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Eric Holcomb, Governor
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Bridge Inspection Memorandum No. 19-05

December 10, 2019

TO: **All Inspection Personnel and Consultants**

FROM: ***/s/Andrew Fitzgerald***
Andrew Fitzgerald
Bridge Inspection Manager
Bridge Management Division

SUBJECT: **Revisions to Part 4 Section 4-4.0 of the Bridge Inspection Manual**

EFFECTIVE: **Immediately**

Indiana Bridge Inspection Manual Part 4 Section 4-4.0, Fatigue and Fracture Critical Inspections, has been revised to ensure full compliance with Federal Highway Administration (FHWA) guidelines, and both state and federal laws. Primary revisions include:

1. Appendix A Sample Fracture Critical Report has been deleted and replaced by Fracture Critical Examples.

2. Appendix B Formerly Fracture Critical Examples is now the Fracture Critical Report Plan of Action Template.

3. Appendix C Fracture critical Report Template has been added.

INDOT BRIDGE INSPECTION MANUAL

PART 3

LOAD RATING

Inspection Memorandum	Revision Date	Sections Affected
18-01	Apr. 2018	3-9.02(01), 3-9.02(02)
18-03	Oct. 2018	3-5.02, Appendix C
18-04	Oct. 2018	3-4.02
19-02	Apr. 2019	3-6.04, Appendix D

The revision date is noted in brackets next to the heading for each affected section.

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LIST OF FIGURES

3-1.0 INTRODUCTION

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

3-2.0 REFERENCE MATERIAL

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

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

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

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

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

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

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

Hartmann, Joseph L. (November 3, 2016). *Load Rating for the FAST Act's Emergency Vehicles*. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, Office of Bridges and Structures.

FHWA. (March 2017). *QUESTIONS AND ANSWERS Load Rating for the FAST Act's Emergency Vehicles*. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, Office of Bridges and Structures.

Size and Weight Regulation, IC 9-20 (2017)

Indiana Department of Transportation. (September 2011). *Bridge Inspection Program Coding Guide, Bridge Reporting for Appraisal & Greater Inventory* (Vols. 1-3)

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

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

3-3.0 ROLES & RESPONSIBILITIES

Load rating roles for bridge owners, the Indiana Department of Transportation, and load rating engineers are described below.

3-3.01 Bridge Owner

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

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

3-3.02 Indiana Department of Transportation

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

3-3.03 Load Rating Engineer

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

3-4.0 VEHICLES

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

3-4.01 Design

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

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

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

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

Figure 3-4.1 Potential Design Vehicles

3-4.02 Legal [Rev. Oct. 2018]

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

Routine Commercial Traffic contains vehicles that represent typical commercial trucking configurations that are also encompassed by the Federal Bridge Formula. In addition to these vehicles are emergency vehicles, EV2 and EV3, required by 23 U.S.C. 127 and provided by the FHWA. The emergency vehicles should be considered to occupy a single lane only and one-lane distribution should be used to represent the low probability of these vehicle types being located adjacent to other heavily loaded vehicles. In addition, a live load factor of 1.3 should be used for emergency vehicles, regardless of the ADTT.

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

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

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

Figure 3-4.2 Required Legal Vehicles

3-4.03 Permit

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

Any bridge on the Indiana Toll Road or any state owned or maintained bridge within 15 miles of a toll road gate shall be rated for the Toll Road Truck configurations. Any bridge located on the Extra-Heavy Duty Highway, as described in IC 9-20-5-4, shall be rated for the Michigan Train Truck configurations. It is acceptable to limit Michigan Train Truck vehicles to one lane located

so as to cause extreme force effects while the other lanes are occupied by regular legal loads. A lane load shall be included with all Toll Road or Michigan Train Truck configurations if required by the MBE depending on rating method and bridge geometry. See Appendix B for supplementary information regarding the Indiana Toll Road and Extra Heavy Duty Highways.

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

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

Figure 3-4.3 Potential Permit Vehicles

3-5.0 METHODS

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

3-5.01 Analytical

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

As discussed in the MBE for LRFR, Inventory and Operating ratings are subcategories to the Design Load Rating category. Values for this category are required when construction work is proposed that will change the structural behavior or capacity of the bridge. For state owned or

maintained bridges rated LRFR, only Inventory values are required when evaluating for design loads; Operating values will only be considered on a case by case basis. For LFR, Inventory corresponds to Design Load Rating and Operating to Legal Load Rating.

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

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

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

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

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

As discussed in MBE 6A.5.4 and with the exception of segmentally constructed bridges, service limit states in regards to crack control should not be considered for determining the load capacity or safe posting load of state owned or maintained reinforced concrete or prestressed concrete in-service bridge components. Crack control may be considered for determining the load capacity or safe posting load for local bridges at the discretion of the owner. This applies to both legal and routine permit loads. For special permit evaluation, use of these provisions is at the discretion of

the permitting engineer. Crack control is a means for ensuring longevity of the structure and is therefore most applicable for design loading.

The condition factor Φ_C and system factor Φ_S shall be used per MBE 6A.4.2.3 & 6A.4.2.4 respectively. Where material properties are unknown, assumptions can be made per MBE 6A.5.2. In regard to MBE 6A.5.8, if the conditions of this article are met for reinforced concrete slab bridges, shear capacity need not be checked for design and legal loads. Similarly, shear need not be evaluated for any proposed work on reinforced concrete slab bridges. For any other reinforced, prestressed, or post-tensioned concrete bridge, the shear capacity shall always be evaluated for design, legal, and permit ratings regardless of condition or distress. When shear controls, refined analysis may be used to more accurately model boundary conditions and loading scenarios.

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

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

3-5.01(03) Other

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

3-5.02 Engineering Judgment [Rev. Oct. 2018]

MBE 6.1.4 discusses the use of engineering judgment in place of or as a supplement to analytical methods when necessary details to load rate are missing or incomplete.

Load rating based on engineering judgement may be used in lieu of analytical methods only when there are no plans or details available and physical measurement of the structural members is not possible, such as the reinforcing bars of a concrete structure. The LRE should consider all available information when determining the load rating, including, but not limited to

- Year of construction and common material properties for that time period,
- assumed design vehicle,
- all measurable structure dimensions,
- redundancy of load path,
- deterioration levels,
- signs of distress such as transverse cracks in high moment regions or diagonal cracks in high shear regions, and
- changes to the structure such as increased dead loads since original construction.

The load rating shall be determined for all vehicles described in Section 3-4.0. Consideration should be given to the size and configuration of vehicles that routinely use the bridge being evaluated. A comparison of shear and moments produced by vehicles that routinely use the bridge to those produced by load rating vehicles that may not routinely use the bridge may aid the Engineer in determining appropriate rating factors.

Engineering judgment may be used to assign lower ratings than computed at the owner's request or to increase conservativeness when desired.

3-6.0 POSTING

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

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

Example:

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

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

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

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

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

3-6.01 Load and Resistance Factor Rating Analysis

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

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

3-6.02 Load Factor Analysis

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

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

3-6.03 Engineering Judgment

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

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

3-6.04 Regulatory Signage [Rev. Apr. 2019]

There are multiple options for restricting vehicle weight. At a minimum, restrictions shall be for gross vehicle weight. At the discretion of the bridge owner, restrictions may be further refined by listing multiple gross vehicle weight restrictions based on the corresponding number of axles for all legal vehicles and for routine permit vehicles (where applicable). Posting for maximum permissible axle weights may be appropriate for short span bridges or critical bridge elements such as floor beams or stringers. Under no circumstances shall a restriction allow a legal or applicable routine permit vehicle in excess of the safe load carrying capacity of the bridge.

Regulatory signs shall conform to the *Indiana Manual on Uniform Traffic Control Devices* (IMUTCD). INDOT has developed additional word message signs for bridge weight limits (safe posting load). The sign details, including specific emergency vehicle signs, have been added to the INDOT Supplemental Sign Catalog and Appendix D of this document until such time as they are incorporated into the IMUTCD. The new signs have a sign code prefix of R12-Y.

Existing IMUTCD Sign R12-1 (WEIGHT LIMIT XX TONS) shall be used when the safe posting load is the same regardless of the number of axles. Each bridge shall be posted for the minimum calculated safe posting load as specified in this chapter. The R12-1 sign may be used when the safe posting load for all axles varies by no more than 2 tons, or if the bridge owner prefers to limit the gross vehicle weight regardless of the number of axles. Use of signs R12-3 (NO TRUCKS OVER XX LBS EMPTY WEIGHT) and R12-5 (WEIGHT LIMIT silhouette) is strongly discouraged as these signs are subject to misinterpretation. When the R12-5 sign is used, the tonnages listed shall correspond to the minimum calculated safe posting load for all legal and applicable routine permit vehicles for the number of axles shown. This means the sign will show a minimum tonnage for vehicles with two axles, three axles, and four or more axles.

Consider using signs R12-Y5 or sign variations R12-Y5a thru -Y5c (WEIGHT LIMIT AXLES XX WEIGHT XX) where the safe posting load varies by the number of axles. The tonnages listed shall correspond to the minimum calculated safe posting load for all legal and applicable routine permit vehicles that correspond to the number of axles shown. The number of axles may be grouped together and use the minimum safe posting load for the group.

For posting required due to emergency vehicle safe posting load, signs R12-1 with R12-Y1P (EMERGENCY VEHICLE) or signs R12-Y4-EVa thru -EVd (EMERGENCY VEHICLE …) shall be used as appropriate based on gross weight or gross weight per number of axles. Alternatively, signs R12-Y1P (EMERGENCY VEHICLE) or signs R12-Y4-EVa thru -EVd (EMERGENCY VEHICLE …) may be omitted provided the bridge is posted for the minimum safe posting load of all legal, applicable routine permit, and emergency vehicle loads using non-emergency vehicle specific signs shown in the IMUTCD and in Appendix D.

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

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

3-7.0 DOCUMENTATION

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

- Title sheet
- Load rating method/program(s) used
- Geometric and material summary of the bridge
- Assumptions
- Rating factors for design vehicles specified on the plans (discussed in Section 3-4.01)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana
- Rating factors and load capacity (in tons) for each applicable legal & routine permit vehicle (discussed in Sections 3-4.02 & 3-4.03)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana
- Safe posting load, as required, for each applicable legal & routine permit vehicle (discussed in Sections 3-4.02 & 3-4.03)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana

- Rating factors and load capacity (in tons) for each applicable special (limited crossing) permit vehicle (discussed in Section 3-4.03)
    - Stamped by a Professional Engineer (PE) licensed in the state of Indiana
- Discussion, sketches, and photos of deterioration (if applicable)

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

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

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

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

3-9.0 PROCEDURE

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

For new, replacement, or rehabilitated structures, Bridge Load Rating requests are required in accordance with the *Indiana Design Manual* (IDM) Chapter 103. All Bridge Load Rating requests for state owned or maintained bridges are required to be requested through the Load Rating Request Application. Any plans, sketches, notes, and photos (where applicable) are required to be uploaded to the Load Rating Request Application.

