concrete bridge types and era-specific guidance like that shown in Figure 12. Figure 13 shows the State V operating capacity table for concrete bridges with no plans and spans greater than 60 ft. This table appears to be similar to those of other state DOTs, but it is unclear whether other tables were developed with a similar study.

Rating Vehicle	OPERATING (Tons)													HS20 (Tons)	
	Standard							CRTS				Emergency			
	T3	SU4	SU5	SU6	SU7	2S2	3S2	SU40	SU45	3S55	3S60	EV2	EV3	Inv	Oper
H10	29	28	29	29	30	36	35	29	29	40	40	29	29	12	31
H15	44	43	44	44	45	55	54	43	44	60	60	44	43	18	46
H20	58	56	58	58	59	72	71	57	59	80	80	58	57	24	61
HS15	67	65	67	67	68	83	82	66	68	92	92	67	66	27	70
HS20	89	86	89	89	91	111	109	89	91	125	125	89	88	36	94
HS25	111	108	111	111	113	138	136	109	112	153	153	111	110	45	117

Figure 13. State V operating capacity table for concrete bridges with spans over 60 ft.

The majority of states employing historic design live loads specify that this method is suited for structures showing no signs of distress. Little guidance is given for how to apply these procedures to bridges with condition ratings below fair. State O does state that ratings should be lowered for "condition ratings that involve advanced deterioration," using condition factors shown in Figure 11 above. Although a detailed procedure is not specified, it can be inferred that the condition factor is used to reduce rating factors based on service history.

5.2.2 Discussion

This methodology is expected to result in conservative assessments of the load-carrying capacity of bridges that continue to perform well in-service. The conservatism occurs because traffic loads have generally increased over time and the conservatism of new designs has generally decreased as engineers adopted increasingly refined design approaches. It seems appropriate for states that adopt this method to make some allowance, as State G does, for engineering judgement to be used to avoid costly over-conservatism.

5.3 Assumed/Measured Property Calculations

5.3.1 State-of-the-Practice

Some state procedures require load rating calculations even when as-built and/or design plans do not exist for concrete bridges. In these instances, engineers are required to use either assumed or measured material and structural properties. Measured properties can include field measurements of structural geometry, non-destructive testing to determine reinforcing bar/strand size and location, and destructive testing to determine concrete properties. Assumed properties used in load rating include era-specific concrete strengths as well as steel quantities based on ideally reinforced sections. These assumed or measured properties are then used in load rating calculations, or in conjunction with one of the other approaches presented.

Multiple DOTs require field measurements for bridges that lack plans. State E requires that field measurements make use of “a measuring tape, a caliper, and a pachometer.” When using field measurements as the basis for load rating evaluation, State D specifies the use of “concrete coring, pachometer or steel coupon sampling if deemed necessary.”

There are a variety of approaches used when assuming properties of concrete bridges with no plans. State M has a developed procedure that assumes an ideally reinforced concrete section. Design concrete compressive strength is assumed to be 2500 psi, with reinforcing steel specified as either 33 ksi or 40 ksi, depending on the era of construction. Calculations following the prescribed methodology result in tables of moment and steel area, an excerpt of which is shown in Figure 14. These values are then used in the load rating process.

At least two state DOTs recommend the assumption of era-based material properties to be used in load rating procedures. State E provides assumed era-specific concrete and reinforcing steel strengths to be used with the required field measurements. Era-specific concrete and steel strengths provided by State E are seen in Figure 15 and Figure 16. Although not presented as tabulated values, State T recommends the use of era-specific material properties and includes these in examples published in their state load rating documentation.

Use this when no plans are available for slab bridges built before 1954.

f'c = 2500　　fy = 33000
fc = 1000　　fs = 18000
n = 12
b = 12
k = n / (n + fs / fc) = 0.4
J = 1 - k / 3 = 0.86666666667
R= 0.5 * fc * J * k = 173.333333333

Depth of Section (in)	d - Depth of Steel (in)	M = R * b * d^2	As = M / (fs * J * d) (in)^2
6	4	33280.000	0.533
6.5	4.5	42120.000	0.600
7	5	52000.000	0.667
7.5	5.5	62920.000	0.733
8	6	74880.000	0.800
8.5	6.5	87880.000	0.867
9	7	101920.000	0.933
9.5	7.5	117000.000	1.000
10	8	133120.000	1.067
10.5	8.5	150280.000	1.133
11	9	168480.000	1.200
11.5	9.5	187720.000	1.267
12	10	208000.000	1.333
12.5	10.5	229320.000	1.400

Figure 14. Excerpt of State M calculations assuming ideally reinforced section

Year of Constructior	Compressive Strength, f_c (ksi)
Before 1959	3.0 - Reinforced Concrete
1959 to 1973	3.0 - Reinforced Concrete 5.0 - Prestressed Beam
After 1973	3.4 - Reinforced Concrete 5.0 - Prestressed Beam

Figure 15. State E era-specific minimum concrete strengths used in load rating

Reinforcing Type	Yield, f_y (ksi)
Unknown, constructed prior to 1954	33
Structural grade	36
Unknown, constructed between 1954 and 1972: billet or intermediate grade	40
Rail or hard grade	50
Unknown, constructed after 1972	60

Figure 16. State E era-specific steel strengths used in load rating

5.3.2 Discussion

It may be necessary to use assumed material and structural properties as the basis for load ratings in some limited circumstances. For instance, this approach may be appropriate if a bridge is being evaluated for a permit load or change in use (i.e. increased traffic loads) and load tests (Section 5.4) are not feasible. However, this approach has important limitations the engineer should bear in mind. For instance, while assumed material properties may be relatively easily justified, it can be difficult to make verifiable assumptions about reinforcement amounts and detailing because each structure is unique and may have unique flaws. Knowledge of standard reinforcement details in use at the time of construction is not evidence the contractor and engineer made no mistakes or omissions of reinforcement in construction of a given structure. It is for this reason that researchers recommend comparisons against similar structures be used primarily as a population screening tool (Section 3.2). Furthermore, use of NDT to verify assumptions is challenging in many cases, as all inspection technologies available for identifying reinforcement details have limitations on their application or utility (Section 2). It may therefore be more prudent to use shear and flexural demands induced by known traffic loads that the bridge has adequately supported as a basis for estimating reinforcement amounts, or, more simply, assign load ratings as a direct function of known or historic traffic loads (Sections 5.1 and 5.2).

5.4 Load Testing

5.4.1 State-of-the-Practice

Although not presented as a mandatory load rating approach, load testing is mentioned by multiple DOTs as an appropriate method when deemed necessary by on-site conditions. State D recommends load testing in cases where bridges are structurally deficient or where posting is required through overly conservative rating approaches. No procedures for load testing are provided, but state documentation specifically mentions collaboration with consultants and/or university engineers. State E includes a chapter in their state bridge load rating manual devoted to load testing. However, this one page chapter does not provide state-specific evaluation procedures and refers to MBE3 Section 8 for guidance [8]. The document does note however, that the State E Structures Research Center will test a minimum of three bridges each fiscal year. Both State C and T indicate that load testing is an appropriate method for load rating concrete bridges with unknown details, but no specific guidance is given for conducting such testing.

5.4.2 Discussion

As described in Section 3.3, proof load tests are currently the only type of load test appropriate for load rating concrete bridges without plans. Given the costs associated with lane closures, mobilization of equipment, instrumentation, etc., proof load tests are costly. It is therefore recommended that proof load testing not be used as a standard methodology for load rating concrete bridges without plans. Rather, proof load testing should be reserved for special circumstances, including for bridges that are structurally deficient, damaged, or severely deteriorated, as well as when evaluating a bridge for overweight vehicles.

Chapter 6: Summary and Recommendations

In response to Federal Highway Administration requirements, many states are confronted with load rating large numbers of concrete bridges that do not have plans but that, in many cases, have performed acceptably in practice for years.

The AASHTO Manual for Bridge Evaluation (MBE [8]) requires that bridge owners implement standardized procedures for assigning load ratings. For bridges with unknown details, the MBE [8] requires that load ratings be based on results from on-site inspections and engineering judgement, but no procedures are specified. The MBE [8] also states that “a concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period and shows no distress.” The MBE [8] is therefore relatively unspecific `with regard to the extent to which existing bridges with unknown details should be investigated and which methodologies for assigning load ratings should be considered acceptable. Bridge owners, engineers, and FHWA representatives often have different expectations. As one engineer put it, “It is unclear what FHWA has allowed and disallowed.” As a result, the practice of load rating bridges without plans varies between states.

The following summarizes findings from a literature review and a survey of practitioners regarding the state-of-the-practice of load rating bridges without plans. Recommendations are made after considering both published evidence and ease of implementation across large inventories of structures.

6.1 Summary

There are several non-destructive evaluation (NDE) methods that can be used to identify reinforcement details, although each has limitations. Visual inspection, intrusive probing, covermeters, ground penetrating radar, and radiography can all be used in various circumstances. These methods can, to varying degrees, be used to locate reinforcement and determine bar spacing, though not all can accurately identify bar size. It would be costly for a bridge owner with thousands of structures without plans to mobilize NDE-based investigations of all structures. Additionally, given the limitations of the various methods, it is likely that not all reinforcement in a bridge would be identified. For example, many methods do not identify bars located behind other reinforcement.

Survey respondents indicated that while NDE methods may be used in special cases, they are not typically integral to the process of load rating bridges without plans.

There are several existing methodologies for load rating bridges without plans. Proof load testing is a robust approach to load rating bridges, but it is also expensive and time consuming. There is a consensus among many researchers that assigning ratings based on known traffic loads, age, and condition is a reasonable and meaningful approach. Given the simplicity, robustness, and cost-effectiveness of this approach, the writers believe it should be the primary method for assigning load ratings to bridges without plans. Others agree. One state bridge engineer asked "Why would we use taxpayer money to suddenly rate the bridge or perform a load test without any specific concerns [about] the bridge?" Stated differently, surviving years in service under traffic loads that are stochastic in nature is evidence of structural reliability that may be comparable to a proof test [11]. The calculated annual reliability of a structure therefore increases when bridge age and traffic loads are considered [10, 11]. With this in mind, little analysis should be necessary to evaluate a structure that has been observed to be in good condition and will continue to carry similar traffic loads.

There are also emergent methodologies for load rating bridges without plans. Researchers have proposed using known information about similar structures to rate structures, although this approach is best suited to screening populations of structures given the sensitivity of load ratings to structure-specific anomalies. Several researchers have also proposed methods for using dynamic load testing results to inform load ratings, but these approaches need further development when they are to be applied to structures without plans.

When implemented in practice by bridge owners such as state Departments of Transportation (DOTs), the details of procedures for load rating bridges without plans tend to differ widely by state. Nevertheless, procedures for load rating bridges without plans in practice tend to fall into one of four groups of methodologies. Ratings are assigned based on:

- Performance under known traffic loads, age, and condition,
- Design loads at the time of construction,
- Analysis of structural models built with assumed material and structural properties, and
- Proof load testing results.

6.2 Recommendations

- To limit the scope of this problem, the writers endorse the following recommendation from a state bridge engineer: “It may be beneficial to have an FHWA notice to local agencies that bridge plans, shop drawings, and materials of similar nature must be kept for the life of the structure. This will limit the number of future structures being built where calculations and drawings being purged after local agency retention period is exceeded, i.e. 10 years or other similar time frame.”
- For bridges that have been in service for several years and are expected to continue to carry similar traffic loads, it is recommended that known traffic loads, bridge age, and bridge condition be used as the primary basis for assigned load ratings. This is a robust and cost-effective approach. This approach is particularly appropriate for bridges in fair or better condition. The MBE [8] acknowledges this, when it states that “a concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal traffic for an appreciable period and shows no distress.” Rational approaches have been developed for extending this approach to bridges with poor or worse condition ratings, and several states are implementing these approaches.
- For bridges that are expected to undergo a change in use, require evaluation for over-weight vehicles, or require special evaluation due to extensive damage or deterioration, there are a few appropriate approaches. The most robust is a proof load test. Alternatively, calculations can be applied to structural models that incorporate material and structural properties inferred from inspections, similar structures of a similar vintage, or results from NDE investigations of the structure. When reinforcement details are assumed based on other structures, assumptions should be verified with observations.

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Appendix A

Survey for Departments of Transportation

Rating Methodologies for Concrete Bridges without Plans

Survey for Departments of Transportation

Thank you for your participation in this survey designed to gather information on the rating of concrete bridges without plans. This information may be included in a final report to the Kansas Department of Transportation and/or subsequent publications. However, other than documenting participation, no identifying information will be associated in published documents with your specific responses.

This survey has three parts. The first gathers contact information for our internal purposes (this information will not be shared outside the research team). The second section is aimed at gathering information about how your state/locality deals with the issue of rating concrete bridges with no plans. The final section is designed to quantify the scope of this issue in your state or locality. As applicable, please provide all requested information and return to the University of Kansas (rlequesne@ku.edu or william.collins@ku.edu) by July 31, 2018.

1: Contact Information

1.1 State/Locality:

1.2 Contact Information:

Name:

Address:

Telephone:

Email:

2: Methods for Rating Concrete Bridges with No Plans:

2.1 What approaches has your state taken to load-rate concrete bridges with no plans? Please select all that apply, and indicate most prominent methods. If relevant, please attach additional details on how your preferred method(s) are used, and in what circumstances.

Load testing

Destructive testing (please specify/see 2.6)

Nondestructive testing (please specify/see 2.6)

Rate based on known traffic loads and condition

Use of ‘engineering judgement’ (please specify)

2.2 Does your state have a formalized process for rating concrete bridges with no plans?

Yes No

2.2 If you responded ‘Yes’ to 2.2 please provide an overview of this process. Please attach any pertinent documentation with your survey responses

2.3 Does your state publish its own bridge evaluation manual?

Yes No

2.4 If you responded ‘Yes’ to 2.3, is the rating process for concrete bridges with no plans addressed in this manual? Please attach (or provide links to) any applicable material with your survey responses.

Yes No

2.5 Does your approach to rating concrete bridges with no plans follow the procedures recommended in the Manual for Bridge Evaluation (MBE)?

Yes No

2.6 Do you use any specific technologies to aid in the process of rating concrete bridges with no plans?

Yes No

2.7 If you responded ‘Yes’ to 2.6, what specific technologies have you used, and what information has this provided? How is this information used in the load rating process?

2.8 Please provide any additional information related to your methods for rating concrete bridges you feel would be beneficial for us as we look into this issue.

2.9 Please list any relevant documentation you have attached to this survey to supplement your responses.

3: Quantifying Scope of this Issue:

3.1 How many bridges exist in your state for which you have no plans?:

3.2 Provide the quantity of no-plan bridges in each of the following categories:

Rolled steel girders:

Built-up (welded/riveted/ bolted) steel plate girders:

Railroad flatcar structures:

Other steel structures:

Timber structures:

Reinforced concrete girders:

Prestressed concrete girders:

Reinforced concrete culverts:

Reinforced concrete slabs:

Other concrete structures (please specify):

Other concrete structures (please specify):

Other (please specify):

3.3. Are all of these bridges currently load rated? If no, are they in the process of being load rated?

3.4. Are Special Haul Vehicle postings currently required for any rated bridges in your state? If so, explain the sign(s) you are using for posting and if they are used in conjunction with any MUTCD signs such as R12-1 or R12-5.

3.5 In your state, who is responsible for rating bridges owned by counties/localities?:

3.6 Has your state ever been required to develop a Plan of Corrective Action for bridge load rating?

Yes No

3.7 If you responded 'Yes' to 3.6, did this include bridges for which you had no plans?

Yes No

3.8 Has your FHWA Division Bridge Engineer approved or disallowed specific methods for load rating bridges with no plans?

Yes No

3.9 If you responded 'Yes' to question 3.8, what methods were approved? What methods were disallowed?

3.10 Has your FHWA Division Bridge Engineer ever requested additional information regarding the rating of bridges with no plans?

Yes No

3.11 If you responded 'Yes' to question 3.10, what additional information was required? How did you approach this situation?

3.12 Please provide any additional information you feel would be beneficial for us as we look into this issue.

Appendix B

Survey Results

Question 2.1: What approaches has your state taken to load-rate concrete bridges with no plans?

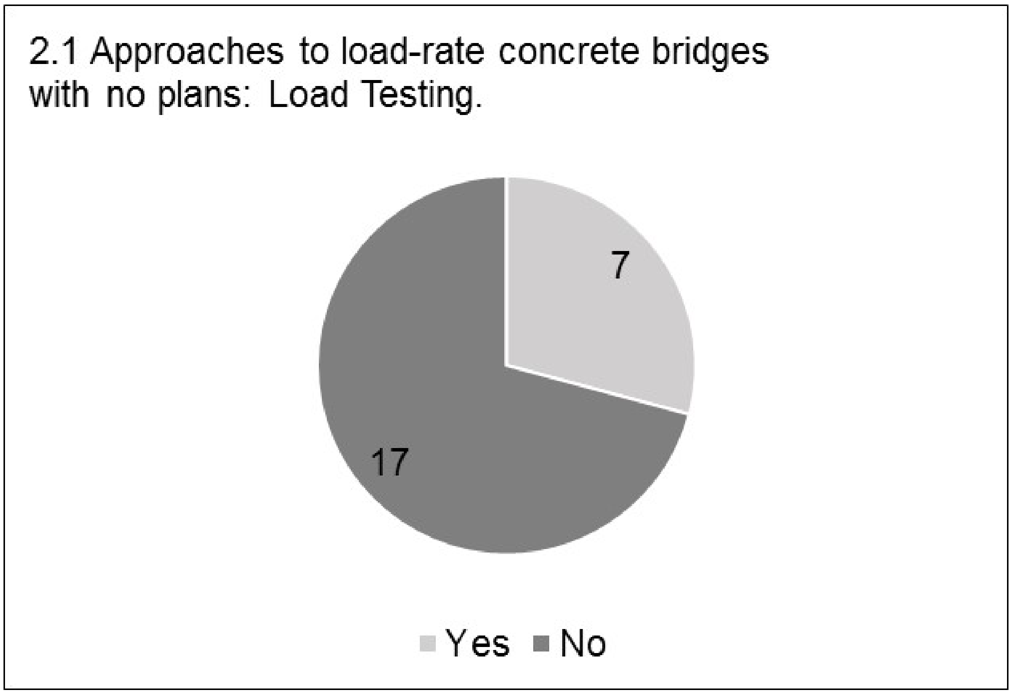


Figure 17. Respondents using load testing to load-rate concrete bridges with no plans

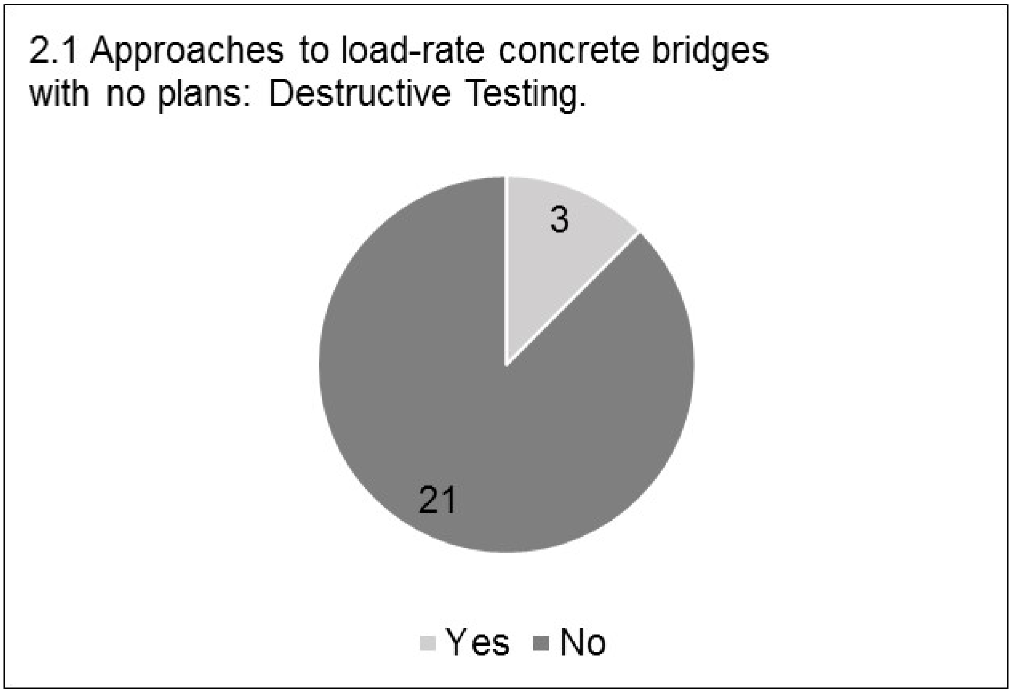


Figure 18. Respondents using destructive testing to load-rate concrete bridges with no plans

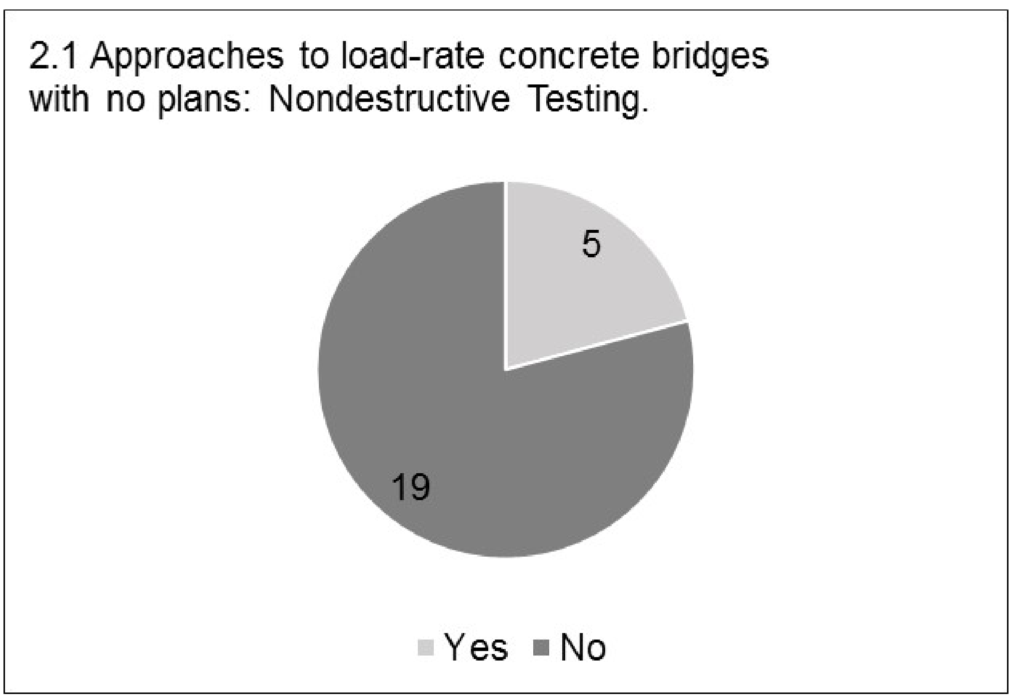


Figure 19. Respondents using nondestructive testing to load-rate concrete bridges with no plans

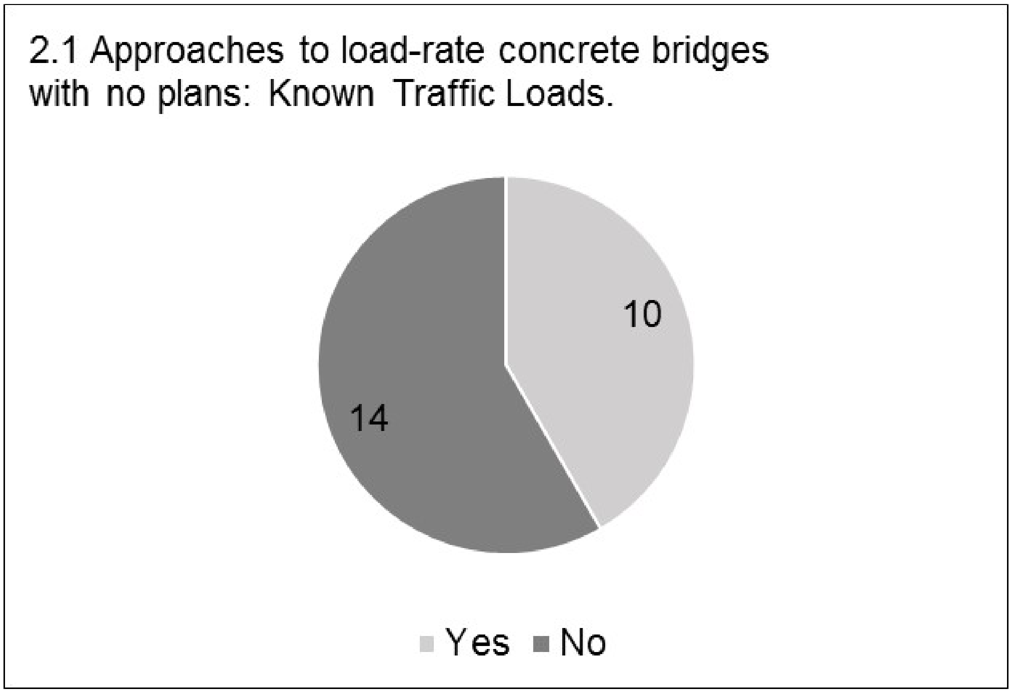


Figure 20. Respondents using known traffic loads to load-rate concrete bridges with no plans

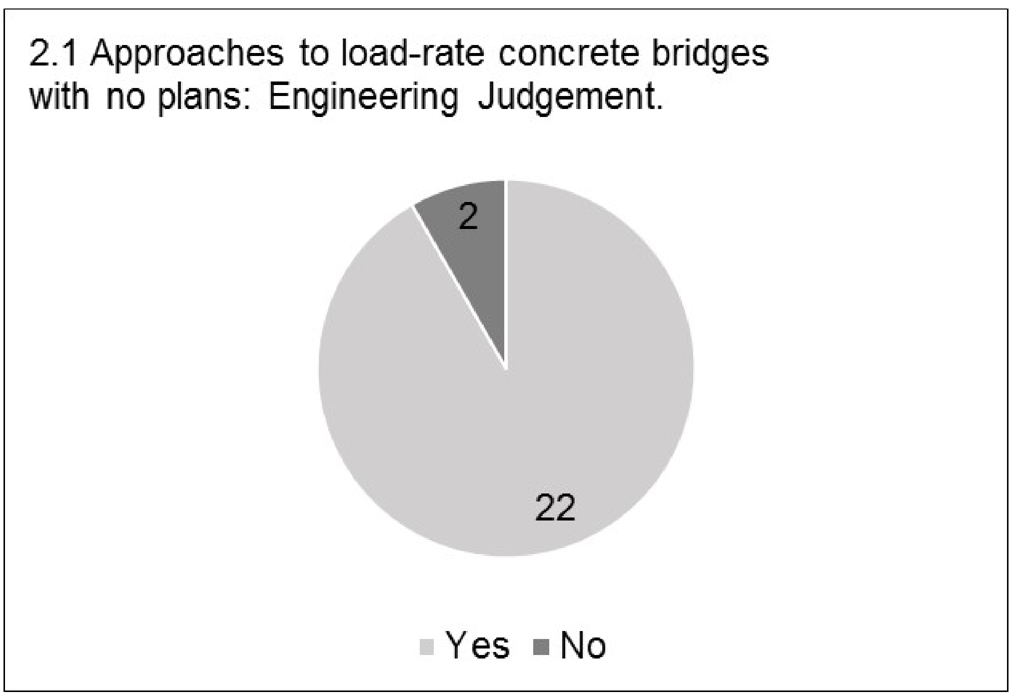


Figure 21. Respondents using engineering judgement to load-rate concrete bridges with no plans

Question 2.2: Does your state have a formalized process for rating concrete bridges with no plans?

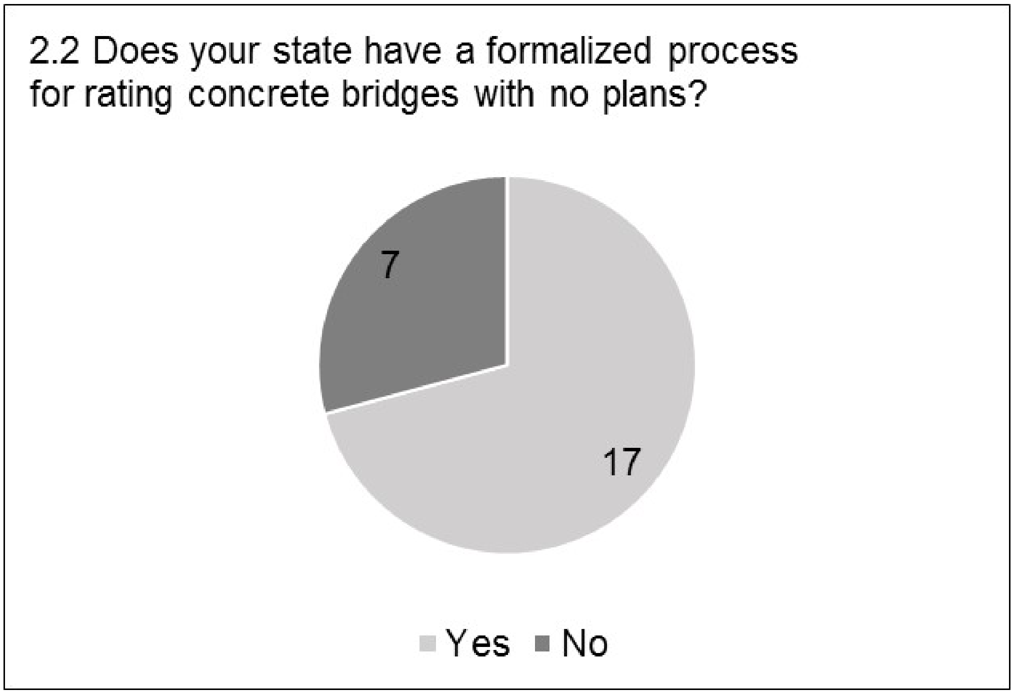


Figure 22. Respondents with a formalized process for rating concrete bridges with no plans

The following details were provided by respondents who indicated their state has a formalized process for rating concrete bridges with no plans. Any identifying information has been removed from the descriptions.

- Era-specific design live loading for state or local agency bridges is determined based on known historical practices within the state. Demand comparisons specific to bridge span length(s) are made between original assumed design live load and today's current standards. Ratings are assigned based on demand comparison ratios. If the demand comparison yields undesirable results (posting for AASHTO Type 3 trucks) and the bridge has a history of known loading, engineering judgment can be used to limit unnecessary bridge postings.
- See attached document (multiple responses) (referenced document provided in Appendix C)

- If the condition of the structure is in satisfactory condition, we rate and post at roadway limits (we have 4 different roadway limits- including county routes, "A" state routes, "AA" state routes, and "AAA" state routes). We have various laws that allow up to 44 tons on any state route or 40 tons on any county route on any type of vehicle when hauling certain cargo, however, the roadway limits of each route are typically less. If the condition of the structure is less than satisfactory, then we post by engineering judgment at half of the roadway limit or, if the condition is serious, at 3 tons.
- If bridge in satisfactory condition, no signs of load distress, not fracture critical, has been carrying traffic for an appreciable period of time, we give it a 1.0 rating factor.
- Engineering judgement ratings are not calculated, therefore, there is substantial reliance on the physical inspection condition rating. Load ratings are assigned to concrete structures without plans using the guidance provided in the "Engineering Judgement Load Rating" [state-specific] memorandum dated April 1, 2016. (referenced document provided in Appendix C)
- Find the ideally reinforced section using the formulas in the description attached. Then use that steel area to load rate the structure. (referenced document provided in Appendix C)
- [State] follows the guidance in MBE for concrete bridges with unknown reinforcement. If the bridge has been carrying legal traffic with no signs of distress we assume a rating factor of 1 and back calculate the reinforcement.
- The [state] LRFR Manual provides the procedures that use the service history, span configuration, and member condition to assign the bridge an operating and inventory rating factor. If a concrete bridge without plans has a long history of service (20 years or more), successfully carrying [state] Legal Loads without distress, its safe capacity can be assumed to be equal to the worst load effect of the Legal Loads (up to the SU4 vehicle). The HL-93 Design Truck Load Inventory Rating can be considered to be in proportion to the load effect of the Legal Truck Loads. This assessment is also reduced to account for NBI condition ratings that involve advanced deterioration or section loss (“Poor” or lower). Since SHVs are relatively newer, in [state] we penalized the SU5, SU6, and SU7 vehicles by restricting them based on the resulting rating factors determined by how much greater

their load effects are above the base legal vehicle used in the rating. This is a conservative management decision since we cannot say for sure if the bridge has seen these heavy compact vehicles over its service life. (referenced document provided in Appendix C)

- NBI Bridges: Most bridges that have no plans are concrete bridges. For these bridges we might take cores to obtain compressive strengths. Usually these same bridges have exposed reinforcing steel whereby we can measure the rebar size and spacing, otherwise we would load test the bridge. Non-NBI Bridges: The same applies with the exception that if the bridge's overall condition rating is 5 or greater and that no steel is exposed, that the bridge is capable of handling today's statutory loads, no cores are taken.
- If existing plans are not available and/or bridge inspection reports do not contain sufficient detail to perform the load rating, an independent Site Assessment is generally required to collect the necessary data to perform the load rating. During the site assessment, field measurements are taken for members that are to be rated. For unknown material properties, there is guidance in the [State] DOT Load Rating Manual. After this information is gathered, the rating process is carried forward analytically, similar to if a structure has plans available. Documentation of engineering judgment must include rating calculations for the critical locations. These calculations are a baseline that should be used to explain how engineering judgment was used to determine the load ratings. All reasonable efforts should be taken to base the Inventory and Operating Ratings on calculated values.
- Field measurements to compare to standards for concrete bridge types that we have in our state. Any engineering judgment that we use we have a flow chart based on design vehicle for the bridge and current condition rating of the bridge.
- Bridges with Unknown Structural Components: for concrete and masonry bridges with no design plans, and when the necessary reinforcing details are unknown and cannot be measured, load capacity ratings may be determined based on field inspection by a qualified bridge inspector followed by evaluation by a qualified engineer. Such a bridge does not need to be posted for load restrictions if it has been carrying normal traffic for an appreciable period of time and shows no sign of distress; Reference the AASHTO Manual

for Bridge Evaluation (MBE) second edition, Sections 6.1.4 and 6A.8.1. General rating guidelines for these structures are:

  - Inventory rating shall be equal to the design truck at the time the bridge was constructed.
  - Operating rating shall be equal to the inventory rating multiplied by 1.667.
  - Legal trucks rating factors shall be equal to 1 when the Superstructure, Substructure, or culvert NBI code is equal or greater than 5. Restriction of permit loads shall be assessed.
  - Posting or restricting of a bridge shall be assessed when NBI code of the superstructure, substructure or culvert is 4 or less or when there are signs of structural distress.
  - The Load Rating Methods WB1551 and WB1554 shall be coded as "0", Administrative.
  - Full documentation for an administrative rating shall be placed in the bridge load rating file.

- [State] developed a process for load rating concrete structures with unknown details years ago, based on multiple concrete structures with known design calculations. Operating ratings were approximated for each bridge, and an inventory to operating ratio was calculated. All of the concrete bridges were grouped into three span length ranges. The live load design vehicle was converted to equivalent vehicles and new values were projected for the various AASHTO and/or state legal vehicles. Three tables, corresponding to the three different span length ranges, were developed for several different rating vehicles. See Appendix A - Judgment Load Rating Concrete Structures of the attached [State] Bridge Load Rating Manual. (referenced document provided in Appendix C)
- Structures with Missing Drawings- For concrete bridges missing reinforcing details and the design live load is known:
  - Estimate the capacity of the bridge or box culvert (if the fill is less than 2') by assuming the load rating factor equals 1.0 for the design load (Examples: HS15, HS20, HS20 Lane, HL93, etc.).

    - Determine the load rating factors for the remaining rating vehicles by calculating the respective live load effects and using the estimated capacity determined from the design load.
- For concrete bridges missing reinforcing details and the design live load is unknown:
    - Provide an administrative rating of 1.0 at the Inventory level and 1.67 at the Operating level for the HS20 truck and remaining rating vehicles. This method is acceptable when the minimum NBI Condition Rating for the bridge is above 4.
- Steel or Timber Structures Missing Drawings:
    - Steel and timber girder bridges without drawings will require field measurements to perform the load rating.

Question 2.3: Does your state publish its own bridge evaluation manual?

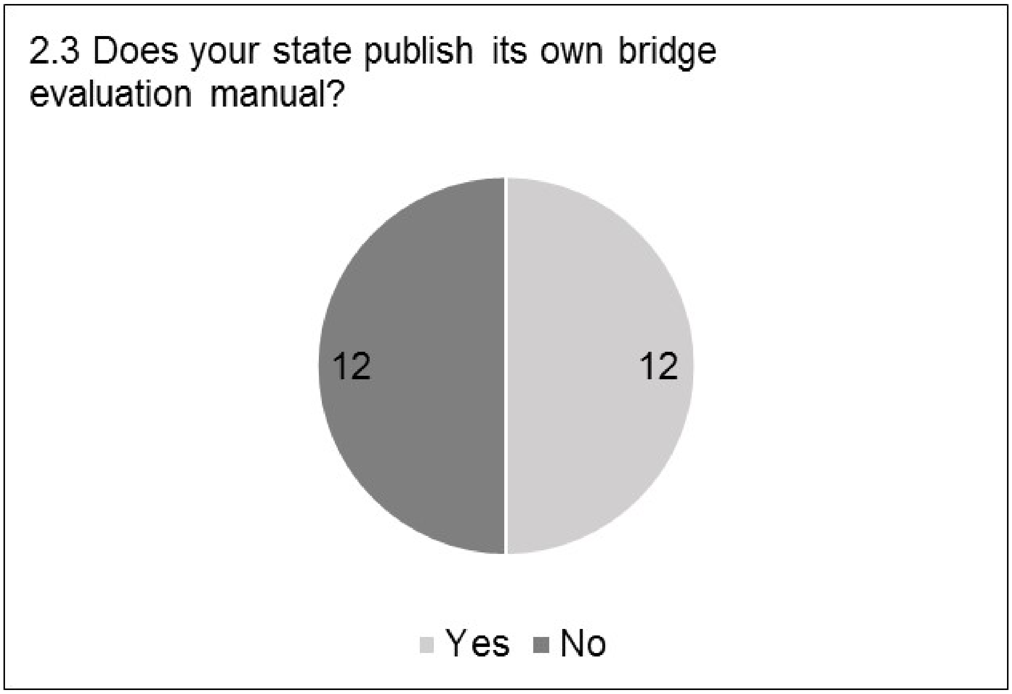


Figure 23. Respondents who publish a state manual for bridge evaluation

Question 2.4: If you responded 'Yes' to 2.3, is the rating process for concrete bridges with no plans addressed in this manual?

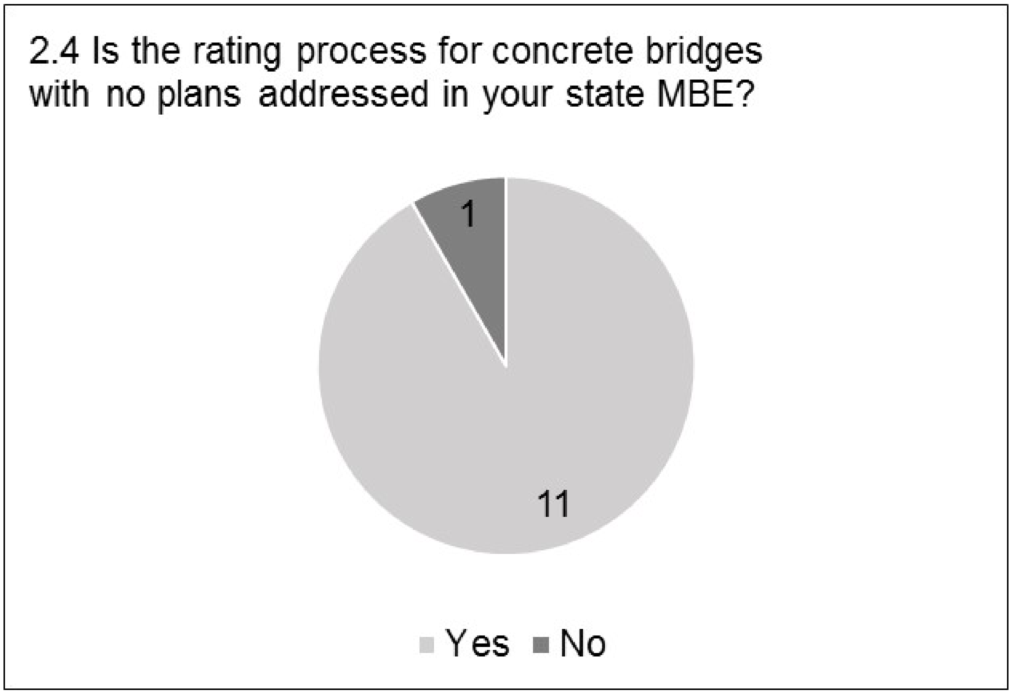


Figure 24. State MBE specifically addresses rating concrete bridges with no plans

Question 2.5: Does your approach to rating concrete bridges with no plans follow the procedures recommended in the Manual for Bridge Evaluation (MBE)?

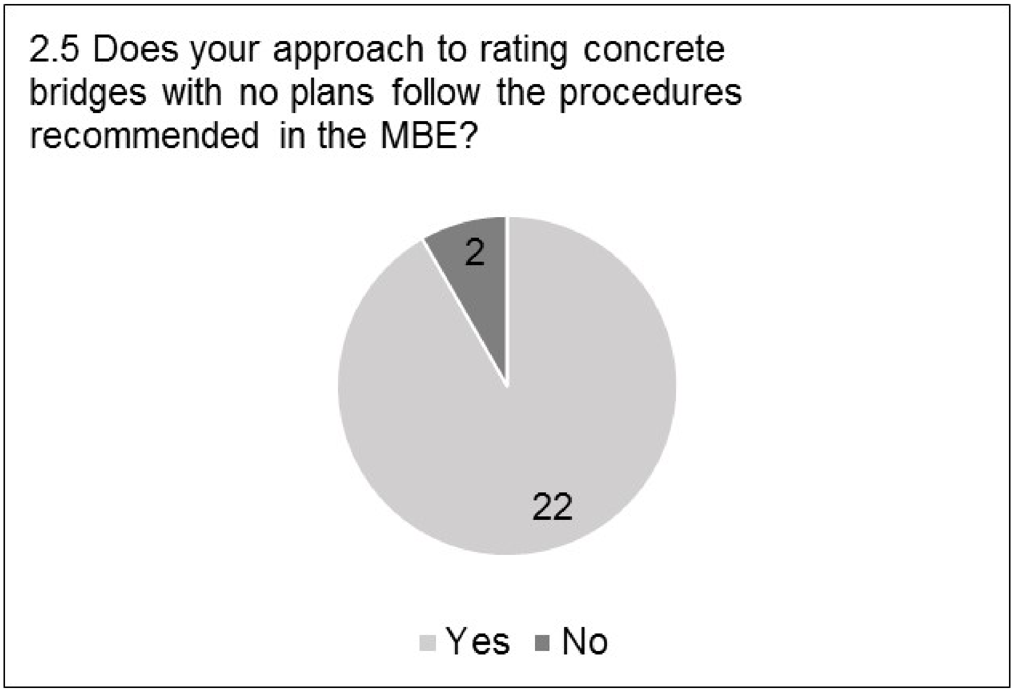


Figure 25. Approach to rating concrete bridges with no plans follows MBE

Question 2.6: Do you use any specific technologies to aid in the process of rating concrete bridges with no plans?

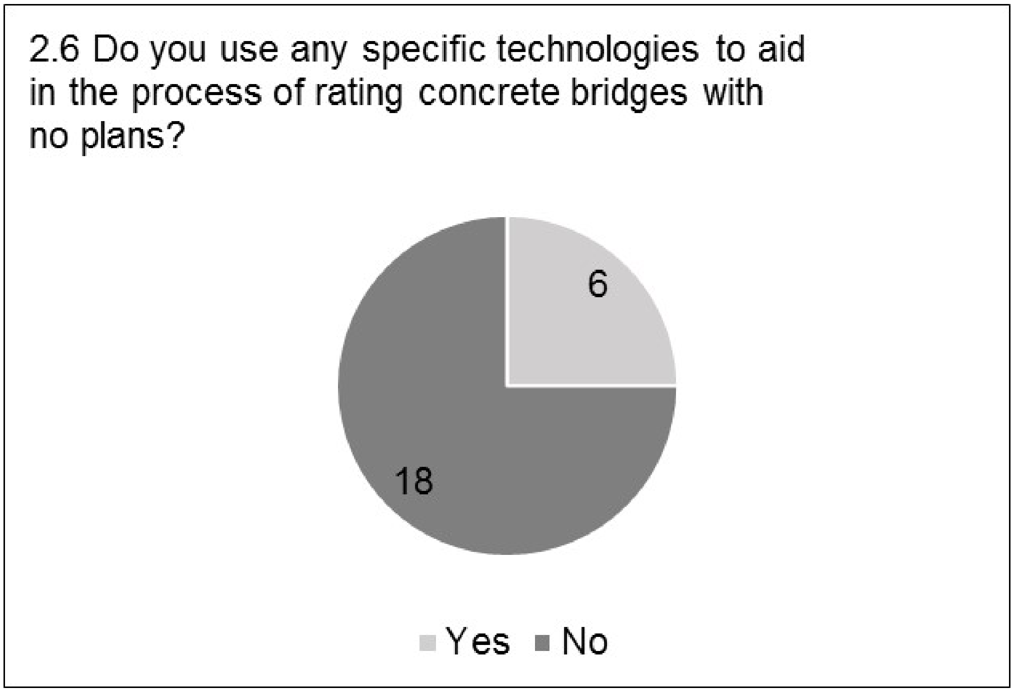


Figure 26. Approach to rating concrete bridges with no plans follows MBE

The following details were provided by respondents who indicated they use specific technologies in the process of rating concrete bridges with no plans.

- NDE rebar locator. Rebar spacing and depth has been used to determine the rebar location, spacing, and size within a portion of the cast-in-place tee-beam structure. Local destructive testing was then completed to verify accuracy of information. After verification, the entire superstructure was surveyed. Unfortunately, interior rebar is usually hidden in the "shadow" of exterior rebar and adjacent rebar is too closely spaced.
- In rare instances scanning equipment and destructive testing have been used to locate rebar and take material samples.
- Typically low-tech:
    - A pachometer
    - Comparable plans from a similar era
    - Occasionally X-ray, to count prestressing strands

    - GPR to develop rebar plans
    - Destructive testing is seldom performed, but sometimes we expose bars to measure or take a material coupon
- GPR scan of prestressed beams to determine the number of prestressed strands in the bottom flange. Strain gages on concrete structures combined with load testing.
- Besides taking cores, strain gauging while load testing.
- GPR scanning if any NDT is used. Primary tool is a database of bridges with known reinforcement, and we use that as a basis to find similar structures to make reasonable assumptions about structures with unknown reinforcement.

Question 3.1: How many bridges exist in your state for which you have no plans?

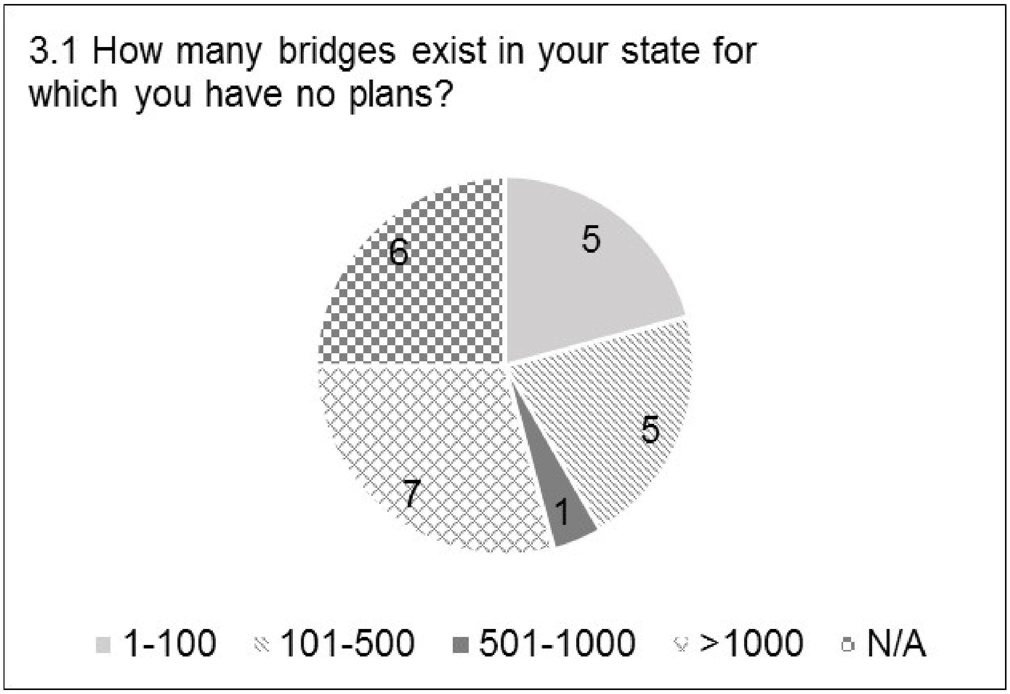


Figure 27. Quantity of bridges with no plans

Question 3.2: Provide the quantity of no-plan bridges in each [category].

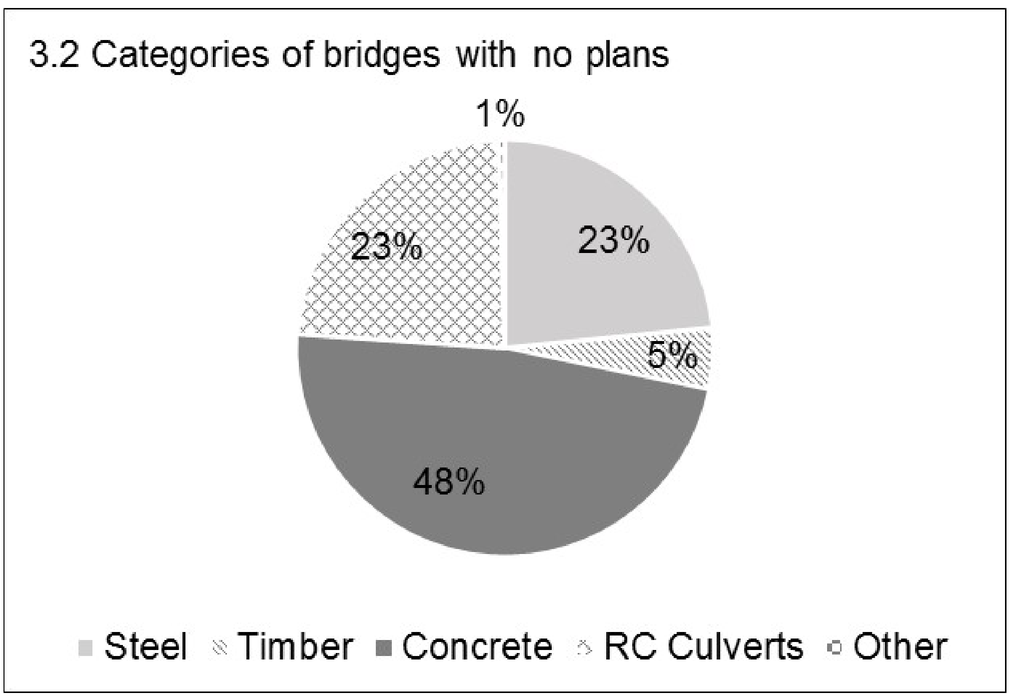


Figure 28. Categories of bridges with no plans

Question 3.3: Are all of these bridges currently load rated? If no, are they in the process of being load rated?

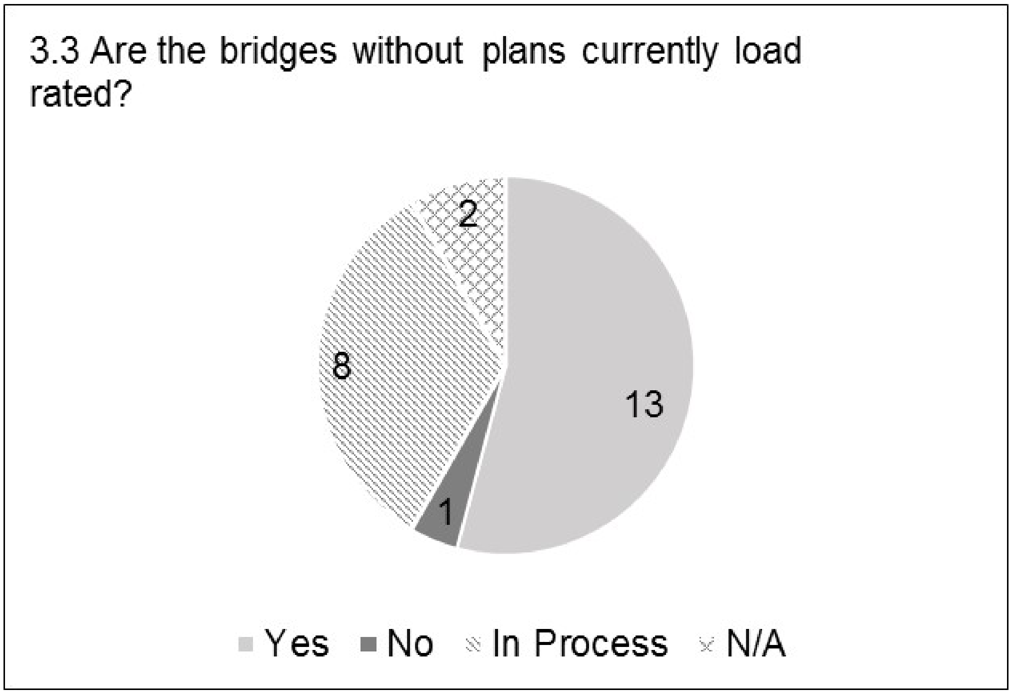


Figure 29. Categories of bridges with no plans

Question 3.4: Are Special Haul Vehicle postings currently required for any rated bridges in your state? If so, explain the sign(s) you are using for posting and if they are used in conjunction with any MUTCD signs such as R12-1 or R12-5.

The following details were provided in response to question 3.4. Any identifying information has been removed from the descriptions.

- [State] posts to the inventory level. [State] uses a "Maximum Axle Group" sign to represent the Tandem, Triple, Quad and SHV axle groups. Conservatively, the minimum of those vehicles is posted at the bridge to minimize the number of signs.
- No (4)
- Yes, per federal requirements on the interstates. However, [state] law does not allow them currently so no bridges are currently posted for these vehicles and no posting signs specific to these vehicles have been developed.
- Yes. The posting sign is in conjunction with MUTCD R12-1.

- Yes. Signs R12-1 or R12-5. See [state] Load Rating Manual. (referenced document provided in Appendix D)
- [State] does not have special posting signs for Special Haul Vehicles. They are grouped in with all Single Unit vehicles and postings.
- Yes, they are R12-4 with the heading of "Weight Limit Single Unit Vehicles" and 3 lines for 5 axles, 6 axles, and 7+ axles.
- Yes. We have not developed standards for signing at this time.
- [State] rates and posts structures for [state] Legal Loads and uses signs such as the MUTCD R12-1 to limit traffic.
- We're utilizing the SHV and EV's in current project however we haven't completed so haven't begun to post for either of these types of loads.
- Yes. 3 level posting for on-system and single level (H20) for off-system.
- We do post for Specialized hauling Vehicles in [state]. At the end of…the [state] LRFR Manual, the different posting signs that [state] developed are discussed and shown. (referenced document provided in Appendix D)
- Yes, the process is currently being formalized. The sign will be very similar to [state] R12-I100, with breakdown of single vehicles by axle number (similar to combinations).
- Yes. In 2015 we replaced the R12-1 silhouette sign with a text only posting sign. The sign shows the posting in tons for single unit and combination vehicles.
- Yes. Please see our attached draft IIM for Load rating which includes signage, and a draft posting decision tree that provides guidance on which sign to select. (referenced document provided in Appendix D)
- SHV's that require posting are covered under our current silhouette sign, which is a variation of the R12-5. Our standard legal load posting sign has five silhouettes - 2 axle SU, 3-axle SU, 4-axle SU (also covers remainder of SU vehicles), 4-axle combination, and 5-axle combination.
- Yes. We use single tonnage signs.
- We have modified the R12-5 sign to accommodate SHVs. The modified sign will have separate limits for 2 & 3 axle single unit trucks (Type 3), 4 & 5 axle single unit trucks (SU4

& SU5), and 6+ axle single unit trucks (SU6 & SU7). Semi-trailer combinations and Truck and Trailer combinations will remain the same.

Question 3.5: In your state, who is responsible for rating bridges owned by counties/localities?

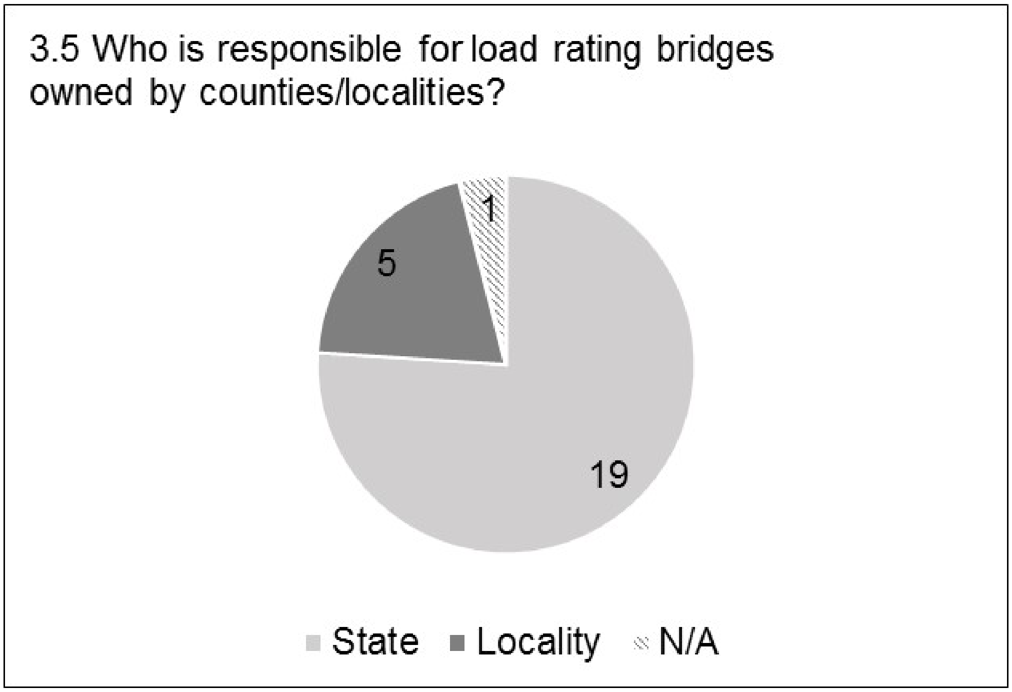


Figure 30. Responsible party for local bridges

The following additional details were provided in response to question 3.5.

- Owners are responsible, but in the absence of load ratings from owners, the state will load rate based on information we have available.
- [State], except self-inspecting agencies.
- Majority are rated by state engineers.
- The state, which typically contracts the work to private firms.
- It is the local agency's responsibility to load rate bridges under their jurisdiction for new construction. However, all load ratings and potential postings must be approved by the [state] Department of Transportation before they are official.

- The local agencies are ultimately responsible for their own ratings; however, consultants (hired by the state) do the majority of the ratings.
- For new structures, we are working with the counties/local entities to have them responsible for load rating information to [state] DOT. For existing structures, [state] DOT performs the load ratings.
- [State] DOT is responsible for rating local agency bridges. However, some counties have elected to hire their own consultants to load rate their bridges if they do not want to wait for [state] DOT to work the rating into our funding program. The local agencies still follow the procedures outlined in the [state] LRFR Manual if they elect to rate bridges themselves.
- The state coordinates consultant load rating for local structures. Ratings for locally owned structures are funded with an 80/20 split between federal dollars and the local government owner.
- All routes in our state are under [state] jurisdiction, except for local city/municipality owned structures. For most city/municipality bridges, [state] will assist by performing load ratings and making recommendations to the city for weight restrictions, if needed.
- The local owner is ultimately responsible, however state load rating engineers perform this duty for them along with oversight. Since 2008, [state] DOT has updated and maintained load ratings for at least 95% of local bridges.

Question 3.6: Has your state ever been required to develop a Plan of Corrective Action for bridge load rating?

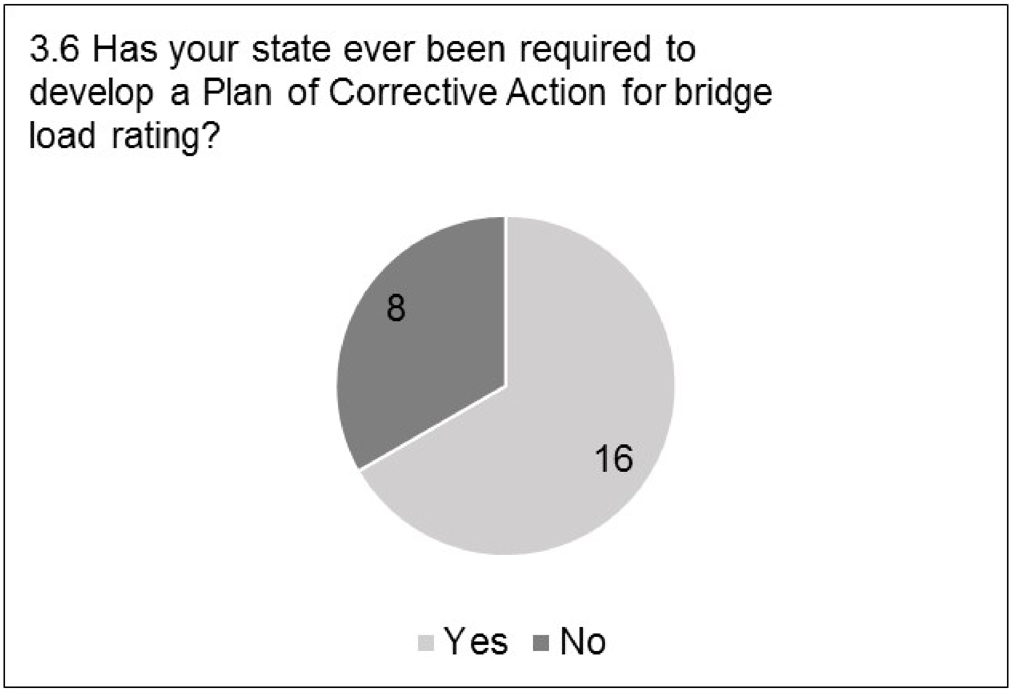


Figure 31. Required Plan of Corrective Action for bridge load rating

Question 3.7: If you responded ‘Yes’ to 3.6, did this include bridges for which you had no plans?

