SECTION 6 – LOAD RATING

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6.1—SCOPE

The following shall supplement *A6.1*.

Bridge rating methods shall be in accordance with the latest AASHTO *The Manual for Bridge Evaluation* (MBE) and supplemental requirements of this document. When updating the rating of any public bridge or performing the rating of a bridge for the first time the rating needs to comply with the Load and Resistance Factor Rating (LRFR). The only exception granted is for timber bridges. They may be rated by LRFR or Allowable Stress Rating (ASR). Any other rating method will only be allowed with a prior written approval from the LADOTD Load Rating Engineer.

All simple bridges shall be rated in accordance with the LRFD live load distribution factors. Higher level refined analysis will only be allowed with a prior written approval from the LADOTD Load Rating Engineer.

AASHTOWare Bridge Rating (BrR) and Bridge Design (BrD) are the official load rating software to be used in LADOTD projects. If a bridge is capable of being defined and analyzed in BrR/BrD, it shall be rated using BrR/BrD. Prior to performing bridge rating, the engineer shall verify the current acceptable versions of approved rating software as well as request permission to use any other software not listed in LADOTD Pre-Approved Software List. An influence line/surface submittal is required for any structure element not rated using BrR/BrD. The influence line submittal form can be downloaded from the Bridge Design Section website (COMPSTIL2 standard input file).

C6.1

The following shall supplement *AC6.1*

LADOTD Load Rating Engineer shall be the engineer who is in charge of the Bridge Rating Unit within the LADOTD Bridge Design Section as defined in *EDSM IV.4.1.2*.

Higher level load ratings may consist of routine computations adjusted for actual material properties as determined from field sampling and tests of the materials. Higher level load ratings may also require the use of refined methods of analysis such as 2-D grillage or 3-D finite element models. Refined methods of analysis are justified where needed to avoid load posting or to ease restrictions on the flow of permitted overweight trucks. Complex structures such as segmental bridges, curved-girders, integral bridges, and cable-stayed, are typically designed using complex analysis methods; therefore, a sophisticated level of analysis is often required to rate these structures.

6.1.1—Assumptions

The following shall supplement *A6.1.1*.

Bridges being investigated for load capacity must be inspected for condition as per the latest edition of the MBE and the FHWA's *Bridge Inspector's Reference Manual*.

For all load ratings based on the LRFR methodology, the load rating data shall be reported to the NBI as a Rating Factor for items 63, 64, 65 and 66, using the HL-93 loading.

The rating engineer shall review the original design and as-built plans as the first source of information for material strengths and stresses. If the material strengths are not explicitly stated on the design plans, LADOTD construction and material specifications applicable at the time of the bridge construction shall be reviewed. This may require consulting the old ASTM or AASHTO Material Specifications active at the time of construction. The MBE also provides guidance and data for older bridge types and materials allowing the evaluation of existing bridges without having to resort to their original design specifications.

Load rating shall include, but is not limited to, analysis of the following items:

- All elements defined as "primary members" as well as splice connections in non-redundant girders and truss connections.
- Capacity of gusset plates and connection elements for non-redundant steel truss bridges.
- Other connections of non-redundant systems.
- Timber and metal bridge decks.
- Concrete decks on non-redundant systems.
- Timber and metal pier elements.
- Hammerhead concrete bent caps.
- Steel framed cap-column bents.
- Straddle bents.
- Pile bent elements –
  - All pile caps,
  - All timber piles,

C6.1.1

The following shall supplement *AC6.1.1*.

Bridge inspections are conducted to determine the physical and functional condition of the bridge, to form the basis for the evaluation and load rating of the bridge, as well as the analysis of overload permit applications. With the use of field measurements, the inspectors should verify the accuracy of the existing bridge plans and sketches on the file. It is especially important to measure and document items that may affect the load capacity, such as alterations to dead loads and section deterioration and damage.

- All piles of scour critical bridges, and
- Piles with other critical conditions.

– Culverts.

– Any other members specifically requested by LADOTD.

For concrete slabs on multi girder bridges, all superstructure elements shall be rated in BrR/BrD. The multi-girder bridge superstructures must be defined using the girder system in BrR/BrD. This includes rating of all girders.

Continuous prestressed concrete girder bridges shall be modeled and rated as simple span bridges unless written exemption is approved by LADOTD Load Rating Engineer.

Future wearing surface should not be included as dead load in the load rating.