Instructions for use of the Load Rating Request Application are available from the Department's Bridge Load Rating Aids.

Load ratings for locally owned structures shall be performed by the owner or its designated appointee.

3-9.01 Frequency

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

3-9.01(01) Project Scoping

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

For state owned or maintained bridges, the District Bridge Asset Engineer (BAE) should review the structure's existing loading rating prior to programming work that adds significant dead load, e.g., a concrete overlay.

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

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

Following the completion of construction work, the bridge file shall be updated within thirty (30) days for state maintained structures. To do this, a Construction Complete request using the Load Rating Request Application is required. The bridge file for locally maintained structures shall be updated within ninety (90) days.

3-9.01(03) Deterioration

For bridges with a minor increase in, or newly discovered minor damage or deterioration, a load analysis shall be performed. At a minimum, a load rating considering deterioration shall be on file for each bridge with a deck condition rating (NBIS Item 58), superstructure condition rating (NBIS Item 59), or culvert condition rating (NBIS Item 61) of 4 or less.

For state owned or maintained structures, the deterioration load rating shall be performed and documented in the bridge file within thirty (30) days of the discovery. Within seven (7) days of the discovery, the District Bridge Inspector is required to make a Condition Change – Deterioration load rating request using the Load Rating Request Application.

For locally maintained structures, the deterioration load rating shall be performed and the bridge file shall be updated within sixty (60) days of the end of the inspection compliance month.

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

3-9.01(04) Critical Findings

For bridges with a significant increase in or newly discovered severe damage or deterioration, a load analysis shall be performed. The analysis shall be performed within seven (7) days and the bridge file updated within fifteen (15) days of the discovery for both state and locally maintained structures. For state maintained bridges, the District Bridge Inspector is required to make a Condition Change – Critical Finding load rating request using the Load Rating Request Application within two (2) days of discovery. Notification shall be immediate for damage or deterioration that is considered severe enough to be an immediate safety concern for the traveling public.

3-9.01(05) Repairs

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

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

3-9.01(06) Permitting

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

3-9.02 Submittal Process & Notification

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

3-9.02(01) General [Rev. Apr. 2018]

For bridge construction projects, owners should be informed of load rating results prior to the commencement of any construction. For state maintained bridges, the load rating summary report and load rating model is required to be made available for review in the Load Rating Request Application within thirty (30) days of the receipt of the original load rating request.

Once the load rating reflects the "in-service" condition of the bridge, the bridge file shall be updated. The load rating summary report, as defined in section 3-7, and the load rating model shall be uploaded to ERMS. Once uploaded, each file will be accessible in BIAS from the ERMS link on the "Asset Info" tab for each bridge; see Figure 3-9.1. Refer to the bridge inspection website for detailed instructions regarding how to attach and upload documentation. Additionally, a new report shall be created in the Bridge Rating Application Database of Indiana (BRADIN) where rating factors shall be updated.

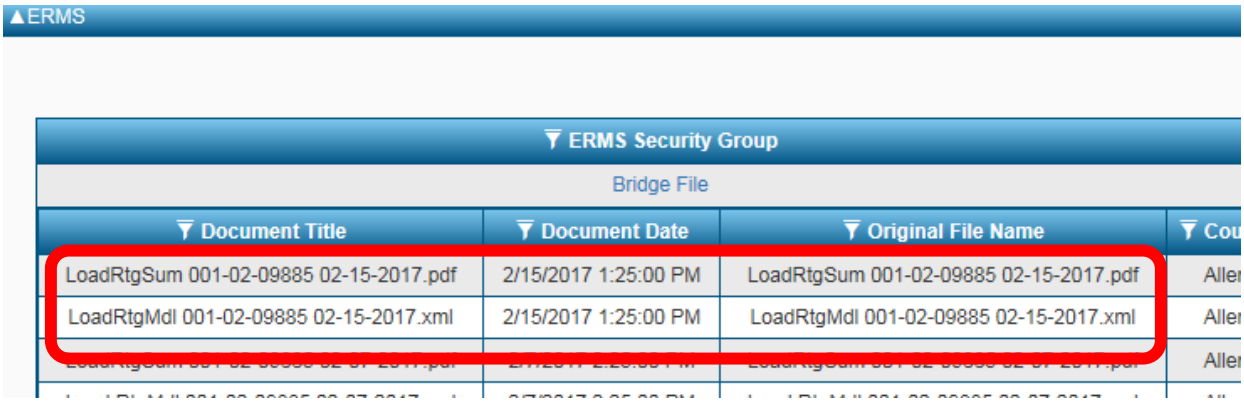


Figure 3-9.1 BIAS ERMS Link to the Bridge File

3-9.02(02) Posting [Rev. Apr. 2018]

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

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

3-10.0 MODELING GUIDELINES & ASSUMPTIONS

This section is under development.