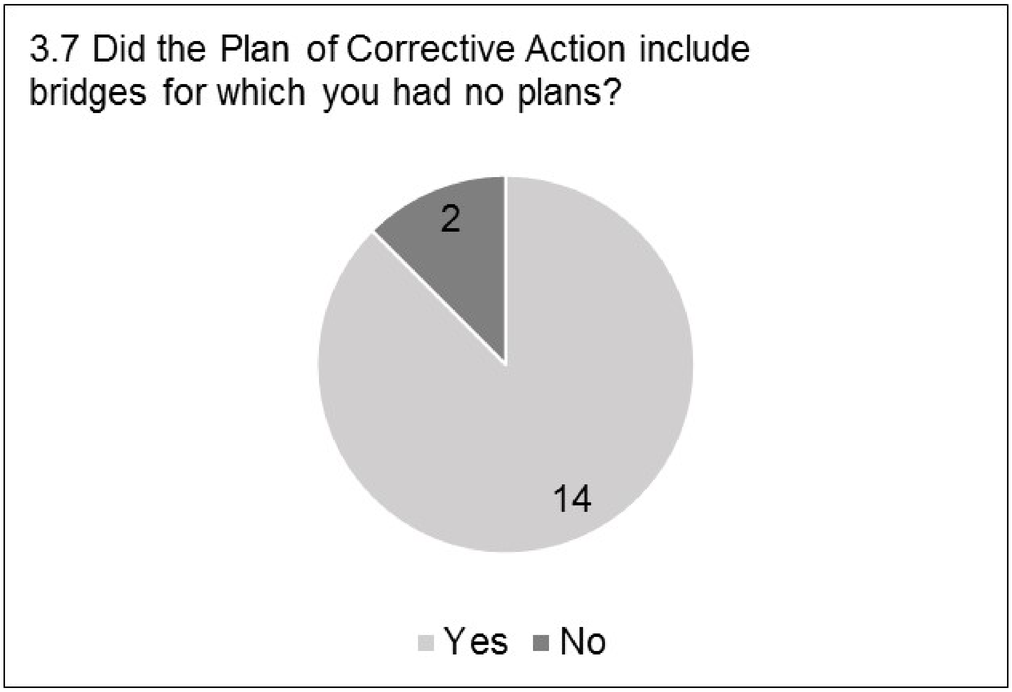


Figure 32. Plan of Corrective Action included rating bridges with no plans

Question 3.8: Has your FHWA Division Bride Engineer approved or disallowed specific methods for load rating bridges with no plans?

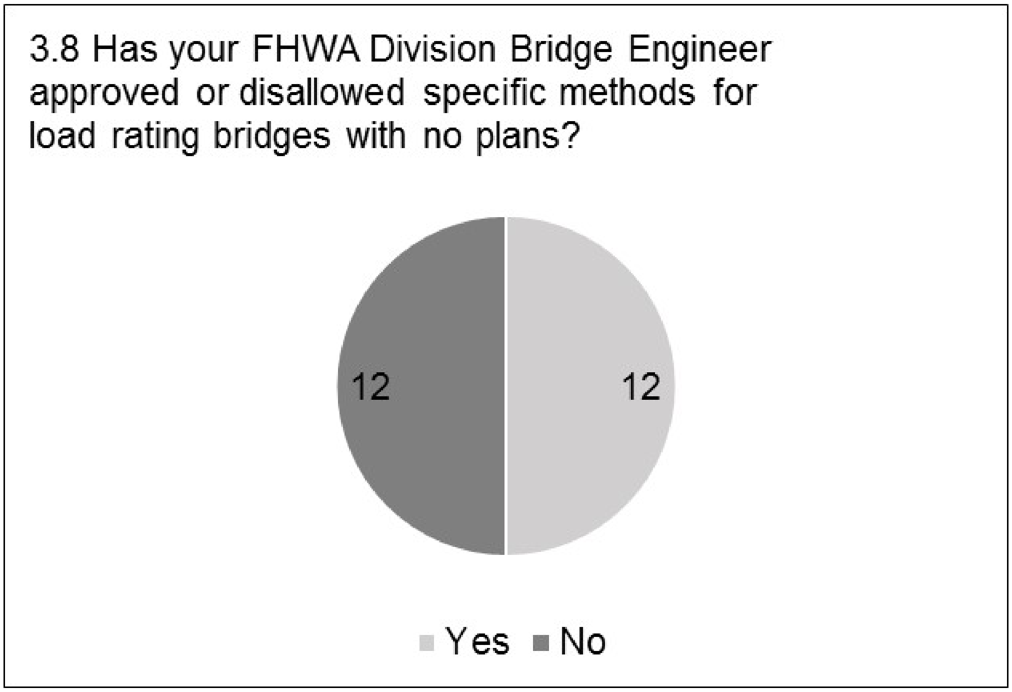


Figure 33. FHWA Division Bridge Engineer involvement for load rating bridges with no plans

Question 3.9: If you responded 'Yes' to question 3.8, what methods were approved? What methods were disallowed? The following details were provided in response to question 3.9.

- Load rating bridges using engineering judgment has been approved provided there is no load-induced structural damage. Bridges with one plan sheet, stamped, and marked with HS20 were not allowed to have an assigned load rating due to the latest FHWA clarification of what is required in order to have a valid assigned rating.
- Assigned by era-specific design for reinforced concrete structures without plans is allowed. Ratings for all other bridge types with sections/dimensions that can be field measured must be calculated.
- The FHWA concurs with our bridge load rating manual, which briefly addresses bridges with no plans. (referenced document provided in Appendix C)
- Approved:
    - Concrete or masonry bridges with no plans; use rational evaluation method.

    - All other bridge types with no plans; analytical load rating using field measurements and material strengths from estimated time of construction. May take material samples for testing if necessary.
    - All bridge types; load test is approved but has not been implemented.
- Disallowed assigned load ratings; approved all methods currently shown in our Load Rating chapter. (referenced document provided in Appendix C)
- It is unclear what FHWA has allowed and disallowed. We are proceeding with engineering judgment as a reasonable, logical approach. FHWA seems okay with this if we have the procedures and policies documented.
- Approval was given to the development of the Engineering Judgement memorandum. Disapproval of assigning load rating for structures without plans without documentation. (referenced document provided in Appendix C)
- The [State] FHWA Division Engineer reviewed our "Concrete Bridges Without Plans Rating Procedure" back in 2010 and gave approval, which we then incorporated the procedures into our load rating manual. (referenced document provided in Appendix C)
- The FHWA Division Bridge Engineer has disallowed load rating bridges based on solely engineering judgment and no calculations. He supports methods that only include analytical models, such as AASHTOWare BrR and FEA programs, with load testing as an option only if the bridge does not rate as expected.

Question 3.10: Has your FHWA Division Bridge Engineer ever requested additional information regarding the rating of bridges with no plans?

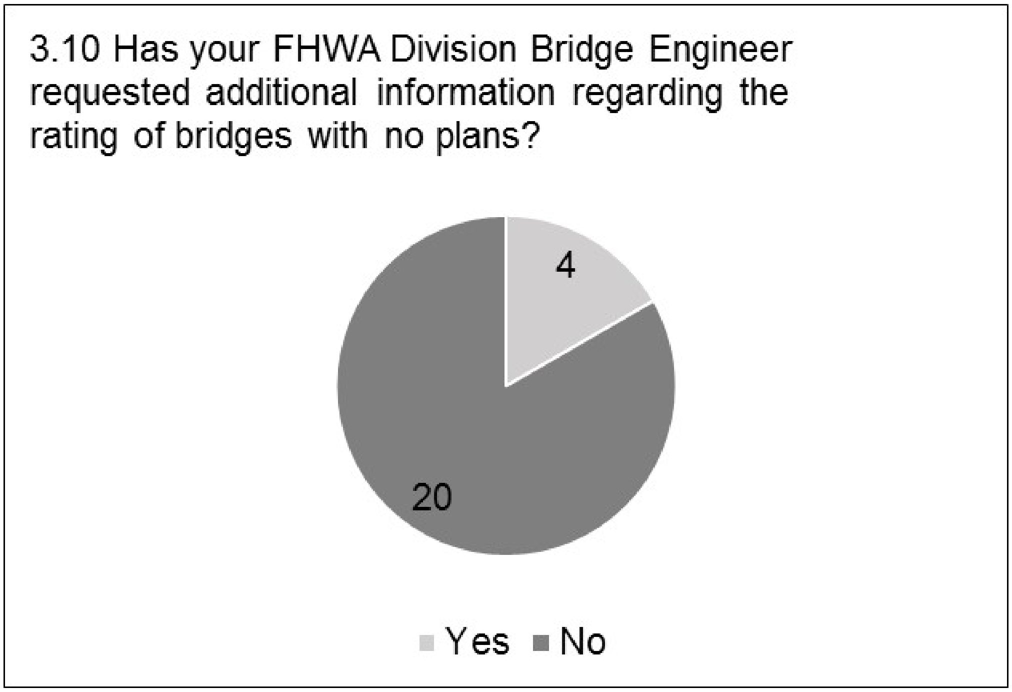


Figure 34. FHWA Division Bridge Engineer request for additional information

Question 3.11: If you responded 'Yes' to question 3.10, what additional information was required? How did you approach this situation? The following additional details were provided in response to question 3.11.

- The additional information requested was primarily related to the development of a plan of corrective action on the processes that would be followed to load rate bridges without plans, more than the load rating itself.
- Policy and procedures for the determination of assumed era-specific live load demands for state and local agency bridges. Meetings were held prior to the signing of our PCAs.
- Load testing.
- Culvert (RCB) were initially assigned ratings based on their design or assumed design loading. Calculations were initially created and charts developed to use in assigning the correct load ratings. Since the initial calculations are no longer available, the charts were deemed not acceptable.

Question 3.12: Please provide any additional information you feel would be beneficial for us as we look into this issue. The following additional details were provided in response to question 3.12.

- In some instances, bridges without sufficient documentation are inherited by the State. Attempts have been made by the State to acquire such information, but usually the contractor or fabricator is unknown or the fabricator is no longer in business. It may be beneficial to have an FHWA notice to local agencies that bridge plans, shop drawings, and materials of similar nature must be kept for the life of the structure. This will limit the number of future structures being built where calculations and drawings being purged after local agency retention period is exceeded, i.e. 10 years or other similar time frame.
- Load ratings based on load testing are limited to the structural capacity and vehicles used for evaluation at the time of the testing. If the structural condition of the bridge changes, the load rating is no longer valid and a new load test will be required. Likewise, if legal vehicle configurations allowed by the State or FHWA change, then new load tests will be required for all bridges that used load testing as a basis. In addition, it is very difficult, if not impossible, to assess the safety of permit loads which by their nature vary in axle configurations and weight.
- For us, the issue often comes down to some version of a scenario in which you've got a load path redundant 50 to 100 year old bridge that is in good condition and has never been formally load rated or load tested. Why would we use taxpayer money to suddenly rate the bridge or perform a load test without any specific concerns with the bridge? If you have specific concerns, then rating or load testing may be a good idea.

Appendix C

Procedures for Load Rating Concrete Bridges with No Plans

[redacted]

5.10 Assigned Load Rating Procedures

When assigning a load rating to any structure, the bridge archive shall be reviewed for the most recent Bridge Inspection Report (BIR), as-builts, design plans, existing calculations, and any indication that the rating factors should be lower than what is prescribed herein. While as-built plans are preferred, design plans may be utilized for assigning the load rating after comparison in the field confirms their applicability. A newly calculated rating or an existing calculated rating, if one exists, shall be used rather than an assigned load rating. Once a structure is assigned a load rating, the condition of the structure must be re-evaluated at every inspection to confirm that the assigned capacities are still valid.

For bridges that do not have distress or deterioration that would affect their load carrying capacity, the provisions of this section shall be used to assign load ratings in the following cases (summarized in *Table 3*):

- Concrete and steel bridges with archived as-built or design plans meeting the conditions described in ***Section 5.10.2*** of these procedures.
- Concrete bridges for which details of the reinforcement are unknown ***(Section 5.10.3)***
- Concrete culverts ***(Section 5.10.4)***
- Concrete or masonry earth filled deck arches ***(Section 5.10.4)***
- When no rating calculations exist, to temporarily establish load ratings for bridges that require calculations until an analysis can be completed for ***(Section 5.10.1)***:
    a. Concrete and steel bridges designed by Allowable Stress Design;
    b. Concrete and steel bridges with an unknown design method;
    c. Concrete and steel bridges with no permit design live load indicated on the design or as-built plans;
    d. Concrete and steel bridges where the as-built or design plans are not stamped or signed by a registered professional engineer;
    e. Steel bridges and culverts with an archived typical section;
    f. Timber bridges with an archived typical section.

Bridges exhibiting distress that may affect load carrying capacity require a more in-depth evaluation for load ratings. This evaluation may entail comparison to similar structures with plans, an additional search for as-built plans, destructive and non-destructive testing, or load testing to more accurately determine the load ratings. Questions on how to proceed may be directed to the Load Rating Branch.

5.10.1 Temporarily Assigned Load Ratings

The procedures outlined in ***Section 5.10.3*** shall be used by the ABME/Inspector to temporarily assign load ratings to a bridge new to the inventory until the ratings can be finalized by the Load Rating Branch.

Note: As of May 15, 2018, ABMEs/Inspectors will no longer complete or archive Load Rating Summary Sheets (LRSS), see ***Section 7.9 – Load Rating Responsibilities*** for more direction.

5.10.2 Assigned Load Ratings for Concrete and Steel Bridges with As-Built or Design Plans

The ***AASHTO Manual for Bridge Evaluation (MBE), Second Edition/2011, Sections C6A.1.1 and C6B.1***, states that a structure designed and checked by LRFD or LFD methods using HL93 or HS20 loading respectively, may not require load rating calculations to determine the inventory and operating rating until changes to the structure occur that would reduce the inventory rating below the design load level.

The following procedures shall be used to assign load ratings to bridges with as-built or design plans:

Concrete and Steel Bridges Designed By Load Factor Design Method (LFD)

For concrete and steel bridges where the as-built or design plans indicate the design method is LFD with at least HS20-44 and Permit as the design live loads, and are signed or stamped by a registered professional engineer, the following National Bridge Inventory (NBI) codes and load ratings shall be assigned:

NBI Item 31, Design Load:	= 5	(MS18 [HS20])
NBI Items 63 & 65, Method Used to Determine Operating and Inventory Rating:	= A	(Assigned rating based on LFD reported in metric tons)
NBI Item 66, Inventory Rating:	RF = 1.00	(32.4 metric tons)
NBI Item 64, Operating Rating:	RF = 1.67	(54.1 metric tons)
Permit Rating:	RF = 1.00	(PPPPP)
All Legal Truck Ratings:	RF = 1.00	

Concrete and Steel Bridges Designed By Load and Resistance Factor Design Method (LRFD)

For concrete and steel bridges where the as-built or design plans indicate the design method is LRFD with at least HL-93 and Permit as the design live loads, and are signed or stamped by a registered professional engineer, the following NBI codes and load ratings shall be assigned:

NBI Item 31, Design Load:	= A	(HL93)
NBI Items 63 & 65, Method Used to Determine Operating and Inventory Rating:	= F	(Assigned rating based on LRFD reported by rating factor (RF) using HL93 loadings)
NBI Item 66, Inventory Rating:	RF= 1.00	(32.4 metric tons)
NBI Item 64, Operating Rating:	RF= 1.30	(42.1 metric tons)
Permit Rating:	RF= 1.00	(PPPPPPPP)*
All Legal Truck Ratings:	RF = 1.00	

* recorded as PPPPP in Bridge Inspection Report.

Concrete and Steel Bridges Designed By Allowable Stress Design Method (ASD) or the Design Method Is Unknown

For concrete and steel bridges where the as-built or design plans indicate the design method is ASD, or when the design method is unknown, load rating calculations are required. When no calculations exist and until load rating calculations are completed, a temporary load rating shall be assigned as directed in *Section 5.10.1* of these procedures.

Concrete and Steel Bridges Where No Permit Design Live Load Is Indicated

Load rating calculations are required regardless of the design method when no Permit design live load is indicated on the as-built or design plans. When no calculations exist and until load rating calculations are completed, the Inventory, Operating and Permit ratings shall be temporarily assigned as directed in *Section 5.10.1* of these procedures.

All Concrete and Steel Bridges where the As-built or Design Plans are not Signed or Stamped by a Registered Professional Engineer

Load rating calculations are required for all concrete and steel bridges when a registered professional engineer signature or stamp is not indicated on the as-built or design plans.

If no rating calculations exist and until load rating calculations are completed, the Inventory, Operating and Permit ratings shall be temporarily assigned as directed in ***Section 5.10.1*** of these procedures.

5.10.3 Assigned Load Ratings for Concrete Bridges with Unknown Reinforcement (no plans available)

The ***Manual for Bridge Evaluation (MBE), Sections 6A.8.1 and 6B.7.1***, indicate that a concrete bridge with unknown reinforcement need not be posted for restricted loads when it has been carrying unrestricted traffic for an appreciable length of time and shows no distress, deterioration, or other condition affecting the load carrying capacity. For concrete bridges with unknown reinforcement, the ***MBE*** allows the Inventory and Operating Ratings to be assigned by administrative procedure substantiated by field evaluation and engineering judgment. The procedure is based on the premise that a structure in good condition should be capable of sustaining the live load for which it was designed or the live load it has historically sustained.

When the most recent inspection indicates no significant distress, the load ratings for a bridge may be assigned based on an assumed capacity derived from its estimated design live load. In cases where this assigned design live load rating indicates the bridge requires posting, then the load ratings for the bridge may be assigned based on an assumed capacity derived from AASHTO legal loads.

Assigned Load Rating Data Sheet and Live Load Moments:

An ***Assigned Load Rating Data Sheet (Attachment A)*** has been established to document the pertinent information used to assign the live load capacity and provide a rationale for the determination of the Inventory and Operating Ratings, the AASHTO legal truck rating factors and the Permit vehicle rating factors. The derivation procedure indicated on this data sheet shall be used for all concrete bridges with unknown reinforcement or other structures assigned ratings using the provisions of this section.

A ***Live Load Moment Table (Attachment B)*** indicating maximum simple span moments for H10, H15 and HS20 design vehicles, AASHTO Legal Trucks, and [redacted] Permit Vehicles has been provided for use with Attachment A in determining assigned load ratings. It is acceptable to utilize these simple span moments to assign load ratings for continuous bridges as well as simple span bridges.

Procedure for Assigning Load Ratings:

The following procedure shall be used to assign load ratings for concrete bridges with unknown reinforcement:

1. Use ***Table 1*** to estimate the design live load based on the design year and the agency responsible for designing the structure.

2. Use the ***Live Load Moment Table*** to identify the live load moments for the controlling span length corresponding to the above estimated design live load, the Type 3, 3S2 and 3-3 trucks and Permit vehicles.

3. Complete the procedure outlined in left column of the ***Assigned Load Rating Data Sheet***, utilizing the live load moments identified above, to derive the appropriate load ratings assuming the moment capacity of the bridge at the Inventory level is equivalent to the design live load moment for the controlling span length.

   The ***Assigned Load Rating Data Sheet*** shall be archived in the same manner as rating calculations.

4. In some cases, the procedure outlined above may result in ***rating factors less than 1.0 for the Type 3, 3S2 and 3-3 trucks,*** particularly when the capacity of the bridge at the Inventory level is assumed to be the H10 design live load. In these cases, additional calculations may be required. If, in the opinion of the rating engineer, the bridge should not be posted, complete the procedure outlined in the right column of the ***Assigned Load Rating Data Sheet*** to derive the appropriate load ratings assuming the moment capacity of the bridge at the Operating level is equivalent to the maximum of the Type 3, 3S2 and 3-3 truck moments for the controlling span length.

5. Code **NBI Item 31** (Design Load) = **0** - Other or Unknown.

6. Code **NBI Items 63 and 65** (Method Used to Determine Operating and Inventory Ratings) **= 0** - Field Evaluation and Documented Engineering Judgment.

Table 1 – Estimated Design Live Load Based on Year of Design and Design Agency		
Design Year	**State Design**	**Local Agency Design**
Before 1944	H15	H10
1944 to 1949	H20-S16-44	H10
1950 to 1956	H20-S16-44	H15
1957 to 1964	H20-S16-44 and Alt	H15
1965 to 1972	HS20-44	H15
1973 to present*	HS20-44, Alt and Permit	HS20-44

* While bridges designed after 2009 may have used HL93 design live loads, SM&I's position is that consistent use of HL 93 design loads in the [redacted] bridge inventory cannot yet be assumed with sufficient certainty.

5.10.4 Assigned Load Ratings for Concrete Culverts and Concrete or Masonry Earth Filled Deck Arches

All structures defined as concrete culverts, concrete earth filled deck arches or masonry earth filled deck arches may have the load ratings assigned if no calculations exist. All assigned ratings must be substantiated by a current inspection that accurately establishes the condition ratings for NBI Item 62 (for culverts) or NBI Items 59 & 60 (for concrete or masonry earth filled deck arches).

The above noted structure types are divided into two load rating categories:

A. Culverts or earth filled deck arches in ***good to fair condition***, defined as:

- NBI Item 62 ≥ 6 for concrete culverts, or
- Both NBI Items 59 and 60 ≥ 5 for concrete or masonry earth filled deck arches.

B. Culverts or earth filled deck arches in ***poor condition***, defined as those with NBI condition ratings less than indicated above.

A. Structures in Good to Fair Condition (NBI Item 62 ≥ 6 or both NBI Items 59 & 60 ≥ 5)

- For structures with ***known design live loads***, the load rating is assigned based on *Table 2*, and NBI Item 31 (Design Load) is coded to correctly reflect the known design live load.

- For structures with ***unknown design live loads***, the design load will be estimated based on *Table 1***.** A load rating is then assigned based on *Table 2*, and NBI Item 31 **(**Design Load) is coded = 0 – Other or Unknown.
- For structures ***where the depth of fill exceeds the distance between faces of end supports or abutments***, the effect of live load on the structure is considered insignificant and may be disregarded. In this case, the load rating is assigned based on *Table 2*, and NBI Item 31 **(**Design Load) is coded = 0 – Other or Unknown.
- For structures *where the depth of fill is less than the distance between faces of end supports or abutments*, the load rating may be temporarily assigned based on *Table 2*, and NBI Item 31 **(**Design Load) is coded = 0 – Other or Unknown.
- For all culverts and concrete or masonry earth filled deck arches where the load rating has been assigned, code NBI Items 63 and 65 (Method Used to Determine Operating and Inventory Ratings) **=** 0 - Field Evaluation and Documented Engineering Judgment.

Table 2- Assigned Rating Factors for :

Concrete Culverts with NBI Item 62 ≥ 6 and
Concrete or Masonry Earth Filled Deck Arches with both NBI Items 59 & 60 ≥ 5

Known or Estimated Design Live Load	Inventory Rating Factor	Operating Rating Factor	Permit Rating
H20 or HS20	1.0	1.67	PPPPP
H15 or HS15	0.75	1.25	PPPPP
H10	0.50	0.84	PPPPP
Insignificant Live Load (Fill depth > distance between faces of supports/abutments)	99.90	99.90	PPPPP

B. Structures in Poor Condition (NBI Item 62 < 6 or either NBI Items 59 & 60 < 5)

When an inspection has determined that a structure is exhibiting distress or deterioration which results in a condition rating of less than 6 for NBI Item 62 (for concrete culverts), or less than 5 for either NBI Items 59 or 60 (for concrete or masonry earth filled deck arches), including those with insignificant live load, a more in-depth evaluation of the load capacity is required. Assistance may be obtained from the Load Rating Branch.

Table 3 – Assigned Load Ratings Coding Summary

	NBI Item 31	NBI Items 63,65	NBI Item 64	NBI Item 66	Permit Rating	All Legal Truck Ratings
CONCRETE AND STEEL BRIDGES WITH AS-BUILT OR DESIGN PLANS						
LFD Method; Design LL = HS20-44 and Permit	**Code = 5** MS18(HS20)	**Code = A** Assigned ratings based on LFD reported in metric tons	**RF = 1.0** 32.4 metric tons	**RF = 1.67** 54.1 metric tons	PPPPP	RF = 1.0
LRFD Method; Design LL = HL93 and Permit	**Code = A** HL93	**Code = F** Assigned ratings based on LRFD reported by rating factor using HL93 loading	**RF = 1.0** 32.4 metric tons	**RF = 1.30** 42.1 metric tons	PPPPPPPP	RF = 1.0
ASD, Unknown Design Method, No Permit LL Indicated, or Temp. Ratings	**Code = 0** Other or Unknown	**Code = 0** Field Evaluation/ Documented Engineering Judgment	Temporarily assigned as directed in Section 5.10.1	Temporarily assigned as directed in Section 5.10.1	Temporarily assigned as directed in Section 5.10.1	Temporarily assigned as directed in Section 5.10.1
CONCRETE BRIDGES WITH UNKNOWN REINFORCEMENT						
	Code = 0 Other or Unknown	**Code = 0** Field Evaluation/ Documented Engineering Judgment	Assigned by procedure in Section 5.10.3	Assigned by procedure in Section 5.10.3	Assigned by procedure in Section 5.10.3	Assigned by procedure in Section 5.10.3
CONCRETE CULVERTS & CONCRETE OR MASONRY EARTH FILLED DECK ARCHES (Only when NBI Item 62 ≥ 6, or NBI Items 59 & 60 ≥ 5)						
Design LL = H20 or HS20	**Code = 4 or 5** if LL known or **Code = 0** if LL estimated	**Code = 0** Field Evaluation/ Documented Engineering Judgment	RF = 1.0 32.4 metric tons	RF = 1.67 54.1 metric tons	PPPPP	RF = 1.0
Design LL = H15 or HS15	**Code = 2 or 3** if LL known or **Code = 0** if LL estimated	**Code = 0** Field Evaluation/ Documented Engineering Judgment	RF = 0.75 24.3 metric tons	RF = 1.25 40.5 metric tons	PPPPP	RF = 1.0
Design LL = H10	**Code = 1** if LL known or **Code = 0** if LL estimated	**Code = 0** Field Evaluation/ Documented Engineering Judgment	RF = 0.50 16.2 metric tons	RF = 0.85 27.5 metric tons	PPPPP	RF = 1.0
Insignificant LL (Fill depth > distance between faces of supports/abutments)	**Code = 0** Other or Unknown	**Code = 0** Field Evaluation/ Documented Engineering Judgment	**RF = 99.90** 99.9 metric tons	**RF = 99.90** 99.9 metric tons	PPPPP	RF = 1.0
ALL STEEL BRIDGES/ CULVERTS & ALL TIMBER BRIDGES w/ ARCHIVED TYPICAL SECTION	**Code = 0** Other or Unknown	**Code = 0** Field Evaluation/ Documented Engineering Judgment	Temporarily assigned as directed in Section 5.10.1	Temporarily assigned as directed in Section 5.10.1	Temporarily assigned as directed in Section 5.10.1	Temporarily assigned as directed in Section 5.10.1

Attachment A –

Assigned Load Rating Data Sheet

The following sheets are to be used to derive the appropriate load ratings assuming the moment capacity of the bridge at the Inventory level is equivalent to the design live load moment for the controlling span length.

Assigned Load Rating Data Sheet for Concrete Bridges without Plans

Structure Name: ___________________________ Year Built: _________

Assumed Design Live Load: ________ Design LL Comments: _________________________________

Condition of bridge: ____

Span Length (ft): _________ Overlay Thickness (in) _________

Using Attachment B, Live Load Moment Table for Assigned Load Rating, fill in all of the moments for each truck for the span length being rated, typically the maximum span of the bridge.

M_{H10}: __________ M_{H15}: __________ M_{HS20}: __________

$M_{Type\ 3}$: __________ $M_{Type\ 3\text{-}S2}$: __________ $M_{Type\ 3\text{-}3}$: __________

$M_{P\text{-}5}$: __________ $M_{P\text{-}7}$: __________ $M_{P\text{-}9}$: __________ $M_{P\text{-}11}$: __________ $M_{P\text{-}13}$: __________

Load Rating based on the Design Live Load:

Design Live Load:

$M_{(\quad)}$: ________ $= M_{Cap(Design)}$
H10, H15, HS20

Inventory Rating:

$$RF_{INV} = \frac{M_{Cap(Design)}}{M_{HS\text{-}20}} = \frac{(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$$

$IR = \frac{\_\_\_\_\_\_}{RF_{INV}}$ x 32.4 = ________ Metric tonnes

Operating Rating: $RF_{OP} = {}^{5}/_{3} \times RF_{INV}$

$RF_{OP} = {}^{5}/_{3} \times$ ________ $= \boxed{\quad}$

$OR = \frac{\_\_\_\_\_\_}{RF_{OP}}$ x 32.4 = ________ Metric tonnes

Legal Load Rating Factors:

Type 3: $RF = \frac{{}^{5}/_{3}\, M_{Cap(Design)}}{M_{Type\ 3}} = \frac{{}^{5}/_{3}(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$

Type 3-S2: $RF = \frac{{}^{5}/_{3}\, M_{Cap(Design)}}{M_{Type\ 3\text{-}S2}} = \frac{{}^{5}/_{3}(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$

Type 3-3: $RF = \frac{{}^{5}/_{3}\, M_{Cap(Design)}}{M_{Type\ 3\text{-}3}} = \frac{{}^{5}/_{3}(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$

Load Rating based on the Maximum AASHTO Legal Load:

Controlling Legal Load: (Highest induced moment)

$M_{Type\ (\quad)}$: ________ $= M_{Cap(Legal)}$
3, 3-S2, 3-3

Operating Rating:

$$RF_{OP} = \frac{M_{Cap(Legal)}}{M_{HS\text{-}20}} = \frac{(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$$

$OR = \frac{\_\_\_\_\_\_}{RF_{OP}}$ x 32.4 = ________ Metric tonnes

Inventory Rating: $RF_{INV} = {}^{3}/_{5} \times RF_{OP}$

$= {}^{3}/_{5} \times$ ________ $= \boxed{\quad}$

$IR = \frac{\_\_\_\_\_\_}{RF_{INV}}$ x 32.4 = ________ Metric tonnes

Legal Load Rating Factors:

Type 3: $RF = \frac{M_{Cap(Legal)}}{M_{Type\ 3}} = \frac{(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$

Type 3-S2: $RF = \frac{M_{Cap(Legal)}}{M_{Type\ 3\text{-}S2}} = \frac{(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$

Type 3-3: $RF = \frac{M_{Cap(Legal)}}{M_{Type\ 3\text{-}3}} = \frac{(\quad\quad)}{(\quad\quad)} = \boxed{\quad}$

Permit Load Rating:

P-5: $RF = \frac{^5/_3\, M_{Cap(Design)}}{M_{P\text{-}5}} = \frac{^5/_3(\quad)}{(\quad)} = \square$

P-7: $RF = \frac{^5/_3\, M_{Cap(Design)}}{M_{P\text{-}7}} = \frac{^5/_3(\quad)}{(\quad)} = \square$

P-9: $RF = \frac{^5/_3\, M_{Cap(Design)}}{M_{P\text{-}9}} = \frac{^5/_3(\quad)}{(\quad)} = \square$

P-11: $RF = \frac{^5/_3\, M_{Cap(Design)}}{M_{P\text{-}11}} = \frac{^5/_3(\quad)}{(\quad)} = \square$

P-13: $RF = \frac{^5/_3\, M_{Cap(Design)}}{M_{P\text{-}13}} = \frac{^5/_3(\quad)}{(\quad)} = \square$

Permit Rating:

P-5: $RF = \frac{M_{Cap\ (Legal)}}{M_{P\text{-}5}} = \frac{(\quad)}{(\quad)} = \square$

P-7: $RF = \frac{M_{Cap\ (Legal)}}{M_{P\text{-}7}} = \frac{(\quad)}{(\quad)} = \square$

P-9: $RF = \frac{M_{Cap\ (Legal)}}{M_{P\text{-}9}} = \frac{(\quad)}{(\quad)} = \square$

P-11: $RF = \frac{M_{Cap\ (Legal)}}{M_{P\text{-}11}} = \frac{(\quad)}{(\quad)} = \square$

P-13: $RF = \frac{M_{Cap\ (Legal)}}{M_{P\text{-}13}} = \frac{(\quad)}{(\quad)} = \square$

Conclusion:

Based on the observed condition of the bridge and any available information, the following rating factors will be used for the load rating of this bridge.

Inventory Rating: ☐

Operating Rating: ☐

Permit Rating:

5 Axle: ☐

7 Axle: ☐

9 Axle: ☐

11 Axle: ☐

13 Axle: ☐

Legal Truck Rating: Type 3: ☐

Type 3-S2: ☐

Type 3-3: ☐

Stamp:

Rated by: ____________________

Date: ____________________

Checked by: ____________________

Date: ____________________

Comments:

____

____

____

____

____

ATTACHMENT B –

Live Load Moment Table

The following sheet is to be used to identify the live load moments for the controlling span length corresponding to the above estimated design live load, the Type 3, 3S2 and 3-3 trucks and Permit vehicles .

Live Load Moment Table

Live Load Moments in Foot-Kips per Wheel Line (without impact)

Span (ft) c/c	H10	H15	HS20	3	3-S2	3-3	P5	P7	P9	P11	P13
5	10.0	15.0	20.0	10.6	9.7	10.0	16.3	16.3	16.3	16.3	16.3
6	12.0	18.0	24.0	12.8	11.6	12.0	19.5	19.5	19.5	19.5	19.5
7	14.0	21.0	28.0	15.2	13.8	14.0	22.8	22.8	22.8	22.8	22.8
8	16.0	24.0	32.0	19.1	17.4	16.0	26.0	26.0	26.0	26.0	26.0
9	18.0	27.0	36.0	23.1	21.1	19.1	30.4	30.4	30.4	30.4	30.4
10	20.0	30.0	40.0	27.2	24.8	22.4	36.0	36.0	36.0	36.0	36.0
11	22.0	33.0	44.0	31.3	28.5	25.8	41.8	41.8	41.8	41.8	41.8
12	24.0	36.0	48.0	35.4	32.3	29.2	47.5	47.5	47.5	47.5	47.5
13	26.0	39.0	52.0	39.6	36.1	32.6	53.3	53.3	53.3	53.3	53.3
14	28.0	42.0	56.0	43.7	39.9	36.0	59.2	59.2	59.2	59.2	59.2
15	30.0	45.0	60.0	47.9	43.7	39.4	65.0	65.0	65.0	65.0	65.0
16	32.0	48.0	64.0	52.1	47.5	42.9	70.9	70.9	70.9	70.9	70.9
17	34.0	51.0	68.0	56.2	51.3	46.3	76.8	76.8	76.8	76.8	76.8
18	36.0	54.0	72.0	60.4	55.1	49.8	82.7	82.7	82.7	82.7	82.7
19	38.0	57.0	76.0	64.6	58.9	53.2	88.6	88.6	88.6	88.6	88.6
20	40.0	60.0	80.0	68.9	62.8	56.7	94.5	94.5	94.5	94.5	94.5
21	42.0	63.0	84.0	73.1	66.6	60.2	100.4	100.4	100.4	100.4	100.4
22	44.0	66.0	88.0	77.3	70.5	63.6	106.4	106.4	106.4	106.4	106.4
23	46.0	69.0	92.0	81.5	75.2	67.1	112.3	112.3	112.3	112.3	112.3
24	48.0	72.0	96.3	85.7	80.3	70.6	118.3	118.3	118.3	118.3	118.3
25	50.0	75.0	103.7	89.9	85.4	74.1	124.2	124.2	124.2	124.2	124.2
26	52.0	78.0	111.1	94.2	90.5	77.5	130.2	130.2	130.2	130.2	130.2
27	54.2	81.3	118.5	98.4	95.6	81.0	138.0	138.0	138.0	138.0	138.0
28	56.7	85.1	126.0	102.6	100.8	84.5	146.9	146.9	146.9	146.9	146.9
29	59.2	88.8	133.5	106.8	105.9	88.0	155.8	155.8	155.8	155.8	155.8
30	61.7	92.5	141.1	113.0	111.0	91.5	164.7	164.7	164.7	164.7	164.7
32	66.6	99.9	156.2	125.3	121.2	101.6	185.1	185.1	185.1	185.1	185.1
34	71.6	107.4	171.8	137.7	131.5	112.3	208.1	208.1	208.1	208.1	208.1
36	76.5	114.8	189.4	150.1	141.7	123.2	231.2	231.2	231.2	231.2	231.2
38	81.5	122.3	207.2	162.4	151.9	134.0	254.4	254.4	254.4	254.4	254.4
40	86.5	129.7	224.9	174.8	162.2	144.8	277.7	277.7	277.7	277.7	277.7
42	91.5	137.2	242.7	187.3	172.4	155.7	301.0	307.2	307.2	307.2	307.2
44	96.4	144.7	260.5	199.7	182.7	166.6	324.4	337.1	337.1	337.1	337.1
46	101.4	152.1	278.3	212.1	192.9	177.5	354.2	371.0	371.0	371.0	371.0
48	106.4	159.6	296.1	224.5	203.2	188.4	384.7	406.9	406.9	406.9	406.9
50	111.4	167.1	313.9	237.0	220.8	199.3	415.2	442.8	442.8	442.8	442.8
52	116.4	174.6	331.8	249.4	238.4	214.3	445.7	478.8	478.8	478.8	478.8
54	121.4	182.0	349.6	261.9	256.1	231.3	476.2	514.7	514.7	514.7	514.7
56	126.3	189.5	367.5	274.3	273.8	248.3	506.6	550.6	550.6	550.6	550.6
58	132.5	198.8	385.4	286.8	291.5	265.3	537.1	586.6	586.6	586.6	586.6
60	139.5	209.3	403.3	299.2	309.2	282.3	567.6	622.5	622.5	622.5	622.5
70	176.8	265.1	492.8	361.6	398.0	372.2	720.1	812.3	831.6	831.6	831.6
80	218.0	327.0	582.4	423.9	487.1	471.9	872.6	1024.4	1069.7	1081.3	1081.3
90	263.3	394.9	672.2	486.3	576.5	571.7	1025.0	1236.6	1340.5	1378.7	1378.7
100	312.5	468.8	762.0	548.7	665.9	671.5	1177.5	1448.9	1612.9	1678.5	1682.0
110	365.8	548.6	851.8	611.2	755.5	771.4	1330.0	1661.2	1885.3	2000.9	2030.9
120	423.0	634.5	941.6	673.6	845.1	871.3	1482.5	1873.5	2157.8	2333.2	2401.1
130	484.3	726.4	1031.5	736.1	934.8	971.2	1635.0	2085.9	2430.3	2665.5	2793.6
140	549.5	824.3	1121.4	798.5	1024.5	1071.1	1787.5	2298.2	2702.7	2997.8	3186.0
150	618.8	928.1	1237.5	861.0	1114.3	1171.0	1940.0	2510.6	2975.2	3330.2	3578.5
160	692.0	1038.0	1384.0	923.5	1204.1	1271.0	2092.5	2723.0	3247.7	3662.5	3971.0
170	769.3	1153.9	1538.5	985.9	1293.9	1370.9	2245.0	2935.4	3520.2	3994.9	4363.4
180	850.5	1275.8	1701.0	1048.4	1383.7	1470.8	2397.5	3147.9	3792.7	4327.3	4755.9
190	935.8	1403.6	1871.5	1110.9	1473.6	1570.8	2550.0	3360.3	4065.1	4659.7	5148.4
200	1025.0	1537.5	2050.0	1173.4	1563.5	1670.8	2702.4	3572.8	4337.6	4992.1	5540.8
250	1531.3	2296.9	3062.5	1485.8	2013.0	2170.6	3464.9	4635.0	5700.1	6654.3	7503.2
300	2137.5	3206.3	4275.0	1798.2	2462.[illegible]	2670.5	4227.4	5697.4	7062.5	8316.6	9465.7

***Reported Values are MAXIMUM moment within the Span (Note that Mid span moment may be lower than the Maximum Value reported here)**

[redacted] Load Rating Procedures for Bridges Without Plans

Introduction

This document serves to describe [redacted]'s load rating procedures for bridge structures that do not have design/construction plans as part of its Bridge Inspection and Load Rating Programs. These procedures fulfill the requirements of National Bridge Inspection Standards regarding the National Bridge Program Metrics, specifically Metric #13 Inspection Procedures - Load Rating.

Procedure Implementations

All bridges without plans are required to have a load rating as per the procedures prescribed in this document. If a bridge without plans does not have an existing load rating or if the existing load rating is not properly documented, it shall be completed during the next routine inspection by [redacted] load rating staff. This document is applicable to bridges meeting the National Bridge Inventory (NBI) requirement as well as non-NBI pipe culvert bridge structures, however, some of the evaluation methodologies discussed below only pertain to NBI bridges.

Evaluation Methodology

[redacted]'s Bridge Management section has identified multiple evaluation options for the load rating assignment of existing bridge structures that do not have plans available. The different evaluation methods account for condition-based assessments, field measurements and load testing activities and are discussed next. Once a thorough search for plans has been completed and no documentation is found then one, or a combination of, these evaluation methods shall be utilized for determination of appropriate load rating data.

Field Measurement Based Evaluation

This method utilizes field measured superstructure and deck geometries in order to complete a traditional load rating analysis using be structural analysis software. The preferred software is BRASS, but other software may be used as long as approval is obtained from [redacted]'s Load Rating Engineer. In addition to field measurements, this method may also include material properties identified from material testing procedures such as concrete coring, pachometer or steel coupon sampling if deemed necessary. Otherwise, the material properties called out in the AASHTO Manual for Bridge Evaluation (MBE) shall be used. Older [redacted] Specifications may be referenced as well for selecting material properties.

When conducting a Field Measurement Based Evaluation, all measurements and data obtained out in the field shall be sketched up and stored with the load rating documentation and within the inspection file.

This evaluation method can be utilized for NBI and non-NBI bridge structures. The load rating shall include the HL-93/HS20 design vehicles, the [redacted] Legal Load and Permit Vehicles as part of the analysis. Essentially, the standard load rating protocol that is described in [redacted]'s Bridge Design Manual (BDM) shall be followed. The structural analysis will provide a more detailed evaluation of the bridge structure and may result in improved load rating factors for the design and legal load vehicles.

The specific load rating factors or weights determined through the structural analysis shall be used when reporting load rating data in the NBI and within the bridge inspection file. Refer to the BDM for standard load rating forms to be used for documenting the load rating results.

Condition Based Evaluation

The condition based evaluation method is the primary method for identifying the load rating for all bridge structures without plans, regardless of material type, that have a minimum NBI Condition Rating of a 5 or higher. Depending on the specific type of structure, it may not be necessary to include consideration of the NBI Substructure Condition Rating for meeting the requirement for use of this method. Factors to take into consideration when selecting this evaluation method should include the age of the bridge, detour length, ADT and comparison of similar bridge structures that have plans and a structural analysis completed.

Bridges evaluated using this method shall have the inventory and operating rating factors for the design vehicle of 1.0 and 1.67 assigned. This correlates to an inventory rating weight of 36 tons and an operating rating weight of 60 tons for the HS20 design vehicle.

Load Test Based Evaluation

This evaluation method utilizes in-service load testing for determining bridge element stresses for back calculation of acceptable load rating analysis. This method may be necessary when the minimum NBI Condition Rating for a particular bridge becomes Structurally Deficient (condition rating $\leq$4). It may also be used if the structural analysis determined through the Field Measurement Based Evaluation method results in the bridge requiring posting. Load testing will need to be accomplished through the use of Bridge Inspection or Bridge Design Consultants, or in collaboration with the University of [redacted]. Coordination with [redacted] District personnel will be needed for scheduling of loaded dump trucks necessary for the load testing. Decision to utilize this method will be discussed between the Load Rating Engineer and the Bridge Management Engineer.

The specific load rating factors or weights determined through the load testing and associated structural analysis shall be used when reporting load rating data in the NBI and within the bridge inspection file. Refer to the Section 108 of the [redacted] BDM for standard load rating forms to be used for documenting the load rating results.

Design Resources

The following reference, design and specification manuals may be utilized for the load rating evaluation of bridges without plans.

[redacted] Standard Specifications

[redacted] Bridge Design Manual (BDM)

AASHTO *LRFD Bridge Design Specifications*, 7th Edition, 2014, with current interims (LRFD)

AASHTO *Manual for Bridge Evaluation* (MBE), 2nd Edition including 2011, 2012, 2013, 2014 and 2015 interim revisions

Design Load Evaluation

The goal in using any, or combination of, the evaluation methodologies identified earlier, is to confirm that a bridge can safely carry the design load vehicle(s) as identified in the MBE. If the evaluation results in the bridge to "Pass" for the design vehicle(s), then the load rating evaluation process is complete and can be finalized. In order for a bridge to "Pass" for the design load vehicle(s), one of the following is required to occur:

- Performing a structural analysis utilizing field measured data and confirming that the calculated rating factor for the design and legal vehicle(s) $\geq$ 1.0 – *Field Measurement Based Evaluation* method.
- The NBI Culvert Condition Rating for a bridge without plans is a 5 or higher - *Condition Based Evaluation* method.
- Performing a structural analysis utilizing load testing data and confirming that the calculated rating factor for the design and legal vehicle(s) $\geq$ 1.0 – *Load Test Based Evaluation* method.

Otherwise, the bridge will require load posting.

Load Posting Evaluation

If the structural analysis results in a rating factor less than 1.0 for any of the [redacted], Specialized Hauling Vehicles, or AASHTO Emergency Legal Vehicles, then the bridge shall be posted as per the load posting process described in the [redacted] BDM. Otherwise, the bridge does not require posting. The posting resolution process shall follow the same protocol as identified in the Load Rating Chapter (Section 108) of the [redacted] BDM.

Documentation

All load rating data, assumptions, calculations, manual excerpts and software output shall be saved and stored as part of the finalized load rating document. The Load Rating Summary Form shall be included for NBI bridges, but is not required for non-NBI bridges unless a structural analysis utilizing a Field Measurement or Load Test Based Evaluation was conducted. Refer to section 108 of the [redacted] BDM for an example of the Load Rating Summary Form.

All documentation from the [redacted] specification excerpts shall be included with the finalized load rating, if applicable.

A paper copy of the finalized load rating document shall be printed and placed in the "active" bridge inspection file. In addition, an electronic copy (PDF) of the load rating document shall be stored in the live database as well as on the appropriate [redacted] network. The Rating Factor, Posting Weight and Permit Analysis Summary forms shall be included when the Field Measurement or Load Test Based Evaluation method is used. A sample of this form can be found in section 108 of the [redacted] BDM.

Once the Load Rater/Bridge Inspector and Load Rating Engineer signs off on the Load Rating Summary form, all documentation shall be provided to the Bridge Management Engineer so the database and inspection file can be updated accordingly and, if necessary, the load posting resolution can be processed. When updating the database and the NBI data fields related to load ratings, the LRFR rating method shall be selected for Field Measurement and Load Test Based Evaluation methods. Similarly, the field evaluation/judgement rating method shall be selected for a Condition Based Evaluation for assigning the load rating. Proper coding of the Design Load NBI item (#31) data field shall adhere to the following protocol unless other documentation states otherwise:

- Year built for bridge is <1959; 4: H 20

- Year built for bridge is >1958 and less than 1996; 5: HS 20

-Year built for bridge is >1995; A: HL 93

Proper coding of the Inventory and Operating Rating Type NBI item (#64 & 66) data fields shall adhere to the following protocol:

-"0" Engineering Judgement/Evaluation for Condition Based Evaluation Method

-"8" LRFR for Field Measurement Based Evaluation Method

-"4" Load Test for Load Test Based Evaluation

Review and QC/QA Procedures

In general, the Quality Control Load Rating procedures for load rating evaluations of bridges without plans shall follow the same protocol as identified in the Load Rating Chapter (Section 108) of the [redacted] BDM. This involves the Load Rating Engineer reviewing the documentation, signing the form and attaching any additional calculations or documentation. All load ratings for bridges without plans will be reviewed and finalized by the Load Rating Engineer. If applicable, any load rating evaluation resulting in a load posting shall be reviewed by the Bridge Management Engineer for review and issuing the appropriate posting resolution.

In order to ensure the Quality Assurance of bridge load rating evaluations, a representative 5% random sampling of NBI bridge load ratings completed will be selected for a Quality Assurance Load Rating review. This will follow the same protocol as the QA Load Rating review process for the Bridge Load Rating Program as identified in Section 108 of the [redacted] BDM.

[redacted] DEPARTMENT OF TRANSPORTATION

BRIDGE LOAD RATING MANUAL, 2018

[redacted]

[redacted]

Chapter 1: Introduction

PURPOSE

This ***Manual*** provides guidance on bridge load rating in [redacted] Load rating analysis approximates safe carrying capacity for bridges, establishes posting restrictions, and estimates strength for permit routing. Such analysis directly supports the Department's Mission, to "… provide a safe transportation system that ensures the mobility of people and goods, enhances economic prosperity, and preserves the quality of our environment and communities."

AUTHORITY

Sections 20.23(3)(a), and 334.048(3), [redacted] Statutes, (F.S.)

REFERENCE

The *Manual of Uniform Minimum Standards for Design, Construction, and Maintenance for Streets and Highways* (commonly known as the "[redacted] Greenbook") requires load rating for all bridges in [redacted]. This ***Manual*** establishes "…uniform minimum standards and criteria for the design, construction, maintenance, and operation of public roads…," for bridge load rating, as part of the Departmental powers and duties described by [redacted] Statutes 334.044.

SCOPE

The principal users of this ***Manual*** will be all persons involved in bridge load rating in [redacted]

DISTRIBUTION

Submit suggestions, and requests for clarification, to the State Load Rating Engineer at *CO-LoadRating@dot.*[redacted]. This ***Manual***, and associated materials (archives, references, Excel Load Rating Summary Form, and examples), are available for download at: *http://www.*[redacted]*/maintenance/LoadRating.shtm*

PROCEDURE FOR REVISIONS AND UPDATES

Permanent Technical Revisions to this ***Manual*** are made annually, or "as-needed." Proposed Revisions are discussed at each Department Load Rating Meeting, held quarterly. Meetings are attended by the District Structures Maintenance Engineers (DSME's), their designated staff specializing in load rating, and a representative of the State Structures Design Office, who constitute the Load Rating Manual Committee. The Committee builds consensus, and uses the Online Review System to comment on Draft Revisions.

Adoption of a Revision is accomplished by responding to all comments submitted by the Committee, and issuing a Memorandum of Adoption endorsed by the State Structures Maintenance Engineer. The Memorandum outlines revisions, provides rationale, and issues directives for implementation. All Load Rating Revisions to this ***Manual*** will be published by the Office of Maintenance. The Forms and Procedures Office will update the effective date of the revised ***Manual***.

DEFINITIONS AND TERMINOLOGY

Design Load—standard live loading for which the structure was designed or appraised. Design Loads are collections of fictitious trucks and point-and-lane loads, which describe or "envelope" real trucks. A Design Load is assessed at two Rating Levels, Inventory and Operating, defined below.

Load Rating—live load carrying capacity of a bridge.

Load Rating Method, Allowable Stress Rating (ASR)—limits capacity to an allowable stress. Dead loads are unfactored, and live loads are factored with impact. In [redacted] ASR load ratings use the HS20 Design Load. ASR follows AASHTO Standard Specifications for Highway Bridges, and MBE Part B.

Load Rating Method, Load Factor Rating (LFR)—uses ultimate strength capacity and factored loading. LFR also incorporates ASR, for some bridge types. In [redacted] LFR load ratings use the HS20 Design Load. LFR follows AASHTO Standard Specifications for Highway Bridges, and MBE Part B.

Load Rating Method, Load and Resistance Factor Rating (LRFR)—load rating method similar to LFR, using more complex factors informed by reliability statistics and refined analysis. LRFR uses the HL93 Design Load. LRFR follows AASHTO LRFD Bridge Design Specifications, and MBE Part A.

Rating Level—safety level of the live load capacity for a highway bridge.

Rating Level, Inventory—unlimited application of live loads at this level will not damage the bridge. This is the lowest rating. Permissible stressing is minimized.

Rating Level, Operating—unlimited application of live loads at this level may shorten the life of the bridge. This is the highest rating. Permissible stressing is maximized.

Rating Level, Legal—in [redacted] excepting LRFR Steel Service, the Legal Level is equivalent to the Operating Level. [redacted] has 7 Legal Loads, described in the Appendix to this ***Manual***, which envelope the truck configurations permitted by [redacted] law.

Rating Level, Routine Permit—in [redacted] excepting certain LRFR Service tests, the Routine Permit Level is equivalent to the Operating Level. [redacted] uses the FL120 Routine Permit Vehicle as a reference vehicle, to infer ratings for other permit trucks.

National Bridge Inventory (NBI)—data required to fulfill the National Bridge Inspection Standards. For a description of the NBI data fields, see the [redacted] Bridge Management System Coding Guide, referenced below.

Pontis/BrM—bridge data management software.

Rating—rated capacity in tons, equivalent to (Gross Vehicle Weight)·(Rating Factor).

Rating Factor (RF)—(Capacity – Dead Load) / (Live Load). Each component of the RF equation is factored.

REFERENCES

Links for the following references are at:
http://www[redacted]/maintenance/LoadRating.shtm

AASHTO LRFD Bridge Design Specifications (LRFD), 8th Ed.

AASHTO Manual for Bridge Evaluation (MBE), 2nd Ed. with 11’ 13’ 14’ 15’ & 16’ Interims.

AASHTO Standard Spec. for Highway Bridges (Std.Spec.), 17th Ed. with 2005 Interims.

[redacted] Bridge and Other Structures Inspection and Reporting Manual, 2016.

[redacted] Bridge Management System Coding Guide (BMS).

[redacted] Construction Project Administration Manual (CPAM).

[redacted] Design Manual (FDM), 2018.

[redacted] Plans Preparation Manual (PPM), 2017.

[redacted] Standard Specifications for Road and Bridge Construction, 2018.

[redacted] Structures Manual Volume 1, Structures Design Guidelines (SDG), 2018.

Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways (GREENBOOK), 2016.

Chapter 2: Load Rating Process and Procedure

CONCEPTS

Utilizing engineering judgment, identify components that may control the load rating, and analyze those components for all applicable limit states and vehicles until the governing member(s) are found. Before confining the analysis to the superstructure, consider the substructure. For example rotted timber piles, settlement, excessive scour, or distressed pile caps would all warrant additional consideration.

Accurate load ratings are essential to permit routing. Operating and FL120 results are used to route permit overloads on State highways in [redacted]. Overloads include blanket permits, like cranes, and special trip permits, such as bridge girder deliveries.

Use an appropriate level of analysis to establish a safe load carrying capacity that does not unduly restrict legal and permit traffic. Begin with a simplified level of analysis. Refine the analysis as necessary to provide a more accurate load rating. "As necessary" means:

1. Appropriately consider posting avoidance.
2. Apply additional scrutiny to results that markedly differ from the Design Load.
3. Apply refinements to results that obviously mischaracterize the safe carrying capacity of the bridge.

Adopt one method of analysis, and do not report a mixed-method summary. For example, if the HL93 Inventory rating uses refined distribution, then the HL93 Operating and FL120 Permit ratings also require refined distribution. Be consistent. The governing methodology and distribution shall apply to the entire structure. While the contents of an analysis may explore several methods, clearly and consistently state which method was ultimately adopted, and which results govern.

DEFINITION, COMPLETE LOAD RATING

A complete load rating is a high-quality PDF report, wherein any scans are 300dpi+ and 75%+ quality compression. Seal digital deliveries unlocked; this retains the original document ("view sealed version"), but permits subsequent comments. Contents include:

1. SUMMARY. Load rating summary form (Excel), sealed by a [redacted] P.E.
2. NARRATIVE. Brief description of inspection findings, methodology, and assumptions.
3. PLANS. Plan sheets required to perform the analysis (not the entire plan set).
4. CALCULATIONS. Inputs, intermediate calculations, and summarized outputs.
5. QUICK CHECK. At a minimum, confirmation of the governing Design Operating Rating; show the factored components of the rating factor equation. A more comprehensive check is recommended, especially when results significantly differ from the original Design Load increased to the Operating Level.

Additionally, submit all inputs in native ready-to-run format. Exceptions include hand calculations, and proprietary worksheets that are sufficiently transparent.

DEFINITION, AS-BUILT LOAD RATING

Typically, an As-Built Load Rating confirms that the Design Load Rating (As-Bid Load Rating) remains valid, and a sealed summary form indicating it is reflective of the As-Built conditions will suffice. However, if the Engineer of Record (EOR) finds that the As-Built condition substantively differs from Design, then an As-Built load rating constitutes a complete revision of the Design Load Rating.

DEFINITION, AS-BUILT DOCUMENTS PACKAGE

The As-Built Structure Documents Package contains select bridge records that the District Structures Maintenance Office (DSMO) is required to store for the life of the bridge (MBE Section 2). For [redacted] projects, follow the CPAM. For other projects, the package is a ZIP archive containing one bridge; PDF contents are either direct-to-pdf, or scanned at 300dpi+ and 75%+ quality compression. The package contains:

1. Foundation records: pile driving records, shaft tip elevations, and boring logs.
2. Structure plans: shop drawings, and As-Built plans (alternatively sealed design plans, with a summary of construction changes).
3. For bridges traversing water, a sealed Hydraulic analysis plan sheet.
4. Sealed As-Built load rating.

TABLE 2-1—EXISTING BRIDGES

PHASE	ACTION
NBI Inspection	In Pontis/BrM Inspection Notes, state whether the current load rating is complete and applicable. The note should indicate who made the determination, and when. "Complete" means that the rating complies with the rules[1] that were in effect when the rating was performed. Historic ratings shall, at a minimum, include a summary and calculations. "Applicable" means that the configuration and condition of the bridge has not substantially changed, since the calculations were performed. If the analysis is incomplete or inapplicable, notify the DSME and begin revisions.
Load Rating Revision	Within 90 days of the date that the NBI Inspection Report was sealed, or earlier as the DSME determines for emergencies, (1) Revisions are to be completed and input into Pontis/BrM, and (2) If the analysis recommends posting for weight, a notification shall be sent to the bridge Owner. For load rating revisions, follow [redacted] Figure 2-1.
Posting	Posting deficiencies shall be addressed within 30 days of receipt of notification to the bridge Owner; see Chapter 7 of this ***Manual***.

1. From time-to-time, interim revisions are required. For example, all structures with transverse floorbeams are required to report transverse data.

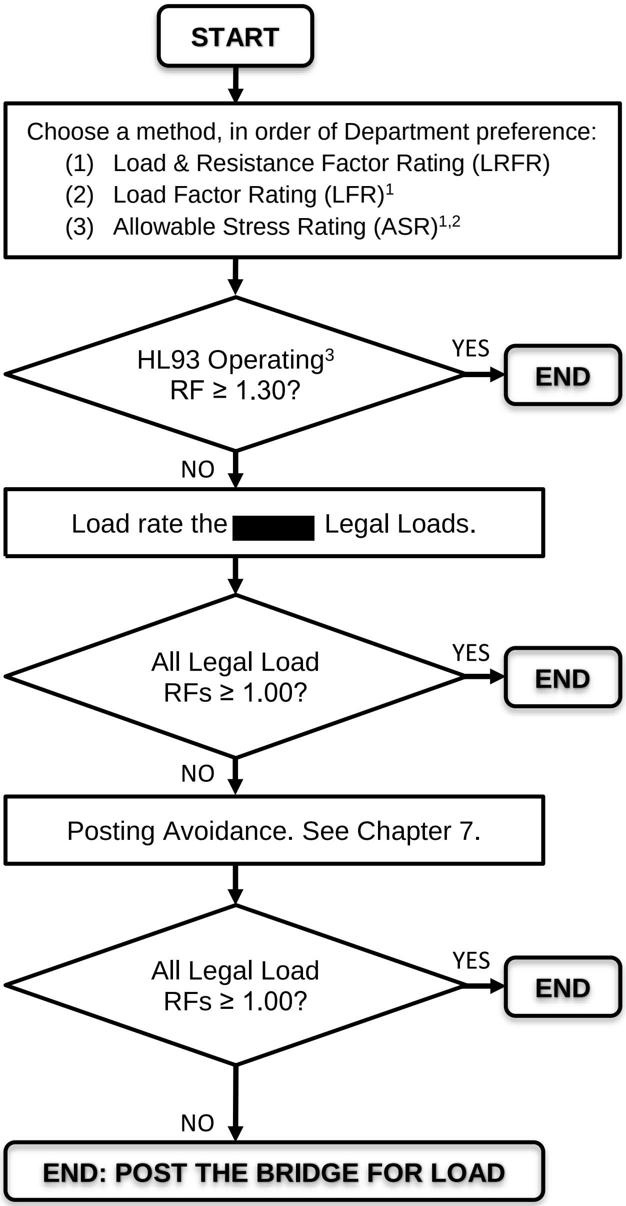
TABLE 2-2—WIDENINGS, REHABILITATIONS, AND NEW BRIDGES

PHASE	ACTION	RESPONSE, LOAD RATING SPECIALIST
90% Superstructure Plans	EOR – Submit[1] Draft Load Rating	Within 30 days, review and return comments to the designer or analyst.
Final Plans (Design-Bid-Build), or Released for Construction (Design-Build)	EOR – Submit[1] sealed Design Load Rating	Within 14 days: • Confirm that review comments were addressed, and respond with a receipt to the EOR. If the rating is acceptable, archive it to EDMS. Otherwise request revisions. • Determine whether the new load rating applies. At a strengthening project, for example, the new rating will not apply until that strengthening has occurred. • Document the determination in Pontis/BrM Structures Notes, and accordingly update or retain the Pontis/BrM load rating data.
Superstructure Nearing Completion	CEI – Submit[1] the As-Built Documents Package	Determine whether the As-Built Documents Package is complete. If so, confirm the schedule for the final inspection. Otherwise, specify insufficiencies within the As-Built Documents Package, schedule a safety inspection, and establish a timeline for completion.
Superstructure Complete	LEAD BRIDGE INSPECTOR – Submit[1] draft inspection	When the initial NBI inspection occurs, or before, apply the As-Built load rating to Pontis/BrM, and archive the data to EDMS. If a load rating is not available, the Engineer responsible for the inspection will use engineering judgment, assign a sealed temporary load rating, and notify the State Load Rating Engineer; complete an analysis and input the results within 90 days of the date that the NBI report was sealed.

