UFC 3-310-08
16 AUG 2010

UNIFIED FACILITIES CRITERIA (UFC)

NON-EXPEDITIONARY BRIDGE INSPECTION, MAINTENANCE, AND REPAIR

UNIFIED FACILITIES CRITERIA (UFC)

NON-EXPEDITIONARY BRIDGE INSPECTION, MAINTENANCE, AND REPAIR

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY (Preparing Activity)

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	Date	Location

This UFC supersedes TM 5-600/AFJPAM 32-1088, *Bridge Inspection, Maintenance, and Repair*, dated December 1994, and Air Force ETL 07-5, *Bridge Inspections*, dated 18 April 2007.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the more stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Center for Engineering and the Environment (AFCEE) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

AUTHORIZED BY:

JAMES C. DALTON, P.E.
Chief, Engineering and Construction
U.S. Army Corps of Engineers

JOSEPH E. GOTT, P.E.
Chief Engineer
Naval Facilities Engineering Command

DENNIS FIRMAN, P.E.
Director of the Air Force Center for Engineering and the Environment
Department of the Air Force

MICHAEL McANDREW
Director, Facility Investment & Management
Office of the Deputy Under Secretary of Defense (Installations and Environment)

UNIFIED FACILITIES CRITERIA (UFC)
NEW DOCUMENT SUMMARY SHEET

Subject: Non-Expeditionary Bridge Inspection, Maintenance, and Repair.

Cancels: TM 5-600/AFJPAM 32-1088, dated December 1994.

Document Description and Need:

- Purpose: To ensure that military garrison/base bridges can remain safely in operation and will behave reliably for civilian and military traffic; the bridges inspected, operated and maintained by military agencies should meet (or exceed) the same standards to which bridges under U.S. civilian jurisdiction are subject.
- Application: This UFC provides guidance so that all military garrison/base bridges are appropriately inspected and the results reported in accordance with current federal standards and Federal Highway Administration (FHWA) criteria; this UFC also provides guidance so all military garrison/base bridges are maintained and repaired in a consistent manner and in accordance with industry standards.
- Need: Currently, there is no coherent and consistent national Department of Defense policy for the inspection, maintenance, and repair of garrison/base bridges; furthermore, TM 5-600/AFJPAM 32-1088, *Air Force Bridge Inspection, Maintenance and Repair Manual*, is over 15 years old and has not kept pace with current federal bridge inspection standards or industry standards for bridge maintenance and repair.

Impact: The publication of UFC 3-310-08 will not result in any increased cost to the Services. Each Service is already in compliance with the National Bridge Inspection Standards (NBIS) and the reporting requirements directed by the Code of Federal Regulations, Title 23, Part 650, Subpart C. The provisions included within this UFC are already being accomplished by each Service as directed by separate Service guidance (Army ER 1110-2111, Air Force ETL 07-5, and Navy UG-6002-OCN).

Non-Unification Issues:

- Not applicable; all agencies affected by this UFC are subject to the same requirements.

CONTENTS

CHAPTER 1: INTRODUCTION

CHAPTER 2: REQUIREMENTS

FIGURES

TABLES

CHAPTER 1

INTRODUCTION

1-1 BACKGROUND.

TM 5-600/AFJPAM 32-1088, *Air Force Bridge Inspection, Maintenance and Repair Manual*, is over 15 years old. Consequently, it has not kept pace with current federal bridge inspection standards or industry standards for bridge maintenance and repair. Navy UG-6002-OCN, *Bridge Inspection and Reporting Guidelines*, is more recent but does not address maintenance or repair issues. Army Engineering Regulation (ER) 1110-2-111, *USACE Bridge Safety Program*, and Army Regulation (AR) 420-1, *Army Facilities Management*, are also more recent, but none of the requirements for Air Force, Army, or Navy have been unified or consolidated. Currently, there is no coherent and consistent national Department of Defense (DOD) policy for the inspection, maintenance, and repair of garrison/base bridges.

1-2 PURPOSE.

This UFC provides guidance so that all military garrison/base bridges are appropriately inspected and the results reported in accordance with current federal standards and Federal Highway Administration (FHWA) criteria. This UFC also provides guidance so all military garrison/base bridges are maintained and repaired in a consistent manner and in accordance with industry standards. The purpose is to ensure that military garrison/base bridges can remain safely in operation and will behave reliably for civilian and military traffic. The bridges inspected, operated, and maintained by military agencies should meet (or exceed) the same standards to which bridges under U.S. civilian jurisdiction are subject.

1-3 SCOPE.

This UFC applies to all military garrison/base bridges, whether located in the contiguous United States (CONUS), or located outside the contiguous United States (OCONUS), including Alaska, Hawaii, U.S. territories and possessions, and foreign territories. This UFC does not apply to expeditionary bridges located in military theaters of operation. This UFC also does not apply to Army Corps of Engineers civil works bridges, located outside of a garrison/base; those bridges are governed by ER-1110-2-111.

1-4 REFERENCES.

Appendix A contains a list of references used in this UFC.

CHAPTER 2

REQUIREMENTS

2-1 THE NATIONAL BRIDGE INSPECTION PROGRAM.

The National Bridge Inspection Standards (NBIS) are the most important resource for any bridge inspection program, whether civilian or military. The standards establish minimum federal requirements for inspection procedures, inspection frequency, personnel qualifications, inspection reports, and bridge inventory records. The program manager of any bridge inspection program should be completely familiar with NBIS. Although not reproduced verbatim in this UFC, the standards are listed in Appendix A as a reference; the NBIS should be consulted whenever a question arises regarding federal inspection requirements.

2-1.1 History of the National Bridge Inspection Program.

The focus during the 1950s and 1960s was on bridge construction and the interstate system rather than inspection or maintenance. This changed in December 1967 when West Virginia's Silver Bridge collapsed into the Ohio River. Congress responded by requiring the Secretary of Transportation to develop national bridge inspection standards and training programs for bridge inspectors. Along with the creation of the NBIS in the early 1970s, several important manuals were released pertaining to bridge inspector training, maintenance and inspection, and recording/coding bridge data. Unfortunately, the NBIS at that time were applicable only to bridges on the Federal Aid highway systems. This was remedied in 1978 with additional funding and a requirement for the inspection and inventory of all public bridges more than 20 feet in length.

During the 1980s, various specialized bridge topics received much more emphasis due to several bridge failures. Some culvert failures led to the publication of a culvert inspection manual in 1986. The Mianus River Bridge in Connecticut collapsed in June 1983, prompting the publication of a manual on fatigue and fracture critical members (FCM) in 1986. In April 1987 the Schoharie Creek Bridge in New York collapsed, prompting a shift in attention to underwater inspection; the FHWA published a technical advisory on scour in 1988. The NBIS were modified in 1988 to add requirements for underwater inspections and identifying fracture critical details. The 1988 NBIS revisions also allowed for special inspections, which are deficiency-specific inspections scheduled by the bridge owner for monitoring suspected or known problems. Furthermore, the revisions added flexibility to the inspection frequency for certain situations. The FHWA also issued a major revision to their coding guide in 1988.

The focus during the 1990s was on bridge management systems; the FHWA sponsored the creation of the "Pontis" system in 1991. The American Association of State Highway and Transportation Officials (AASHTO) revised their condition evaluation manual in 1994 and the FHWA coding guide was revised again in 1995. Funding levels for bridge maintenance, repair, and rehabilitation continued to increase in the 1990s and 2000s to try to meet the nation's needs. The FHWA bridge inspector training manual was revised

and updated in 2002; it was renamed *Bridge Inspector's Reference Manual* (BIRM), and incorporated previously independent culvert and fracture critical supplements. The NBIS were again revised in 2004, taking effect in 2005. The BIRM was revised once more in 2006. Following the I-35 bridge collapse into the Mississippi River on August 1, 2007, in Minneapolis, the FHWA issued technical advisory T 5140.29. Their final recommendations focused on non-load-path-redundant steel truss bridges, urging bridge owners to include gusset plate capacity as part of the initial load rating, and also to review previous and future load ratings for consideration of gusset plate capacity, especially where temporary or permanent modifications may alter the dead load or overall stress levels in the bridge.

2-1.2 Goal of the National Bridge Inspection Program.

The goal of the National Bridge Inspection Program is to establish minimum standards for the proper inspection, evaluation, and inventory of the nation's bridges in order to maintain public roadway bridges over 20 feet long in a safe, usable condition.

2-1.3 Details of the National Bridge Inspection Program.

2-1.3.1 Overview

The 2005 NBIS contain 9 sections: purpose, applicability, definitions, bridge inspection organization, qualifications of personnel, inspection frequency, inspection procedures, inventory, and reference manuals. The NBIS are part of the Code of Federal Regulations, Title 23, Part 650, Subpart C, and may be located in the Federal Register; publication details are given in Appendix A.

2-1.3.2 Bridge Inspection Organization

State and federal agencies are required to have a bridge inspection organization to implement bridge inspections within their jurisdiction, provide quality control (QC) and quality assurance (QA) for their policies and procedures, and maintain a current bridge inventory, including records of the inspection reports and load ratings. At the head of this bridge inspection organization is the program manager.

2-1.3.3 Qualifications of Personnel

In accordance with NBIS, the following are the minimum requirements for the functional roles of program manager, team leader, load rater, and inspection diver:

- The program manager must have successfully completed an FHWA-approved comprehensive bridge inspection training course and either be a registered professional engineer (PE) or have 10 years of bridge inspection experience.

- The inspection team leader must have completed an FHWA-approved comprehensive bridge inspection training course and either be a PE, have five years of bridge inspection experience, be certified as a Level III or IV Bridge

Safety Inspector by the National Institute for Certification in Engineering Technologies (NICET), or have some type of engineering degree from a college or university with appropriate levels of bridge inspection experience (two years with bachelor's degree and four years with associate's degree).

- The individual responsible for load rating must be a PE.

- The underwater bridge inspection diver must maintain qualification per paragraph 2-3.3 and must have completed an FHWA-approved comprehensive bridge inspection training course or other FHWA-approved underwater bridge inspection diver training course.

2-1.3.4 Inspection Frequency

When a bridge is first built it will receive an initial or inventory inspection which serves as a baseline for all future inspections. Routine or periodic inspections track the condition of the bridge and changes that have occurred since the initial inspection. The standard maximum interval for routine bridge inspections is 24 months. Certain bridges will require inspection at more frequent intervals, based on their deficiencies and other characteristics. Certain bridges subject to NBIS requirements may be inspected at less frequent intervals, not to exceed 48 months, provided that the extension is justified by inspection results with supporting analysis and FHWA written approval. See Appendix B, Section 2 for inspection frequency alteration procedures.

Other types of inspections are special inspections, damage inspections, and in-depth inspections; these will have varying frequencies and levels of detail, depending on the particular situation. Special or interim inspections are used by the bridge owner to monitor known or suspected deficiencies. Damage inspections are unscheduled and used to assess human or environmental actions. In-depth inspections are close-up inspections, sometimes involving non-destructive testing, to identify hidden or non-obvious deficiencies; fracture critical inspections and underwater inspections are variants of the in-depth inspection.

The standard maximum interval for fracture critical member (FCM) inspections is 24 months. Certain FCM will require inspection at more frequent intervals, based on their deficiencies and other characteristics. The standard maximum interval for underwater structural element inspections is 60 months. Certain underwater structural elements will require inspection at more frequent intervals, based on their deficiencies, scour susceptibility, and other characteristics. Certain underwater structural elements subject to NBIS requirements may be inspected at less frequent intervals, not to exceed 72 months, provided that the extension is justified by inspection results with supporting analysis and FHWA written approval.

2-1.3.5 Inspection Procedures

Each bridge shall be inspected in accordance with AASHTO MBE-1, *Manual for Bridge Evaluation*. A minimum of one qualified team leader shall be present at all times during

initial, routine, in-depth, FCM, and underwater inspections. Each bridge shall be rated in accordance with AASHTO MBE-1 and posted or restricted when necessary in accordance with AASHTO or local transportation department ordinances. Records shall be maintained, including the inspection reports and follow-up actions taken; findings shall be recorded on standardized agency forms. Complex bridges and bridges with FCMs, underwater elements, or scour critical status shall be identified and given special attention according to the appropriate procedures. QC and QA procedures shall be implemented, along with periodic field reviews, bridge inspection refresher training for program managers and team leaders, and independent reviews of reports and calculations. A follow-up procedure shall be established by the agency to ensure that critical findings are addressed in a timely manner.

2-1.3.6 Inventory

The agency shall prepare and maintain a bridge inventory. Structure inventory and appraisal (SI&A) data shall be collected and transmitted to the FHWA in accordance with FHWA-PD-96-001, *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*. The data shall be entered into a state or federal agency's inventory within 90 days of an inspection, a change in load restriction, a closure status change, or the completion of bridge modifications; for other agencies the time limit is 180 days.

2-2 COMPLIANCE WITH THE NATIONAL BRIDGE INSPECTION PROGRAM.

Unless noted otherwise, military branches (including the Army, Navy, and Air Force) shall be in compliance with the NBIS. These organizations are federal agencies and, as such, must comply with the relevant requirements of NBIS regarding all bridges within the jurisdiction of that particular Service branch.

2-2.1 Introduction.

One goal of this UFC is to ensure DOD compliance with the letter of the NBIS regulations for garrison/base bridges in U.S. territory and the spirit of the NBIS regulations for garrison/base bridges in foreign territory. Items of concern specific to military applications and items not covered by NBIS are also addressed in this UFC.

2-2.2 Industry Practice.

The inspection and load rating of roadway bridges shall be in accordance with the latest industry practice. The 1994 AASHTO *Manual for Condition Evaluation of Bridges*, along with all subsequent interim revisions through 2003, was incorporated by reference in the NBIS. This AASHTO standard has now been superseded by AASHTO MBE-1, *Manual for Bridge Evaluation*, 1st Edition.

Indispensable references include FHWA-NHI-03-001 (Volume 1) and -03-002 (Volume 2), *Bridge Inspector's Reference Manual*; FHWA-PD-96-001 (with 2003 errata); and

AASHTO bridge design specifications (both AASHTO HB-17, *Standard Specifications for Highway Bridges*, and AASHTO LRFDUS-4-M, *LRFD Bridge Design Specifications*).

Additional important references include the AASHTO/AWS D1.5M/D1.5:2008, *Bridge Welding Code*; AASHTO MBI-1, *Movable Bridge Inspection, Evaluation, and Maintenance Manual*; the FHWA *Manual on Uniform Traffic Control Devices for Streets and Highways*; and FHWA HEC-18 (NHI-01-001), *Evaluating Scour at Bridges*.

2-2.3 Exceptions and Special Requirements.

All special military inspection requirements, exceptions, and non-NBIS issues are addressed in paragraph 2-3.

2-3 SPECIAL REQUIREMENTS FOR DEPARTMENT OF DEFENSE BRIDGE INSPECTION.

2-3.1 Introduction.

The NBIS regulations are intended for public-access highway/roadway bridges in U.S. territory. For the purposes of the NBIS and this UFC, a “reportable bridge” is defined as a bridge or culvert over 20 feet in length, measured along the roadway centerline, which carries automobile (vehicular) traffic across some obstruction, such as a body of water, railway, or another roadway. For bridges, the length is measured between undercopings of abutments or spring lines of arches. For culverts, the length is measured between the extreme ends of openings for multiple boxes, or is equal to the opening for a single box or pipe; it may also include multiple pipes when the clear distance between openings is less than half of the smaller contiguous opening.

Non-public bridges, pedestrian bridges, and railroad bridges all fall outside the NBIS scope. Short-span bridges are defined as structures with a length of 20 feet or less, measured along the roadway centerline, carrying vehicular traffic across an obstruction; they also fall outside the NBIS scope. Recommendations for all of these special situations (i.e., “non-reportable bridges”) are given in the following paragraphs. Bridges in foreign territory would technically not be considered “reportable” per NBIS, but for the purpose of this UFC they shall be inspected as though they are “reportable” if all other NBIS requirements (i.e., length and traffic) are met. See the simplified bridge inspection flowchart in Appendix B, Section 5.

2-3.2 Bridge Inspection Organization.

Each Service shall be responsible for establishing and maintaining a bridge inspection program. At the head of the program is the program manager. Each garrison/base commander is responsible for the condition of all bridges within his or her jurisdiction in accordance with the National Bridge Inspection Standards (NBIS), 23 CFR 650C, Federal Register Vol. 69 No. 239, 14 December 2004. Consequently, each garrison/base commander is ultimately responsible for determining which bridges are inspected, whereas the program manager is responsible for implementing and/or

reviewing those inspections. All roadway bridges shall be deemed public, regardless of the level of security or restricted access, unless the garrison/base commander designates otherwise (with the program manager's approval). By designating roadway bridges as public, they become subject to NBIS inspection regulations (provided that length requirements are met), thus reducing or eliminating loopholes in the inspection process. Consequently, non-public designations should be avoided unless warranted by very special circumstances. Point of contact information for each Service branch's bridge program is found in Appendix B, Section 3.

2-3.3 Responsibilities and Qualifications.

The personnel responsibilities, other than those specified in paragraph 2-3.2, shall be as defined in NBIS. Minimum qualifications shall be as specified in NBIS, with the additional requirement that underwater bridge inspectors shall have a commercial diver certification. Diver training certification must conform to Section 30.A.06 of Army Engineering Manual (EM) 385-1-1, *Safety and Health Requirements*.

