# REPORT NO. C-11-04

# BRIDGE LOAD AND RESISTANCE FACTOR RATING (LRFR) ASSESSMENT – STATEWIDE

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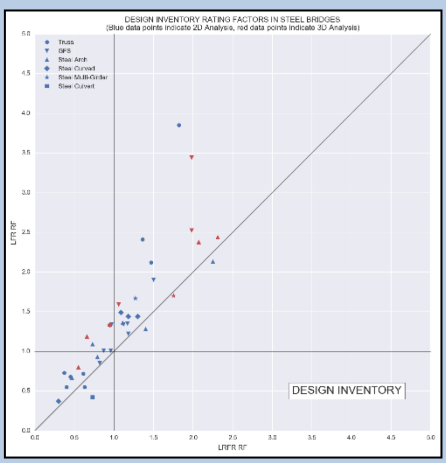


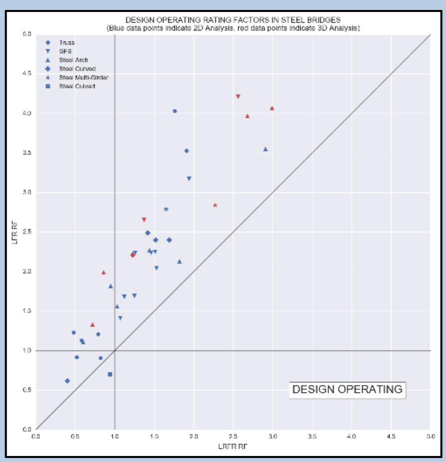


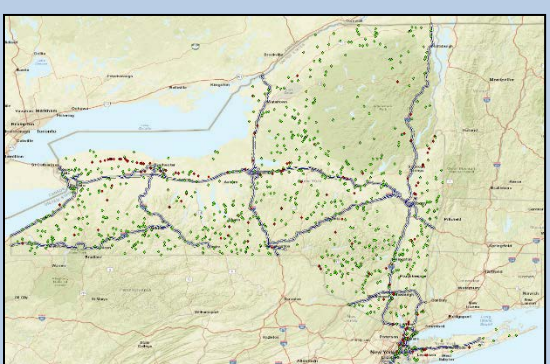

**FINAL REPORT**

(INCLUDES LEVEL I RATINGS)

**OCTOBER 2020**

PREPARED FOR

NEW YORK STATE DEPARTMENT OF TRANSPORTATION

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**FINAL REPORT**

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**OCTOBER 2020**

## DISCLAIMER

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16. Abstract

This purpose of this project is to validate the draft New York State Department of Transportation LRFR Engineering Instruction developed to provide guidance on application of the LRFR methodology as specified in the AASHTO *Manual for Bridge Evaluation* to the evaluation of bridges in New York State through the testing of Level II and Level I ratings to support LRFR implementation.

This report documents the Level I ratings of 23 complex bridges and culverts using 2D and 3D finite element (FE) analysis methods. Ratings and load posting evaluations were determined based on both EI 05-034 and the Draft LRFR EI to compare the results of the Load Factor Rating (LFR) and LRFR methodologies. The impact of LRFR ratings on load postings and R-postings for NYS bridges is evaluated.

The report provides guidance in load rating and posting requirements of AASHTO Specialized Hauling Vehicles (SHVs) for both LFR and LRFR methodologies, proposes updates to the LFR based EI 05-034 "Load Rating/Posting Guidelines for State Owned Highway Bridges," documents suggested "Load and Resistance Factor Rating (LRFR) Blue Pages," describes an approach to derive LRFR Condition Factors using AASHTO element inspection data, and documents recommended revisions to the draft LRFR EI.

In addition, a statewide bridge inventory screening for SHV and the FAST Act Emergency Vehicles (EV) is performed and the results are presented.

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APPENDIX B - NYSDOT LRFR Blue Pages
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# Executive Summary

This project serves to validate the draft New York State Department of Transportation LRFR Engineering Instruction developed to provide guidance on application of the Load and Resistance Factor Rating (LRFR) methodology as specified in the AASHTO Manual for Bridge Evaluation to the evaluation of bridges in New York State (NYS) through the testing of Level II and Level I ratings to support LRFR implementation.

This report pertains to the Level I ratings of 23 complex bridges and culverts using 2D and 3D finite element (FE) analysis methods. Ratings and load posting evaluations were determined based on both EI 05-034 and the Draft LRFR EI, and results of the Load Factor Rating (LFR) and LRFR methodologies were compared. This direct comparison generally yielded scattered results due to the differences in the live loads, live load distribution, dynamic load allowance, and resistance calculations in the LRFR and LFR methodologies.