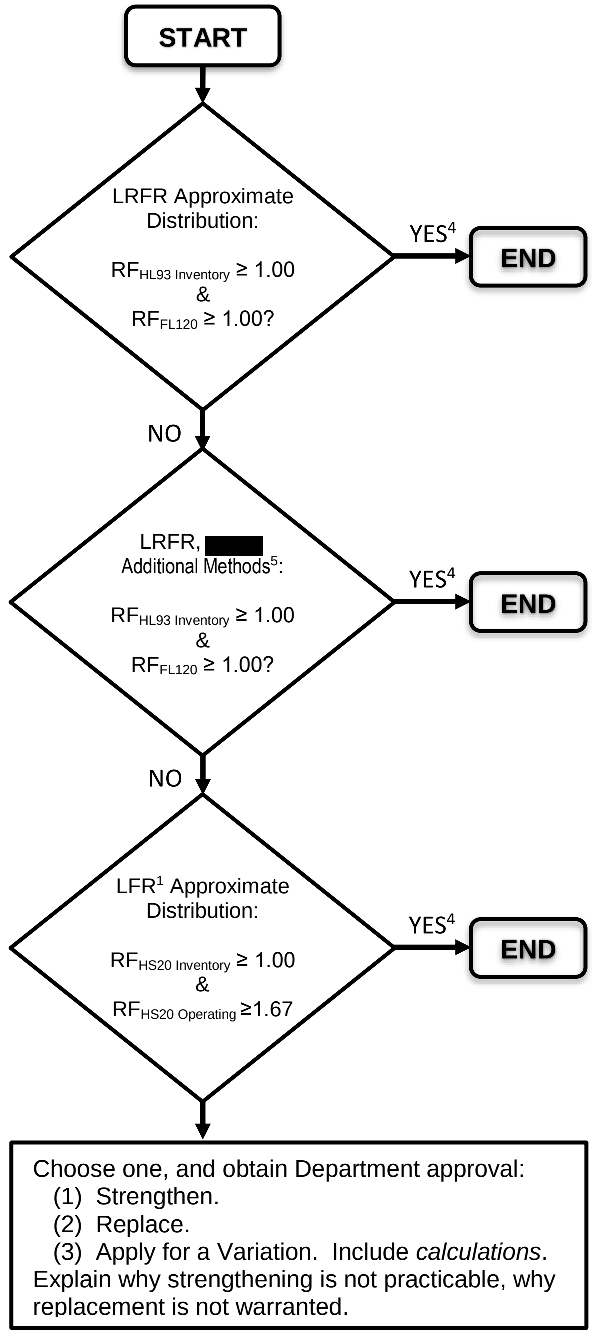
1. Submit deliverables to DX-LoadRating@dot.state.fl.us, where “X” is the District No. For example, District 1 is *D1-LoadRating@dot.state.fl.*

For widenings and rehabilitations, follow [redacted] Figure 2-2, and [redacted] Structures Design Guidelines, Chapter 7. For new bridges, provide Strength for the FL120 ($RF_{FL120} \geq 1.00$), and comply with [redacted] Structures Design Guidelines. New (non-widening) precast culvert projects must provide a load rating, or contract language that requires the Contractor to provide a load rating in accordance with this ***Manual***.

[redacted] Figure 2-1— Existing Bridges



[redacted] Fig.2-2—Widening & Rehab.



1. LFR and ASR are not permitted among spans exceeding 200 feet.
2. ASR is not permitted for bridges on the National Highway System.
3. At existing bridges, if $RF_{HL93\ Operating}$ < 1.30, or if LFR/ASR, assess the Legal Loads.
4. Widenings and rehabilitations need not assess the [redacted] Legal Loads; the HL93, FL120, and HS20 Rating Factor requirements are sufficient.
5. [redacted] Additional Methods can be found at SDG 7.1.1 C.

COMMENTARY, DX-LOADRATING EMAIL

The delivery email DX-LoadRating@dot.[redacted]where "X" is the District Number, reliably specifies the address of the reviewer and end-user of the documents that this chapter requires. Submissions may also be accomplished by alternative means established by contract documents, provided that the delivery mechanism is effective and efficient. For example, the CPAM process of notifying the DSME is also acceptable.

CITATIONS, EXTERNAL MANUALS

Load rating involves Design, Construction, and Maintenance. Participants include State, Toll, and Local authorities. To accommodate a variety of participants, and to develop a coherent and practicable load rating policy and process, this ***Manual*** draws from other manuals.

SDG. Structures Design Guidelines (SDG), from 2018 [redacted] Structures Manual Volume 1, governs all Department structures design, and informs all bridge structures design in [redacted] At 90% plans, perform a load rating (1.7). For bridge-size culverts, see 3.15.14. For bascule bridges, see 8.4. Widen and rehabilitate bridges in accordance with Chapter 7. This ***Manual*** adopts the SDG, and the SDG refers to this ***Manual*** for load rating. However note these differences:

1. In addition to the standard Load Rating Summary Form (Excel), the Design of new bridges and widenings also requires a Load Rating Plan Sheet. See: *http://www.[redacted]/structures/CADD/standards/CurrentStandards/LRFRsummaryTables.pdf*
2. The design of bascule bridges requires an unpinned span lock assumption, as a part of the load rating analysis. For the appraisal of existing bascule bridges, this ***Manual*** defers to the local District Structures Maintenance Engineer for specific instructions.

GREENBOOK. Locally-owned bridges conform to the Manual of Uniform Minimum Standard for Design, Construction and Maintenance for Streets and Highways (commonly referred to as the [redacted] "Greenbook"). Design per LRFD (Ch.17 C). Perform a hydraulic analysis (Ch.17 C.4a). Provide certain As-Built structure documents (Ch.17 D). For load rating, refer to this ***Manual*** (Ch.17 H).

PPM/FDM. All State-owned bridges, and many others, abide by the [redacted] Plans Preparation Manual (PPM), or the new [redacted] Design Manual (FDM). The FDM replaces the PPM for Design-Bid-Build projects that start in 2018, and Design-Build projects that start in 2019 (*http://www*[redacted]*esign/Bulletins/RDB17-12.pdf*). For Design Variations allowing deficient strength, seek a recommendation from the Office of Maintenance, and approval from the State Structures Design Engineer, by providing calculations and a "Detailed explanation of why the criteria or standard cannot be complied with or is not applicable" (PPM Vol. 1 Ch. 23, or FDM 122.4). For all projects, see the load rating sections (PPM Vol. 1 at 26.17, or FDM 121.17).

CPAM. The [redacted] Construction Project Administration Manual (CPAM) specifies procedures for the construction of State projects. Non-State projects may also utilize the CPAM, or concepts within the CPAM. Submit As-Built bridge documents (5.12.8). Provide As-Built load ratings and inspections notice to the DSME (10.11.3, 10.11.4). Archive certain As-Built documents to Construction Documents Management System (CDMS), and attribute those documents with the Structure Number (10.11.5). Incidentally, the maximum retention time for CDMS documents is 15 years; Structures Maintenance reviews and archives As-Built documents more durably, for 99 years.

Chapter 3: Responsibilities

DISTRICT STRUCTURES MAINTENANCE OFFICE

1. Ensure that every bridge within the jurisdiction of the District is properly load rated, timely updated, and accurately reported to the Bridge Management Database, in accordance with this ***Manual***.
2. Perform and review load ratings. Review all new load ratings cursorily, and at least 10% of new load ratings thoroughly, with separate and unique review calculations for the governing elements.
3. Review NBI inspections, and determine whether the present load rating remains complete and applicable.
4. Administer and verify bridge load posting with the District Local Bridge Coordinator.
5. Provide information to the Overweight/Over-Dimensional Permit Office to facilitate safe routing.
6. Assist the Office of Maintenance, other branches of the Department, and local authorities.
7. Write and maintain a Quality Control (QC) Plan that explains how these tasks are accomplished. The QC Plan need not reiterate the contents of this ***Manual***; instead, the QC Plan should emphasize day-to-day tracking and documentation.

DISTRICT MAINTENANCE ENGINEER

Designate staff to inform the Overweight/Over-Dimensional Permit Office of temporary clearance restrictions due to construction activity. Additionally, advise upon the best time to move permitted cargo, with respect to special events and local traffic conditions.

OFFICE OF MAINTENANCE

1. Annually perform a Quality Assurance Review (QAR) of the load rating performance of each District. The current schedule, monitoring plans, critical requirements and compliance indicators are included in the Quality Assurance Plan available at the internal Office of Maintenance SharePoint site: *http://cosharepoint.dot.state.fl.us/sites/maintenance/*
2. Assist Districts, other branches of the Department, and local authorities.
3. Maintain this ***Manual***.
4. Resolve inconsistencies arising from [redacted] guidance.
5. Provide training, share new procedures, and respond to questions.

6. Provide load rating examples.
7. Review load posting requests for State-maintained bridges.
8. Provide courtesy reviews, for Districts and local agencies.
9. Perform evaluations and load ratings for State-owned bridges to improve commercial truck mobility.

STATE STRUCTURES DESIGN OFFICE

1. Review this ***Manual***.
2. Review new and proposed design methods.
3. Assist the Office of Maintenance with load testing and complex analysis.

CONSULTANTS

1. Assist the Department in accordance with contract documents.
2. Perform and review load ratings in accordance with this ***Manual***.
3. Write and maintain a Quality Control (QC) Plan that explains how load rating reviews are performed and documented. Within the QC Plan, include a Quality Assurance Review (QAR) component, which investigates and reports upon the quality of the work product, annually or more frequently. The QC plan will state where the QAR records are kept.

CHAPTER SEQUENCE

This ***Manual*** retains a legacy numbering sequence; chapter numbers 4 and 5 are omitted.

Chapter 4

This Chapter is reserved for future use. MBE Section 4—Inspection is unmodified.

Chapter 5

This Chapter is reserved for future use. MBE Section 5—Materials is unmodified.

Chapter 6: Load Rating Analysis

Chapter 6 of this ***Manual*** modifies the current AASHTO Manual for Bridge Evaluation (MBE). The MBE governs on all relevant topics not directly addressed in this ***Manual***.

6.1—SCOPE

Remove: “No preference is placed on any rating method. Any of these three methods identified above may be used to establish live load capacities and load limits for the purposes of load posting.”

Add: “The load rating of all bridges shall be in accordance with Chapter 2 of this ***Manual***. The Department prefers LRFR.”

C6.1

Add: For segmental bridges, since ASR and LFR are inadequate, use LRFR. For spans exceeding 200 feet, since MBE Part B legal loading is excessive, use LRFR.

Regarding ASR, in 1993 the FHWA requested that all ASR ratings on the National Highway System (NHS) be rerated with LFR. [redacted] and FHWA agreed that only structurally deficient or functionally obsolete NHS ratings required re-rating. These, and all subsequent revisions to NHS ratings, shall use either LFR or LRFR.

6.1.4—Bridges with Unknown Structural Components

Replace subsection with: For bridges that lack plans, perform field measurements. At a minimum, the field kit should include a measuring tape, a caliper, and a pachometer. Use plans from a similar bridge or era-appropriate code to conservatively approximate the reinforcement, and analyze the bridge. If the reinforcement cannot be estimated, and the bridge shows no distress, an assigned load rating is acceptable. Otherwise perform additional non-destructive testing as necessary, and analyze or proof-test the bridge.

6.1.5.2—Substructures

Add: Analyze all straddle bents.

Part A: LRFR

6A.1.5—Load and Resistance Factor Rating

Remove: "A detailed rating flow chart is included in Appendix A6A."

Add: The routine [redacted] rating process is described in Chapter 2 of this ***Manual**.*

6A.1.5.2—Legal Load Rating

Remove: "Live load factors are selected based on the truck traffic conditions at the site."

Add: Legal live load factors are consistently applied for all traffic conditions.

6A.1.5.3—Permit Load Rating

Remove: "Calibrated load factors by permit type and traffic conditions at the site are specified for checking the load effects induced by the passage of the overweight truck."

Add: FL120 Routine Permit live load factors are consistently applied for all traffic conditions. Special Permits shall follow the MBE requirements, unless otherwise specified in writing by the Office of Maintenance.

6A.2—LOADS FOR EVALUATION

6A.2.3.1—Vehicular Live Loads (Gravity Loads): LL

Replace subsection with: Live load models include: (1) HL93 Design Load, (2) [redacted] Legal Loads, and (3) FL120 Routine Permit. For Design, Legal, and Routine Permits, apply consistent live load factors for all traffic conditions, as specified in [redacted] Table 6A.4.2.2-1. For Special Permits, use the Actual Permit Truck, and live load factors as specified by the MBE.

6A.3.2—Approximate Methods of Structural Analysis

Add: Extend the range of applicability for approximate distribution as described at SDG 2.9. Also, if concrete parapets or barriers are continuous near midspan (without open joints), neglect the exterior beam rigid section assumption at LRFD Eq. C4.6.2.2.2d-1.

C6A.3.2

Add: Continuous parapets and barriers stiffen the exterior section. While parapets and barriers are susceptible to vehicular impacts, the same is true for beams (over-height vehicular impacts). Load testing has shown that, while the parapet-beam stiffness does attract load, the stresses are lower than the rigid section assumption surmises. The modification only applies to continuous parapets; the rigid section assumption may apply to bridges with parapets containing open joints near midspan.

6A.3.3—Refined Methods of Analysis

Add: Refined methods include two or three dimensional models using grid or finite-element analysis. Excepting parapet self-weight, and posting avoidance, refined analyses may not benefit from edge stiffening effects from barriers or other appurtenances. On the load rating summary form, state the name and the version of the software that was used. Within the load rating narrative, explain why refined analysis was used.

6A.4—LOAD RATING PROCEDURES

6A.4.1—Introduction

Replace subsection with: Use 6A.4.2—General Load-Rating Equation with [redacted] Table 6A.4.2.2-1—LRFR Limit States and Load Factors. Evaluate FL120 Permit, HL93 Inventory, and HL93 Operating. For existing bridges, if the HL93 Operating Rating Factor is less than 1.30, then additionally evaluate the [redacted] Legal Loads.

6A.4.2—General Load Rating Equation

6A.4.2.1—General

Add:

RATING = RF·GVW = Permissible weight in tons

RF = Rating factor

GVW = Gross vehicle weight (axle loading of the heaviest truck that the vehicle considers)

For example, the rating for the HL93 is (36 tons)·(HL93 Rating Factor), irrespective of whether the tandem or another combination governs. Likewise, for a long-span bridge, the rating for an SU4 is (35 tons)·(SU4 Rating Factor), even if the lane-and-truck combination governs.

C6A.4.2.1

Add: While permit routing uses rating factors, the Bridge Management System retains ratings in terms of tons. The RATING = RF·GVW standard forms a reliable way to reconstruct rating factors from ratings in tons.

6A.4.2.2—Limit States

Replace Table 6A.4.2.2-1 with:

[redacted] **Table 6A.4.2.2-1—LRFR Limit States and Load Factors**

Bridge Type	Limit	DC[7]	LL Inventory	LL Operating	LL Legal	LL [redacted]120
Steel[3]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35
	Service[2] II	1.00	1.30	1.00	1.30	0.90
Reinforced Concrete[4]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35
	Service[2] I	NA	NA	NA	NA	NA
Prestressed Concrete[5]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35
	Service[2] III	1.00	0.80	NA, 0.80[5]	NA, 0.80[5]	NA, 0.70[5]
Post Tension I-Girder[6]	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35
	Service[2] III	1.00	0.80	0.80	0.80	0.70
Timber	Strength[1]	1.25/0.90	1.75	1.35	1.35	1.35
	Service[2]	NA	NA	NA	NA	NA

1. "Strength" includes flexure, shear, and compression. Typically appraise both flexure and shear. Determine whether compression and axial effects need be assessed, also.
2. "Service" means the allowable tension limit for the beam material.
3. Steel Service II need only be checked for compact girders.
4. For reinforced concrete box culverts, see 6A.5.12.
5. Prestressed girders in good condition shall only apply Service III to the Inventory Level; assess Operating Legal and Permit Levels with Strength. However, for prestressed girders exhibiting distress or corrosion:
    - include Service III for the Operating Legal and Permit Levels
    - limit stresses to [redacted] Table 6A.5.4
    - use the Service III live load factors in the table above.
6. For segmental post-tension box girders, see 6A.5.11.
7. Field-measure wearing surfaces; $\gamma_{DC} = \gamma_{DW}$.

6A.4.2.4—System Factor, φ_s

Add: System factors, in [redacted] Tables 6A.4.2.4-1 (General), 6A.4.2.4-2 (Steel), and 6A.5.11.6-1 (Post-Tension), shall apply for flexural and axial effects at the Strength Limit States. Higher values than those tabulated may be considered on a case-by-case basis with the approval of the Department. System factors shall not be less than 0.85, nor greater than 1.3.

Replace Table 6A.4.2.4-1 with:

[redacted] **Table 6A.4.2.4-1—General System Factors (φ_s)**

Superstructure Type	φ_s
Rolled/Welded Members in Two-Girder/Truss/Arch Bridges[1]	0.85
Riveted Members in Two-Girder/Truss/Arch Bridges	0.90
Multiple Eyebar Members in Truss Bridges	0.90
Floor beam spacing > 12 feet, discontinuous deck	0.85
Floor beam spacing >12 feet, continuous deck	0.90
Redundant Stringer subsystems between Floor beams	1.00
All beams in non-spliced concrete girder bridges	1.00
Steel Straddle Bents	0.85

Add: [redacted] **Table 6A.4.2.4-2—System Factors (φ_s) for Steel Girder Bridges**

No. Girder Webs	φ_s With Diaphragms[1]	φ_s Without Diaphragms
2	0.90	0.85
3	1.00	0.90
4 or more	1.00	1.00

1. "With Diaphragms" means that there are at least three evenly spaced intermediate diaphragms (excluding end diaphragms) in each span. The above tabulated values may be increased by 0.05 for riveted members.

6A.4.4—Legal Load Rating

Replace subsection with: When $RF_{HL93.Operating}$ < 1.30, analyze the [redacted] Legal Loads with the applicable limit states and load factors provided in [redacted] Table 6A.4.2.2-1. Legal loads are described in the Appendix to this ***Manual***. Apply the same [redacted] Legal Loads to each loaded lane; do not mix trucks. Excepting box culverts and segmental bridges, use multiple presence factors per LRFD 3.6.1.1.2.

C6A.4.4—Legal Load Rating *(add this subsection)*

Districts may request that the legal loads be assessed irrespective of the HL93 Operating rating. [redacted] applies uniform live load factors, for all Average Daily Truck Traffic. [redacted] legal vehicles sufficiently envelope AASHTO SHVs.

6A.4.5—Permit Load Rating

Add: For the FL120, only use the insertion 6A.4.5.A below, and its references. For special single-trip permits, perform the analysis in accordance with MBE requirements, unless otherwise specified in writing by the Office of Maintenance.

6A.4.5.A—FL120 Permit *(add this subsection)*

For all LRFR analyses, assess the FL120 with the applicable limit states and load factors provided in [redacted] Table 6A.4.2.2-1. The FL120 is depicted in the Appendix to this ***Manual***. The FL120 is present in all loaded lanes; do not mix the FL120 with other truck types. Excepting new box culverts, use a multiple presence factor of 1.00 for single-lane FL120 distribution, and multiple presence factors per LRFD 3.6.1.1.2 for multi-lane FL120 distribution.

C6A.4.5.A

Add: The FL120 permit load is conceived to be a benchmark to past HS20 Load Factor Design. LFR Strength live load factors were $\gamma_{Inventory}$ = 2.17 and $\gamma_{Operating}$ = 1.30. Since $\gamma_{Inventory}/\gamma_{Operating}$ = 1.67, if $RF_{HS20.LFR.Inventory}$ > 1.00, then $RF_{HS20.LFR.Operating}$ > 1.67 and $RATING_{HS20.LFR.Operating}$ > 60 tons. Hence, the FL120 truck is 1.67·HS20 truck, or 60 tons.

6A.5—CONCRETE STRUCTURES

Add: When assessing prestress condition among corroded or cracked beams, recommended reading includes:

1. Naito, Clay et al. "Forensic Examination of a Noncomposite Adjacent Precast Prestressed Concrete Box Beam Bridge." *Journal of Bridge Engineering* July/August 2010, Figure 13.
2. Hartle, Raymond. "I-70 Overpass Beam Failure at Lakeview Drive Bridge." *https://www.nhi.fhwa.dot.gov/downloads/other/real_solutions_presentations/real_solutions_presentation_2008_07.pdf#page=22#page=22*.

Replace Table 6A.5.2.1-1 with:

[redacted] **Table 6A.5.2.1-1—Minimum Strength of Concrete by Year of Construction**

Year of Construction	Compressive Strength, f_c (ksi)
Before 1959	3.0 - Reinforced Concrete
1959 to 1973	3.0 - Reinforced Concrete 5.0 - Prestressed Beam
After 1973	3.4 - Reinforced Concrete 5.0 - Prestressed Beam

Replace Table 6A.5.2.2-1 with:

[redacted] **Table 6A.5.2.2-1—Yield Strength of Reinforcing Steel**

Reinforcing Type	Yield, f_y (ksi)
Unknown, constructed prior to 1954	33
Structural grade	36
Unknown, constructed between 1954 and 1972: billet or intermediate grade	40
Rail or hard grade	50
Unknown, constructed after 1972	60

6A.5.2.3—Prestressing Steel

Add: For prestressing losses, use LRFD 5.9.3.3—Approximate Estimate of Time-Dependent Losses.

6A.5.4—Limit States

Replace "Table 6A.4.2.2-1" with "[redacted] Table 6A.4.2.2-1."

Add: [redacted] **Table 6A.5.4—Stress Limits for Concrete Bridges**

Condition	Design Inventory	Operating & Permit
Compressive Stress – All Bridges (Longitudinal or Transverse) Compressive stress under effective prestress, permanent loads, and transient loads. When web or flange slenderness exceeds 15, apply a reduction (LRFD 5.6.4.7 and 5.9.2.3.2).		
All environments	0.60f'c	0.60f'c
Longitudinal Tensile Stress for Concrete with Bonded/Unbonded Prestressing, Non-Segmental		
Extremely aggressive corrosion environment	$3\sqrt{f'c}$ psi	$7.5\sqrt{f'c}$ psi
Slightly or moderately aggressive corrosion environments	$6\sqrt{f'c}$ psi	$7.5\sqrt{f'c}$ psi

Add: For prestressed beams in good condition, do not apply Service III to the Operating and Permit Levels; see notes at [redacted] Table 6A.4.2.2-1. For segmental post-tension bridges, see stress limits at [redacted] Tables 6A.5.11-1 & 6A.5.11-2.

6A.5.4.2.2a—Legal Load Rating

Remove subsection (for Service III, see [redacted] Table 6A.4.2.2-1).

6A.5.4.2.2b—Permit Load Rating

Replace subsection with: For special single-trip permit loads having Flexure Strength load factors less than 1.30, consider a lower tendon limit at 90% yield. Otherwise neglect this check.

C6A.5.4.2.2b

Add: When the 90% yield lower tendon limit is rigorously analyzed under typical load factors, it does not meaningfully govern. Since the check is not helpful, difficult to properly execute, and confused with other flavors of “Service I,” it is no longer specified for normal load rating.

6A.5.7—Evaluation for Flexural and Axial Force Effects

Add: Flat slab longitudinal edge beams (LRFD 4.6.2.1.4b) and exterior flat slab beams (types “f” and “g” in LRFD Tables 4.6.2.2.2d-1 and 4.6.2.2.3b-1) may be neglected, provided:

1. Curbs or barriers are present, concrete, and continuous (no open joints).
2. The exterior strength per foot meets or exceeds the interior strength per foot.

Flat slab beams (cross sections “f” and “g” in LRFD Table 4.6.2.2.1-1) may use the simplification provided in LRFD Table 4.6.2.2.1-3, where I/J = 0.54(d/b) + 0.16, for LRFD distribution factor Tables 4.6.2.2.2b-1 and 4.6.2.2.3a-1.

C6A.5.7

Add: For additional discussion on edge beams, see C6A.3.2.

6A.5.8—Evaluation for Shear

Replace subsection with: When using Modified Compression Field Theory (MCFT) at LRFD 5.7.3.4.2—General Procedure, (1) Follow MBE Figure 6A.5.8-1, and count the stirrup area intersected by the failure plane $0.5 \cdot d_v \cdot \cot(\theta)$ on each side of the section under consideration, (2) Apply the appropriate load factor. An HL93 Operating rating, for example, would use $\gamma_{LL.Strength.I.Operating} = 1.35$ in its capacity calculations. See "Prestressed concrete shear capacity is load-dependent," at MBE Example A3, page A-115.

For prestressed members governed by shear where $RF_{LRFR.FL120} < 1.00$, use refined distribution under LRFD 8th Ed., or LRFD 7th Ed. 5.8.3.4.3—Simplified Procedure with approximate distribution. Alternatively, narrate why those procedures should not apply to the bridge or element under consideration (excessive debonding under the web at the governing location, relevant research or load testing, girder condition, etc.).

Reinforced and prestressed slab-type bridges may omit the shear check, provided good condition near the bearing areas. Other concrete bridge types will include a shear check for all vehicles and rating levels assessed.

C6A.5.8

Add: Shear cracking has occurred among beams that were heavily debonded under the web. Scrutinize original plans for this defect; where it is found, consider strengthening. Additionally, for shear, an independent check of the governing section is recommended.

6A.5.10—Temperature, Creep, and Shrinkage Effects

Add: For segmental post-tension elements, apply [redacted] Tables 6A.5.11-1 & 6A.5.11-2.

6A.5.11—Rating of Segmental Concrete Bridges

Add: The evaluation of segmental post-tension structures is unusually complex. Before performing a load rating analysis, as part of the scope development, peruse bridge inspection reports, gather As-Built data (construction methods, construction sequences with dates, concrete cylinder strength test data), and review this section. Identify any local details (i.e. diaphragms, anchorage zones, blisters, deviation saddles, etc.) exhibiting distress, and add their evaluation to the scope. Component dead load is obtained through the process of segment erection following the planned construction sequences, changing boundary conditions from stage to stage taking into account long term loss of prestress at Day 4000, including secondary forces post-tensioning. For expanded guidance on segmental post-tension bridge evaluation, see:
http://www.[redacted]gov/structures/posttensioning/NewDirectionsPostTensioningVol10A.pdf

6A.5.11.2—General Rating Requirements

Add: Apply [redacted] Tables 6A.5.11-1, 6A.5.11-2, and 6A.5.11.6-1. Load rate HL93-Inventory, HL93-Operating, and FL120-Permit, for all six tests in [redacted] Table 6A.5.11-1. For limit states where $RF_{HL93Operating} < 1.30$, also load rate the [redacted] Legal Loads; confine Legal Load assessments to marginal limit states where $RF_{HL93Operating} < 1.30$.

Use MBE Equation 6A.4.2.1-1 as expanded below, to determine the rating factor. The variance of sign, ±, is implicit for all variables.

$$RF = \frac{C - \left[\gamma_{DC} \cdot DC + \gamma_{DW} \cdot DW + \gamma_{EL} \cdot EL + \gamma_{FR} \cdot FR + \gamma_{CR} \cdot (TU + CR + SH)\right]}{\gamma_{LL} \cdot (LL + IM)}$$

RF Rating factor
C Factored capacity.
γ Load factor
DC Component dead load
DW Wearing dead load
EL Permanent locked-in erection forces
FR Bearing friction, or frame action
TU Uniform temperature
CR Creep
SH Shrinkage
LL Live load
IM Dynamic impact

Add: [redacted] **Table 6A.5.11-1—LRFR Live Load Factors for Segmental Bridges**

Direction & Limit		Inventory	Operating[1] and FL120[1]
Longitudinal	Strength, Flexure	1.75	1.35
	Strength, Shear	1.75	1.35
	Service III, flanges	1.00	0.90 SL[2]
	Service III, web	1.00	0.90 SL[2]
Transverse[3]	Strength, Flexure	1.75	1.35
	Service I	1.00	1.00

1. Apply the multiple presence factor (mpf) to all loaded lanes, per LRFD 3.6.1.1.2, except make the single-lane mpf 1.00 for Operating and [redacted]120 Permit Levels.
2. “SL” means the number of striped lanes; consider 1 ≤ lanes loaded ≤ SL.
3. For transverse limits, omit the lane load; neglect the 0.64klf HL93 lane load, and do not consider the 0.20klf legal and FL120 lane loads.

Add: [redacted] Table 6A.5.11-2—Stress Limits for Segmental Bridges

Longitudinal Tensile Stress in Precompressed Tensile Zone	**Inventory**	**Operating[4]**
Components with bonded or combined with unbonded prestressing with no reinforcement across the joint (Type A Joint[1]), extremely aggressive environment	3√f'c (psi)	3√f'c (psi)
Components with bonded or combined with unbonded prestressing with no reinf. across the joint (Type A Joint[1]), slightly or moderately aggressive environment	6√f'c (psi)	6√f'c (psi)
Components with bonded or combined with unbonded prestressing with auxiliary bonded reinforcement across the joint (Type A Joint[1]), extremely aggressive environment	3√f'c (psi)	6√f'c (psi)
Components with bonded or combined with unbonded prestressing with auxiliary bonded reinf. across the joint (Type A Joint[1]), slightly/moderately aggressive environment	6√f'c (psi)	6√f'c (psi)
Components with unbonded prestressing only (Type A Joint[1]) without auxiliary bonded reinforcement across the joint, extremely aggressive environment	Zero tension	Zero tension
Components with unbonded prestressing only (Type A Joint[1]) without auxiliary bonded reinforcement across the joint, slightly or moderately aggressive environment	Zero tension	3√f'c (psi)
Components with unbonded prestressing (Type B Joint[2]), all environments	100 psi (comp.)	Zero tension
Longitudinal Tensile Stress in other areas	**Inventory**	**Operating[4]**
Area without auxiliary bonded reinforcement[3]	Zero tension	Zero tension
In areas with auxiliary bonded reinforcement[3]	6√f'c (psi)	6√f'c (psi)
Principal Tensile Stress at Neutral Axis in Web	**Inventory**	**Operating[4]**
All types of segmental bridges	3.5√f'c (psi)	3.5√f'c (psi)
Transverse Stresses	**Inventory**	**Operating[4]**
Components with bonded prestressing and auxiliary bonded reinforcement, all environments	3√f'c (psi)	6√f'c (psi)

1. Type A Joint: Cast-in-place concrete joint, wet concrete or epoxy match cast joint between precast units.
2. Type B Joint (Dry joint): Match-cast joint between precast units without epoxy. Note that Type B Joints are not allowed in new segmental bridge design.
3. Auxiliary bonded reinforcement: Areas of bonded reinforcement sufficient to resist the tensile force in concrete computed based on an uncracked section, where reinforcement is proportioned using a stress of 0.5 f_{yield}, not to exceed 30 ksi.
4. Legal and Permit vehicles use Operating stress levels.

6A.5.11.4—Design-Load Rating

Add: The capacity of a section is determined by using any of the relevant formulae or methods in the LRFD Specifications, including more rigorous analysis techniques involving strain compatibility. When capacity depends upon a combination of both internal (bonded) and external (unbonded) tendons, use a more rigorous technique.

Determine capacity with actual strengths, rather than specified or assumed material strengths and characteristics. Concrete strength is to be found from records, or verified by suitable tests. If no data is available, the specified design strength is to be assumed and appropriately increased for time dependent maturity. All new designs assume the plan-specified concrete properties. Post-construction records will include updated concrete properties.

6A.5.11.5—Service Limit State

Add: Allowable Service Limit stresses, given in [redacted] Tables 6A.5.11-1 and 6A.5.11-2, are intended to ensure a minimum level of durability for [redacted] bridges that avoids the development or propagation of cracks or the potential breach of corrosion protection afforded to post-tensioning tendons.

C6A.5.11.5C *(add this subsection commentary)*

Type “A” Joints, with minimum bonded longitudinal reinforcement across cast-in-place joints, are limited to a tensile stress of $3\sqrt{f'c}$ or $6\sqrt{f'c}$ (psi) for the Inventory level.

Type “A” Epoxy Joints with discontinuous reinforcement are limited to a tensile stress of zero tension for Inventory (AASHTO Guide Specification for Segmental Bridges and LRFD Table 5.9.4.2.2-1). Operating stress is similarly limited to zero tension, or 200psi for joints in good condition (the tension strength of properly prepared epoxy joints exceeds concrete tension strength).

Type “B” Dry Joints with external tendons were designed to a longitudinal tensile stress limit of zero. In 1989, a requirement for 200 psi residual compression was introduced with the first edition of the AASHTO Guide Specification for Segmental Bridges. This was subsequently revised in 1998 to 100 psi compression. Service level design inventory ratings shall be based on a residual compression of 100 psi for dry joints. For design operating, legal, and permit ratings, the limit is zero tension. (Reference: AASHTO Guide Specification for Segmental Bridges and LRFD Table 5.9.4.2.2-1).

For all joint types, longitudinal Inventory stress limits are similar to Operating stress limits; reduced reliability is attained by using the number of striped lanes.

A check of the principal tensile stress has been introduced to verify the adequacy of webs for longitudinal shear at service. The Service limit state principal stress rating factor is the ratio between the live load shear stress required to induce the maximum principal tensile stress to that induced by the live load factor shown in [redacted] Table 6A.5.11-1. The check is made at the neutral axis, or at the critical elevation, and it includes torsion effects. Sections should be considered only at locations greater than "H/2" from the edge of the bearing surface or face of diaphragm, where classical beam theory applies: i.e. away from discontinuity regions. In general, verification at the elevation of the neutral axis may be made without regard to any local transverse flexural stress in the web itself given that in most large, well-proportioned boxes the maximum web shear force and local web flexure are mutually exclusive load cases. This is a convenient simplification. However, should the neutral axis lie in a part of the web locally thickened by fillets, then the check should be made at the most critical elevation, taking into account any coexistent longitudinal flexural stress. Also, if the neutral axis (or critical elevation) lies within 1 duct diameter of the top or bottom of an internal, grouted duct, the web width for calculating stresses should be reduced by half the duct diameter.

6A.5.11.6—System Factors: φ_s

Replace subsection with: For longitudinal flexure, apply [redacted] Table 6A.5.11.6-1.

Replace Table 6A.5.11.6-1 with:

[redacted] **Table 6A.5.11.6-1, System Factors (φ_s) for Post-Tensioned Concrete Girders**

Girders	Span Type	Hinges Required for Mechanism	φ_s Number of Tendons per Web 1	2	3	4
2	Interior	3	0.85	0.90	0.95	1.00
	End	2	0.85	0.85	0.90	0.95
	Simple	1	0.85	0.85	0.85	0.90
3 or 4	Interior	3	1.00	1.05	1.10	1.15
	End	2	0.95	1.00	1.05	1.10
	Simple	1	0.90	0.95	1.00	1.05
5 or more	Interior	3	1.05	1.10	1.15	1.20
	End	2	1.00	1.05	1.10	1.15
	Simple	1	0.95	1.00	1.05	1.10

6A.5.12—Rating of Reinforced Concrete Box Culverts

Replace Table 6A.5.12.5-1 with:

[redacted] **Table 6A.5.12.5-1—Limit States and Load Factors for Culvert Load Rating**

Description	Minimum	Maximum	LL mpf
$DC_{\text{Component Dead Load}}$	0.90	1.25	NA
$EV_{\text{Vertical Earth}}$	0.90	(η=1.05)·(1.30)	NA
$EH_{\text{Horizontal Earth}}$	1.00	(η=1.05)·(1.35)	NA
$LL,LS_{\text{HL93 Inventory}}$	0	1.75	1.20
$LL,LS_{\text{HL93 Operating}}$	0	1.35	1.20
$LL,LS_{\text{Legal Operating}}$	0	1.35	1.00
$LL.LS_{\text{FL120 Permit, Existing}}$	0	1.35	1.00
$LL,LS_{\text{FL120 Permit, New Section}}$	0	1.35	1.20

1. Simplify the assessment by assuming that the pavement and road base is 120pcf soil; avoid separate computations for DW and ES (wearing surface and earth surcharge).
2. Where “h” is the height of soil, use
   - F_e·(120 pcf)·(h) = max & min vertical earth load (F_e from LRFD 12.11.2.2.1-2)
   - (60 pcf)·(h) = maximum horizontal earth load
   - (60 pcf)·(h) = maximum horizontal live load, equivalent surcharge height
   - (30 pcf)·(h) = minimum horizontal earth load
3. Only consider one lane loaded, and apply the appropriate single-lane live load multiple presence factor (mpf) to the distribution factor lateral to the effective span length.

[redacted] **Table 6A.5.12.5-1** *(add this table commentary)*

While $mpf_{\text{FL120 Permit, Existing}}$ = 1.00 for existing culverts and existing sections of culverts, $mpf_{\text{FL120 Permit}}$ = 1.20 for new culverts and new portions of a culvert extension in design. The inconsistency is intended. Historically, [redacted] constructed culverts under Allowable Stress Design with more than adequate capacity. With the 2013 Interim Revisions and $mpf_{\text{FL120 Permit, Existing}}$ = 1.00, the State can (1) continue with the capabilities of its existing structures, (2) avoid needless replacement, and (3) fully adopt LRFR. For new culverts, $mpf_{\text{FL120 Permit, Existing}}$ = 1.20 will help to ensure that new culverts will accommodate future fill depths, live loads, and methodologies.

For additional guidance, see SDG 3.15, and the culvert example at: *http://www.[redacted]gov/maintenance/LoadRating.shtm*

6A.6—STEEL STRUCTURES

6A.6.4.1—Limit States, Design Load Rating

Replace the second paragraph with: Bridges shall not be rated for fatigue. If fatigue crack growth is anticipated, use Section 7 of the MBE to develop an estimate of the remaining fatigue life. Thoroughly document and explain all assumptions and interpretations.

6A.6.13—Moveable Bridges *(add this subsection)*

For new bascule bridges, see SDG 8.4, and show that the Strength I Design Operating rating exceeds 1.0 when span locks are disengaged; however report the Strength I Operating Rating with the span locks engaged. For existing bridges, contact the District Structures Maintenance Engineer for specific instructions.

6A.8—POSTING OF BRIDGES

Add: Posting of weight restrictions on bridges shall follow the procedures given in Chapter 7 of this ***Manual***.

6A.8.2—Posting Loads

*Strike any reference to AASHTO legal loads, and replace with the [redacted] Legal Loads as defined in the Appendix to this **Manual**.*

6A.8.3—Posting Analysis

Replace subsection with: The safe posting load shall be taken as the weight in tons for each [redacted] legal load truck multiplied by the corresponding rating factor. A Bridge Owner may close a structure at any posting threshold, however bridges with an operating rating less than 3 tons for any [redacted] legal load must be closed.

Appendix A6A—Load and Resistance Factor Rating Flow Chart

Remove entire subsection (use [redacted] Figures 2-1 and 2-2)

Appendix B6A—Limit States and Load Factors for Load Rating

Remove entire subsection (use [redacted] Table 6A.4.2.2-1)

Appendix D6A—AASHTO Legal Loads

*Remove entire subsection (use the Appendix to this **Manual**).*

Part B: LFR & ASR

6B.1—GENERAL

Add: All Load Rating Analyses must comply with Chapter 2 of this ***Manual***.

6B.1.1—Application of Standard Design Specifications

Replace subsection with: Except as specifically modified in this ***Manual***, or upon direct approval from the Department, explicitly follow the most recent editions of:

- AASHTO Std. Spec. for Highway Bridges
- AASHTO Guide Spec. for Horizontally Curved Steel Girder Highway Bridges
- AASHTO Std. Spec. for Movable Highway Bridges

6B.5—NOMINAL CAPACITY: C

Add: [redacted] **Table 6B.5.3—LFR Limit States and Load Factors**

Bridge Type	Limit	DL_{max}	LL Inventory	LL Operating
Steel	Strength[1]	1.30	2.17	1.30
	Service[2]	1.00	1.67	1.00
Reinforced Concrete	Strength[1]	1.30	2.17	1.30
	Service[2]	NA	NA	NA
Prestressed Concrete	Strength[1]	1.30	2.17	1.30
	Service[2]	1.00	1.00	NA
Post-Tension I-Girder[3]	Strength[1]	1.30	2.17	1.30
	Service[2]	1.00	1.00	NA
Timber[4]	Strength[1]	NA	NA	NA
	Service[2]	NA	NA	NA

Notes on following page.

Notes, [redacted] Table 6B.5.3:

1. “Strength” includes flexure and shear; consider axial effects where warranted.
2. “Service” means the allowable tension limit for the beam material.
3. For segmental box girders, use LRFR.
4. LFR excludes timber; use LRFR or ASR.

6B.5.2.4—Concrete

Replace subsection with: Unknown concrete strengths may be estimated with [redacted] Table 6A.5.2.1-1—Minimum Strength of Concrete by Year of Construction.

6B.5.3.2—Reinforced Concrete

Replace subsection with: Unknown concrete reinforcement strength may be estimated with [redacted] Table 6A.5.2.2-1—Yield Strength of Reinforcing Steel.

6B.5.3.3—Prestressed Concrete

*Remove the Prestressing Steel Tension check (see C6A.5.4.2.2b, this **Manual**).*

Add: For prestressed girders exhibiting distress or corrosion, consider using LRFR. For prestressed members governed by shear where $RF_{LFR.HS20.Operating} < 1.67$, use LRFR and 6A.5.8, or narrate why the LRFR method should not apply.

6B.6—LOADINGS

Add: Live load tables are given in the Appendix of this ***Manual.***

6B.6.2—Rating Live Load

Add: Omit the 24-kip military tandem at Std.Spec. 3.7.4.

C6B.6.2 *(add this subsection commentary)*

This coheres with past policy, and preserves a stable live loading model for permit routing. HS20 Design has considered the tandem for all Interstate bridges since 1976 Std.Spec. Interims. Meanwhile HS20 Evaluation has traditionally excluded the tandem (see MBE at Page A-72, MBE at Table C6B-1, 1982 [redacted] Load Rating Manual at Plate I, 1995 Load Rating Manual at Table VII-2, [redacted] BARS customization file "BigJohn.std," the Pontis load rating dataset, and the 2013 load rating calculations for Bridge No. 750004).

6B.6.2.3—Lane Loads

Replace subsection with: The HS20 vehicle considers point-and-lane loading.

6B.6.2.4—Sidewalk Loadings

Replace subsection with: Unless site-specifics suggest otherwise, do not apply pedestrian loading.

C6B.6.2.4

Replace subsection with: While load capacity evaluation typically omits pedestrian load (MBE 6A.2.3.4), design explicitly includes pedestrian loading (Std.Spec 3.14 and LRFD 3.6.1.6).

6B.6.4—Impact.

Replace subsection with: Typically apply full impact per Std. Spec. See Chapter 7 for impact reductions. Add to Std.Spec. 3.8.2.2: When utilizing Eq. 3-1 for shear impact due to truck loads, the length L may be interpreted as the distance from the point under consideration to the nearest reaction; alternatively, shear impact for axle loading may be taken as 30%.

6B.7—POSTING OF BRIDGES

6B.7.1—General

Replace the third paragraph with: If a concrete culvert with depths of fill 2.0 ft or greater with known details or with unknown components (such as culverts without plans) has been carrying normal traffic for an appreciable period and is in fair or better condition, as determined by a physical inspection of the culvert by a qualified inspector and documented in the inspection report, the culvert may be assigned an inventory load rating factor of 0.90 and an operating load rating factor of 1.50 for the HS-20 design load and need not be posted for restricted loading; these rating factor levels are less than those required by [redacted] Fig.2-2, which precludes extension or widening without analytical proof of adequate capacity. The load rating shall be documented in accordance with this ***Manual***.

6B.7.2—Posting Loads

Replace subsection with: For LFR ratings, evaluate the [redacted] Legal Loads as depicted within the Appendix. LFR is limited to bridges whose maximum span is less than 200 feet ([redacted] Figure 2-1). Simply use one truck, for LFR/ASR; omit truck trains, and partial-weight combinations. Assume the same legal loads are in each loaded lane; do not mix trucks. Replace the AASHTO legal loads with the [redacted] Legal Loads shown in the Appendix to this ***Manual***.

Chapter 7: Posting of Bridges and Posting Avoidance

7.1—GENERAL

For bona-fide emergencies, immediately do all things necessary to protect public safety. For non-emergency posting, follow the provisions within this Chapter.

If load rating calculations conclude that any of the [redacted] Legal Loads, as defined in the Appendix to this ***Manual***, have an operating rating factor less than 1.0, then the bridge must be posted for weight within 30 days after receipt of official posting notification from the Department.

Post bridges in accordance with [redacted] Standard Plans Index 700-107 (formerly Standard No. 17357). A blanket weight restriction sign (MUTCD Sign No. R12-1) may substitute the three-silhouette sign (MUTCD Sign No. R12-5). The three silhouettes represent:

- Single Unit (SU Class) trucks: SU2, SU3, and SU4.
- Combination (C Class) trucks with a single trailer: C3, C4, and C5.
- Combination truck with two trailers or a single unit truck with one trailer: ST5.

For each silhouette/class, post the lowest sub-legal rating, and truncate. For example:

RF_{SU2} = 1.12 GVW_{SU2} = 17 tons $RATING_{SU2}$ = 19.0 tons
RF_{SU3} = 0.89 GVW_{SU3} = 33 tons $RATING_{SU3}$ = 29.5 tons
RF_{SU4} = 0.99 GVW_{SU4} = 35 tons $RATING_{SU4}$ = 34.6 tons

Here, the SU posting is 29 tons. 29.5 is truncated, or rounded down. The SU2 is neglected, because the SU2 rating is greater than the SU2 gross vehicle weight (GVW).

In order to satisfy federal requirements regarding AASHTO SHV vehicles, for the circumstance where the analysis does recommend posting for C-Class combination trucks, but does not recommend posting for the SU-Class, post the SU-Class for 35 tons. This provides a safe posting for AASHTO SU trucks. For example:

RF_{SU2} = 2.09 GVW_{SU2} = 17 tons $RATING_{SU2}$ = 35.9 tons
RF_{SU3} = 1.08 GVW_{SU3} = 33 tons $RATING_{SU3}$ = 36.1 tons
RF_{SU4} = 1.02 GVW_{SU4} = 35 tons $RATING_{SU4}$ = 36.1 tons
RF_{C5} = 0.97 GVW_{C5} = 40 tons $RATING_{C5}$ = 38.6 tons

Here, the C posting is 38 tons and the SU posting is 35 tons. For rationale, see:
[redacted] *SU Load Posting Signs for AASHTO SHV-SU Trucks (2017 11-14)*.

7.2—WEIGHT POSTING PROCEDURES, STATE-MAINTAINED BRIDGES

When weight restrictions are required on a Department-maintained bridge, the District Structures Maintenance Engineer (DSME) will consult with the State Load Rating Engineer, consider posting-avoidance techniques, and recommend posting levels.

Within the load rating narrative, explain the cause of the low load rating, characterize impacts to traffic, and include a detour map. Develop a remedy (repair, strengthening, or replacement). Estimate costs and provide a timeline for execution of the remedy. Solicit recommendations from the District Traffic Operations Engineer, and order weight restriction signs from the Lake City Sign Shop.

Send the completed load rating as official notification to the District Maintenance Engineer and State Structures Maintenance Engineer. Then post the structure within 30 days.

7.3—WEIGHT POSTING PROCEDURE, BRIDGES NOT MAINTAINED BY THE DEPARTMENT

When weight restrictions are required on a bridge that is not maintained by the Department, users of this ***Manual*** will follow this procedure. The Department or its consultant will analyze the bridge, and the Department's District Local Bridge Coordinator will forward weight posting recommendations to the local agency bridge owner.

The local agency bridge owner shall post the bridge, and notify the Department's District Local Bridge Coordinator that the posting recommendation has been put into effect. If the required weight posting recommendation is not acted upon by the local agency bridge owner within 30 days of the initial notification by the District Local Bridge Coordinator, the Department shall post the bridge immediately, and all posting costs incurred by the Department shall be assessed to the local agency bridge owner.

The local agency bridge owner may subsequently perform its own analysis. However, such analysis does not exempt the local agency bridge owner from taking the mandatory steps to post the bridge within the 30 days, and any conclusions reached in the subsequent analysis finding that the posting restriction is not required must be accepted by the Department before load restrictions are removed.

7.4—POSTING AVOIDANCE

Posting avoidance modifies AASHTO design specifications to mitigate weight limit and permit mobility restrictions at existing bridges. Posting avoidance techniques are not applicable to new bridges, rehabilitation projects, or widening projects. However several techniques are available for existing bridges; select the ones that apply. Within the load rating narrative, explain and justify the selection.

ROUND-UP. Rating factor results from the approximate AASHTO distribution equations may be rounded-up by up to 5%. SDG 7.1.1.C.1 also permits rounding for widenings, but confines the provision to approximately-distributed LRFR results.

REFINED ANALYSIS. Analytical refinements may be used to improve load distribution. Permissible methods include finite element analysis, and moment redistribution (LRFD 4.6.4, and Std.Spec. 10.48.1.3).

DYNAMIC ALLOWANCE FOR IMPROVED SURFACE CONDITIONS. Where the transitions from the bridge approaches to the bridge deck across the expansion joints are smooth and where there are minor surface imperfections or depressions on the bridge deck, the dynamic load allowance may be reduced to 20%.

BARRIER STIFFNESS. An analysis may reasonably consider stiffening effects from parapets and barriers. Additionally consider the adverse effects.

STRIPED LANES. Striped lanes may be used for Service limits.

STEEL SERVICE. An analysis may neglect Steel Service if these factors are considered: fatigue, Average Daily Truck Traffic (ADTT), and the replacement schedule. For example, bridges with exceptionally low traffic, like certain water management structures, may neglect Steel Service with no additional analytical consideration. However steel structures on more typical throughways must consider ADTT and fatigue before neglecting the Steel Service limit.

Chapter 8: Load Rating of Bridges through Load Testing

GENERAL

To more accurately approximate load carrying capacity, the Department uses nondestructive load testing as described by MBE Section 8. Testing typically seeks an enhanced rating, and load testing can show that a bridge has additional capacity well beyond a traditional analysis. However testing can also discover stress spiking, or unforeseen deflections, which diminish the rating. In either case, whether the results are stronger or weaker than an approximate analysis would conclude, those load test results will better inform design and maintenance policy.

LOAD TEST CANDIDATES

Load test candidates either restrict the flow of trucks, or cannot be satisfactorily analyzed by traditional means. Annually, the State Load Rating Engineer will confer with District Structures Maintenance Engineers, the Permitting Office, and the Structures Research Center, to develop and refine a load test list. The State Load Rating Engineer will establish priorities, and the Structures Research Center will schedule the load tests in conjunction with the Districts.

It is anticipated that the Structures Research Center will perform a minimum of three (3) load tests each fiscal year. Within 60 days of completion of the load test, The Structures Research Center will send the load test report to the District Structures Maintenance Engineer and the State Load Rating Engineer. Within 14 days of receipt, the District Structures Maintenance Engineer will update the BrM/Pontis database with the results of the load test report.

LOAD TEST REPORTS

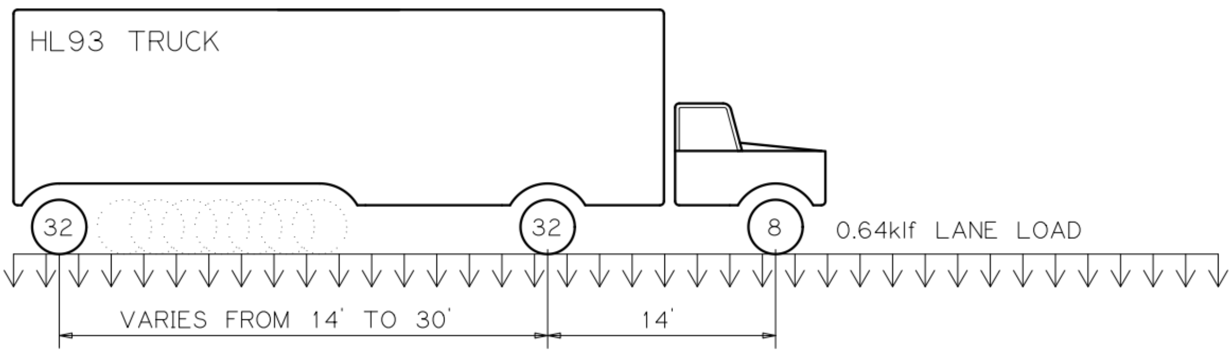
In addition to the "Complete Load Rating" requirements, specified in Chapter 2 of this ***Manual***, load test reports also feature an expanded narrative that discusses test procedure and analytical interpretation.

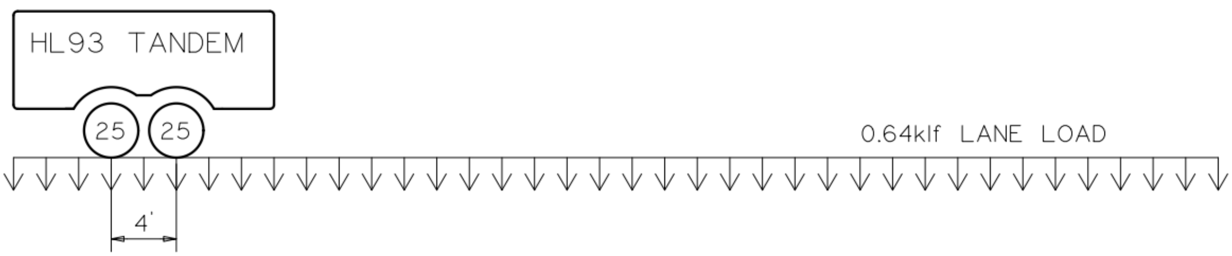
APPENDIX

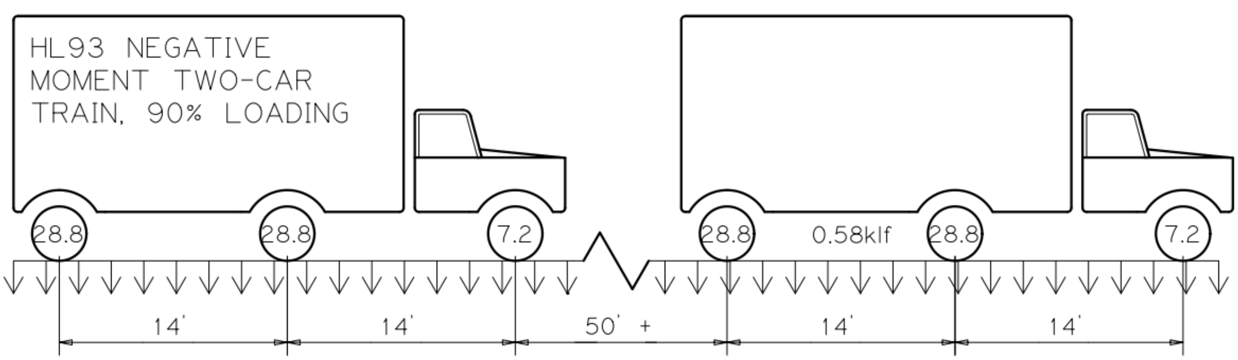
The Appendix defines live loads, and offers example Load Rating Summary Forms. For the Load Rating Summary Form Excel worksheet, and additional materials, see: *http://www.[redacted]gov/maintenance/LoadRating.shtm*

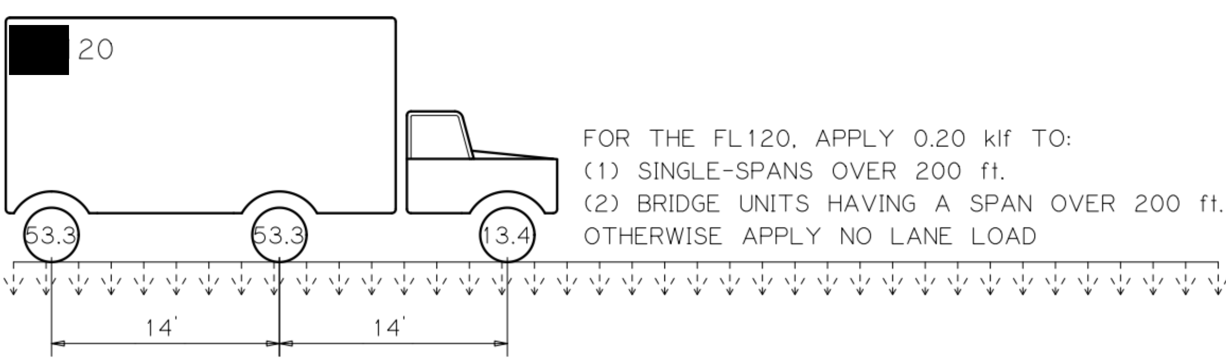
LRFR HL93 & [redacted]120 PERMIT

Axles in kip. Gage widths are 6 feet. Apply patch lane loads for maximum effects.



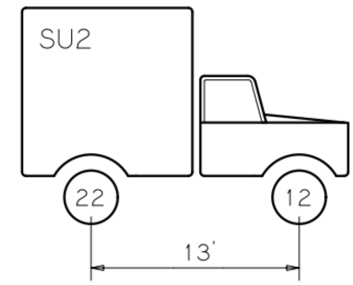


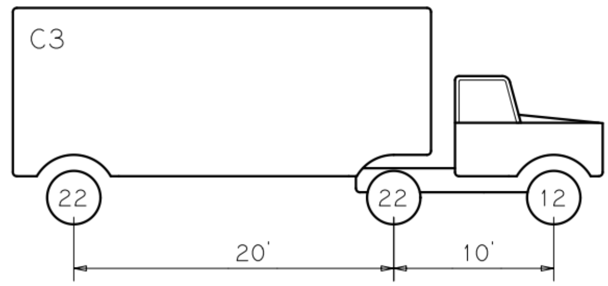


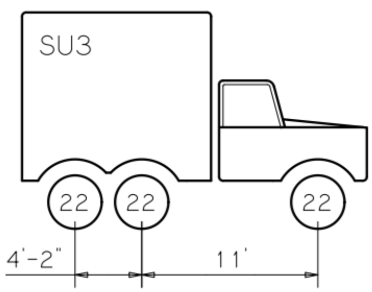


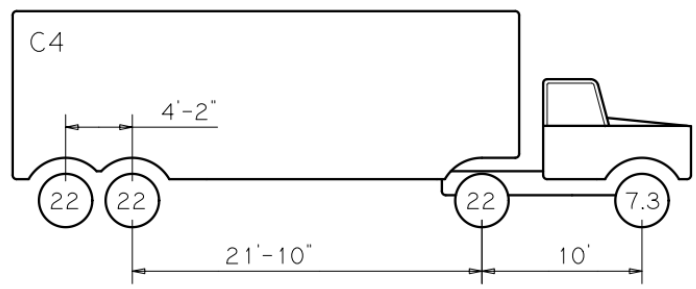
[redacted] LEGAL LOADS

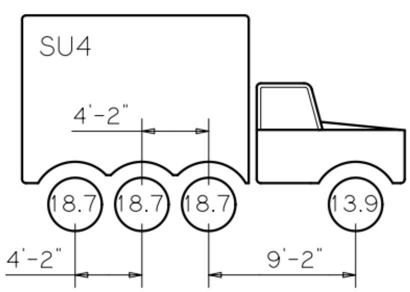
Axle Loading is in kip. Gage widths are 6 feet.

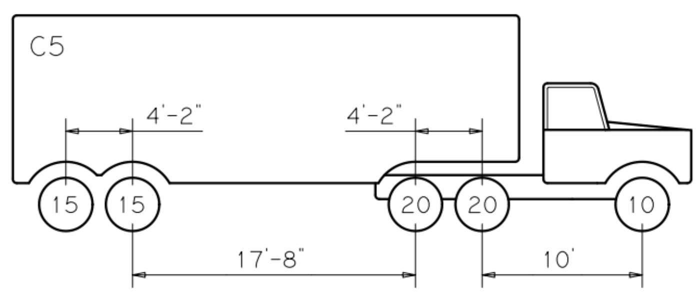


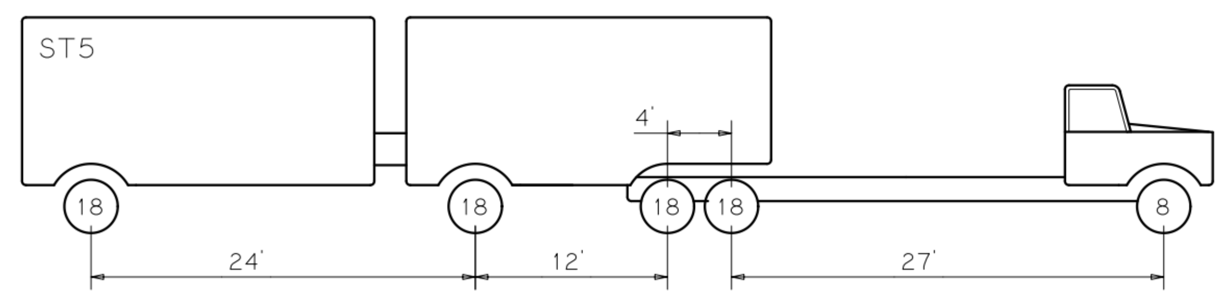










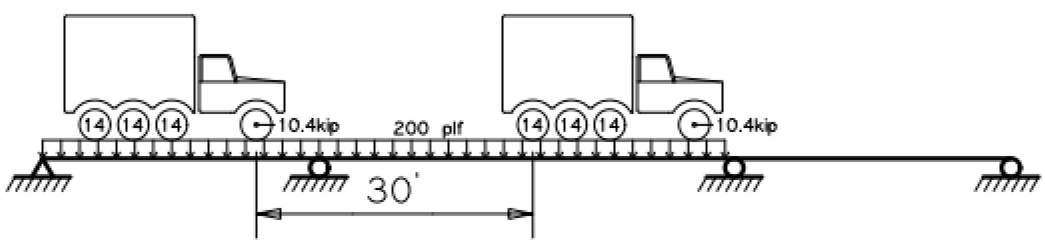


LRFR LEGAL LOAD COMBINATIONS

For all spans and effects, consider a single legal truck.

For spans exceeding 200 feet, or for bridge units with one span that exceeds 200 feet, consider one truck at 75% axle weights with full impact, combined with 100% 0.2klf lane loading at 0% impact. Use patch lane loading (continuous or discontinuous) to obtain the maximum effects. The figure below depicts maximum positive moment in Span 1.

For continuous structures of any length, negative moments and reactions at interior supports shall consider two legal trucks at 75% axle weights with full impact, combined with 100% 0.2klf lane loading at 0% impact. Separate the two trucks with 30 feet clear spacing, and point the trucks in the same direction. The figure below depicts the SU4 negative moment combination for Pier 2.