As per FHWA Technical Advisory T5140.29, dated January 15, 2008, in the evaluation of load capacity on existing non-load path redundant steel bridges, the capacity of gusset plates shall be checked to reflect changes in condition or dead load, to make permit or posting decisions, or to account for structural modifications or other alterations that result in significant changes in stress levels.

Gusset plates and connection elements of existing non-load path redundant steel bridges that have not undergone a load capacity evaluation in the past shall be checked for compliance with *Technical Advisory T5140.29* and MBE.

Previous load ratings should also be reviewed for bridges which have been subjected to significant changes in stress levels, either temporary or permanent, to ensure that the capacities of gusset plates were adequately considered.

6.1.3—Evaluation Methods

The following shall supplement *A6.1.3.*

If directed by LADOTD, the safe load capacity for a structure can be determined from full scale non-destructive field load tests, which may be desirable to establish a more accurate safe load carrying capacity than calculated by analysis. Refer to the *MBE Section 8* for information on conducting field load tests and using the results to establish a new or updated load rating. This approach to bridge rating will only be allowed with prior written approval from the LADOTD Load Rating Engineer.

6.1.4—Bridges with Unknown Structural Components

C6.1.4

The following shall supplement *A6.1.4.*

Any assigned rating shall be adequately documented per FHWA Memorandum "*Action: Assigned Load Ratings*" dated September 29, 2011.

6.1.8—Qualifications and Responsibilities

The following shall supplement *A6.1.8*.

Refer to Section 1.4 for additional requirements.

6.1.9—Documentation of Load Rating

The following shall supplement *A6.1.9.*

Load rating calculations and documentation shall be incorporated into a comprehensive rating report to facilitate updating the information and calculations in the future. The load rating shall be completely documented in writing including all background information such as, structure description, vicinity map, bridge layout plans with details, field inspection reports, material and load test data, all supporting computations, and a clear statement of all assumptions made in calculating the load rating. Sketches shall be provided to document section losses incorporated in the analysis. Inspection reports, testing reports, and articles referenced as part of the load rating shall be documented. When refined methods of analysis or load testing are used, the load rating report shall include live load distribution factors for all rated members, determined through such methods. The computer model files and associated documentation shall become part of the bridge load rating records and deliverables. An influence line/surface submittal is required for any member not rated by BrR/BrD. An electronic version of the load rating report including the BrR/BrD input data file and any computer models used in the analysis shall be submitted to LADOTD.

The following checklists for rating reports and submittals shall be utilized to assist and standardize the review process and rating report preparation.

<u>Rating report:</u>

- Cover sheet including recall number.

- Stamped and signed Bridge Load Rating Summary Sheet including the engineering seal and initials of the Rater, the Checker, and the Reviewer. The electronic copy of Load Rating Summary Sheet can be downloaded from Bridge Design Section website.
- List of all assumptions.
- List of all material values.
- Discussion of current condition of the bridge and any assumption based on that.
- The critical rating values.
- Rating output of every rated member.
- Influence line (if applicable).
- Hand calculations, sample calculations.
- All bridge plans – (included on a separate electronic transfer media, i.e. CD or jump drive, if file size is too large to be included within the rating documents).

Submittals:

- Rating report shall be prepared for each bridge (one hard copy, one PDF copy). When a project consists of several bridges, rating report shall be prepared for each individual bridge.
- Rating model shall be prepared for each bridge. Each bridge shall have one AASHTOWare BrR/BrD model. For multi-span bridges, the bridge span numbers shall follow the numbering system in the inspection report (NBI Inventory).
- All submittals shall be in the form of removable storage, such as CD, USB flash drive, large file transfer or ProjectWise. Email submittals are strictly prohibited for bridge load rating reports and inspection reports.

Refer to Section 6A.1.1 for additional requirements on as-designed rating documentation.

PART A—LOAD AND RESISTANCE FACTOR RATING

6A.1—INTRODUCTION

6A.1.1—General

C6A.1.1

The following shall supplement *A6A.1.1*.

New, Replaced, or Rehabilitated Bridges:

As-designed LRFR bridge rating shall be performed by the design engineer and included in contract plans for all projects including new, replaced, and rehabilitated bridges.

As-designed bridge ratings shall include the inventory and the operating ratings for the HL-93, and the inventory rating for the LADV-11. If the inventory rating for the HL-93 is less than 1 (as may be the case for rehabilitated bridges), additional ratings for all legal trucks including SHVs shall be also provided in accordance with Section 6A.4.1.