Overall, the LRFR methodology produced lower design rating factors than the LFR methodology for steel bridges. However, in reinforced concrete arch bridges, significantly higher LRFR design rating factors were observed. For T-beam and RC Frame type concrete bridges, LRFR and LFR results were less distinct.

LRFR legal load ratings were higher than LFR legal load ratings at the Inventory level, while they were generally lower than LFR legal load ratings at the Operating level for all bridge types. LRFR and LFR permit load ratings were similar for steel bridges, while LRFR permit load ratings were significantly higher than LFR ratings for concrete bridges.

NYSDOT LRFR procedures are based on the SU4 and Type 3S2 live load models. As the SHV loads exceeds the weight of a legal SU4 configuration, a significant number of bridges that were previously unposted for legal loads are likely to require posting for the other SHVs. Use of refined, 3D finite element analysis generally yields higher rating factors than 2D analysis and can help decrease the number of bridges that may require posting in both LFR and LRFR methodologies.

This project additionally included the following:

- Evaluation of the impact of LRFR ratings on load postings for NYS bridges, including the impact of AASHTO Specialized Hauling Vehicles (SHV) and FAST Act Emergency Vehicles (EV).
- Guidance in load rating and posting requirements of SHVs for both LFR and LRFR methodologies.
- Proposed updates to the EI 05-034 “Load Rating/Posting Guidelines for State Owned Highway Bridges” document to include SHVs in the load rating/posting process.
- Development of the “Load and Resistance Factor Rating (LRFR) Blue Pages.”
- An approach to derive LRFR Condition Factors using AASHTO element inspection data.

- Recommended revisions to the draft LRFR EI.

Based on the results from this investigative study, the following recommendations are made:

- Currently, ratings and postings are performed using EI 05-034, which utilizes the LFR method and the H truck. NYSDOT LRFR procedures are based on the SU4 truck as the representative single unit rating vehicle, as it would provide the lowest posting load compared to SU5, SU6, and SU7 vehicles. As the SHV loads exceeds the weight of a legal SU4 configuration, a significant number of bridges that were previously unposted would require posting for the other SHVs.
- Revisions to EI 05-034 for LFR posting using SHVs and revisions to the draft LRFR EI, developed to follow bridge LRFR methodology as specified in the AASHTO *Manual for Bridge Evaluation* (MBE), have been developed based on the results of this study. A "Load and Resistance Factor Rating (LRFR) Blue Pages" document has also been created. This is analogous to the NYSDOT LRFD Blue Pages. See Appendix B.
- An approach to deriving LRFR Condition Factors using element inspection data has been recommended and included in the LRFR Blue Pages. EI 05-034 Table 2 has been updated, incorporating AASHTO Element Condition State ratings.
- Per the latest FHWA directive, and the MBE refinements, SHV ratings and Emergency Vehicles ratings required by the FAST Act were applied for the screenings of state and locally owned bridges. This study has identified bridges that are at risk of being controlled by SHV ratings and EV ratings and may require posting. The screening will promote efficiency in load rating analysis for these load models. The study investigated all NYS highway bridges with available load ratings in the database (13,988 bridges).
- Other recommendations from this study include:
  - For the LRFR methodology, two criteria for R-Posting bridges were recommended in the draft EI. Recommended methodology was developed based on the load rating results.
  - For bridges on the local system the use of LRFR legal load factors provided in the AASHTO MBE 3rd Edition (2018) is recommended. This would be a departure from the Draft EI and has been incorporated in the LRFR Blue Pages. State owned and Interstate bridges should be rated with NY specific legal load factors given in the Draft EI.
  - Guidance on the use of all SHVs in load ratings and postings has been added to the LFR and LRFR EI and Blue Pages.

# 1 Introduction

The goal of this project is "To validate and test the draft LRFR EI developed to follow the LRFR methodology as specified in the AASHTO MBE using Level II and Level I ratings".

The work completed under this project can be grouped into three distinct categories:

- Level II load ratings of 314 bridges
- Level I load ratings of 23 bridges and culverts
- Special studies to support LRFR implementation in New York State

This report pertains to the Level I ratings of 23 complex bridges and culverts not ratable using AASHTOWare BrR. A separate report on Level II ratings was prepared and submitted in October 2013. This separate report is included in this document as Appendix D for completeness.