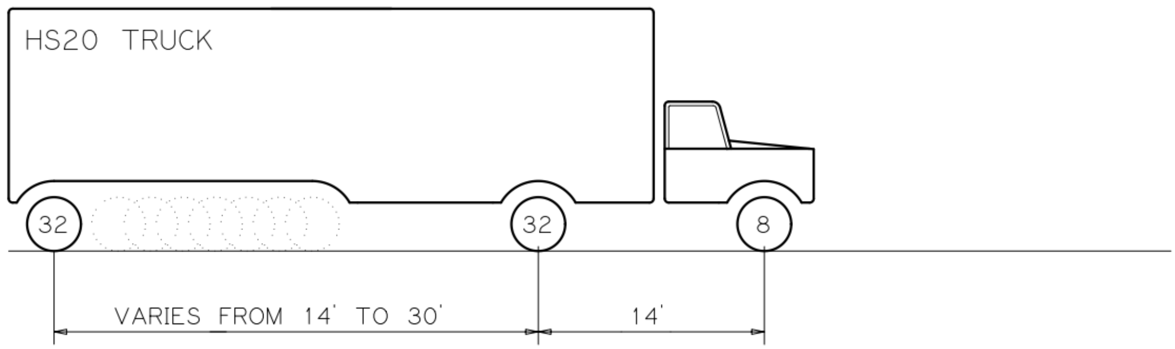


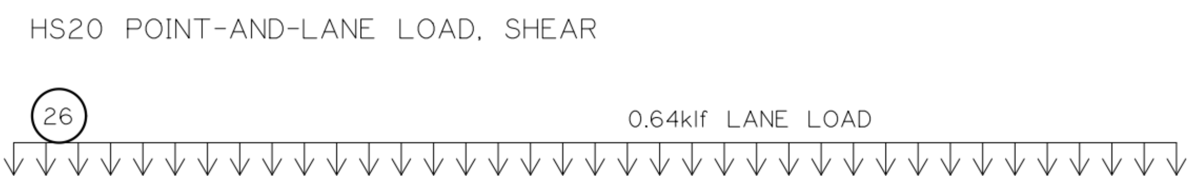
LFR LEGAL LOAD COMBINATIONS

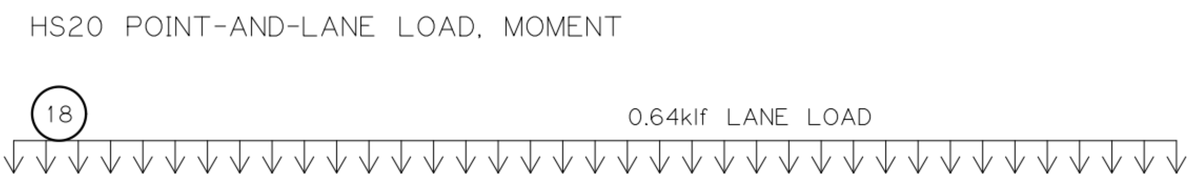
For all spans and effects, consider a single legal truck. This ***Manual*** prohibits LFR for spans exceeding 200 feet, so analysts need not apply the MBE 6B.7.2 100% weight truck train.

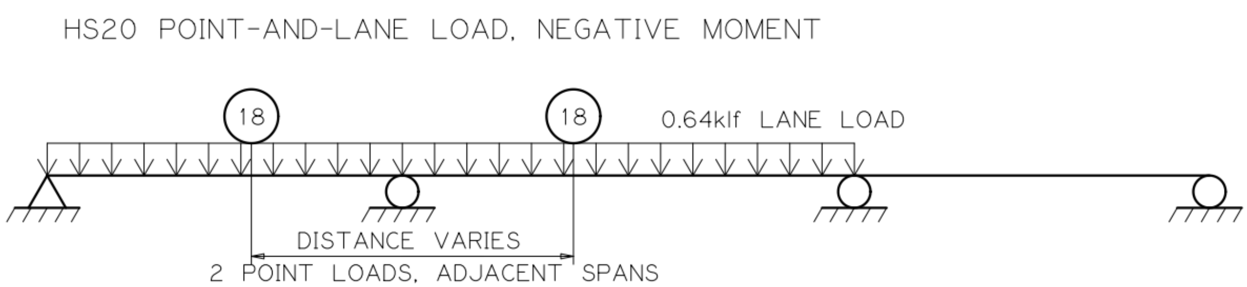
LFR HS20, EVALUATION DESIGN LOADING

Axles in kip. Gage widths are 6 feet. Apply patch lane loads for maximum effects.









LRFR LIVE LOAD WITH IMPACT, PER LANE

Span	IM_{AXL}	IM_{LANE}	HL93	FL120	SU2	SU3	SU4	C3	C4	C5	ST5
(ft)	(%)	(%)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)
5	33%	0%	55.2	88.7	36.6	36.6	31.1	36.6	36.6	33.3	29.9
10	33%	0%	114.4	177.3	73.2	91.7	82.9	73.2	91.7	83.4	76.6
15	33%	0%	205.0	266.0	109.7	162.7	176.2	109.7	162.7	147.9	134.9
20	33%	0%	301.0	354.7	146.3	234.8	269.4	153.3	234.8	213.5	193.9
30	33%	0%	506.2	625.4	243.3	440.3	476.8	264.0	380.1	376.9	351.4
40	33%	0%	727.9	997.0	354.4	658.8	708.2	387.6	525.8	543.1	529.9
60	33%	0%	1359.2	1787.8	578.5	1096.7	1172.3	754.9	956.6	1061.7	887.9
80	33%	0%	2059.9	2582.2	803.6	1535.1	1637.1	1124.8	1436.7	1591.4	1356.0
100	33%	0%	2825.5	3378.0	1029.1	1973.7	2102.2	1495.7	1919.8	2122.0	1884.9
150	33%	0%	5020.9	5370.1	1593.6	3070.6	3265.4	2424.7	3132.6	3450.1	3210.8
200	33%	0%	7617.2	7363.6	2158.4	4167.7	4428.9	3354.6	4348.3	4779.2	4538.8
200.1	33%	0%	7622.8	8368.1	2620.4	4169.9	4431.3	3517.8	4350.7	4781.8	4541.4
250	33%	0%	10614	10920	3605	5511	5757	4776	5735	6144	5962
300	33%	0%	14010	13602	4716	7021	7317	6161	7336	7828	7647

Span	IM_{AXL}	IM_{LANE}	HL93	FL120	SU2	SU3	SU4	C3	C4	C5	ST5
(ft)	(%)	(%)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)
5	33%	0%	44.2	70.9	29.3	34.1	29.0	29.3	34.1	31.0	28.7
10	33%	0%	56.4	70.9	29.3	46.3	43.5	29.3	46.3	42.1	38.3
15	33%	0%	62.4	75.7	31.4	50.4	53.9	34.6	50.4	46.5	41.5
20	33%	0%	66.3	92.2	34.8	59.5	61.4	37.2	52.4	51.5	47.9
30	33%	0%	75.6	109.9	38.3	68.9	72.0	39.9	58.4	57.6	55.9
40	33%	0%	86.2	122.4	40.0	73.6	77.2	47.9	66.7	66.5	59.9
60	33%	0%	100.1	134.8	41.8	78.4	82.5	56.7	77.0	75.8	71.8
80	33%	0%	110.2	141.0	42.6	80.7	85.2	61.2	82.1	83.5	77.8
100	33%	0%	118.8	144.7	43.1	82.1	86.8	63.8	85.2	88.1	81.4
150	33%	0%	137.8	149.7	43.8	84.0	88.9	67.4	89.3	94.2	86.2
200	33%	0%	155.3	152.2	44.2	85.0	89.9	69.2	91.3	97.2	90.9
200.1	33%	0%	155.3	172.2	53.1	85.0	89.9	71.9	91.3	97.2	90.9
250	33%	0%	172.2	178.6	58.3	89.1	92.9	77.7	94.4	99.3	95.5
300	33%	0%	188.8	184.6	63.4	94.4	98.2	83.2	100.0	105.2	102.0

Replace MBE Tables E6A-1 and E6A-2 with the one above, noting corrections to the MBE for the HL93. The live load for some Legal vehicles may increase step-wise, at 200 feet, when the 75% axle and 100% 0.20klf dual-car train begins to apply; the combination may be conservatively considered for shorter span lengths, also. See the Load Rating Summary (Excel) at sheet "LL," for additional span lengths.

LFR LIVE LOAD WITH NO IMPACT, PER LANE

Span	IM_{AXL}	IM_{LANE}	HS20	SU2	SU3	SU4	C3	C4	C5	ST5
(ft)	(%)	(%)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)	(k-ft)
5	0%	0%	40.0	27.5	27.5	23.4	27.5	27.5	25.0	22.5
10	0%	0%	80.0	55.0	68.9	62.3	55.0	68.9	62.7	57.6
15	0%	0%	120.0	82.5	122.3	132.5	82.5	122.3	111.2	101.4
20	0%	0%	160.0	110.0	176.6	202.6	115.3	176.6	160.5	145.8
30	0%	0%	282.1	183.0	331.0	358.5	198.5	285.8	283.4	264.2
40	0%	0%	449.8	266.5	495.3	532.5	291.4	395.4	408.4	398.4
60	0%	0%	806.5	435.0	824.6	881.5	567.6	719.2	798.3	667.6
80	0%	0%	1164.9	604.2	1154.2	1230.9	845.7	1080.3	1196.5	1019.6
100	0%	0%	1523.9	773.8	1484.0	1580.6	1124.6	1443.5	1595.5	1417.2
150	0%	0%	2475.0	1198.2	2308.7	2455.2	1823.0	2355.3	2594.1	2414.2
200	0%	0%	4100	1623	3134	3330	2522	3269	3593	3413
200.1	0%	0%	4104	3439	6349	6407	4210	5153	5641	4020
250	0%	0%	6125	5180	9638	9850	6306	7616	8304	6152
300	0%	0%	8550	7371	13645	13773	8966	10775	11741	8596

Span	IM_{AXL}	IM_{LANE}	HS20	SU2	SU3	SU4	C3	C4	C5	ST5
(ft)	(%)	(%)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)	(kip)
5	0%	0%	32.0	22.0	25.7	21.8	22.0	25.7	23.3	21.6
10	0%	0%	32.0	22.0	34.8	32.7	22.0	34.8	31.7	28.8
15	0%	0%	34.1	23.6	37.9	40.5	26.0	37.9	35.0	31.2
20	0%	0%	41.6	26.2	44.7	46.1	28.0	39.4	38.7	36.0
30	0%	0%	49.6	28.8	51.8	54.1	30.0	43.9	43.3	42.0
40	0%	0%	55.2	30.1	55.4	58.1	36.0	50.1	50.0	45.0
60	0%	0%	60.8	31.4	58.9	62.0	42.7	57.9	57.0	54.0
80	0%	0%	63.6	32.1	60.7	64.0	46.0	61.7	62.8	58.5
100	0%	0%	65.3	32.4	61.7	65.2	48.0	64.0	66.2	61.2
150	0%	0%	74.0	33.0	63.2	66.8	50.7	67.1	70.8	64.8
200	0%	0%	90.0	33.2	63.9	67.6	52.0	68.7	73.1	68.3
200.1	0%	0%	90.0	76.3	140.6	145.0	92.2	117.3	123.4	94.3
250	0%	0%	106.0	91.3	168.3	169.3	111.1	139.1	147.0	112.7
300	0%	0%	122.0	104.9	193.7	197.5	126.5	155.9	166.5	125.9

Replace MBE Tables C6B-1 and C6B-2 with the one above. For LFR, the MBE reports live load in wheel-lines (half-axle, or half-lane); this table uses 1 lane. For spans over 200 feet, the LFR truck train applies to one lane; use LRFR methodology for spans over 200 feet. See the Load Rating Summary (Excel) at sheet "LL," for additional span lengths.

RATING FACTORS (RFs) FOR PERMITS

Permits are typically routed by comparing the available capacity ($RF \cdot LL_{\text{Reference Vehicle}}$) to the permit live load, for the spans under consideration. The table below illustrates the minimum single-span simply-supported longitudinal Operating Rating Factors needed to pass all blanket permit trucks in [redacted] considering both moment and shear. For example, say the span length is 100 feet; to pass all routine [redacted] blanket permits, $RF_{HL93.Operating} \geq 1.24$, or RF[redacted]$_{120.Permit} \geq 1.04$, or $RF_{HS20.Operating} \geq 1.73$.

SPAN	LRFR	LRFR	LFR
Length	HL93	[redacted]120	HS20
(ft)	(RF_{needed})	(RF_{needed})	(RF_{needed})
5	1.09	0.68	1.13
10	1.21	0.96	1.60
15	1.20	0.99	1.64
20	1.24	0.97	1.62
30	1.29	0.99	1.65
40	1.32	0.96	1.61
60	1.22	0.93	1.55
80	1.23	0.98	1.63
100	1.24	1.04	1.73
150	1.32	1.22	1.85
200	1.30	1.33	1.72
200.1	1.30	1.18	1.72
250	1.24	1.20	1.55
300	1.18	1.20	1.40

An [redacted]120 example for a span length of 100 feet follows. [redacted]120 column three (3) is:

$$\max\left(\left(\frac{\max\left(LL_{Permits.Moment}\left(L_{span}\right)\right)}{\max\left(LL_{\text{[redacted]}120.Moment}\left(L_{span}\right)\right)} \quad \frac{\max\left(LL_{Permits.Shear}\left(L_{span}\right)\right)}{\max\left(LL_{FL120.Shear}\left(L_{span}\right)\right)}\right)\right)$$

If the span length is 100 feet, and $RF_{FL120} = 1.04$, then $RF_{CRANE\ 3}$ is inferred as:

$LL_{FL120} = 3378$ kip·ft

$LL_{CRANE\ 3} = 3500$ kip·ft

$RF_{CRANE\ 3} = 1.04 \cdot 3378/3500 = 1.00$

Crane 3 governs the 100ft. span in flexure, over all other blanket permit vehicles. Therefore, RF[redacted]$_{120} \geq 1.04$ is sufficient for all blanket permits.

EXAMPLE LOAD RATING SUMMARY 1

Bridge No.	991957	**Analysis Method:**	ASR - Allowable Stress
Location	[redacted]i		
Description	3 Simply-supported spans, 26-60-26 feet. 60ft. T-Beam Governs.		

[redacted] Bridge Load Rating Summary Form (Page 1 of 1)

Rating Type	Rating Type	Gross Axle Weight (tons)	Moment/Shear/[redacted]		Dead Load Factor	Live Load Factor	Live Load Distrib. Factor (axles)	Rating Factor	Span No. - Girder No., Interior/Exterior, %Span[redacted]	RF·Weight (tons)
Level	**Vehicle**	**Weight**	**Member Type**	**Limit**	**DC**	**LL**	**LLDF**	**RF**	**Governing Location**	**RATING**
Inventory	HS20	36	Reinf. Concrete	Service	1.00	1.00	0.351	0.551	Beam 2-5, Interior, 50%L	19.8
Operating	HS20	36	Reinf. Concrete	Service	1.00	1.00	0.351	0.751	Beam 2-5, Interior, 50%L	27.1
Permit	[redacted]20	60	Reinf. Concrete	NA	NA	NA				-1
Operating Max Span	HS20	36	Reinf. Concrete	Service	1.00	1.00	0.351	0.751	Beam 2-5, Interior, 50%L	27.1
Legal	SU2	17	Reinf. Concrete	Service	1.00	1.00	0.351	1.391	Beam 2-5, Interior, 50%L	23.7
	SU3	33	Reinf. Concrete	Service	1.00	1.00	0.351	0.730	Beam 2-5, Interior, 50%L	24.1
	SU4	35	Reinf. Concrete	Service	1.00	1.00	0.351	0.684	Beam 2-5, Interior, 50%L	23.9
	C3	28	Reinf. Concrete	Service	1.00	1.00	0.351	1.073	Beam 2-5, Interior, 50%L	30.1
	C4	36.7	Reinf. Concrete	Service	1.00	1.00	0.351	0.854	Beam 2-5, Interior, 50%L	31.3
	C5	40	Reinf. Concrete	Service	1.00	1.00	0.351	0.760	Beam 2-5, Interior, 50%L	30.4
	ST5	40	Reinf. Concrete	Service	1.00	1.00	0.351	0.903	Beam 2-5, Interior, 50%L	36.1

Original Design Load	Unknown (original plans NA)	
Rating Type, *Analysis*	Allowable Stress (AS)	
Distribution Method	Others	
Impact Factor	27.0%	(axle loading)
HS20 Gov. Span Length	60.0	(feet)
Recommended Posting	[redacted] to 39.9% below (0.601-0.700) (Required)	
Recommended SU Posting*	23	(tons)
Recommended C Posting	30	(tons)
Recommended ST5 Posting	36	(tons)
Floor Beam Present?	No	
Segmental Bridge?	No	
Project No. & Reason	NA	Update
Plans Status	NA (use field measurements)	
Software Name, Version	MathCAD	

Performed by:	Andrew DeVault	Date:	12/11/14
Checked by:	Roger Liu	Date:	12/11/14
Sealed By:	Andrew DeVault	Date:	12/15/14
FL P.E. No.:	#75796		
Cert. Auth. No.:	State Agency		
Phone & email:	[redacted]		
Company:	[redacted] Office of [redacted]		
Address:	[redacted]		

P.E. Seal

COMMENTS BY THE ENGINEER

Page 1/23. Contents: summary, narrative, plans, calcs, check.

Unknown plans. Fair condition.

Posting avoidance/mitigation applied.

Unsealed example; the Bridge No. and name is ficticious.

This 12-01-2017 summary follows the [redacted] Bridge Load Rating Manual (BLRM), and the [redacted] BMS Coding Guide.
*Recommended SU Posting levels for [redacted] SU trucks adequately restricts AASHTO SU trucks; see BLRM Chapter 7.

[redacted] gov/maintenance/LoadRating.shtm

EXAMPLE LOAD RATING SUMMARY 2

Bridge No.	180021	**Analysis Method:**	LRFR-LRFD
Location	[redacted]		
Description	Four simple spans, 35 - 35 - 56 - 56 feet. Composite steel girder.		

[redacted] Bridge Load Rating Summary Form (Page 1 of 1)

Rating Type	Rating Type	Gross Axle Weight (tons)	Moment/Shear/[redacted]		Dead Load Factor	Live Load Factor	Live Load Distrib. Factor (axles)	Rating Factor	Span No. - Girder No., Interior/Exterior, %Span[redacted]	RF·Weight (tons)
Level	**Vehicle**	**Weight**	**Member Type**	**Limit**	**DC**	**LL**	**LLDF**	**RF**	**Governing Location**	**RATING**
Inventory	HL93	36	Steel	Service	1.00	1.30	0.698	0.907	Beam 3-3, Interior, 50%L	32.6
Operating	HL93	36	Steel	Service	1.00	1.00	0.698	1.179	Beam 3-3, Interior, 50%L	42.4
Permit	[redacted]20	60	Steel	Strength, Shear	1.25/0.90	1.35	0.814	0.937	Beam 2-3, Interior, 0%L	56.2
Permit Max Span	[redacted]20	60	Steel	Strength, Moment	1.25/0.90	1.35	0.698	0.965	Beam 3-3, Interior, 50%L	57.9
Legal	SU2	17	Steel	Service	1.00	1.30	0.698	2.030	Beam 3-3, Interior, 50%L	34.5
	SU3	33	Steel	Service	1.00	1.30	0.698	1.092	Beam 3-3, Interior, 50%L	36.0
	SU4	35	Steel	Service	1.00	1.30	0.698	1.023	Beam 3-3, Interior, 50%L	35.8
	C3	28	Steel	Service	1.00	1.30	0.698	1.634	Beam 3-3, Interior, 50%L	45.8
	C4	36.7	Steel	Service	1.00	1.30	0.698	1.295	Beam 3-3, Interior, 50%L	47.5
	C5	40	Steel	Service	1.00	1.30	0.698	1.164	Beam 3-3, Interior, 50%L	46.6
	ST5	40	Steel	Service	1.00	1.30	0.698	1.362	Beam 3-3, Interior, 50%L	54.5

Original Design Load	HS15 or H-15-S12	
Rating Type, *Analysis*	Load Testing	
Distribution Method	AASHTO Formula	
Impact Factor	33.0%	(axle loading)
FL120 Gov. Span Length	35.0	(feet)
Recommended Posting	[redacted] Above legal loads. Posting Not Required.	
Recommended SU Posting*	99	(tons)
Recommended C Posting	99	(tons)
Recommended ST5 Posting	99	(tons)
Floor Beam Present?	No	
Segmental Bridge?	No	
Project No. & Reason	NA	Update
Plans Status	Built	
Software Name, Version	Hand Calcs - MathCAD	

Performed by:	Will Po	Date:	11/11/14
Checked by:	Charlie Parker	Date:	12/11/14
Sealed By:	Mario Bauza	Date:	12/15/14
FL P.E. No.:	#2804119		
Cert. Auth. No.:	State Agency		
Phone & email:	[redacted]		
Company:	[redacted] Office of Maintenance		
Address:	[redacted]		

P.E. Seal

COMMENTS BY THE ENGINEER

Page 1/40. Contents: summary, narrative, plans, calcs, check.

Fair condition.

AASHTO-distributed results adjusted by diagnostic load test.

Unsealed example summary; numbers & names are ficticious.

This 12-01-2017 summary follows the [redacted] Bridge Load Rating Manual (BLRM), and the [redacted] BMS Coding Guide.
*Recommended SU Posting levels for [redacted] SU trucks adequately restricts AASHTO SU trucks; see BLRM Chapter 7.

[redacted] gov/maintenance/LoadRating.shtm

EXAMPLE LOAD RATING SUMMARY 3

Bridge No.	729999	**Analysis Method:**	LRFR-LRFD	[redacted] **Bridge Load Rating Summary Form (Page 1 of 1)**
Location	[redacted]			
Description	Four simple spans: 47-89-89-48 feet. Composite prestress girder.			

Rating Type	Rating Type	Gross Axle Weight (tons)	Moment/Shear/[redacted]		Dead Load Factor	Live Load Factor	Live Load Distrib. Factor (axles)	Rating Factor	Span No. - Girder No., Interior/Exterior, %Span[redacted]	RF·Weight (tons)
Level	**Vehicle**	**Weight**	**Member Type**	**Limit**	**DC**	**LL**	**LLDF**	**RF**	**Governing Location**	**RATING**
Inventory	HL93	36	Prestressed	Service	1.00	0.80	0.570	1.100	Beam 2-10, Interior, 50%L	39.6
Operating	HL93	36	Prestressed	Strength, Shear	1.25/0.90	1.35	0.870	1.310	Beam 2-10, Interior, 30%L	47.2
Permit	[redacted]0	60	Prestressed	Strength, Axial	1.25/0.90	1.35	0.870	1.020	Beam 2-10, Interior, 30%L	61.2
Permit Max[redacted]	[redacted]		Prestressed	[redacted] Shear	1.25/0.90	1.35	0.870	1.020	Beam 2-10, Interior, 30%L	61.2
	SU2	17	Prestressed	NA	NA	NA				-1
	SU3	33	Prestressed	NA	NA	NA				-1
	SU4	35	Prestressed	NA	NA	NA				-1
Legal	C3	28	Prestressed	NA	NA	NA				-1
	C4	36.7	Prestressed	NA	NA	NA				-1
	C5	40	Prestressed	NA	NA	NA				-1
	ST5	40	Prestressed	NA	NA	NA				-1

Original Design Load	HS20 or HS20-S16-44	
Rating Type, *Analysis*	LRFR-LRFD	
Distribution Method	AASHTO Formula	
Impact Factor	33.0%	(axle loading)
FL120 Gov. Span Length	88.2	(feet)
Recommended Posting	At/Above legal loads. Posting Not Required.	
Recommended SU Posting*	99	(tons)
Recommended C Posting	99	(tons)
Recommended ST5 Posting	99	(tons)
Floor Beam Present?	No	
Segmental Bridge?	No	
Project No. & Reason	213387-7-52-01	Widening
Plans Status	Design or Construction	
Software Name, Version	Conspan 13.0	

Performed by:	Miles Davis	Date:	08/17/59
Checked by:	Henri Mancini	Date:	01/01/64
Sealed By:	David Bowie	Date:	02/23/15
FL P.E. No.:	#999999		
Cert. Auth. No.:	#999999		
Phone & email:	850-414-5200, consultant@firm.com		
Company:	Round Midnight Engineering		
Address:	[redacted]		

P.E. Seal

COMMENTS BY THE ENGINEER

Page 1/90. Contents: summary, narrative, plans, calcs, check.

Unsealed example summary; numbers & names are ficticious.

This 12-01-2017 summary follows the [redacted] Bridge Load Rating Manual (BLRM), and the [redacted] BMS Coding Guide.
*Recommended SU Posting levels for [redacted] SU trucks adequately restricts AASHTO SU trucks; see BLRM Chapter 7.

[redacted] gov/maintenance/LoadRating.shtm

SYNOPSIS OF SIGNIFICANT REVISIONS, 2015

The 2015 [redacted] Bridge Load Rating Manual rewrote the 2014 Manual. The organization and intent was largely retained. However the word count was reduced significantly, and the following changes were significant:

1. Add an updating procedure, for Technical Revisions.
2. Revise prestress Operating and Permit ratings to Strength, not Service. However retain Service for prestress exhibiting distress or corrosion.
3. Remove the prestress Service I Lower Tendon Limit for LFR and LRFR-[redacted]120. See commentary at C6A.5.4.2.2b.
4. Clarify LRFD prestress shear capacity. Either use the General Method per LRFD, or the "Simplified" method (ACI as modified by LRFD).
5. Narrow LFR and ASR. Exclude LFR and ASR from spans exceeding 200ft.
6. Require Legal Load assessments for LFR and ASR, regardless of the Design Operating Rating.
7. Simplify system factors for steel bridges; do not apply different system factors to different spans on the same bridge unit.
8. Simplify culvert analysis by providing criteria for wall assessments.
9. Remove requirements that older culverts be appraised by LFR. The 2013 LRFD Interims broadened the effective strip width, and LRFR is now similar to LFR.
10. Describe load rating deliverables, and specify the mechanics of their submission and adoption (Chapter 2—Process).
11. Specify what a load rating is, its minimum contents.
12. Simplify segmental analysis. First, for all Design Operating, Legal Operating, and Routine Permit ratings, use $\gamma_{LL.Service}$ = "0.90 SL," and a single-lane multiple presence factor of 1.0 (consistent). Second, use Inventory Service I transverse $3\cdot\sqrt{fc}\cdot psi$, for all environments, which coheres with LRFD 5.9.4.1.2-1, and redacts slightly aggressive $6\cdot\sqrt{fc}\cdot psi$ (conservative, and consistent). Third, redact step-by-step instructions (see Volume 10 A: Load Rating Post-Tensioned Concrete Segmental Bridges, now somewhat outdated). Finally, redact specific instructions for shear in segmentals (defer to the latest LRFD).

SYNOPSIS OF SIGNIFICANT REVISIONS, 2016

The 2016 [redacted] Bridge Load Rating Manual largely retains the 2015 Manual. The following changes are notable:

1. Chapter 2—Process: Definition, Complete Load Rating. Add a provision for digital delivery. Specify "unlocked," and say why.
2. Chapter 2—Process: Table 2-1—Existing Bridges. For load rating reviews coincident to bridge inspections, change the location of the note documenting the review from "Structure Notes" to "Inspection Notes." Additionally, remove "the results are, by inspection, reasonable" as vague.
3. Chapter 6—Load Rating Analysis: 6A.5.12—Rating of Reinforced Concrete Box Culverts. Rewrite the subsection, provide guidance, and link to an example.

SYNOPSIS OF SIGNIFICANT REVISIONS, 2017

1. 6A.5.7—allow simplified distribution for flat slab beams.
2. 6.1.5.2—explicitly require that straddle bents be analyzed.

SYNOPSIS OF SIGNIFICANT REVISIONS, 2018

1. 7.1—Posting, General. Add provisions to restrict AASHTO SHV-SU trucks.
2. 7.2—Posting, State-Maintained Bridges. Simplify.
3. 6B.5.3.3—Prestressed Concrete. Where RFLFR.HS20.Operating < 1.67, use LRFR.
4. 6A.5.11—Rating of Segmental Bridges. Revise load factor and stress tables.
5. Update and correct code references throughout.

4.4.3.3 Rational Evaluation Method

When the use of empirical methods is justified and approved by [redacted], the design and legal load rating can be assigned using the rational evaluation method. This method is based on the premise that the inventory rating, operating rating, and load posting are proportional to each other and can be assigned based on condition ratings.

Using this methodology, Table 4.4-5 gives **suggested** rating factors and load postings for a given superstructure, substructure, or culvert condition rating:

	LFR Design Load Rating Factors		Load Postings (Tons)		
Condition Rating	Inventory	Operating	Single Unit	3 or 4 Axle Combinations	5 or More Axle Combinations
Good to Excellent - No signs of structural deterioration or distress.	1.00	1.66	No Posting Required		
Fair - Initial evidence of structural deterioration or distress. (No restrictions required)	0.75	1.25	No Posting Required		
Poor - Some structural deterioration or distress. (Legal Loads Only restriction)	0.60	1.00	No Posting Required		
Serious - Advanced structural deterioration or distress evident. (Load posting required) *(See Note 1)*	0.39	0.65	15	20	25
	0.21	0.35	8	12	14
Critical - Severe structural deterioration or distress evident.	0.13	0.22	5		

Table 4.4-5 – Rational Evaluation Method Rating Factors and Load Postings

Note 1: The upper and lower values related to the seriousness of the deterioration or distress (i.e. is it closer to Poor (upper) or Critical (lower)). The load rater may alternatively require a single load posting based on the Single Unit load posting. Weight restrictions on township roads are typically single load postings.

When using this method, the “Inventory Load Rating Method” (ISIS Item 65) shall be coded as “0” (Field evaluation and documented engineering judgment).

[redacted] BRIDGE INSPECTION MANUAL

PART 3

LOAD RATING

TABLE OF CONTENTS

LIST OF FIGURES

Figure	**Title**	

3-1.0 INTRODUCTION

The primary purpose of this part of the manual is to establish a uniform policy of load rating procedures and standards for determining the safe load carrying capacity of bridges within the state of [redacted] This part is heavily influenced by the guidelines established in Section 6 of the *Manual for Bridge Evaluation*, 2nd Edition, including all interim revisions. Any variance with these guidelines is discussed in the sections to follow. At no point shall the requirements set forth in this document be in conflict with state or federal law. In the event of discrepancy, the law shall apply.

3-2.0 REFERENCE MATERIAL

AASHTO. (2008). *The Manual for Bridge Evaluation* (1st ed.). Washington, DC: American Association of State Highway and Transportation Officials.

AASHTO. (2011 with 2011, 2013, 2014, 2015, and 2016 Interim Revisions). *The Manual for Bridge Evaluation* (2nd ed.). Washington, DC: American Association of State Highway and Transportation Officials.

** References to the MBE in this manual refer to the 2nd Edition and its Interim Revisions. However 23 CFR 650.317 references the 1st Edition, making this the binding edition.**

AASHTO. (2002). *Standard Specifications for Highway Bridges* (17th ed.). Washington, DC: American Association of State Highway and Transportation Officials.

AASHTO. (2014 with 2015 and 2016 Interim Revisions). *AASHTO LRFD Bridge Design Specifications* (7th ed.). Washington, DC: American Association of State Highway and Transportation Officials.

Vehicle weight limitations – Interstate System, 23 U.S.C. 127 (2017)

National Bridge Inspection Standards, 23 CFR 650 subpart C (2016)

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(2011 with Revisions 1, 2, and 3). [redacted] *Manual on Uniform Traffic Control Devices for Streets and Highways*. http://www.in.gov/dot/div/contracts/design/mutcd/2011rev3MUTCD.htm

[redacted] Department of Transportation. (2013-2017). [redacted] *Design Manual*. http://www.in.gov/[redacted]design_manual/design_manual_2013.htm

3-3.0 ROLES & RESPONSIBILITIES

Load rating roles for Bridge Owners, the [redacted] Department of Transportation, and Load Rating Engineers are described below.

3-3.01 Bridge Owners

Bridge Owners in [redacted] include the state, counties, other local agencies, toll roads, and private firms owning bridges open to public traffic. For bridges within their authority, bridge owners are responsible for the following items:

- Ensuring all bridges within their jurisdiction are load rated for their in-service condition.
- Ensuring that new, replacement, or rehabilitated bridges are load rated no later than the initial inspection.
- Quality control and maintaining of all required load rating documentation.
- Posting of bridges as required.

3-3.02 [redacted] Department of Transportation

The [redacted] Department of Transportation ([redacted] is responsible for ensuring bridge owners are in compliance with the *National Bridge Inspection Standards* (NBIS) as given in 23 CFR 650 Subpart C, Bridges, Structures, and Hydraulics.

3-3.03 Load Rating Engineers

Qualifications for Load Rating Engineers (LRE) are discussed in Part 1 of this manual. LREs must certify and be actively involved in reviewing the quality and accuracy of all load ratings performed. A qualified LRE is also responsible for submitting all required documentation as specified in 3-9.02.

3-4.0 VEHICLES

Vehicles are classified into three main subcategories: design, legal, and permit. Each of these categories is discussed in greater detail below. Vehicle configurations are shown in Appendix A.

3-4.01 Design

Design vehicles are live loads used for the purpose of designing new, replacement, or rehabilitation bridge projects. Applicable design vehicles are listed on the plans for which the structural element in question was designed. Rules regarding the applicability of design vehicles are specified in the [redacted] *Design Manual* (IDM). See Figure 3-4.1 for a list of potential design vehicles. Additionally, rating factors at the Design Inventory Level for both the H-20 and HS-20 vehicles shall reflect the existing condition of the bridge as required by the Federal Highway Administration (FHWA). Furthermore, general Toll Road and Michigan Train Truck applicability is discussed below as well as in IDM 403-3.01.

Any bridge on the [redacted] Toll Road or any state owned or maintained bridge within 15 miles of a toll road gate shall be rated for the Toll Road Truck configurations including a 0.64 klf lane load. Any bridge located on the Extra-Heavy Duty Highway, as described in IC 9-20-5-4, shall be rated for the Michigan Train Truck configurations including a 0.64 klf lane load. See Appendix B for supplementary information regarding the [redacted] Toll Road and Extra Heavy Duty Highways.

Truck Configuration
HL-93
Fatigue*
H-20
HS-20
HS-25
Alternate Military
Toll Road Loading No. 1
Toll Road Loading No. 2
Special Toll Road Truck
Michigan Train Truck #5
Michigan Train Truck #8

* The Fatigue configuration shall be used for evaluating the Fatigue Limit State per MBE Table 6A.4.2.2-1 whenever HL-93 is specified on applicable plans

Figure 3-4.1 Potential Design Vehicles

3-4.02 Legal

Legal vehicles are live loads used for the sole purpose of determining the safe load carrying capacity and posting of a bridge. This legal category is described in the Manual for Bridge Evaluation (MBE) section 6A.4.4 for Load and Resistance Factor Rating (LRFR) and 6B.7.2 for Load Factor Rating (LFR). Every bridge in [redacted] is required to be rated for the vehicles listed in Figure 3-4.2; any vehicle not explicitly mentioned in the MBE shall be considered a "state legal load" as discussed in the MBE. For LRFR, the vehicles are broken down into two subcategories, Routine Commercial Traffic and Specialized Hauling.

Routine Commercial Traffic contains vehicles that represent typical commercial trucking configurations that are also encompassed by the Federal Bridge Formula. In addition to these vehicles are emergency vehicles required by 23 U.S.C. 127 and provided by the FHWA and other typical configurations that double as design vehicles.

Specialized Hauling contains single unit, short wheelbase, multiple axle trucks typical of construction, waste management, and bulk cargo/commodities hauling industries. These configurations are also encompassed by the Federal Bridge Formula.

Truck Configuration	LRFR Subcategory
H-20	Routine Commercial Traffic
HS-20	Routine Commercial Traffic
Alternate Military	Routine Commercial Traffic
AASHTO Type 3	Routine Commercial Traffic
AASHTO Type 3S2	Routine Commercial Traffic
AASHTO Type 3-3	Routine Commercial Traffic
Lane-Type*	Routine Commercial Traffic
EV2	Routine Commercial Traffic
EV3	Routine Commercial Traffic
NRL**	Specialized Hauling
SU4	Specialized Hauling
SU5	Specialized Hauling
SU6	Specialized Hauling
SU7	Specialized Hauling

* Load and Resistance Factor Rating (LRFR) only
** Not to be used for load posting

Figure 3-4.2 Required Legal Vehicles

3-4.03 Permit

Permit vehicles are live loads that exceed legal load limitations. These vehicles can be issued routine or special permits. Vehicles for which routine permits are commonly issued shall be used for determining the safe load capacity and posting of a bridge. Special permits are for less frequent loads and often with additional limitations. Permit load rating is discussed in MBE 6A.4.5 for Load and Resistance Factor Rating (LRFR) and MBE 6B.8 for Load Factor Rating (LFR). See Figure 3-4.3 for a list of potential permit vehicles.

Any bridge on the [redacted] Toll Road or any state owned or maintained bridge within 15 miles of a toll road gate shall be rated for the Toll Road Truck configurations. Any bridge located on the Extra-Heavy Duty Highway, as described in IC 9-20-5-4, shall be rated for the Michigan Train Truck configurations. It is acceptable to limit Michigan Train Truck vehicles to one lane located so as to cause extreme force effects while the other lanes are occupied by regular legal loads. A lane load shall be included with all Toll Road or Michigan Train Truck configurations if required by the MBE depending on rating method and bridge geometry. See Appendix B for supplementary information regarding the [redacted] Toll Road and Extra Heavy Duty Highways.

Where analytical rating methods are used on state owned or maintained bridges, the "Special" vehicles, as shown in Figure 3-4.3 below, shall be evaluated. These "Special" vehicles shall be single trip, mixed with traffic, and without reduction in speed.

Routine	Special
Toll Road Loading No. 1	Superload – 11 Axles
Toll Road Loading No. 2	Superload – 13 Axles
Special Toll Road Truck	Superload – 14 Axles
Michigan Train Truck #5	Superload – 19 Axles (305K)
Michigan Train Truck #8	Superload – 19 Axles (480.09K)

Figure 3-4.3 Potential Permit Vehicles

3-5.0 METHODS

Analytical methods shall be used for load rating whenever possible. Engineering judgement may be used to supplement calculations. If necessary bridge geometry or material properties are not available and cannot be obtained economically, then engineering judgment may be used in place of analytical methods. In addition, bridge owners have the right to add conservativeness at their discretion; this can mean posting the bridge at a lower tonnage than required by analysis.

3-5.01 Analytical

The two primary analytical methods are Load and Resistance Factor Rating (LRFR) and Load Factor Rating (LFR). The department's vehicle classifications as defined in Section 3-4 most closely align with LRFR but still apply to LFR as well. An important distinction between the two methodologies is their definition of Inventory and Operating ratings.

As discussed in the MBE for LRFR, Inventory and Operating ratings are subcategories to the Design Load Rating category. Values for this category are required when construction work is proposed that will change the structural behavior or capacity of the bridge. For state owned or maintained bridges rated LRFR, only Inventory values are required when evaluating for design loads; Operating values will only be considered on a case by case basis. For LFR, Inventory corresponds to Design Load Rating and Operating to Legal Load Rating.

Regardless of method, the Legal Load category is always required whenever a load rating is performed. By definition, this means that Operating ratings are only required for LFR since they fall under the Design category for LRFR.

LRFR shall be used for any new or replacement superstructure. For state owned or maintained bridges, LRFR shall be used regardless of the original design method. In certain situations, LRFR is more restrictive than what earlier design codes required. This can lead to overly conservative ratings for existing structures that are performing well. In these situations, other rating methods may be considered. See Section 3-10.1 for additional details. Any situation not listed in 3-10.1 will require the approval of the [redacted] load rating staff.

AASHTOWARE Bridge Rating "BrR" shall be used to perform load ratings whenever possible. It is permissible to use other programs and/or engineering judgment is cases where the use of BrR is insufficient or not plausible due to program limitations. Additional resources are available on the bridge design website including a list of programs that may be used to supplement BrR.

3-5.01(01) Load and Resistance Factor Rating (LRFR)

Load and Resistance Factor Rating (LRFR) analysis shall follow the procedures outlined in MBE Section 6A except as noted in this manual. As defined in this manual and discussed in the MBE, ratings fall into three categories, Design Load, Legal Load, and Permit Load. Please refer to Section 3-4 in this manual for a list of vehicles that fall within each category and a discussion regarding their applicability. In short, for determining the load capacity or safe posting load of a bridge, all vehicles within the Legal Load category and applicable vehicles designated as Routine Permit are required.

As discussed in MBE 6A.5.4 and with the exception of segmentally constructed bridges, service limit states in regards to crack control need not be considered for determining the load capacity or safe posting load of reinforced concrete or prestressed concrete in-service bridge components. This applies to both legal and routine permit loads. These provisions should not be considered for capacity or posting determinations on state owned or maintained bridges. For special permit evaluation, use of these provisions is at the discretion of the permitting engineer. Crack control is a means for ensuring longevity of the structure and is therefore most applicable for design loading.

The condition factor Φ_C and system factor Φ_S shall be used per MBE 6A.4.2.3 & 6A.4.2.4 respectively. Where material properties are unknown, assumptions can be made per MBE 6A.5.2.

In regard to MBE 6A.5.8, if the conditions of this article are met for reinforced concrete slab bridges, shear capacity need not be checked for design and legal loads. Similarly, shear need not be evaluated for any proposed work on reinforced concrete slab bridges. For any other reinforced, prestressed, or post-tensioned concrete bridge, the shear capacity shall always be evaluated for design, legal, and permit ratings regardless of condition or distress. When shear controls, refined analysis may be used to more accurately model boundary conditions and loading scenarios.

3-5.01(02) Load Factor Rating (LFR)

Load Factor Rating (LFR) analysis shall follow the procedures outlined in MBE 6B except as noted in this manual. As defined in this manual, ratings fall into three categories, Design Load, Legal Load, and Permit Load. Please refer to Section 3-4 in this manual for a list of vehicles that fall within each category and a discussion regarding their applicability. In short, for determining the load capacity or safe posting load of a bridge, all vehicles within the Legal Load category and applicable vehicles designated as Routine Permit are required. When referencing MBE 6B, Inventory is equivalent to Design Load and Operating is equivalent to both Legal Load and Permit Load.

3-5.01(03) Other

If the LRFR method is not used, bridges designed by the Allowable or Working Stress Method should be rated LFR, see Section 3-5.01(02).

3-5.02 Engineering Judgment

Engineering judgment may be used in place of or as a supplement to analytical methods if necessary details to load rate are missing or incomplete, see MBE 6.1.4 for additional discussion. Furthermore, engineering judgment may be used to assign lower ratings than computed at the owner's request or to increase conservativeness when desired.

When assigning load ratings, the gross vehicle weight and axle weights of each vehicle, as defined in Section 3-4, may be reduced from the values shown in Appendix A. It is permissible to reduce all weights by an equal percentage or by a different amount depending on available information. Consideration can be made to axle configuration as it may be more appropriate or beneficial to restrict high concentrated loads differently than more evenly distributed loads.

3-6.0 POSTING

Bridges that cannot safely carry legal or state routine permit loads, as defined in Section 3-4, must be posted. This is represented by a legal or routine permit rating factor of less than 1.0 for any of the required vehicles. Posting for design loads is conservative and therefore will only be allowed at the discretion of the Bridge Owner.

If **any** legal or applicable state routine permit vehicle rates below 1.0, then the bridge shall be posted for the safe posting load of **all** required vehicles; this applies to each vehicle even if it rates higher than 1.0. This is necessary because although only one vehicle may actually fall below the 1.0 rating factor threshold, the calculated load capacity or safe posting load may in fact be higher than a different legal vehicle that has a lighter gross vehicle weight.

Example:

Vehicle 1 (4-Axle, GVW = 38 Tons)

- Legal Rating Factor = 0.9 → Safe Posting Load = 34 Tons

Vehicle 2 (4-Axle, GVW = 26 Tons)

- Routine Permit Rating Factor = 1.1 → Safe Posting Load = 28 Tons

Based on the example above, even though Vehicle 2 has a higher rating factor than Vehicle 1, Vehicle 2 still has the lower safe posting load. Therefore it would be unsafe to post the bridge for 34 tons. Rating vehicles can be grouped together by the number of axles to determine the lowest tonnage for each group; see Section 3-6.04 for acceptable signage.

3-6.01 Load and Resistance Factor Rating Analysis

Where analytical models have been developed consistent with Section 3-5.01(01), load posting criteria shall conform to MBE 6A.8 except as noted below. The load capacity is determined according to MBE 6A.4.4.4. For rating factors below 1.0, the safe posting load is determined according to MBE 6A.8.3. For rating factors greater than or equal to 1.0, the safe posting load is equivalent to the load capacity.

All applicable AASHTO, state legal, and routine permit loads listed in the MBE and Section 3-4 in this manual shall be evaluated for posting purposes. The NRL "notional load" shall not be used as justification for ignoring the AASHTO Specialized Hauling Vehicles.

3-6.02 Load Factor Analysis

Where analytical models have been developed consistent with Section 3-5.01(02), load posting criteria shall conform to MBE 6B.7 except as noted below. The load capacity is determined according to MBE 6B.4.1. The safe posting load calculation is equivalent to the load capacity and further discussed in MBE 6B.7.3.

All applicable AASHTO, state legal, and routine permit loads listed in the MBE and Section 3-4 in this manual shall be evaluated for posting purposes. The NRL "notional load" shall not be used as justification for ignoring the AASHTO Specialized Hauling Vehicles.

3-6.03 Engineering Judgment

Where engineering judgment is warranted per Section 3-5.02, the load posting criteria shall conform to Section 3-6.02.

All applicable AASHTO, state legal, and routine permit loads listed in the MBE and Section 3-5 in this manual shall be evaluated for posting purposes. The NRL "notional load" shall not be used as justification for ignoring the AASHTO Specialized Hauling Vehicles.

3-6.04 Regulatory Signage

Regulatory signs shall conform to the [redacted] *Manual on Uniform Traffic Control Devices* (IMUTCD), see Figure 3-6.1.

There are multiple options for restricting vehicle weight. At a minimum, restrictions shall be for gross vehicle weight; posting for maximum permissible axle weights should be at the discretion of the Bridge Owner. When using the R12-1 sign, each bridge shall be posted for the minimum calculated safe posting load as specified in this chapter. If instead using the R12-5 silhouette sign, the tonnages listed shall correspond to the minimum calculated safe posting load for the legal and routine permit configurations that match the number of axles shown. This means the sign will list a minimum tonnage for vehicles with 2-axles, 3-axles, and 4 or more axles.

For bridge closures, the R11-2 sign shall be posted. Note per the IMUTCD Section 6F.08, "the words BRIDGE OUT (or BRIDGE CLOSED) may be substituted for ROAD (or STREET) CLOSED where applicable." Additionally, non-movable barriers and barricades per the standard specifications shall be erected at each end of the bridge to prevent crossing by vehicles and pedestrians.

At a minimum, additional signage shall be placed at the nearest intersection prior to the bridge in all directions to allow for vehicles to turn around. On limited access highways, additional signage shall be placed prior to the nearest exit ramp to allow for overweight vehicles to exit the highway. Any other signage shall conform to the IMUTCD and used at the discretion of the roadway owner.

Figure 3-6.1 Example Regulatory Signage per the IMUTCD

3-7.0 DOCUMENTATION

An example of the required documentation is shown in Appendix C. The load rating summary report, at a minimum, shall consist of the following:

- Title sheet
- Load rating method/program(s) used
- Geometric and material summary of the bridge
- Assumptions

- Rating factors for design vehicles specified on the plans (discussed in Section 3-4.01)
  - Stamped by a licensed Professional Engineer (PE) in the state of [redacted]
- Rating factors and load capacity (in tons) for each applicable legal & routine permit vehicle (discussed in Sections 3-4.02 & 3-4.03)
  - Stamped by a licensed Professional Engineer (PE) in the state of [redacted]
- Safe posting load, as required, for each applicable legal & routine permit vehicle (discussed in Sections 3-4.02 & 3-4.03)
  - Stamped by a licensed Professional Engineer (PE) in the state of [redacted]
- Rating factors and load capacity (in tons) for each applicable special (limited crossing) permit vehicle (discussed in Section 3-4.03)
  - Stamped by a licensed Professional Engineer (PE) in the state of [redacted]
- Discussion, sketches, and photos of deterioration (if applicable)

If necessary details to load rate the bridge analytically are unavailable and engineering judgment is used per Section 3-5.02, the load rating summary report shall include the following note.

> *In accordance with the Manual for Bridge Evaluation, Second Edition, 2011, Section 6.1.4*
> – *Necessary details for this bridge are unavailable. A physical inspection of the bridge was performed by a qualified inspector and evaluated by a qualified engineer to establish an approximate load rating based on rational criteria.*

3-8.0 QUALITY CONTROL (QC) & QUALITY ASSURANCE (QA)

For a more detailed discussion of Quality Control (QC) and Quality Assurance (QA), refer to Part 2 of this manual. In short, load rating engineers are responsible for ensuring a high degree of accuracy and consistency for any performed ratings. The [redacted] Department of Transportation's load rating staff will periodically review calculations and documentation for accuracy and completeness. Rating inaccuracies or any errors or deficiencies of procedure shall be addressed immediately.

3-9.0 PROCEDURE

This chapter discusses when to perform a load rating, what to submit, and who to notify.

For new, replacement, or rehabilitated structures, requests shall be made in accordance with the [redacted] *Design Manual* (IDM) Chapter 103. All load rating requests for state owned or maintained bridges, shall be sent to [redacted] Coordinator 8 ([redacted]IN.gov) with the Load

Rating Request Form attached and any plans, sketches, notes, and photos if applicable made accessible in BIAS. Load ratings for locally owned structures shall be performed by the owner or its designated appointee.

3-9.01 Frequency

In general, load ratings are required whenever there is a change in condition from one inspection to another. Load ratings may also be required whenever new bridge construction projects are proposed. A description of various load rating situations is discussed in the sections below.

3-9.01(01) Project Scoping

Prior to programming bridge work, owners should consider load rating to help determine whether to rehabilitate or replace existing structures. This is particularly useful when deciding whether to use a rigid or thin deck overlay. It is also useful to determine if existing bridge rail can be replaced. There are limits to the effectiveness of load rating at this early stage. A more complicated rehabilitation (i.e. widening, replacing members, etc.) requires a set of plans to accurately model.

For state owned or maintained bridges, District Bridge Asset Managers shall request from [redacted] Coordinator 8 that a load rating evaluation be performed for any structures under consideration for an overlay or other minor rehabilitation work.

3-9.01(02) New, Replacement, or Rehabilitated Structures

Bridge owners should consider requiring a load rating be performed prior to any new, replacement, or rehabilitation work to take place on their bridge assets; this shall be done no later than the initial inspection for locally maintained structures. For state owned or maintained structures, a load rating analysis shall be performed prior to construction; see Chapter 14 of the [redacted] Design Manual for specific requirements.

Following the completion of construction work, the bridge file shall be updated within thirty (30) days for state maintained structures. To do this, a request shall come from the district bridge inspector and be sent to [redacted] Coordinator 8. The bridge file for locally maintained structures shall be updated within ninety (90) days.

3-9.01(03) Deterioration

For bridges with a minor increase in or newly discovered minor damage or deterioration, a load analysis shall be performed. At a minimum, a load rating considering deterioration shall be on file for each bridge with a deck condition rating (NBIS Item 58), superstructure condition rating (NBIS Item 59), or culvert condition rating (NBIS Item 61) of 4 or less. For state owned or maintained structures, the load rating shall be performed and the bridge file updated within thirty (30) days of discovery. To do this, a request shall come from the District Bridge Inspector and be sent to [redacted] Coordinator 8 within seven (7) days of discovery. For locally maintained structures, the load rating shall be performed and the bridge file updated within sixty (60) days of the end of the inspection compliance month.

See Section 3-9.01(04) for requirements regarding more severe changes in condition. Additionally, if there is loss of bearing area or a substructure condition rating (NBIS Item 60) of 3 or less, consideration should be made to reducing the load rating. See Section 3-10.2 for more information regarding the modeling of deterioration.

3-9.01(04) Critical Findings

For bridges with a significant increase in or newly discovered severe damage or deterioration, a load analysis shall be performed. This shall be performed within seven (7) days and the bridge file updated within fifteen (15) days of discovery for both state and locally maintained structures. For state maintained bridges, the District Bridge Inspector shall notify [redacted] Coordinator 8 of the request within two (2) days of discovery. Notification shall be immediately for damage or deterioration considered severe enough to be an immediate safety concern for the traveling public.

3-9.01(05) Repairs

Bridge owners should consider requiring a load rating be performed prior to any repairs to take place on their bridge assets. For state maintained structures, this shall be done prior to reopening the bridge for closure situations or prior to construction for non-closure situations. Refer to the [redacted] *Design Manual* for requesting a load rating for state maintained bridges. For locally maintained structures, ratings shall be performed no later than the initial inspection.

Following the completion of construction work, the bridge file shall be updated within thirty (30) days for state maintained structures and within ninety (90) days for locally maintained structures.

3-9.01(06) Permitting

Load ratings should be utilized when making determinations regarding the issuance of permits for overweight vehicles.

3-9.02 Submittal Process & Notification

The submittal process & notification can be broken into two categories, general and posting.

3-9.02(01) General

For bridge construction projects, owners should be informed of load rating results prior to the commencement of any construction. For state maintained bridges, an email containing the load rating summary report and model shall be sent to [redacted] Coordinator 8 within thirty (30) days of the receipt of the original load rating request.

Once the load rating reflects the "in-service" condition of the bridge, the bridge file shall be updated. The load rating summary report, as defined in section 3-7, shall be attached to BIAS. Both the summary report and the load rating model shall be uploaded to ERMS. Once uploaded, each file will be accessible in BIAS from the ERMS link on the "Asset Info" tab for each bridge; see Figure 3-9.1. Refer to the bridge inspection website for detailed instructions regarding how to attach and upload documentation.

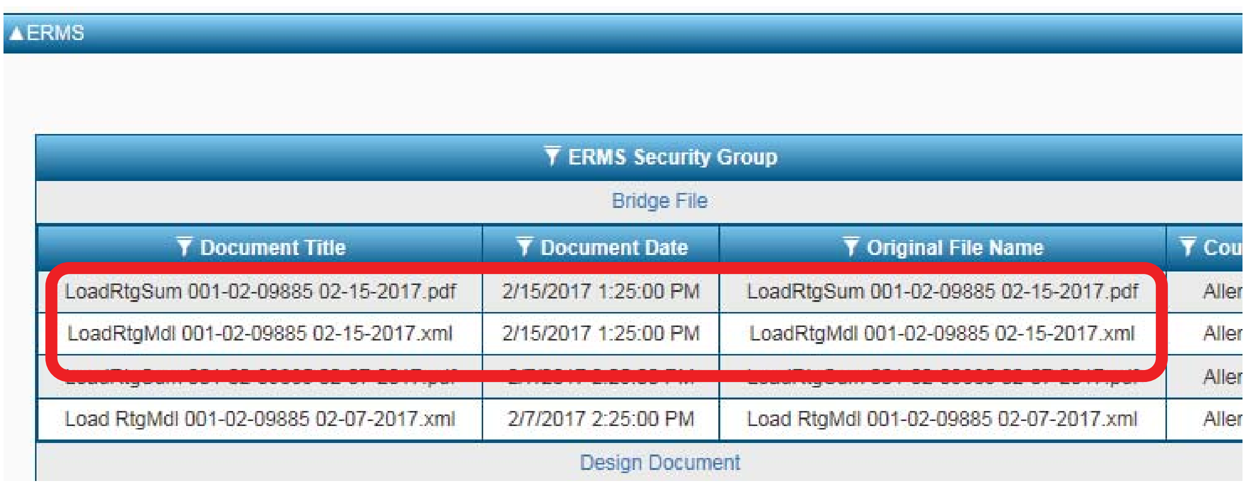

Figure 3-9.1 BIAS ERMS Link to the Bridge File

3-9.02(02) Posting

In addition to the general process in Section 3-9.02(01), the Bridge Owner shall immediately be notified by the load rating engineer if load posting or any other restriction are required as discussed in Section 3-6. For state bridges, a summary of the details should be emailed to the District Bridge Asset Engineer and copied to the Bridge Director, Bridge Inspection Manager, District Bridge Inspection Engineer, System Assessment Manager, and the Technical Services Director.

Bridge owners shall have up to thirty (30) days to post all required signage and/or barriers. Once in place, the NBIS items in BIAS shall be updated by the load rater within thirty (30) days to reflect the posting. See the bridge inspection website for detailed instructions. Additionally, photos should be uploaded to BIAS that show the bridge posting/closure items in place.