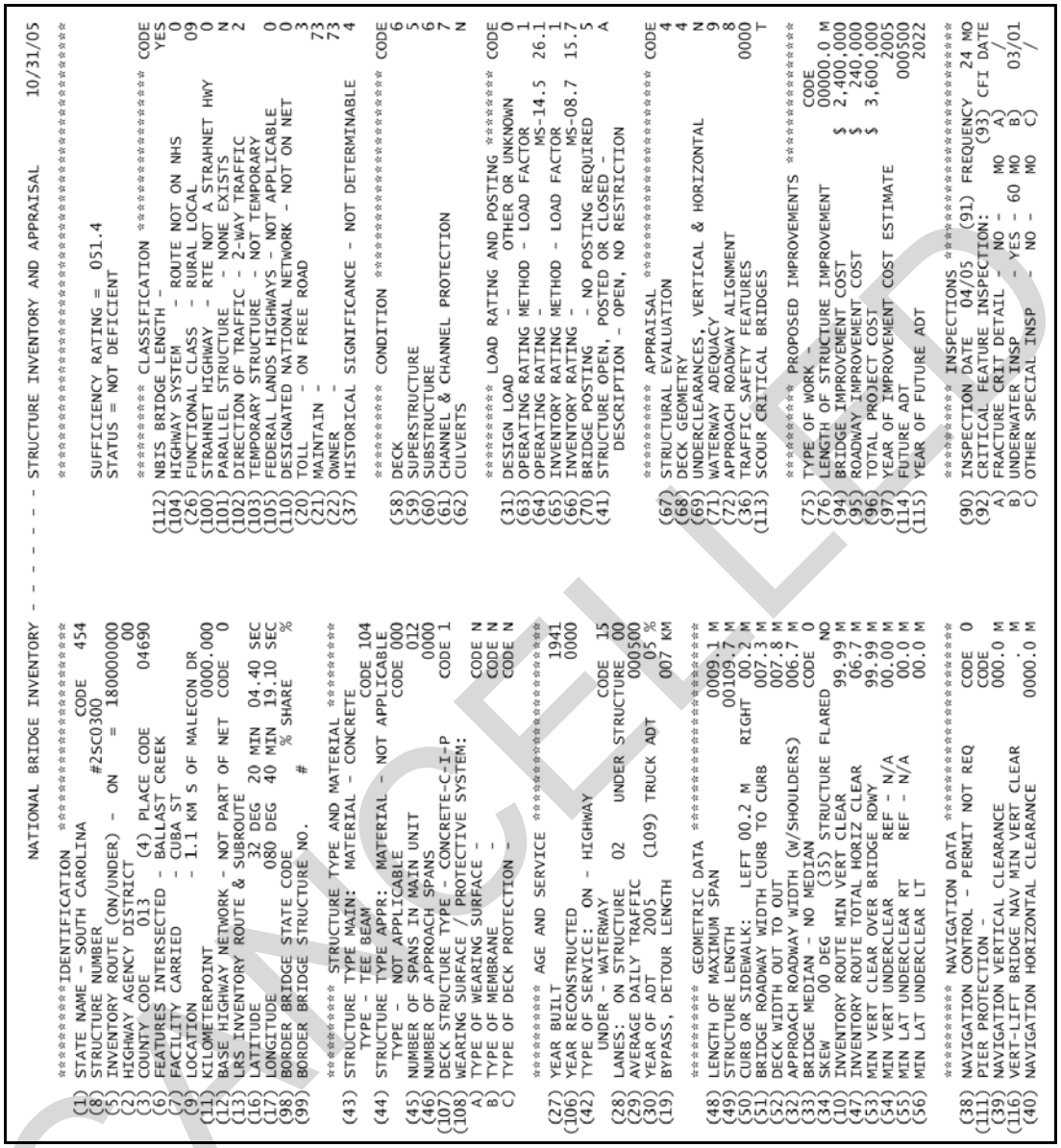
Attention should also be paid to the issue of ownership versus responsible party. There have been examples where ownership, use, and maintenance were shared between military and civilian agencies, or where transfer of ownership between a military agency and another agency (either civilian or military) was only partially completed. Such situations must be carefully monitored to ensure that the legal responsibility for maintenance (and therefore inspection) is clearly established. The absence of legally binding language may lead to a potentially unsafe bridge due to lack of inspection, maintenance, and repair.

2-3.4 Bridge Inventory and Reporting.

An inventory of all bridges shall be maintained by the Service branch with jurisdiction over those bridges. Reporting of inspection findings shall be per each individual agency's policy and FHWA-PD-96-001. A typical SI&A coding form is shown in Figure 2-1. Inspection data, including inventory and appraisal data (SI&A data), shall be collected and maintained for all bridges that are inspected, even if they are technically not subject to NBIS requirements. However, it is not necessary to transmit inventory and appraisal data to the FHWA for bridges on any garrison/base in foreign territory or for "non-reportable" bridges. There is one exception to this: the FHWA needs to be advised about "non-reportable" bridges that go over a Federal Aid highway, Strategic Highway Network (STRAHNET) route or connector, or other important structure. Inventory data (not appraisal information) on bridges that fall into this category should be reported if no record of the bridge has been previously reported or if the bridge is modified.

It is not necessary for all DOD agencies to have the same standard report format or inventory system; however, each agency shall, at a minimum, use an internally consistent system and standardized inspection forms. For the purposes of internal recordkeeping, each agency's standard SI&A form may be further modified, as desired, to better reflect bridge data in a foreign territory.

Figure 2-1 Typical SI&A Coding Form



2-3.5 Bridge Inspections.

Because all garrison/base bridges are designated as public, unless otherwise specified, all roadway bridges (including culverts) over 20 feet in length shall be inspected per NBIS. Roadway bridges and culverts over 20 feet in length which are located on a garrison/base in foreign territory shall also be inspected per NBIS criteria; only the FHWA reporting requirement is waived for these situations, as explained in subsection 2-3.4.

The inspection interval shall be as specified per NBIS and as referenced in paragraph 2-1.3.4 of this UFC. For bridges on U.S. territory, the maximum inspection frequency may be modified as per NBIS, provided that the FHWA grants written approval.

Appendix B, Section 2, contains criteria to assist the program manager to determine if it is appropriate to request an alteration to bridge inspection frequency. Before the program manager requests an alteration to underwater inspection frequency, it may be helpful to review FHWA-DP-80-1, *Underwater Inspection of Bridges*. This report not only lists various factors that affect the needed frequency of underwater inspection but also contains valuable information on underwater inspection techniques, underwater repair techniques, and scour issues.

2-3.6 Load Rating.

Load rating shall be performed for all roadway bridges that meet the NBIS definition of a bridge (over 20 feet measured along the centerline of roadway). The load rating shall be calculated in accordance with AASHTO MBE-1. For bridges on a garrison/base in foreign territory, if the foreign country's bridge code is more stringent than AASHTO, the foreign bridge code shall govern the load rating. Besides the standard AASHTO live loads and, if applicable, more stringent foreign code live loads, the load rating shall also include the military load classification (MLC); refer to Appendix B, Section1, for more information on military vehicle live loads. Appropriate MLC signs shall be placed at both ends of the bridge; this shall be done for all vehicular bridges requiring a load rating (i.e., all roadway bridges over 20 feet long). Posting of bridges for civilian vehicles, when determined to be necessary from the load rating, shall be in accordance with local requirements (typically state legal load limits, or the foreign code legal load limits); see Appendix B, Section 4, for state posting loads.

2-3.7 Fracture Critical Members (FCM).

An FCM is defined by NBIS as a steel member in tension, or with a tension element, whose failure would probably cause a portion of the bridge, or the entire bridge, to collapse. These members require a "hands-on" or "arm's-length" inspection per NBIS, in accordance with the BIRM and industry standard procedures. Cracks and defects detected in an inspection shall be followed with a fatigue and/or fracture analysis of the member. The analysis should be used to determine the remaining useful life and critical crack size.

2-3.8 Scour Evaluation.

Inspections shall determine if further analysis is warranted for scour, and, if necessary, further investigation shall be recommended. Guidance on scour is found in FHWA HEC-18; also see Appendix A for FHWA scour plans of action which are required for all scour-critical bridges. As a minimum, all bridges shall receive a Level 1 qualitative evaluation for scour; refer to FHWA HEC-18. Depending on the Level 1 results, higher level analyses may be necessary to reach a final determination regarding scour-criticality.

Of course, damage inspections (as per NBIS) should be scheduled following flood events to check for scour-related issues. Furthermore, scour re-evaluations (either Level 1 or higher) may be necessary if field inspections reveal unanticipated

environmental changes (e.g., significant silting) or if modifications are made to the bridge or channel (e.g., pier widening).

2-3.9 Pedestrian Bridges.

These bridges fall outside the NBIS scope and are not usually reported to the FHWA; see paragraph 2-3.4 for exceptions. However, the garrison/base commander is strongly encouraged to request the program manager to regularly inspect these structures as part of the agency's bridge inspection program. The program manager in this case shall determine an appropriate inspection frequency. If an inspection and load rating are performed, the bridge shall be posted for reduced pedestrian traffic if the load rating is less than 60 pounds per square foot (psf). If the load rating is performed and is found to be less than 40 psf, the bridge shall be closed to pedestrian traffic until it is repaired. AASHTO GSDPB-1, *Guide Specifications for Design of Pedestrian Bridges*, is a good reference for this topic.

2-3.10 Railroad Bridges.

Unless they also carry vehicular traffic, these bridges fall outside the NBIS scope and are not usually reported to the FHWA; see paragraph 2-3.4 for exceptions. However, the garrison/base commander is strongly encouraged to request the program manager to regularly inspect these structures as part of the agency's bridge inspection program. The program manager in this case shall determine an appropriate inspection frequency. The Federal Railroad Administration (FRA) states that prevailing industry practice is to inspect railroad bridges at least annually. Guidance on inspection procedures for railroad bridges may be found in the FRA's *Statement of Agency Policy on the Safety of Railroad Bridges* (Code of Federal Regulations, Title 49, Part 213, Appendix C) and in the American Railway Engineering and Maintenance-of-Way Association (AREMA) *Bridge Inspection Handbook*. Guidance on load rating for railroad bridges is in AREMA *Manual for Railway Engineering*.

2-3.11 Other Bridges (Non-Public or Short-Span).

These bridges fall outside the NBIS scope and are not usually reported to the FHWA; see subsection 2-3.4 for exceptions. Generally, there will be no non-public structures as all garrison/base bridges are designated as having the potential for public access. But there are many bridges and culverts shorter than 20 feet in length that carry appreciable traffic. Because of this, the garrison/base commander is strongly encouraged to request the program manager to regularly inspect these short-span structures as part of the agency's bridge inspection program. The program manager in this case shall determine an appropriate inspection frequency.

2-3.12 Seismic Evaluation.

All bridges shall be evaluated to determine if further analysis is warranted for seismic activity, and, if necessary, further investigation shall be recommended. Refer to Part 1 of FHWA-RD-94-052, *Seismic Retrofitting Manual for Highway Structures*. The retrofit

philosophy in FHWA-RD-94-052 is performance-based and distinguishes between important, new bridges and less-important bridges near the end of their service life. Based on bridge importance and desired service life, categories are assigned for screening, in-depth evaluation, and retrofitting. Numerous retrofit options exist, such as restrainers, bridge seat extensions, column jackets, footing overlays, and soil remediation. Of course, damage inspections (as per NBIS) should be scheduled after seismic events to evaluate bridge safety.

2-3.13 Quality Control (QC) and Quality Assurance (QA) Procedures.

The program manager shall determine the specific QC review procedures. The program manager shall also determine the QA audit schedule and specific procedures. However, as a minimum, 5 percent of bridge inspection teams and 5 percent of the inspected bridges shall be audited annually in some manner (e.g., through field reviews of inspection teams or office reviews of inspection reports). In addition, an FHWA-approved refresher training course shall be required every five years for program managers and team leaders, as well as for inspectors eligible for the refresher course (i.e., those inspectors having previously completed the FHWA-approved comprehensive training course). Once established, QC/QA procedures for each agency shall be compiled in a manual which is readily available to all personnel involved with bridge inspection; this manual shall be updated to reflect any procedural changes.

2-3.14 Data Storage.

File retention and organization policies shall be determined by the program manager, but shall be a minimum of one inspection cycle (typically two years) for hard copies of inspection reports and load ratings. It is strongly recommended that the hard copies be maintained for two full inspection cycles (typically four years). If only one hard copy per report is maintained, it shall be kept at the garrison/base on which the subject bridge is located; if multiple hard copies per report are maintained, it is recommended that one copy also be located at the central offices of the program manager. Electronic copies of inspection reports and load ratings shall be maintained indefinitely, along with bridge inventory database information.

2-3.15 Special Bridge Types.

Although originally intended for temporary, battlefield applications, prefabricated Bailey and Mabey-Johnson truss panel bridges often remain in use in a permanent capacity. Army Field Manual (FM) 5-277, *Bailey Bridge*, contains useful information on the Bailey system and load capacities.

Because there are many variations of the Bailey and Mabey-Johnson bridge systems, it is recommended that the manufacturer's literature be consulted prior to performing a load rating of these bridge types. In lieu of using the manufacturer's loading data, it is also permissible to load-rate these bridges as a generic truss; however, this procedure will be time-consuming due to the amount of calculations involved.

Model and training bridges are also commonly found on the garrison/base. They are often referred to as research, development, testing and evaluation (RDT&E) models, simulations, or replicas. These are not real property, are not reportable, and should not be part of the garrison/base bridge inventory database, nor should they be part of the National Bridge Inventory (NBI). They should be closed off to all traffic (other than vehicles used for testing or training) and stored in a secure, locked area when not in use. If a load rating or actual regular traffic use on these bridges is desired, a special inspection will be necessary first.

2-4 PROCEDURES FOR BRIDGE MAINTENANCE.

2-4.1 Introduction.

Another goal of this UFC is to ensure that garrison/base bridges are maintained in a safe, usable condition. Preventive maintenance is a planned strategy of cost-effective treatments applied at the proper time to preserve and extend the useful life of a bridge.

2-4.2 Industry Practice.

Bridge maintenance shall be conducted in accordance with the latest industry practice. Valuable references include the American Concrete Institute (ACI) 345.1R-06, *Guide for Maintenance of Concrete Bridge Members*; AASHTO MM-4, *Maintenance Manual for Roadways and Bridges*; and FHWA-NHI-03-045, *Bridge Maintenance Training Reference Manual*.

General maintenance encompasses cleaning activities such as annual water-flushing of all decks, drains, bearings, joints, pier caps, abutment seats, rails, and parapets (typically in the spring). Preventive maintenance encompasses routine activities such as painting, minor coating and sealant applications, minor deck patching, and railing repairs. Stream channel maintenance encompasses activities such as debris removal.

2-4.3 Exceptions and Special Requirements.

This subsection is reserved for future revisions to this UFC.

2-5 PROCEDURES FOR BRIDGE REPAIR.

2-5.1 Introduction.

An additional goal of this UFC is to ensure that bridge deficiencies are discovered and repaired in a timely manner so that garrison/base bridges can remain open and in a safe, usable condition.

2-5.2 Industry Practice.

Bridge repairs shall be conducted in accordance with the latest industry practice. Valuable references include Part 2 of FHWA-RD-94-052, *Seismic Retrofitting Manual*

for Highway Structures, and FHWA HEC-23 (NHI-01-003), *Bridge Scour and Stream Instability Countermeasures*.

Repairs encompass activities such as jacking up the structure, epoxy injection of cracks, adjusting bearing systems, sealing expansion joints, major deck patching, major applications of coatings and sealants, and reinforcement of structural members like stringers, beams, piers, pier caps, pile caps, abutments, and footings. Stream channel repairs encompass activities such as stabilizing banks and correcting erosion problems.

2-5.3 Exceptions and Special Requirements.

This subsection is reserved for future revisions to this UFC.

GLOSSARY

AASHTO— American Association of State Highway and Transportation Officials
ACI—American Concrete Institute
ADTT—average daily truck traffic
AFJPAM—Air Force joint pamphlet
AREMA—American Railway Engineering and Maintenance-of-Way Association
AWS—American Welding Society
BIRM—*Bridge Inspector's Reference Manual*
DOD—Department of Defense
EM—Engineering Manual
ER— Engineering Regulation
FCM—fracture critical member
FHWA—Federal Highway Safety Administration
FM—Field Manual
FRA—Federal Railway Administration
LRFD—load and resistance factor design
MLC—military load classification
NATO—North Atlantic Treaty Organization
NBIS—*National Bridge Inspection Standards*
PE—Professional Engineer
psf—pound per square foot
psi—pound per square inch
QA—quality assurance
QC—quality control
RDT&E—research, development, testing and evaluation
SI&A—structure inventory and appraisal
STANAG—Standardization Agreement
TM—Technical Manual

APPENDIX A

REFERENCES

49 CFR 213, Appendix C, *Statement of Agency Policy on the Safety of Railroad Bridges*, Federal Register Vol. 74 No. 8, 13 January 2009, http://www.fra.dot.gov/downloads/safety/SafetyRRBridges2009.pdf

AASHTO GSDPB-1, *Guide Specifications for Design of Pedestrian Bridges*, 1st Edition, 1997, American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, DC 20001, https://bookstore.transportation.org/item_details.aspx?ID=1154

AASHTO HB-17, *Standard Specifications for Highway Bridges*, 17th Edition, 2002, American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, DC 20001, https://bookstore.transportation.org/item_details.aspx?ID=51

AASHTO LRFDUS-4-M, *LRFD Bridge Design Specifications, Customary U.S. Units,* 4th Edition, 2007, with 2008 and 2009 Interim Revisions, American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, DC 20001, https://bookstore.transportation.org/item_details.aspx?ID=879

AASHTO MBE-1, *The Manual for Bridge Evaluation*, 1st Edition, 2008, American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, DC 20001, https://bookstore.transportation.org/item_details.aspx?ID=1343

AASHTO MBI-1, *Movable Bridge Inspection, Evaluation, and Maintenance Manual*, 1st Edition, 1998, American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, DC 20001, https://bookstore.transportation.org/item_details.aspx?ID=76

AASHTO MM-4, *Maintenance Manual for Roadways and Bridges*, 4th Edition, 2007, American Association of State Highway and Transportation Officials, 444 N. Capitol Street, N.W., Suite 249, Washington, DC 20001, https://bookstore.transportation.org/item_details.aspx?ID=1170

AASHTO/AWS D1.5M/D1.5:2008, *Bridge Welding Code*, 2008, with 2009 AASHTO Interim Revisions, American Welding Society, 550 N.W. LeJeune Road, Miami, FL 33126, https://bookstore.transportation.org/item_details.aspx?ID=1183

ACI 345.1R-06, *Guide for Maintenance of Concrete Bridge Members*, 14 March 2006, American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333-9094, http://www.concrete.org/bookstorenet/ProductDetail.aspx?itemid=345106

AR 420-1, *Army Facilities Management*, 12 February 2008, with Rapid Action Revision, 28 March 2009, Headquarters, Department of the Army, Washington, DC, http://www.army.mil/USAPA/epubs/pdf/r420_1.pdf