The LADV-11 live load model shall be evaluated at the inventory level for all limit states indicated in the "Design" column in the Louisiana LRFR Limit States Table in Section 6A.4.1. For the evaluation of the Service III Limit State for the LADV-11 only, a load factor of 0.9 shall be used.

The following As-Designed Bridge Rating Factor Tables, which show the most critical as-designed ratings for each structure, shall be included on the general notes sheet as appropriate.

For Bridges with HL-93 Inventory Rating $\geq$ 1.0:

As-Designed Bridge Rating Factor Table			
Structure No.		Recall No.	
Vehicle	Superstructure	Substructure	Notes
HL-93 (INV)			
HL-93 (OPR)			
LADV-11(INV)			

For Bridges with HL-93 Inventory Rating < 1.0:

As-Designed Bridge Rating Factor Table				
Structure No.		Recall No.		
Vehicle	GVW(KIPS)	Superstructure	Substructure	Notes
HL-93 (INV)				
HL-93 (OPR)				
LADV-11 (INV)				
LA TYPE 3	41.0			
LA TYPE 3-S2	73.0			
TYPE 3-3	80.0			
LA TYPE 6	80.0			
LA TYPE 8	88.0			
NRL	80.0			
SU4	54.0			
SU5	62.0			
SU6	69.5			
SU7	77.5			
Lane-Type Legal Load Model-1*				
Lane-Type Legal Load Model-2 **				
* Per *MBE Appendix D6A Figure D6A-4* ** Per *MBE Appendix D6A Figure D6A-5*				

The as-designed bridge rating report shall be prepared in accordance with Section 6.1.9. The report shall be sent by the LADOTD Bridge Task Manager to the LADOTD Load Rating Engineer in two submittals. The initial submittal shall be made within thirty days after 100% Final Plans are completed. The second submittal shall be made after the completion of the shop drawing review period and shall be updated to include any changes from plan revisions, change orders, and/or shop drawing reviews. In case of no modifications, a letter stating that no changes were made should be submitted to the LADOTD Load Rating Engineer in lieu of a

second report submittal. If a consultant performs the as-designed bridge ratings, the reports shall be submitted to the LADOTD Bridge Task Manager who will in turn submit them to the LADOTD Load Rating Engineer. The final as-built bridge rating, which will incorporate any changes made after the shop drawing review period, will be performed by a bridge rating engineer and is not the responsibility of the designer.

If the bridge is open to traffic during any phase of rehabilitation, the contractor performing the rehabilitation is responsible to rate the bridge. The rating shall include construction loads and traffic loads anticipated during the construction period. The contractor shall provide the rating results to the LADOTD Load Rating Engineer before commencing construction in accordance with the requirements of Section 6.1.9 of this document.

Existing Bridges:

The load rating engineer shall review the bridge inspection file to determine if a new analysis is required per LADOTD's *Engineering Directives & Standards Manual (EDSM) No. I.1.1.15*. The validity of the existing rating shall be questioned when condition changes have occurred since the last load rating. The condition changes include, but not limited to, the following:

- The primary member condition rating has changed.
- Dead load has changed due to resurfacing, alterations, and additions. Typical items include modification of barriers and the addition of utilities.
- Section properties have changed due to deterioration, rehabilitation, re-decking or other alterations.
- Damage due to vessel or vehicular impacts.
- Cracking of primary members.
- Losses at critical connections.
- Bridge is under construction.
- Soil and substructure settlement and/or a reduction in stability.

Foundation capacities determination for as-built bridge ratings shall use actual soil borings when available. Otherwise, the Louisiana Signal Foundation Design Zones map posted on the LADOTD Traffic Service Section website shall be

used to determine the soil strength zones. The following presumptive soil strengths shall be used.

Zone	Shear Strength (psf)
1	500
2	1000
3	2000
4	250

The use of different strength values may be allowed when justifications are approved by the LADOTD Load Rating Engineer.

6A.4—LOAD-RATING PROCEDURES

6A.4.1—Introduction

The following shall supplement *A6A.4.1*.

Live loads to be used in the rating of bridges are selected based upon the purpose and intended use of the rating results. Live load models outlined below shall be evaluated for the strength, service and fatigue limit states in accordance with the Louisiana LRFR Limit States Table at the end of this section:

1) Design load rating is a first-level rating performed for all bridges using the HL-93 loading at the Inventory (design) and Operating levels. Additionally, a LAVD-11 (inventory) rating is required for all new bridges. If the HL-93 Inventory RF>1.0, no legal load rating is required for substructure rating.