## 1.1 Level II Ratings

In the first rating task of this project (Task 3), 314 bridges (state and local), selected by NYSDOT in collaboration with HNTB, were rated with AASHTOWare BrR software using both Load Factor Rating (LFR) and Load Resistance and Factor Rating (LRFR) methodologies following the procedures outlined in the Draft EI document for LRFR ratings and the EI 05-034 document for LFR ratings. Comparative ratings were performed at all three primary levels: Design, Legal and Permit rating levels. The load models that were utilized in the rating analysis were the AASHTO design loads (HS-20 or HL-93), NY legal loads (SU4 and Type 3S2), NY divisible permits (NYP 6 thru NYP 13), and NY non-divisible permits (NYP1 thru NYP 5). Load Posting values and R-posting values in both methodologies were calculated. The load posting criteria were based on the Draft EI document for LRFR ratings and the EI 05-034 document for LFR ratings. Comparative study of the results was prepared using tables and graphs of the LFR and LRFR ratings, load postings and R-postings for all bridges.

## 1.2 Level I Ratings

In the second rating task (Task 4) Level I ratings for a total of 23 bridges and culverts not ratable by BrR were performed using 2D and 3D finite element (FE) analysis methods. Bridge types rated using Level I methods are as follows:

- RC Frame
- RC Arch
- Concrete T-Beam

- Steel Truss
- Steel Arch
- Steel Girder-Floorbeam-Stringer
- CMP Steel Culvert
- Steel Curved Girder
- Steel Multi-Girder

Ratings based on both Load Factor Rating (LFR) and Load and Resistance Factor Rating (LRFR) methodologies were determined. STAAD Pro software was used for the FE analysis of most bridges. MDX was used for curved girder analysis. CANDE was used to rate the steel culverts. Member resistance calculations utilizing MATHCAD spreadsheets were developed both for LFR and LRFR methodologies. The analysis also included load posting and R-posting evaluations, where results from LFR and LRFR methodologies were compared, similar to the Level II ratings. The load posting criteria were based on the Draft EI document for LRFR ratings and the EI 05-034 document for LFR ratings.

Tasks 4-1 and 4-3 covered a set of 11 bridges not ratable using BrR. Level I ratings using FE analysis was done on RC frame, RC arch and steel truss bridges typically found in NY state. In Task 4-2 of this project, Level I load ratings were performed for CMP steel culverts found in New York State that cannot be load rated with the BrR software. Load ratings were performed by 3D finite element analysis based on both LFR) and Load and Resistance Factor Rating (LRFR) methodologies. In Task 4-4 Level I ratings for four curved girder bridges were also load rated by both methods. MDX was used as the primary load rating software and one bridge was load rated by 3D finite element modeling with STAAD Pro. Task 4-5 included Level I ratings of two steel arch bridges. Task Order 4-7 included three girder-floorbeam bridges and Task Order 4-9 contained one steel multi-girder bridge with 9 spans for Level I ratings. A listing of bridges and culverts rating broken down by subtasks is given in Section 2.1. Final report for Task 4 – Level I Ratings was compiled under Task 4-8. In addition to Level I ratings, Task 4 also included additional subtasks to assist NYSDOT with load rating issues related to recent FHWA directives and with statewide LRFR implementation. These tasks are summarized below:

## 1.3 Special Studies to Support LRFR Implementation in New York State

1. In Task Order 4-6, the impact of individual AASHTO Specialized Hauling Vehicles (SHV) in LFR and LRFR Ratings and postings for New York State was evaluated. The scope of this task was to investigate two related issues pertaining to the use of Specialized Hauling Vehicles (SHVs) in load ratings and postings:

1. Rerun Level II ratings to ascertain impact of using SU5, SU6 & SU7 in LRFR postings. Currently LRFR ratings are required only for SU4 loading.
2. Update EI 05-034 and LFR posting to include SHVs

Currently ratings and postings are performed using EI 05-034 which utilizes the LFR method and the H-20 truck. NYSDOT LRFR procedures are based on the SU4 truck as the representative single unit rating vehicle as it would provide the lowest posting load. The evaluation for all SHVs was achieved by rerunning the 314 Level II bridges in BrR with the SU4, SU5, SU6, and SU7 vehicles for LRFR and rerunning the H-20 for LFR. Incorporating the three heavier SHVs and testing the draft LRFR EI for posting using those results provided valuable information for NYSDOT policy evaluation and implementation. It was noted that as the posting load exceeds the weight of a legal SU4 configuration that a significant number of other bridge that were previously unposted would require posting for the other SHVs.

Revisions to EI 05-034 for LFR posting and the draft LRFR EI, developed to follow bridge LRFR methodology as specified in the AASHTO Manual for Bridge Evaluation, have been developed based on this study results.