AREMA *Bridge Inspection Handbook*, 2008, American Railway Engineering and Maintenance-of-Way Association, 10003 Derekwood Lane, Suite 210, Lanham, MD 20706, http://www.arema.org

AREMA *Manual for Railway Engineering*, 2009, American Railway Engineering and Maintenance-of-Way Association, 10003 Derekwood Lane, Suite 210, Lanham, MD 20706, http://www.arema.org

EM 385-1-1, *Safety and Health Requirements*, 15 September 2008, Department of the Army, U.S. Army Corps of Engineers, Washington, DC 20314-1000, http://140.194.76.129/publications/eng-manuals/em385-1-1/2008_English/toc.html

ER 1110-2-111, *USACE Bridge Safety Program*, 1 August 2007, with Errata 1, 4 October 2007, Department of the Army, U.S. Army Corps of Engineers, Washington, DC 20314-1000, http://140.194.76.129/publications/eng-regs/er1110-2-111/toc.htm

FHWA HEC-18 (NHI-01-001), *Evaluating Scour at Bridges*, 4th Edition, May 2001, Federal Highway Administration National Highway Institute, 4600 N. Fairfax Drive, Suite 800, Arlington, VA 22203, http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=17&id=37

FHWA HEC-23 (NHI-01-003), *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance*, 2nd Edition, March 2001, Federal Highway Administration National Highway Institute, 4600 N. Fairfax Drive, Suite 800, Arlington, VA 22203, http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=23&id=49

FHWA *Manual on Uniform Traffic Control Devices for Streets and Highways*, 2003 Edition; Revised November 2004; Revised December 2007, Federal Highway Administration, http://mutcd.fhwa.dot.gov/pdfs/2003r1r2/pdf_index.htm

FHWA Scour Plans of Action, Federal Highway Administration, http://www.fhwa.dot.gov/engineering/hydraulics/bridgehyd/poa.cfm

FHWA-DP-80-1, *Underwater Inspection of Bridges*, November 1989, Federal Highway Administration Demonstration Projects Division, 400 7th Street, S.W., Washington, DC

20590, http://www.fhwa.dot.gov/engineering/hydraulics/library_arc.cfm?pub_number=27&id=3

FHWA-NHI-03-001, *Bridge Inspector's Reference Manual*, Volume 1, October 2002; Revised December 2006, Federal Highway Administration National Highway Institute (HNHI-10), 4600 N. Fairfax Drive, Suite 800, Arlington, VA 22203, http://www.fhwa.dot.gov/bridge/bripub.htm

FHWA-NHI-03-002, *Bridge Inspector's Reference Manual*, Volume 2, October 2002; Revised December 2006, Federal Highway Administration National Highway Institute (HNHI-10), 4600 N. Fairfax Drive, Suite 800, Arlington, VA 22203, http://www.fhwa.dot.gov/bridge/bripub.htm

FHWA-NHI-03-045, *Bridge Maintenance Training Reference Manual*, March 2003, Federal Highway Administration National Highway Institute, http://www.nhi.fhwa.dot.gov/training/NHIStoreSearchResults.aspx?get=&COURSE_NO=134029&KEYWORD=&TITLE

FHWA-PD-96-001, *Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges*, December 1995, with Errata Sheet, December 2003, Federal Highway Administration Office of Engineering, Bridge Division, Bridge Management Branch, Washington, DC 20590, http://www.fhwa.dot.gov/bridge/bripub.htm

FHWA-RD-94-052, *Seismic Retrofitting Manual for Highway Structures: Part 1 – Bridges*, 1 December 2006, Federal Highway Administration, http://mceer.buffalo.edu/publications/Bridge_and_Highway_Reports/seismic_retrofit_manual

FHWA-RD-94-052, *Seismic Retrofitting Manual for Highway Structures: Part 2 – Retaining Structures, Slopes, Tunnels, Culverts, and Roadways*, 1 December 2006, Federal Highway Administration, http://mceer.buffalo.edu/publications/Bridge_and_Highway_Reports/seismic_retrofit_manual

FM 3-34.343, *Military Nonstandard Fixed Bridging*, 12 February 2002, Headquarters, Department of the Army, Washington, DC, http://www.apd.army.mil/

FM 5-277, *Bailey Bridge*, 9 May 1986, with Change 1, 15 August 1991, Headquarters, Department of the Army, Washington, DC, http://www.apd.army.mil/

National Bridge Inspection Standards (NBIS), 23 CFR 650C, Federal Register Vol. 69 No. 239, 14 December 2004, http://www.fhwa.dot.gov/bridge/nbis.htm

NATO STANAG 2021, *Military Load Classification of Bridges, Ferries, Rafts and Vehicles*, 6th Edition, 7 September 2006, North Atlantic Treaty Organization, http://nsa.nato.int/nsa/ to request access to protected tab

UG-6002-OCN, *Bridge Inspection and Reporting Guidelines*, 1 October 2006, Department of the Navy, NFESC, Building 36, Suite 333, 720 Kennon St., S.E., Washington Navy Yard, DC 20374, http://www.wbdg.org/ccb/DOD/UFC/ufc_3_310_08_navy_guidelines.pdf

APPENDIX B

BEST PRACTICES

SECTION 1 MILITARY LOAD CLASSIFICATION (MLC) AND MILITARY VEHICLE LIVE LOAD DATA

Excerpted from FM 3-34.343, *Military Nonstandard Fixed Bridging*, Appendix B, "Vehicle Classification", 12 February 2002, Headquarters, Department of the Army, Washington, DC:

[Note: Minor edits have been made for this appendix to eliminate non-relevant material, typos, and page number references from FM 3-34.343. Ultimately, all data herein is based on NATO STANAG 2021.]

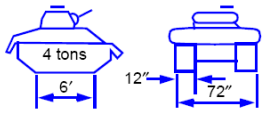
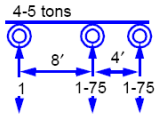
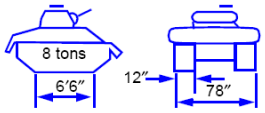
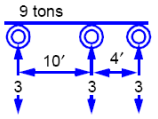
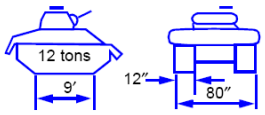
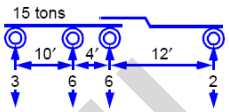
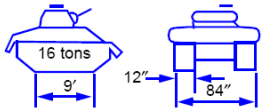
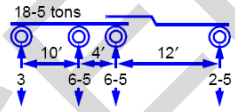
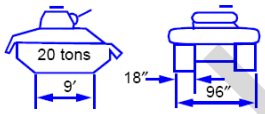
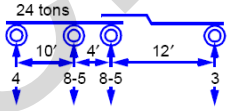
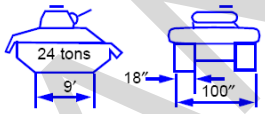
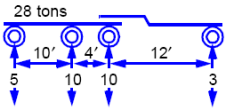
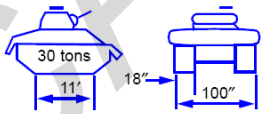
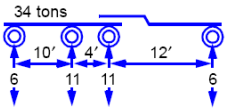
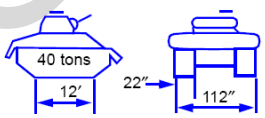
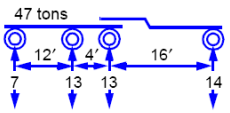
Vehicles are assigned MLC numbers, which represent the loading effects they have on a bridge. The MLC does not represent the actual weight of a vehicle. It represents a combination of factors that include gross weight, axle spacing, weight distribution to the axles, and speed. All standard Army vehicles and special equipment that use bridges of military importance have an MLC. Trailers that are rated with a payload of 1 1/2 tons or less are exceptions. They have a combined classification with their towing vehicle. Classifying vehicles, trailers, or vehicle combinations with a gross weight of 3 tons or less is optional.

Table B1-1 shows 16 standard classes of hypothetical vehicles ranging from 4 to 150. The weight of the tracked vehicle in short tons was chosen as the classification number. A wheeled vehicle has a weight greater than its classification number. Each classification number has a specified maximum single-axle load. Also specified are the maximum tire load, the minimum tire size, and the maximum tire pressure. The classification numbers were originally developed from studies of the hypothetical vehicles having characteristics about the same as those actual military vehicles of NATO nations.

The moment and shear forces produced by the hypothetical vehicles or single-axle loads are provided in Tables B1-2 and B1-3. These figures are based on the assumption that the nearest ground contact points of two different vehicles (wheeled or tracked) are 100 feet apart. Table B1-1 gives critical tire loads and tire sizes.

Standard classification curves were developed for classifying vehicles, for designing nonstandard bridges, and for estimating the capacity of existing bridges. Each standard class has a moment and a shear curve (Figure B1-1 and Figures B1-2 through B1-4). The maximum moment and shear forces were induced against the simple-span lengths by the hypothetical vehicles for each standard class. These forces were plotted to determine the curves. The actual values for the curves are found in Tables B1-2 and B1-3. Note that in the curves, shear is represented in units of kips; however, in Table B1-3, shear is represented in units of tons. No allowance is made for impact, and the assumption is made that all vehicles will maintain the normal convoy spacing of 100 feet between ground contact points.

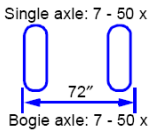
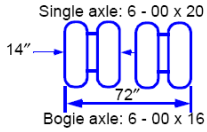
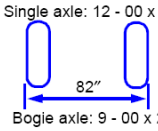
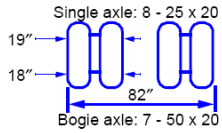
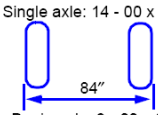
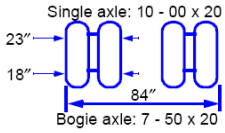
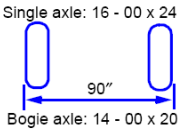
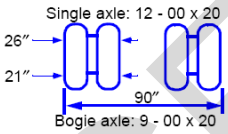
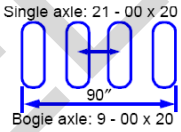
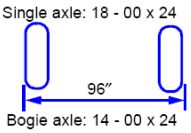
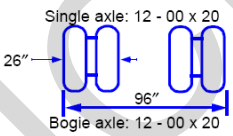
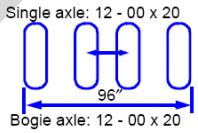
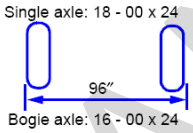
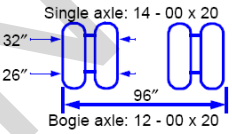
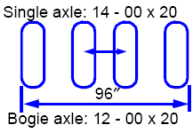
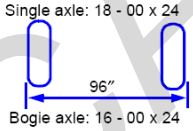
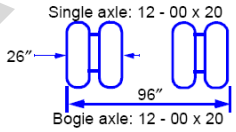
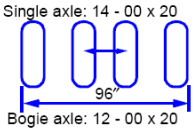
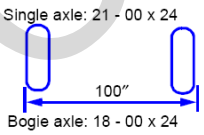
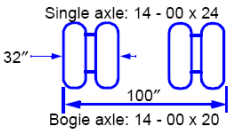
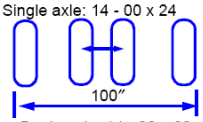
Table B1-1 Standard Classes of Hypothetical Vehicles

Hypothetical Vehicles for Classification of Actual Vehicles and Bridges			
1	2	3	4
Class	Tracked Vehicles	Wheeled Vehicles	
		Axle Loads and Spacing	Maximum Single-Axle Load (in Short Tons)
4			
8			
12			
16			
20			
24			
30			
40			

NOTES:
1. The single-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum single-axle loads given in Column 4.
2. The bogie-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum bogie-axle loads shown on the diagrams in Column 3.
3. The maximum tire pressure for all tires shown in Column 8 should be taken as 75 psi. The first dimension of tire size refers to the overall width of the tire and the second dimension is the rim diameter of the tire.

[Note: There is a typo in Column 3, Class 12 above, as the axle loads shown do not add up to 15 tons. The middle two axles should be labeled 5, not 6.]

Table B1-1 Standard Classes of Hypothetical Vehicles (continued)

Hypothetical Vehicles for Classification of Actual Vehicles and Bridges				
1	5	6	7	8
Class	Wheeled Vehicles			
	Minimum Wheel Spacing and Tire Sizes of Critical Axles			Maximum Tire Load and Minimum Tire Size
4				 2,500 lb on 7 - 50 x 20
8				 5,500 lb on 12 - 00 x 20
12				 8,000 lb on 14 - 00 x 20
16				 10,000 lb on 16 - 00 x 24
20				 11,000 lb on 18 - 00 x 24
24				 12,000 lb on 18 - 00 x 24
30				 13,500 lb on 18 - 00 x 24
40				 17,000 lb on 21 - 00 x 24

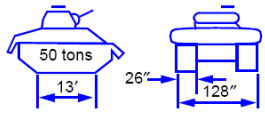
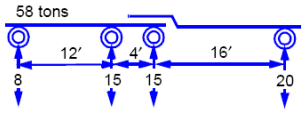
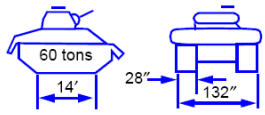
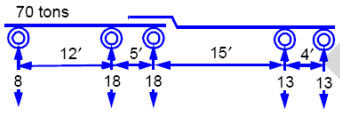
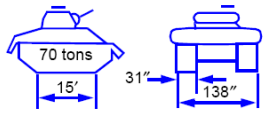
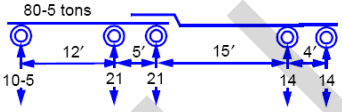
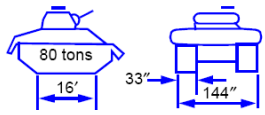
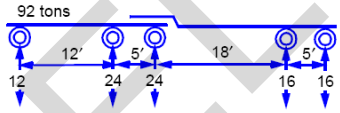
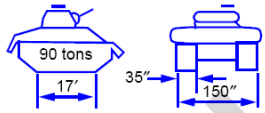
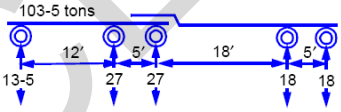
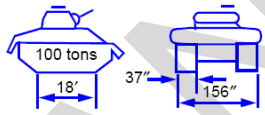
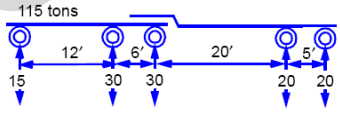
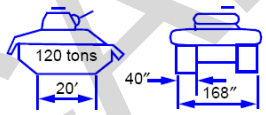
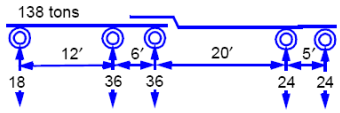
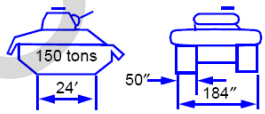
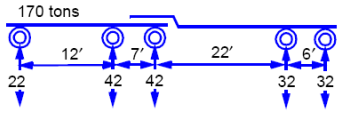
NOTES:

1. The single-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum single-axle loads given in Column 4.

2. The bogie-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum bogie-axle loads shown on the diagrams in Column 3.

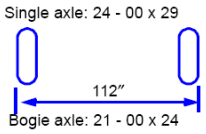
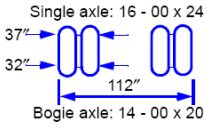
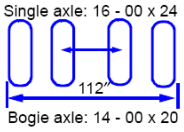
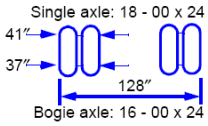
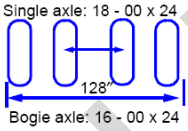
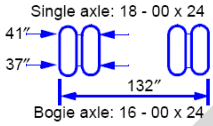
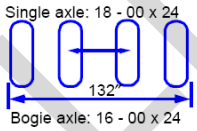
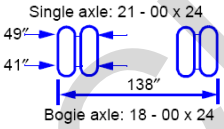
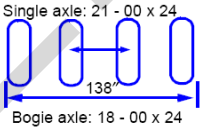
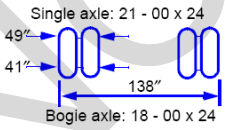
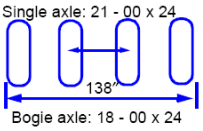
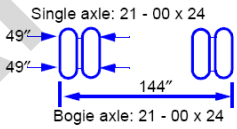
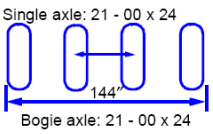
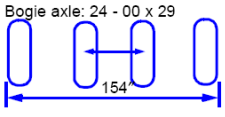
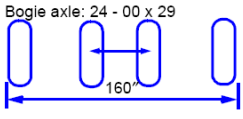
3. The maximum tire pressure for all tires shown in Column 8 should be taken as 75 psi. The first dimension of tire size refers to the overall width of the tire and the second dimension is the rim diameter of the tire.

Table B1-1 Standard Classes of Hypothetical Vehicles (continued)

Hypothetical Vehicles for Classification of Actual Vehicles and Bridges			
1	2	3	4
Class	Tracked Vehicles	Wheeled Vehicles	
		Axle Loads and Spacing	Maximum Single-Axle Load (in Short Tons)
50			
60			
70			
80			
90			
100			
120			
150			

NOTES:
1. The single-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum single-axle loads given in Column 4.
2. The bogie-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum bogie-axle loads shown on the diagrams in Column 3.
3. The maximum tire pressure for all tires shown in Column 8 should be taken as 75 psi. The first dimension of tire size refers to the overall width of the tire and the second dimension is the rim diameter of the tire.

Table B1-1 Standard Classes of Hypothetical Vehicles (continued)

Hypothetical Vehicles for Classification of Actual Vehicles and Bridges				
1	5	6	7	8
Class	Wheeled Vehicles			
	Minimum Wheel Spacing and Tire Sizes of Critical Axles			Maximum Tire Load and Minimum Tire Size
50				
60				
70				
80				
90				
100				
120				
150				

NOTES:
1. The single-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum single-axle loads given in Column 4.
2. The bogie-axle tire sizes shown in Columns 5, 6, and 7 refer to the maximum bogie-axle loads shown on the diagrams in Column 3.
3. The maximum tire pressure for all tires shown in Column 8 should be taken as 75 psi. The first dimension of tire size refers to the overall width of the tire and the second dimension is the rim diameter of the tire.