2a) State legal load rating includes the LA Type 3, LA Type 3-S2, AASHTO Type 3-3, LA Type 6, and LA Type 8 vehicles given in Figure: Rating Trucks for Louisiana State Legal Loads in Section 6A.4.4.2.1a. Lane-Type legal load models in Figure *D6A-4* and Figure *D6A-5* of *MBE Appendix D6A* are to be used for spans greater than 200 ft, negative moment, or interior reactions.

2b) Specialized hauling vehicle rating uses the Notional Rating Load (NRL) in Figure *D6A-6* of *MBE Appendix D6A* as the screening vehicle. If the NRL RF < 1.0 for a bridge, then rate for the posting vehicles SU4, SU5, SU6, and SU7 in Figure *D6A-7* of *MBE Appendix D6A*.

Louisiana LRFR Limit States Table

Bridge Type	Limit State	Design	Legal	Permits
		HL-93 LADV-11	LA Type 3 LA Type 3-S2 Type 3-3 LA Type 6 LA Type 8 Lane Loads NRL SU4, SU5 SU6, SU7	
Steel	Strength I	●	●	
	Strength II			●
	Service II	●	●	●
	Fatigue	●		
Reinforced Concrete	Strength I	●	●	
	Strength II			●
	Service I			●
Prestressed Concrete (non-segmental)	Strength I	●	●	
	Strength II			●
	Service III	●		
	Service I			●
Timber	Strength I	●	●	●

6A.4.2—General Load-Rating Equation

6A.4.2.2—Limit States

The following shall supplement *A6A.4.2.2.*

Service and fatigue limit states to be evaluated during a load rating analysis shall be as given in the Louisiana LRFR Service and Fatigue Limit States and Load Factors Table at the end of this section.

<u>For concrete bridges the followings apply:</u>

- For non-segmental prestressed concrete bridge LRFR provides a limit state check for cracking of concrete (Service III) by limiting concrete tensile stresses under service loads. Service III check shall be performed for design load ratings of prestressed concrete bridges. The allowable tensile stress in the precompressed tensile zone for the Inventory level design load check shall

C6A.4.2.2

The following shall supplement *AC6A.4.2.2.*

be $0.19\sqrt{f'_c}$ in ksi units. The allowable tensile stress in the precompressed tensile zone for the Operating level design load check shall be $0.24\sqrt{f'_c}$ in ksi units.

- Service I and Service III limit states are mandatory for load rating of segmental concrete box girder bridges.
- Service I limit state shall be checked for permit load ratings.

A Service I load combination for reinforced concrete components and prestressed concrete components has been introduced in LRFR to check for possible inelastic deformations in the reinforcing steel during heavy permit load crossings. This check shall be applied to permit load checks and sets a limiting criterion of $0.9F_y$ in the extreme tension reinforcement. Limiting steel stress to $0.9F_y$ is intended to ensure that there is elastic behavior and that cracks that develop during the passage of overweight vehicles will close once the vehicle is removed. It also ensures that there is reserved ductility in the member.

<u>For steel bridges the followings apply:</u>

- Steel structures shall satisfy the overload permanent deflection check under the Service II load combination for design load, legal load, and permit load ratings using load factors as given in the Louisiana LRFR Limit States Table. Maximum steel stress is limited to 95% and 80% of the yield stress for composite and non-composite compact girders, respectively. When making this check for an overweight permit where the truck weight is known, use a live load factor of 1.0.

In situations where fatigue-prone details are present (category C or lower), a fatigue limit state rating factor for infinite fatigue life shall be computed. If directed by LADOTD Bridge Rating Engineer, bridge details that fail the infinite-life check can be subject to the more complex finite-life fatigue evaluation using evaluation procedures given in Section 7 of the MBE. Bridges shall not be posted due to the failure of infinite fatigue life only.

Louisiana LRFR Service and Fatigue Limit States and Load Factors Table

Bridge Type	Limit State	Dead Load	Dead Load	Design Load		Legal Load	Permit Load
				Inventory	Operating		
		DC	DW	LL	LL	LL	LL
Steel	Service II	1.00	1.00	1.30	1.00	1.30	1.00
	Fatigue	0.00	0.00	0.75	—	—	—
Reinforced Concrete	Service I	1.00	1.00	—	—	—	1.00
Prestressed Concrete (non-segmental)	Service III	1.00	1.00	1.00*	—	—	1.00
	Service I	1.00	1.00	—	—	—	1.00

*Use 0.9 for LADV-11 per Section 6A.1.1.