- In Task Order 4-8, the "Load and Resistance Factor Rating (LRFR) Blue Pages" document was developed, which incorporated articles that would be deleted from the AASHTO Manual for Bridge Evaluation 3rd Edition, and replaced with provisions specific to NYSDOT LRFR methodology. This is analogous to the NYSDOT LRFD Blue Pages. See Appendix B.

- In Task Order 4-10, an approach to deriving LRFR Condition Factors using element inspection data was investigated. NYSDOT has implemented inspection data collection using AASHTO Elements in 2016. This requires that Table 2 in the Draft LRFR EI needs to be revised to incorporate AASHTO Element Condition Ratings. In addition, the Condition Factor referred to in the LRFR Draft EI - Section 2.7.1 – Table 2 should be revised to include the AASHTO element data. It is thus necessary to redesign Table 2, incorporating AASHTO Element Condition State ratings.

- Task Order 4-11 was initiated to investigate NYS bridges with available load ratings for SHV postings per the latest FHWA directive, and the MBE refinements. Also, Emergency Vehicles ratings required by the FAST Act were also included in the screening. The most efficient and accurate process from these two guidelines were applied for the SHV and EV screenings under this task. This included state and locally owned bridges. This study has identified bridges that are at risk of being controlled by SHV ratings and EV ratings and may require posting. The screening is intended to promote efficiency in load rating analysis for these load models so that spans that are most susceptible to overstress from SHVs and EVs are load rated first. The study investigated all NYS highway bridges with available load ratings in the database (13988 bridges).

- In Task Order 4-8 the findings from these statewide ratings and posting studies were compiled into a final report. The report covers items as noted below:
  - For the LRFR methodology, two criteria for R-Posting bridges were recommended in the draft EI. Recommended methodology was developed based on the load rating results.
  - Review of likely impact on load posting and R-posting of bridges with the change to LRFR for state and local bridges.
  - For bridges on the local system the use of LRFR legal load factors provided in the AASHTO MBE 3rd Edition (2018). This would be a departure from the Draft EI. State owned and Interstate bridges should be rated with NY specific legal load factors given in the draft EI.
  - Comparisons of 2D and 3D Level I ratings.
  - Selecting Condition Factors when using AASHTO Element data.
  - Impact of the use of SU4 truck as a legal / posting load given in the draft EI in future LRFR ratings and postings when all SHV trucks are being used.

Impacts from SHV and EV postings to comply with the latest FHWA directives. Updates to the Load Factor Rating EI and the draft LRFR EI to incorporate the use of all SHVs for posting.

# 2 Level I Load Rating Results

## 2.1 Level I Bridges

Level I Bridges that were analyzed in this study are listed in Table 2.1.

**Table 2.1** – List of Level I Bridges

| LEVEL I BRIDGES | | | | | |
|---|---|---|---|---|---|
| **TASK** | **BIN/Bridge Type** | **Spans** | **Analysis Type** | **Rated by** | **Locality** |
| 4.0 | 1059320 (RC T-Beam) | 1 | 3D | HNTB | Local |
| | 1075059 (Concrete Arch) | 1 | 2D | HNTB | State |
| | 4443160 (Steel Truss) | 1 | 2D | HNTB | Local |
| 4.1 | 1016990 (Steel Truss) | 1 | 3D | HNTB | Local |
| | 1044220 (Concrete Arch) | 2 | 2D | HNTB | State |
| | 1075880 (Concrete Arch) | 2 | 2D | HNTB | State |
| | 1046510 (Concrete Arch) | 1 | 3D & 2D | HNTB | Local |
| | 1051960 (RC Frame) | 1 | 3D & 2D | HNTB | State |
| | 1050180 (RC Frame) | 1 | 2D | HNTB | Local |
| | 1045360 (RC Frame) | 2 | 2D | HNTB | State |
| 4.2 | 5521680 (Steel Culvert) | 1 | 2D | Prudent | Local |
| | 1091510 (Steel Culvert) | 1 | 2D | Prudent | State |
| 4.3 | 1076419 (RC Frame) | 1 | 2D | HNTB | State |
| 4.4 | 1069090 (Steel Curved) | 5 | 2D | Prudent | State |
| | 1069610 (Steel Curved) | 2 | 2D | Prudent | State |
| | 1090530 (Steel Curved) | 3 | 2D | Prudent | State |
| | 1053060 (Steel Curved) | 2 | 2D | Prudent | State |
| | | | 3D | HNTB | State |
| 4.5 | 1041200 (Steel Arch) | 1 | 3D & 2D | HNTB | State |
| | 1023380 (Steel Arch) | 3 | 2D | HNTB | State |
| 4.7 | 1001360 (Girder Floorbeam Stringer) | 1 | 2D | HNTB | State |
| | 1046790 (Girder Floorbeam Stringer) | 1 | 2D | HNTB | State |
| | 1004540 (Girder Floorbeam Stringer) | 1 | 2D & 3D | HNTB | State |
| 4.9 | 1004279 (Steel Multi Girder) | 8 | 2D & 3D | HNTB | State |

## 2.2 Level I Rating Methodology

Load rating for Level I ratings follow the flowchart given in Figure 2.1.