Table B1-2 Wheeled- and Tracked-Vehicle Moment (in kip-feet)

Class	Wheeled/ Tracked	Span Length (feet)										
		4	6	8	10	12	14	16	18	20	25	30
4	W	4.96	7.44	9.92	12.40	14.88	17.92	21.40	25.60	30.00	41.00	52.20
	T	2.64	6.00	9.92	14.00	18.00	22.10	25.90	29.90	34.00	44.00	54.00
8	W	10.96	16.44	21.90	27.40	32.90	38.30	43.60	49.30	54.80	71.00	93.60
	T	4.88	11.04	19.04	27.00	35.00	43.10	50.90	59.00	66.80	87.00	106.80
12	W	16.00	24.00	32.00	40.00	48.00	56.00	64.00	72.00	80.80	112.50	145.20
	T	5.44	12.00	21.30	33.00	44.90	57.10	69.10	81.00	92.80	123.00	153.00
16	W	20.00	30.00	40.00	50.00	60.00	70.00	80.00	92.50	105.20	144.00	184.20
	T	7.12	15.96	28.50	44.00	60.00	75.90	91.80	108.00	124.00	164.00	204.00
20	W	22.00	33.00	44.00	55.00	70.80	87.40	104.00	121.00	137.60	188.50	241.00
	T	8.88	20.00	35.50	55.00	74.90	94.90	114.90	135.00	154.80	205.00	255.00
24	W	24.00	36.00	48.00	64.00	83.30	102.80	122.60	142.20	162.00	223.00	285.00
	T	10.64	24.00	42.70	66.00	90.00	114.00	137.90	162.00	186.00	246.00	306.00
30	W	26.70	40.40	53.90	70.40	91.70	113.10	134.70	156.60	178.00	246.00	316.00
	T	10.88	24.50	43.70	68.20	97.40	127.40	157.40	187.60	218.00	293.00	367.00
40	W	34.00	51.00	68.00	85.00	108.30	133.80	159.40	185.00	210.00	277.00	359.00
	T	13.36	30.00	53.30	83.40	120.00	158.90	200.00	240.00	280.00	380.00	480.00
50	W	40.00	60.00	80.00	100.00	125.00	154.30	183.70	213.00	243.00	320.00	415.00
	T	15.36	34.60	61.60	96.20	138.50	187.60	237.00	288.00	338.00	463.00	587.00
60	W	46.00	69.00	92.00	115.00	138.00	170.00	205.00	240.00	276.00	365.00	474.00
	T	17.12	38.50	68.60	107.20	154.30	210.00	270.00	330.00	390.00	540.00	690.00
70	W	51.00	76.40	101.90	127.40	157.90	198.20	239.00	280.00	322.00	426.00	557.00
	T	18.64	42.00	74.70	116.60	168.00	229.00	298.00	368.00	438.00	613.00	787.00
80	W	56.00	84.00	112.00	140.00	180.50	227.00	273.00	320.00	368.00	486.00	636.00
	T	20.00	45.00	80.00	125.00	180.00	245.00	320.00	400.00	480.00	680.00	880.00
90	W	60.00	90.00	120.00	151.80	203.00	225.00	308.00	360.00	414.00	547.00	716.00
	T	21.20	47.60	84.60	132.40	190.60	259.00	339.00	427.00	518.00	743.00	967.00
100	W	64.00	96.00	128.00	160.00	203.00	259.00	317.00	375.00	434.00	581.00	765.00
	T	22.20	50.00	89.00	138.80	199.90	272.00	356.00	450.00	550.00	800.00	1,050.00
120	W	72.00	108.00	144.00	180.00	243.00	311.00	380.00	450.00	520.00	697.00	918.00
	T	24.00	54.00	96.00	150.00	216.00	294.00	384.00	486.00	600.00	900.00	1,200.00
150	W	84.00	126.00	168.00	210.00	253.00	331.00	410.00	491.00	572.00	777.00	1,032.00
	T	25.00	56.30	100.00	156.20	225.00	306.00	400.00	506.00	625.00	975.00	1,350.00

Table B1-2 Wheeled- and Tracked-Vehicle Moment (in kip-feet) (continued)

Class	Wheeled/ Tracked	Span Length (feet)									
		35	40	45	50	55	60	70	80	90	100
4	W	63.70	75.20	86.40	97.00	108.90	120.00	142.80	164.80	187.20	210.00
	T	63.70	73.80	83.70	94.00	103.40	114.00	134.40	153.60	174.60	194.00
8	W	116.20	138.40	161.10	183.00	206.00	228.00	273.00	318.00	364.00	408.00
	T	126.70	147.20	167.40	187.00	207.00	227.00	267.00	307.00	347.00	386.00
12	W	180.60	218.00	256.00	293.00	331.00	368.00	444.00	518.00	592.00	668.00
	T	182.70	213.00	243.00	273.00	303.00	332.00	393.00	453.00	513.00	572.00
16	W	229.00	275.00	321.00	367.00	414.00	460.00	552.00	645.00	736.00	830.00
	T	244.00	284.00	324.00	364.00	404.00	444.00	524.00	603.00	684.00	764.00
20	W	299.00	359.00	419.00	479.00	539.00	599.00	718.00	838.00	958.00	1,078.00
	T	305.00	355.00	405.00	455.00	505.00	554.00	655.00	755.00	855.00	954.00
24	W	353.00	422.00	492.00	562.00	633.00	702.00	843.00	982.00	1,121.00	1,262.00
	T	366.00	426.00	486.00	546.00	606.00	666.00	785.00	906.00	1,026.00	1,146.00
30	W	398.00	482.00	567.00	652.00	737.00	822.00	991.00	1,162.00	1,130.00	1,500.00
	T	442.00	518.00	592.00	667.00	743.00	817.00	967.00	1,117.00	1,267.00	1,418.00
40	W	442.00	553.00	671.00	788.00	905.00	1,022.00	1,257.00	1,493.00	1,728.00	1,962.00
	T	580.00	680.00	780.00	880.00	980.00	1,080.00	1,280.00	1,480.00	1,679.00	1,880.00
50	W	511.00	656.00	800.00	945.00	1,090.00	1,235.00	1,525.00	1,814.00	2,100.00	2,390.00
	T	713.00	838.00	962.00	1,087.00	1,212.00	1,338.00	1,588.00	1,837.00	2,090.00	2,340.00
60	W	584.00	740.00	914.00	1,089.00	1,263.00	1,438.00	1,786.00	2,140.00	2,490.00	2,840.00
	T	840.00	990.00	1,140.00	1,290.00	1,440.00	1,590.00	1,890.00	2,190.00	2,490.00	2,790.00
70	W	688.00	856.00	1,057.00	1,257.00	1,458.00	1,658.00	2,060.00	2,460.00	2,870.00	3,270.00
	T	963.00	1,138.00	1,312.00	1,478.00	1,662.00	1,837.00	2,190.00	2,540.00	2,890.00	3,240.00
80	W	786.00	936.00	1,103.00	1,332.00	1,561.00	1,790.00	2,250.00	2,710.00	3,170.00	3,630.00
	T	1,080.00	1,280.00	1,480.00	1,680.00	1,880.00	2,080.00	2,480.00	2,880.00	3,280.00	3,680.00
90	W	884.00	1,053.00	1,242.00	1,499.00	1,757.00	2,010.00	2,530.00	3,050.00	3,560.00	4,080.00
	T	1,193.00	1,418.00	1,643.00	1,867.00	2,090.00	2,320.00	2,770.00	3,220.00	3,670.00	4,120.00
100	W	953.00	1,140.00	1,328.00	1,543.00	1,828.00	2,110.00	2,690.00	3,260.00	3,830.00	4,410.00
	T	1,300.00	1,550.00	1,800.00	2,050.00	2,300.00	2,550.00	3,050.00	3,550.00	4,050.00	4,550.00
120	W	1,143.00	1,368.00	1,593.00	1,851.00	2,195.00	2,540.00	3,230.00	3,910.00	4,600.00	5,290.00
	T	1,500.00	1,800.00	2,100.00	2,400.00	2,700.00	3,000.00	3,600.00	4,200.00	4,800.00	5,400.00
150	W	1,297.00	1,562.00	1,827.00	2,092.00	2,405.00	2,830.00	3,670.00	4,520.00	5,560.00	6,210.00
	T	1,725.00	2,100.00	2,478.00	2,850.00	3,230.00	3,600.00	4,350.00	5,100.00	5,850.00	6,600.00

Table B1-2 Wheeled- and Tracked-Vehicle Moment (in kip-feet) (continued)

Class	Wheeled/ Tracked	Span Length (feet)									
		110	120	130	140	150	160	170	180	190	200
4	W	233	254	278	270	321	346	367	389	414	448
	T	213	233	255	274	294	314	333	353	391	428
8	W	453	499	543	588	633	678	724	767	813	880
	T	427	468	507	546	588	627	666	706	775	852
12	W	744	818	892	969	1,044	1,117	1,193	1,267	1,341	1,416
	T	634	694	754	812	873	934	993	1,051	1,136	1,248
16	W	922	1,015	1,108	1,198	1,293	1,386	1,476	1,570	1,661	1,752
	T	845	924	1,004	1,084	1,164	1,245	1,323	1,404	1,516	1,664
20	W	1,199	1,318	1,438	1,557	1,677	1,798	1,918	2,040	2,160	2,280
	T	1,054	1,154	1,256	1,355	1,455	1,555	1,656	1,753	1,896	2,080
24	W	1,401	1,543	1,682	1,823	1,962	2,100	2,240	2,380	2,520	2,660
	T	1,265	1,385	1,505	1,627	1,746	1,866	1,986	2,110	2,280	2,500
30	W	1,670	1,841	2,010	2,180	2,350	2,520	2,690	2,860	3,030	3,200
	T	1,566	1,718	1,867	2,020	2,170	2,310	2,470	2,620	2,790	3,070
40	W	2,200	2,430	2,670	2,900	3,140	3,370	3,610	3,840	4,080	4,310
	T	2,080	2,280	2,480	2,680	2,880	3,080	3,280	3,480	3,680	4,050
50	W	2,680	2,970	3,260	3,550	3,840	4,130	4,420	4,710	5,000	5,290
	T	2,590	2,840	3,090	3,340	3,590	3,840	4,090	4,340	4,590	5,020
60	W	3,190	3,540	3,880	4,230	4,580	4,930	5,280	5,630	5,990	6,330
	T	3,090	3,390	3,690	4,000	4,290	4,590	4,890	5,190	5,490	5,970
70	W	3,670	4,070	4,470	4,880	5,280	5,680	6,080	6,490	6,890	7,290
	T	3,590	3,940	4,290	4,640	4,990	5,340	5,690	6,040	6,390	6,900
80	W	4,090	4,550	5,010	5,460	5,930	6,380	6,840	7,300	7,760	8,820
	T	4,080	4,480	4,880	5,280	5,680	6,080	6,480	6,880	7,280	7,810
90	W	4,600	5,110	5,630	6,150	6,670	7,180	7,700	8,220	8,730	9,250
	T	4,570	5,020	5,470	5,920	6,370	6,820	7,270	7,720	8,170	8,700
100	W	4,980	5,560	6,130	6,710	7,280	7,860	8,430	9,000	9,580	10,160
	T	5,050	5,550	6,050	6,550	7,050	7,550	8,050	8,550	9,050	9,570
120	W	5,980	6,670	7,360	8,050	8,740	9,430	10,120	10,810	11,500	12,180
	T	6,000	6,600	7,200	7,800	8,400	9,000	9,600	10,200	10,800	11,400
150	W	7,060	7,910	8,760	9,600	10,450	11,300	12,150	13,000	13,850	14,700
	T	7,350	8,100	8,850	9,600	10,350	11,100	11,850	12,600	13,350	14,100

Table B1-2 Wheeled- and Tracked-Vehicle Moment (in kip-feet) (continued)

Class	Wheeled/ Tracked	Span Length (feet)									
		210	220	230	240	250	260	270	280	290	300
4	W	491	532	579	619	665	733	799	868	934	1,002
	T	466	502	538	586	645	707	767	823	887	948
8	W	966	1,052	1,136	1,224	1,310	1,414	1,550	1,686	1,821	1,956
	T	924	1,003	1,076	1,162	1,285	1,404	1,523	1,641	1,763	1,884
12	W	1,491	1,593	1,734	1,877	2,020	2,160	2,310	2,450	2,660	2,890
	T	1,361	1,474	1,587	1,704	1,855	2,040	2,220	2,400	2,580	2,750
16	W	1,848	1,958	2,130	2,390	2,490	2,660	2,840	3,020	3,290	3,570
	T	1,814	1,967	2,120	2,270	2,480	2,710	2,950	3,200	3,430	3,680
20	W	2,400	2,540	2,770	3,000	3,230	3,460	3,690	3,920	4,270	4,630
	T	2,270	2,460	2,650	2,840	3,100	3,400	3,690	3,990	4,290	4,600
24	W	2,800	2,970	3,240	3,500	3,700	4,040	4,310	4,580	4,990	5,410
	T	2,720	2,950	3,170	3,400	3,720	4,070	4,430	4,790	5,160	5,510
30	W	3,370	3,590	3,910	4,240	4,570	4,890	5,220	5,550	6,020	6,530
	T	3,350	3,630	3,910	4,200	4,510	4,960	5,410	5,860	6,310	6,760
40	W	4,550	4,780	5,140	5,590	6,040	6,490	6,940	7,400	7,850	8,310
	T	4,430	4,800	5,180	5,560	5,940	6,520	7,120	7,720	8,320	8,920
50	W	5,580	5,870	6,370	6,930	7,480	8,030	8,590	9,150	9,710	10,270
	T	5,490	5,950	6,430	6,900	7,380	8,040	8,790	9,540	10,290	11,040
60	W	6,680	7,030	7,410	8,070	8,740	9,410	10,050	10,760	11,430	12,110
	T	6,530	7,090	7,650	8,220	8,800	9,510	10,410	11,310	12,210	13,110
70	W	7,690	8,100	8,500	9,260	10,030	10,800	11,570	12,350	13,130	13,910
	T	7,550	8,200	8,860	9,530	10,200	10,940	11,990	13,040	14,090	15,140
80	W	8,680	9,140	9,600	10,180	11,060	11,940	12,830	13,720	14,610	15,500
	T	8,550	9,300	10,060	10,810	11,580	12,340	13,520	14,720	15,920	17,120
90	W	9,770	10,290	10,810	11,450	12,450	13,440	14,430	15,440	16,440	17,440
	T	9,530	10,380	11,220	12,080	12,940	13,800	15,010	16,360	17,710	19,060
100	W	10,730	11,300	11,880	12,450	13,480	14,580	15,690	16,800	17,910	19,030
	T	10,500	11,440	12,380	13,330	14,280	15,230	16,450	17,950	19,450	21,000
120	W	12,870	13,570	14,260	14,940	16,170	17,490	18,820	20,200	21,500	22,800
	T	12,380	13,500	14,630	15,760	16,910	18,050	19,200	21,000	22,800	24,600
150	W	15,550	16,400	17,250	18,100	19,300	20,900	22,500	24,200	25,800	27,500
	T	14,910	16,320	17,720	19,140	20,600	22,000	23,400	24,700	27,200	29,400

Table B1-3 Wheeled- and Tracked-Vehicle Shear (in tons)

Class	Wheeled/ Tracked	Span Length (feet)									
		4	6	8	10	12	14	16	18	20	25
4	W	2.50	2.50	2.63	2.80	2.92	3.14	3.31	3.44	3.55	3.74
	T	1.33	2.00	2.50	2.80	3.00	3.14	3.25	3.33	3.40	3.52
8	W	5.50	5.50	5.50	5.50	5.50	5.50	5.63	6.00	6.30	6.84
	T	2.46	3.69	4.75	5.40	5.83	6.14	6.38	6.56	6.70	6.96
12	W	8.00	8.00	8.00	8.00	8.33	8.57	9.13	9.56	9.90	10.52
	T	2.67	4.00	5.33	6.60	7.50	8.14	8.62	9.00	9.30	9.84
16	W	10.00	10.00	10.00	10.40	10.83	11.14	11.75	12.22	12.60	13.28
	T	3.56	5.33	7.11	8.80	10.00	10.86	11.50	12.00	12.40	13.12
20	W	11.00	11.33	12.75	13.60	14.17	14.57	15.38	16.00	16.50	17.40
	T	4.44	6.67	8.89	11.00	12.50	13.57	14.38	15.00	15.50	16.40
24	W	12.00	13.33	15.00	16.00	16.67	17.14	18.13	18.89	19.50	20.60
	T	5.53	8.00	10.67	13.20	15.00	16.28	17.25	18.00	18.60	19.68
30	W	13.50	14.67	16.50	17.60	18.33	18.86	20.00	20.89	21.60	22.88
	T	5.46	8.18	10.91	13.64	16.25	18.22	19.69	20.83	21.75	23.40
40	W	17.00	17.33	19.50	20.80	21.67	22.29	22.75	23.89	24.80	26.72
	T	6.67	10.00	13.33	16.67	20.00	22.86	25.00	26.67	28.00	30.40
50	W	20.00	20.00	22.50	24.00	25.00	25.71	26.25	27.56	28.60	31.60
	T	7.69	11.54	15.38	19.23	23.08	26.78	29.69	31.94	33.75	37.00
60	W	23.00	23.00	24.75	27.00	28.50	29.57	30.38	31.44	32.70	35.52
	T	8.57	12.86	17.14	21.43	25.72	30.00	33.75	36.67	39.00	43.20
70	W	25.50	25.50	28.88	31.50	33.25	34.50	35.44	36.75	38.33	41.16
	T	9.33	14.00	18.67	23.33	28.00	32.67	37.19	40.83	43.75	49.00
80	W	28.00	28.00	33.00	36.00	38.00	39.43	40.50	42.00	43.80	47.04
	T	10.00	15.00	20.00	25.00	30.00	35.00	40.00	44.44	48.00	54.40
90	W	30.00	31.50	37.13	40.50	42.75	44.36	45.56	47.25	49.28	52.92
	T	10.59	15.88	21.18	26.47	31.76	37.06	42.35	47.50	51.75	59.40
100	W	32.00	32.00	37.50	42.00	45.00	47.14	48.75	50.00	52.50	57.00
	T	11.11	16.67	22.22	27.78	33.33	38.89	44.44	50.00	55.00	64.00
120	W	36.00	36.00	45.00	50.40	54.00	56.57	38.50	60.00	63.00	68.40
	T	12.00	18.00	24.00	30.00	36.00	42.00	48.00	54.00	60.00	72.00
150	W	42.00	42.00	47.25	54.60	59.50	63.00	65.63	67.67	70.40	77.52
	T	12.50	18.75	25.00	31.25	37.50	43.75	50.00	56.25	62.50	78.00