3-10.0 MODELING GUIDELINES & ASSUMPTIONS

Section under development…

3-11.0 APPENDICES

3-11.1 Appendix A: Vehicle Configurations

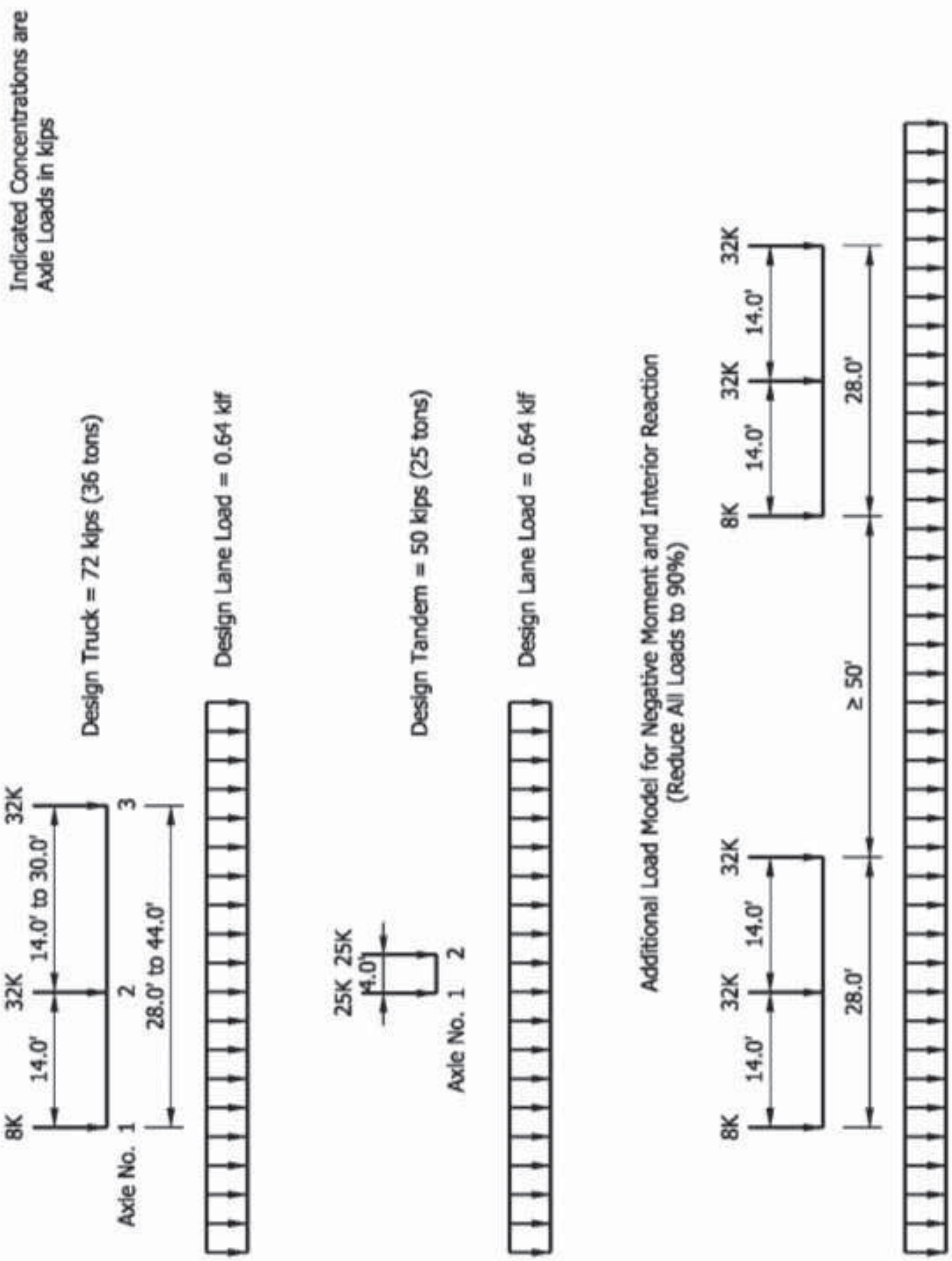

Figure A-1
HL-93 Loading

172

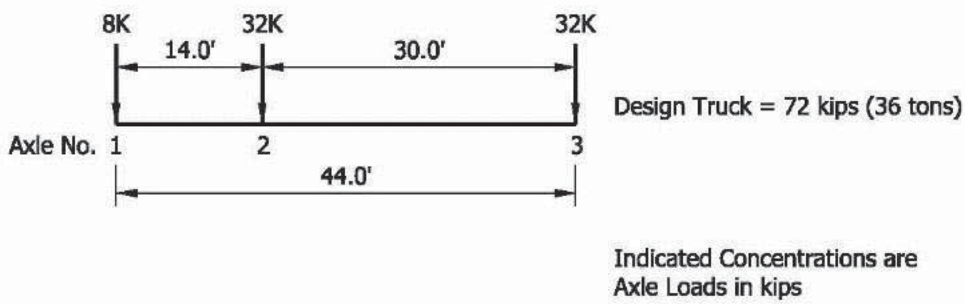

Figure A-2
Fatigue Loading

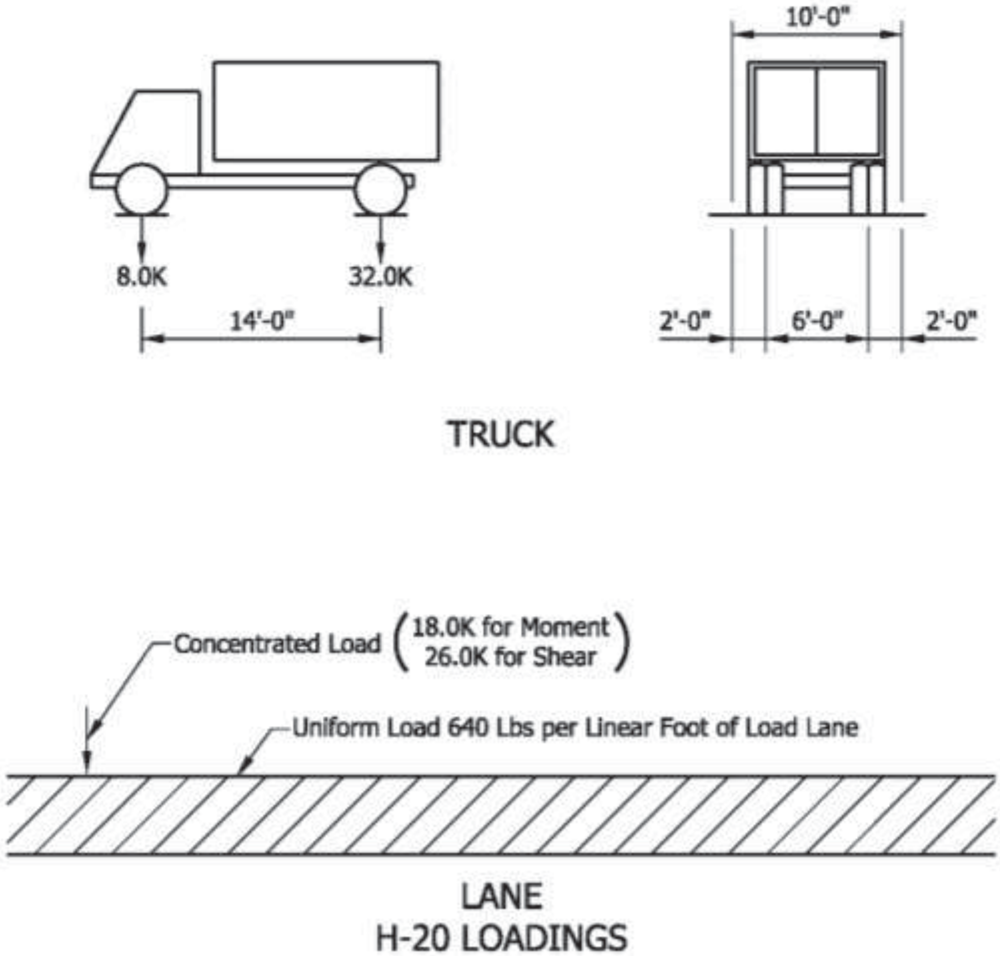

Figure A-3
H-20 Loading

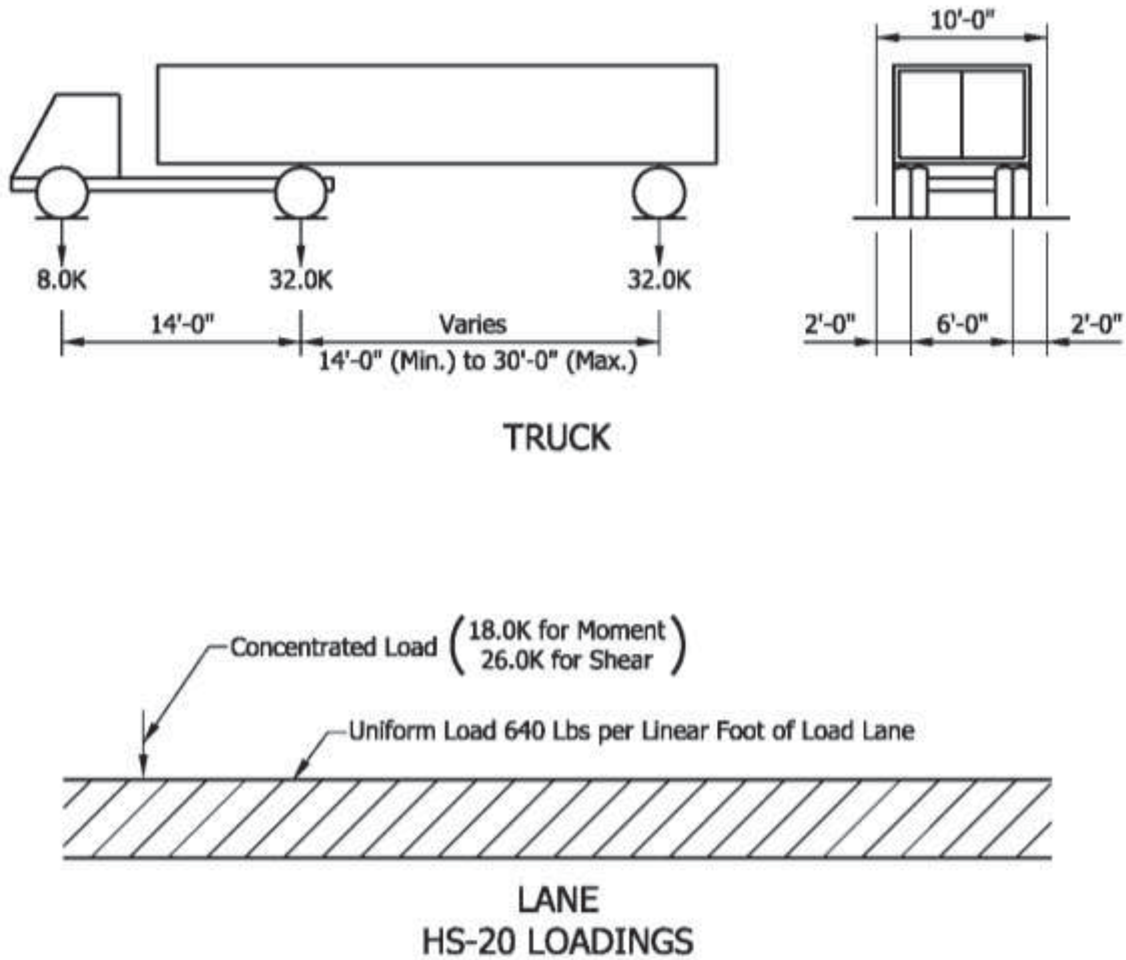

Figure A-4
HS-20 Loading

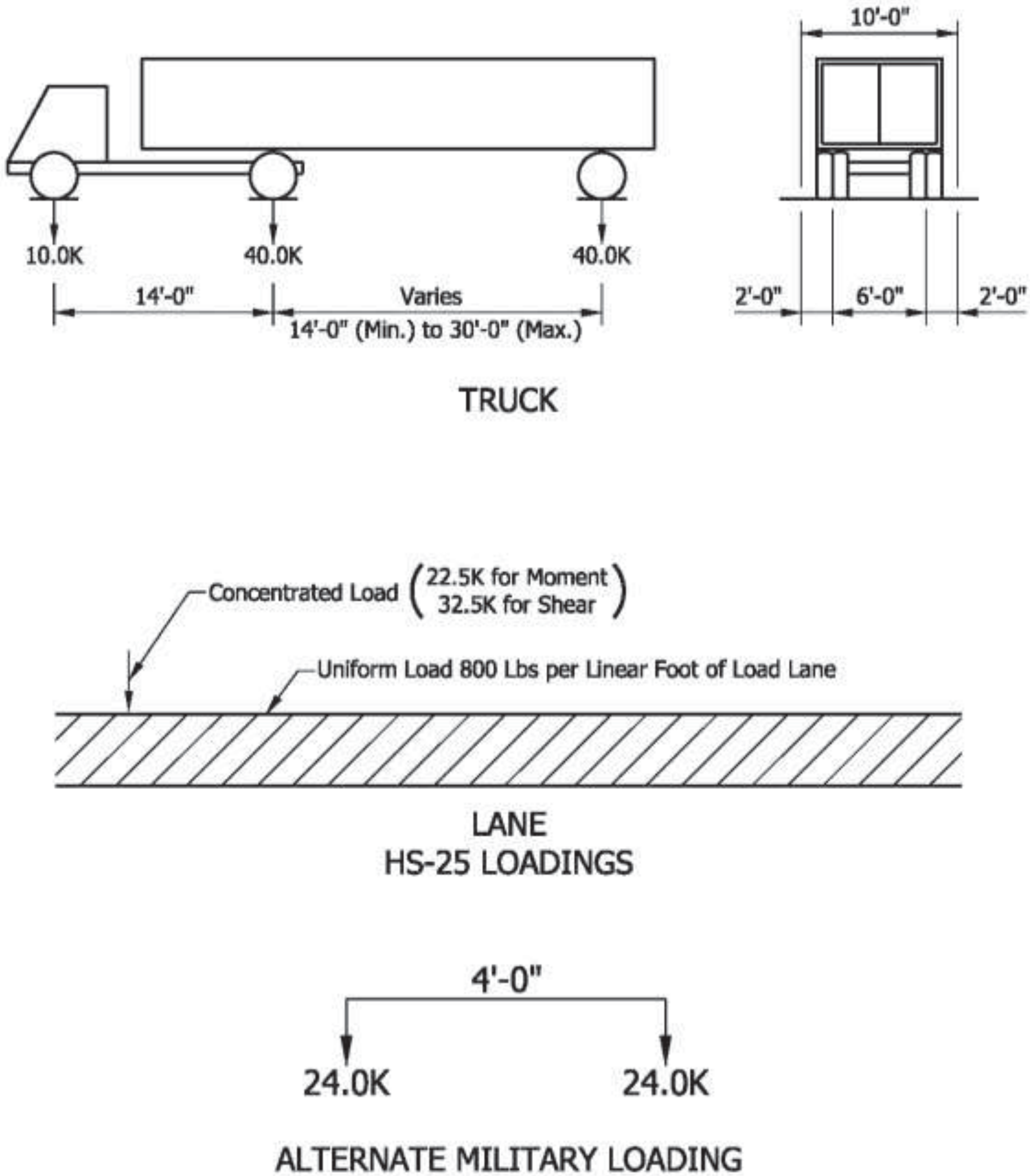

Figure A-5
HS-25 And Alternate Military Loading

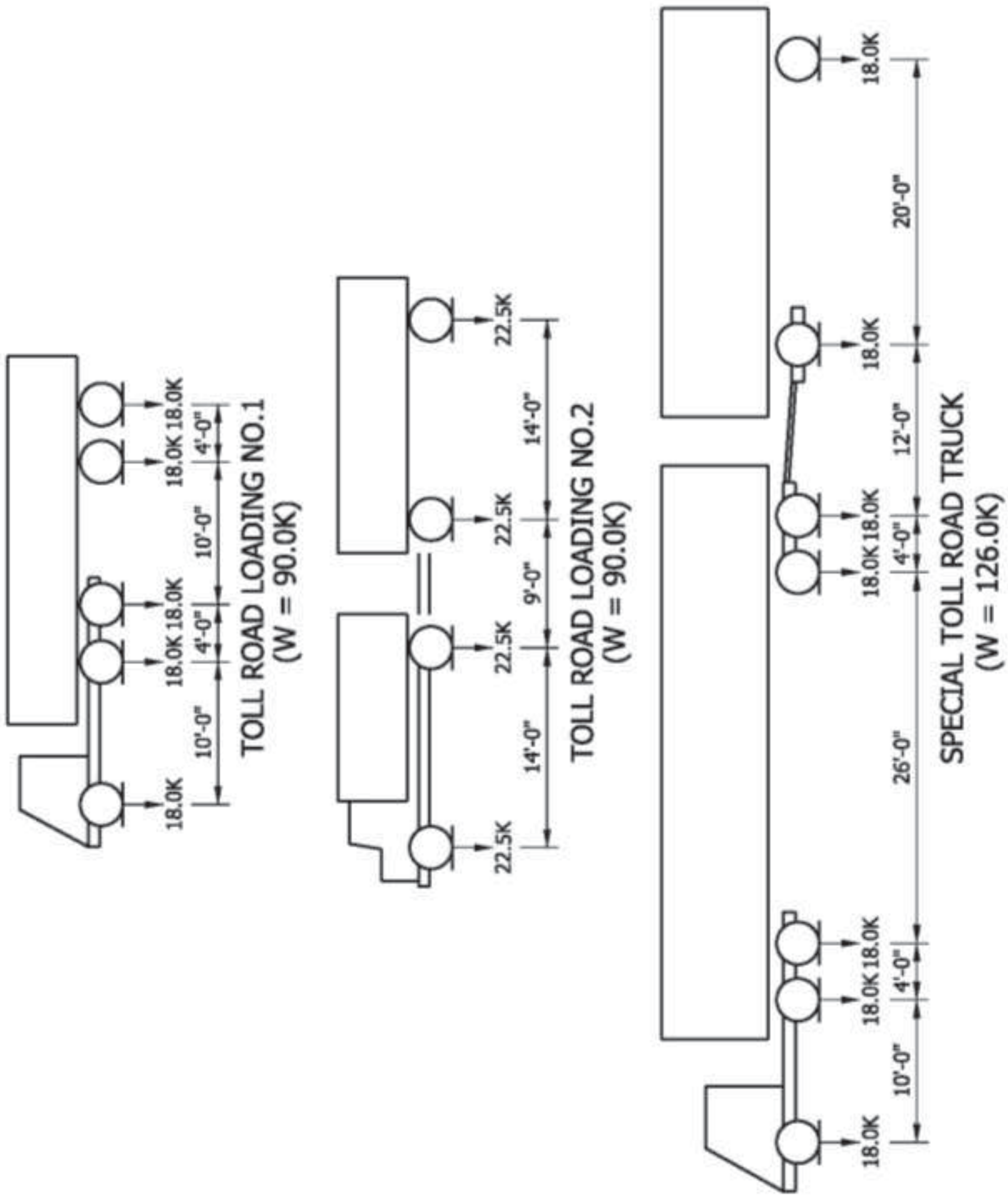

Figure A-6
Toll Road Truck Loads

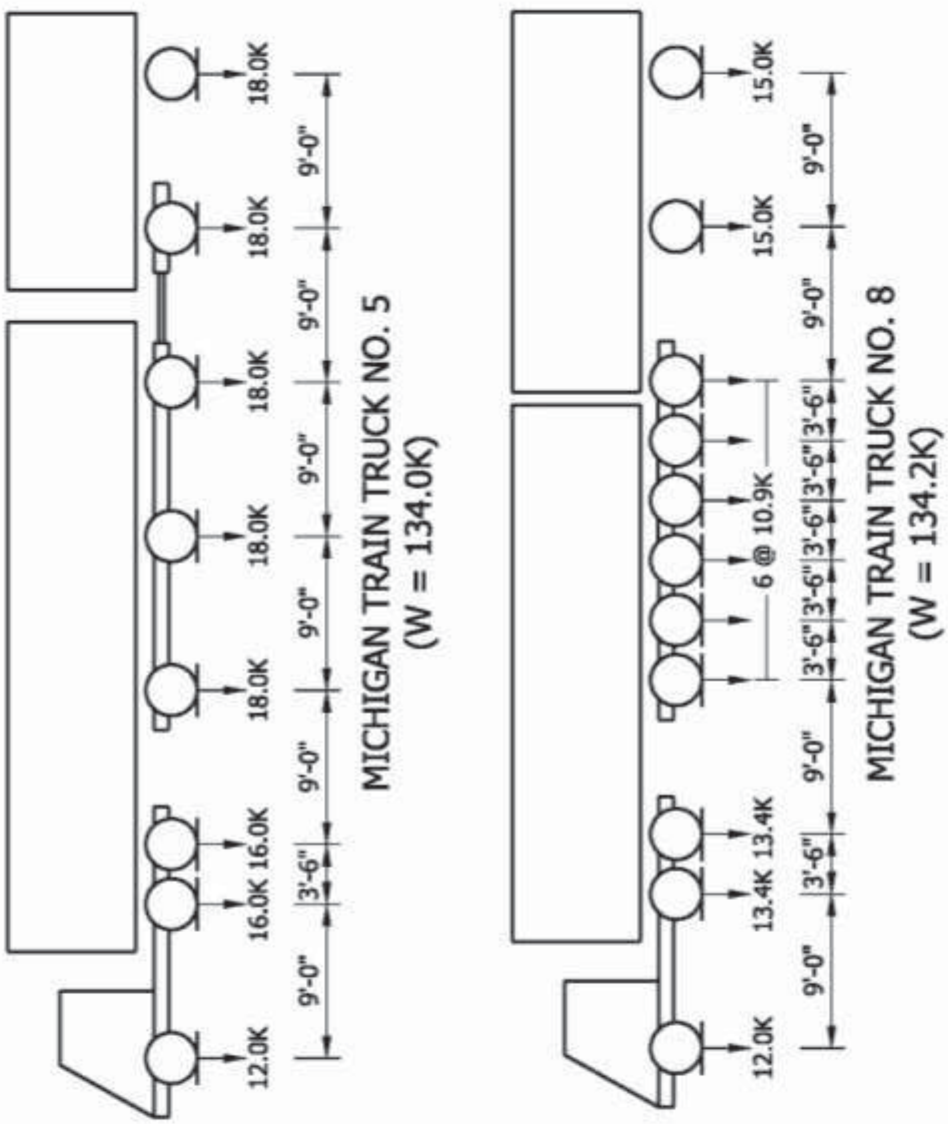

Figure A-7
Michigan Train Truck Loads

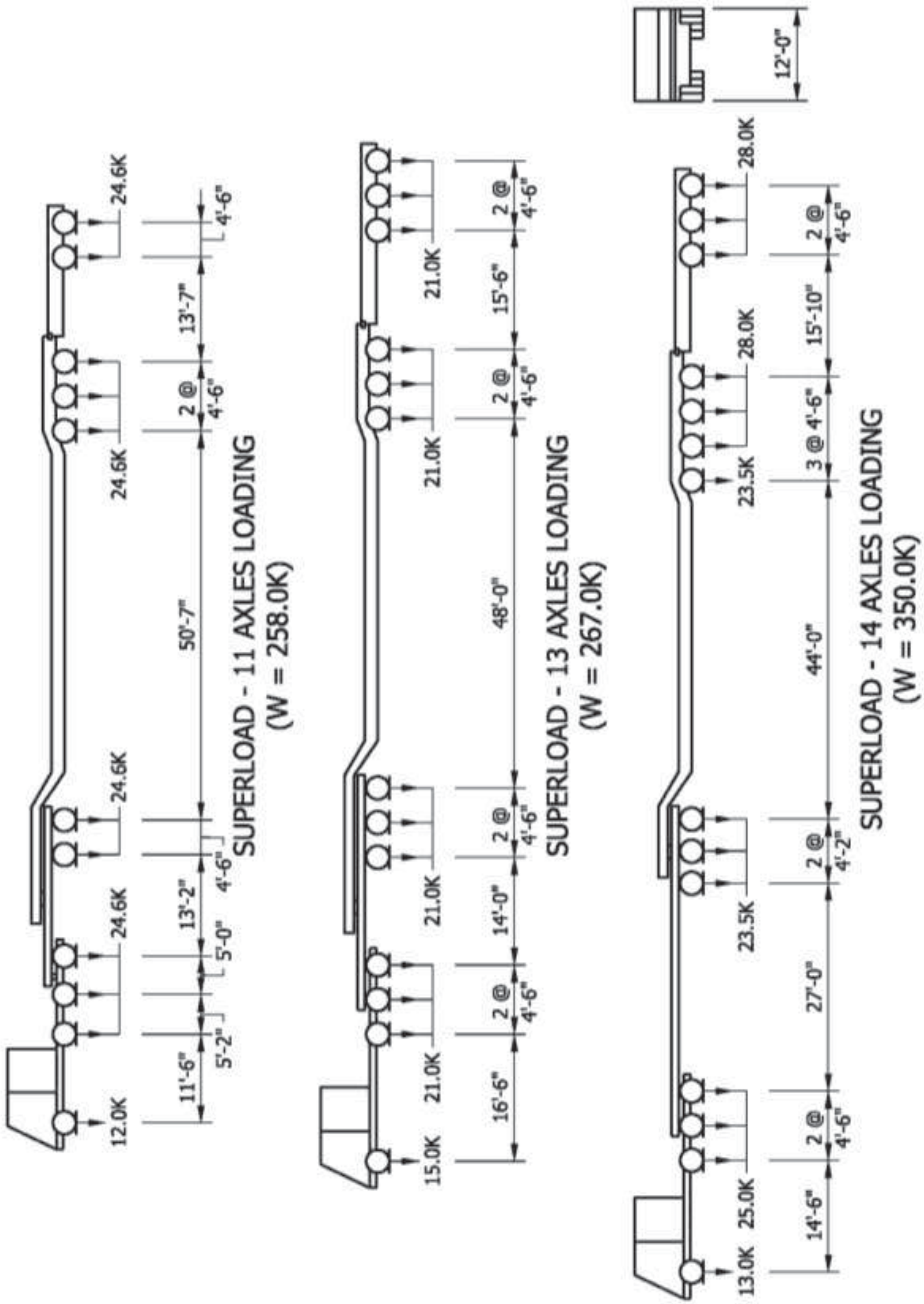

Figure A-8
Superload Vehicle Loads

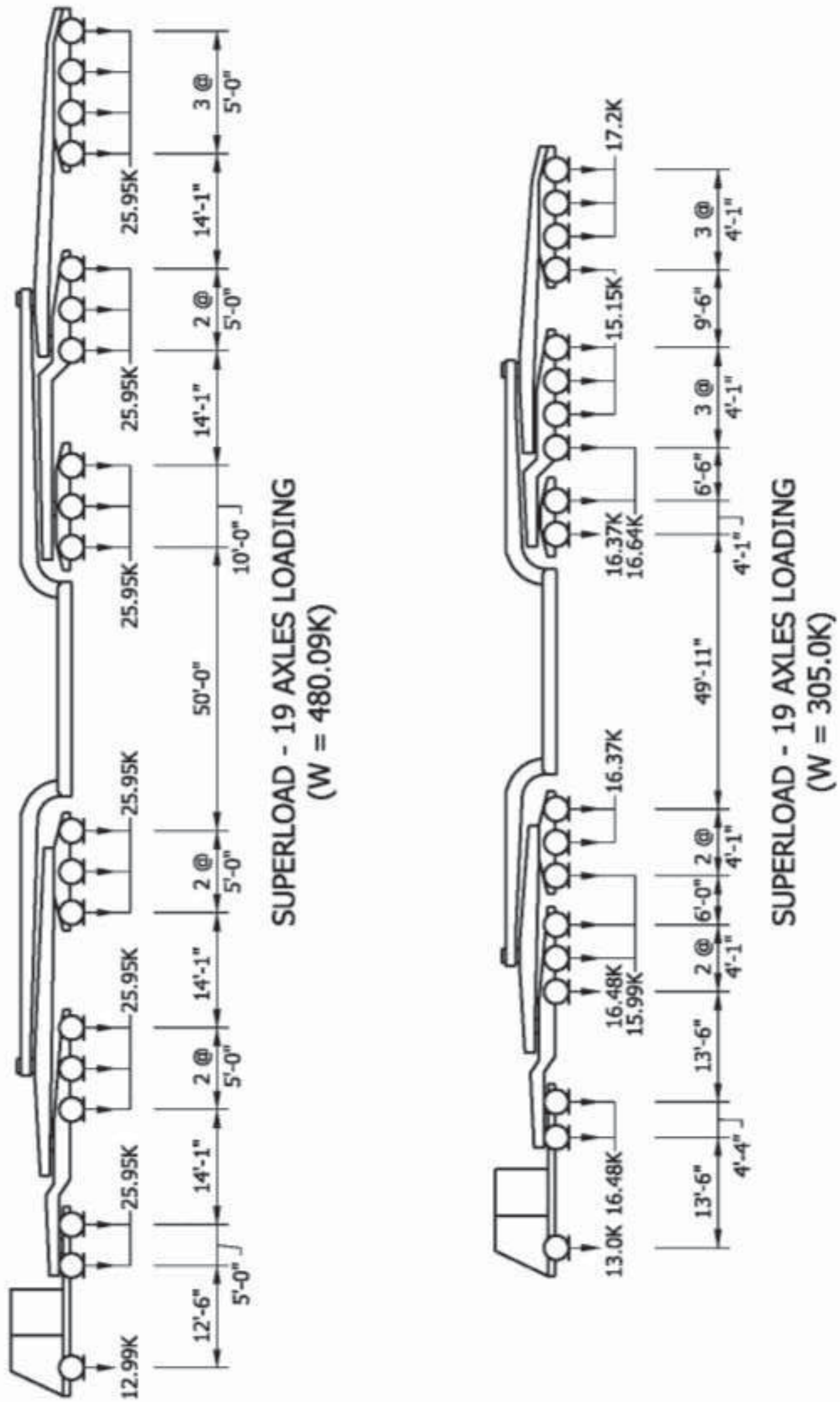

Figure A-9
Superload Vehicle Loads

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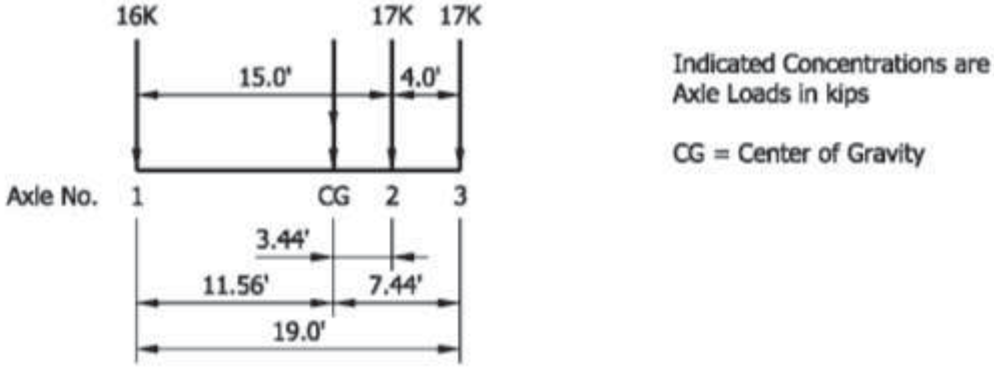
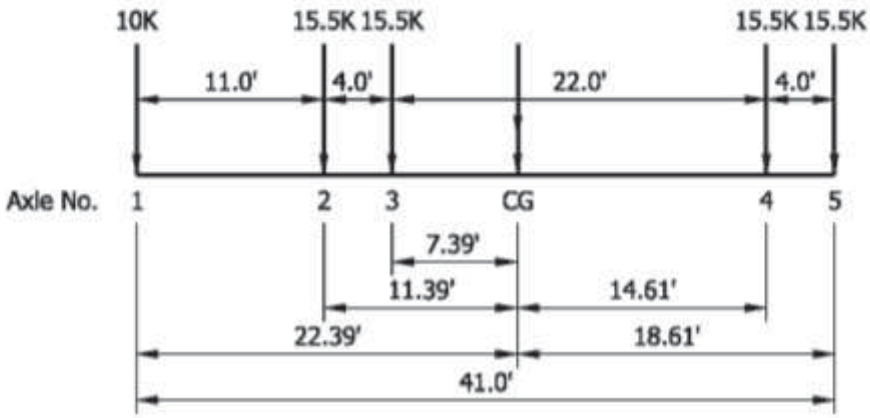
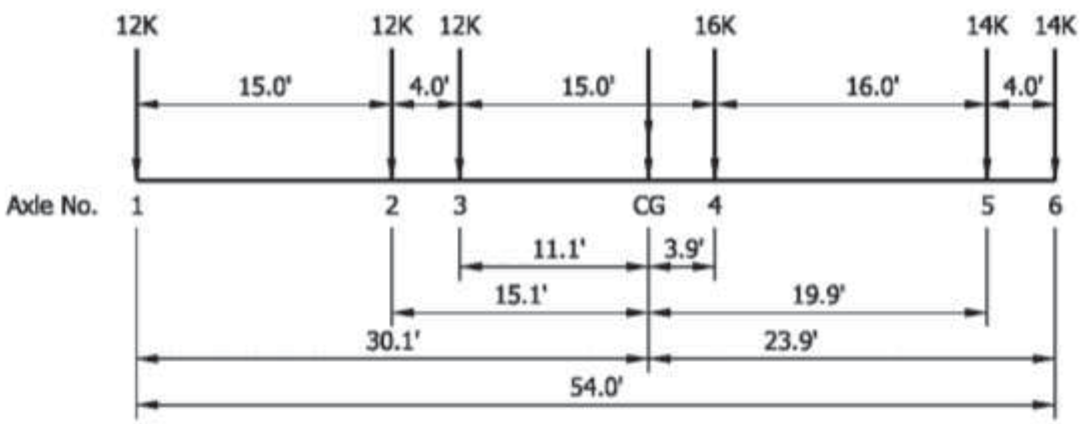


TYPE 3 UNIT
Weight = 50 kips (25 tons)



TYPE 3S2 UNIT
Weight = 72 kips (36 tons)



TYPE 3-3 UNIT
Weight = 80 kips (40 tons)

Figure A-10
AASHTO Legal Loads

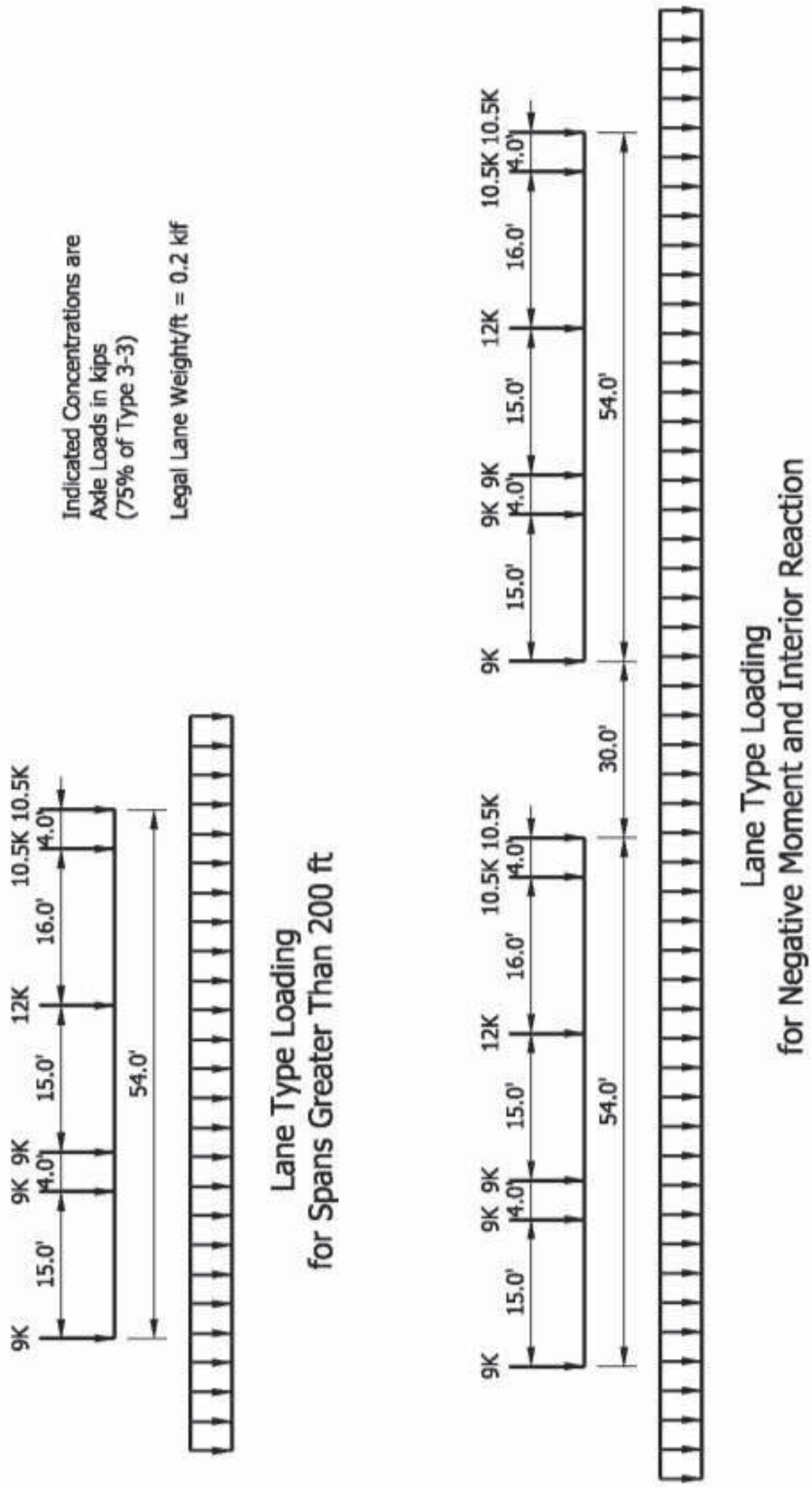
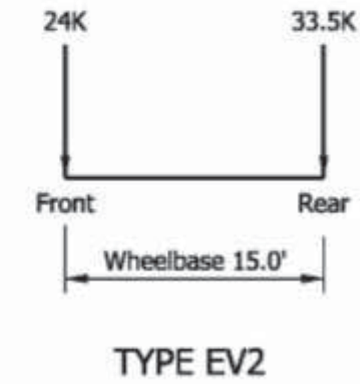


Figure A-11
Lane-Type Loading



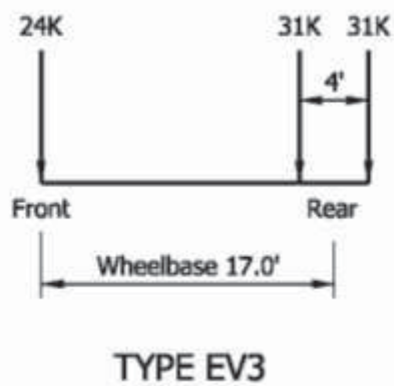
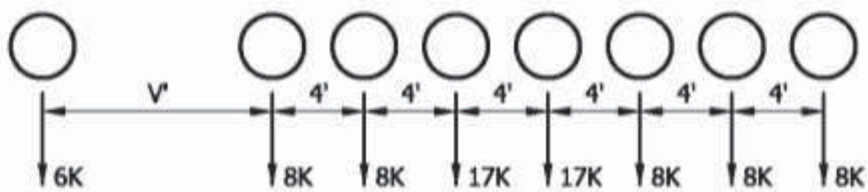


Figure A-12
FAST Act EV Loads



V = Variable Drive Axle Spacing - 6'-0" to 14'-0". Spacing to be used is that which produces maximum load effects.

Axles that do not contribute to the maximum load effect under consideration shall be neglected.

Maximum GVW = 80 Kips

Axle Gage Width = 6'-0"

Figure A-13
Notional Rating Load (NRL)

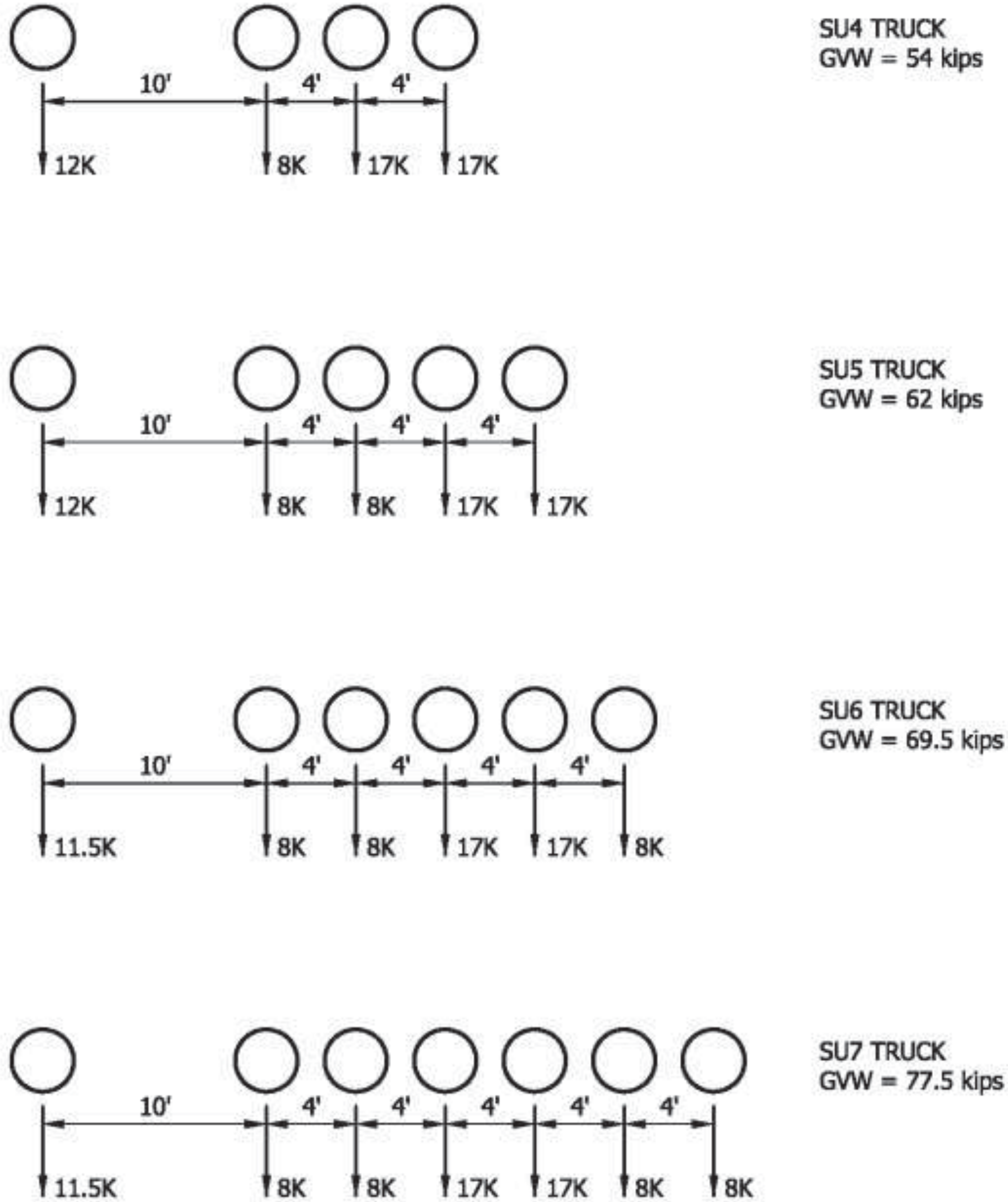


Figure A-14
Specialized Hauling Vehicles (SHV)

IC 9-20-5

Chapter 5. Heavy Duty Highways and Extra Heavy Duty Highways

IC 9-20-5-1

Establishment and designation of heavy duty and extra heavy duty highways; removal of designation; publication of map

Sec. 1. (a) The [redacted] department of transportation may adopt rules under IC 4-22-2 to do the following:

(1) Establish and designate a highway as a heavy duty highway.
(2) Remove the designation of a highway or part of a highway as a heavy duty highway.

(b) The [redacted] department of transportation shall adopt rules under IC 4-22-2 to do the following:

(1) Establish and designate a highway as an extra heavy duty highway.
(2) Remove the designation of a highway or part of a highway as an extra heavy duty highway.

(c) Rules described in subsection (b)(1) must do the following:

(1) Designate the highways listed in section 4 of this chapter (before its expiration) as extra heavy duty highways.
(2) Establish maximum size and weight limits for vehicles operated with a special weight permit on an extra heavy duty highway as set forth in section 5 of this chapter (before its expiration).

(d) The [redacted] department of transportation shall periodically publish a map showing all highways designated by the department at the time as heavy duty or extra heavy duty highways.

As added by P.L.2-1991, SEC.8. Amended by P.L.66-2012, SEC.1.

IC 9-20-5-2

Maximum weight limitations; heavy duty highways

Sec. 2. Whenever the [redacted] department of transportation designates a heavy duty highway, the department shall also fix the maximum weights of vehicles that may be transported on the highway. The maximum weights may not exceed the following limitations:

(1) A vehicle may not have a maximum wheel weight, unladen or with load, in excess of eight hundred (800) pounds per inch width of tire, measured between the flanges of the rim, or an axle weight in excess of twenty-two thousand four hundred (22,400) pounds.
(2) The total weight concentrated on the roadway surface from any tandem axle group may not exceed eighteen thousand (18,000) pounds for each axle of the assembly.
(3) The total gross weight, with load, in pounds of a vehicle or combination of vehicles may not exceed eighty thousand (80,000) pounds.

As added by P.L.2-1991, SEC.8.

IC 9-20-5-3
Designation of heavy duty highways; conditions

Sec. 3. The [redacted] department of transportation may not designate a highway as a heavy duty highway unless the department finds that the highway is:

(1) so constructed and can be so maintained; or
(2) in such condition;

that the use of the highway as a heavy duty highway will not materially decrease or contribute materially to the decrease of the ordinary useful life of the highway.
As added by P.L.2-1991, SEC.8. Amended by P.L.198-2016, SEC.340.

IC 9-20-5-4
Extra heavy duty highways; listing; expiration

Sec. 4. (a) In addition to the highways established and designated as heavy duty highways under section 1 of this chapter, the following highways are designated as extra heavy duty highways:

(1) Highway 41, from 129th Street in Hammond to Highway 312.
(2) Highway 312, from Highway 41 to State Road 912.
(3) Highway 912, from Riley Road in East Chicago to the U.S. 20 interchange.
(4) Highway 20, from Clark Road in Gary to Highway 39.
(5) Highway 12, from one-fourth (1/4) mile west of the Midwest Steel entrance to Highway 249.
(6) Highway 249, from Highway 12 to Highway 20.
(7) Highway 12, from one and one-half (1 1/2) miles east of the Bethlehem Steel entrance to Highway 149.
(8) Highway 149, from Highway 12 to a point thirty-six hundredths (.36) of a mile south of Highway 20.
(9) Highway 39, from Highway 20 to the Michigan state line.
(10) Highway 20, from Highway 39 to Highway 2.
(11) Highway 2, from Highway 20 to Highway 31.
(12) Highway 31, from the Michigan state line to Highway 23.
(13) Highway 23, from Highway 31 to Olive Street in South Bend.
(14) Highway 35, from South Motts Parkway thirty-four hundredths (.34) of a mile southeast to the point where Highway 35 intersects with the overpass for Highway 20/Highway 212.
(15) State Road 249 from U.S. 12 to the point where State Road 249 intersects with Nelson Drive at the Port of [redacted]
(16) State Road 912 from the 15th Avenue and 169th Street interchange one and six hundredths (1.06) miles north to the U.S. 20 interchange.

(17) U.S. 20 from the State Road 912 interchange three and seventeen hundredths (3.17) miles east to U.S. 12.
(18) U.S. 6 from the Ohio state line to State Road 9.
(19) U.S. 30 from Allen County/Whitley County Line Road (also known as County Road 800 East) to State Road 9.
(20) State Road 9 from U.S. 30 to U.S. 6.
(21) State Road 39 from Interstate 80 to U.S. 20.
(22) State Road 3 north from U.S. 6 to U.S. 20, U.S. 20 west from State Road 3 to State Road 9, State Road 9 north from U.S. 20 to the Michigan state line. However, the total gross weight, with load, of a vehicle or combination of vehicles operated with a special weight permit on these highways may not exceed ninety thousand (90,000) pounds.
(23) Highway 912, at an intersection approximately thirty hundredths (.30) of a mile southwest of the intersection of Dickey Road and Riley Road in East Chicago. The total gross weight, with load, of a vehicle or combination of vehicles operated with a special weight permit on this highway may not exceed two hundred sixty-four thousand (264,000) pounds.

(b) This section expires on the later of the following dates:
(1) The date on which rules described in section 1(c)(1) of this chapter are finally adopted.
(2) December 31, 2014.

As added by P.L.2-1991, SEC.8. Amended by P.L.12-1991, SEC.4; P.L.123-1993, SEC.1; P.L.124-1993, SEC.1; P.L.119-1995, SEC.2; P.L.45-1999, SEC.1; P.L.79-2000, SEC.3; P.L.147-2002, SEC.2; P.L.10-2004, SEC.1; P.L.17-2006, SEC.1; P.L.134-2007, SEC.1; P.L.120-2011, SEC.1; P.L.66-2012, SEC.2.

IC 9-20-5-4.5
Repealed

(Repealed by P.L.123-1993, SEC.2.)

IC 9-20-5-5
Maximum size and weight limitations; extra heavy duty highways; expiration

Sec. 5. (a) Except as provided in subsection (b), the maximum size and weight limits for vehicles operated with a special weight permit on an extra heavy duty highway are as follows:
(1) A vehicle may not have a maximum wheel weight, unladen or with load, in excess of eight hundred (800) pounds per inch width of tire, measured between the flanges of the rim.
(2) A single axle weight may not exceed eighteen thousand (18,000) pounds.
(3) An axle in an axle combination may not exceed thirteen thousand (13,000) pounds per axle, with the exception of one (1) tandem group that may weigh sixteen thousand (16,000) pounds per axle or a total of thirty-two thousand (32,000)

pounds.

(4) Except as provided in section 4(a)(22) of this chapter, the total gross weight, with load, of any vehicle or combination of vehicles may not exceed one hundred thirty-four thousand (134,000) pounds.

(5) Axle spacings may not be less than three (3) feet, six (6) inches, between each axle in an axle combination.

(6) Axle spacings may not be less than eight (8) feet between each axle or axle combination.

(b) A vehicle operated in accordance with section 4(a)(23) of this chapter may not have a:

(1) maximum wheel weight, unladen or with load, in excess of one thousand six hundred fifty (1,650) pounds per inch width of tire, measured between the flanges of the rim; or

(2) single axle weight that exceeds sixty-five thousand (65,000) pounds.

(c) This section expires on the later of the following dates:

(1) The date on which rules described in section 1(c)(2) of this chapter are finally adopted.

(2) December 31, 2014.

As added by P.L.2-1991, SEC.8. Amended by P.L.134-2007, SEC.2; P.L.120-2011, SEC.2; P.L.66-2012, SEC.3; P.L.13-2013, SEC.35.

IC 9-20-5-6
Safety procedures; implementation

Sec. 6. The [redacted] department of transportation shall implement procedures that, in cooperation with the state police department and local police departments, enhance the safety of citizens along and near extra heavy duty highways listed in section 4 of this chapter (before its expiration) or described in rules adopted by the [redacted] department of transportation under section 1 of this chapter.

As added by P.L.2-1991, SEC.8. Amended by P.L.66-2012, SEC.4.

IC 9-20-5-7
Special weight permits; extra heavy duty highways; fee; additional permit fee

Sec. 7. (a) The owner or operator of a vehicle or combination of vehicles having a total gross weight in excess of eighty thousand (80,000) pounds but less than two hundred sixty-four thousand (264,000) pounds must:

(1) obtain a special weight registration permit;

(2) register annually and pay annually a registration fee to the department of state revenue; and

(3) install an approved automated vehicle identifier in each vehicle operating with a special weight permit;

to travel on an extra heavy duty highway.

(b) The fee for an annual registration under subsection (a) is twenty-five dollars ($25). The fee imposed under this section must be deposited in the motor carrier regulation fund established under IC 8-2.1-23.

(c) The department of state revenue may impose an additional permit fee in an amount that may not exceed one dollar ($1) on each trip permitted for a vehicle registered under subsection (a). This additional fee is for the use and maintenance of an automated vehicle identifier. The fee imposed under this section must be deposited in the motor carrier regulation fund established under IC 8-2.1-23.

As added by P.L.2-1991, SEC.8. Amended by P.L.122-1993, SEC.2; P.L.129-2001, SEC.30; P.L.120-2011, SEC.3; P.L.198-2016, SEC.341.

IC 9-20-5-8

Conditions under which permits not to be issued

Sec. 8. The [redacted] department of transportation may not issue a permit under this chapter for the operation of a vehicle if any of the following conditions apply:

(1) The owner or operator of the vehicle has not complied with IC 8-2.1-24.

(2) The owner or operator of the vehicle has not provided the [redacted] department of transportation with the owner's or operator's Social Security number or federal identification number.

(3) The owner or operator of the vehicle has not registered the vehicle with the bureau, if the vehicle is required to be registered under IC 9-18.

As added by P.L.122-1993, SEC.3. Amended by P.L.110-1995, SEC.30.

[redacted]

[redacted]

MEMORANDUM TO: Project Engineers
Project Design Engineers

FROM: [redacted]
State Structures Engineer

DATE: April 1, 2016

SUBJECT: Engineering Judgement Load Rating

To ensure all bridges are appropriately evaluated for their safe load carrying capacity, the National Bridge Inspection Standards (NBIS) [23 Code of Federal Regulations §650.313] stipulates all structures, longer than twenty feet on publicly owned roads, are to be load rated in accordance with the AASHTO *Manual for Bridge Evaluation* (MBE).

Typically, a conventional bridge analysis and load rating model is used to compute the safe load carrying capacity. This approach allows bridge owners to make decisions regarding the safe load carrying capacity for legal and permitted loads or when emergencies arise. However, in some situations an analysis and load rating model cannot be developed due to a lack of information.

This policy addresses the appropriate use of engineering judgement load ratings as a means of complying with the NBIS requirements for structures that cannot be load rated due to a lack of sufficient information. This policy should not be confused with the concept of assigning ratings for certain bridges based on the design load, as presented in the 2nd edition of the MBE (2011). The policy does not address the use of assigned load rating.

Field Evaluation and Engineering Judgement

Prior to performing an engineering judgement load rating, make every effort to locate the structure plans or obtain the field data required to perform the analysis and load rating. Engineering judgement load ratings shall only be given to structures where a load rating analysis cannot be performed due to a lack of necessary information and/or field measurements and shall be based on field evaluation and engineering judgement.

The term "field evaluation and engineering judgement" as it relates to the load rating of structures, should not be confused with the practice of applying engineering knowledge to provide solutions to problems. For the purposes of load rating, field evaluation and engineering judgement is the use of information gathered by a qualified bridge inspector or load rating engineer as the basis to use professional judgement to determine the load rating. The load rating engineer must use the inspection information and data, available knowledge of the design live load, live load history and the current condition of the structure to support the engineering judgement load rating. Plans from a similar structure, with known details, designed or built during the same time period may also provide the basis for an engineering judgement load rating.

Typically, engineering judgement ratings will be limited to structure types identified in this policy, unless approved by the State Load Rating Engineer.

Structures Where Engineering Judgement Ratings Shall Not Be Applied

Steel Bridges

Steel bridges without plans can be analyzed and load rated using information and data/measurements collected from the field. Ensure the bridge inspection report provides sufficient data/measurements, such as the plate girder or beam dimensions and remaining thickness of the steel section, to perform the analysis and load rating.

Use the structure year built and the MBE - Table 6A.6.2.1-1 to establish the steel material properties. The year built is documented in the Structure Inventory & Appraisal data sheet (NBI Item #27). In addition, assume the following:

- Non-composite action for beams on bridges with concrete decks, unless the physical inspection reveals the deck is composite with the beams.
- Fully braced compression flange for beams on bridges with a timber floor if the timber nailers are sound and in good condition.
- Unbraced compression flange if the timber nailers are decayed.

Timber Bridges

Analyze and load rate timber structures based on data/measurements collected from the field. Use the Working Stress (Allowable Stress) method and assume the timber is Southern Pine (dense select structural). Material properties shall be in accordance with the *National Design Specification for Wood Construction* (NDS).

Structural Plate

Structural plate structures are typically corrugated metal (steel or aluminum) plate (CMP) structures which depend on the interaction with the backfill material for stability and the ability to carry loads. When properly constructed, CMP structures perform as a compression ring with little bending resistance.

Load rate corrugated metal plate structures based on data/measurements collected from the field. When information on the structure type and components cannot be determined in the field, contact the supplier/manufacturer and request the information necessary to perform a load rating. In addition, the supplier/manufacturer may be able to provide assistance with the load rating.

When load rating CMP structures, investigate defects that may affect the load rating, such as:

- Flattening of the top arch elements or sides.
- Differential settlement or undermining.
- Erosion of material from underneath and alongside of the structure due to water infiltrating the material.

Structures Where Engineering Judgement Ratings Are Acceptable

Engineering judgement load ratings will apply to concrete superstructures and concrete box culverts with unknown reinforcement. Since engineering judgement ratings are not calculated, there is substantial reliance on the physical inspection condition rating. Assign load ratings to concrete structures using the guidance provided in this section.

In accordance with the MBE Article 6.1.4, concrete structures with unknown details need not be load posted if they have been carrying normal traffic for an appreciable period and show no significant signs of visible structural distress.

Documentation required for load ratings based on field evaluation and engineering judgement includes, but is not limited to the following information:

- Statement of efforts made to obtain design plans.
- Summary of the field evaluation noting the Bridge Inspector's condition ratings and comments on structural defects.
- Description of the structure load path, e.g. level of redundancy, traffic history and evidence of damage due to routine traffic or overloads.
- Engineering judgement applied and methodical justification for the load rating and/or load posting, when applicable.
- Conclusive statement that the load rating is based on "field evaluation and engineering judgement" to facilitate proper coding of NBI Items #63 and #65.

Reinforced Concrete Box Culverts (RCBCs)

Historically, an inventory rating of HS20 and operating rating of HS26 has been assigned to RCBCs. HS26 is an intermediate rating between the inventory rating and the corresponding operating rating. This practice, which is in variance with MBE Article 6B.7.1, will be continued since it has been successfully used over a significant period of time and satisfactorily envelopes force effects of [redacted] legal vehicles; i.e. RF_{Op} = 1.0 for legal loads and load posting is not required.

For proprietary culvert systems, such as the Con/Span® and Bebo® precast arch systems, make every effort to contact the producer of the structure to obtain additional details or plans and assistance with the load rating.

For the HS-20 design load, assign HS20 (RF_{Inv} = 1.0) for the inventory load rating and HS26 (RF_{Op} = 1.3) for the operating load rating to cast-in-place RCBCs that satisfy all of the following criteria:

- Unknown reinforcement details.
- Fill depths ≥ 2.0 ft.
- Carrying normal traffic for an appreciable period (> 5 years).
- Condition grade ≥ 5 (NBI Item #62).

Culverts that do not satisfy the criteria above may be assigned alternate load ratings. Review inspection reports for evidence of structural distress, such as flexural or shear cracks. Use the culvert condition rating (NBI Items #62) and Table 1 to assign a load rating. Consider whether the NBI Condition Rating reflects the load carrying capacity of the structure. If a low condition rating is due to a deficiency, such as significant scouring at the ends of the culvert, that does not affect the structure’s load carrying capacity, a higher engineering judgement rating is appropriate, if adequate justification is furnished.

Table 1: RCBCs – Engineering Judgement Load Rating

NBI Condition Rating	Inventory Rating ($RF_{Inv.}$)	Operating Rating ($RF_{Op.}$)
9	HS20.0 (1.00)	HS26.0 (1.30)
8	HS20.0 (1.00)	HS26.0 (1.30)
7	HS20.0 (1.00)	HS26.0 (1.30)
6	HS20.0 (1.00)	HS26.0 (1.30)
5	HS16.6 (0.83)	HS21.6 (1.08)
4	HS8.0 (0.40)	HS10.4 (0.52)
3 or 2	• Assign appropriate rating less than that for NBI Condition Rating of 4.	
0 or 1	• Culvert closed.	

For culverts with a condition rating < 5, use engineering judgement to also estimate a safe load carrying capacity for single vehicles (SV) with 2 to 7 axles and truck tractor semi-trailers (TTST) with 3 to 7 axles. Culverts with a NBI condition rating ≤ 3 and are open to traffic will require extensive justification for the engineering judgement load rating.

This policy provides guidance for complying with the NBIS requirements for structures without plans. However, there are cases where assigning a load rating to a structure with plans is appropriate. For example, when the load rating of a RCBC with known reinforcement results in RF_{Op} < 1.0, and this result is clearly inconsistent with the in-service performance of the structure. In accordance with MBE Article 6B.7.1 the RCBC need not be load posted; so long as the other three criteria are met from paragraph three of this section, then use the guidance for RCBCs with unknown reinforcement details to propose an engineering judgement load rating for approval by the State Load Rating Engineer.

Reinforced Concrete Bridges

Reinforced concrete bridges in the State primarily consist of cast-in-place deck slab superstructures (slab bridges) and reinforced concrete deck girders (RCDGs). RCDGs are reinforced concrete beams which were cast monolithically with the reinforced concrete deck and are typically analyzed as reinforced concrete T-beams.

Review inspection reports for evidence of structural distress, such as flexural or shear cracks. For reinforced concrete bridges that are in fair or better condition; i.e. superstructure condition grade ≥ 5 (NBI Item# 59), use the structure year built (NBI Item#27) and Table 2 to assign a load rating.

Table 2: Reinforced Concrete Bridges – Modified Design Load Rating

Span (ft.)	Built Prior to 1950*		Built After 1950**	
	Inventory	Operating	Inventory	Operating
15	HS15.0	HS19.5	HS20.0	HS26.0
20	HS15.0	HS19.5	HS20.0	HS26.0
25	HS14.5	HS18.8	HS19.3	HS25.1
30	HS13.1	HS17.0	HS17.5	HS22.7
35	HS12.3	HS16.0	HS16.4	HS21.3
40	HS11.5	HS15.0	HS15.4	HS20.0
45	HS11.0	HS14.3	HS14.7	HS19.1
50	HS10.6	HS13.8	HS14.2	HS18.5
55	HS10.4	HS13.5	HS13.8	HS18.0
60	HS10.1	HS13.2	HS13.5	HS17.6
65	HS10.0	HS13.0	HS13.3	HS17.3
70	HS9.8	HS12.8	HS13.1	HS17.0
75	HS9.7	HS12.6	HS12.9	HS16.8
80	HS9.6	HS12.5	HS12.8	HS16.6
85	HS9.5	HS12.4	HS12.7	HS16.5
90	HS9.4	HS12.3	HS12.6	HS16.3
95	HS9.4	HS12.2	HS12.5	HS16.2
100	HS9.3	HS12.1	HS12.4	HS16.1
105	HS9.2	HS12.0	HS12.3	HS16.0
110	HS9.2	HS12.0	HS12.3	HS15.9
115	HS9.2	HS11.9	HS12.2	HS15.9
120	HS9.1	HS11.9	HS12.2	HS15.8

* Assumes at least H-15 design load was used for structures built before 1950.
** Assumes at least H-20 design load was used for structures built in 1950 or later.

Most reinforced concrete bridges with unknown structural details have been carrying normal traffic for decades without a need for load posting. The engineering judgement load ratings provided in the table above are derived from an assumed design load, but may not reflect the as-built condition or in-service performance of the structure. Reinforced concrete bridges that exhibit no signs of structural distress or significant deterioration need not be load posted, in accordance with MBE Article 6.1.4.

For reinforced concrete bridges that exhibit structural distress, significant deterioration or have a superstructure condition rating of 4, use engineering judgement to also estimate a safe load carrying capacity, for single vehicles (SV) with 2 to 7 axles and truck tractor semi-trailers (TTST) with 3 to 7 axles. Structures with a NBI superstructure condition rating ≤ 3 and are open to traffic will require extensive justification for the engineering judgement load rating. Justification should include, but is not limited to an assessment of the following:

- Condition of load carrying components.
- Level of load path redundancy.
- Reconstruction or modifications to the structure.
- Measurable deformations.
- Comparison to comparable structures of known design.
- Observed performance of the structure under traffic.

Prestressed Concrete Bridges

Review inspection reports for evidence of structural distress, such as flexural or shear cracks. For prestressed concrete bridges use the lower of the superstructure or substructure condition ratings (NBI Items #59 and #60) and Table 3 to assign a load rating. Consider whether the condition rating reflects the load carrying capacity of the structure. If a low condition rating is due to a deficiency that does not affect the structure's load carrying capacity, a higher engineering judgement rating is appropriate, if adequate justification is furnished.

Table 3: Prestressed Concrete Bridges – Engineering Judgement Load Rating

Lowest NBI Condition Rating (Superstructure and Substructure only)	Inventory Rating ($RF_{Inv.}$)	Operating Rating ($RF_{Op.}$)
9	HS20.0 (1.00)	HS33.4 (1.67)
8	HS20.0 (1.00)	HS33.4 (1.67)
7	HS19.0 (0.95)	HS31.7 (1.59)
6	HS16.6 (0.83)	HS27.7 (1.39)
5	HS12.6 (0.63)	HS21.0 (1.05)
4	HS8.0 (0.40)	HS13.4 (0.67)
3 or 2	• Assign appropriate rating less than that for NBI Condition Rating of 4.	
0 or 1	• Bridge closed.	

For structures with a superstructure condition rating < 5, use engineering judgement to also estimate a safe load carrying capacity, for single vehicles (SV) with 2 to 7 axles and truck tractor semi-trailers (TTST) with 3 to 7 axles. Structures with a NBI superstructure condition rating ≤ 3 and are open to traffic will require extensive justification for the engineering judgement load rating. Justification should include, but is not limited to an assessment of the following:

- Condition of load carrying components.
- Level of load path redundancy.
- Reconstruction or modifications to the structure.
- Measurable deformations.
- Comparison to comparable structures of known design.
- Observed performance of the structure under traffic.

This policy for engineering judgement load ratings is effective immediately. The Inspection Manual will be updated at a later date.

[redacted]

Cc: [redacted]
Division Bridge Engineer, FHWA

TO: BRIDGE RATING FILE

FROM: [redacted], BRIDGE DIVISION

DATE: 25 JULY 1991

SUBJECT: RATING OF CONCRETE SLAB BRIDGES WHEN PLANS ARE NOT AVAILABLE

When plans are not available for determining concrete and steel properties use the following procedure.

Assume that $F_c' = 2500$ psi & that d = slab thickness - 2"

Use f_s as given in AASHTO Maintenance Section 5.4.4.

Determine and use the area of reinforcing steel for an ideally ~~(balanced)~~ reinforced section as follows:

1. Determine E_c
2. Determine $n = E_s / E_c$
3. Determine $k = n / (n + (f_s/f_c))$
4. Determine $j = 1 - k/3$
5. Determine $R = .5\ f_c\ j\ k$
6. Determine $M = R\ b\ d^2$
7. Determine $A_s = M / f_s\ j\ d$
8. Always round A_s down.

Use the HW8100 program for determining H ratings.

MEMORANDUM

TO: Bridge Rating File

FROM: [redacted] TB
Bridge Division

DATE: December 11, 1997

SUBJECT: Rating Slab Bridges Using Virtis Program

For slab bridges built before 1961.

Allowable Stress
For operating rating use .9 Fy for reinforcing steel.

Load Factor
For operating rating use 1.1 for ⌀ factor when calculating ⌀ Mn.