3-11.0 APPENDICES

3-11.1 Appendix A: Vehicle Configurations

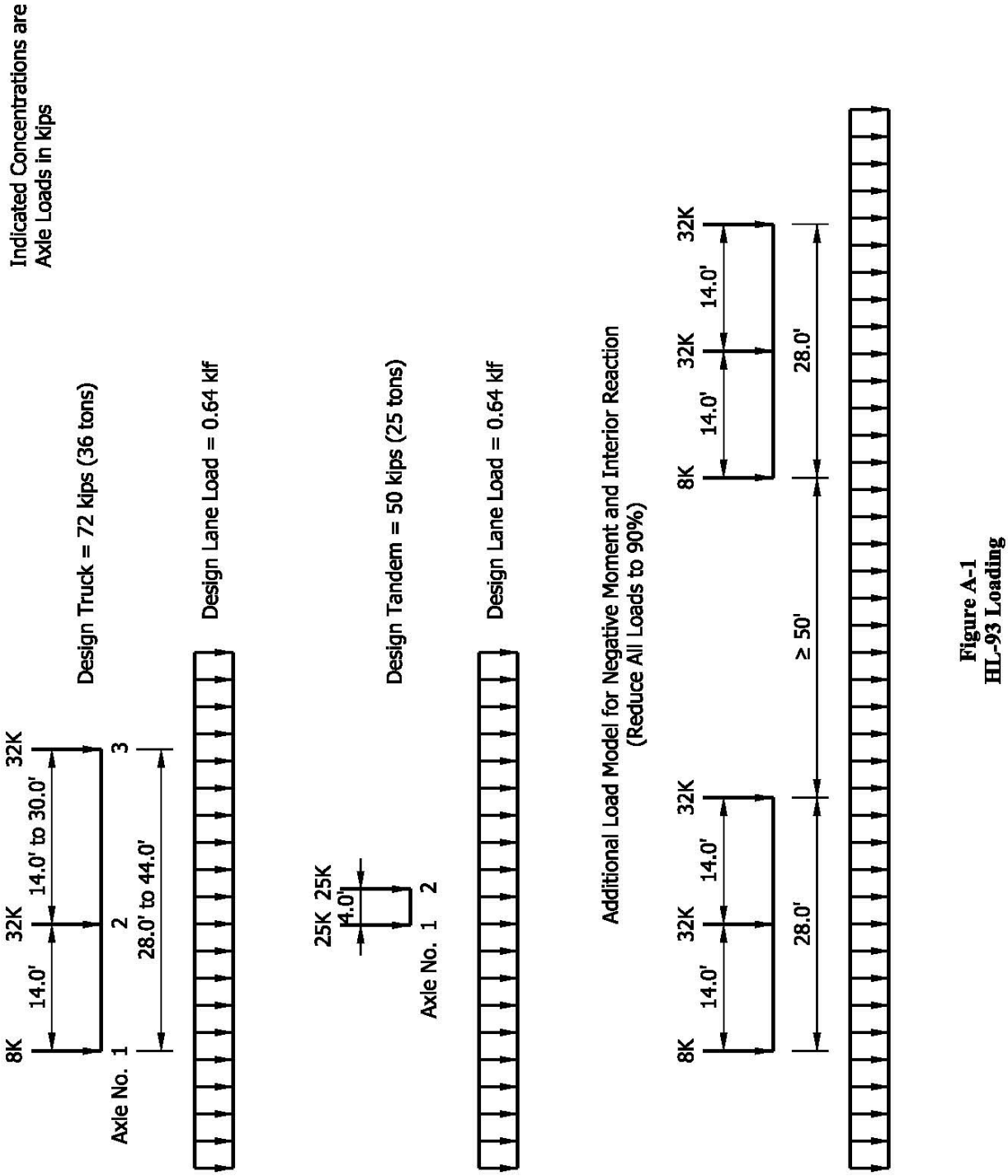


Figure A-1
HL-93 Loading

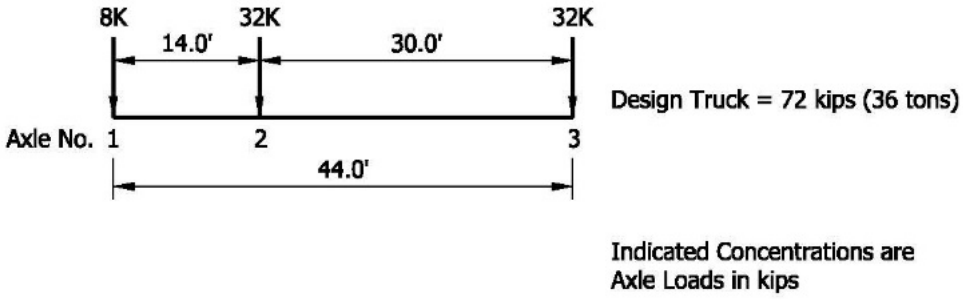


Figure A-2
Fatigue Loading

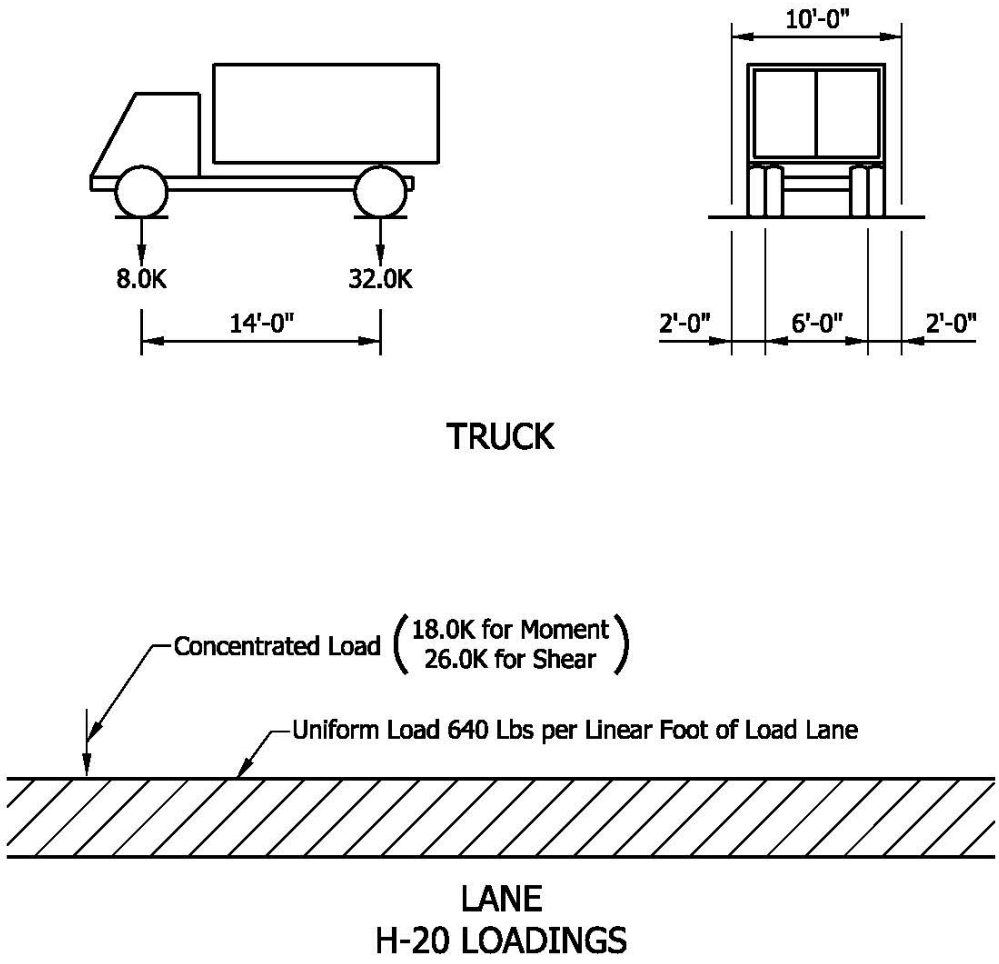


Figure A-3
H-20 Loading

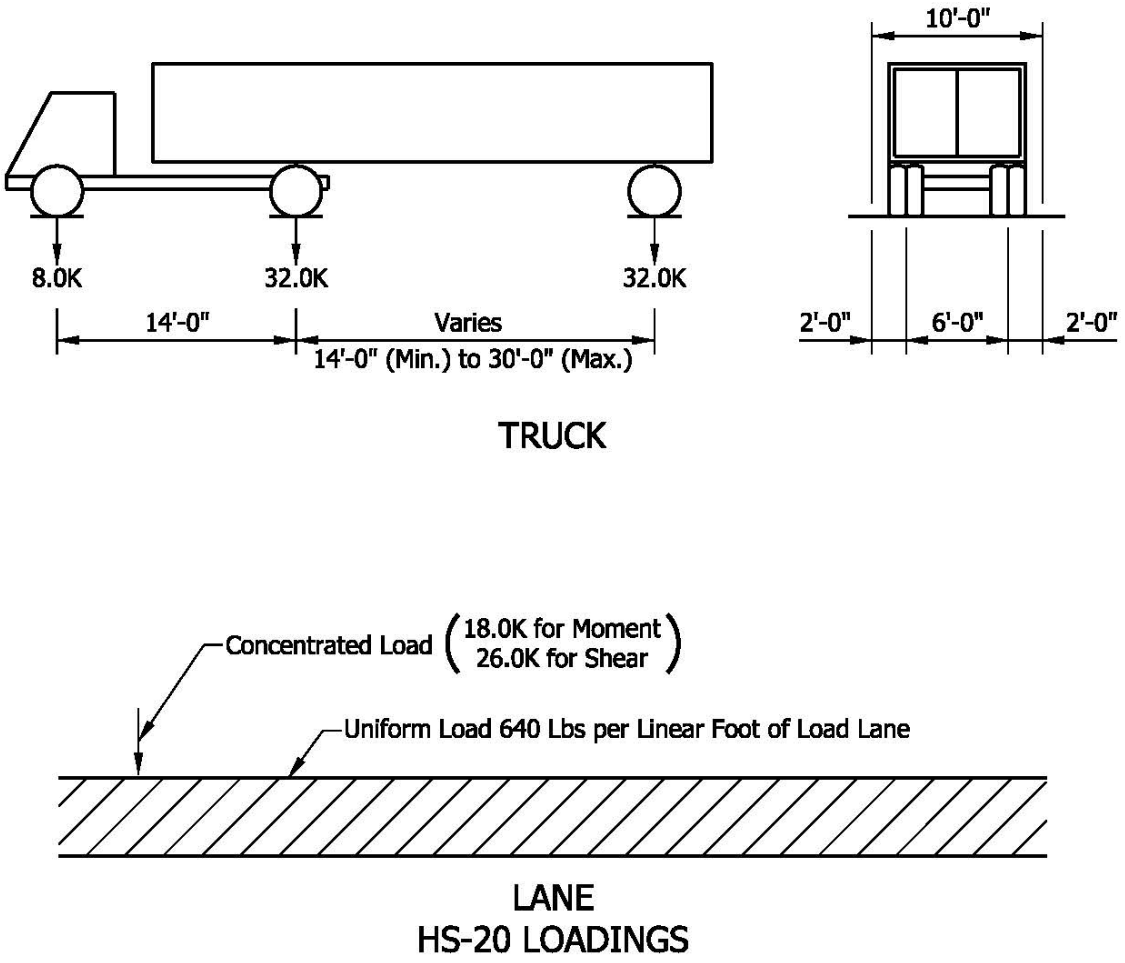


Figure A-4
HS-20 Loading