Table B1-3 Wheeled- and Tracked-Vehicle Shear (in tons) (continued)

Class	Wheeled/ Tracked	Span Length (feet)										
		30	35	40	45	50	55	60	70	80	90	100
4	W	3.87	3.96	4.03	4.08	4.12	4.15	4.18	4.23	4.26	4.29	4.31
	T	3.60	3.66	3.70	3.73	3.76	3.78	3.80	3.83	3.85	3.87	3.88
8	W	7.20	7.46	7.65	7.80	7.92	8.02	8.10	8.23	8.33	8.40	8.46
	T	7.13	7.26	7.35	7.42	7.48	7.53	7.57	7.63	7.68	7.71	7.74
12	W	10.93	11.23	11.45	11.62	11.76	11.87	12.13	12.54	12.85	13.09	13.28
	T	10.20	10.46	10.65	10.80	10.92	11.02	11.10	11.23	11.32	11.40	11.46
16	W	13.73	14.06	14.30	14.49	14.64	14.76	14.87	15.34	15.74	16.04	16.29
	T	13.60	13.94	14.20	14.40	14.56	14.69	14.80	14.97	15.10	15.20	15.28
20	W	18.00	18.43	18.75	19.00	19.20	19.36	19.50	19.97	20.48	20.87	21.18
	T	17.00	17.43	17.75	18.00	18.20	18.36	18.50	18.72	18.88	19.00	19.10
24	W	21.33	21.86	22.25	22.56	22.80	23.00	23.17	23.46	24.03	24.47	24.82
	T	20.40	20.92	21.30	21.60	21.84	22.04	22.20	22.46	22.65	22.80	22.92
30	W	23.73	24.34	24.80	25.16	25.60	26.36	27.00	28.00	28.75	29.33	29.80
	T	24.50	25.28	25.88	26.33	26.70	27.00	27.25	27.64	27.94	28.17	28.35
40	W	28.93	30.51	31.70	32.62	33.36	34.42	35.47	37.11	38.35	39.31	40.08
	T	32.00	33.14	34.00	34.67	35.20	35.64	36.00	36.57	37.00	37.33	37.60
50	W	34.67	36.86	38.50	40.31	42.08	43.53	44.73	46.63	48.05	49.16	50.04
	T	39.17	40.72	41.88	42.78	43.50	44.09	44.58	45.36	45.94	46.39	46.75
60	W	39.93	42.09	45.45	47.29	48.76	49.96	51.43	54.09	56.08	57.62	58.86
	T	46.00	48.00	49.50	50.67	51.60	52.36	53.00	54.00	54.75	55.33	55.60
70	W	45.97	49.40	51.98	53.98	55.58	56.89	58.22	61.40	63.79	65.64	67.13
	T	52.50	55.00	56.88	58.33	59.50	60.46	61.25	62.50	63.44	64.17	64.75
80	W	49.20	53.26	56.60	59.20	61.28	62.98	64.40	66.63	69.70	72.18	74.16
	T	58.67	61.72	64.00	65.78	67.20	68.36	69.33	70.86	72.00	72.89	73.60
90	W	55.35	59.91	63.68	66.60	68.94	70.85	72.45	74.96	78.41	81.20	83.43
	T	64.50	68.14	70.88	73.00	74.70	76.09	77.25	79.07	80.44	81.50	82.35
100	W	60.02	64.57	69.00	72.44	75.20	77.45	79.33	82.29	84.69	88.06	90.75
	T	70.00	74.28	77.50	80.00	82.00	83.64	85.00	87.14	88.75	90.00	91.00
120	W	72.02	77.49	82.80	86.93	90.24	92.94	95.20	98.74	101.60	105.70	108.90
	T	80.00	85.71	90.00	93.33	96.00	98.18	100.00	102.90	105.00	106.70	108.00
150	W	82.98	85.66	89.45	95.76	101.20	105.40	109.00	114.70	121.60	127.00	131.30
	T	90.00	98.57	105.00	110.00	114.00	117.30	120.00	124.30	127.50	130.00	132.00

Table B1-3 Wheeled- and Tracked-Vehicle Shear (in tons) (continued)

Class	Wheeled/ Tracked	Span Length (feet)									
		110	120	130	140	150	160	170	180	190	200
4	W	4.33	4.52	4.83	5.13	5.39	5.61	5.81	5.99	6.15	6.29
	T	3.94	4.27	4.56	4.80	5.01	5.20	5.36	5.51	5.64	5.76
8	W	8.51	8.75	9.28	9.90	10.44	10.91	11.33	11.70	12.03	12.33
	T	7.83	8.47	9.05	9.54	9.97	10.35	10.68	10.98	11.24	11.48
12	W	13.44	13.57	13.77	14.21	15.13	16.04	16.86	17.59	18.24	18.83
	T	11.52	12.20	13.10	13.89	14.56	15.15	15.67	16.13	16.55	16.92
16	W	16.50	16.65	16.89	17.41	18.55	19.67	20.69	21.59	22.41	23.14
	T	15.35	16.27	17.48	18.51	19.41	20.20	20.89	21.51	22.06	22.56
20	W	21.44	21.65	21.95	22.63	24.12	25.58	26.89	28.07	29.12	30.06
	T	19.19	20.33	21.85	23.14	24.27	25.25	26.12	26.89	27.58	28.20
24	W	25.11	25.35	25.71	26.51	28.28	29.98	31.51	32.87	33.67	35.18
	T	23.03	24.40	26.22	27.77	29.12	30.30	31.34	32.27	33.09	33.84
30	W	30.18	30.50	30.95	31.91	33.92	35.98	37.36	39.53	41.03	42.38
	T	28.50	29.55	31.85	33.86	35.60	37.13	38.47	39.67	40.74	41.70
40	W	40.71	41.23	41.68	42.86	44.24	46.75	49.36	51.84	54.06	56.06
	T	37.82	38.89	41.85	44.57	46.93	49.00	50.82	52.44	53.89	55.20
50	W	50.76	51.37	51.88	53.46	55.29	58.40	61.60	64.62	67.33	69.76
	T	47.04	48.08	51.54	55.00	58.00	60.63	62.94	65.00	66.84	68.50
60	W	59.87	60.71	61.43	62.41	63.57	67.18	70.99	74.74	78.17	81.26
	T	56.18	57.14	60.92	65.14	68.80	72.00	74.82	77.33	79.58	81.60
70	W	68.35	69.36	70.22	71.35	73.88	76.65	80.99	85.31	89.31	92.89
	T	65.23	66.11	70.00	75.00	79.33	83.13	86.47	89.44	92.10	94.50
80	W	75.78	77.13	78.28	79.26	81.71	84.35	87.95	92.62	97.43	101.80
	T	74.18	75.00	78.85	84.57	89.60	93.89	97.77	101.20	104.30	107.10
90	W	85.25	86.77	88.06	89.16	91.92	94.89	98.85	104.20	109.60	114.50
	T	83.04	83.82	87.56	93.86	99.60	104.60	109.10	113.00	116.50	119.70
100	W	92.95	94.79	96.35	97.68	100.00	103.50	106.90	112.20	117.90	123.50
	T	91.82	92.59	96.15	102.90	109.30	115.00	120.00	124.40	128.40	132.00
120	W	111.50	113.80	115.60	117.20	120.00	124.20	128.20	134.60	141.50	148.20
	T	109.10	110.00	113.10	120.00	128.00	135.00	141.20	146.70	151.60	156.00
150	W	134.80	137.70	140.20	142.30	144.80	149.80	154.80	160.30	168.20	176.30
	T	133.60	135.00	137.00	142.90	152.00	161.30	169.40	176.70	183.20	189.00

Table B1-3 Wheeled- and Tracked-Vehicle Shear (in tons) (continued)

Class	Wheeled/ Tracked	Span Length (feet)									
		210	220	230	240	250	260	270	280	290	300
4	W	6.42	6.54	6.70	6.96	7.22	7.47	7.69	7.90	8.09	8.27
	T	5.87	6.05	6.31	6.55	6.77	6.97	7.16	7.33	7.49	7.64
8	W	12.60	12.84	13.10	13.53	14.04	14.54	15.00	15.43	15.83	16.20
	T	11.70	12.03	12.55	13.02	13.46	13.87	14.24	14.59	14.92	15.22
12	W	19.36	19.85	20.29	20.69	21.06	21.50	22.15	22.91	23.67	24.38
	T	17.26	17.58	18.23	18.97	19.66	20.28	20.87	21.41	21.91	22.38
16	W	23.80	24.40	24.94	25.45	25.91	26.43	27.22	28.16	29.10	29.98
	T	23.01	23.43	24.31	25.30	26.21	27.05	27.82	28.54	29.21	29.84
20	W	30.91	31.69	32.40	33.05	33.65	34.32	35.36	36.58	37.80	38.94
	T	28.76	29.29	30.39	31.62	32.76	33.81	34.78	35.68	36.52	37.30
24	W	36.17	37.07	37.90	38.65	39.34	40.14	41.36	42.79	44.21	45.54
	T	34.51	35.15	36.47	37.95	39.31	40.57	41.73	42.81	43.82	44.76
30	W	43.60	44.71	45.72	46.65	47.50	48.48	49.91	51.60	53.34	54.96
	T	42.57	43.36	44.47	46.31	48.06	49.67	51.17	52.55	53.84	55.05
40	W	57.87	59.51	61.01	62.38	63.65	64.82	66.21	67.70	69.81	72.04
	T	56.38	57.45	58.70	61.00	63.36	65.54	67.56	69.43	71.17	72.80
50	W	71.96	73.96	75.79	77.47	79.01	80.43	82.19	84.11	86.73	89.48
	T	70.00	71.36	72.74	75.31	78.30	81.06	83.61	85.98	88.19	90.25
60	W	84.06	86.60	88.92	91.05	93.01	94.82	96.49	98.60	100.92	103.87
	T	83.43	85.09	86.65	89.29	92.88	96.23	99.33	102.20	104.90	107.40
70	W	96.13	99.08	101.80	104.20	106.50	108.60	110.60	113.00	115.60	118.90
	T	96.67	98.64	100.40	103.10	107.10	111.10	114.70	118.10	121.30	124.30
80	W	105.70	109.20	112.50	115.50	118.20	120.70	123.10	125.30	128.10	131.00
	T	109.60	112.00	114.10	116.70	121.00	125.50	129.80	133.70	137.40	140.80
90	W	118.90	122.90	126.60	129.90	133.00	135.80	138.50	140.90	144.10	147.40
	T	122.60	125.20	127.60	130.10	134.50	139.70	144.50	149.00	153.20	157.10
100	W	128.60	133.20	137.40	141.30	144.80	148.10	151.10	153.90	156.80	160.60
	T	135.20	138.20	140.90	143.50	147.70	153.50	158.90	163.90	168.60	173.00
120	W	154.30	159.80	164.90	169.50	173.80	177.70	181.40	184.70	188.20	192.70
	T	160.00	163.60	167.00	170.00	174.00	180.00	186.70	192.90	198.60	204.00
150	W	184.10	191.20	197.77	203.60	209.10	214.40	218.80	223.10	227.10	231.50
	T	194.30	199.10	203.50	207.50	211.30	216.30	223.40	231.40	239.00	246.00