[redacted]

Distribution factor increased by 1.3

Use this when no plans are available for slab bridges built before 1954.

f'c = 2500   fy = 33000
fc = 1000   fs = 18000
n = 12
b = 12
k = n / (n + fs / fc) = 0.4
J = 1 - k / 3 = 0.86666666667
R= 0.5 * fc * J * k = 173.333333333

Depth of Section (in)	d - Depth of Steel (in)	M = R * b * d^2	As = M / (fs * J * d) (in)^2
6	4	33280.000	0.533
6.5	4.5	42120.000	0.600
7	5	52000.000	0.667
7.5	5.5	62920.000	0.733
8	6	74880.000	0.800
8.5	6.5	87880.000	0.867
9	7	101920.000	0.933
9.5	7.5	117000.000	1.000
10	8	133120.000	1.067
10.5	8.5	150280.000	1.133
11	9	168480.000	1.200
11.5	9.5	187720.000	1.267
12	10	208000.000	1.333
12.5	10.5	229320.000	1.400
13	11	251680.000	1.467
13.5	11.5	275080.000	1.533
14	12	299520.000	1.600
14.5	12.5	325000.000	1.667
15	13	351520.000	1.733
15.5	13.5	379080.000	1.800
16	14	407680.000	1.867
16.5	14.5	437320.000	1.933
17	15	468000.000	2.000
17.5	15.5	499720.000	2.067
18	16	532480.000	2.133
18.5	16.5	566280.000	2.200
19	17	601120.000	2.267
19.5	17.5	637000.000	2.333
20	18	673920.000	2.400
20.5	18.5	711880.000	2.467
21	19	750880.000	2.533
21.5	19.5	790920.000	2.600
22	20	832000.000	2.667
22.5	20.5	874120.000	2.733
23	21	917280.000	2.800
23.5	21.5	961480.000	2.867
24	22	1006720.000	2.933
24.5	22.5	1053000.000	3.000
25	23	1100320.000	3.067
25.5	23.5	1148680.000	3.133
26	24	1198080.000	3.200
26.5	24.5	1248520.000	3.267
27	25	1300000.000	3.333
27.5	25.5	1352520.000	3.400
28	26	1406080.000	3.467
28.5	26.5	1460680.000	3.533
29	27	1516320.000	3.600
29.5	27.5	1573000.000	3.667
30	28	1630720.000	3.733
30.5	28.5	1689480.000	3.800
31	29	1749280.000	3.867
31.5	29.5	1810120.000	3.933
32	30	1872000.000	4.000
32.5	30.5	1934920.000	4.067
33	31	1998880.000	4.133
33.5	31.5	2063880.000	4.200
34	32	2129920.000	4.267
34.5	32.5	2197000.000	4.333
35	33	2265120.000	4.400
35.5	33.5	2334280.000	4.467
36	34	2404480.000	4.533

Use this when no plans are available for slab bridges built after 1954.

f'c = 2500 fy = 40000
fc = 1000 fs = 20000
n = 12
b = 12
k = n / (n + fs / fc) = 0.375
J = 1 - k / 3 = 0.875
R= 0.5 * fc * J * k = 164.0625

Depth of Section (in)	d - Depth of Steel (in)	M = R * b * d^2	As = M / (fs * J * d) (in)^2
6	4	31500.000	0.450
6.5	4.5	39867.188	0.506
7	5	49218.750	0.563
7.5	5.5	59554.688	0.619
8	6	70875.000	0.675
8.5	6.5	83179.688	0.731
9	7	96468.750	0.788
9.5	7.5	110742.188	0.844
10	8	126000.000	0.900
10.5	8.5	142242.188	0.956
11	9	159468.750	1.013
11.5	9.5	177679.688	1.069
12	10	196875.000	1.125
12.5	10.5	217054.688	1.181
13	11	238218.750	1.238
13.5	11.5	260367.188	1.294
14	12	283500.000	1.350
14.5	12.5	307617.188	1.406
15	13	332718.750	1.463
15.5	13.5	358804.688	1.519
16	14	385875.000	1.575
16.5	14.5	413929.688	1.631
17	15	442968.750	1.688
17.5	15.5	472992.188	1.744
18	16	504000.000	1.800
18.5	16.5	535992.188	1.856
19	17	568968.750	1.913
19.5	17.5	602929.688	1.969
20	18	637875.000	2.025
20.5	18.5	673804.688	2.081
21	19	710718.750	2.138
21.5	19.5	748617.188	2.194
22	20	787500.000	2.250
22.5	20.5	827367.188	2.306
23	21	868218.750	2.363
23.5	21.5	910054.688	2.419
24	22	952875.000	2.475
24.5	22.5	996679.688	2.531
25	23	1041468.750	2.588
25.5	23.5	1087242.188	2.644
26	24	1134000.000	2.700
26.5	24.5	1181742.188	2.756
27	25	1230468.750	2.813
27.5	25.5	1280179.688	2.869
28	26	1330875.000	2.925
28.5	26.5	1382554.688	2.981
29	27	1435218.750	3.038
29.5	27.5	1488867.188	3.094
30	28	1543500.000	3.150
30.5	28.5	1599117.188	3.206
31	29	1655718.750	3.263
31.5	29.5	1713304.688	3.319
32	30	1771875.000	3.375
32.5	30.5	1831429.688	3.431
33	31	1891968.750	3.488
33.5	31.5	1953492.188	3.544
34	32	2016000.000	3.600
34.5	32.5	2079492.188	3.656
35	33	2143968.750	3.713
35.5	33.5	2209429.688	3.769
36	34	2275875.000	3.825

SECTION 15: LOAD RATING CONCRETE BRIDGES WITHOUT EXISTING PLANS

This procedure pertains to concrete bridges (reinforced or prestressed) that have no plans *and* whose cross-section cannot be estimated from field measurements. Standard precast prestressed concrete slabs and boxes can normally be determined from field measurements. Contact the [redacted] Load Rating Unit for questions regarding standard members. The following procedure is NOT a load and resistance factor rating (LRFR), but is rather a load rating that is based on engineering judgment.

15.1 Methodology

Without as built plan sheets, the bridges capacity cannot be calculated. Although the loads could still be factored, the resistance cannot be determined therefore, the LRFR methodology cannot be used. In these situations the service history, span configuration, and member condition will be used to assign the bridge an operating and inventory rating factor.

If a concrete bridge without plans has a long history of service (20 years or more), successfully carrying [redacted] Legal Loads without distress, its safe capacity can be assumed to be equal to the worst load effect of the Legal Loads (up to the SU4 vehicle). The HL-93 Design Truck Load Inventory Rating can be considered to be in proportion to the load effect of the Legal Truck Loads. This assessment should then be reduced to account for NBI condition ratings that involve advanced deterioration or section loss (“Poor” or lower).

15.2 Preliminary Files for Superstructure (Mathcad)

For reinforced concrete bridges without existing plans, the preliminary file name and extension for superstructure analysis is SUPERSTRUCTURE.xmcd.

Note: Because the dot multiplier symbol is very small and can easily be overlooked in Mathcad printouts, when typing equations, surround all multiplied factors with parentheses.

15.2.1 Header

Use the Mathcad header feature to indicate Bridge Number (upper right corner), Bridge Name (top line center), load rater and date (2nd line left) and File Name and Page Number (2nd line right). Use the Bridge Name as defined in the Definitions, Article 1.3.3 of this Manual.

Since the bridge number and name are contained in the Mathcad header, they do not show up while working on the file, only when printing or doing a Print Preview. To avoid confusion over which bridge you are working on, it is good practice to place the bridge number and name near the top of the file in the right margin (outside the printable area).

Just below the Mathcad header section, document the bridge structure type. For state bridges the span description (“Spans” field) from the Bridge Log is adequate for this purpose.

Note: the Mathcad regions at the top in the right margin (outside the printable area) are there for 2 purposes. The units definitions are necessary for Mathcad to understand some commonly used units in structural engineering (without them, Mathcad would generate errors because it is unable to interpret them). The row of nonstandard characters is there in case the user might want to copy them elsewhere to clarify the calculations.

15.2.2 Condition Factor

Condition factors used in this analysis are **NOT** the same condition factors from MBE T6A.4.2.3-1 which are reproduced in section 1.4.1.3. The factors listed in Table 8.2.2-1 are not to be used for LRFR analysis. Due to the increased uncertainty in this method of analysis, the condition factors will more severely impact the overall load rating when compared to the LRFR condition factors.

Document any decisions regarding the condition factor of the bridge in this section. In addition to the superstructure condition rating (NBI Item 59), also consider the substructure condition rating (NBI Item 60). Review the inspection notes for any deficiencies in pile caps or crossbeams. If there are notes regarding crossbeams in poor condition, and this condition factor is less than the value listed for the superstructure, then use the substructure condition rating when determining the condition factor.

Table 8.2.2-1

NBI Item 59 (or 60), Superstructure (or Substructure) Condition Rating	Condition Factor (CF)
5 “Fair Condition” or better	1.00
4 “Poor Condition”	0.50
3 “Serious Condition” *****	0.25
2 “Critical Condition” *****	0.12

- For bridges in “Serious” or “Critical” condition, a case-by-case posting evaluation and immediate action are required. Engineering judgment should always be used when determining the necessary immediate action. Examples of immediate action include but are not limited to; restricting traffic to one lane, posting for the minimum of 3 tons GVW, or closure.

15.2.3 Span Layout

Document the span lengths that will be used for analysis. Only unique span lengths should be evaluated. Span lengths can be pulled from the bridge log, field measurements, or the bridge inspection report. Without detailed plans these span lengths will be considered approximate.

Spans will generally be considered to be simply supported. Without detailed as-built drawings showing negative moment steel over interior supports, it is difficult to determine if a structure is continuous. For the purpose of this analysis, it is reasonable to assume that all spans are simply supported for dead and live loads.

15.2.4 Live Loads

List the live load cases for use in analysis. These should always be as shown below:

HL-93 Design Truck
HL-93 Design Tandem
HL-93 Design Truck Train
Design Lane Load
[redacted] Legal Type 3 Truck
Legal Type 3S2 Truck
Legal Type 3-3 Truck
[redacted] SU4 Legal Truck
SU5 Legal Truck
SU6 Legal Truck
SU7 Legal TruckFAST Act EV2 Truck
FAST Act EV3 Truck

15.2.5 Analysis Sections

Document the locations that will be analyzed. Normally this will include the BRASS default 1/10th points and 0.45L of the span. Due to variation in axle spaces the maximum live load moment may not be at 0.50L. Therefore, 0.45L will also be analyzed.

15.2.6 BRASS Results

BRASS analysis instructions are listed in section 8.3. The results from the analysis will be documented here for rating factor computations.

After successfully running the BRASS analysis, open SUPERSTRUCTURE.OUT. Scroll down to where the live load girder actions are reported. The BRASS output heading for this section is:

```
           ** UNFACTORED GIRDER ACTIONS DUE TO APPLIED LIVE LOADS **
(Adjusted for Dynamic Load Allowance, Distribution Factors, and Live Load Scale Factor)
                      ** CONSTRUCTION STAGE 1 **
```

This section of the BRASS output file will report the moment, axial, shear, reaction, and deflection actions due to the five live load cases that were defined for analysis. For each load case, go through the analysis points and report the maximum moment.

Below is an example of the BRASS Output file for live load case 1 (AASHTO LRFD HL-93 Design Truck):

POINT NO.	MOMENT POS	--- NEG (ft-kips)
1-0.000	0.0	-0.0
1-0.100	64.4	0.0
1-0.200	104.3	0.0
1-0.300	127.0	0.0
1-0.400	144.8	0.0
1-0.450	149.1	0.0
1-0.500	150.5	0.0
1-0.600	144.9	0.0
1-0.700	127.0	0.0
1-0.800	104.3	0.0
1-0.900	64.4	0.0
1-1.000	0.0	-0.0

Calculate the maximum moment for the HL-93 Design Vehicle, the standard legal vehicles, and the legal Specialized Hauling Vehicles (SHVs).

The maximum legal load moment will be the greater moment of the following four load cases:

- [redacted] Legal Type 3
- [redacted] Legal Type 3S2
- [redacted] Legal Type 3-3
- [redacted] SU4

Maximum HL-93 moment will be the maximum of the following 3 load cases:

- HL-93 Design Truck with the maximum HL-93 Design Lane
- HL-93 Design Tandem with the maximum HL-93 Design Lane
- HL-93 Design Truck Train with the maximum HL-93 Design Lane

15.2.7 Rating Factor Calculations

The maximum moment effect from the legal load trucks is assumed to result in a rating factor equal to 1.0, if the bridge has a history of successfully carrying [redacted] legal loads, and has a condition rating greater than or equal to fair. The condition of the bridge is taken into account with the condition factor specified in section 15.2.2. Use equation 15.2.7-1 to calculate the rating factor for the [redacted] Legal trucks and the HL-93 Inventory rating.

$$RF_{LoadCase} = \left(\frac{M_{Legal}}{M_{LoadCase}} \right) * (CF) \qquad \text{(Equation 15.2.7-1)}$$

Where: M_{Legal} is the maximum legal load affect from the Type 3, Type 3S2,Type 3-3, and SU4 loading.

$M_{LoadCase}$ is the maximum load affect for the load case of interest. This will be for the other legal loads that have lesser load effects than that used for M_{Legal}, the load effects for the SU5, SU6, and SU7 vehicles, and the load effects for the Continuous Trip and Single Trip Permit Vehicles.

CF is the condition factor from section 15.2.2.

Due to Specialized Hauling Vehicles being relatively new technology, [redacted] feels that most bridges have not supported a large population of these vehicles during their service life. Being that the multiple, closely spaced axles, of these vehicles can produce load effects (for some bridges) greater than 50% of what is seen from the standard legal vehicles, [redacted] has decided to not allow the SU5, SU6, and SU7 vehicles to cross concrete bridges without plans without some sort of load restriction. For most bridges, these vehicles will result in higher load effects than the standard legal vehicles and the SU4. Since these procedures will set the rating factor to 1.0 for the greatest load effect of the standard legal vehicles and SU4 vehicle for bridges that have a fair or better condition rating, these procedures will result in rating factors less than 1.0 for the SU5, SU6, and SU7 vehicles and for most permit vehicles. This will require that every bridge that is rated by this procedure will end up being load posted for these vehicles.

The rating factor the HL-93 Operating level is calculated using equation 15.2.7-2.

$$RF_{HL93\_Operat} = \left(RF_{HL93\_Invent} \right) * \left(\frac{5}{3} \right) \qquad \text{(Equation 15.2.7-2)}$$

Where: RF_{HL93_Invent} is the inventory rating factor calculated for the HL-93 truck loading using equation 15.2.7-1.

15.3 BRASS Analysis

BRASS-GIRDER will be used to evaluate the live load comparison. BRASS-GIRDER is different from the previous BRASS-GIRDER(LRFD) program in that it no longer uses text file inputs, but instead utilizes a Graphical User Interface (GUI) with data saved in xml file format. Instead of developing new procedures to populate the GUI of BRASS-GIRDER, this manual will continue to give instructions on how to create the text input file for BRASS-GIRDER(LRFD). Once the file is ready for analysis, the user will run the text input file through the BRASS-GIRDER translator that will create the xml input file used to populate the new GUI. From there the user will be able to run the analysis within BRASS-GIRDER. Because only live load moments are needed, the BRASS-GIRDER(LRFD) input file commands will be substantially different than a normal LRFR analysis.

15.3.1 BRASS Input File Conventions

Use the heavily commented sample file provided as a template, copied to a new bridge-number-specific folder (with a new filename if appropriate) and then modified for the actual Load Ratings.

- General conventions

  Use the full length of each command name except the COMMENT (3-1.1) command shall be only COM.

  Precede each command or logical group of similar commands (except for the COMMENT command) with a comment referring to the Article number in the BRASS-GIRDER(LRFD) Command Manual. For example, precede an ANALYSIS (4-1.1) command with a comment command thus:

  ```
  COM 4-1.1
  ANALYSIS B, 1, REV, T, N
  ```

  Generally, leave in all comments found in the template (unless they become totally irrelevant to a particular input file), modifying them and adding more comments as required to fit the specific conditions of the rating. Use comments liberally with the expectation that someone unfamiliar with the BRASS-GIRDER(LRFD) program and unfamiliar with the bridge will need to read the data file and fully understand it.

  Leave parameters blank (spaces between commas) where they are irrelevant to the specific structure. Although trailing commas can be omitted where all parameters to the right are to be blank, it is recommended to clarify your intentions by showing the blank parameters separated by commas. However, avoid leaving blank parameters such as material strengths where default values would apply. Enter the default values to make the dataset more meaningful to a future user.

  Show in-line calculations (what the BRASS Manual calls in-line arithmetic) within a parameter (between commas) to convert units from feet to inches where the command parameter requires inches. However, note that BRASS has the following limitations on in-line calculations: It cannot handle parentheses within in-line calculations, and it cannot correctly handle more than one multiplication or division operator in any one term, i.e. use no more than one multiplication or division between plus and minus signs. Other than these in-line calculations, the best place to put calculations is in the Preliminary File rather than in the BRASS comments.

  Whenever a BRASS-GIRDER(LRFD) input file contains a series of occurrences of the same command, vertically aligning the same command parameters for clarity is encouraged. This practice simplifies the process of changing values of parameters when cloning an old BRASS file for use in a new bridge. Inserting spaces as required to accomplish this is harmless. However, do not use tab characters to accomplish this. They are misinterpreted by BRASS-(LRFD) as the next parameter, and are likely to cause fatal errors.

- Input File Sections

  To make it easier for a subsequent user to find their way around the Input File, separate the BRASS input file into logical sections (large groups of commands) by using spaced comments as indicated in the sample files. Typically, an input file for an RCDG will be divided into the following sections:

  ```
  COM
  COM  ***** Live Load Analysis Only *****
  COM

  COM
  COM  ***** Material Properties *****
  ```

```
COM

COM
COM  ***** Section Geometry *****
COM

COM
COM  ***** Span Length and Section Information *****
COM

COM
COM  ***** Live Loads *****
COM

COM
COM  ***** Distribution Factors *****
COM

COM
COM   ***** Critical Flexural Sections *****
COM
```

- Specific conventions

At the beginning of every input file, use the BRIDGE-NAME (2-1.3) command to provide the 5- or 6-character NBI Bridge Number, followed by the Bridge Name. Use the Bridge Name as defined in the Definitions, Article 1.3.3 of this Manual.

Next, use the ROUTE (2-1.5) command to provide the mile point and signed Route Number where applicable (always required for State-owned bridges). Note the signed Route Number is not the same as the [redacted] internal (maintenance) Highway Number.

Use 2 lines of the TITLE (2-1.6) command. Use the first TITLE line to provide the file name and describe which girder(s) this file applies to. Use the second TITLE line to provide the purpose or work grouping of the Load Rating.

Use the AGENCY (2-1.1) command to identify the Load Rating as being performed according to [redacted] standards. This command should always be the same:

```
COM 2-1.1
AGENCY [redacted] DOT
```

Use the ENGINEER (2-1.2) command to indicate the load rater.

Use the UNITS (2-1.4) command to force BRASS to always use US (English) units for both input and output. BRASS normally defaults to US units, but it has been found that when referenced dimensions get large, BRASS will automatically assume the large dimensions are in millimeters and will convert the units when it calculates the resistance of the member. Using the UNITS command will not allow BRASS to arbitrarily convert the units during an analysis.

```
COM 2-1.4
UNITS US
```

Use the ANALYSIS (4-1.1) command to provide BRASS with parameters needed to do a rating analysis. The “continuous beam model” is the preferred choice (“B” in parameter 1) as long as there is no need to include columns in the analysis and the bridge has ≤ 13 spans.

Parameter 3 is coded as “REV” because rating factors from this analysis will not be used. Only the live load effects will be pulled from the BRASS output. This command would normally be the same:

```
COM 4-1.1
ANALYSIS B, 1, REV, T, N,
```

Use the POINT-OF-INTEREST (4-1.2) command to set BRASS to generate user-defined points of interest from subsequent OUTPUT-INTERMEDIATE (5-2.1) commands.

```
COM 4-1.2
POINT-OF-INTEREST U
```

Leaving the 2nd parameter of BRASS command 5-1.1 blank causes BRASS to not report a large additional output file for each point of interest. The additional output information is not normally needed. Use of “Y” for parameter 2 to turn on this additional output may be justified at sections where there is a need to account for partially developed bars. If these additional .OUT files are generated, they do not need to be printed in the Load Rating Report.

Use the OUTPUT (5-1.1) command to control the wide variety of output options. Code the first parameter with “2L” to output the live load actions at all node points. Dead loads do not need to be output for this analysis. This command would normally be the same:

```
COM 5-1.1
OUTPUT 2L, N, , , 1, , , , , , , , ,
```

Beginning with BRASS-GIRDER(LRFD) v.1.6.1, the effective top flange width is calculated and applied to the section properties automatically. Use the OUTPUT-EFF-WIDTH (5-7.3) command to direct BRASS to not output its effective flange width calculations. This command would normally be the same:

```
COM 5-7.3
OUTPUT-EFF-WIDTH N
```

Code all BRASS models in the same direction as the girder elevation appears on the plans, i.e. from left to right on the plans, regardless of mile point direction.

In the “Material Properties” section, use the CONC-MATERIALS (8-1.1) command to provide the material properties consistent with the notes on the bridge plans. Although there are exceptions, a typical RCDG structure from the 1950’s or early 1960’s would have the following properties command:

```
COM 8-1.1
CONC-MATERIALS 0.15, 3.3, 40.0, 40.0, 9, , , 170.0, , ,
```

In the “Section Geometry” section, define one rectangular section. Since this is only a live load moment comparison the actual cross section does not need to be used. Capacities and dead loads will not be calculated. Define a 12” wide rectangular concrete section. This command would normally be the same:

```
COM --- Section 1
COM 8-2.2
CONC-RECT-SECTION 1, 12, 12
```

In the “Span Lengths and Section Information” section, define each span beginning with the appropriate command from Chapter 11 of the *BRASS-GIRDER(LRFD) Command Manual.* Variation in the girder profile need not be accounted for. Follow this command with a SPAN-

SECTION (11-2.1) command to assign the previously defined section to cumulative ranges from the left end of the span. The following is an example of the series of commands to define one span:

```
COM --- Span 1, 19.00' Geometry

COM 11-1.5, 11-1.6, 11-2.1
SPAN-GENERAL-LENGTH 1, 19.00*12
SPAN-GENERAL-SEGMENT 1, 12.00, L, 19.00*12, 12.00
SPAN-SECTION 1, 1, 19.00*12, 1
```

Use the SUPPORT-FIXITY (11-4.1) command to define the boundary conditions of each span, for example:

```
COM --- Support Fixities

COM 11-4.1
SUPPORT-FIXITY 1, R, R, F
SUPPORT-FIXITY 2, F, R, F
```

15.3.2 BRASS Input Adjustments

- BRASS-GIRDER(LRFD) Input Adjustment Type 1-2: These adjustments that are normally listed in the Sections for other bridge types are not necessary for this analysis. The rating factors from this analysis are not being used, only the unfactored live load truck moments are of interest.

- BRASS-GIRDER(LRFD) Input Adjustment Type 3:

Using the BRASS-GIRDER(LRFD) LOAD-LIVE-CONTROL (12-4.1) command to apply the default Design and Legal Load sets would have 3 undesirable consequences:

(a) BRASS would apply the Fatigue Design Load that is not needed for RCDG structures, generating unwanted output
(b) BRASS would default to listing the Design Load outputs *after* all the other loads, potentially causing confusion in transferring loads to the [redacted] Load Rating Summary Workbook
(c) BRASS would apply the AASHTO 3S2 Legal Load which is lighter than the [redacted] Legal 3S2 load.

Therefore, use the LOAD-LIVE-DEFINITION (12-4.3) commands to define each Design and Legal Load separately, and use the LOAD-LIVE-CONTROL (12-4.1) command to define only parameter 1 (direction control, normally “B” for traffic in both directions) and parameter 7 (wheel advancement denominator, normally 100), as follows:

```
COM  BRASS-GIRDER(LRFD) INPUT ADJUSTMENT TYPE 3:
COM  All live loads will be entered individually
COM  Design Loads entered as live load definitions  1 thru  4
COM  Legal  Loads entered as live load definitions  3 thru  9

COM 12-4.1
LOAD-LIVE-CONTROL B, , , , , , 100
```

In structures with short spans, especially short cantilevers, BRASS may “crash” because the span is divided into live load advancement increments that are too small. If this occurs and you have a small span, try decreasing parameter 7 to the largest number for which BRASS will work, often 50 or sometimes even less.

Thus the complete live load definition command set is as follows:

```
COM Code the HL-93 Design Vehicles, [redacted] Legal
COM trucks, and [redacted] Permit Vehicles for use in
COM moment comparison. Do not code any live load
COM scale factors (Parameter 6). Live load factors
COM will be set to 1.0 for all vehicles.

COM 12-4.3
LOAD-LIVE-DEFINITION  1, HL-93-TRUCK , DTK, D, ,
LOAD-LIVE-DEFINITION  2, HL-93-TANDEM, DTM, D, ,
LOAD-LIVE-DEFINITION  3, HL-93-TRKTRA, TKT, D, ,
LOAD-LIVE-DEFINITION  4, HL-93-LANE  , DLN, D, ,
LOAD-LIVE-DEFINITION  5, OR-LEG3     , TRK, L, ,
LOAD-LIVE-DEFINITION  6, ORLEG3S2    , TRK, L, ,
LOAD-LIVE-DEFINITION  7, ORLEG3-3    , TRK, L, ,
LOAD-LIVE-DEFINITION  8, OR-SU4      , TRK, L, ,
LOAD-LIVE-DEFINITION  9, OR-SU5      , TRK, L, ,
LOAD-LIVE-DEFINITION 10, OR-SU6      , TRK, L, ,
LOAD-LIVE-DEFINITION 11, OR-SU7      , TRK, L, ,
LOAD-LIVE-DEFINITION 12, EV2         , TRK, L, ,
LOAD-LIVE-DEFINITION 13, EV3         , TRK, L, ,
```

- BRASS-GIRDER(LRFD) Input Adjustment Type 4:

Using the LOAD-LIVE-DYNAMIC BRASS Command 12-4.2, code the fixed impact percentage to 00.0% for all load cases. Since this is only a live load moment comparison, no impact will be applied. The following commands should not be changed:

```
COM Impact is not varied for load comparison. Code 00.0%
COM fixed impact (Parameter 2, and 3) for all load cases.

COM 12-4.2
LOAD-LIVE-DYNAMIC D, 00.0, 00.0,
LOAD-LIVE-DYNAMIC L, 00.0, 00.0,
```

Using the DIST-BEAM-SCHEDULE BRASS command (12-5.1) will manually set the distribution factors equal to 1.0. This analysis is only to compare live load effects. Coding the distribution factors to 1.0 will allow the user to compare unfactored live loads. The following commands should remain unchanged:

```
COM Forces distribution factors equal to 1.0
COM 12-5.1
DIST-BEAM-SCHEDULE 1, V, 1.0, 1.0, , ,
DIST-BEAM-SCHEDULE 1, M, 1.0, 1.0, , ,
DIST-BEAM-SCHEDULE 1, D, 1.0, 1.0, , ,
```

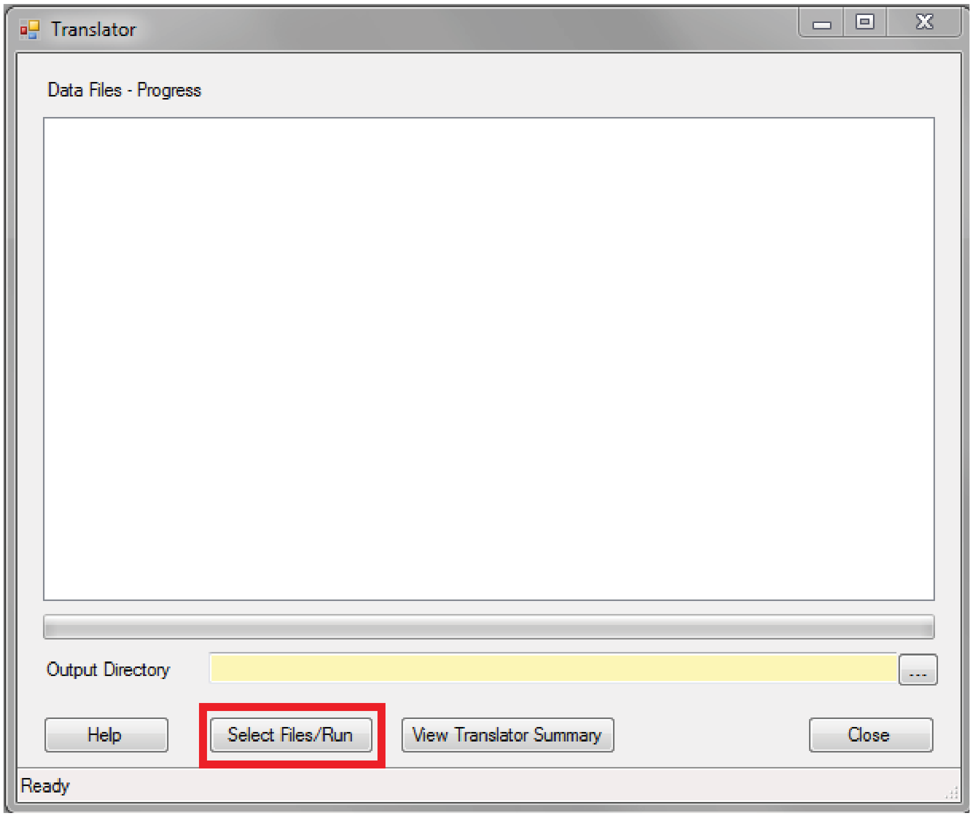
15.3.3 Running BRASS

Open the BRASS-GIRDER GUI interface. Because it is more efficient to use BRASS-GIRDER(LRFD) Input Files generated from previous ones, the GUI interface will not be used to generate input files.

The BRASS-GIRDER(LRFD) input file must first be translated into a BRASS-GIRDER xml file that will then populate the GUI interface in BRASS-GIRDER. The steps for translating and running the input files in BRASS-GIRDER is as follows:

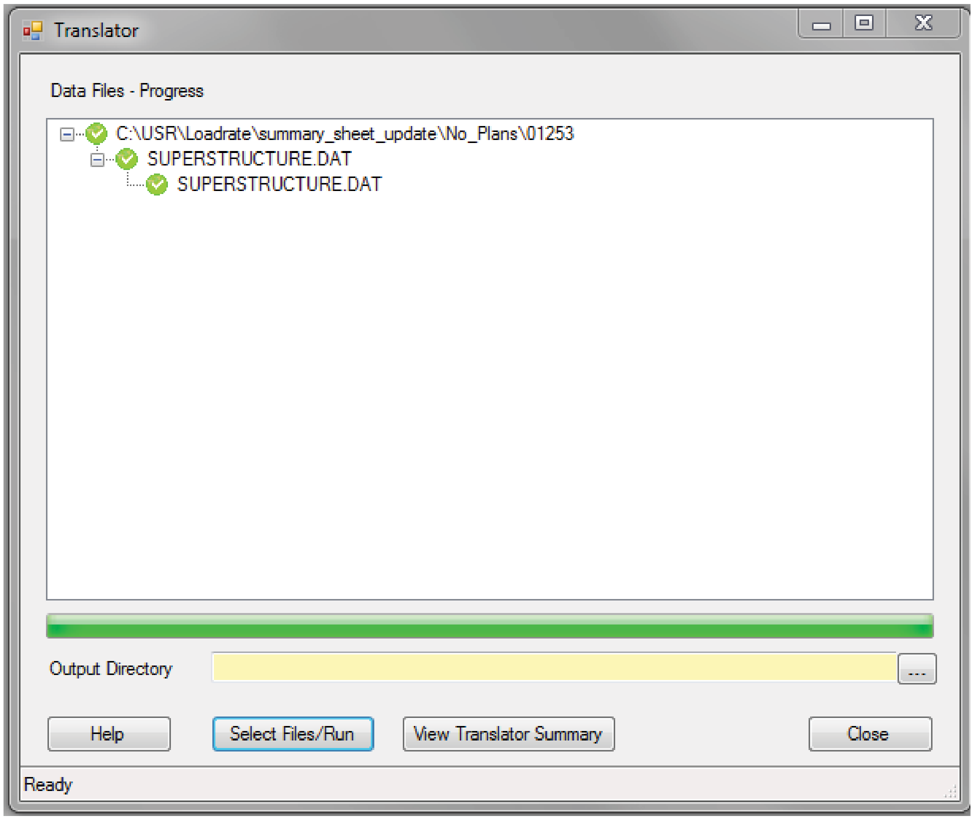
1. Start the BRASS-GIRDER program. From the “File” menu, hover your mouse pointer over “Translate (DAT to XML)”. Select the option for “BRASS-GIRDER(LRFD)”.

2. The Translator window will then open on your screen. Click on the button that says “Select File/Run”, as shown in the red outlined box in the following figure.



3. In the next window that appears, navigate to the location where the BRASS-GIRDER(LRFD) input file that you wish to run is stored, and select that file. Click on the “Open” button at the bottom right of this window.

4. The Translator window will then open back up and the selected file will run through the translation. If there are any errors detected during the translation, a red “X” will be displayed next to the file name in the window and an error file will be generated. Refer to the error file to decipher what is causing the error during translation. Once corrected, follow these steps again to translate the file. If successful, a green check will appear next to the file name as shown in the following figure:



5. Click the “Close” button at the bottom right of the Translator window. Within BRASS-GIRDER, select “Open” under the File menu. Select the BRASS XML file that was just created from the Translator program. Click on the “Open” button at the bottom right of this window.

6. BRASS-GIRDER will then load the model into the GUI. Under the “Execute” menu, select “Analysis Engine” to run the analysis. Or you can simply click on the green traffic light icon on the toolbar.

7. Verify that the output directory is the same as where the input files are located, and then click the “OK” button. A black DOS window will appear showing program progress. Depending on your system speed and memory and the complexity of the structure, the execution process may take a few seconds or several minutes. Upon completion of the analysis, a text output file will be generated within the same directory. You can now use a text editor to open and view the BRASS output.

When making changes or corrections to BRASS files, [redacted] prefers that all changes be made within the BRASS-GIRDER(LRFD) input file so that it becomes the master document for the BRASS model. Reviewing this text input file will be quicker and more efficient than trying to navigate the GUI to verify that the bridge is being modelled correctly. Thus, any time the text input file is modified, the above steps will have to be repeated to translate the text input file into a BRASS XML file before the analysis is re-ran in BRASS-GIRDER.

15.3.4 BRASS Errors

If an error file is generated (same prefix, .ERR extension), open this file with your text editor and try to interpret what BRASS is telling you. The vast majority of error messages will point you to a straightforward typographical error or omission in your input. At the beginning of your experience with BRASS, do not expect a successful execution until one or more typographical errors have been corrected.

When executing BRASS-GIRDER, if you get an error message regarding zeros in the stiffness matrix, look at the ANALYSIS (4-1.1) command, parameter 1, and check to see if you are running a Frame type model on a structure with more than 6 spans. In such cases the Beam type model (the recommended default) is required (with a maximum of 13 spans).

When executing BRASS-GIRDER, you may get an error message stating, "*The effective web width (b_v) cannot be zero. This causes a divide-by-zero error in the compression field computations.*" This most likely means that you have selected points that are too close to another defined point of interest within your BRASS input file. A general rule is not to have points closer than six inches from one another. Verify in your input file that you have correctly entered the web width parameter while defining your BRASS sections. Also check in the "Span Length and Section Information" portion of the input file to see that the ranges of the elements are not too close to each other.

A rare error can sometimes occur in executing BRASS-GIRDER where the processing of the analysis takes a considerable amount of time, and then produces a very large output file (around 600 megabytes) along with an error file. The program will report an "Interpolation Error". This occurs on files that have a BRASS span of 99.99 ft and was attempting to increment each truck across the span at 100 increments (as specified in the LOAD-LIVE-CONTROL command). We found that one of two simple workarounds can correct the error: 1) round the BRASS spans from 99.99 ft to 100.00 ft, or 2) increase the live load increment from 100 to 105 in the LOAD-LIVE-CONTROL command. The second method is the preferred option as it only requires a correction in one command, where as adjusting the span lengths would have required doing it for multiple spans for the bridge that experienced this error.

When executing BRASS-GIRDER, if you get an unexpected termination of the program while attempting to run a file, check the BRASS error file (*.err) to see if it states that, "Standard Vehicle: OLEG3S2 is not presently stored in the standard vehicle library file." This usually means that the user did not update the names of the Legal Vehicle in the BRASS input file. In the early part of 2009, [redacted] made a small revision to the vehicle library so that both the old Tier 1 and LRFR rating methodologies would use the same legal vehicles for their analysis. As a result, [redacted] changed the names of the legal vehicles. To correct the error, make the following changes to the names of the legal vehicles in the BRASS input file:

Original Vehicle Names	Previous Vehicle Name	Current Vehicle Name
OLEG3	[redacted]LEG3	[redacted]-LEG3
OLEG3S2	[redacted]LEG3S2	[redacted]LEG3S2
OLEG3-3	[redacted]LEG3-3	[redacted]LEG3-3
SU4	SU4	[redacted]-SU4
SU5	SU5	[redacted]-SU5
SU6	SU6	[redacted]-SU6
SU7	SU7	[redacted]-SU7

15.3.5 BRASS Output Files

BRASS-GIRDER has been known to "run perfectly" and still produce completely wrong results. Although a successful run may indicate a lack of errors, it is prudent to search the main output (**.**OUT) file for the words "error" and "warning" to check out the seriousness of the problem, and to do a "reality check" on the Rating Factors. Unexpected Rating Factor results often indicate an error in the BRASS coding.

We recommend that, at the very least, load raters routinely employ the following two BRASS verification measures:

(1) Do a reasonability check on the section properties. This is why we routinely code "Y" in

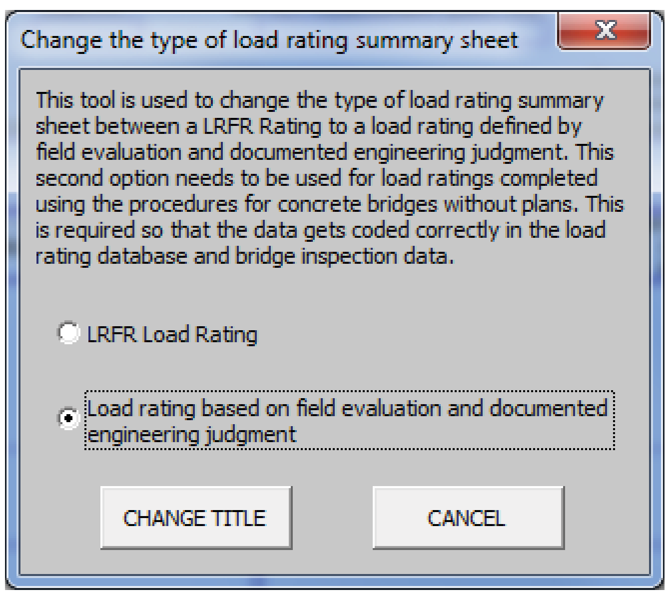
parameter 2 of the OUTPUT (5-1.1) command, to provide a list of girder properties at each node point. (Search the Output File for “Calculated Properties” in each span). It is not uncommon to make errors in the concrete section definitions, the SPAN-UNIF-HAUNCH (11-1.3) command or the SPAN-SECTION (11-2.1) commands that can result in a girder profile that is quite different than the one you expected.

(2) Do a reasonability check on the distribution of shears and moments across the structure. This is especially critical if you have an expansion joint within the structure that you have modeled by coding a hinge near one of the internal supports. Check if you are getting nearly-zero moments at the support next to the hinge. (It can’t be truly zero because of the offset of the hinge from the support, but the moment value should be quite low). There have been cases where, due to numerical instabilities in the analysis process, unreasonably high moments were present at the support. The solution is usually to increase the offset of the hinge from the support in small increments until the reported moments behave as expected (sometimes increasing the offset by hundredths of a foot can make all the difference!).

If you really have doubts about what BRASS is giving you, be aware that you can use additional commands in the OUTPUT- group (BRASS-GIRDER(LRFD) Manual, Chapter 5) to generate additional output that may facilitate your detective work. Use caution – the size of this output can be daunting.

15.4 Reporting Rating Factors

The rating factors that were calculated in SUPERSTRUCTURE.XMCD will be reported using the LRFR Load Rating summary sheet. Since these procedures for rating concrete bridges without plans do not produce a LRFR load rating, the user needs to select the “CHANGE TYPE OF LOAD RATING” button along the bottom of the load rating summary sheet. This will then open the following dialog box:



For this type of load rating, the user needs to select, “Load rating based on field evaluation and documented engineering judgment.” Then click the “CHANGE TITLE” button at the bottom left of the dialog box. In doing so, the title of every page in load rating summary will be changed from “LRFR Load Rating” to “Engineering Judgment Load Rating.” Making this distinction is necessary so that the load rating method is recorded correctly within the National Bridge Inventory (NBI).

15.4.1 Getting Started

Open the Excel template **LR.XLTM** and, after filling in the Bridge Number cell, use File / Save As to save it in the bridge-specific Load Rating folder using the bridge-specific file name LRnnnnnn.XLSM, where nnnnnn is the 5- or 6-digit NBI Bridge Number. The same template will be used for both State and Local Agency Load Rating Summary sheets. **LR.XLTM** contains all the code necessary to run the built-in VBA modules (no separate file is required).

Note: The practice of starting with a complete summary workbook from a previous bridge as a seed file instead of beginning with a blank LR.XLTM template is discouraged. Eventually, the practice of copying seed files from previous load ratings will result in lingering errors from old data, a summary workbook that does not function properly, or one that does not report results consistent with current standards. Always begin a new bridge with a fresh LR.XLTM template. With the possibility of continuing development of the template or changes in reporting requirements, occasionally the template will be updated on the [redacted] FTP site, and users will be notified to retrieve the updated file. Note: due to truck name changes required by the anticipated consolidation of BRASS-Girder(STD) and BRASS-GIRDER(LRFD), a different version of **LR.XLTM** is required for use with BRASS-GIRDER(LRFD) Version 7.4 and later. To maintain backwards compatibility with old load ratings, both the old and new versions of **LR.XLTM** are stored in separate folders on the [redacted] FTP server.

15.4.2 Summary Workbook Features

The Load Rating Summary Workbook is divided horizontally into the Load Rating Summary Report (Page 1) and the Load Rating Worksheets (Pages 2 and above). The Rating Factors and section information for each investigated section are listed in the Load Rating Worksheets with one column allocated to each investigated section (8 sections per page). This information is summarized by copying the most critical and second most critical sections for each rating vehicle into the Load Rating Summary Sheet (Page 1), by clicking on the **Refresh** button or typing Ctrl-r.

The Load Rating Summary Report (Page 1) is divided vertically into a Bridge Header Area (top half) and the Controlling Rating Factor Area (bottom half). The Header Area contains basic National Bridge Inventory information and certain parameters that may have an influence on the outcome of the Load Rating. The Controlling Rating Factor Area lists the rating vehicles and their live load Factors along the left edge and two groups of columns for the 1st and 2nd controlling members. Each group of columns provides the Rating Factor (R.F.), Limit State, force type (+M,-M or V), combined Resistance Factor (Φ), member description, span and location of the investigated section. Note the Φ column heading refers to the combined Resistance Factor $\Phi = \phi\phi_c\phi_s$.

In both the Load Rating Summary Report (Page 1) and the Load Rating Worksheets (Pages 2 and above) of the Load Rating Summary Workbook, the rating vehicles are divided into horizontal bands (groups of rows) for Design and Legal Loads, CTP (Continuous Trip Permit) Vehicles, and STP (Single Trip Permit) vehicles. The bottom band of rows provides additional Rating Factors for a single lane of STP vehicles as “fall-back” positions for unsuccessful multiple-lane STP ratings. This is accomplished by adjusting the Rating Factor for multiple lanes by multiplying by the ratio of live load distribution factors (γ_L) and dividing out the multiple presence factor (m) that was originally included in the live load distribution factor (gm) by default. The last row of each group of STP vehicles is labeled “SPECIAL” and is reserved for evaluation of a specific super-load permit vehicle (one that exceeds MCTD Tables 4 or 5). When evaluating a super Load, “SPECIAL” in cell R54C2 is overwritten with a specific permit vehicle designation, ideally one that matches the truck name that has been added to the BRASS Vehicle Library. This new designation is then echoed to other appropriate cells.

15.4.3 Header Information

In the comments section document the following: “This rating is based on [redacted] LRFR Chapter 8, Load Rating Concrete Bridges without Existing Plans. The bridges capacity could not be calculated. Rating factors were computed based on live load moment comparison and bridge condition.”

In the Bridge Header Area (upper half) of the Load Rating Summary Report, enter all the required bridge inventory and inspection information in the input (boxed) cells. Use the Bridge Name as defined in the Definitions, Article 1.3.3 of this Manual.

For the Bridge Number, NBI Feature Intersected (Item 6), Bridge Name, Highway Name, Highway Number, Milepost, District, County, Design loading, Owner, Span Description, Other Description, Firm, Engineer, Year of ADTT, Elements 325 and 326, and NBI Status Items #41 and #103, the information must be entered as text.

To ensure data consistency when the Summary Workbook information is imported into the Load Rating Database, please note the following:

- In the "SPAN DESCR" cell, show only the span description (sequential list of span lengths and structure types from the Bridge Log).
- In the "FIRM QC REVIEWER(S)" cell, input the name or names of the individuals who participated in the checking process.
- The "[redacted] QC CHECK BY" cell, is reserved for [redacted] personnel. Upon submission of a load rating [redacted] will perform a cursory review of the load rating. Once finishing the check insert your name verifying that the check was performed.
- In the "OTHER DESCR" cell, put all other descriptions that may define the structure (e.g. sidewalk information, overlay information, deck-to-streambed distance, skew, seismic or metric design note, etc.)
- In the "HIGHWAY NAME" cell, for state-owned bridges use the list in this location:
- http://www.[redacted]gov/[redacted]TD/TDATA/rics/docs/2010AlphaNumericHighways.pdf
- In the "HIGHWAY #" cell, enter NBI Item 122 (found in the upper-left corner of the SI&A sheet).
- In the "MILEPOST" cell, enter only the numeric value, without any alphabetic prefix or suffix.
- In the "ADT" and "ADTT" cells, enter the total ADT and ADTT on the entire structure, i.e. the 2-way ADT for a 2-way structure and the 1-way ADT for a 1-way structure. Note - this is for database purposes only, and is *not* the same as the one-direction ADTT that is used to determine live load factors for the load rating.
- Several of the input (boxed) cells are provided with drop-down boxes to limit input choices. In the case of the "DESIGN LOADING" cell, note that some bridge plans will show "H20 – S16" loading, which is the same as HS20 loading. Also note that an "HS" loading is *not* the same as the "H" loading with the same number of tons. Refer to the ***AASHTO Standard Specifications for Highway Bridges*** (2002), Article 3.7, for the older design loadings.
- Where the text begins with a number (Highway Number, Year of ADTT), ensure that Excel treats the cell entry as text by preceding it with an apostrophe.
- For State Bridges, the Highway number is 3 characters, including leading zeros if needed. (For example, Hwy "1" is entered as "001").
- Enter single dates only, in the form MM/DD/YYYY. Do ***not*** use the Excel TODAY() or NOW() function – dates should reflect when the main load rating work was performed, and should not change whenever someone opens the file.
- For State-owned bridges, in the "OWNER" cell enter "[redacted] and in the "CALCULATION BOOK" cell enter a calculation book number obtained from the Bridge Section Load Rating Unit. For Load Ratings, always use a calculation book that is separate from the calculation book for design calculations.
- For non-state-owned bridges, to determine what to enter in the "OWNER" cell, use NBI item 22 (2-digit Owner Code) in conjunction with NBI Item 3 (County) or 4 (5-digit Place Code, also known as the FIPS Code). The value of these fields are found in the Structure Inventory and Appraisal Sheet (SI&A) that accompanies the Bridge Inspection Report, and a table of FIPS Codes for [redacted] can be found among the load rating references and tools. For example, for a local agency bridge having an Item 26 of "04" (city or municipal highway agency) and an Item 4 of "22550" (Elgin), in the "OWNER" cell the user would enter "City of Elgin". For a local agency bridge having an Item 22 of "02" (county highway agency) and an Item 3 of

"Clackamas", in the "OWNER" cell the user would enter "Clackamas County". Please note that Items 3 and 4 are not to be used by themselves to determine ownership, because they describe only location, regardless of ownership.

- Use the optional "Comments" area to document any unusual decisions or features about the Load Rating (maximum 250 characters).
- The cells for Impact (1+I) and the dead load factors γ_{DC} and γ_{DW} are provided with their usual default values (they can be changed if necessary). The cells for the number of sections evaluated, and the Inventory and Operating Ratings in HS tons are calculated automatically when information is available. The cell for NBI Item 70 is calculated according to the NBI coding guide using LRFR Equation 6-7 (Article 6.8.3) for the recommended level of posting.

15.4.4 Inserting Rating Factors

Do not use the automated import rating factor tools. The rating factors reported by BRASS are not relevant to this analysis. Instead manually type the rating factors as they were calculated in the SUPERSTRUCTURE.xmcd file. The rating factors will have to be input in the first analysis section column. The refresh button can then be used to copy the rating factors to the first page the summary sheet. An example of the manually input rating factors is shown below:

SECTION EVALUATED	**1**
LRFD Brass .OUT File Name:	Superstructure.xmcd
FORCE TYPE (+/-M, V, T, C or B):	+M
PHI (Resistance Factor):	1.00
MEMBER (eg. Int. girder):	Superstructure
SPAN (eg. 1 of 4):	1 of 1
LOCATION (eg. 0.1L):	Max Moment
SINGLE LANE DF	1.000
MULTI-LANE DF	1.000
DESIGN & LEGAL VEHICLES	
HL93 (INVENTORY)	0.68 St1
TYPE 3 (50K)	1.00 St1
TYPE 3S2 (80K)	1.00 St1
TYPE 3-3 (80K)	1.22 St1
TYPE 3-3 & LEGAL LANE	
TYPE 3-3 TRAIN & LEGAL LANE	
SU4 TRUCK (54K)	**0.87 St1**
SU5 TRUCK (62K)	**0.83 St1**
SU6 TRUCK (69.5K)	**0.80 St1**
SU7 TRUCK (77.5K)	**0.80 St1**

The summary sheet will automatically calculate the Inventory and Operating tonnage values. Rating factors for permit loads will not be calculated at this time.

[redacted] DEPARTMENT OF TRANSPORTATION

STRUCTURE AND BRIDGE DIVISION

INSTRUCTIONAL AND INFORMATIONAL MEMORANDUM

GENERAL SUBJECT: Load Rating and Posting of Structures (Bridges and Culverts)	NUMBER: IIM-S&B-86.2
SPECIFIC SUBJECT: N/A	Date: December 13, 201X
	SUPERSEDES: IIM-S&B-86.1
DIVISION ADMINISTRATOR APPROVAL:	/original signed/ [redacted] State Structure and Bridge Engineer Approved: XXXXXX XX, 201X

Changes are shaded.

EFFECTIVE DATE:

This Memorandum is effective on xxxx xx, 2018.

PURPOSE

To establish guidelines for load rating and posting of structures (bridges and culverts).

SCOPE

Individuals or entities performing load rating services for the [redacted] Department of Transportation ([redacted] shall adhere to the requirements herein. Entities must meet Federal and State statutory and regulatory requirements. [redacted] preferences and guidance are strongly encouraged to provide consistent treatment to motorists statewide.

The [redacted] Load Rating Manual (in the publication process) can be used in conjunction with this policy document. It is intended to provide additional guidance and clarifications on the intent of the policy statements in this IIM, but will not supersede any policy directive of this IIM.

ANALYSIS METHOD, SOFTWARE REQUIREMENTS AND LOAD RATING PROCESS

The load rating of all structures shall be performed in accordance with these guidelines and the latest American Association of State Highway and Transportation Officials (AASHTO), "*Manual for Bridge Evaluation*" (MBE). All load rating analyses shall use the Load and Resistance Factor Rating (LRFR) method, except for those structures noted under either the "SPECIAL CRITERIA" or "SAFE POSTING LOAD" sections below.

Typically, only superstructure elements, including integral pier caps, require load ratings, except as follows:

- Decks shall be evaluated where the condition or geometry (supported by two girders/beams or single cell box, excessive span between girders/beams, etc.) of the deck is suspected to govern the load rating.
- Substructure elements shall be evaluated where the condition or geometry of the substructure element(s) are suspected to govern the load rating. Scenarios of where substructure element conditions may prompt a load rating include extensive section loss, scour/undermining, settlement, collision damage and as needed for reviewing over weight load permit requests. Timber substructures (i.e. Bent Caps) can often control the load rating for a structure.
- Should any primary load carrying member or detail be suspected of not performing up to its design capacity, that member or detail shall be considered in the overall structural analysis.
- Unless otherwise directed by the Assistant District Structure and Bridge Engineer for Safety Inspection, the Load Rating Program Manager, or their designee(s), cross frames in curved girders and in highly skewed bridges need not be rated.

Newly designed steel structures shall not be load rated using plastic analysis. Steel Superstructures that are completely replaced above the substructure shall not be load rated using plastic analysis.

Repaired superstructure concrete decks that have been rotomilled or hydromilled for the full transverse and longitudinal length of the carriageway may be considered effective for the full depth of the deck, unless in the opinion of the engineer, evidence exists to reduce the effective depth of the composite section.

AASHTOWare Br|R® software shall be used for load rating bridges, except as follows: Steel curved girders shall be rated using DESCUS® software. Ratings of all other structures that are beyond the capabilities of BrIR® and DESCUS including segmental or/and spliced Bulb Tee sections shall be completed using LARSA 4D. Other software platforms may be used in exceptional circumstances with prior approval of the Load Rating Program Manager. All structures analyzed in LARSA 4D or other exceptional use software shall be rated for the additional special permit vehicles available by emailing haulingpermits@[redacted]gov.

Information regarding the current [redacted] approved version of AASHTOWARE Br|R®, DESCUS® and LARSA 4D may be found on the [redacted] Structure and Bridge web site under "Useful Information."

When using Br|R®, each bridge shall be entered as a system of girders, not as single structural elements (line girder analysis). In addition, a bridge alternative(s) must be defined and appropriately marked to allow for the load rating to be run from the Bridge Explorer window. After each significant change in condition, collision incident and/or construction event (including As-Built conditions, maintenance/rehabilitation activities, etc.) a new bridge alternative shall be developed and the structure re-rated.

Culverts shall be evaluated using current guidance and load rating principles included in Appendix A of this document.

WHEN LOAD RATINGS ARE REQUIRED

An updated or new load rating will be required in accordance with the table below.

Reason for Rating	Timeframe to Complete	Commentary
New structures Widenings Superstructure replacements Deck Replacements Repairs/Rehabilitation[4]	As-designed load rating(s) shall be submitted with final plan submissions For Design-Build, P3 or similar processes, as-designed load rating(s) shall be submitted as part of the process to obtain plan approval before superstructure construction begins The As-Built load rating shall be submitted within 90 days after opening the structure or portion of the structure to traffic [1], [3]	Where applicable, the load rating shall accurately model all stages of construction
Changes in loading (overlay, etc.) and changes in condition due to deterioration[5] (section loss, etc.), repairs, rehabilitation, and collision damage.	Within 90 days after becoming aware of the change [1], [2], [3]	

[1] If the changes in loadings or conditions (including shop drawings review or As-built) are significant, the changes shall be evaluated immediately by the District Structure and Bridge Engineer or their designee. As a precautionary measure, engineering judgment may be used to lower the load rating capacity of the structure for the safety of the traveling public until the load rating is performed. This determination shall be recorded in the load rating documentation.

[2] For complex and unusual structures, the deadline may be extended as approved by the Assistant State Structure and Bridge Engineer for Safety and Inspection as necessary to initiate a load rating contract. Until a contract can be initiated, the District Structure and Bridge Engineer or their designee as a precautionary measure may exercise engineering judgment to assign the load rating capacity of the structure.

[3] All load rating values that are entered into the bridge inventory, from engineering calculation, or if lowered by engineering judgment, shall be sealed and placed in the bridge file.

[4] Any temporary measure left in place under live traffic during a repair, such as jacking and blocking, shall be evaluated to determine if it controls the rating for the affected portion of the structure while in place. All conditions that lower the controlling rating shall be reported to the permitting section 30 days prior to being in place along with the expected duration and dates of the temporary condition. Item 103 in the inventory shall be coded appropriately for temporary conditions.

[5] An updated load rating shall be considered for all structures when the Superstructure or Culvert General Condition Rating (GCR) drops to 4.

As a part of each structure's regular safety inspection, the District Structure and Bridge Engineer or their designee will determine if the load rating on file reflects the current capacity of the structure and will be responsible for updating the load rating as necessary. If a new load rating is not warranted, this determination shall be recorded in the "Structural Analysis" section of the safety inspection report.

DOCUMENTS REQUIRED FOR LOAD RATINGS

The District Structure and Bridge Engineer or their designee is responsible for ensuring that all supporting documentation is available to rate the structure in its current condition. At a minimum, the following information is required:

- Plans or drawings/sketches of a structure (including original and rehabilitation plans)
- Latest safety inspection report
- The average daily traffic (ADT) and percent truck traffic
- Prior load rating files (as applicable)

If there is insufficient documentation to load rate a structure (i.e. missing or incomplete data regarding field conditions, size of structure elements or the geometry of the structure), a site visit may be warranted to complete the load rating. See the "SPECIAL CRITERIA" section below for additional guidance.

SPECIAL CRITERIA

I. BRIDGES WITH UNKNOWN DETAILS

For bridges where necessary details for load rating are not available from plans or field measurements (e.g. concrete bridges with unknown reinforcement); knowledge of the live load used in the original design, the current condition and/or live load history of the structure may be used to provide a basis for assigning a safe load capacity. The assumptions made to determine the safe load capacity shall be documented on the [redacted] Load Rating Summary Form (SB502).

Additionally, load tests may be performed to establish a safe load capacity of such bridges.

In general, concrete bridges with unknown reinforcement details need not be posted for restricted loading if they have been carrying normal traffic and show no signs of distress. For simple span structures, see Appendix B for determining rating capacities. Normal traffic is generally considered to be the [redacted] legal loads, but specific knowledge or engineering judgment on a case by case basis, at the discretion of the District Structure and Bridge Engineer or their designee may be appropriate for establishing the baseline loading case for concrete bridges with unknown reinforcement details. For other requirements on restrictions, see sheet 13 for the "INSTRUCTIONS FOR STRUCTURE RESTRICTION AND POSTING" section below.

II. FATIGUE ANALYSIS

Fatigue analysis and fatigue evaluation are generally not required when performing a load rating analysis. Fatigue may warrant consideration in conjunction with section losses in some bridge systems at the discretion of the District Structure and Bridge Engineer or their designee.

III. TRUSS AND STRINGER/FLOORBEAM BRIDGE SYSTEMS

Bridges whose superstructure elements include trusses and/or stringer/floorbeam systems may be rated using Load Factor Rating (LFR) until Br|R® has the capability to rate these elements in LRFR.

IV. SEGMENTAL AND/OR SPLICED BULB TEE STRUCTURES

This IIM is not intended to replace AASHTO MBE, AASHTO LRFD, [redacted] Specifications, Post Tensioning Institute (PTI), American Segmental Bridge Institute (ASBI) or other [redacted] requirements. It is to clarify issues related to post-tensioning, supplement existing requirements, and provide guidance for rating a structure that will carry traffic for 75 or more years.

Analysis requirements:

New Structures: Principle stresses shall be evaluated for all post-tensioned structure webs, joints, or D-regions using LRFR/LRFD

Design Load Rating Requirements:

The design shall incorporate all IIM-S&B-80 modifications.

Losses:

Losses due to elastic shortening shall be calculated in accordance with AASHTO LRFD 7th Edition (2014) Article 5.9.5.2.3

Time-dependent losses shall be computed in accordance with AASHTO LRFD 7th Edition (2014) article 5.9.5.4 for time-dependent losses, even when another method is allowed by AASHTO.

At Pre Award Construction (PAC), or when the plans are submitted to be approved for construction, the Engineer of Record (EOR) shall submit a sealed rating which meets the following two additional requirements to those established elsewhere in this IIM:

Ideal condition:

For the as-designed condition, the structure shall be rated in a bonded state for all tendon ducts filled with grout. The controlling rating factors for all loadings prescribed by this IIM shall be greater than 1.0.

For the as-designed condition, in an unbonded state for all tendon ducts filled with flexible filler, the controlling rating factors for all loadings prescribed by this IIM shall be greater than 1.0.

Corroded condition:

In addition to IIM-S&B-80 requirements, the designer shall consider the loss and replacement of all original tendons where flexible filler is required. Loss of tendons shall be considered one at a time. The failure of any one tendon shall not result in any rating condition defined by this IIM having a Rating Factor (RF) less than 1.0.

Existing Structures: Structures designed and opened prior to January 1, 2007 may be rated using LFR. Principle stresses, and other serviceability checks, may be considered, but the final rating may be based on the strength of the member.

GENERAL CRITERIA FOR LRFR

All factors and methodology that are not discussed in this document shall be as defined in the AASHTO Manual for Bridge Evaluation (MBE).

The following factors shall be as defined in the same version of the AASHTO LRFD Bridge Design Specifications with any modifications that are in use by the Department at the time of rating.

- Live load distribution factors
- Dead load distribution factors
- Dynamic Load Allowance (IM, impact factor); and no reduction shall be applied for riding surface conditions.

LIMIT STATES: The following table shows applied limit states for LRFR.

Bridge Type	Limit State	Design	Legal /SHV	Permit
		HL-93 HS-20	[redacted] **Type 3,** [redacted] **Type 3-S2, EV2, EV3, SU4, SU5, SU6, SU7, NRL**	**BP-90, BP-115**
Steel	Strength I	✓	✓	
	Strength II			✓
	Service II	✓	✓	✓
Reinforced Concrete	Strength I	✓	✓	
	Strength II			✓
	Service I			✓
Prestressed Concrete (non-segmental)	Strength I	✓	✓	
	Strength II			✓
	Service III	✓[6]	✓[7]	
	Service I			✓
Prestressed Concrete (segmental)	Strength I	✓	✓	
	Strength II			✓
	Service III	✓	✓	
	Service I			✓
Timber	Strength I	✓	✓	
	Strength II			✓

(6) For non-segmental Prestressed Concrete bridges, Service III need not be checked for HL-93 at the Operating Level as Service III is a Design level check for crack control in prestressed components.

(7) While the Service III limit state is appropriate to consider in non-segmental Prestressed Concrete bridges that exhibit cracking, Service III may be considered optional at the discretion of the District Structure and Bridge Engineer for legal loads in non-segmental Prestressed Concrete bridges.

CONDITION FACTOR: Unless otherwise specified by the District Structure and Bridge Engineer, the following condition factors shall be used in load rating bridges:

Structural Condition of Member	Condition Factor
Good/Satisfactory/Fair	1.00
Poor	0.9

The factors in this table are from MBE Table 6A.4.2.3-1 adjusted upward by 0.05 for section properties that are accurately verified by field measurements.