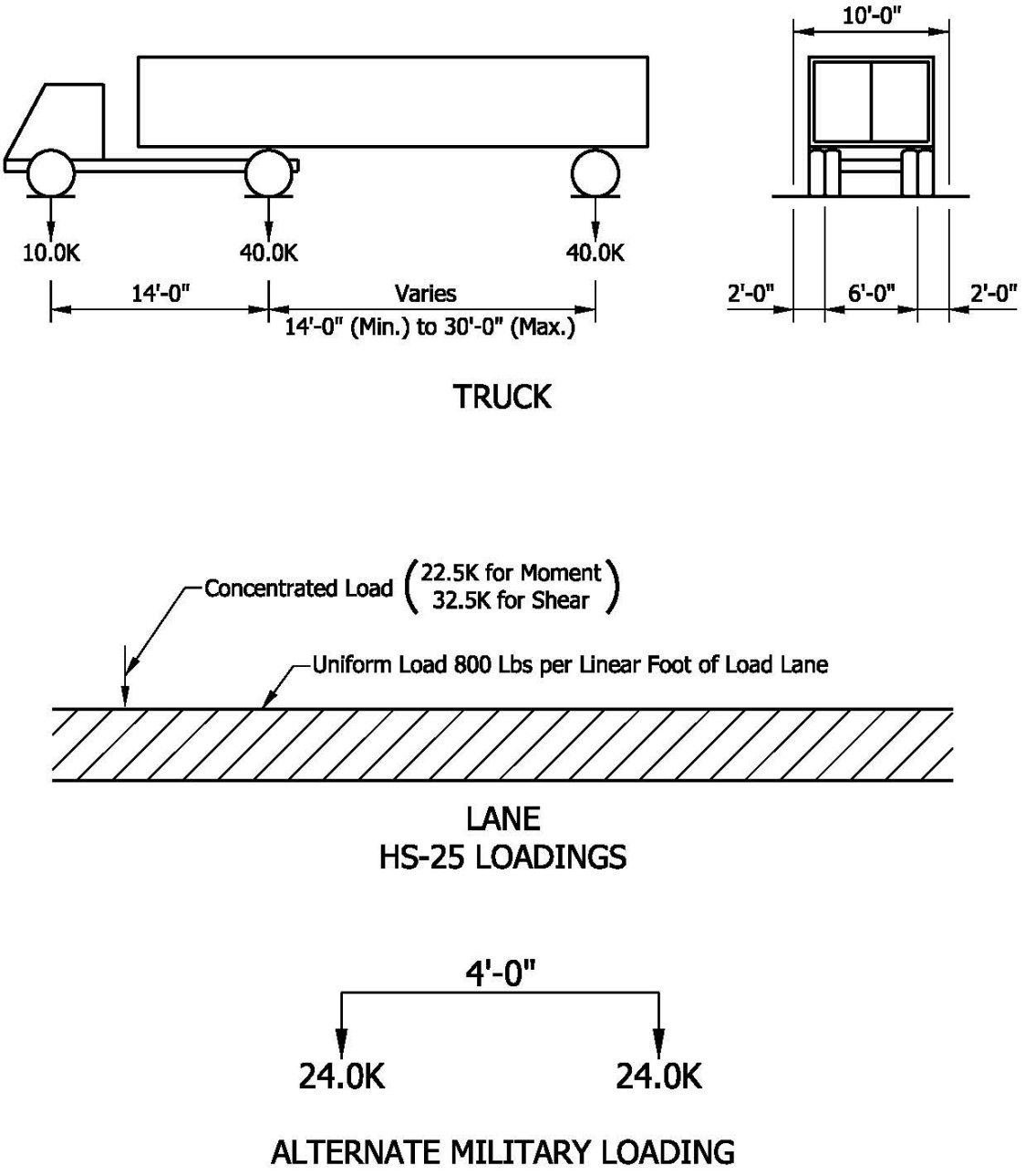


Figure A-5
HS-25 And Alternate Military Loading

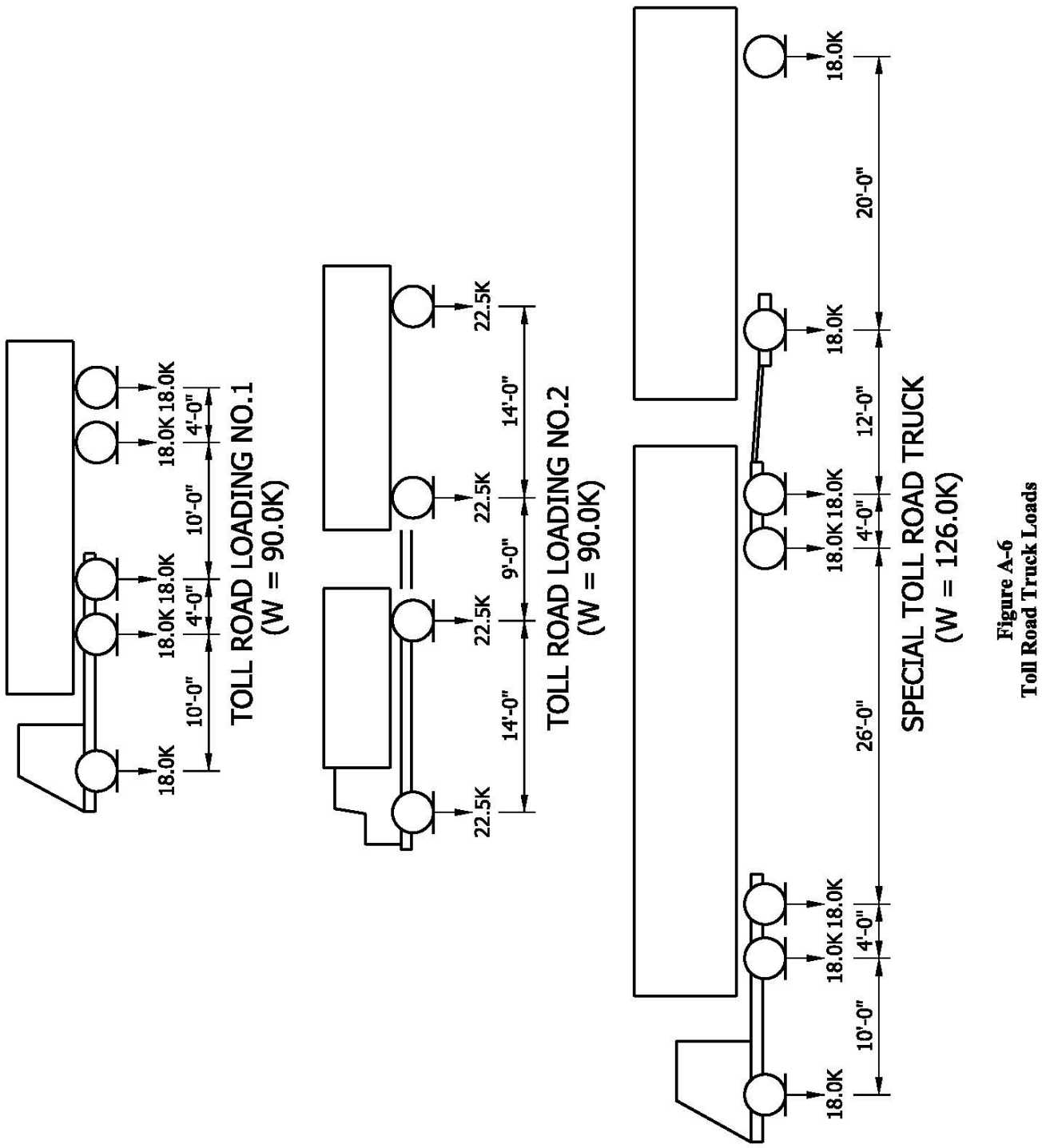
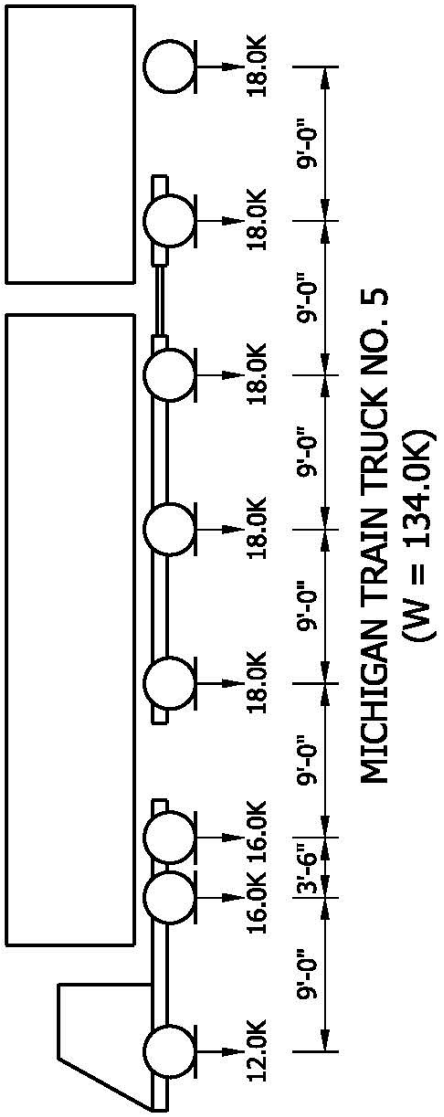


Figure A-6
Toll Road Truck Loads



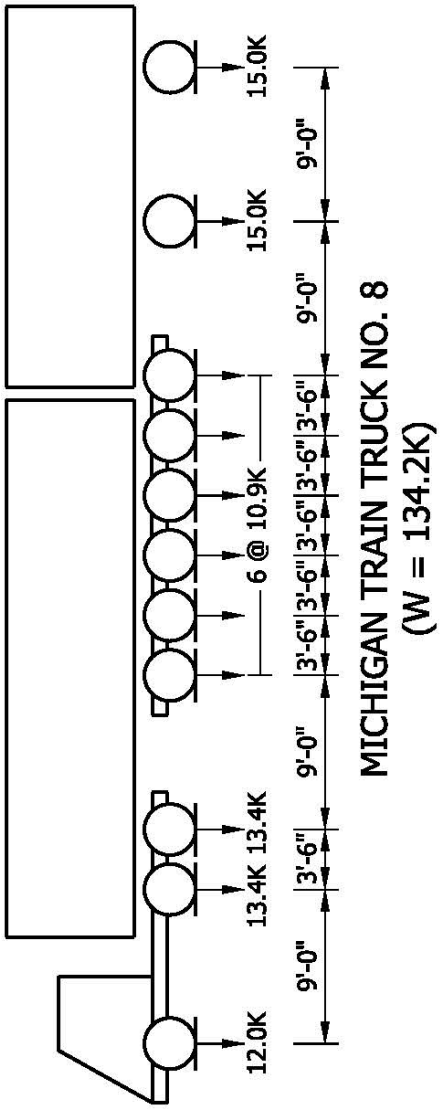


Figure A-7
Michigan Train Truck Loads

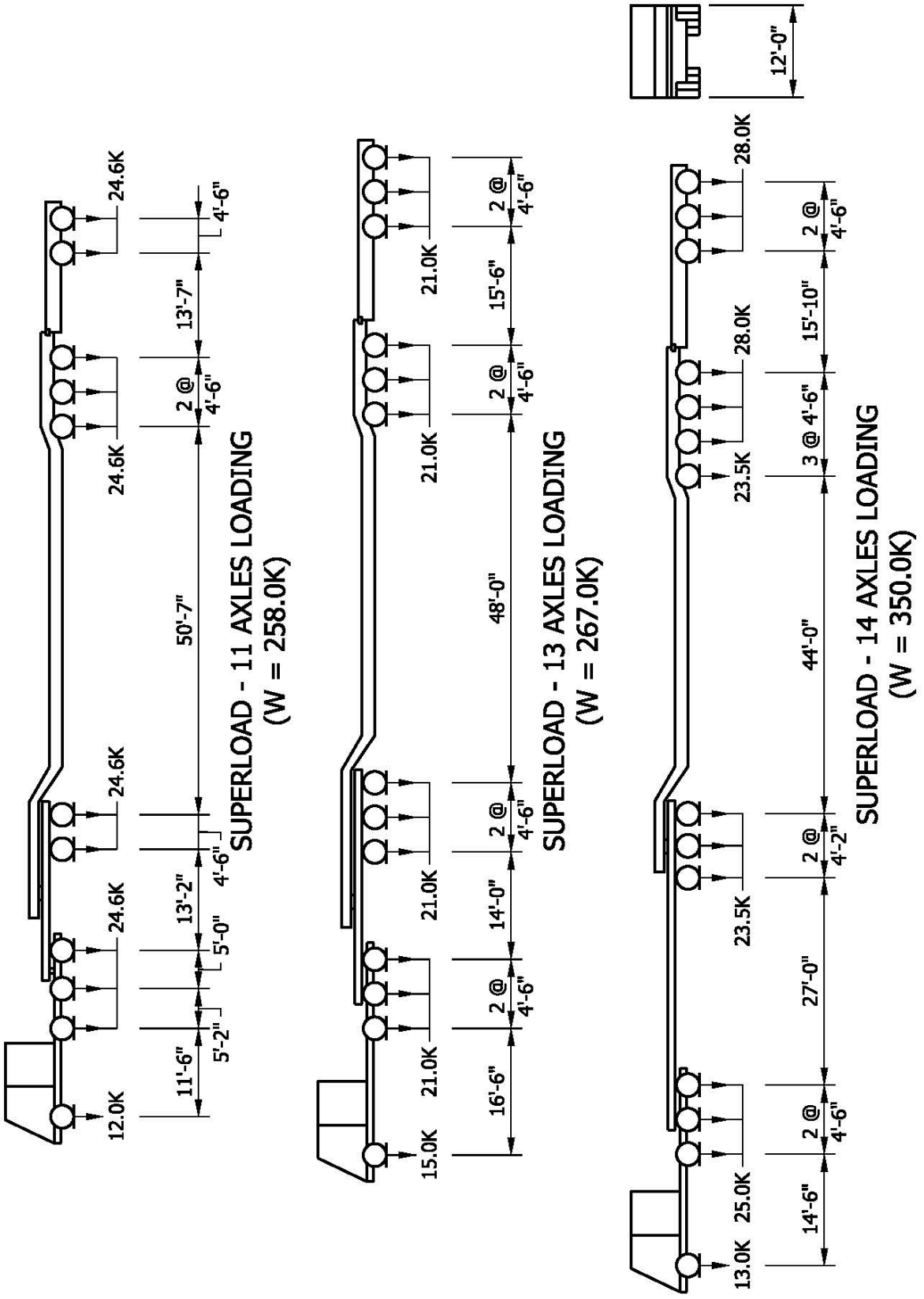
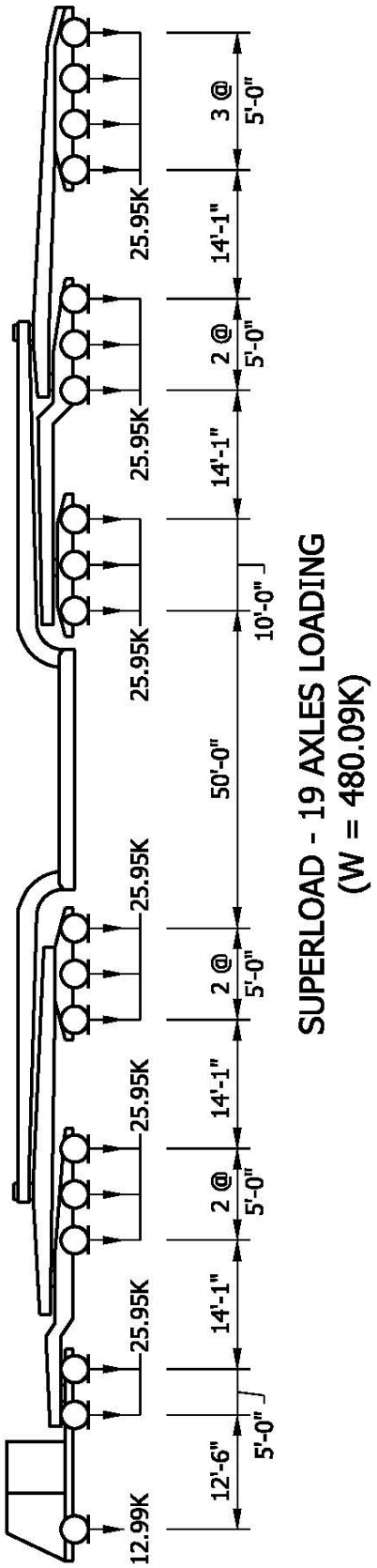