6A.4.2.3—Condition Factor: φ_c

C6A.4.2.3

The following shall supplement *A6A.4.2.3.*

LADOTD policy is to set the condition factor equal to the values presented in MBE. The Condition Factor ϕ_c does not account for accurate section loss, but is used in addition to section loss. For instance, a concrete member may receive a low condition rating due to heavy cracking and spalling or due to the deterioration of the concrete matrix. Such deterioration of concrete components may not necessarily reduce their calculated flexural resistance, but it is appropriate to apply the reduced condition factor in the LRFR load rating analysis. If there are also losses in the reinforcing steel of this member, they should be measured and accounted for in the load rating. It is appropriate to also apply the reduced condition factor in the LRFR load rating analysis, even when the as-inspected section properties are used in the load rating as this reduction by itself does not fully account for the impaired resistance of the concrete component.

6A.4.3—Design Load Rating

6A.4.3.1—Purpose

C6A.4.3.1

The following shall supplement *A6A.4.3.1*.

The following shall supplement *AC6A.4.3.1*.

HL-93 Inventory shall be used as the screening level for Louisiana legal loads.

The LADV-11 shall be rated at inventory level only. The results of the LADV-11 Inventory rating shall be used as the screening level for Louisiana permit loads.

The design-load (HL-93 and LADV-11) ratings assess the performance of existing bridges utilizing the LRFD HL-93 design loading and design standards with dimensions and properties for the bridge in its present as-inspected condition. It is a measure of the performance of existing bridges to new bridge design standards contained in the LRFD Specifications. The design-load rating produces Inventory and Operating level rating factors for the HL-93 loading.

6A.4.4—Legal Load Rating

6A.4.4.2—Live Loads and Load Factors

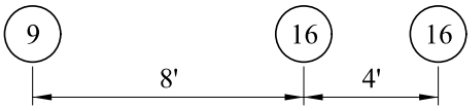
6A.4.4.2.1—Live Loads

6A.4.4.2.1a—Routine Commercial Traffic

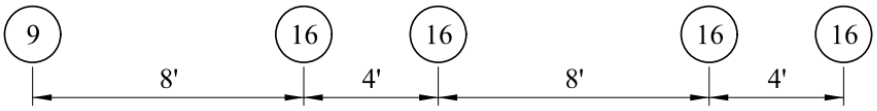
The following shall supplement *A6A.4.4.2.1a.*

The live load to be used in the LRFR rating for posting considerations for routine commercial traffic should be any of the State legal loads LA Type 3, LA Type 3-S2, AASHTO Type 3-3, LA Type 6, and LA Type 8 given in Figure: Rating Trucks for Louisiana State Legal Loads. They are sufficiently representative of routine commercial truck configurations in use in Louisiana and are used as vehicle models for load rating and for bridge posting purposes.

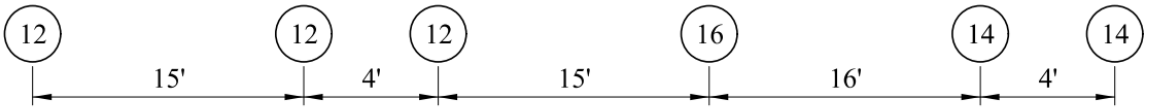
The evaluation of live-load factors for AASHTO legal loads for the Strength I Limit State shall be taken as given in MBE.



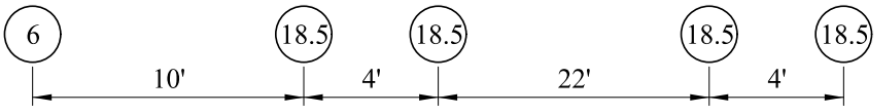
LA Type 3 GVW = 41 kips



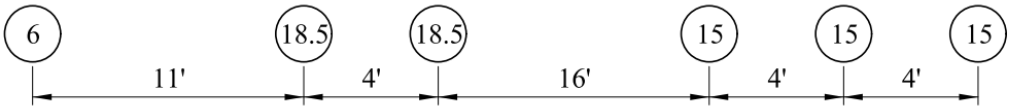
LA Type 3-S2 GVW = 73 kips



AASHTO Type 3-3 GVW = 80 kips



LA Type 6 GVW = 80 kips



LA Type 8 GVW = 88 kips

Rating Trucks for Louisiana State Legal Loads

6A.4.4.2.2—Live Load Factors

C6A.4.4.2.2.