VEHICLE CONFIGURATIONS FOR LOAD RATING

As defined below and/or as defined in the MBE, all structures shall be evaluated for the following vehicles except as noted:

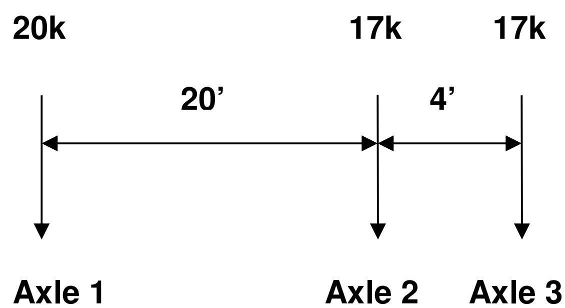
I. DESIGN LOAD:

a. HL-93 (only used for LRFR ratings)
b. HS-20

II. LEGAL LOAD:

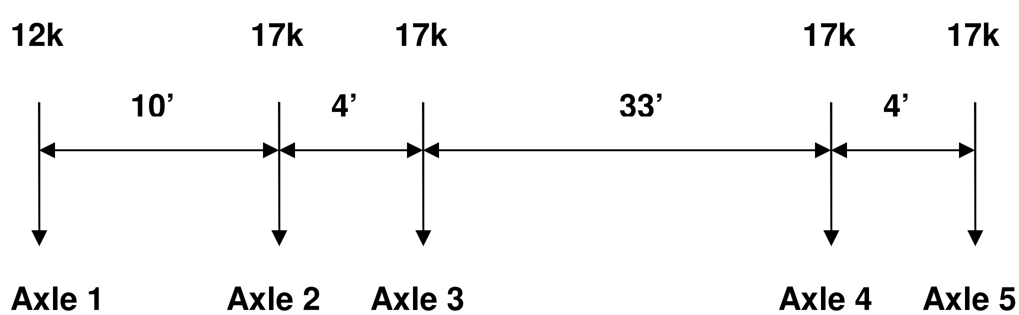
a. [redacted] Legal Loads

1. [redacted] Type 3 (Single Unit Truck)



GVW = 27 Tons, CG is 13.85' from Axle 1

2. [redacted] Type 3S2 (Truck and Semi Trailer)



GVW = 40 Tons, CG is 25.92' from Axle 1

b. AASHTO Lane-Type Legal Loads for structures meeting the criteria below. (only used for LRFR ratings)

- Negative moment and interior reaction for all span lengths
- Spans greater than 200 ft.

c. AASHTO Specialized Hauling Vehicles (SHV)

1. SU4
2. SU5
3. SU6
4. SU7
5. Notional Rating Load (NRL)

d. Fixing America's Surface Transportation (FAST) Act (Public Law 114-94)

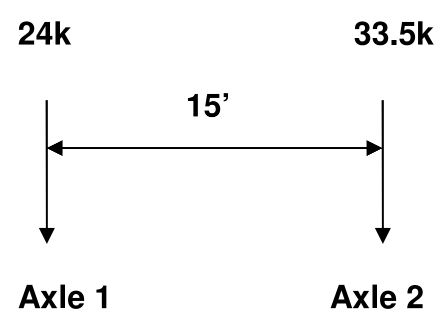
Load Ratings for the FAST Act vehicles in this section shall be performed for all bridges in accordance with *Code of* [redacted] § 46.2-1102. The rating shall be done at the Operating (LFR and ASR [for Timber or Masonry members]*) or Legal Load Rating (LRFR) level in accordance with the methods specified in the AASHTO MBE with two exceptions:

* While FHWA's policy exception remains in place.

1. Multiple presence: If necessary, when combined with other unrestricted loads for rating purposes, the emergency vehicle needs only to be considered in a single lane of one direction of a structure.
2. Live load factor: A live load factor of 1.3 should be utilized in the LRFR or LFR methods.

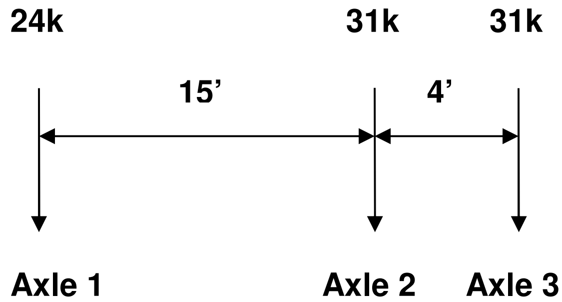
Posting of the FAST Act vehicles will be discussed separately.

1. Emergency Vehicles (EV2 and EV3)
   - EV2



GVW = 28.75 Tons

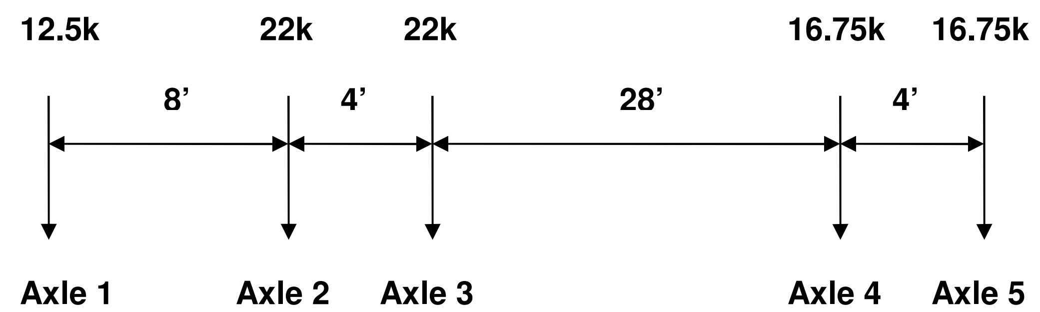
- EV3



GVW = 43 Tons

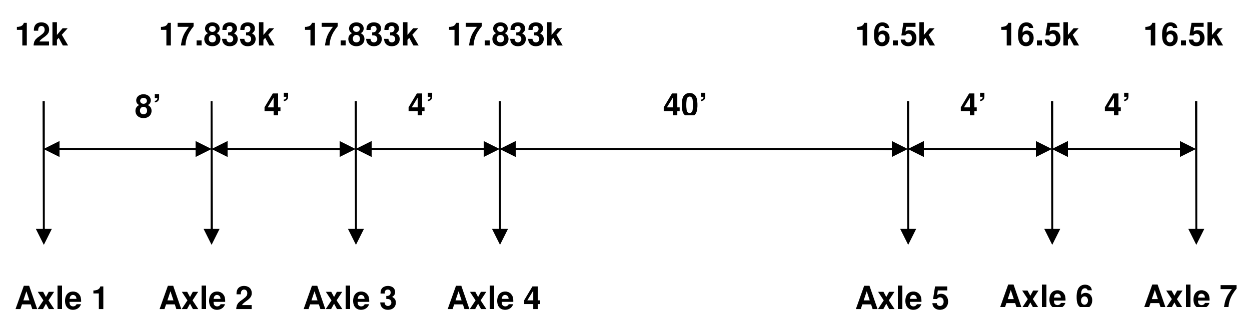
III. PERMIT LOAD:

e. BP-90: 90,000 lb vehicle



GVW = 45 Tons, CG is 20.52’ from Axle 1

f. BP-115: 115,000 lb vehicle



GVW = 57.5 Tons, CG is 31.41’ from Axle 1

SAFE POSTING LOAD

LRFR METHOD:

- When the RF for one or both [redacted] Legal Loads is < 1.0, the structure shall be posted[8]:

- If the RF ≥ 1.0 for the [redacted] Legal Loads (Type 3 and 3S2) and the RF < 1.0 for NRL, a posting analysis will be performed to resolve posting requirements based on the capacity ratings of the [redacted] Legal Loads and the Specialized Hauling Vehicles.

- In LRFR, the safe posting load of Legal Load, Specialized Hauling, and FAST ACT vehicles shall be based on the legal load rating value.

- The posting of the Fast Act Vehicles is by Gross Weight, Tandem Weight pro-rated by the Rating Factor (RF) and Single Axle pro-rated by the RF. Additional posting guidance is provided by the FHWA in their Q&A document published March, 2017. Please see item 31. https://www.fhwa.dot.gov/bridge/loadrating/fast1410_qa.pdf

LOAD FACTOR RATING (LFR) METHOD:

For structures not designed using LRFD and where a load rating in LRFR results in a lower rating capacity or rating factor than when using other evaluation methods (LFR / engineering judgment), or vice versa **and** this situation affects the posting condition of the structure; the District Bridge Engineer or designee may determine which method (LRFR / LFR / engineering judgment)** of evaluation will be used for rating. This decision shall be documented on the Load Rating Summary Form for Structures (SB502) and only the ratings and/or rating factors for the method of evaluation used will be entered in the form.

In LFR, The safe posting load of Legal Load and Specialized Hauling Vehicles shall be as follows[8]:

- Steel or timber superstructures - the capacity at a load level midway between inventory and operating shall be used[8].
- Concrete superstructures - the capacity at the operating level shall be used.
- If the HS20 Operating load < 3 Tons, the bridge shall be closed[8].

Equivalent Capacity Coefficients for various trucks and simple span lengths are shown in Appendix B of this document with an example in Appendix C.

The methodology/actions taken to arrive at the safe posting load shall be documented. In special situations, which shall be documented on the Load Rating Summary Form for Structures (SB502), engineering judgment may be used to post or not post a structure.

** Note: Timber and masonry members may still be rated in ASD per FHWA's policy exception while it remains in place.

(8) See page 15 for Note 8.

INSTRUCTIONS FOR STRUCTURE RESTRICTION AND POSTING

In accordance with the "SAFE POSTING LOAD" section above, if the Rating Factor (RF) for any Specialized Hauling Vehicle is less than 1.0, that structure shall be posted for the safe posting load(s) for the legal and Specialized Hauling Vehicles.

Structures which require a weight restriction for the five-axle, BP-90 (45 ton blanket permit vehicle) at operating level shall be posted for legal vehicles[8].

Structures which do not require a weight restriction for the BP-90, but do require a weight restriction for the seven-axle, BP-115 (57.5 ton blanket permit vehicle) at operating level shall be denoted on the Restricted Structures Map if located on an interstate or primary in accordance with the current IIM-S&B-35 with a symbol of "45T" and State Item 50 in the inventory system shall be coded 'T'[8].

Bridges that do not have plans of their structural details, have been carrying traffic for a substantial length of time, and do not show signs of distress need not be posted; However, these structures shall be denoted on the Restricted Structures Map with a symbol of "45T" and State Item 50 in the inventory system shall be coded 'T'[8].

Structures that have gusset plates on main members shall have all gusset plates rated. Where the gusset plate rating controls the rating of the structure, all capacity and posting decisions for the structure shall be determined from the gusset plate rating.

Concrete slab span structures are rated for interior and exterior strips. The rating for the exterior strip need not control the rating of the structure if it is not located in the travelway.

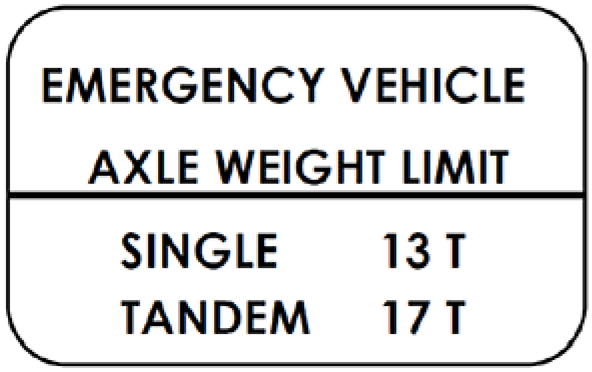
The R12-V2 Sign may be annotated as follows:

2-3 Axles………………… Use the [redacted] 27 Ton Vehicle
4-5 Axles………………… Use the minimum of the SU-4 and SU-5 vehicle
6+ Axles…………………. Use the minimum of the SU-6 and SU-7 vehicle
Semi……………………… Use the [redacted] 40 Ton Vehicle[3]

If the load posting values are 15 Tons and below, consideration should be given to using a R12-1 sign with a single tonnage called out. [8]

For the FAST Act Emergency vehicles in section II.) d., when a load rating results in a rating factor less than 1.0 for LFR or LRFR, the bridge shall be appropriately posted for both the governing single axle weight limit and tandem axle weight limit derived from the emergency vehicle configurations. (23 CFR 650.313(c)). When posting is necessary, the following sign formats using the appropriate weight limits may be considered. Additional posting guidance is provided by the FHWA in their Q&A document published March, 2017. Please see item 31. https://www.fhwa.dot.gov/bridge/loadrating/fast1410_qa.pdf

[(8)] See page 15 for Note 8.



Information regarding restrictive signage may be found in the current IIM-S&B-27 and for the Restricted Structure Atlas may be found in the current IIM-S&B-35.

(8) The District Structure and Bridge Engineer or his/her designee may elect to assign loads using Allowable Stress Design or engineering judgment for posting purposes. This shall be sealed and documented along with any rating and posting values provided by LFR or LRFR analysis methods and placed in the bridge file.

REQUIRED DOCUMENTATION

All supporting documentation regarding the load rating of a structure shall be placed under the Multi-Media attachments for the corresponding structure in the Br|R® database.

Every structure shall have a Br|R® file in the [redacted] database. If a structure is rated by a means other than Br|R® (e.g. DESCUS or LARSA), the file in the database shall give clear guidance where the appropriate deliverables are to be found.

STRUCTURES RATED IN Br|R®

A typical Br|R® load rating analysis submittal includes the following deliverables electronically:

1. A Br|R® XML export file for [redacted] database, for which the load rating can be run from the Bridge Explorer Window
2. Signed and Sealed, PDF of the completed Load Rating Summary Form for Structures (SB502) with all of the assumptions clearly stated. PDF may be signed and sealed electronically in accordance with the current IIM-S&B-79.
3. Screenshot of "Bridge Rating Results" from Br|R®
4. Hand calculations of the dead loads, live load distribution factors, and assumptions as needed in Microsoft Word or Excel, Mathcad, or PDF format. Excel and/or Mathcad are preferred.
5. If applicable, standard plan sheets (in TIFF or PDF format) used for load rating

Consultants performing load ratings for [redacted] may have additional requirements as specified in the Memorandum of Agreement and/or Letter of Agreement.

STRUCTURES NOT RATED IN Br|R®

For the structures that are not rated in Br|R®, an independent load rating report is required. The load rating report shall include the Load Rating Summary Form for Structures (SB502) with all assumptions clearly stated, the standards and/or plans and which type of software, including version, was used for the load rating. In addition, a brief description of how the evaluation was performed and the analysis documentation (or where it is located) shall be placed into the Br|R® file in the [redacted] database for the structure. As appropriate, hand calculations and/or the electronic input and output of the software program used shall be noted in the report; including the controlling rating and conditions (force and location) for all rated members clearly identified in a table format.

QUALITY CONTROL AND QUALITY ASSURANCE PROCESS

Load ratings shall be performed and checked by different persons. One of the individuals (rater / checker / reviewer) shall be a Professional Engineer in the Commonwealth of [redacted] who will sign and seal the Load Rating Summary Form for Structures (SB502).

The quality control (QC) review will verify that appropriate assumptions were made to develop the load rating, calculations were performed correctly and any discrepancies were satisfactorily addressed.

The quality assurance (QA) review will verify that the load rating analysis, including the load rating output and calculations, has been performed, checked and/or reviewed by a Professional Engineer in the Commonwealth of [redacted] and assure that the results and assumptions are reasonable.

LOAD RATING PERFORMED BY [redacted] PERSONNEL

QC and QA reviews are required for all load ratings performed by [redacted] personnel. QC reviews will be performed by the checker, and QA reviews will be performed by the checker or an independent reviewer.

LOAD RATING PERFORMED BY CONSULTANTS

District personnel shall perform QA/QC reviews of load ratings developed by consultants. QC shall be performed for a minimum of five percent (5%) of the load ratings performed in a calendar year. QA reviews shall be performed for all load ratings.

LOAD RATING SUBMITTED BY THE LOCALITIES

The District Office should receive a signed and sealed copy of the load ratings provided by the localities, municipalities and other entities. QA reviews shall be performed for all the bridges.

UPDATING INVENTORY RECORDS

Updating the inventory signifies that the load ratings have been accepted by the District Office. The table below summarizes the coding guidance for some of the Federal and State items. For a structure, all vehicle ratings and safe posting load shall be from one method of analysis (i.e. LRFR or LFR or Engineering Judgment).

	LRFR	**LFD**	**Engineering Judgment**
FED ITEM 63	3	1	0
FED ITEM 64	HS20 OPR Ratings	HS20 OPR Ratings	See Appendix C
FED ITEM 65	3	1	0
FED ITEM 66	HS20 INV Ratings	HS20 INV Ratings	See Appendix C
STATE ITEM 47	O	O for Concrete M for steel	O
STATE ITEM 48	R	L	A
	SU4 Ratings	SU4 Operating Ratings	See Appendix C
	SU5 Ratings	SU5 Operating Ratings	See Appendix C
	SU6 Ratings	SU6 Operating Ratings	See Appendix C
	SU7 Ratings	SU7 Operating Ratings	See Appendix C
	NRL Ratings	NRL Operating Ratings	See Appendix C
	EV2 Ratings	EV2 Operating Ratings	See Appendix C
	EV3 Ratings	EV3 Operating Ratings	See Appendix C

In addition, Central Office load rating personnel will perform QA and QC reviews, which will be at a minimum, one bridge per District per quarter.

All QC reviews must be documented along with any findings.

CC: Chief Engineer
Deputy Chief Engineer
Division Administrators
District Administrators
District Construction Engineers
District Maintenance Engineers
Assistant State Structure and Bridge Engineers
District Structure and Bridge Engineers
Residency Administrators
Structure and Bridge Program Managers

[redacted]

Structure and Bridge

LOAD RATING SUMMARY FORM FOR STRUCTURES

Rte.:

Over:

[redacted] Structure No.:

FED. ID:

County:

District:

Rated By: Date:

Checked By: Date:

[redacted] Reviewer: ______________

PE Seal

SIGNATURE:____________________
NAME: ______________________

CALCULATION TOOLS AND METHOD USED:
REASON FOR RATING:

	GVW (TONS)	RATING	CONTROLLING MEMBERS	CONTROLLING LOCATION	CONTROLLING FORCE
DESIGN LOAD		FACTOR			
HL-93 (INV)	N/A		***		
HL-93 (OPR)	N/A		***		
		TONS			
HS-20 (INV)	36				
HS-20 (OPR)	36				
LEGAL LOADS		TONS	**		
[redacted] Type 3	27				
[redacted] Type 3S2	40				
*LANE	40		***		
PERMIT LOAD		TONS			
BP-90	45				
BP-115	57.5				
SH VEHICLES		TONS			
NRL:	40				
SU4:	27				
SU5:	31				
SU6:	34.75				
SU7:	38.75				

* Not applicable for single spans less than and equal to 200 feet.
** FOR LFR or ASD: Denote if it is a mid range or operating level for posting and provide the safe posting load. ASD is only applicable for timber or masonry members.
*** Not applicable for LF/AS rating methods.

Firm name or logo

[redacted]

Structure and Bridge

LOAD RATING SUMMARY FORM FOR STRUCTURES

	GVW (TONS)	RATING	CONTROLLING MEMBERS	CONTROLLING LOCATION	CONTROLLING FORCE
EV2 VEHICLES		TONS			
Single Axle					
Gross Weight					
EV3 VEHICLES		TONS			
Single Axle					
Tandem Axles					
Gross Weight					

** FOR LFR or ASD: Denote if it is a mid range or operating level for posting and provide the safe posting load. ASD is only applicable for timber or masonry members.

Firm name or logo

[redacted]

Structure and Bridge

LOAD RATING SUMMARY FORM FOR STRUCTURES

INSPECTION REPORT USED FOR THIS RATING:

ASSUMPTIONS/COMMENTS BY LOAD RATING ENGINEER:

Sample of Completed Load Rating Summary Form

[redacted]

Structure and Bridge

LOAD RATING SUMMARY FORM FOR STRUCTURES

Route: Indian Village Trail (Route 666)
Over: Wolf Creek

VA Str. No.: 6061
FED. ID: 03124

County: Bland
District: Bristol

Rated By: CK — Date: Jul, 2010
Checked By: JR — Date: Jul, 2010
[redacted]eviewer: RFR
Calculation Tools/Method Used: Virtis 6.1
Basis for Rating: Conversion to LRFR

[redacted]

Signature: YOUR SIGNATURE
Name: YOUR NAME

	GVW (TONS)	RATING	CONTROLLING MEMBERS	CONTROLLING LOCATION	CONTROLLING FORCE
DESIGN LOAD		FACTOR			
HL-93 (INV)	N/A	1.161	Typical Exterior Girder	0.5L	Flexure
HL-93 (OPR)	N/A	1.506	Typical Exterior Girder	0.5L	Flexure
		TONS			
HS-20 (INV)	36	54.6	Typical Exterior Girder	0.269L	Flexure
HS-20 (OPR)	36	70.8	Typical Exterior Girder	0.269L	Flexure
LEGAL LOAD		TONS			
SINGLE	27	69.2	Typical Exterior Girder	0.269L	Flexure
TRUCK & SEMI	40	92.6	Typical Exterior Girder	0.269L	Flexure
*LANE	40	-	-		
PERMIT LOAD		TONS			
BP-90	45	86.6	Typical Exterior Girder	0.269L	Flexure
BP-115	57.5	115.2	Typical Exterior Girder	0.269L	Flexure
SH VEHICLES		TONS			
NRL	40	66.2	Typical Exterior Girder	0.5L	Flexure
SU4	27	63.1	Typical Exterior Girder	0.5L	Flexure
SU5	31	65.3	Typical Exterior Girder	0.5L	Flexure
SU6	34.75	65.6	Typical Exterior Girder	0.5L	Flexure
SU7	38.75	66.8	Typical Exterior Girder	0.5L	Flexure

* Not applicable for simple span less than 200 feet.

[redacted]

Structure and Bridge

ASSUMPTIONS/COMMENTS BY LOAD RATING ENGINEER:

Comments:

1. HS-20 Truck is the controlling HS-20 load case.
2. The controlling Design Loads (Inventory) and Legal Limit states are Strength I.
3. The controlling Design Loads (Operating) and Permit Limit States are Strength II.

Assumptions:

Bridge No: 03124 - 3 Span Steel Multi-Girder Bridge.

1. Material properties not noted in the plans are based on the year of construction. Materials used for the analysis are Structural Steel, ASTM A36, Grade 36, Cast-In-Place Concrete, Class A4, f'c =4.0 ksi, Reinforcing steel, Grade 40.
2. The slab thickness was reduced by 0.5" per [redacted] IIM-S&B-80 for composite properties.
3. Superimposed dead load was distributed uniformly to all girders.
4. LRFD Live load distribution factors were computed by Virtis.
5. 1¼" thick Latex or concrete overlay was used for IR Analysis. After scarifying ½" there is a net increase of ¾" to the deck thickness.
6. The LRFD effective slab width used for composite properties was the full tributary width as outlined in Section 4.6.2.6 of the AASHTO LRFD Bridge Design Specifications (2008 Interims).
7. The following deteriorations were taken into consideration in the IR Analysis:

Span 1 (Beam 4@Pier 1) 1.4% web loss 0' to 1.33'

Span 1 (Beam 5@Pier 1) 2.8% web loss 0' to 1.33'

Span 2 (Beam 5@Pier 1) 2.8% web loss 0' to 1.84'

Span 2 (Beam 2@Pier 2) 1.7% web loss 0' to 2.0'

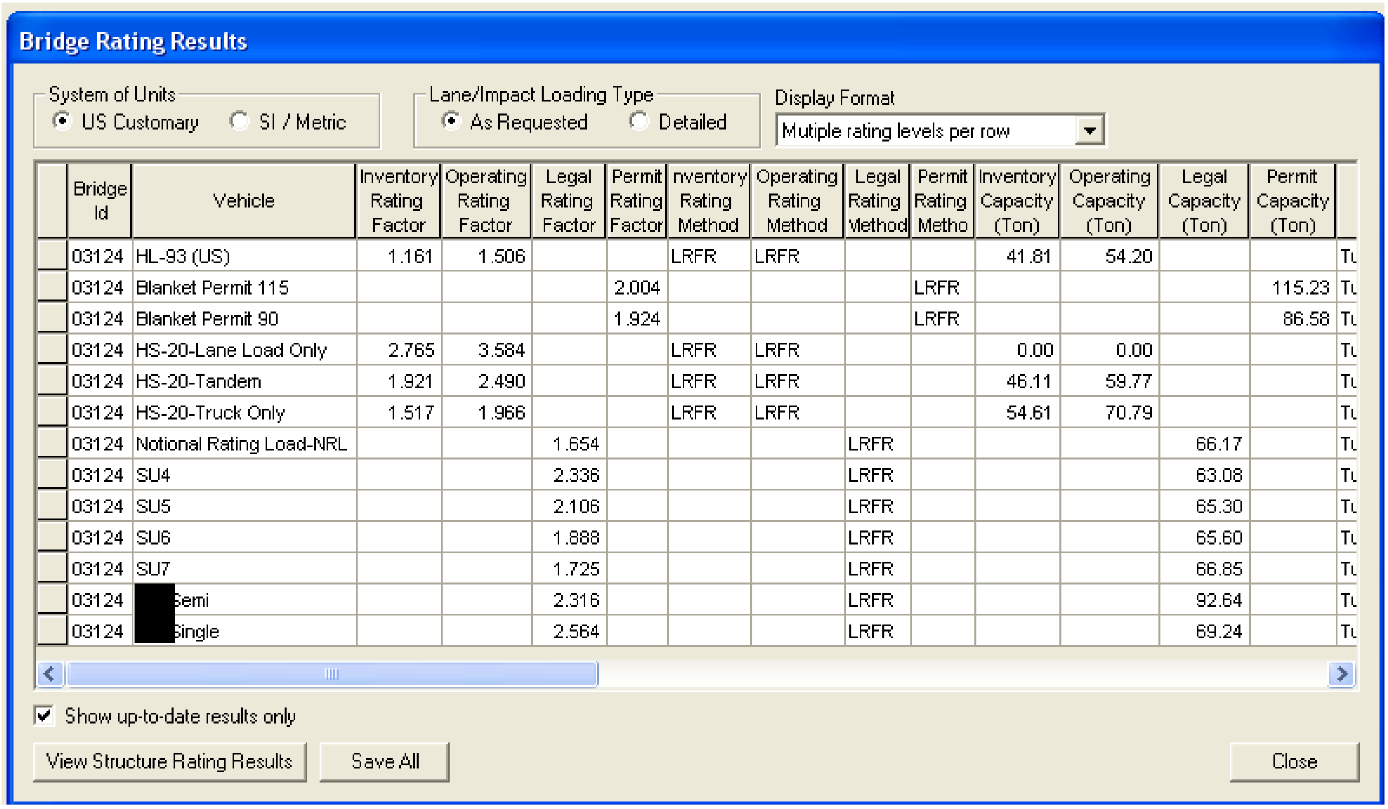
Span 2 (Interior Beams) 15% Bottom flange loss 0' to 3.0'

Span 3 (Beam 4@Pier 2) 1.7% web loss 0' to 2.0'

Span 3 (Beam 5@Pier 2) 40% Bottom flange loss 0' to 2.0'

8. Per IR, Condition factor for the bridge was used corresponding to Fair (Superstructure Rating= 5); ϕc=1.00

Sample Screen Shot of Bridge Rating Results



Bridge Id	Vehicle	Inventory Rating Factor	Operating Rating Factor	Legal Rating Factor	Permit Rating Factor	nventory Rating Method	Operating Rating Method	Legal Rating Method	Permit Rating Metho	Inventory Capacity (Ton)	Operating Capacity (Ton)	Legal Capacity (Ton)	Permit Capacity (Ton)	
03124	HL-93 (US)	1.161	1.506			LRFR	LRFR			41.81	54.20			Tu
03124	Blanket Permit 115				2.004				LRFR				115.23	Tu
03124	Blanket Permit 90				1.924				LRFR				86.58	Tu
03124	HS-20-Lane Load Only	2.765	3.584			LRFR	LRFR			0.00	0.00			Tu
03124	HS-20-Tandem	1.921	2.490			LRFR	LRFR			46.11	59.77			Tu
03124	HS-20-Truck Only	1.517	1.966			LRFR	LRFR			54.61	70.79			Tu
03124	Notional Rating Load-NRL			1.654				LRFR				66.17		Tu
03124	SU4			2.336				LRFR				63.08		Tu
03124	SU5			2.106				LRFR				65.30		Tu
03124	SU6			1.888				LRFR				65.60		Tu
03124	SU7			1.725				LRFR				66.85		Tu
03124	[redacted]emi			2.316				LRFR				92.64		Tu
03124	[redacted]ingle			2.564				LRFR				69.24		Tu

APPENDIX A

ANALYSIS AND RATING CODES FOR CULVERTS AND PIPES

GENERAL NOTES

When an analysis is not required or if there is not enough information to perform an analysis a rating should be 'assumed'. If the structure has been carrying highway traffic and shows no signs of distress, it can be assumed that the structure can carry legal loads.

Analysis of culverts may be completed using Br|R®. If Br|R® is used to model other non-culvert structures, care shall be taken to review the live load factor applied by the program and determine if it is appropriate to use the culvert, or bridge value.

For concrete box culverts and concrete pipes the definition of "no signs of distress" will be the same as that used for concrete slabs.

For metal pipes the definition of "no signs of distress" will include, but not be limited to:

- No excessive cross-section deformation.
- Changes to measured dimensions of installed metal pipe not greater than five percent (5%) of design dimensions.
- No visible signs of plate cracking, crimping or bolt hole tears.
- Plates appear to be properly fitted.
- Bolts in longitudinal seams show no signs of fatigue or overstress.
- No visible signs of measurable section loss.
- No lifting of the invert at either end of the pipe.
- No piping. Piping is referred as seepage along the outside of the culvert barrel that may remove supporting material.

When signs of distress are evident, the affect of the distress on the load carrying capacity of the structure must be considered. If an analysis has been previously performed, it should be modified to include the areas of distress and a new rating generated. If the rating was assumed, consideration must be given to reducing the load carrying capacity of the structure to some level below legal limit. The appropriate assumed load limit shall be determined on a case-by-case basis and using engineering judgment.

In the past, a fill height less than 15 feet would indicate that live load should be applied to a culvert or a pipe when an analysis was prepared. Due to existing design criteria for precast concrete box culverts, 20 feet would be a more conservative approach for these types of structures. For simplicity, the instructions below use 20 feet as the cut-off for all types of pipes and culverts. It is still considered appropriate to use 15 feet for non-precast concrete box culverts.

FILL HEIGHTS GREATER THAN OR EQUAL TO 20 FEET

CONCRETE BOX CULVERTS (PRE-CAST AND CAST-IN-PLACE) AND PIPES OF ALL MATERIAL AND DESIGN TYPES

For fill heights greater than or equal to 10 feet, [redacted] considers the effect of the live load to be insignificant. Therefore, an analysis is not required.

- Federal Item 66 (Inventory Rating) will be coded 99.
- Federal Item 64 (Operating Rating) will be coded 99.
- State Item 45 (Rated Capacity, Single Unit) will be coded 99.
- State Item 46 (Rated Capacity, Semi) will be coded 99.
- State and Federal Items for the SU and FAST Act vehicles.
- State Item 48 (Method of Analysis) will be coded 'L'.
- State Item 49A (Computer File Name) shall be coded as the "brkey" of the structure (5 digit Federal ID).
- State Item 49B (Last Run Date) shall be left blank.
- For Concrete Culverts - State Item 47 (Stress Level) shall be coded as 'O' (Operating).
- For Metal Culverts - State Item 47 (Stress Level) shall be coded as 'M' (Midrange).

FILL HEIGHTS LESS THAN 20 FEET

CONCRETE BOX CULVERTS (PRE-CAST AND CAST-IN-PLACE)
BUILT 1988 OR BEFORE
BUILT USING A PLAN OR STANDARD

- Analysis must be performed (using the load factor method) to determine:
  - Federal Item 66 (Inventory Rating)
  - Federal Item 64 (Operating Rating)
  - State Item 45 (Rated Capacity, Single Unit)
  - State Item 46 (Rated Capacity, Semi).
  - State and Federal Items for the SU and FAST Act vehicles.
- State Item 49A (Computer File Name) shall be coded as the "brkey" of the structure (5 digit Federal ID).
- State Item 49B (Last Run Date) shall be left blank.
- State Item 47 (Stress Level) shall be coded as 'O' (Operating).

CONCRETE BOX CULVERTS (PRE-CAST AND CAST-IN-PLACE)
BUILT AFTER 1988
BUILT USING A STANDARD OR A PLAN

- If built to a standard, use the chart attached to determine:
  - Federal Item 66 (Inventory Rating).
  - Federal Item 64 (Operating Rating).
- State Item 48 (Method of Analysis) will be coded 'L' (charts were developed using load factor analysis).
- If built to a plan, an analysis (using the load factor method) must be performed to determine:
  - Federal Item 66 (Inventory Rating)
  - Federal Item 64 (Operating Rating)
  - State Item 45 (Rated Capacity, Single Unit)
  - State Item 46 (Rated Capacity, Semi).
- State Item 48 (Method of Analysis) will be coded 'L'.

- State Item 45 (Rated Capacity, Single Unit)
  Apply Federal Item 64 (Operating Rating) (see above) to the 'Equivalent Capacity Coefficients' chart in Appendix B. The span length used in the chart shall be taken from State Item 23 (Drainage Structure – Width or Diameter).
- State Item 46 (Rated Capacity, Semi)
  Apply Federal Item 64 (Operating Rating) (see above) to the 'Equivalent Capacity Coefficients' chart in Appendix B. The span length used in the chart shall be taken from State Item 23 (Drainage Structure – Width or Diameter).
- State Item 49A (Computer File Name) shall be coded as the "brkey" of the structure (5 digit Federal ID).
- State Item 49B (Last Run Date) shall be left blank.
- State Item 47 (Stress Level) shall be coded as 'O' (Operating).
- Items for SU and FAST Act Vehicles to be defined by the release of this IIM. Values for each vehicle should be obtained by the process defined in Appendix C.

CONCRETE BOX CULVERTS (PRE-CAST AND CAST-IN-PLACE)
NOT BUILT BY A STANDARD OR A PLAN

- Federal Item 66 (Inventory Rating) code 36.
- Federal Item 64 (Operating Rating) code 49.
- State Item 45 (Rated Capacity, Single Unit) code 27
- State Item 46 (Rated Capacity, Semi) code 40.
- State Item 48 (Method of Analysis) will be coded 'A' (Assumed). It will be unknown which AASHTO design standards were used.
- Items for SU and FAST Act Vehicles to be defined by the release of this IIM. Values for each vehicle should be obtained by the process defined in Appendix C.

All CONCRETE AND METAL PIPES

- Federal Item 66 (Inventory Rating) code 36.
- Federal Item 64 (Operating Rating) code 49.
- State Item 45 (Rated Capacity, Single Unit) code 27
- State Item 46 (Rated Capacity, Semi) code 40.
- State Item 48 (Method of Analysis) will be coded 'A' (Assumed) since it will be unknown which AASHTO standards were used to design the specific structure.
- State Item 49A (Computer File Name) shall be coded as the "brkey" of the structure (5 digit Federal ID).
- State Item 49B (Last Run Date) shall be left blank.
- Items for SU and FAST Act Vehicles to be defined by the release of this IIM. Values for each vehicle should be obtained by the process defined in Appendix C.
- Concrete pipes
  - State Item 47 (Stress Level) shall be coded 'O' (Operating).
- Metal pipes
  - State Item 47 (Stress Level) shall be coded 'M' (Midrange).

Rating Chart for BOX CULVERTS

		SINGLE								DOUBLE							
		HEIGHT OF FILL								HEIGHT OF FILL							
SPAN	HEIGHT	0 TO 2		2 TO 5		5 TO 10		10 TO 15		0 TO 2		2 TO 5		5 TO 10		10 TO 15	
		INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR
3	3	46	77	96	99	99	99	99	99	62	99	99	99	99	99	99	99
3	4	60	99	86	99	99	99	99	99	62	99	99	99	99	99	99	99
4	3	54	90	99	99	99	99	99	99	52	87	99	99	99	99	99	99
4	4	51	86	91	99	99	99	99	99	52	87	99	99	99	99	99	99
4	5	49	83	84	99	99	99	99	99	51	85	99	99	99	99	99	99
4	6	51	86	77	99	99	99	99	99	50	83	99	99	99	99	99	99
5	3	50	84	71	99	99	99	99	99	45	76	99	99	99	99	99	99
5	4	48	81	67	99	99	99	99	99	48	81	99	99	99	99	99	99
5	5	51	85	63	99	99	99	99	99	47	78	99	99	99	99	99	99
5	6	48	80	82	99	99	99	99	99	46	77	99	99	99	99	99	99
5	7	51	85	78	99	99	99	99	99	46	77	96	99	99	99	99	99
6	4	50	84	74	99	99	99	99	99	45	76	82	99	99	99	99	99
6	5	48	81	66	99	99	99	99	99	46	76	79	99	99	99	99	99
6	6	47	78	64	99	99	99	99	99	48	80	76	99	99	99	99	99
6	7	49	83	72	99	99	99	99	99	47	79	73	99	99	99	99	99
6	8	55	92	75	99	99	99	99	99	46	77	70	99	99	99	99	99
7	4	45	75	65	99	99	99	99	99	45	75	71	99	96	99	99	99
7	6	46	77	67	99	97	99	99	99	47	79	65	99	85	99	99	99
7	8	48	81	68	99	86	99	99	99	46	76	66	99	75	99	99	99
7	10	52	87	79	99	85	99	99	99	46	77	67	99	79	99	99	99
8	4	45	76	64	99	91	99	99	99	49	81	64	99	71	99	99	99
8	6	49	82	56	94	79	99	99	99	46	77	68	99	67	99	99	99
8	8	44	74	64	99	78	99	99	99	46	77	63	99	76	99	99	99
8	10	50	84	58	97	73	99	99	99	47	78	64	99	75	99	99	99
9	4	48	80	59	99	74	99	99	99	46	76	64	99	66	99	99	99
9	6	43	72	47	79	83	99	99	99	48	80	56	93	79	99	99	99
9	8	46	77	50	84	74	99	99	99	45	76	60	99	76	99	99	99
9	10	44	74	52	86	81	99	99	99	48	81	63	99	68	99	99	99
9	12	52	87	49	83	96	99	99	99	48	81	64	99	78	99	99	99
10	4	43	73	61	99	59	99	99	99	47	79	57	95	64	99	99	99
10	6	39	65	62	99	76	99	99	99	45	76	55	93	79	99	99	99
10	8	46	77	55	91	63	99	99	99	48	81	57	96	78	99	99	99
10	10	41	69	55	91	61	99	99	99	48	81	59	98	62	99	99	99
10	12	45	75	57	96	36	56	99	99	46	77	63	99	59	99	99	99
12	6	46	78	47	79	73	99	99	99	43	73	50	84	64	99	99	99
12	8	48	80	57	96	56	93	99	99	45	75	50	83	63	99	99	99
12	10	40	66	47	79	64	93	99	99	48	81	48	81	63	99	99	99
12	12	44	74	55	91	67	93	99	99	44	74	48	81	61	99	99	99

		TRIPLE								QUADRUPLE							
		HEIGHT OF FILL								HEIGHT OF FILL							
		0 TO 2		2 TO 5		5 TO 10		10 TO 15		0 TO 2		2 TO 5		5 TO 10		10 TO 15	
SPAN	HEIGHT	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR	INV	OPR
3	3	60	99	99	99	99	99	99	99	59	98	99	99	99	99	99	99
3	4	58	97	99	99	99	99	99	99	51	85	99	99	99	99	99	99
4	3	51	85	99	99	99	99	99	99	49	82	99	99	99	99	99	99
4	4	49	82	99	99	99	99	99	99	45	75	88	99	99	99	99	99
4	5	47	79	99	99	99	99	99	99	47	79	88	99	99	99	99	99
4	6	46	77	99	99	99	99	99	99	45	76	89	99	99	99	99	99
5	3	52	87	96	99	99	99	99	99	45	75	89	99	99	99	99	99
5	4	45	75	96	99	99	99	99	99	43	72	73	99	99	99	99	99
5	5	44	73	92	99	99	99	99	99	42	70	67	99	99	99	99	99
5	6	43	71	86	99	99	99	99	99	43	72	64	99	99	99	99	99
5	7	45	76	82	99	99	99	99	99	43	72	64	99	99	99	99	99
6	4	42	71	64	99	99	99	99	99	43	72	57	95	99	99	99	99
6	5	44	74	64	99	99	99	99	99	41	69	56	93	99	99	99	99
6	6	44	73	64	99	99	99	99	99	41	68	55	91	99	99	99	99
6	7	46	77	63	99	99	99	99	99	39	66	59	99	99	99	99	99
6	8	46	77	67	99	99	99	99	99	42	70	62	99	99	99	99	99
7	4	43	72	67	99	94	99	99	99	42	71	63	99	94	99	99	99
7	6	43	72	67	99	81	99	99	99	40	67	61	99	81	99	99	99
7	8	44	73	63	99	72	99	99	99	42	71	58	98	70	99	99	99
7	10	43	71	61	99	75	99	99	99	42	70	59	98	75	99	99	99
8	4	41	68	57	95	70	99	99	99	44	74	62	99	65	99	99	99
8	6	40	66	65	99	77	99	99	99	45	76	53	88	65	99	99	99
8	8	42	71	63	99	71	99	99	99	44	74	58	97	70	99	99	99
8	10	44	74	61	99	77	99	99	99	45	76	58	97	77	99	99	99
9	4	42	70	44	74	61	99	99	99	44	74	70	99	80	99	99	99
9	6	38	63	40	66	62	99	99	99	46	77	70	99	72	99	99	99
9	8	42	70	45	75	64	99	99	99	44	74	68	99	68	99	99	99
9	10	43	72	48	80	64	99	99	99	44	74	65	99	65	99	99	99
9	12	44	73	44	74	65	99	99	99	44	74	55	93	64	99	99	99
10	4	43	72	46	76	76	99	99	99	46	76	64	99	68	99	99	99
10	6	40	67	42	70	71	99	99	99	42	70	65	99	68	99	99	99
10	8	42	71	45	75	86	99	99	99	48	81	72	99	65	99	99	99
10	10	42	71	45	75	85	99	99	99	48	81	73	99	72	99	99	99
10	12	43	71	45	76	68	99	99	99	46	77	61	99	66	99	99	99
12	6	43	71	45	76	56	93	99	99	44	73	49	83	56	93	99	99
12	8	43	72	45	76	57	95	99	99	45	76	48	81	43	72	99	99
12	10	43	72	46	77	72	99	99	99	45	76	49	83	52	87	99	99
12	12	43	73	46	77	69	99	99	99	46	78	59	99	65	99	99	99

SPAN	HEIGHT	OVERSIZE							
		0 TO 2		2 TO 5		5 TO 10		10 TO 15	
		INV	OPR	INV	OPR	INV	OPR	INV	OPR
12	14	47	78	55	93	65	99	99	99
12	16	55	92	60	99	72	99	99	99

SPAN	HEIGHT	OVERSIZE							
		0 TO 2		2 TO 5		5 TO 10		10 TO 15	
		INV	OPR	INV	OPR	INV	OPR	INV	OPR
14	8	38	64	46	76	60	99	99	99
14	10	40	67	50	84	61	99	99	99

SPAN	HEIGHT	OVERSIZE							
		0 TO 2		2 TO 5		5 TO 10		10 TO 15	
		INV	OPR	INV	OPR	INV	OPR	INV	OPR
14	12	40	68	45	75	55	92	99	99
14	14	43	73	49	83	62	99	99	99
14	16	49	82	53	89	57	95	99	99

APPENDIX B
Equivalent Capacity Coefficients - Simple Spans
(For longitudinal members controlled by flexure)

Span (FT.)	HS20 GROSS	[redacted] Type 3	[redacted] Type 3S2	SU4	SU5	SU6	SU7	NRL	PERMIT BP-90	PERMIT BP-115	EV2	EV3
2	1	1.200	2.092	1.412	1.621	1.817	2.026	2.092	1.818	2.866	0.763	1.233
4	1	1.200	2.092	1.412	1.621	1.817	2.026	2.092	1.818	2.866	0.763	1.233
6	1	1.200	2.092	1.412	1.621	1.817	2.026	2.092	1.818	2.866	0.763	1.233
8	1	1.200	2.092	1.412	1.621	1.817	2.026	2.092	1.818	2.866	0.763	1.233
10	1	1.176	1.743	1.091	1.253	1.404	1.566	1.616	1.515	2.047	0.763	1.027
12	1	1.059	1.569	0.947	1.088	1.219	1.360	1.404	1.364	1.720	0.763	0.925
14	1	0.988	1.464	0.866	0.994	1.115	1.243	1.283	1.273	1.543	0.763	0.863
16	1	0.941	1.394	0.814	0.934	1.047	1.168	1.205	1.212	1.433	0.763	0.822
18	1	0.908	1.345	0.777	0.867	0.946	1.054	1.088	1.123	1.358	0.763	0.793
20	1	0.882	1.307	0.750	0.820	0.878	0.979	1.010	1.061	1.303	0.763	0.771
22	1	0.863	1.230	0.729	0.785	0.829	0.924	0.954	1.015	1.261	0.763	0.753
24	1	0.847	1.172	0.713	0.758	0.792	0.883	0.912	0.980	1.228	0.763	0.740
26	1	0.834	1.127	0.700	0.737	0.763	0.839	0.853	0.952	1.176	0.763	0.729
28	1	0.824	1.092	0.689	0.720	0.740	0.804	0.808	0.929	1.135	0.763	0.719
30	1	0.882	1.151	0.720	0.764	0.782	0.840	0.837	0.986	1.194	0.826	0.771
32	1	0.933	1.200	0.745	0.802	0.816	0.871	0.861	1.034	1.242	0.844	0.793
34	1	0.976	1.242	0.766	0.833	0.846	0.896	0.880	1.074	1.283	0.859	0.811
36	1	1.015	1.278	0.784	0.861	0.871	0.917	0.897	1.110	1.317	0.871	0.826
38	1	1.048	1.309	0.799	0.872	0.881	0.924	0.905	1.141	1.347	0.881	0.839
40	1	1.078	1.336	0.813	0.881	0.889	0.930	0.912	1.168	1.374	0.890	0.850
42	1	1.072	1.360	0.824	0.889	0.897	0.935	0.918	1.192	1.396	0.897	0.860
44	1	1.067	1.381	0.835	0.896	0.904	0.939	0.924	1.213	1.417	0.904	0.869
46	1	1.062	1.400	0.844	0.902	0.909	0.943	0.928	1.233	1.435	0.909	0.876
48	1	1.058	1.417	0.852	0.908	0.914	0.946	0.932	1.250	1.451	0.914	0.883
50	1	1.054	1.432	0.860	0.913	0.919	0.949	0.936	1.266	1.466	0.919	0.889
52	1	1.051	1.446	0.866	0.917	0.923	0.952	0.939	1.280	1.480	0.923	0.894
54	1	1.048	1.459	0.872	0.921	0.927	0.954	0.942	1.293	1.492	0.927	0.899
56	1	1.046	1.471	0.878	0.925	0.930	0.956	0.945	1.306	1.503	0.930	0.904
58	1	1.044	1.481	0.883	0.928	0.933	0.958	0.947	1.317	1.513	0.933	0.908
60	1	1.042	1.491	0.888	0.931	0.936	0.960	0.950	1.327	1.523	0.936	0.912
62	1	1.040	1.501	0.892	0.934	0.939	0.962	0.952	1.337	1.531	0.939	0.915
64	1	1.038	1.509	0.896	0.936	0.941	0.963	0.954	1.332	1.540	0.941	0.918
66	1	1.037	1.517	0.900	0.939	0.943	0.965	0.955	1.314	1.547	0.943	0.921
68	1	1.035	1.525	0.903	0.941	0.945	0.966	0.957	1.299	1.554	0.945	0.924
70	1	1.034	1.531	0.906	0.943	0.947	0.967	0.959	1.285	1.561	0.947	0.927
75	1	1.031	1.511	0.913	0.947	0.951	0.970	0.962	1.255	1.575	0.951	0.933
80	1	1.028	1.453	0.920	0.951	0.955	0.972	0.965	1.230	1.588	0.955	0.937
85	1	1.026	1.407	0.925	0.955	0.958	0.974	0.967	1.210	1.599	0.958	0.942
90	1	1.024	1.370	0.930	0.958	0.961	0.976	0.969	1.193	1.599	0.961	0.945
95	1	1.023	1.339	0.934	0.960	0.963	0.977	0.971	1.179	1.582	0.963	0.949
100	1	1.022	1.312	0.938	0.962	0.965	0.979	0.973	1.167	1.534	0.965	0.952
105	1	1.020	1.290	0.941	0.964	0.967	0.980	0.974	1.156	1.489	0.967	0.954

Span (FT.)	HS20 GROSS	[redacted] Type 3	[redacted] Type 3S2	SU4	SU5	SU6	SU7	NRL	PERMIT BP-90	PERMIT BP-115	EV2	EV3
110	1	1.019	1.270	0.944	0.966	0.969	0.981	0.976	1.146	1.452	0.969	0.956
115	1	1.018	1.253	0.946	0.968	0.970	0.982	0.977	1.138	1.419	0.970	0.959
120	1	1.017	1.238	0.949	0.969	0.972	0.983	0.978	1.131	1.391	0.972	0.960
125	1	1.017	1.225	0.951	0.971	0.973	0.983	0.979	1.124	1.367	0.973	0.962
130	1	1.016	1.213	0.953	0.972	0.974	0.984	0.980	1.118	1.345	0.974	0.964
135	1	1.015	1.202	0.955	0.973	0.975	0.985	0.981	1.112	1.326	0.975	0.965
140	1	1.014	1.193	0.957	0.974	0.976	0.985	0.981	1.107	1.309	0.976	0.967
145*	1	1.016	1.186	0.960	0.977	0.979	0.988	0.984	1.105	1.296	0.979	0.970
150*	1	1.036	1.202	0.982	0.998	1.000	1.009	1.005	1.124	1.309	1.000	0.991
160*	1	1.078	1.237	1.025	1.041	1.043	1.051	1.048	1.162	1.336	1.043	1.034
170*	1	1.120	1.272	1.068	1.084	1.085	1.094	1.090	1.201	1.367	1.086	1.077
180*	1	1.162	1.309	1.111	1.127	1.128	1.137	1.133	1.240	1.399	1.129	1.120
190*	1	1.204	1.347	1.155	1.170	1.172	1.180	1.176	1.281	1.433	1.172	1.163
200*	1	1.247	1.386	1.198	1.213	1.215	1.223	1.219	1.321	1.469	1.215	1.207

*HS20 LANE LOAD WAS USED FOR THESE SPANS

Equivalent Capacity Coefficients - Simple Spans
(For longitudinal members controlled by shear at bearings)

Span (FT.)	HS20 GROSS	[redacted] Type 3	[redacted] Type 3S2	SU4	SU5	SU6	SU7	NRL	PERMIT BP-90	PERMIT BP-115	EV2	EV3
2	1	1.200	2.092	1.412	1.621	1.817	2.026	2.092	1.818	2.866	0.763	1.233
4	1	1.200	2.092	1.412	1.621	1.817	2.026	2.092	1.818	2.866	0.763	1.233
6	1	1.059	1.569	1.059	1.216	1.363	1.520	1.569	1.364	2.150	0.763	0.925
8	1	0.941	1.394	0.941	1.081	1.211	1.351	1.394	1.212	1.911	0.763	0.822
10	1	0.882	1.307	0.833	0.957	1.073	1.196	1.235	1.136	1.592	0.763	0.771
12	1	0.847	1.255	0.774	0.889	0.996	1.111	1.147	1.091	1.433	0.763	0.740
14	1	0.824	1.220	0.737	0.817	0.916	1.022	1.055	1.013	1.337	0.763	0.719
16	1	0.908	1.280	0.800	0.867	0.972	1.084	1.119	1.081	1.433	0.821	0.793
18	1	0.971	1.321	0.846	0.902	1.011	1.128	1.137	1.130	1.455	0.833	0.848
20	1	1.020	1.352	0.852	0.928	1.040	1.160	1.150	1.166	1.470	0.841	0.872
22	1	1.059	1.375	0.857	0.948	1.063	1.185	1.159	1.194	1.481	0.847	0.874
24	1	1.091	1.393	0.861	0.941	1.055	1.177	1.167	1.216	1.490	0.852	0.876
26	1	1.065	1.407	0.864	0.935	1.050	1.171	1.173	1.235	1.497	0.856	0.877
28	1	1.046	1.420	0.866	0.930	1.045	1.166	1.178	1.250	1.503	0.859	0.878
30	1	1.041	1.445	0.877	0.937	1.053	1.174	1.188	1.277	1.524	0.871	0.889
32	1	1.037	1.467	0.887	0.942	1.052	1.173	1.190	1.299	1.542	0.881	0.897
34	1	1.034	1.486	0.895	0.946	1.048	1.169	1.186	1.319	1.558	0.889	0.905
36	1	1.032	1.502	0.902	0.950	1.044	1.158	1.177	1.336	1.571	0.897	0.911
38	1	1.029	1.517	0.908	0.954	1.041	1.145	1.170	1.351	1.583	0.903	0.917
40	1	1.027	1.530	0.914	0.956	1.038	1.134	1.164	1.365	1.593	0.909	0.922
42	1	1.026	1.541	0.919	0.959	1.036	1.125	1.158	1.377	1.602	0.914	0.927
44	1	1.024	1.551	0.923	0.961	1.034	1.117	1.148	1.388	1.610	0.919	0.931
46	1	1.023	1.560	0.927	0.963	1.032	1.110	1.139	1.398	1.617	0.923	0.934
48	1	1.022	1.569	0.930	0.965	1.030	1.104	1.131	1.396	1.624	0.926	0.937
50	1	1.020	1.576	0.934	0.967	1.029	1.098	1.123	1.380	1.630	0.930	0.940
52	1	1.019	1.583	0.937	0.968	1.027	1.093	1.117	1.355	1.636	0.933	0.943
54	1	1.019	1.544	0.939	0.970	1.026	1.089	1.111	1.334	1.641	0.936	0.945
56	1	1.018	1.509	0.942	0.971	1.025	1.084	1.106	1.315	1.645	0.938	0.947
58	1	1.017	1.478	0.944	0.972	1.024	1.081	1.101	1.299	1.649	0.941	0.949
60	1	1.016	1.451	0.946	0.973	1.023	1.077	1.097	1.283	1.653	0.943	0.951
62	1	1.016	1.426	0.948	0.974	1.022	1.074	1.093	1.270	1.657	0.945	0.953
64	1	1.015	1.404	0.950	0.975	1.021	1.071	1.089	1.257	1.653	0.947	0.955
66	1	1.015	1.385	0.951	0.976	1.020	1.069	1.086	1.246	1.625	0.949	0.956
68	1	1.014	1.367	0.953	0.977	1.020	1.066	1.082	1.236	1.600	0.950	0.958
70	1	1.014	1.350	0.955	0.977	1.019	1.064	1.079	1.226	1.572	0.952	0.959
75	1	1.013	1.315	0.958	0.979	1.017	1.059	1.073	1.205	1.506	0.955	0.962
80	1	1.012	1.287	0.961	0.981	1.016	1.054	1.067	1.188	1.454	0.958	0.965
85	1	1.011	1.263	0.963	0.982	1.015	1.050	1.063	1.174	1.412	0.961	0.967
90	1	1.010	1.242	0.965	0.983	1.014	1.047	1.059	1.161	1.377	0.963	0.969
95	1	1.010	1.225	0.967	0.984	1.013	1.044	1.055	1.150	1.347	0.965	0.971
100	1	1.009	1.210	0.969	0.985	1.013	1.042	1.052	1.141	1.322	0.967	0.972
105	1	1.009	1.197	0.971	0.986	1.012	1.039	1.049	1.132	1.300	0.969	0.974

Span (FT.)	HS20 GROSS	[redacted] Type 3	[redacted] Type 3S2	SU4	SU5	SU6	SU7	NRL	PERMIT BP-90	PERMIT BP-115	EV2	EV3
110	1	1.008	1.185	0.972	0.986	1.011	1.037	1.046	1.125	1.281	0.970	0.975
115	1	1.008	1.175	0.973	0.987	1.011	1.036	1.044	1.118	1.264	0.972	0.976
120	1	1.007	1.166	0.975	0.988	1.010	1.034	1.042	1.112	1.249	0.973	0.977
125	1	1.007	1.158	0.976	0.988	1.010	1.032	1.040	1.107	1.236	0.974	0.978
130*	1	1.018	1.163	0.988	1.000	1.021	1.043	1.050	1.115	1.238	0.986	0.990
135*	1	1.039	1.180	1.009	1.021	1.042	1.063	1.071	1.133	1.253	1.008	1.012
140*	1	1.060	1.198	1.031	1.042	1.063	1.084	1.091	1.152	1.268	1.029	1.033
145*	1	1.081	1.216	1.052	1.064	1.084	1.104	1.111	1.171	1.284	1.051	1.055
150*	1	1.102	1.234	1.074	1.085	1.105	1.125	1.132	1.191	1.300	1.073	1.076
160*	1	1.145	1.271	1.117	1.128	1.147	1.167	1.173	1.230	1.334	1.116	1.119
170*	1	1.188	1.310	1.161	1.171	1.190	1.209	1.215	1.270	1.370	1.159	1.163
180*	1	1.230	1.349	1.204	1.215	1.233	1.251	1.258	1.311	1.407	1.203	1.206
190*	1	1.274	1.389	1.248	1.258	1.276	1.294	1.300	1.352	1.444	1.247	1.250
200*	1	1.317	1.429	1.292	1.302	1.319	1.337	1.343	1.393	1.483	1.290	1.294

* HS20 LANE LOAD WAS USED FOR THESE SPANS

APPENDIX C
EXAMPLE OF A RATING PROCEDURE
BRIDGES FOR WHICH PLANS ARE NOT AVAILABLE

If a normal bridge does not show signs of distress, has been carrying normal traffic for an appreciable length of time and capable of carrying legal loads at operating level, the steps to calculate ratings for other vehicles are as follows:

Assume:

Operating level rating for [redacted] Type 3 (Single Unit Truck) as 27 tons
Operating level rating for [redacted] Type 3S2 (Truck and Semi Trailer) as 40 tons

Refer to Appendix B (Equivalent Capacity Coefficients - Simple Spans) for the coefficients. Generally, shear does not control the rating.

For a span of 40':

Coefficients from the table in Appendix B for 40' span:

Span (FT.)	HS20 GROSS	[redacted] Type 3	[redacted] Type 3S2	SU4	SU5	SU6	SU7	NRL	PERMIT BP-90	PERMIT BP-115	EV2	EV3
40	1	1.078	1.336	0.813	0.881	0.889	0.930	0.912	1.168	1.374	0.890	0.850

First, find the HS20 operating rating:

HS20 operating rating = 27 tons / 1.058 = 25.51 tons, round to 26 tons
= 40 tons / 1.364 = 29.32 tons, round to 29 tons

Minimum of these two values is the HS20 operating rating,

Therefore, HS operating rating = 26 tons.

Using LFR coefficients: HS inventory rating = 26 tons /1.67 = 15 tons

From the HS20 operating rating, rating for other vehicles can be obtained.

BP-90 operating rating = 26 tons x 1.194 = 31.03 tons, round to 31 tons
BP-115 operating rating = 26 tons x 1.399 = 36.37 tons, round to 36 tons

At the discretion of the District Bridge Engineer, a different legal vehicle may be established as the baseline case for determining the operating carrying capacity of the structure. The steps to calculate the ratings of the other vehicles still follow the same procedure outlined above.

[redacted]

Structure and Bridge

INTRA-DEPARTMENTAL MEMORANDUM

Bridge Signage Form

City/County: ____________________

Route: ____________________ **Over:** ____________________

Structure No.: ____________________

To: ____________________ **From:** ____________________ **Date:** Insert Date

(Insert Title of Responsible Manager) — District Structure & Bridge Engineer

SIGNAGE AFFECTED

☐ Weight Restriction ☐ Vertical Clearance Restriction ☐ Object Markers ☐ Other

Inspection and/or analysis by the District Structure and Bridge Section revealed that the signage for the above referenced bridge is: (check all that apply)

☐ Required and not in place. ☐ Incorrect and needs to be lowered.

☐ No longer required and needs to be removed. ☐ Incorrect and needs to be raised.

☐ Missing or damaged and needs to be replaced. ☐ Obscured.

☐ Advance warning signs are not placed in accordance with Section 46.2-1130 of the Code of [redacted]

☐ Comments ____________________

SIGNING FOR WEIGHT RESTRICTION OF STRUCTURE shall adhere to the latest version of the [redacted] Supplement to the Manual of Uniform Traffic Control Devices (MUTCD), Part 2 – Signs, Section 2B.59 and shall indicate a maximum capacity of:

Posted Sign	Posted Weight (Tons)			
☐ R12-1	____ All Vehicles			
☐ R12-V2	____ 2+ Axles	____ 3+ Axles		
☐ R12-5/R12—V1	____ 2+ Axles	____ 3+ Axles	____ Gross Weight	
☐ R12-V4	____ 2+ Axles	____ 3+ Axles	____ SU4 & SU5	____ SU6 & SU7

SIGNING FOR VERTICAL CLEARANCE OF STRUCTURE shall adhere to the latest version of the [redacted] Supplement to the (MUTCD), Part 2 – Signs, Section 2C.27 and shall indicate a maximum clearance of:

____ feet ____ inches

The above signage deficiency was corrected on the following date: ____________________

Signature: ____________________

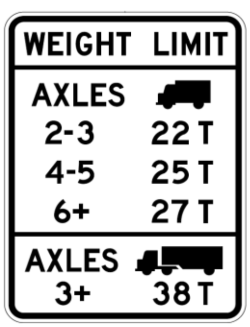
(Insert Title of Responsible Manager)

Once the deficiency is corrected, please forward the original of this form to the District Structure & Bridge Engineer and copy the District Structure & Bridge Safety Inspection Engineer.