Figure A-8
Superload Vehicle Loads



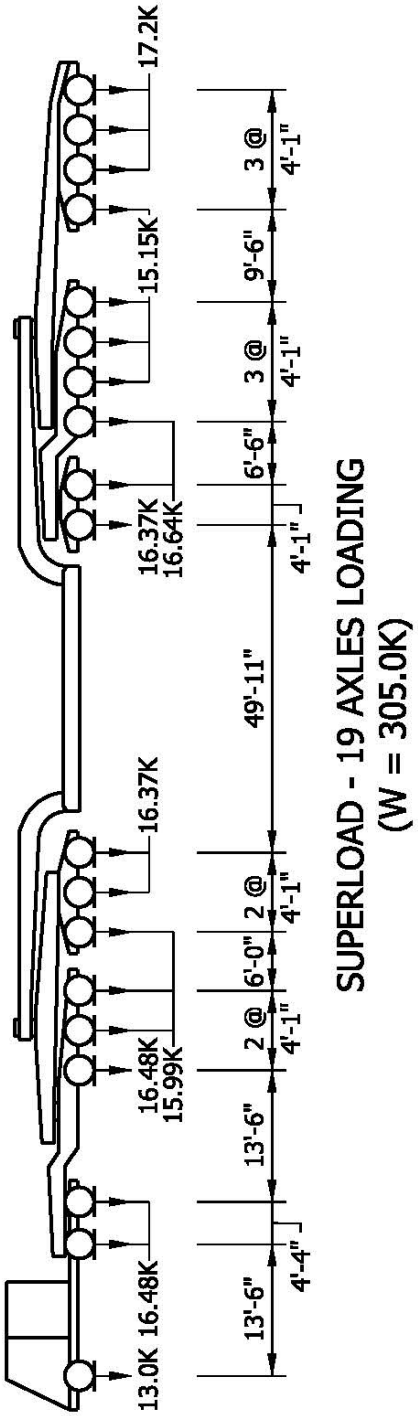


Figure A-9
Superload Vehicle Loads

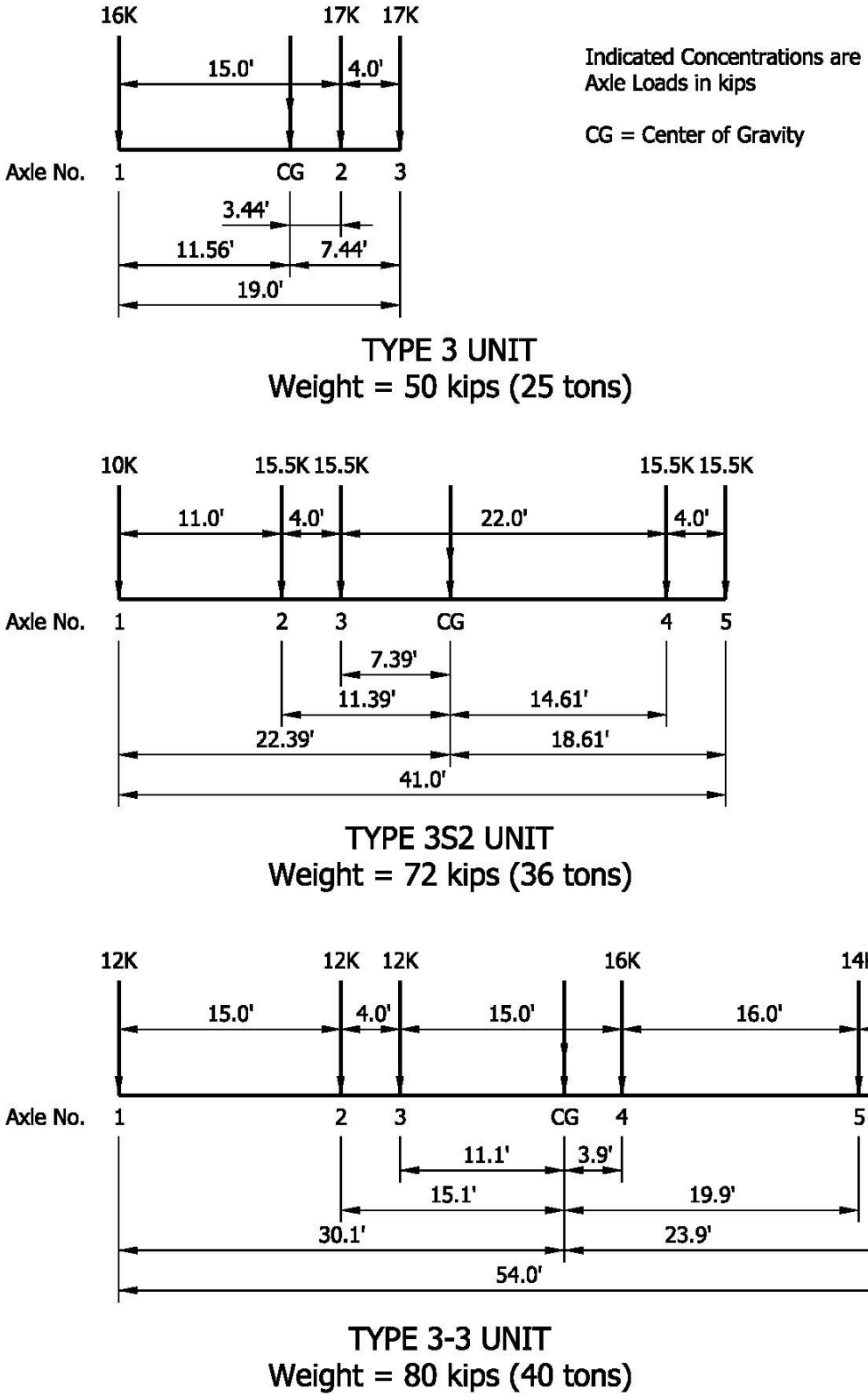


Figure A-10
AASHTO Legal Loads

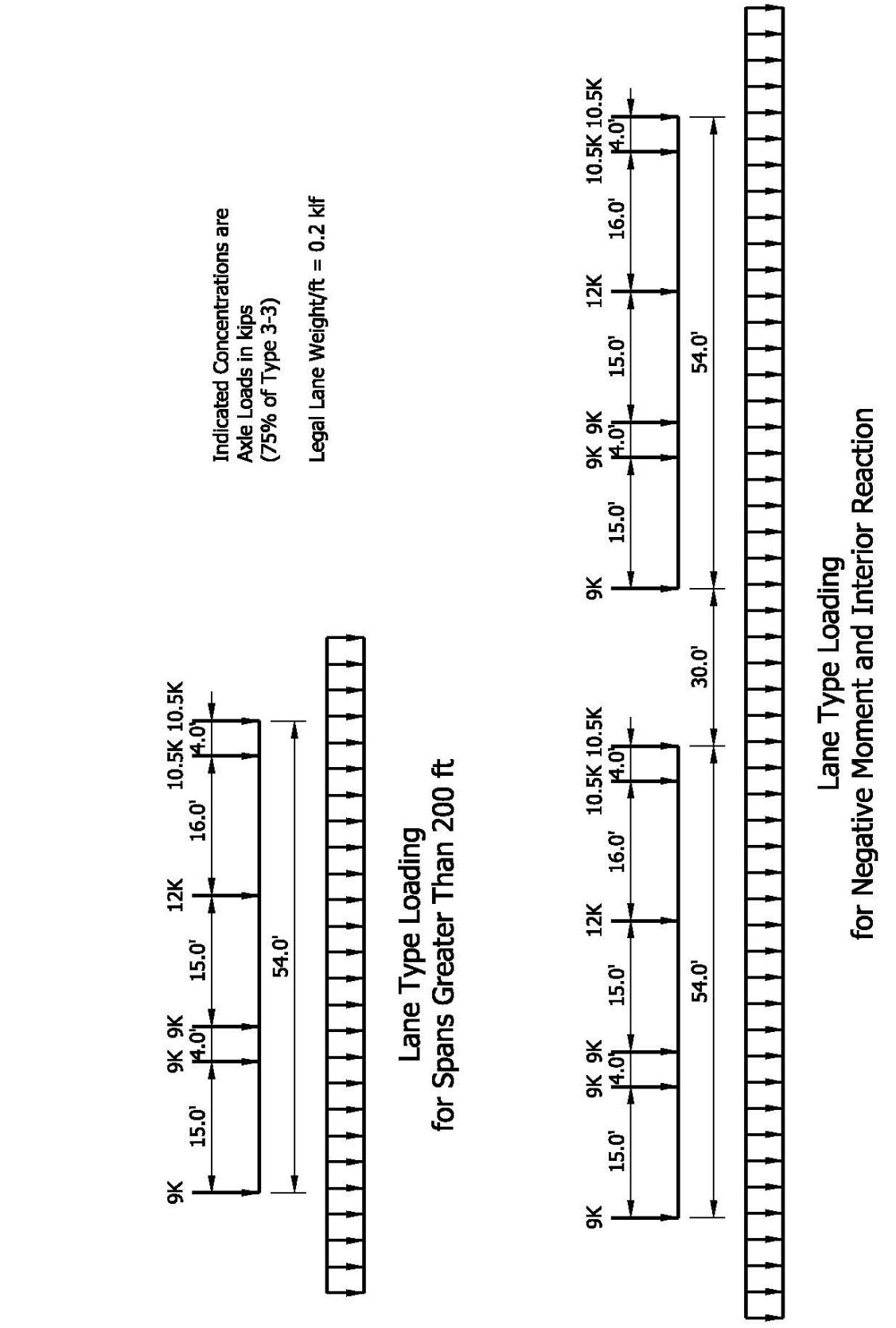
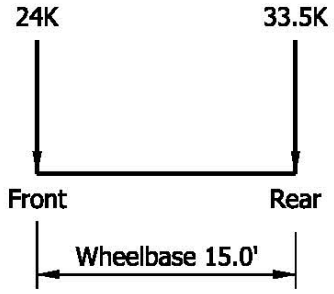
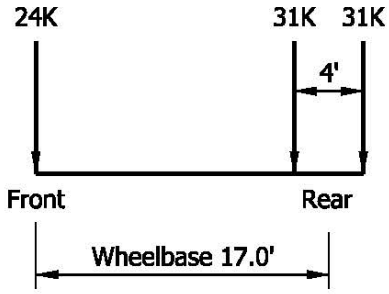


Figure A-11
Lane-Type Loading

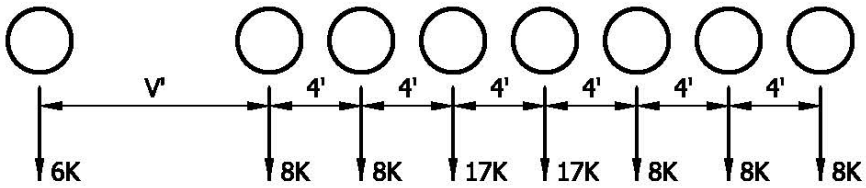


TYPE EV2



TYPE EV3

Figure A-12
FAST Act EV Loads



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

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

Maximum GVW = 80 Kips

Axle Gage Width = 6'-0"

Figure A-13
Notional Rating Load (NRL)