Figure B1-1 Wheeled Bending Moment

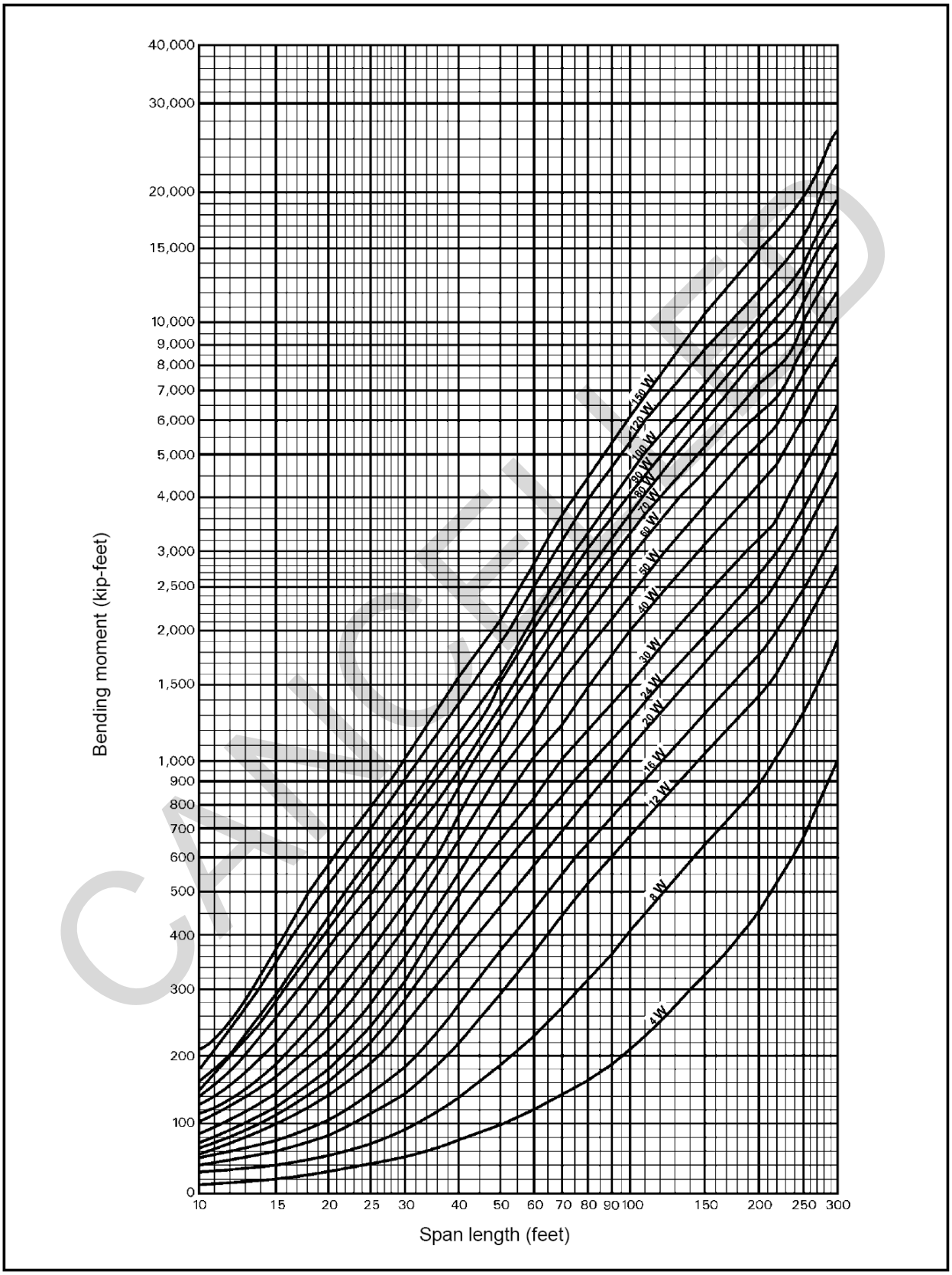


Figure B1-2 Tracked Bending Moment

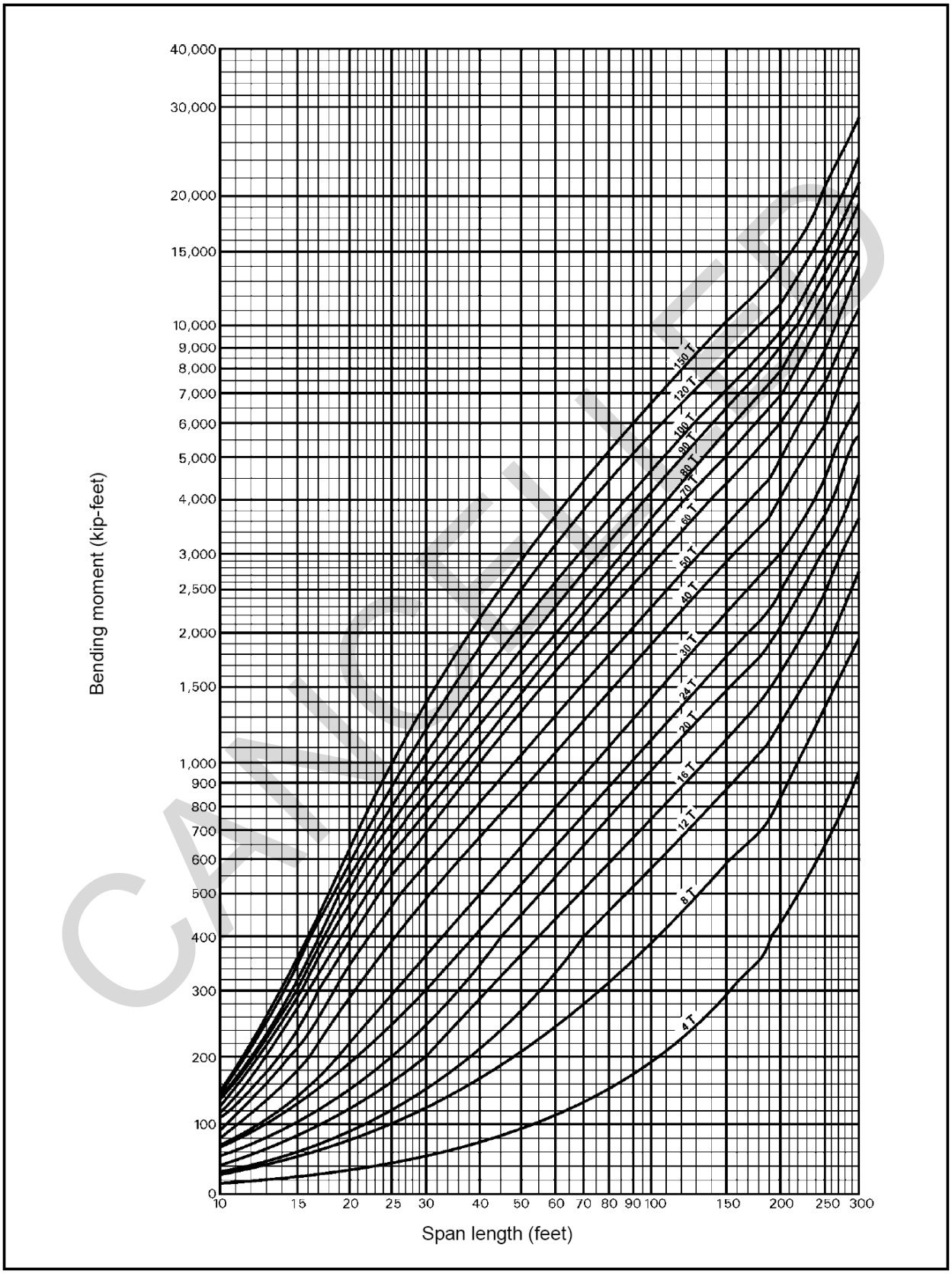


Figure B1-3 Wheeled Shear

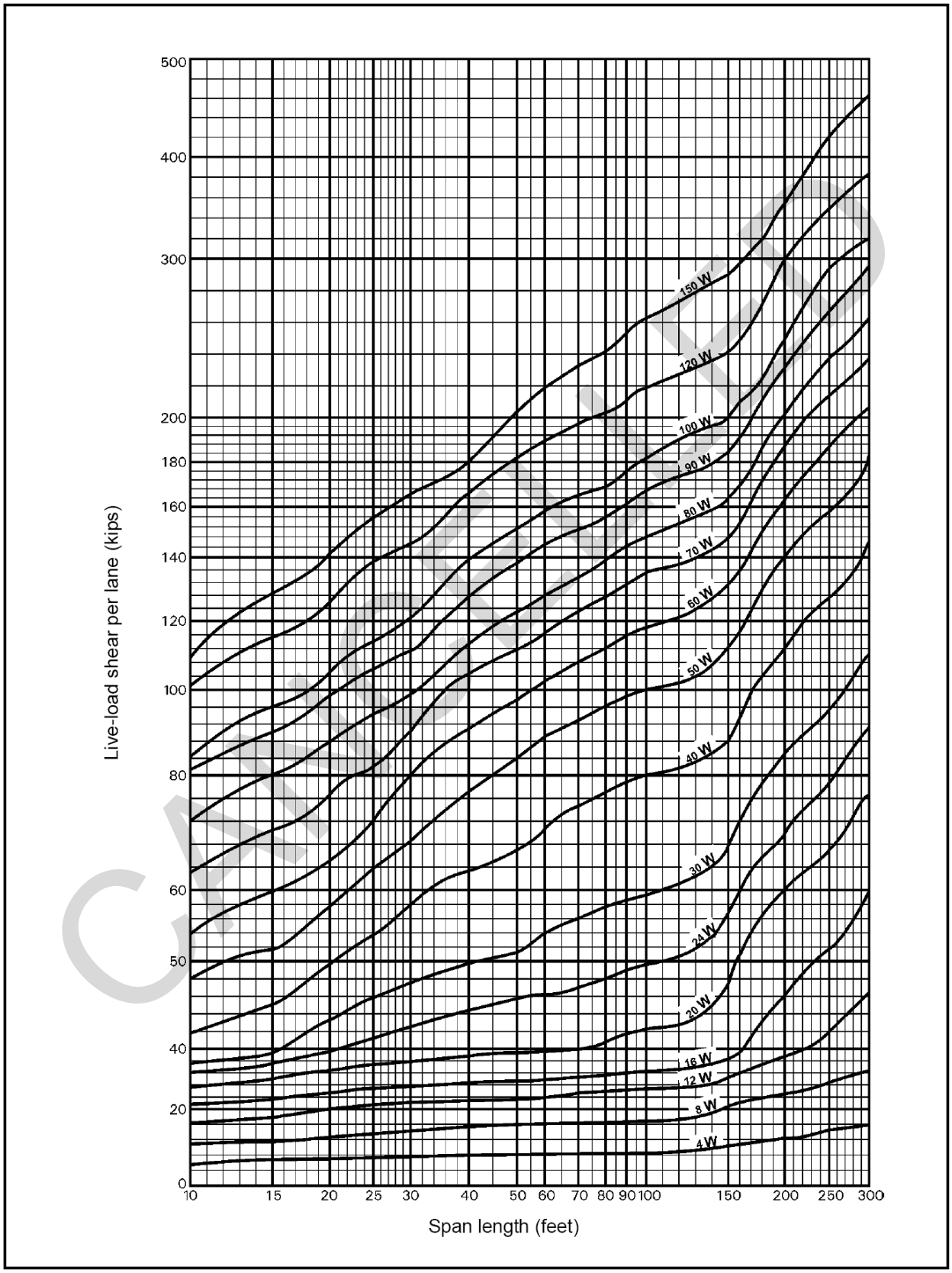
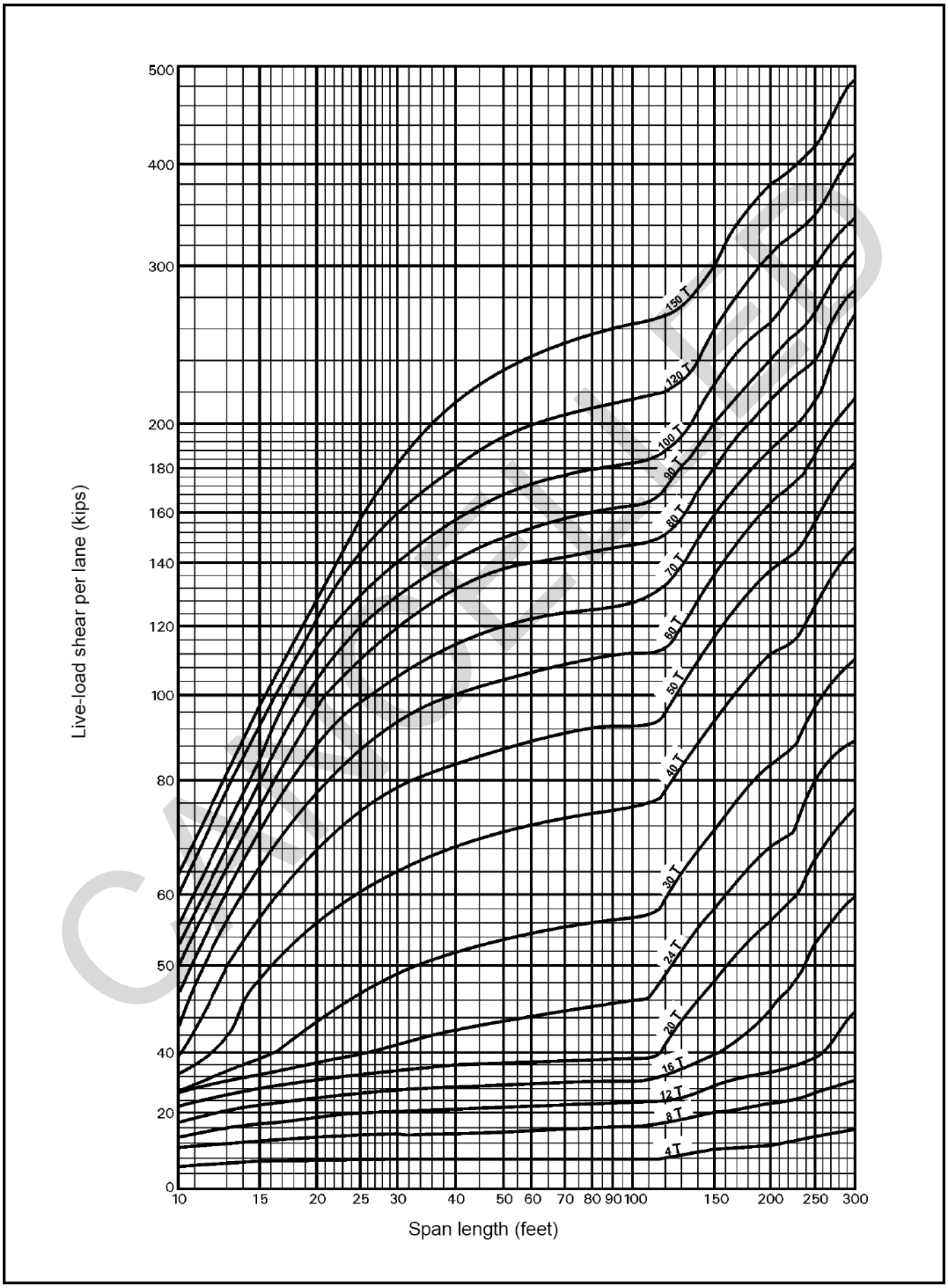


Figure B1-4 Tracked Shear



SECTION 2

CRITERIA FOR PROGRAM MANAGER TO ALTER INSPECTION FREQUENCY

Excerpted from U.S. Department of Transportation Federal Highway Administration's:

TECHNICAL ADVISORY

REVISIONS TO THE NATIONAL BRIDGE INSPECTION STANDARDS (NBIS)

T 5140.21
September 16, 1988

[Note: The material below is taken from a technical advisory for an outdated version of NBIS. The most current version of NBIS is listed in Appendix A. The recommendations in this technical advisory are provided here only to offer the program manager some general guidelines as to what situations might warrant altered inspection frequency and what minimum information the FHWA will need to approve an extended inspection cycle. It should be noted that the varied inspection frequency could be either more often or less often than the standard interval, although FHWA approval is only required for a lengthened inspection interval. Some minor edits have been made below to eliminate outdated or non-relevant information.]

5. IMPLEMENTATION GUIDELINES

a. Varying the Frequency of Routine Inspection. The intent of this NBIS revision is to maintain a 2-year interval as the normal inspection frequency for routine inspection. However, the revised rule includes provisions for adjusting the frequency of routine inspection for certain types or groups of bridges to better conform with their inspection needs. Criteria used for selecting bridges that will have inspection intervals exceeding 2 years must be approved by the FHWA.

(1) The following list is intended as a guide for identifying classes of bridges that, in general, would not be considered for routine inspection at intervals longer than 2 years. This list is also appropriate for identifying bridges that are candidates for routine inspection at intervals more frequent than every 2 years.

(a) Bridges with any condition rating of 5 or less.

(b) Bridges that have inventory ratings less than the State's legal load.

(c) Structures with spans greater than 100' in length.

(d) Structures without load path redundancy.

(e) Structures that are very susceptible to vehicular damage, e.g., structures with vertical over or underclearances less than 14'-0", narrow thru or pony trusses.

(f) Uncommon or unusual designs or designs where there is little performance history, such as segmental, cable stayed, etc.

(2) A new or newly rehabilitated bridge should not be considered for inspection intervals longer than 2 years until it has received an inventory inspection and an in-depth inspection 1 or 2 years later. No bridge should be considered for inspection intervals longer than 2 years unless the bridge has received an in-depth inspection and this inspection revealed no major deficiencies.

(3) The interval established for routine inspections should be evaluated and, if necessary, adjusted after each inspection.

(4) Regardless of the frequency selected for routine inspection, individual bridge members may require differing types and frequency of inspection (e.g., fracture critical members, distressed members and underwater members). In addition, any structure that has been subjected to an earthquake, a major flood, or any other potentially damaging event should immediately receive a damage inspection.

(5) Proposed inspection programs that call for routine inspection at intervals longer than 2 years must be approved by the FHWA Regional Administrator in consultation with the Washington Headquarters office.

(6) The FHWA will send approvals of acceptable Federal agency proposals directly to the Federal agencies and copies will be distributed through normal FHWA channels to affected States.

(7) Submissions to the FHWA for increased inspection intervals must contain the following information as a minimum.

(a) The criteria used in establishing the interval between inspections. The criteria developed for establishing the interval between inspections, if greater than 2 years, shall include the following:

1 Structure type and description.

2 Structure age.

3 Structure load rating.

4 Structure condition and appraisal ratings.

5 Volume of traffic carried.

6 Average daily truck traffic (ADTT).

7 Major maintenance or structural repairs performed within the last 2 years.

8 An assessment of the frequency and degree of overload that is anticipated on the structure.

(b) A discussion of failure experience, maintenance history, and latest inspection findings for the group of structures identified.

(c) The proposed inspection interval.

SECTION 3

POINT OF CONTACT INFORMATION FOR SERVICE BRANCHES

Note: This contact information is valid as of the date of publication for this UFC.

Department of the Army:

Ali A. Achmar
Army Bridge Inspection Program Manager
HQ IMCOM, ATTN: IMPW-E
2509 Dunston Road Bldg 2007, 3rd Floor
Fort Sam Houston, TX 78234
Telephone: 210-295-0993
BB: 210-426-6872
Email: ali.achmar@us.army.mil

Mike Dean
Army Bridge Inspection Program Proponent
OACSIM, ATTN: DAIM-ODF
NC1 Presidential Towers
2511 Jefferson Davis Highway
Arlington, VA 22202
Telephone: 703-601-0703
Email : mike.dean@us.army.mil

Department of the Navy:

Jerry McFeeters, P.E.
Navy Bridge Inspection Program Manager
Naval Facilities Engineering Service Center
ECDET Building 36, Suite 333
720 Kennon St., S.E.
Washington Navy Yard, DC 20374-5063
Telephone: 202-433-5369
Email: jerry.mcfeeters@navy.mil

Danny Green
Navy Bridge Inspection Program Coordinator
Naval Facilities Engineering Service Center
ECDET Building 36, Suite 333
720 Kennon St., S.E.
Washington Navy Yard, DC 20374-5063
Telephone: 202-433-5194
Cellular: 757-647-3573
Fax: 202-433-5089
Email: danny.r.green.ctr@navy.mil

Department of the Air Force:

Jeffrey Nielsen, P.E.
Air Force Bridge Inspection Program Manager
HQ Air Force Civil Engineer Support Agency
139 Barnes Dr, Suite 1
Tyndall AFB, FL 32403
Telephone: 850-283-6332
Email: jeffrey.nielsen@tyndall.af.mil

SECTION 4

STATE LEGAL LOAD LIMITS FOR POSTING

Excerpted from National Cooperative Highway Research Program (NCHRP) Report 575, *Legal Truck Loads and AASHTO Legal Loads for Posting*, Chapter 2, "Findings", 2007, Transportation Research Board, Business Office, 500 Fifth Street NW, Washington, DC 20001:

[Note: All figures have been renumbered for this appendix.]

The following is a summary of the state of the practice with respect to legal loads, based on the survey responses from 45 states:

Question 2.1: Which of the following best describes the legal vehicles in your state?

• AASHTO loads only (11 states): Arizona, California, Indiana, Kansas, Massachusetts, Nebraska, Nevada, Oregon, South Carolina, West Virginia, and Wyoming.
• State loads only (23 states): Alabama, Alaska, Arkansas, Delaware, Florida, Georgia, Idaho, Illinois, Kentucky, Michigan, Minnesota, Missouri, New Hampshire, New York, North Carolina, North Dakota, Ohio, Pennsylvania, South Dakota, Tennessee, Texas, Virginia, and Wisconsin.
• Both (11 states): Colorado, Connecticut, Hawaii, Iowa, Louisiana, Mississippi, New Jersey, New Mexico, Oklahoma, Rhode Island, and Washington.

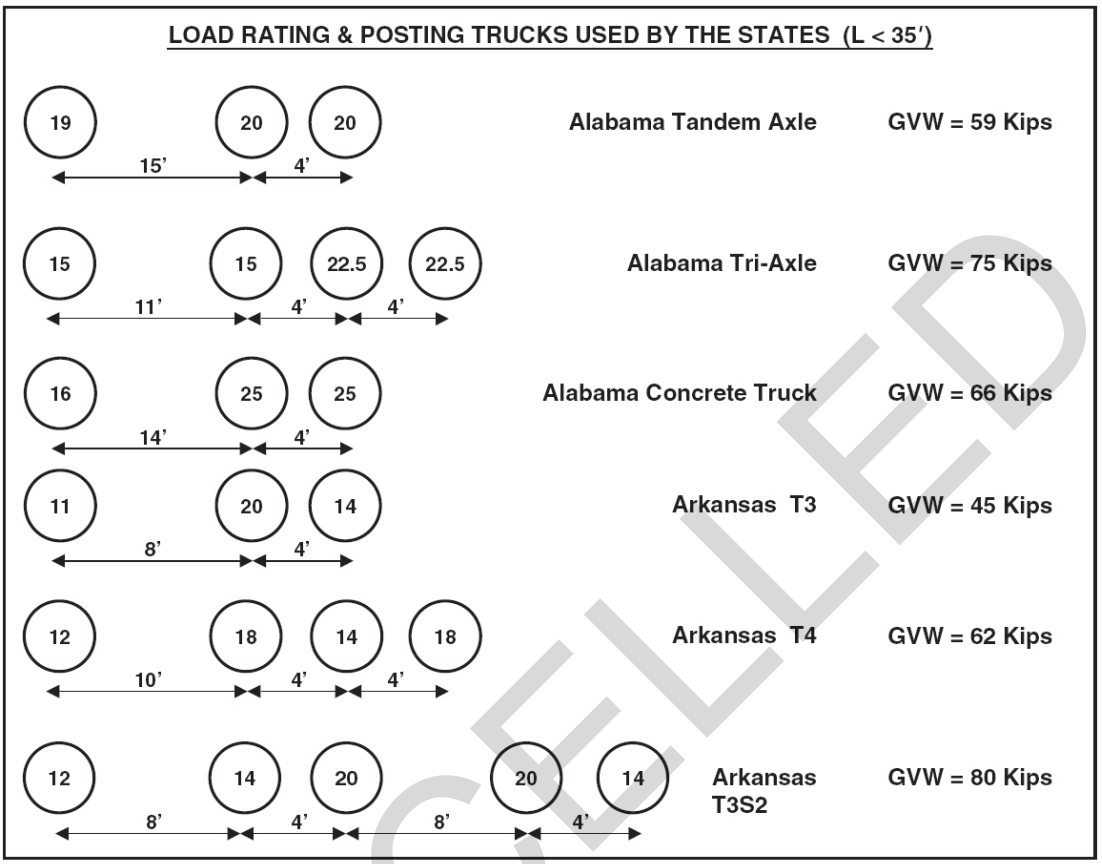
A large number of state legal load configurations currently in use were obtained from the states that use state legal loads only or a combination of state and AASHTO legal loads. They included both single-unit and combination trucks. They were a combination of Formula B and non-Formula B trucks as revealed through further analysis and discussed in this report. As the purview of this research is short multi-axle SHVs, only single-unit trucks under 35 ft long and within the 80,000-lb weight limit were extracted for further review and analysis. A seven-axle, 35-ft-long SHV is allowed a gross weight of 80,500 lbs under FBF requirements, slightly over the maximum under federal weight laws and the 80,000-lb gross weight limit. Therefore, any increase of length would not lead to increased gross weight. It was also felt that this length limit would adequately encompass the SHVs in operation and at the same time leave out the longer combination vehicles. There was no consideration given to the type of vehicle or the number of axles in preparing this shortlist of state legal loads. Some states identify the type of vehicle being modeled by a state legal load, whereas in other cases it may only be a schematic axle configuration with all data needed for bridge rating and posting. Figures B4-1 through B4-7 present schematic axle configurations of state legal loads used for load rating and posting by the various states identified and are also sufficiently different from the AASHTO legal load models.