The following shall supplement *AC6A.4.4.2.2.*

In cases where site traffic conditions are unavailable from the bridge file, the LADOTD Transportation Planning and Safety Section should be contacted for current ADTT information for the route carried by the bridge or routes with a similar functional classification.

ADTT may also be estimated from Average Daily Traffic (ADT) data for the site.

6A.4.4.3—Dynamic Load Allowance: *IM*

The following shall supplement *A6A.4.4.3*.

For all ratings, the dynamic load allowance (IM) shall be 33%. For legal load ratings a reduced IM maybe allowed on a case by case basis. The appropriateness for a reduced factor needs to be established by LADOTD and will only be allowed when requested by LADOTD.

6A.4.5—Permit Load Rating

6A.4.5.5—Dynamic Load Allowance: *IM*

The following shall supplement *A6A.4.5.5.*

For all ratings, the dynamic load allowance (IM) shall be 33%. For permit load ratings a reduced IM maybe allowed on a case by case basis. The appropriateness for a reduced factor needs to be established by LADOTD and will only be allowed when requested by LADOTD.

6A.5.8—Evaluation for Shear

The following shall supplement *A6A.5.8.*

MBE states that in-service concrete bridges that show no visible signs of shear distress need not be checked for shear when rating for the design load or legal loads. However, LADOTD requires that the shear capacity of all existing reinforced and prestressed concrete bridge members, with the exception of concrete slab bridges (COSLAB, COPCSS, CCOVSL, COVSLB), shall be evaluated for shear for the design loads, legal loads, and permit loads.

6A.8—POSTING OF BRIDGES

6A.8.1—General

The following shall supplement *A6A.8.1*.

Strength limit state is used for checking the ultimate capacity of structural members and is the primary limit state utilized by LADOTD for determining posting needs. Service and fatigue limit

C6A.8.1

The following shall supplement *AC6A.8.1*.

National Bridge Inspection Standards (NBIS), 23 CFR 650 requires the rating of all structures defined as highway bridges located on public roads as to its safe loading capacity. The

states are utilized to limit stresses, deformations, and cracking under regular service conditions. In LRFR, Service and Fatigue limit states are checked in the sense that a posting or permit decision does not have to be dictated by the result. These serviceability checks provide valuable information for the engineer to use in the decision making process.

bridge rating needs to be in accordance with the MBE. As a result of the bridge load rating, if a bridge is shown as not capable of carrying statutory loads, it is to be posted for a lesser load limit. The decision to load post or restrict a bridge will be made by the bridge owner, based on LADOTD's load-posting practice. When the maximum unrestricted legal loads exceed that which is allowed under the legal rating, the bridge shall be posted in accordance with this document, applicable EDSMs, or State law.

REFERENCES

AASHTO LRFD Bridge Design Specifications, Latest Edition, American Association of State Highway and Transportation Officials, Washington D.C.

AASHTO *The Manual for Bridge Evaluation*, Latest Edition, American Association of State Highway and Transportation Officials, Washington D.C.

Bridge Gross Weight Formula, U.S. Department of Transportation and FHWA Publication.

FHWA *Bridge Inspector's Reference Manual (BIRM)*, Latest Edition, Federal Highway Administration, U.S. Department of Transportation, Washington, DC.

LADOTD *Engineering Directives and Standard Manual (EDSM) I.1.1.8 and I.1.1.15 for Posting and Frequency of Re-rating Policy*, Latest Edition, State of Louisiana Department of Transportation and Development, Baton Rouge, LA.

LADOTD *Engineering Directives and Standard Manual (EDSM) IV.4.1.2 for Louisiana Bridge Maintenance-Bridge Inspection and Load Rating Standard*, Latest Edition, State of Louisiana Department of Transportation and Development, Baton Rouge, LA.

Louisiana Legislative Act 35 of 1978 for Posting Advisory Weight Limit Signs.

Louisiana Legislative Act 686 of 1987 (House Bill No. 1542) for Compliance of Bridge Formula.

Louisiana Legislative Act 1342 of 1997 (Senate Bill No. 792) for Permit Vehicle, Gross Vehicle Weight, and Axle Load and Spacing Limitation.

NBIS - National Bridge Inspection Standards, http://www.fhwa.dot.gov/bridge/nbis.cfm.

LADOTD *Regulation for Trucks, Vehicles and Loads*, Latest Edition.

Timber Construction Manual, Latest Edition, American Institute of Timber Construction.

Timber Design Specifications, Latest Edition, USDA Forest Service.