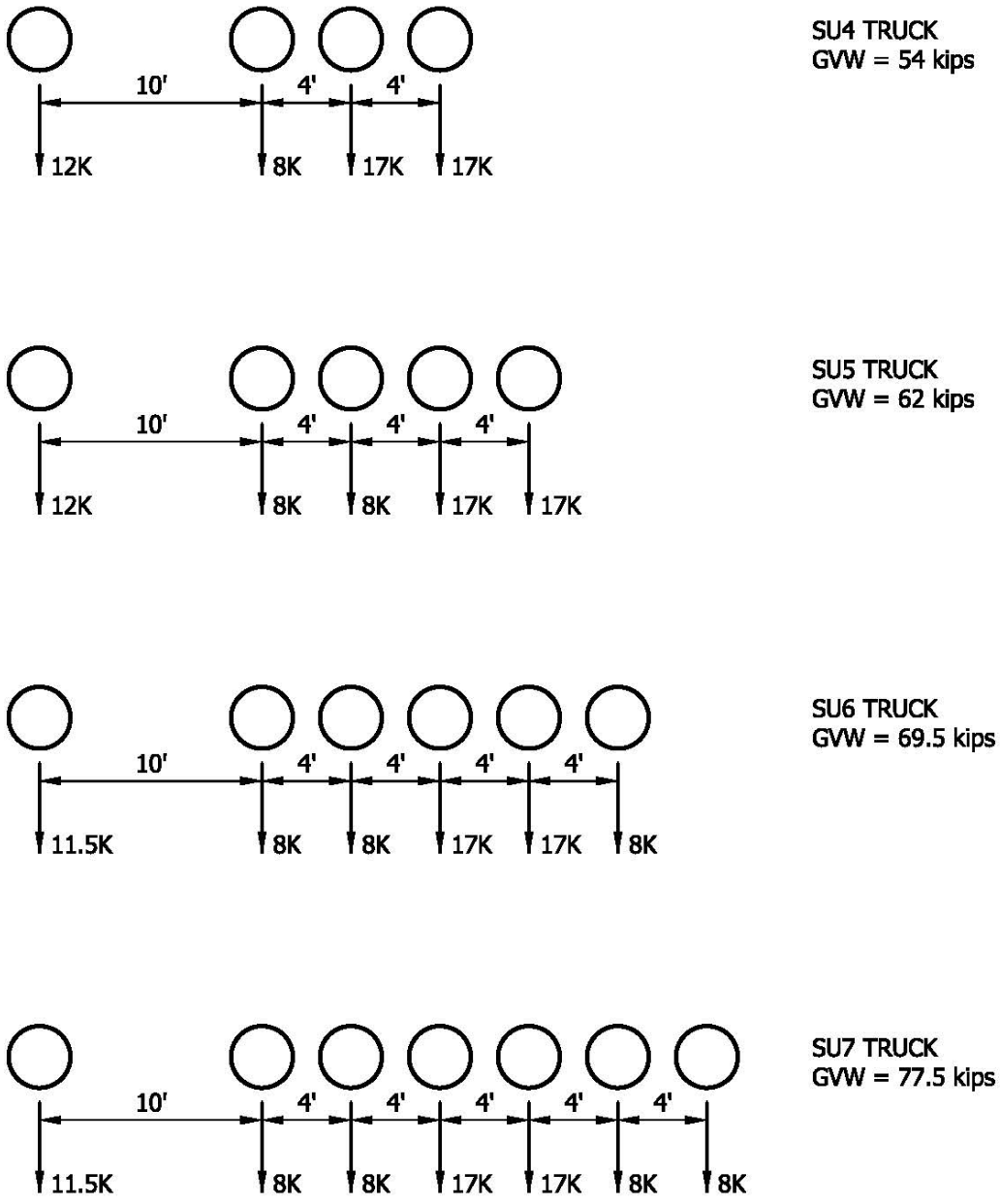


Figure A-14
Specialized Hauling Vehicles (SHV)

3-11.2 Appendix B: Extra-Heavy Duty Highways

3-11.3 Appendix C: Load Rating Report Documentation Examples [Rev. Oct. 2018]

3-11.4 Appendix D: Regulatory Sign Details [Added Apr. 2019]

Indiana Department of Transportation

FRACTURE CRITICAL PLAN OF ACTION TEMPLATE

Structure No.:	XXXXXXXXXX [NBI XXXXXX]	**Date:**	XX/XX/XXXX
Road:	XXXXXXXXXX	**Stream:**	XXXXXXXXXX

Must contain the following:

1. Brief summary of bridge's history, repairs, rehabs
2. Sketch of bridge's framing plan with fracture critical members highlighted
3. Access options (for example: underbridge truck, bucket truck, rope access) with personnel, time, and traffic control requirements
4. Tools needed

Written by: XXXXX XXXXX, District Bridge Inspection Engineer / Consultant Engineer

Signed: _____ **Date:** _____

Indiana Department of Transportation

FRACTURE CRITICAL REPORT TEMPLATE

Structure No.:	XXXXXXXXXX [NBI XXXXXX]	**Date:**	XX/XX/XXXX
Road:	XXXXXXXXXX	**Stream:**	XXXXXXXXXX

Must contain the following:

1. Location Map (only necessary if not included in BIAS report)
2. Fracture Critical Plan of Action
3. Discussion of inspection details including:
    - weather conditions
    - duration
    - personnel (only necessary if not included in BIAS inspection info tab)
    - access (additional, optional, helpful information would be traffic control and equipment used)
4. Discussion of inspection findings and recommendations
5. Discussion of rationale for fracture critical inspection frequency change (only necessary if frequency is changed)
6. National Bridge Inventory form (only necessary if not included in BIAS report)
7. Element Inspection form (only necessary if inspection resulted in a change to element data on an NHS bridge)
8. Photographs of select fracture critical members and connections including at least those:
    - rated ‘4’ or less
    - not included in previous reports up to 10 years old
    - with cracks

9. Table of inspection findings for fracture critical members and connections:

Connection/Member	**Fatigue Category**	**NBI Rating**	**Comments**
Each FC member has an individual row	AASHTO scale	NBI 58, 59, 60 scale	Include cracks, section remaining, damage; if applicable
Each FC connection has an individual row	AASHTO scale	NBI 58, 59, 60 scale	Include cracks, section remaining, damage; if applicable

10. Table of inspection findings for fracture critical truss panel point gusset plates (only necessary for trusses):

Connection	**Gusset Thickness**	**Location of Measurement**	**Method of Measurement**
Each outside FC panel point gusset has an individual row	Each thickness record to be reported on an individual row	Description or reference to photo with location marked	i.e. calipers, tape measure, d-meter, etc.
Each inside FC panel point gusset has an individual row	Each thickness record to be reported on an individual row	Description or reference to photo with location marked	i.e. calipers, tape measure, d-meter, etc.

4-4.0 FATIGUE AND FRACTURE CRITICAL INSPECTIONS

4-4.01 The Fracture Critical Inspection

Proper identification, classification, inspection, and reporting of all fracture critical bridges and the subsequent members are crucial to the longevity of Indiana's bridges and the safety of the public. Uniformity in reporting will allow the inspectors to accurately and closely monitor any problems throughout the life of the structure. Detailed and accurate reporting also allows the bridge owner to maintain and repair the bridge before major problems evolve.

4-4.01(01) Classification of Fracture Critical Members

The FHWA defines a fracture critical member as a steel member in tension, or with a tension element, whose failure would probably cause a portion of the, or the entire, bridge to collapse. A fracture critical bridge is one that contains a fracture critical member. The FHWA presents two criteria for identifying a fracture critical bridge:

1. There must be steel members in tension. These loading conditions may include tensile forces and flexure. Load analysis may indicate some members experience a stress reversal (varies from tension to compression) under various loads. Such members shall be included under this criteria.
2. There must be no load path redundancy of the bridge, in which no other structural elements are capable of carrying the load if a main load-carrying member fails. For a bridge to be defined as non-load path redundant, it must have two or less load paths.

Some bridge types that may be considered fracture critical include, but are not limited to, these types:

1. Truss bridges containing two main load-carrying members
2. Through girder bridges
3. Two-girder bridges
4. Tied arch bridges
5. Box girders
6. Cable-stayed bridges
7. Suspension bridges
8. Steel rigid frame bridges
9. Bridges containing steel cross-girders or steel pier caps

See Appendix A for examples of fracture critical bridges, components, bending diagrams, typical crack locations, and typical pin-and-hanger parts. Timber covered bridges (trusses) with steel vertical tension hangers are not coded as fracture critical (Item 92A). Unless a structural analysis indicates these are primary members, they are to be considered a non-fracture-critical secondary member.

Once a bridge is designated as fracture critical, each individual member and connection must be identified for the inspection. Any attachment connected to the tension area of a fracture critical member and having a length in the direction of the tension stress greater than four inches shall be considered part of the tension component and, therefore, shall be considered fracture critical. For definition purposes and uniformity in reporting, the portions of the fracture critical member within a minimum of 12 inches of the entire connection (gusset plates, connection plates, etc.) shall be considered a fracture critical connection, whereas the portion of the tension member beyond the 12-inch window shall be considered a fracture critical member. See Figures 4:4-1 through 4:4-3 for examples of this definition. The Inspection Team Leader shall use sound judgment to expand the minimum 12-inch criteria to include additional fatigue details, and also consider the scale of the bridge and associated members. Floor beam connections, lateral bracing connections, bearings, gusset plates, connection angles, pins, hangers, etc. are all typically considered a part of the fracture critical connection.