Michigan uses 28 truck models as legal loads that are divided into three levels: normal, designated, and special designated. The special designated loading applies to Interstate highways and meets applicable federal weight laws. The normal loading

defines the maximum loading for all Michigan roads. For the normal and designated loading there is no direct maximum for the total GVW. There is an indirect maximum caused by the length of vehicle and the number and spacing of axles. Michigan allows up to 11 axles for legal vehicles. Michigan trucks meeting the selection criteria are shown in Figures B4-4 and B4-5. North Carolina uses eight single-unit trucks having up to seven axles and five combination trucks as state legal loads. Different axle and gross weights are allowed for Interstate and non-Interstate bridges (higher for non-Interstate, see Figures B4-6 and B4-7). They were defined as state legal loads based upon a statewide traffic study in 1995 and by closely matching the Formula B gross weight requirements. Under grandfather rights, trucks are allowed to exceed the federal limit for tandem axles by up to 10% (maximum tandem axle weight of 38 K, gross weight not to exceed 80 Kips). Pennsylvania truck TK527 (see Figure B4-4) was developed in 2001 to envelope an entire group of five- to seven-axle trucks that are legal in Pennsylvania. The seven-axle truck with two consecutive axles carrying 41.2 Kips (grandfather rights) produces moments and shears in excess of the five- and six-axle vehicles allowed under Pennsylvania law. It serves as a notional posting vehicle to represent this series of vehicles. For easy identification the truck was designated “TK527.” Of the six consecutive rear axles, the first four are lift axles, each carrying 8.24 Kips. Studies have shown that the TK527 vehicle exceeds the HS20 and ML80 load effects in the span range of 80 to 175 ft.

Several states (Delaware, Florida, Georgia, Kentucky, New Hampshire, Ohio, Michigan, Texas, and North Carolina) use a short two-axle truck 9 ft to 17 ft long as a posting load. The triaxle dump truck with a tridem axle in the rear is a common posting load in many states (Alabama, Arkansas, Connecticut, Delaware, Florida, Kentucky, Michigan, New Hampshire, North Carolina, Pennsylvania, and Tennessee). In some states, these short heavy trucks are allowed to operate under the grandfather exemptions for non-conforming vehicles less than 73.28 Kips—a fact that is reflected in the legal load used for posting. Ohio uses a tri-axle dump that meets FBF requirements. Certain state legal loads are variations of the H, HS, AASHTO Type 3, Type 3S2, and Type 3-3. Georgia uses a modified H20 truck, and Mississippi uses a short version of the HS truck weighing 80 Kips. Many states have a three-axle Type 3 truck that is often a shorter version of the AASHTO Type 3, typically in the 14–16 ft range. In Alabama, Mississippi, and Texas, the three-axle truck models a concrete truck.

Figure B4-1 State Posting Loads (axle load in kips)



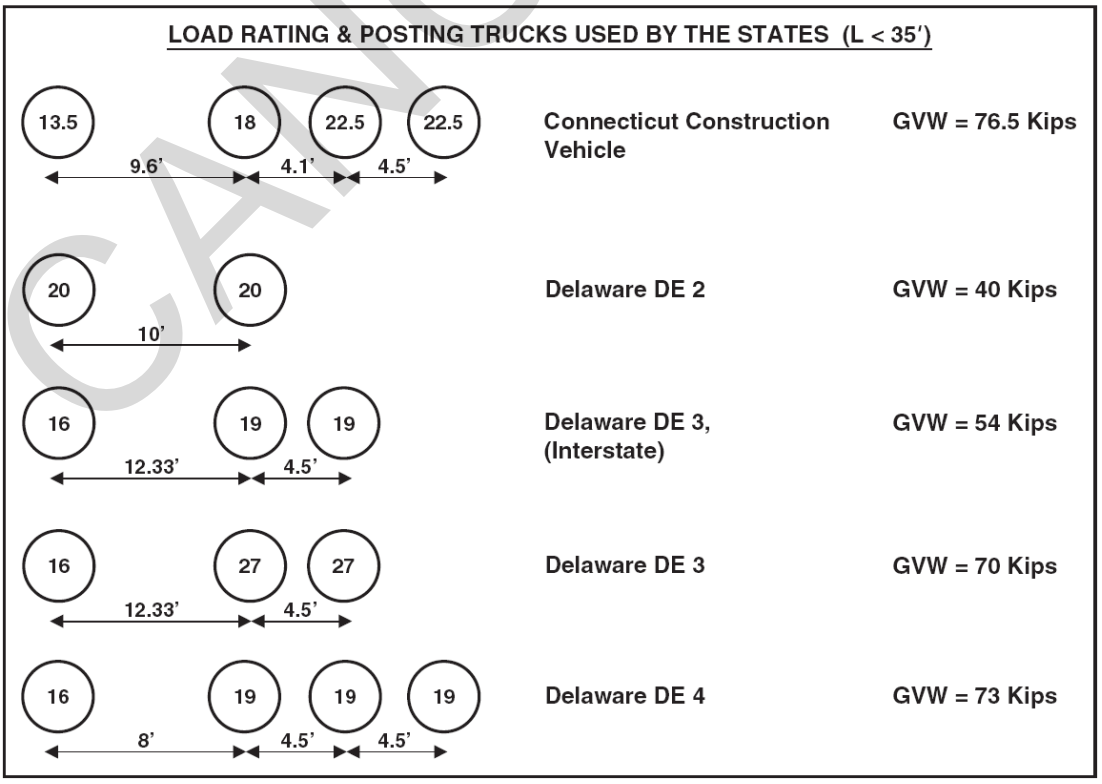
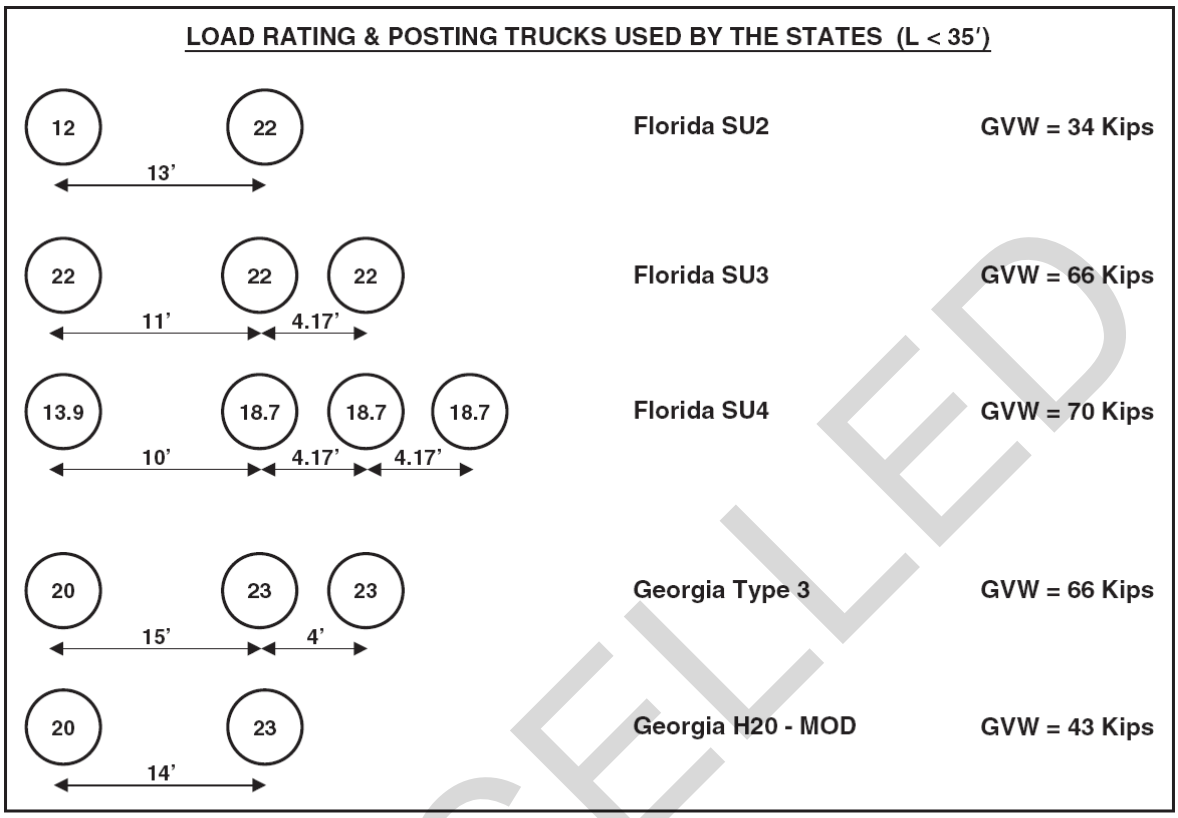


Figure B4-2 State Posting Loads (axle load in kips)



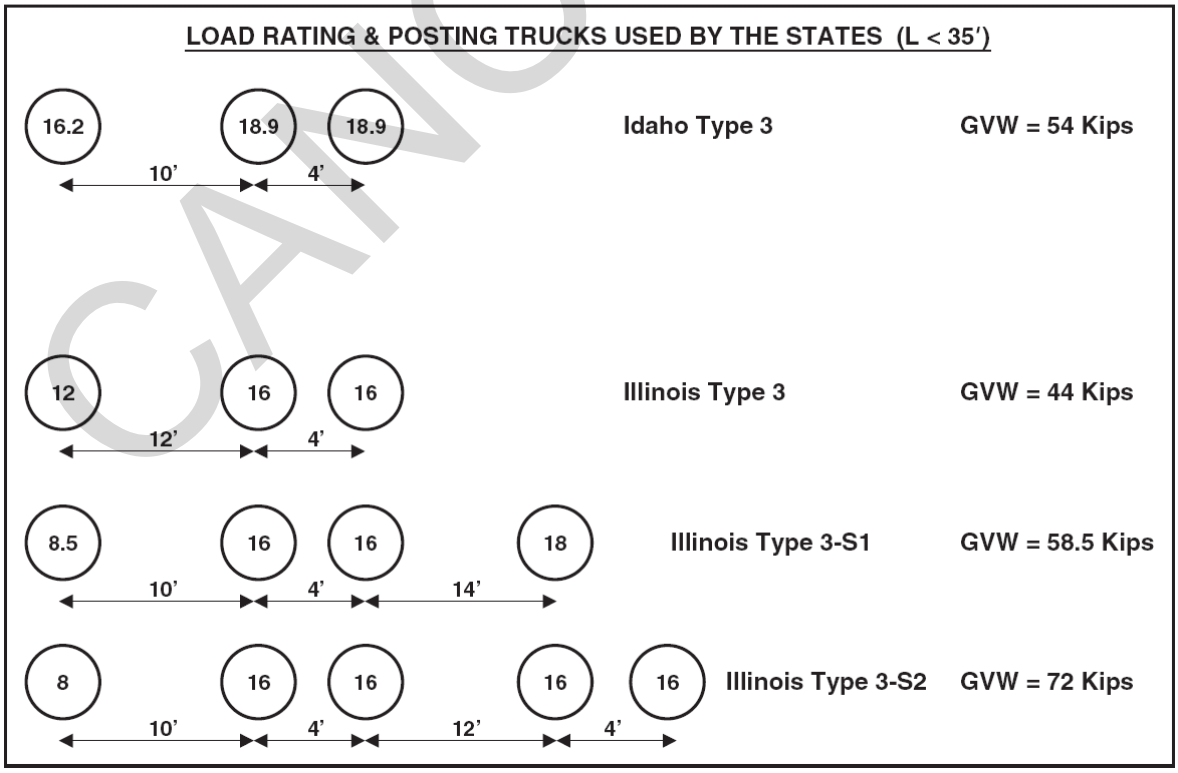
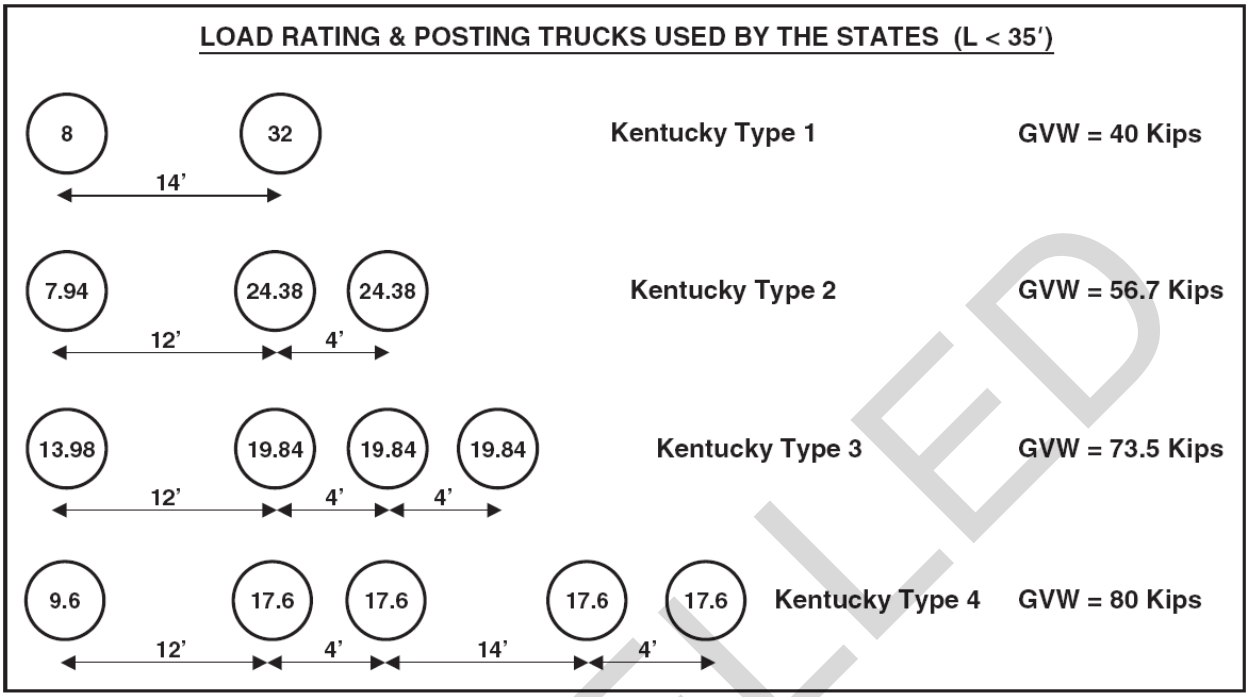


Figure B4-3 State Posting Loads (axle load in kips)