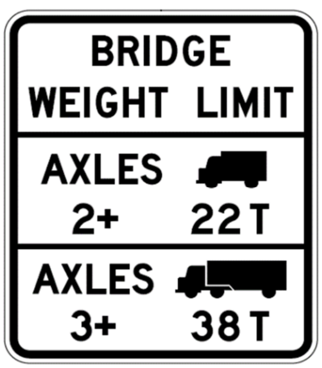
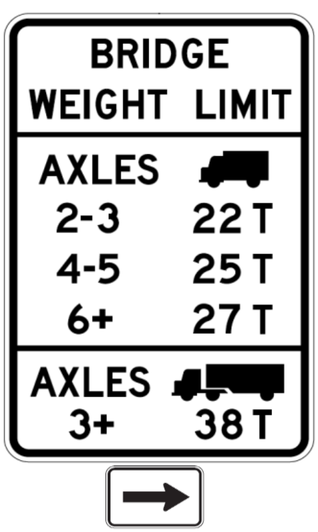
Form SB503

LOAD POSTING SIGNS

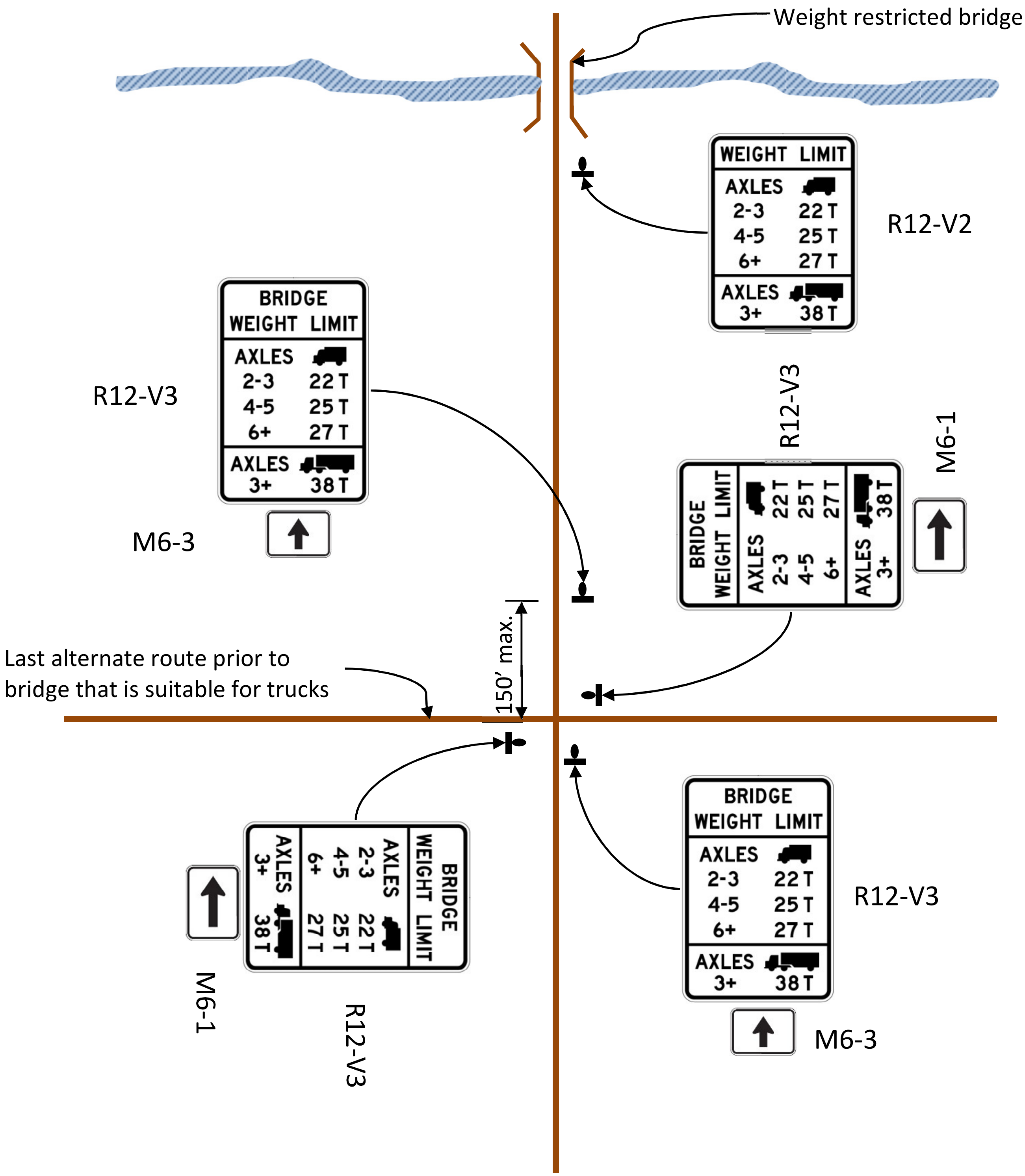
Signs Posted at Bridge

Cat.	Sign	Designation	Conventional Road	45+ mph Multilane Divided	Limited Access
A		R12-1	24” x 30”	36” x 48”	n/a
B		R12-V4	36” x 36”	54” x 60”	n/a
C		R12-V2	36” x 48”	54” x 72”	6 0” x 84”

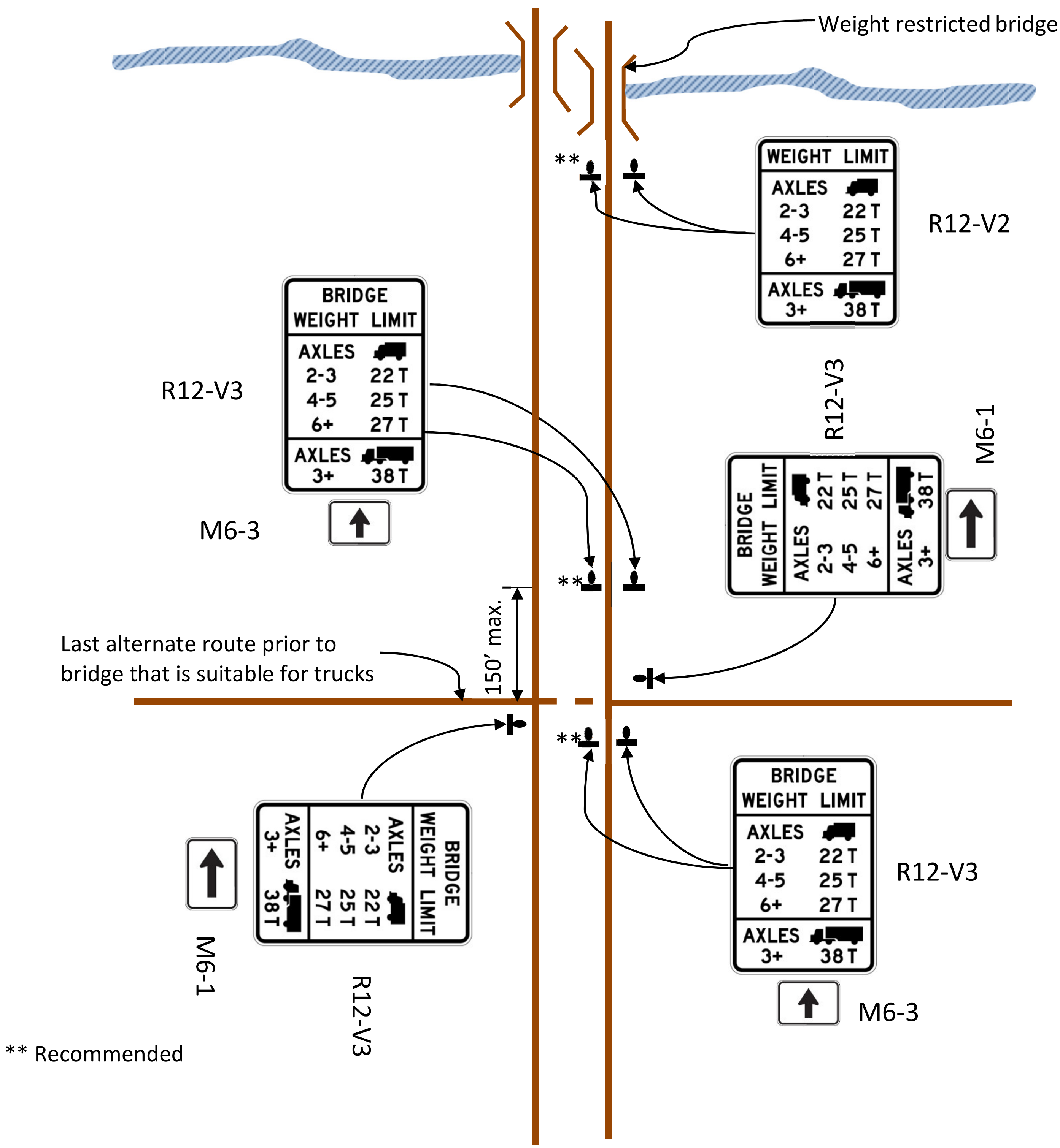
Signs Posted at Approaches (Advanced Warning Signs)

Cat.	Sign	Designation	Conventional Road	45+ mph Multilane Divided	Limited Access
A		R12-V6 M6-1 (arrow)	24” x 36” + 21” x 15”	36” x 54” + 30” x 21”	n/a
B		R12-V5 M6-1 (arrow)	36” x 42” + 21” x 15”	54” x 72” + 30” x 21”	n/a
C		R12-V3 M6-1 (arrow)	36” x 54” + 21” x 15”	54” x 84” + 30” x 21”	60” x 90” + 30” x 21”

Example of Bridge Weight Signing on Conventional Road



Example of Bridge Weight Signing on Divided Highway



5-2.3 *Bridges With Unknown Structural Components*

For concrete and masonry bridges with no design plans, and when the necessary reinforcing details are unknown and cannot be measured, load capacity ratings may be determined based on field inspection by a qualified bridge inspector followed by evaluation by a qualified engineer. Such a bridge does not need to be posted for load restrictions if it has been carrying normal traffic for an appreciable period of time and shows no sign of distress; Reference the AASHTO *Manual for Bridge Evaluation* (MBE) second edition, Sections 6.1.4 and 6A.8.1. General rating guidelines for these structures are:

- Inventory rating shall be equal to the design truck at the time the bridge was constructed. Operating rating shall be equal to the inventory rating multiplied by 1.667.
- Legal trucks rating factors shall be equal to 1 when the Superstructure, Substructure, or culvert NBI code is equal or greater than 5. Restriction of permit loads shall be assessed.
- Posting or restricting of a bridge shall be assessed when NBI code of the superstructure, substructure or culvert is 4 or less or when there are signs of structural distress.

The Load Rating Methods WB1551 and WB1554 shall be coded as " 0", Administrative.

Full documentation for an administrative rating shall be placed in the bridge load rating file.

The table below shows typical design loads and the era they were utilized. The information in the table is based on State bridge inventory and it is dependent on the class of highway.

	Design Load in Tons	Design Era
H-10	10	Early 1900- mid 20's
H-15	15	Mid 1910's-Mid 1960's
H-20	20	Mid 1910's-1920's
HS-15	27	Mid 1940's-Late 60's
HS-20	36	Mid-1940's- Early 2000's

*Administrative ratings imply ratings based on Field evaluation and Documented Engineering Judgment.

5-2.4 *Data Management*

The WSBIS database shall be updated within 30 days from the completion and approval of a load rating of a structure.

5-2.5 *Posting Requirements*

Posting of a structure shall occur when the Operating rating factor for any of the legal loads is less than 1 based on the Load Factor or Allowable Stress Methods or the rating factor for any of the legal loads is less than 1 based on the Load and Resistance Factor Method. Legal loads in the State consist of the three AASHTO legal trucks, Type 3 (Single Unit), Type 3S2 (Truck-Semi Trailer) and Type 3-3 (Truck Trailer), the SUV's (SU4, SU5, SU6 and SU7). Emergency Vehicles EV2 and EV3 are also considered legal loads on the Interstate and within one road mile from the interstate per FHWA Memo dated November 3, 2016.

Agencies generally post a bridge between the Inventory Rating and the Operating Rating using the Load Factor Method and Allowable Stress Methods. The minimum permissible posting value is three tons at inventory or operating levels. Bridges not capable of carrying a minimum gross live load of three tons shall be closed. Follow the MBE for calculating the posting limits.

Appendix A
Judgment Load Rating Concrete Structures

The purpose of this directive is to revise the statewide policy for assigning load ratings to those concrete structures that must be rated by judgment due to the lack of sufficient information and/or plans to allow a structural analysis to be completed. This directive is intended to include concrete structures such as arches, beams, girders, slab bridges, etc., which are in good or fair condition and for which little or no design load information is available, or for concrete, steel or aluminum culverts where an analysis cannot be performed by normal procedures.

These tables should not be used for material types other than the specific group of bridges described in this directive. However, the values in the tables may be useful as a guide in assigning rating values for other types of structures where an analysis cannot be completed by hand or available computer software. In this situation, the Assistant District Engineer, Bridge (ADEB) should determine rating values based on judgment, but this policy should not be referenced as the basis for that judgment.

The current edition of the Manual for Bridge Evaluation (MBE) allows concrete bridges with unknown details to be exempt from posting if it has been carrying normal traffic for an appreciable length of time and shows no distress; however, it may need to be inspected at more frequent intervals than bridges with calculated load ratings or with load ratings determined from load testing. The MBE and the National Bridge Inspection Standards (NBIS) limit the operating rating level as the maximum permissible live load to which the structure may be subjected. Any bridge that has an assigned operating rating lower than the legal load for a vehicle on that route system must be posted at levels that satisfy the [redacted] posting policy.

The rating tables contained herein represent reasonably accurate rating values for concrete bridges similar to those used for development of the tables. However, actual ratings for some specific bridges may be significantly different than what the tables predict, and the ADEB may use judgment to assign values different from those shown in the tables. For example, our experience with concrete arches has shown that those structures are capable of safely carrying loads much higher than their original design load. The ADEB may use his judgment to assign rating values that would not require the bridge to be posted. Concrete beams, girders, and slabs have not performed as well as arches and may not be suitable structures for this exception.

It is emphasized that the tables are to be used for superstructures that are in good or fair condition and of the Division of Highways quality construction. Bridges that are coded poor or critical in the SI&A should be evaluated by the ADEB, and the rating values should be reduced appropriately considering the degree of deterioration, excessive dead load, signs of distress, and other factors that may be important in assigning the judgment ratings and justifying the safe load capacity. The condition rating of these bridges should be based on the condition of the main load carrying element and not secondary elements. For arch bridges this would normally be the arch ring and not the spandrel, parapet or wing walls. It may be appropriate to review/revise condition codes for all of these structures that are rated poor or critical.

The rating tables were developed from design calculations of six arches, six thru girders and eight tee beams with spans ranging from 25 to 80 feet. Operating ratings were approximated for each bridge and an inventory to operating ratio was calculated. For convenience, all of the concrete bridges were grouped into three span length ranges. The live load design vehicle was converted to equivalent vehicles and new values were projected for the various AASHTO or State legal vehicles shown in the tables.

To use the rating tables, first determine the rating vehicle as described below. Once the rating vehicle has been determine, select the appropriate table based on span length and use the corresponding ratings for reporting on form DS-25.

If one of the following design vehicles or design criteria is known, use the corresponding rating vehicle:

Design Vehicle/Criteria	Rating Vehicle
15 Ton Roller	H15
100 psf	H15
150 psf	H20

If the design load is unknown, use the following rating vehicles based on the date of construction or estimated date of construction:

Date Built	Rating Vehicle
Prior to 1921	H10
1921 thru 1943	H15 or H20*
1944 and Newer	HS15

* Routes which were a part of the mainline road system during this period should be assigned the higher value.

All of the various precast concrete beam structures produced through the late 1980 were designed for an HS20 live load. Structures produced after the late 1980's were designed for an HS25 live load. If the design loading is known to be a conventional H or HS AASHTO vehicle, use that as the rating vehicle. If the design loading is known to be HL93, use HS25 as the rating vehicle.

TABLE 1

Spans less than 41'

Rating Vehicle	OPERATING (Tons)														HS20 (Tons)	
	Standard							CRTS				Emergency				
	T3	SU4	SU5	SU6	SU7	2S2	3S2	SU40	SU45	3S55	3S60	EV2	EV3		Inv	Oper
H10	30	26	28	29	31	37	43	28	32	45	45	29	28		16	35
H15	45	40	42	43	46	55	65	42	48	67	67	44	43		24	52
H20	60	53	56	57	62	73	86	56	63	89	89	58	57		32	70
HS15	51	45	48	49	52	62	73	47	54	76	76	50	48		27	59
HS20	69	61	64	66	71	84	101	64	73	103	103	67	65		36	79
HS25	84	74	79	80	86	103	121	78	89	125	125	82	79		45	99

TABLE 2

Spans 41' through 60'

Rating Vehicle	OPERATING (Tons)													HS20 (Tons)	
	Standard							CRTS				Emergency			
	T3	SU4	SU5	SU6	SU7	2S2	3S2	SU40	SU45	3S55	3S60	EV2	EV3	Inv	Oper
H10	28	27	28	28	29	39	41	28	29	46	46	28	27	13	31
H15	42	40	42	42	43	59	61	42	43	69	69	42	41	19	46
H20	57	54	57	57	59	79	83	56	58	93	93	57	56	26	61
HS15	60	57	60	60	62	84	87	59	61	97	97	60	59	27	65
HS20	68	65	68	68	70	95	99	67	71	123	123	68	66	36	72
HS25	99	94	99	99	102	138	144	98	101	162	162	99	97	45	107

TABLE 3

Spans longer than 60'

Rating Vehicle	OPERATING (Tons)													HS20 (Tons)	
	Standard							CRTS				Emergency			
	T3	SU4	SU5	SU6	SU7	2S2	3S2	SU40	SU45	3S55	3S60	EV2	EV3	Inv	Oper
H10	29	28	29	29	30	36	35	29	29	40	40	29	29	12	31
H15	44	43	44	44	45	55	54	43	44	60	60	44	43	18	46
H20	58	56	58	58	59	72	71	57	59	80	80	58	57	24	61
HS15	67	65	67	67	68	83	82	66	68	92	92	67	66	27	70
HS20	89	86	89	89	91	111	109	89	91	125	125	89	88	36	94
HS25	111	108	111	111	113	138	136	109	112	153	153	111	110	45	117

Appendix D

Information Provided Related to Special Haul Vehicles

Chapter 7: Posting of Bridges and Posting Avoidance

7.1—GENERAL

For bona-fide emergencies, immediately do all things necessary to protect public safety. For non-emergency posting, follow the provisions within this Chapter.

If load rating calculations conclude that any of the [redacted] Legal Loads, as defined in the Appendix to this ***Manual***, have an operating rating factor less than 1.0, then the bridge must be posted for weight within 30 days after receipt of official posting notification from the Department.

Post bridges in accordance with [redacted] Standard Plans Index 700-107 (formerly Standard No. 17357). A blanket weight restriction sign (MUTCD Sign No. R12-1) may substitute the three-silhouette sign (MUTCD Sign No. R12-5). The three silhouettes represent:

- Single Unit (SU Class) trucks: SU2, SU3, and SU4.
- Combination (C Class) trucks with a single trailer: C3, C4, and C5.
- Combination truck with two trailers or a single unit truck with one trailer: ST5.

For each silhouette/class, post the lowest sub-legal rating, and truncate. For example:

$RF_{SU2} = 1.12$ $GVW_{SU2} = 17$ tons $RATING_{SU2} = 19.0$ tons
$RF_{SU3} = 0.89$ $GVW_{SU3} = 33$ tons $RATING_{SU3} = 29.5$ tons
$RF_{SU4} = 0.99$ $GVW_{SU4} = 35$ tons $RATING_{SU4} = 34.6$ tons

Here, the SU posting is 29 tons. 29.5 is truncated, or rounded down. The SU2 is neglected, because the SU2 rating is greater than the SU2 gross vehicle weight (GVW).

In order to satisfy federal requirements regarding AASHTO SHV vehicles, for the circumstance where the analysis does recommend posting for C-Class combination trucks, but does not recommend posting for the SU-Class, post the SU-Class for 35 tons. This provides a safe posting for AASHTO SU trucks. For example:

$RF_{SU2} = 2.09$ $GVW_{SU2} = 17$ tons $RATING_{SU2} = 35.9$ tons
$RF_{SU3} = 1.08$ $GVW_{SU3} = 33$ tons $RATING_{SU3} = 36.1$ tons
$RF_{SU4} = 1.02$ $GVW_{SU4} = 35$ tons $RATING_{SU4} = 36.1$ tons
$RF_{C5} = 0.97$ $GVW_{C5} = 40$ tons $RATING_{C5} = 38.6$ tons

Here, the C posting is 38 tons and the SU posting is 35 tons. For rationale, see:
[redacted] *SU Load Posting Signs for AASHTO SHV-SU Trucks (2017 11-14)*.

7.2—WEIGHT POSTING PROCEDURES, STATE-MAINTAINED BRIDGES

When weight restrictions are required on a Department-maintained bridge, the District Structures Maintenance Engineer (DSME) will consult with the State Load Rating Engineer, consider posting-avoidance techniques, and recommend posting levels.

Within the load rating narrative, explain the cause of the low load rating, characterize impacts to traffic, and include a detour map. Develop a remedy (repair, strengthening, or replacement). Estimate costs and provide a timeline for execution of the remedy. Solicit recommendations from the District Traffic Operations Engineer, and order weight restriction signs from the [redacted] Sign Shop.

Send the completed load rating as official notification to the District Maintenance Engineer and State Structures Maintenance Engineer. Then post the structure within 30 days.

7.3—WEIGHT POSTING PROCEDURE, BRIDGES NOT MAINTAINED BY THE DEPARTMENT

When weight restrictions are required on a bridge that is not maintained by the Department, users of this ***Manual*** will follow this procedure. The Department or its consultant will analyze the bridge, and the Department's District Local Bridge Coordinator will forward weight posting recommendations to the local agency bridge owner.

The local agency bridge owner shall post the bridge, and notify the Department's District Local Bridge Coordinator that the posting recommendation has been put into effect. If the required weight posting recommendation is not acted upon by the local agency bridge owner within 30 days of the initial notification by the District Local Bridge Coordinator, the Department shall post the bridge immediately, and all posting costs incurred by the Department shall be assessed to the local agency bridge owner.

The local agency bridge owner may subsequently perform its own analysis. However, such analysis does not exempt the local agency bridge owner from taking the mandatory steps to post the bridge within the 30 days, and any conclusions reached in the subsequent analysis finding that the posting restriction is not required must be accepted by the Department before load restrictions are removed.

7.4—POSTING AVOIDANCE

Posting avoidance modifies AASHTO design specifications to mitigate weight limit and permit mobility restrictions at existing bridges. Posting avoidance techniques are not applicable to new bridges, rehabilitation projects, or widening projects. However several techniques are available for existing bridges; select the ones that apply. Within the load rating narrative, explain and justify the selection.

ROUND-UP. Rating factor results from the approximate AASHTO distribution equations may be rounded-up by up to 5%. SDG 7.1.1.C.1 also permits rounding for widenings, but confines the provision to approximately-distributed LRFR results.

REFINED ANALYSIS. Analytical refinements may be used to improve load distribution. Permissible methods include finite element analysis, and moment redistribution (LRFD 4.6.4, and Std.Spec. 10.48.1.3).

DYNAMIC ALLOWANCE FOR IMPROVED SURFACE CONDITIONS. Where the transitions from the bridge approaches to the bridge deck across the expansion joints are smooth and where there are minor surface imperfections or depressions on the bridge deck, the dynamic load allowance may be reduced to 20%.

BARRIER STIFFNESS. An analysis may reasonably consider stiffening effects from parapets and barriers. Additionally consider the adverse effects.

STRIPED LANES. Striped lanes may be used for Service limits.

STEEL SERVICE. An analysis may neglect Steel Service if these factors are considered: fatigue, Average Daily Truck Traffic (ADTT), and the replacement schedule. For example, bridges with exceptionally low traffic, like certain water management structures, may neglect Steel Service with no additional analytical consideration. However steel structures on more typical throughways must consider ADTT and fatigue before neglecting the Steel Service limit.

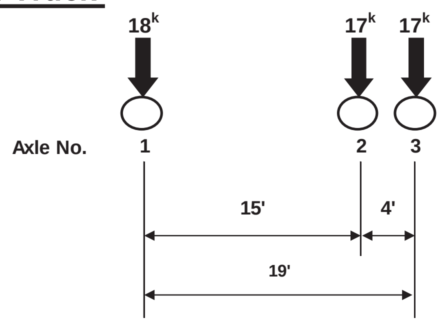
[redacted] LEGAL LOADS - Load Rating LRFR

Revised April 26, 2018

[redacted] TYPE 3 Legal Truck

3 Axle Vehicle
Gross Weight = 52 k

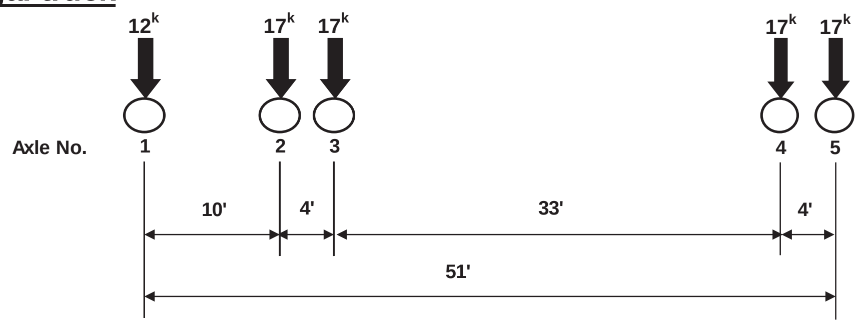
Note:
This truck is greater than the standard AASHTO Type 3, which has Gross Weight = 50 k



[redacted] TYPE 3S2 Legal truck

5 Axle Vehicle
Gross Weight = 80 k

Note:
This truck is greater than the standard AASHTO Type 3S2, which has Gross Weight = 72 k



TYPE 3-3 Legal Truck

6 Axle Vehicle
Gross Weight = 80 k

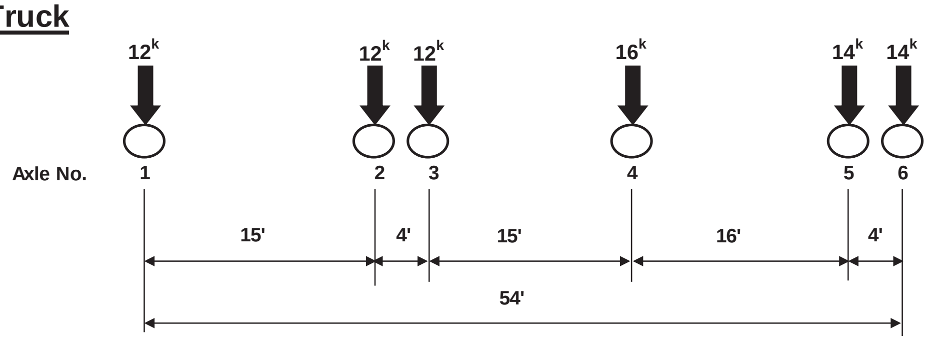


Figure 1.5.1.2A

1.5.1.3 Specialized Hauling Vehicles (SHVs)

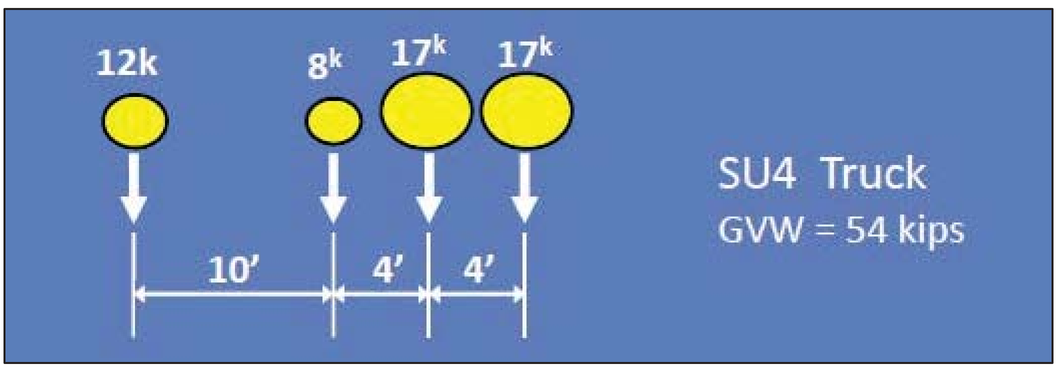
Specialized Hauling Vehicles (SHVs) are legal vehicles with legal axle weights that meet the Federal Bridge Formula (Formula B) equation for maximum axle group weight and represent short wheel based vehicles with multiple drop axles (such as modern concrete and dump trucks). These vehicles are commonly used in the construction, waste management, bulk cargo and commodities hauling industries. These vehicles consist of moveable axles that raise or lower as needed for weight, and result in higher loads concentrated over shorter distance.

Since the 1975 adoption of the American Association of State Highway and Transportation Officials (AASHTO) family of three legal loads, the trucking industry has introduced specialized single-unit trucks with closely spaced multipleaxles that make it possible for these short-wheelbase trucks to carry the maximum load of up to 80,000 lbs and still meet the “Formula B” equation. The AASHTO family of three legal loads selected at the time to closely match the Formula B in the short, medium, and long truck length ranges do not represent these newer axle configurations. These SHV trucks cause force effects in bridges that exceed the stresses induced by the Type 3, Type 3S2, or Type 3-3 legal vehicles by over 50 percent in certain cases. The shorter bridge spans are most sensitive to the newer SHV axle configurations.

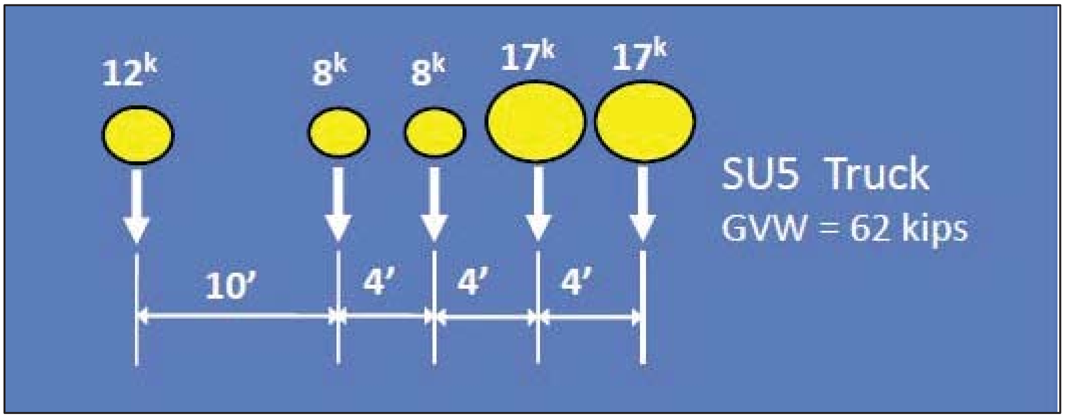
The Federal Highway Administration (FHWA) sent a memo to all states on November 15, 2013 requiring every state to post bridges for SHVs that do not pass a load rating analysis for these vehicles, in addition to the current standard legal vehicles.

Four Specialized Hauling Vehicle models were adopted by AASHTO in 2005 to represent new trucks that comply with Formula B and meet all Federal weight regulations.

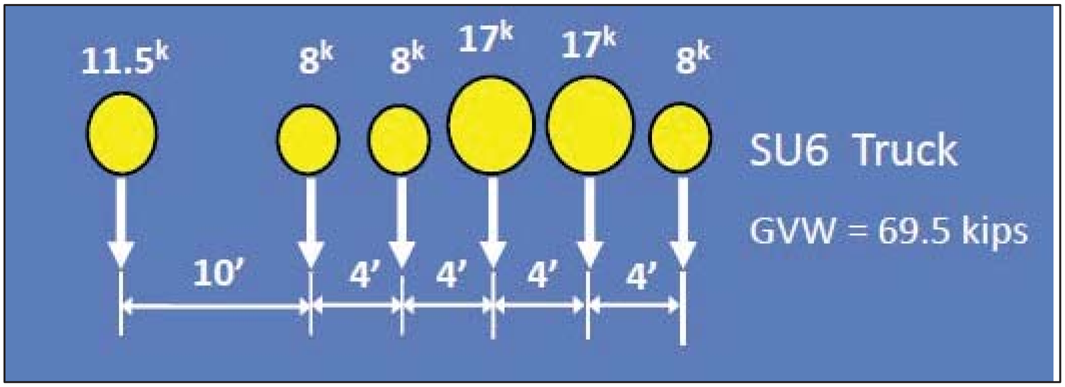
The first National SHV model is the SU4, which is a four axle vehicle with a gross vehicle weight of 54,000 LBS (27 tons).

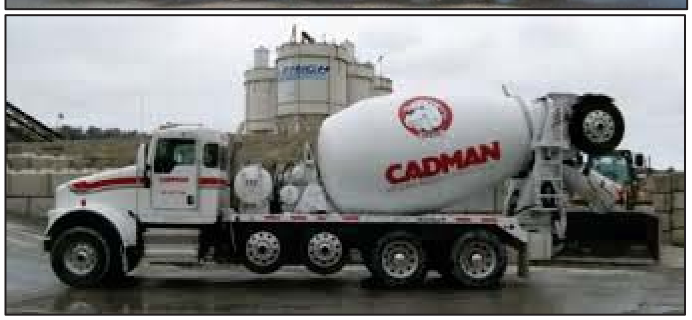


The second National SHV model is the SU5, which a five axle vehicle with a gross vehicle weight of 62,000 LBS (31 tons).

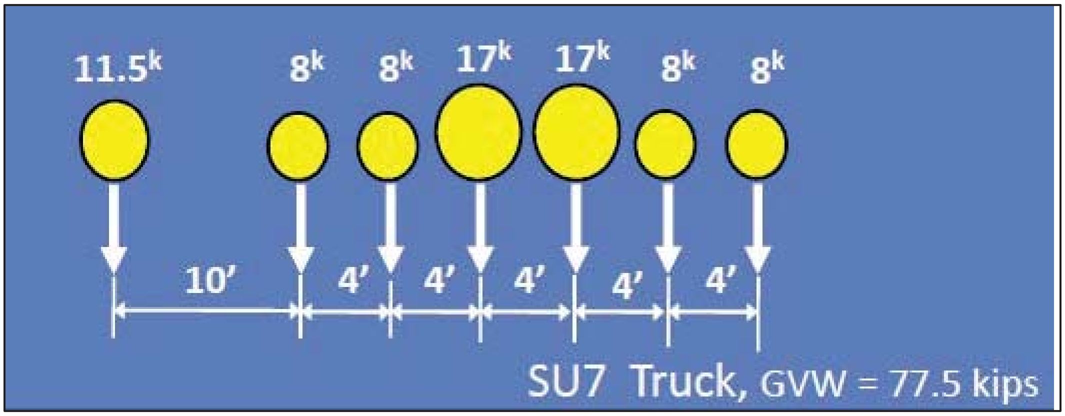


The third National SHV model is the SU6, which is a six axle vehicle with a gross vehicle weight of 69,500 LBS (34.75 tons).





The fourth National SHV model is the SU7, which is a seven axle vehicle with a gross vehicle weight of 77,500 LBS (38.75 tons).








The effect of these 4 vehicles, designated SU4 (4 axles) through SU7 (7 axles), is upper-bounded by the introduction of a single 80-kip Notional Rating Load (NRL). Because this notional load has variable axle spacing, at this time it cannot be accommodated in BRASS without re-coding. Just as it is [redacted] policy to rate for specific Legal, CTP and STP vehicles even when a bridge is adequate for the HL-93 notional loading, in a similar manner [redacted] will require rating for each of the specific SHVs (SU4 through SU7), regardless of the results that might be obtained by rating with the NRL.

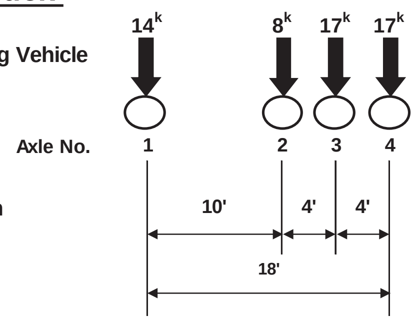
As stated in Section 1.5.1.2, the 2017 [redacted] Legislative Session passed House Bill 2462 into law, which allows commercial trucks that use natural gas as a fuel source to increase their allowed Gross Vehicle Weight by 2,000 LBS to compensate for the weight of the tanks and engine hardware needed to use the cleaner fuel source. [redacted] Motor Carrier Division has stated that natural gas is not a viable fuel source for long haul trucking operations. Therefore, [redacted] has modified the load rating models for only the Type 3 legal vehicle and the Specialized Hauling Vehicles (SHVs) by adding 2,000 LBS to the steer axles. As a result, we now have an [redacted] specific load rating vehicle model for the Type 3 and SHVs (the new [redacted] SHV models are shown here to the right)..

When a load rating shows that a bridge does not have sufficient capacity for any one of the four Specialized Hauling Vehicle models, the bridge must be posted for load. Posting signs must conform to the *Manual on Uniform Traffic Control Devices* (MUTCD). The MUTCD only has one sign (R12-5) that has silhouettes of trucks for load posting; which are for the three standard legal vehicles. The MUTCD does not allow any other silhouettes of trucks to be used on signs, so there will be no new silhouettes depicting the SHVs on a posting sign. Plus, there is a safety issue of having truck drivers attempting to count the number of axles depicted on a sign while travelling at highway speeds.

The MUTCD does allow the language on posting signs to be modified to account for the posting of

[redacted]-SU4 Legal Truck

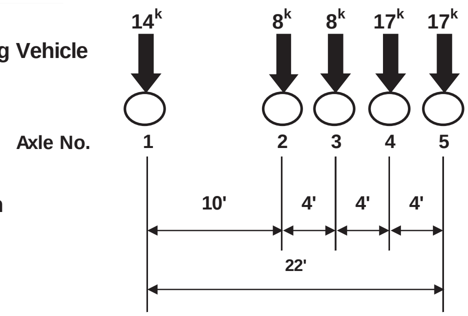
4 Axle Specialized Hauling Vehicle
Gross Weight = 56 k



Note:
This truck is greater than the standard AASHTO SU4, which has Gross Weight = 54 k

[redacted]-SU5 Legal Truck

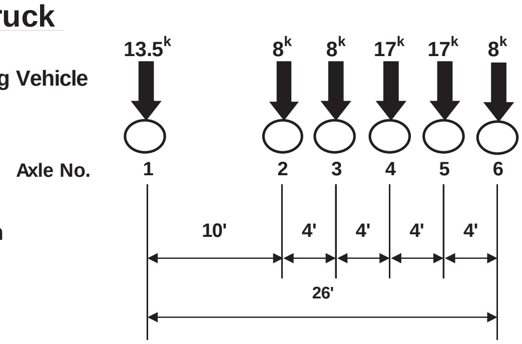
5 Axle Specialized Hauling Vehicle
Gross Weight = 64 k



Note:
This truck is greater than the standard AASHTO SU5, which has Gross Weight = 62 k

[redacted]-SU6 Legal Truck

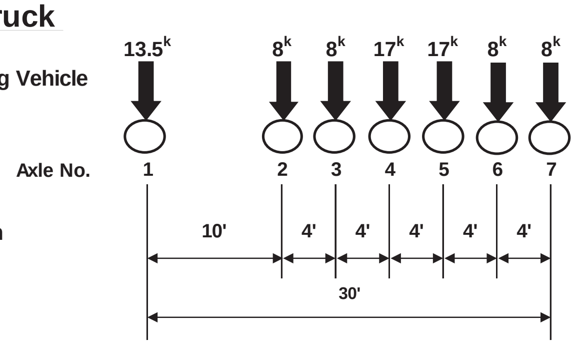
6 Axle Specialized Hauling Vehicle
Gross Weight = 71.5 k



Note:
This truck is greater than the standard AASHTO SU6, which has Gross Weight = 69.5 k

[redacted]-SU7 Legal Truck

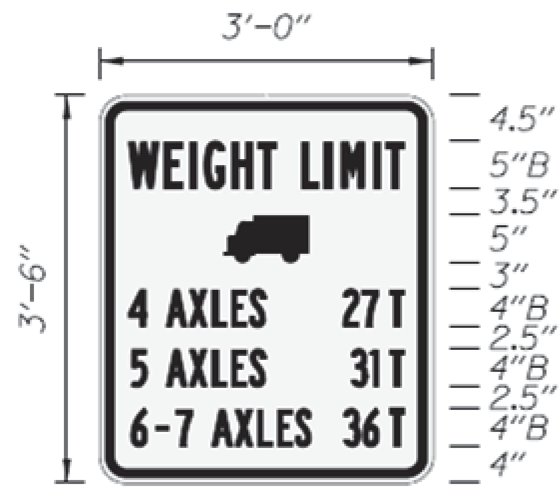
7 Axle Specialized Hauling Vehicle
Gross Weight = 79.5 k



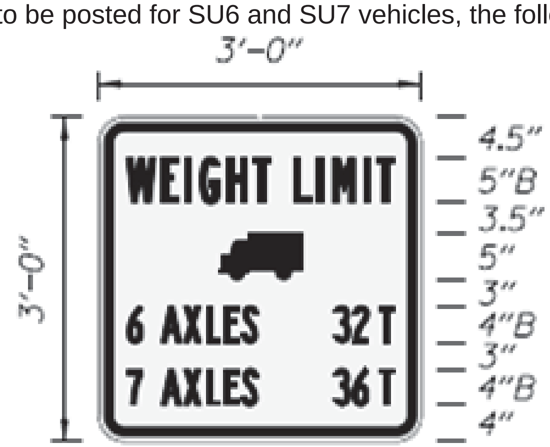
Note:
This truck is greater than the standard AASHTO SU7, which has Gross Weight = 77.5 k

Specialized Hauling Vehicles. It is up to each state to determine the language to be used on the posting signs for SHVs. [redacted] worked with the freight industry, Motor Carrier Enforcement, and local agencies to establish signs for the load posting for SHVs in [redacted] has designed new posting signs that will be used under different scenarios when a bridge requires posting for the standard legal vehicles and/or SHVs.

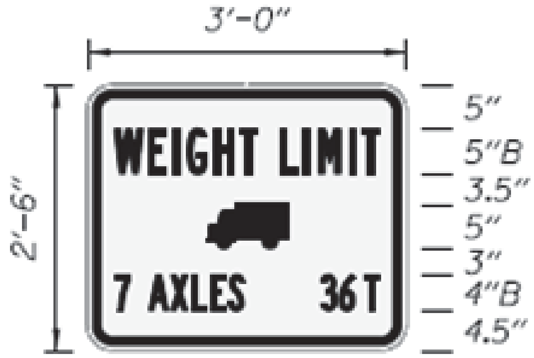
The first posting sign has three variations that can be used when the bridge has sufficient capacity for the three standard legal vehicles, but needs to be load posted for one or more of the legal 4-7 axle Specialized Hauling Vehicles. Since SHV trucks can cause force effects in bridges that exceed the stresses induced by the Type 3, Type 3S2, or Type 3-3 legal vehicles by over 50 percent in certain cases, there is a possibility that a bridge has sufficient capacity for legal axle weights and 80,000 LBS GVW for routine commercial traffic, but does not have sufficient capacity for the different SHV configurations. Instead of penalizing all trucks from using the bridge, the following posting signs were developed to restrict single unit vehicles to a lower gross vehicle weight. The posted weight for each single unit vehicle will be determined on a case-by-case basis for the safe load capacity of the bridge. When a bridge needs to be posted for SU4 or SU5 vehicles (which will also require the SU6 and SU7 vehicles to be posted), but the standard legal vehicles do not need to be posted, the following sign will be used:



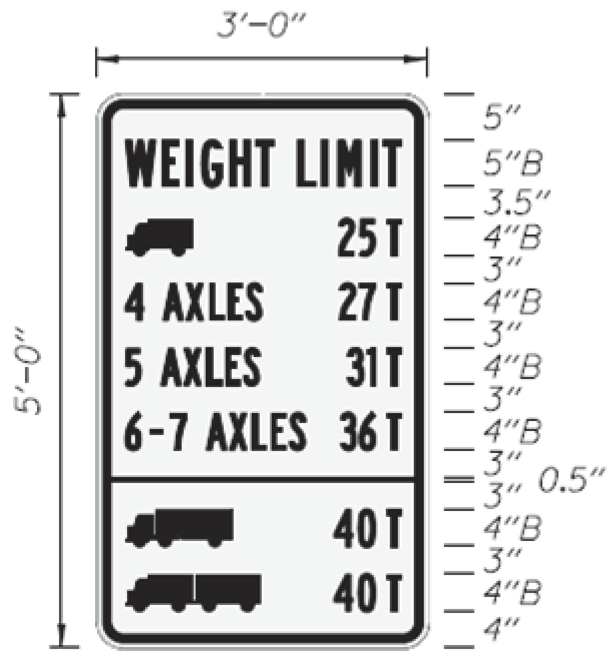
When a bridge only needs to be posted for SU6 and SU7 vehicles, the following sign will be used:



When a bridge only needs to be posted for the SU7 vehicle, the following sign will be used:



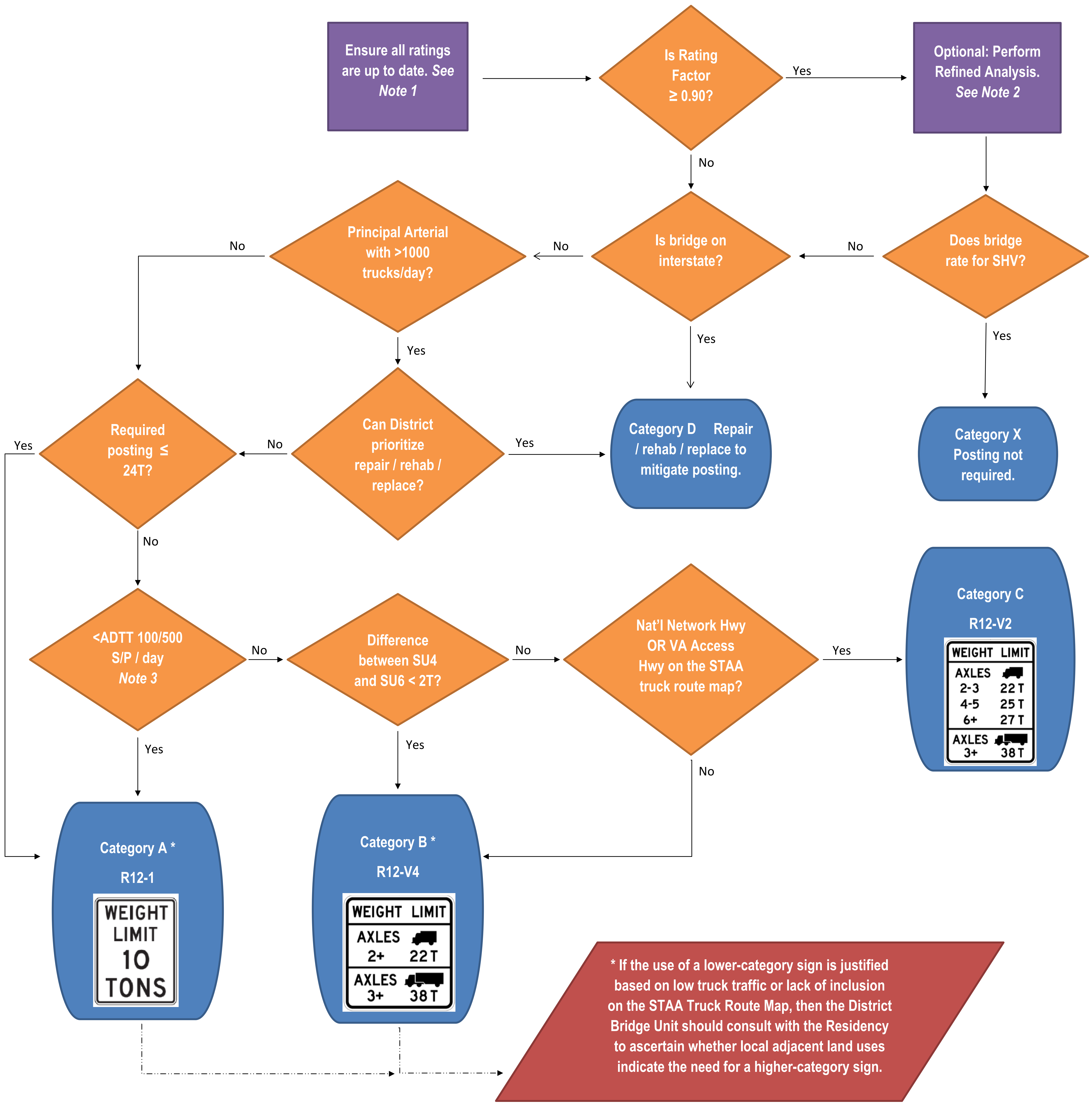
When a bridge needs to be posted for the standard legal loads, which will also require load posting for the SHVs, the following sign will be used:



These new posting signs are now included as an update to the [redacted] Sign Policy and Guidelines for the State Highway System, which is now available on the [redacted] Traffic-Roadway Section Sign Policy Information website:

https://www.[redacted]gov/[redacted]Engineering/Pages/Sign-Policy.aspx

SHV Posting Decision Tree



Note 1: All bridge ratings should reflect details of latest Inspection Report. Any bridge rated in BrR Version 6.2 or below OR performed prior to 2013 should be re-rated in-house or by contractor using BrR Version 6.7.

Note 2: Central Office to provide guidance on Refined Analysis method.

Note 3: Use ADTT of >100/Day for Secondary Roads or >500/Day for Primary Roads

5-2.3 Bridges With Unknown Structural Components

For concrete and masonry bridges with no design plans, and when the necessary reinforcing details are unknown and cannot be measured, load capacity ratings may be determined based on field inspection by a qualified bridge inspector followed by evaluation by a qualified engineer. Such a bridge does not need to be posted for load restrictions if it has been carrying normal traffic for an appreciable period of time and shows no sign of distress; Reference the AASHTO *Manual for Bridge Evaluation* (MBE) second edition, Sections 6.1.4 and 6A.8.1. General rating guidelines for these structures are:

- Inventory rating shall be equal to the design truck at the time the bridge was constructed. Operating rating shall be equal to the inventory rating multiplied by 1.667.
- Legal trucks rating factors shall be equal to 1 when the Superstructure, Substructure, or culvert NBI code is equal or greater than 5. Restriction of permit loads shall be assessed.
- Posting or restricting of a bridge shall be assessed when NBI code of the superstructure, substructure or culvert is 4 or less or when there are signs of structural distress.

The Load Rating Methods WB1551 and WB1554 shall be coded as “ 0”, Administrative.

Full documentation for an administrative rating shall be placed in the bridge load rating file.

The table below shows typical design loads and the era they were utilized. The information in the table is based on State bridge inventory and it is dependent on the class of highway.

	Design Load in Tons	Design Era
H-10	10	Early 1900- mid 20’s
H-15	15	Mid 1910’s-Mid 1960’s
H-20	20	Mid 1910’s-1920’s
HS-15	27	Mid 1940’s-Late 60’s
HS-20	36	Mid-1940’s- Early 2000’s

*Administrative ratings imply ratings based on Field evaluation and Documented Engineering Judgment.

5-2.4 Data Management

The WSBIS database shall be updated within 30 days from the completion and approval of a load rating of a structure.

5-2.5 Posting Requirements

Posting of a structure shall occur when the Operating rating factor for any of the legal loads is less than 1 based on the Load Factor or Allowable Stress Methods or the rating factor for any of the legal loads is less than 1 based on the Load and Resistance Factor Method. Legal loads in the State consist of the three AASHTO legal trucks, Type 3 (Single Unit), Type 3S2 (Truck-Semi Trailer) and Type 3-3 (Truck Trailer), the SUV’s (SU4, SU5, SU6 and SU7). Emergency Vehicles EV2 and EV3 are also considered legal loads on the Interstate and within one road mile from the interstate per FHWA Memo dated November 3, 2016.

Agencies generally post a bridge between the Inventory Rating and the Operating Rating using the Load Factor Method and Allowable Stress Methods. The minimum permissible posting value is three tons at inventory or operating levels. Bridges not capable of carrying a minimum gross live load of three tons shall be closed. Follow the MBE for calculating the posting limits.

In general, posting of a structure, when warranted, shall occur as soon as possible but not to exceed 90 days from the time posting requirements have been verified and within 60 days from the date of the posting letter is sent to the region by the Statewide Program Manager. In instances where the load carrying capacity of a bridge is significantly reduced, such as by impact to the structure, posting or closing of the bridge shall occur as soon as it is determined it is not safe to carry legal vehicular loads.

When possible, additional tests such as concrete strength or steel yield strength shall be performed to validate the assumption in the load rating analysis, hence mitigate the need for posting or restriction of the bridge. Strengthening or repair of an element should also be considered to eliminate the need for posting or restriction.

Load Posting Signs for structures where needed, shall follow the Manual on Uniform Traffic Control Devices (MUTCD) and [redacted] *Sign Fabrication Manual* M 55-05. See Exhibit 5-1 through Exhibit 5-3 for additional signage information.

All bridges requiring load posting also require additional advance posting signs in advance of the nearest intersecting roads, ramps or a wide point in the road where a driver can detour or turn around.

Exhibit 5-1 AASHTO Legal Trucks Posting

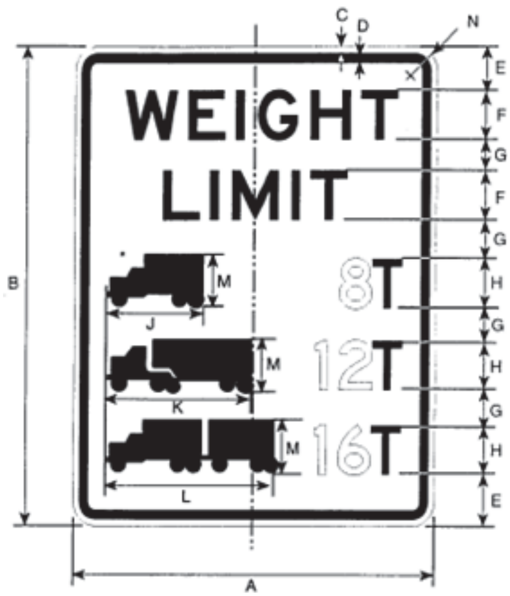


Exhibit 5-2 Emergency Vehicles Posting

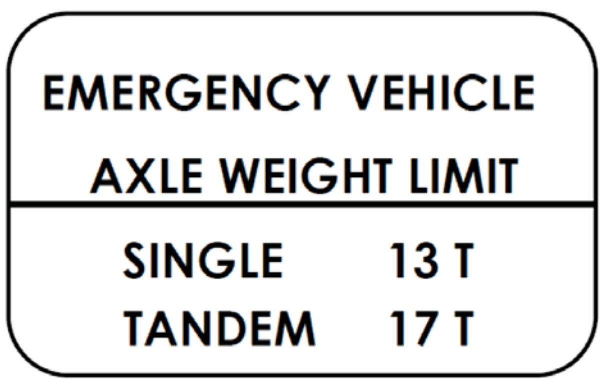


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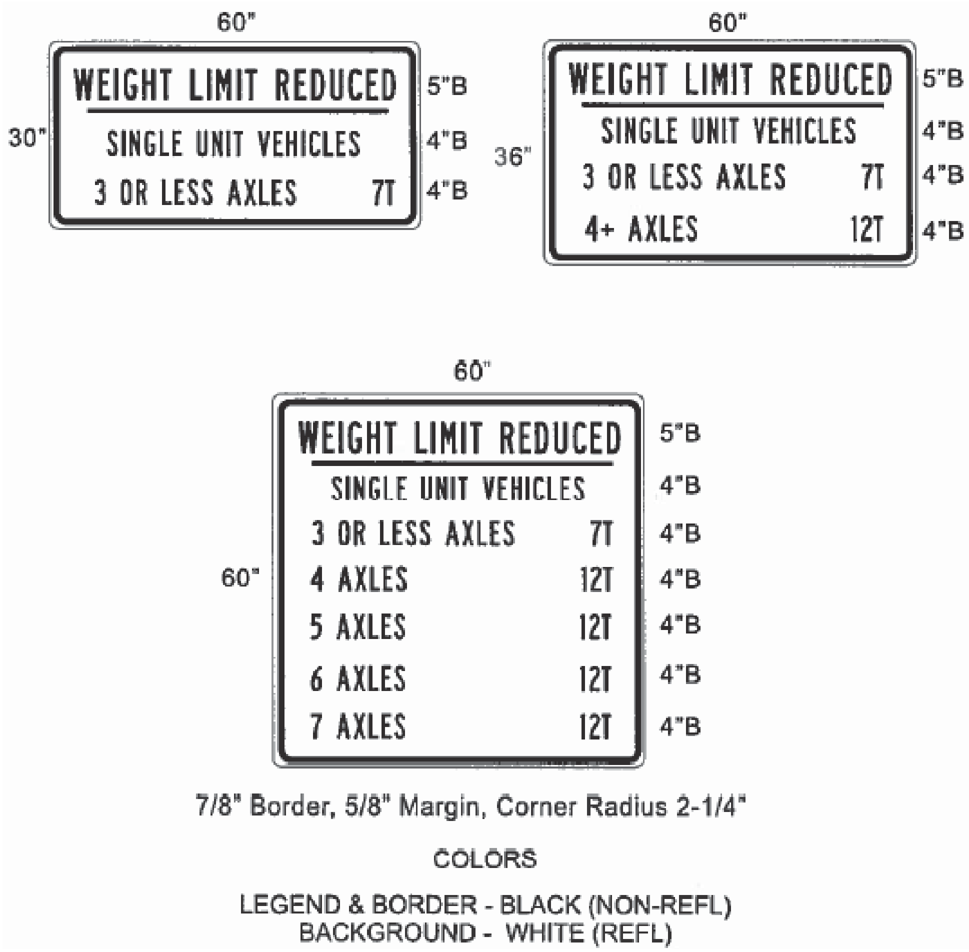
Exhibit 5-3 SUV Posting Signs



5-2.6 *Overload Permits*

Overweight loads traveling over state or local agency roads are required to obtain permits/ approval from the state, county, or city maintaining those roadways. No permit loads shall be allowed over posted bridges. The first step in evaluating a permit is to determine if the configuration meets RCW 46.44 for maximum gross weight, load per axle, or axle group (E-Snoopi) is a tool on [redacted] Commercial Vehicle website is used to calculate axle weight per RCW). The second step is to evaluate the structures on the traveled route. This can be accomplished in two methods.

The first method, which is more precise for a specific structure, is to model the permit load moving on the bridge and calculating its load rating factor. A single lane distribution factor can be used in the model, which means that no other trucks are permitted in the adjacent lanes. A rating factor equal to or above 1 means the permit truck can safely travel over the particular structure. Permit loads that have unusual configuration or have more than 8 tires per axles shall be evaluated using this method.

The second method is more general and the engineer shall be extremely cautious when applying it to ensure that the permit load is enveloped by one of the typical rated trucks. The method calculates the maximum weight per axle allowed over a bridge and is dependent on the load rating factors for the particular structure, as follows:

- **Truck Type SA**

  Definition: Construction Equipment Tires (a.k.a., Super Single Axle) (RCW 46.44.091(3))

  Range: Up to 45,000 lbs. per axle.

  Criteria: Using the Load Rating Factor for the Overload 1 Truck (a.k.a., OL1), which has a dual axle weighing 43,000 lbs., the equation is 45,000 lbs. * Rating Factor * *43/45 rounded to the nearest 500 lbs.

- **Collection Truck (RCW 46.44.041) Restriction List Truck Type S/A**

  Definition: Two-axle trucks where the rear drive axle is the item in question on non-interstate routes only.

  Range: Up to 26,000 lbs. on rear axle.

  Criteria: Using the Load Rating Factor for the AASHTO1 Truck (a.k.a., Type 3), which has a dual axle weighing 34,000 lbs., the equation is **26,000 lbs.** * **Rating Factor** * **26/34** rounded to the nearest 500 lbs.

- **Truck Type T/D**

  Definition: Three-axle trucks where the rear tandem drive axles are the item in question on non-interstate routes only.

  Range: Up to 42,000 lbs. on rear dual.

  Criteria: Using the Load Rating Factor for the AASHTO1 Truck (a.k.a., Type 3), which has a dual axle weighing 34,000 lbs., the equation is **42,000 lbs.** * **Rating Factor** * **34/42** rounded to the nearest 500 lbs.

- **Tow Truck (RCW 46.44.015) Restriction List**

  Truck Type: Tow truck with tandem (dual) drive axles.

  Definition: Three axle tow truck with tandem drive axles towing a variety of vehicles.

  Range: Up to 48,000 lbs. on drive dual axles.

  Criteria: Using the Load Rating Factor for the AASHTO2 Truck (a.k.a., Type 3S2), which has dual weighing 31,000 lbs., the equation is **48,000 lbs.** * **Rating Factor** * **31/48** rounded to the nearest 500 lbs.

- **Truck Type CL8**

  Definition: Class 8 Short Hitch five-axle combination (three-axle tractor with a two-axle trailer).

  Range: Up to 21,500 lbs. per axle in dual group and 20,000 to 22,000 for a single axle.

  Criteria: Use the Load Rating Factor for the OL1 Truck based on single lane distribution factor. The equation is **22,000 lbs.*** **Rating Factor** rounded to the nearest 500 lbs.

- **Truck Type BL**

  Definition: Big load six plus axle combination and three to four axle single units.

  Range: Up to 22,000 lbs. per axle in dual and tridem groups and up to 22,000 lbs. for a single axle.

  Criteria: Use the Load Rating Factor for the OL2 Truck based on a single lane distribution factor. The equation is **22,000 lbs.* Rating Factor*** Modifying Factor (MF)* rounded to the nearest 500 lbs. In some instances engineering judgment may be used in establishing restrictions on a structure.

  *Modifying Factor (MF) is 1.15 if Superstructure or Substructure Condition is 6 or above; 1.10 for Condition of 5 and 1 for 4 or less. The MF is applicable to concrete and steel members. For timber members the MF is 1.

For permits traveling over State routes, [redacted] can request the weighing of a permit load at any time, however, here are typical triggers:

- Analysis shows that the load is close to overstressing one or more bridges.
- Multiple load requests: 10 or more loads in the 200-300 thousand pound range.
- 5 or more loads over 300 thousand pounds.
- Any load over 500,000 pounds.

Commentary: *The SA load is assumed to act as a tandem axle due to the size of the tire. The occurrence of these permitted loads are occasional, hence, the OL1 was used to envelope these vehicles due to the lower Live Load Factor instead of the Type 3S2 which was previously used.*

The MF multiplier applied to the BL is used since the OL2 is an envelope truck and is not permitted in the State. The Engineer shall use the MF with extreme caution and it shall not be applied to every permit load. The previous methodology which applied a Multiplier Factor based on the number of lanes is not valid any longer.

5-3 Scour Evaluation

All bridges spanning waterways are required by the NBIS to have a scour evaluation. A scour evaluation is done to identify the susceptibility to erosion of streambed material and the degree of foundation element stability. The evaluation should include as-built foundation details, current condition of the foundation, a stream bed cross section profile, and stream flow rates. The initial evaluation is a screening tool to evaluate the susceptibility of a structure to scour. If a structure is found to be vulnerable to scour, an analysis shall be performed by a professional engineer with hydraulics expertise to assess the scour issues or identify the proper repairs/countermeasures.

As the bridge foundation condition changes and/or the stream bed characteristics change, the scour criticality may have to be reanalyzed. Scour evaluations shall be reviewed and updated every 12 years, if necessary.

Upon determining that a bridge is scour critical, the agency needs to develop a written plan of action (POA) to monitor, mitigate, or close the bridge. For additional information, see FHWA HEC 18 Evaluating Scour at Bridges.