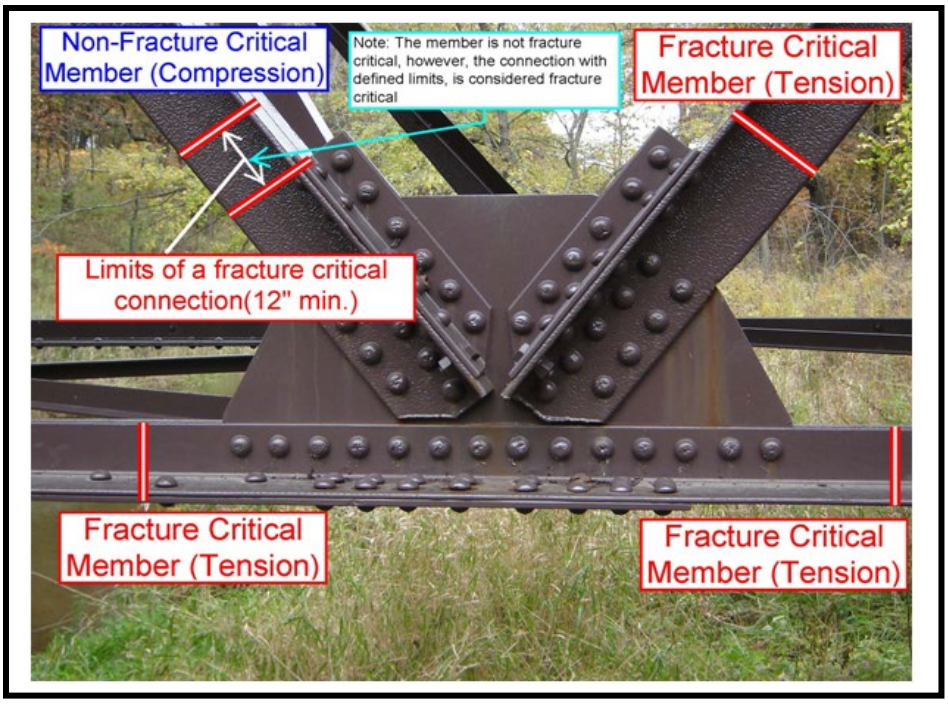


Figure 4:4-1: Fracture Critical Truss Connection

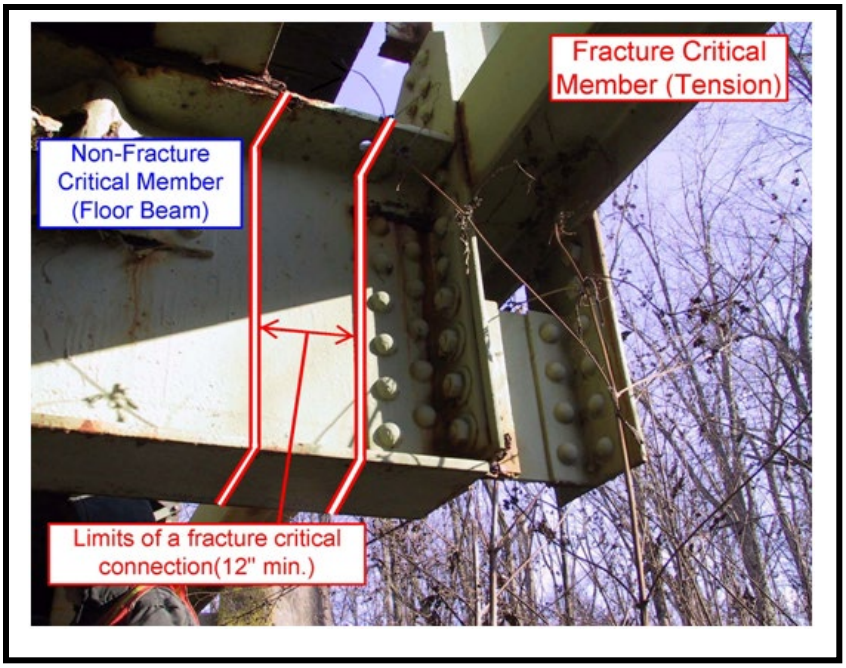


Figure 4:4-2: Fracture Critical Floor Beam Connection

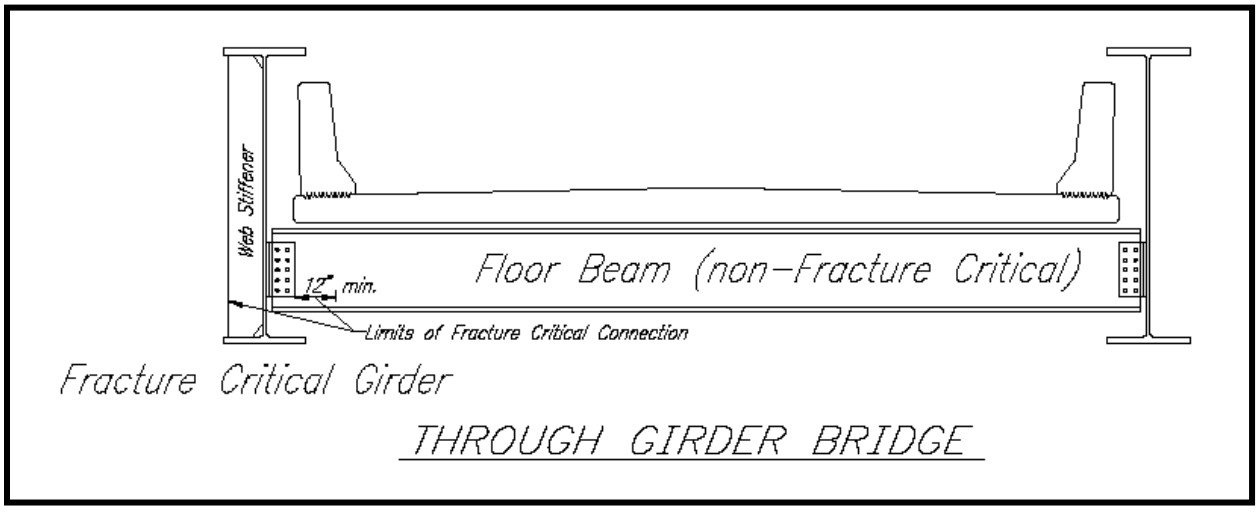


Figure 4:4-3: Fracture Critical Connection at Through Girder

In the event the original design plans of a fracture critical bridge clearly indicate that a tension member is not fracture critical due to internal redundancies within the bridge, these members will still require a detailed Fracture Critical Inspection. These tension members may only be omitted from the Fracture Critical Inspection if permission is given by both the owner and the State Program Manager.

4-4.01(02) Inspector Qualification

All Inspection Team Leaders for fracture critical bridges must:

1. Meet requirements in Part 1, Chapter 2
2. Possess adequate knowledge and understanding of how a fracture critical bridge functions, and where possible defects may occur
3. Possess suitable knowledge of the function of the specific bridge undergoing the inspection and, subsequently, the more complex bridges will warrant more knowledgeable, experienced inspectors; knowledge includes the understanding and ability to perform testing or recommend advanced testing procedures at problem areas; must be current on issues with the type of bridges being inspected
4. Physical ability to provide a hands-on inspection of all fracture critical members and connections in the individual bridge

4-4.01(03) Inspection Interval

Fracture Critical Inspections shall be performed at a regular interval not to exceed 24 months. If necessary, the inspection interval may be reduced.

4-4.01(04) Inspection Preparation

The fracture critical Plan of Action must be developed and/or reviewed and updated prior to performing a Fracture Critical Inspection. The inspection Plan of Action plays a crucial role in assisting all current and future inspectors at the bridge. The Plan of Action serves as an important first step in performing a thorough and complete investigation of all fracture critical members, while identifying necessary means, methods, and equipment required to perform this inspection. The inspection Plan of Action is a required element for every fracture critical report. These minimum requirements must be met for acceptance of the report by the Indiana Department of Transportation (INDOT. A template inspection Plan of Action is included in Appendix B. A template report is included in Appendix C.

At a minimum, the inspection Plan of Action shall include the following:

1. Sketch(es) of the superstructure with locations of all fracture critical members and connections clearly identified. This includes:
    - An elevation view for trusses with locations labeled by letters and numbers similar to the nomenclature indicated in Figure 4:4-4 with north arrow
    - A framing plan and elevation view for a through girder with detail locations labeled by letters and numbers similar to the nomenclature indicated in Figure 4: 4-5 with north arrow
2. A brief historical fact statement, such as a summary of repairs and rehabilitations

or prior history of any problems

3. All inspection tools and access equipment expected to be used for the inspection
4. Traffic control requirements

Other items that should be reviewed and made available to the inspector, if available, prior to the inspection include the following:

1. Existing bridge plans and any repair/rehabilitation plans
2. Historical data and maintenance history of the bridge
3. Prior load ratings or a preliminary load rating (invaluable in determining fracture critical members)
4. Prior inspection reports

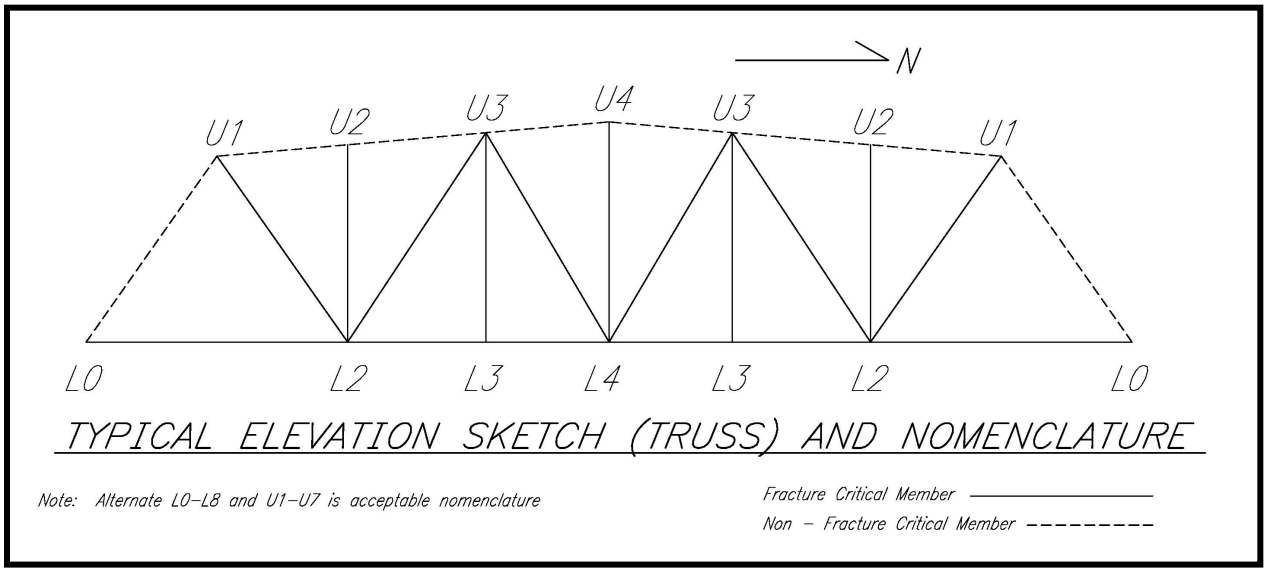


Figure 4:4-4: Example Inspection Plan Sketch (Truss)

Note: Panel points are typically labeled beginning from South to North or from West to East in Figure 4:4-4.