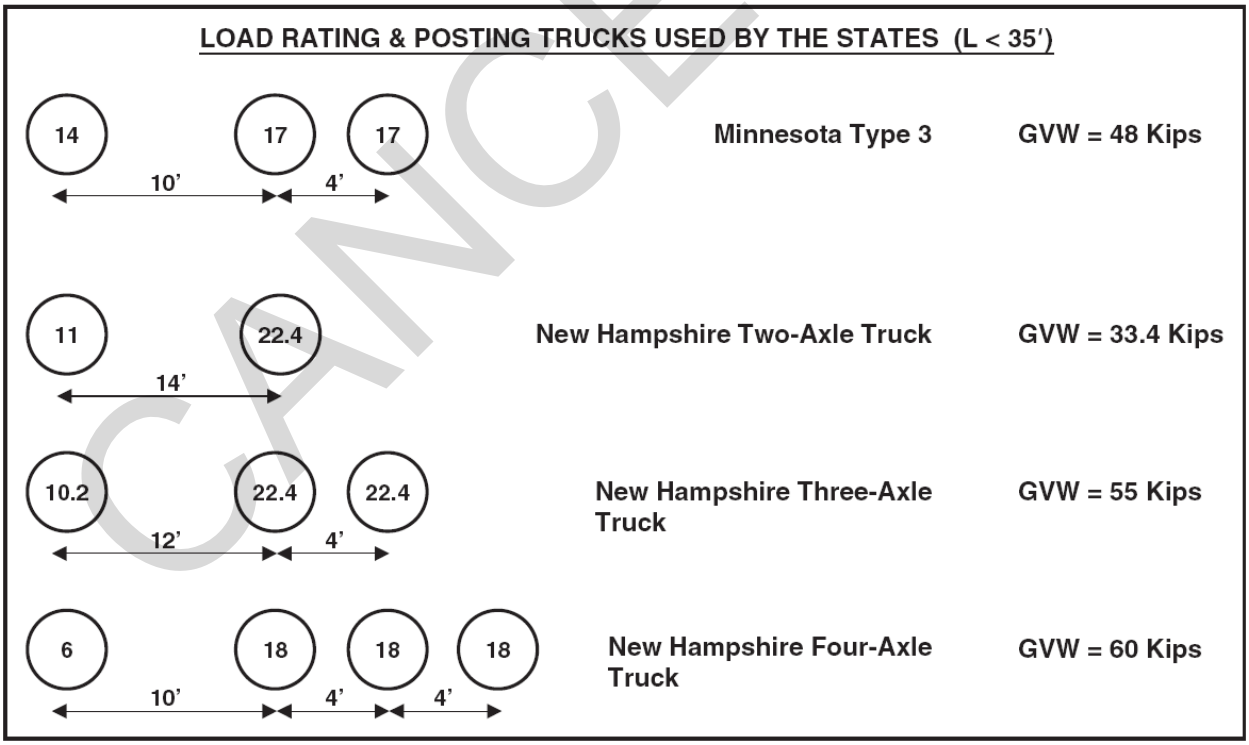
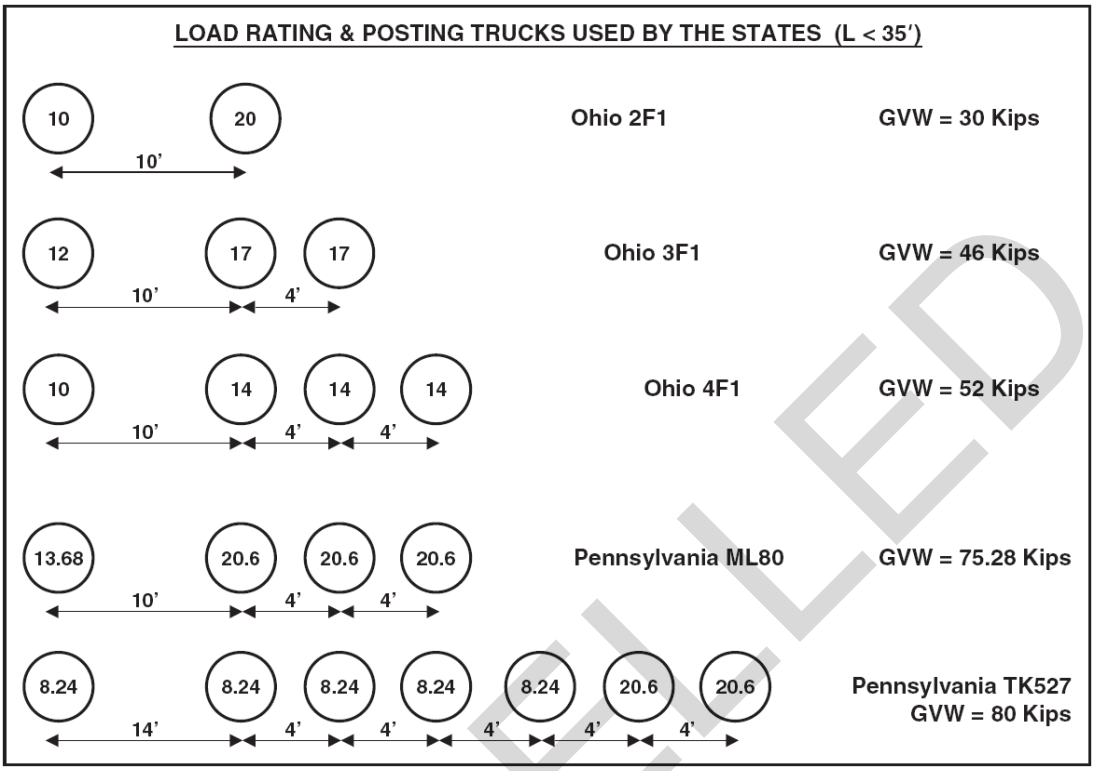


Figure B4-4 State Posting Loads (axle load in kips)



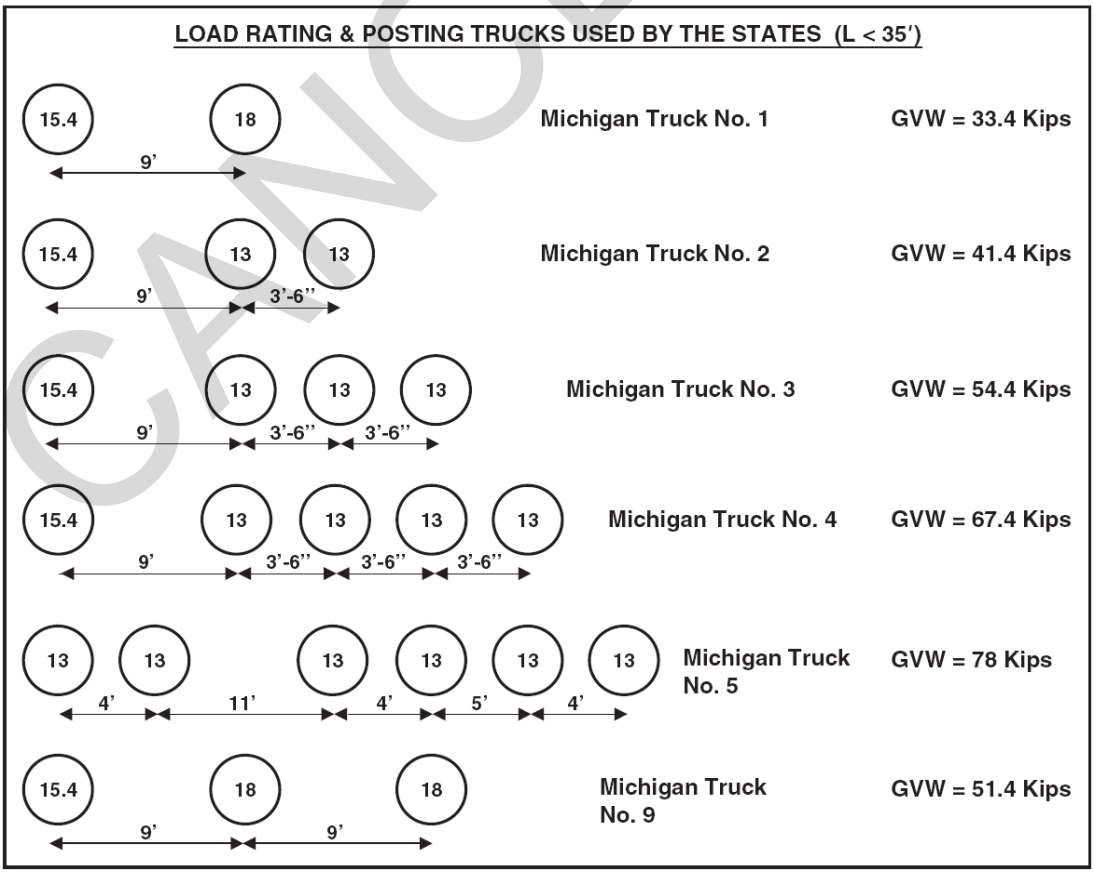
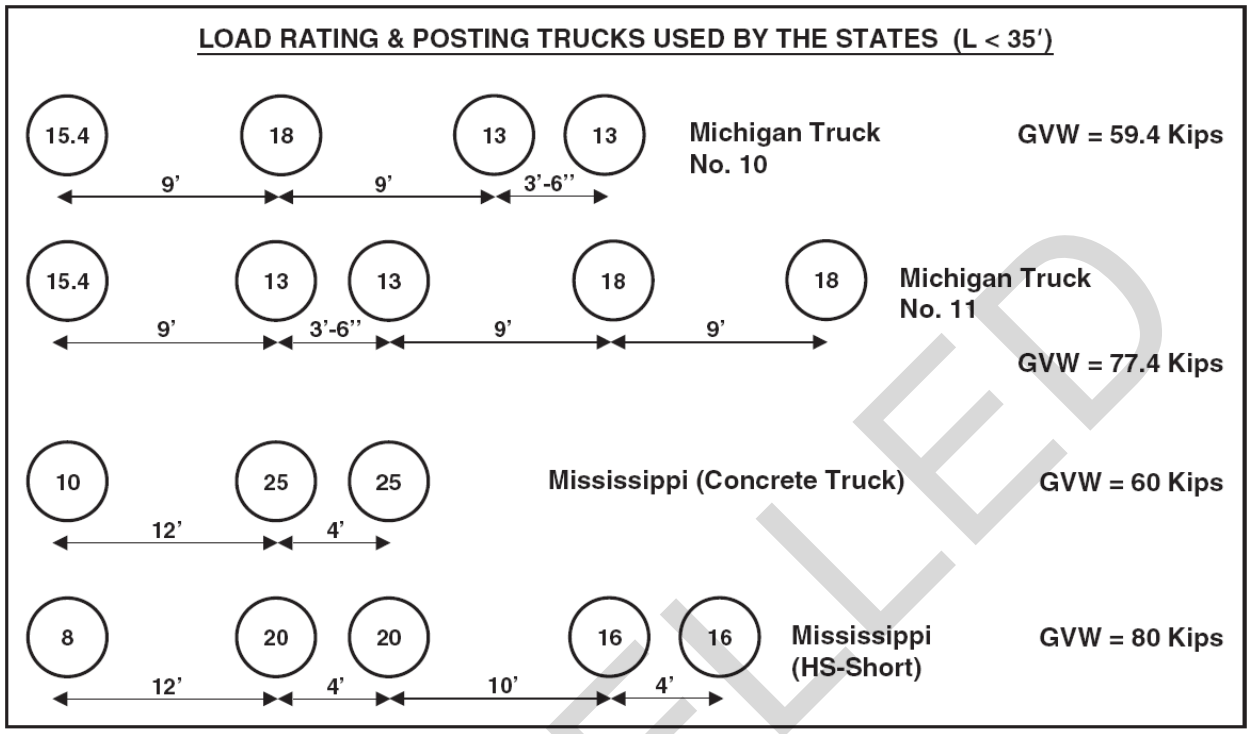


Figure B4-5 State Posting Loads (axle load in kips)



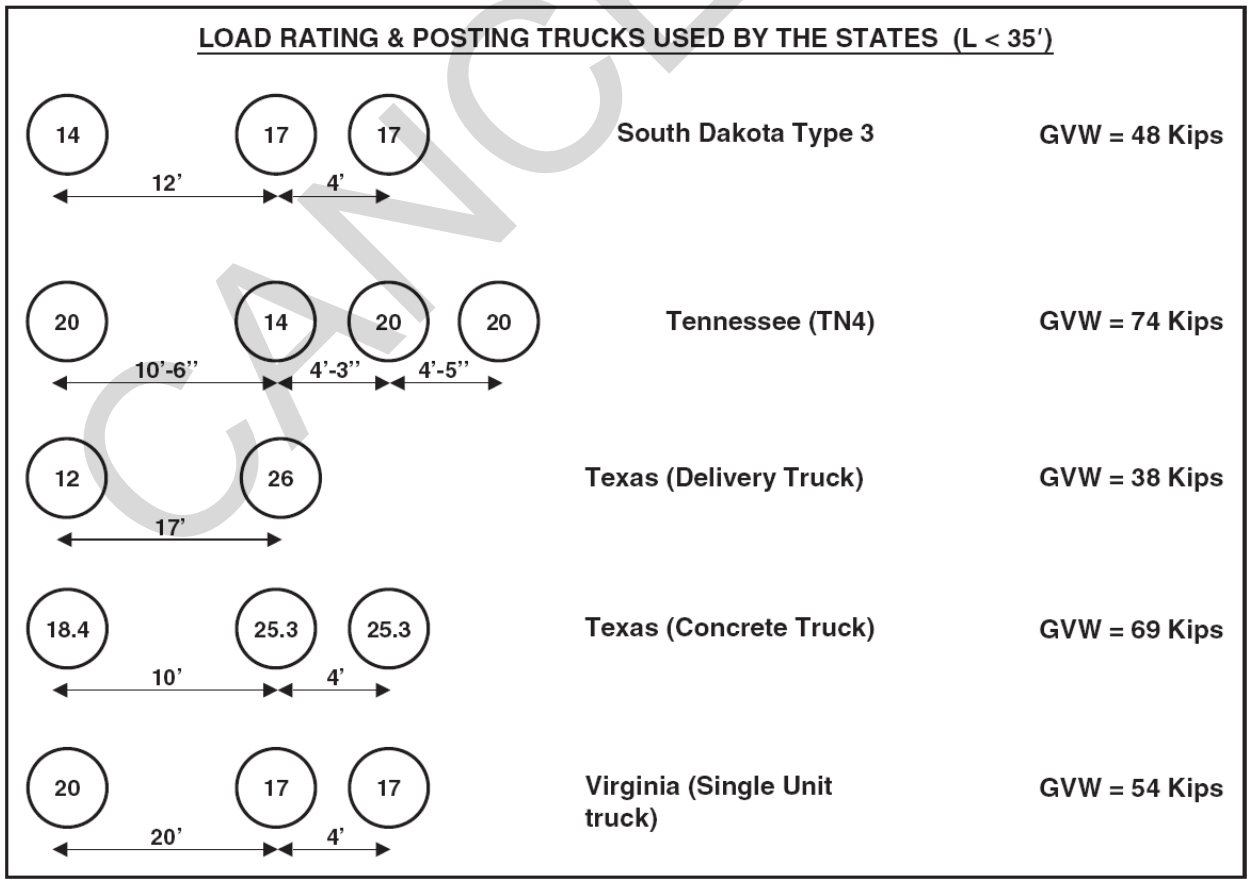


Figure B4-6 State Posting Loads (axle load in kips)

NORTH CAROLINA LEGAL LOADS

ALL BRIDGES EXCEPT THOSE CARRYING INTERSTATE TRAFFIC

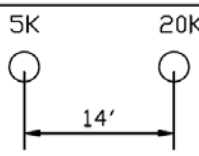
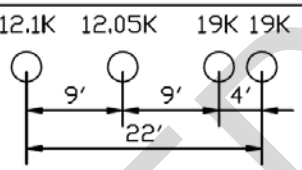
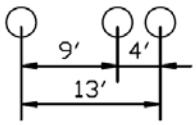
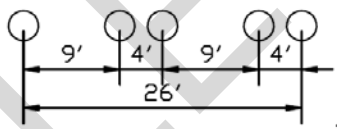
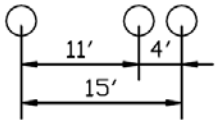
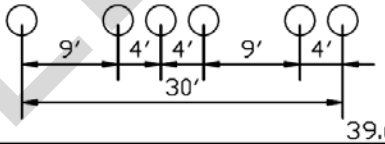
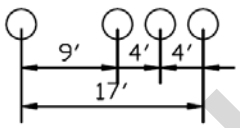
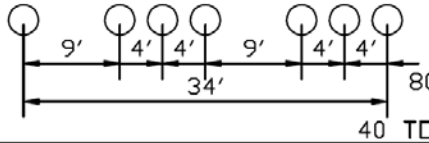
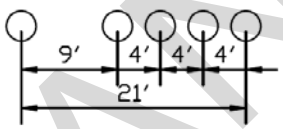
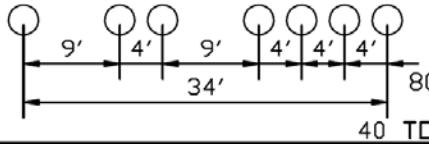
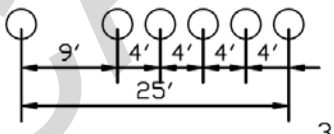
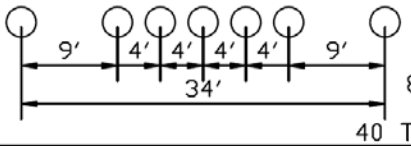
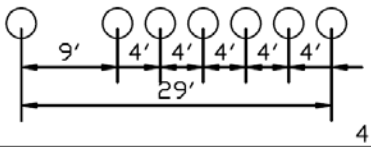
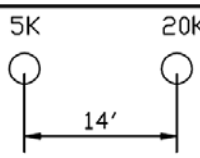
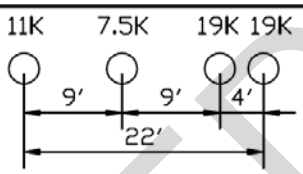
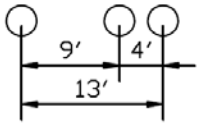
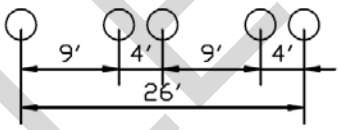
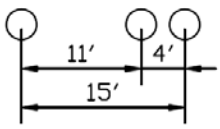
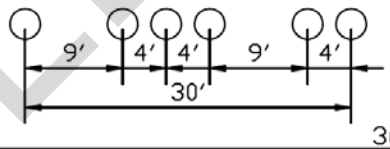
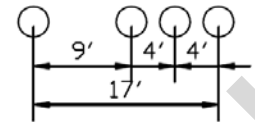
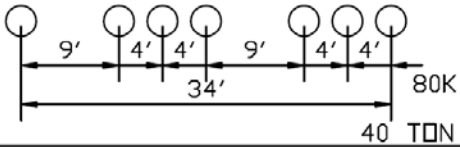
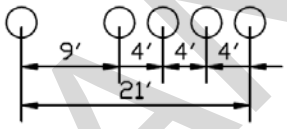
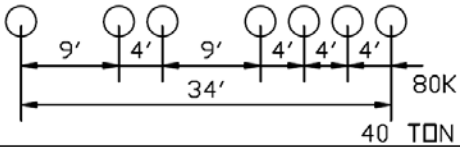
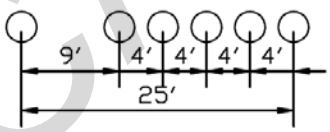
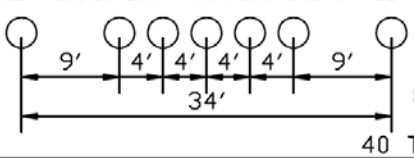
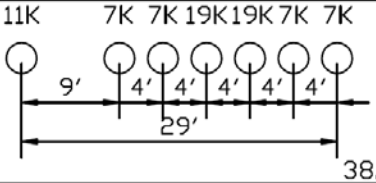
SINGLE VEHICLE (SV)		TRUCK TRACTOR SEMI-TRAILER (TTST)	
REF. #	SCHEMATIC	REF. #	SCHEMATIC
SH		T4A	
S3A		T5B	
S3C		T6A	
S4A		T7A	
S5A		T7B	
S6A			
S7A			
S7B			

Figure B4-7 State Posting Loads (axle load in kips)

NORTH CAROLINA LEGAL LOADS

BRIDGES CARRYING INTERSTATE TRAFFIC

SINGLE VEHICLE (SV)		TRUCK TRACTOR SEMI-TRAILER (TTST)	
REF. #	SCHEMATIC	REF. #	SCHEMATIC
SH		T4A	
S3A		T5B	
S3C		T6A	
S4A		T7A	
S5A		T7B	
S6A			
S7A			
S7B			

SECTION 5

SIMPLIFIED BRIDGE INSPECTION FLOWCHART