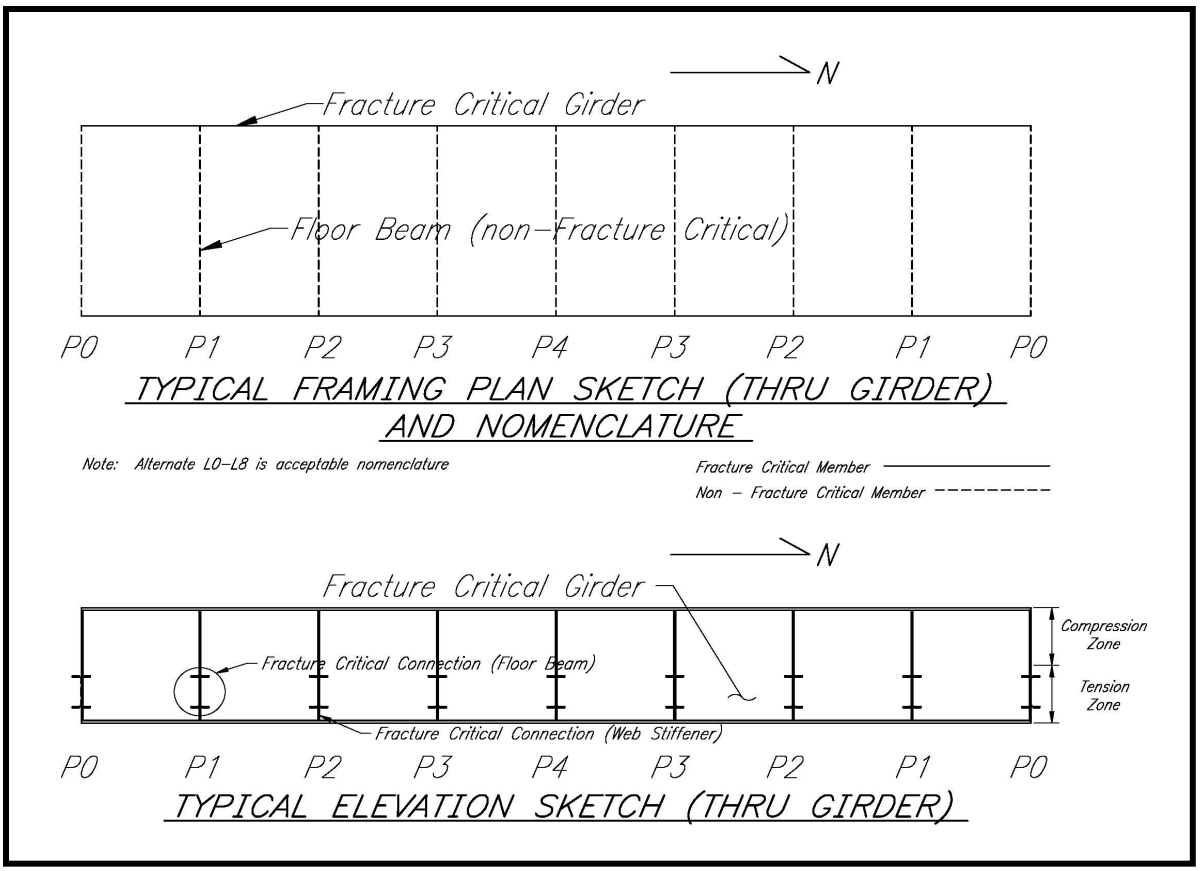


Figure 4:4-5: Example Inspection Plan Sketches (Through Girder)

4-4.01(05) Field Inspection

The National Bridge Inspection Standard requires a hands-on inspection of all fracture critical members and/or components. Hands-on is defined as being within arm's reach (i.e. two feet) of these components. The hands-on inspection requirement warrants the utilization of ladders, man lifts, climbing, and under-bridge vehicles to inspect all fracture critical components and members. Cracks and other deficiencies cannot be adequately located and inspected with the utilization of binoculars or outside of the inspector's reach from the member.

Primary compression members, floor beams, and secondary members such as lateral bracing, portal bracing, etc. are not considered fracture critical. These items require inspection and reporting during the Routine Inspection cycle. However, special consideration should be given to ensure that all primary and secondary members are inspected during the Routine or Fracture Critical Inspection and that no members have been missed during the entire inspection cycle. At a minimum, the Inspection Team Leader should perform a brief walkthrough of all secondary and non-fracture critical primary members during the Fracture Critical Inspection as a simple means to ensure all members have been inspected. When expensive equipment such as an under-bridge vehicle or man lift is utilized during the Fracture Critical Inspection, the Inspection Team Leader

should strongly consider and plan to utilize this equipment for the inspection of any difficult-to-inspect, non-fracture critical members or problem areas on the bridge.

It is imperative that the inspector adequately identify and inspect each fracture critical member and fatigue detail. Inspection for fatigue cracks in welded bridges should be performed at, but not limited to, the following locations:

For out-of-plane distortion in welded bridges, inspect the following locations if present:

1. Girder webs at floor beam and diaphragm connections
2. Ends of diaphragm connection plates in girder bridges
3. Box girder webs at diaphragms
4. Lateral bracing gusset plates on girder webs at floor beam connections
5. Floor beam and cantilever bracket connections to girders
6. Pin-connected hanger plates and fixed-pin plates

For main members in welded bridges, inspect the following locations, if present:

1. Ends of welded cover plates
2. Groove welds in flange plates
3. Butt welds in longitudinal stiffeners
4. Web plates with cut-outs and filler welds
5. Intersecting groove welds
6. Welded repairs and reinforcement
7. Back-up bar splices
8. Other stress risers

For connections and attachments in welded bridges, inspect the following locations, if present:

1. Cut short flanges
2. Coped beam ends
3. Blocked flange plates
4. Welded rigid connections of cross-girders at bents
5. Welded flange attachments
6. Intersecting welds at gusset plates and diaphragms

In general, the locations where fatigue cracks develop in riveted and bolted bridges are similar to those in welded bridges. Inspection for fatigue cracks in riveted or bolted bridges should be

performed at, but not limited to, the following locations:

1. Rivets/bolts at end connections (check for cracking and prying)
2. End connection angle
3. Girder webs at floor beam connections
4. Floor beam connections to girders
5. Diaphragm connections to girders
6. Cantilever bracket connections to girders
7. Truss hangers
8. Eyebars (see Figures 4:4-6 and 4:4-7)
9. Tack welds
10. Rivet heads and bolts made of certain types and ages of steel on older bridges may have fatigue issues, especially if pack rust has developed between connection members; additional stress may be placed on the nut or rivet head at these locations

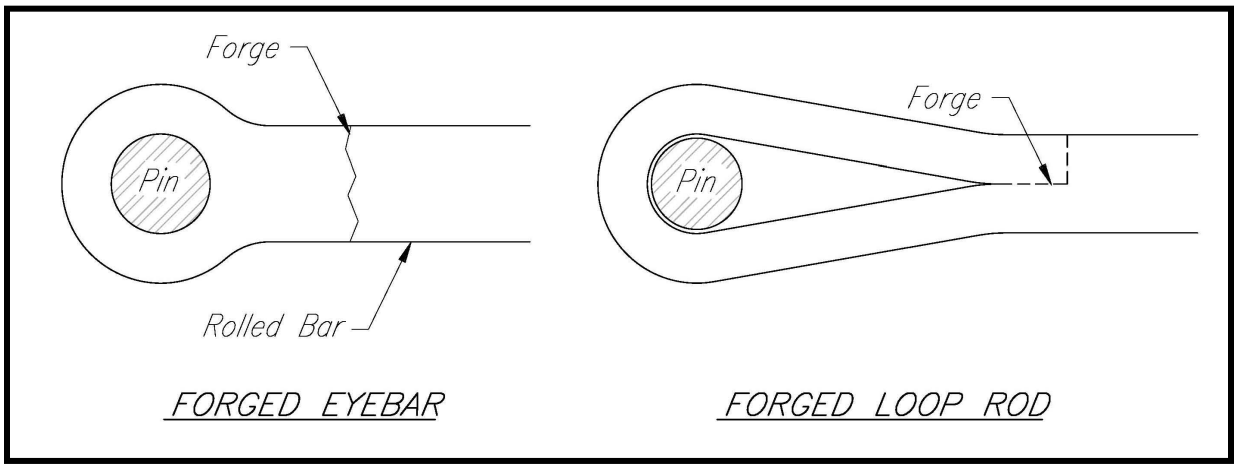


Figure 4:4-6: Typical Pin and Eyebar Details

The thickness of primary truss gusset plates should be measured as a part of a Fracture Critical Inspection. If the section cannot be adequately measured with traditional measurement devices, inspectors should use an appropriate NDT technology to assess the gusset plate condition and quantify the plate thickness.

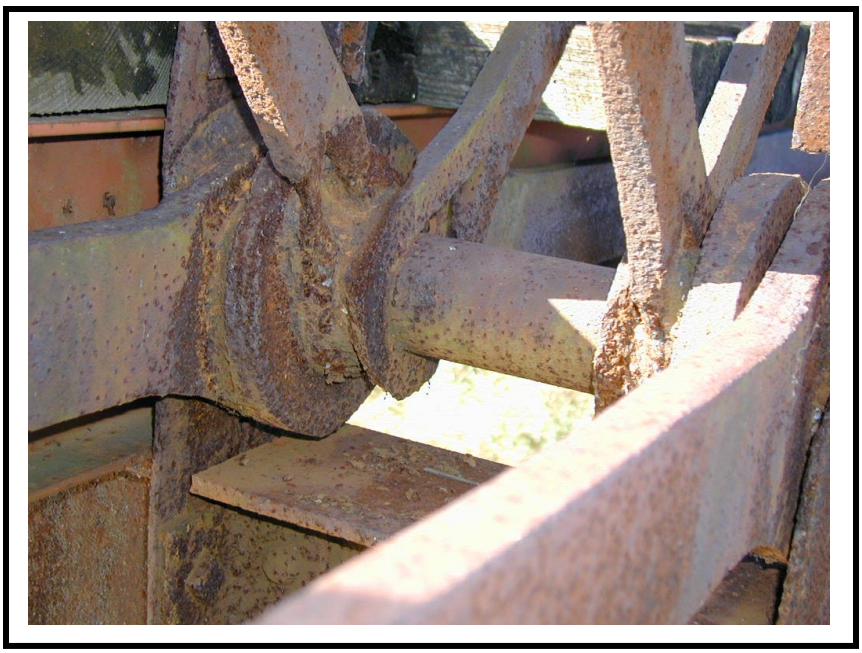


Figure 4:4-7: Forged Eyebar with Extensive Section Loss

4-4.01(06) Field Inspection Reporting

Each bridge owner has unique requirements and preferences for bridge reporting. The guidelines listed in this section are the minimum reporting requirements for acceptance of a fracture critical report. Although these minimum requirements must be met for acceptance of the report by INDOT, the inspecting agency may provide alternate report formats meeting internal guidelines, as long as the criteria set forth in this chapter are met. A template inspection report has been provided in Appendix C. The following are minimum requirements for a Fracture Critical Inspection report:

1. Inspection Plan of Action
2. General statement discussing inspection procedures
3. Date, temperature, and weather conditions of the inspection
4. Time duration of the inspection
5. Inspection Team Leaders and Inspection Team Members present at the inspection
6. General summary of inspection results
7. Testing performed, and locations of these tests, if applicable
8. Recommendations for repairs and maintenance
9. Photographs of every fracture critical member, connection, or component assigned a condition rating of 4 or less

10. Photographs of each fracture critical member at a frequency of not greater than 10 years (to be included in the bridge file)
11. Photographs of any cracks inspected
12. Rationale for changing the inspection interval, if applicable
13. Documentation of inspection results for each individual member and/or component, including the following:
    a) Individual member rating
    b) Noted areas of section loss; report section remaining
    c) AASHTO fatigue category
    d) Brief statement discussing any cracks
    e) Documentation of fatigue damage
    f) A table showing the primary truss gusset plates, thickness measurement taken, location of each measurement, and the inspection procedure used to take each measurement