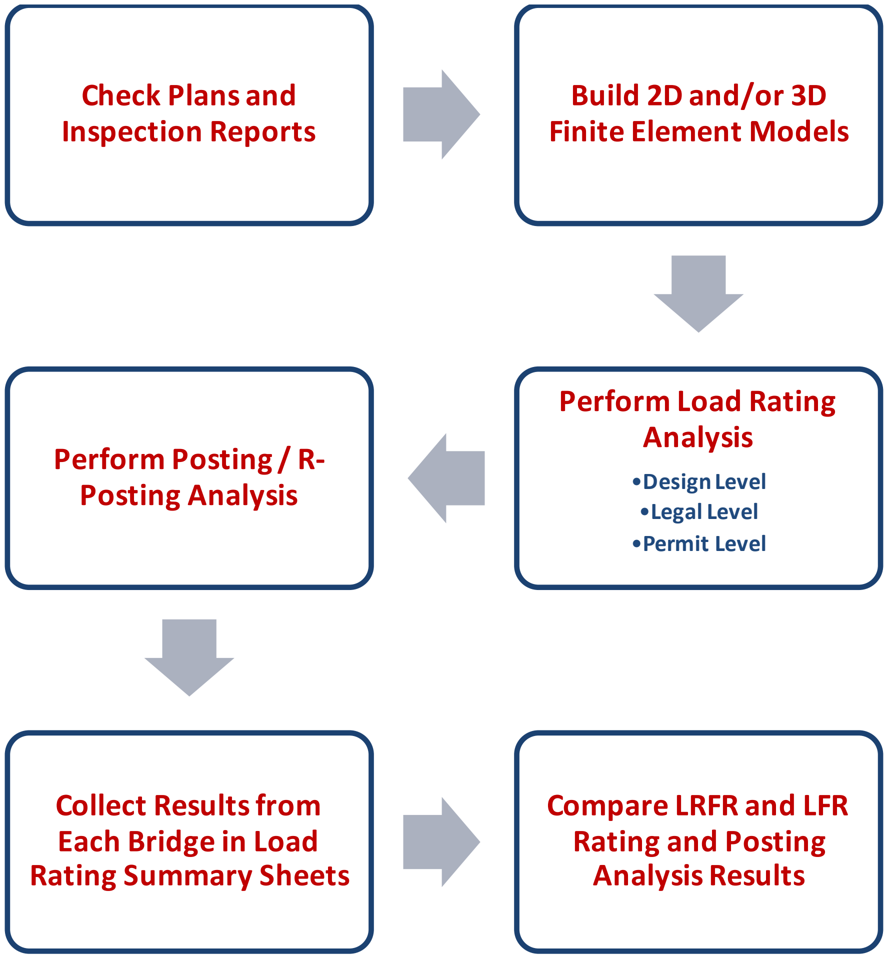



**Figure 2.1 –** Level I Load Rating Methodology Flowchart

- STAAD Pro software was used for the FE analysis of most bridges.
- MDX was used for curved girder analysis.
- CANDE was used to rate the steel culverts.
- Member resistance calculations utilizing MATHCAD spreadsheets were developed both for LFR and LRFR methodologies
- Comparative Level I LFR & LRFR ratings were performed at all three primary levels:
    - Design, Legal and Permit rating levels.
- Load Posting values and R-posting values in LFR & LRFR were calculated.
- Live Loads and Load Factors
    - Design loads (HL-93 and HS-20)

- NY legal loads (SU4 and 3S2)
- NY divisible permits (NYP6 thru NYP 13)
- NY non-divisible permits (NYP1 thru NYP 5)
- Legal Load Rating of Local Bridges using LRFR Live Load Factors in the MBE
- NY specific LRFR legal load factors for state-owned bridges as given in the Draft EI

- Posting of Bridges for R-Permit Restrictions
  - The need for R-posting was determined for divisible loads per the Draft EI requirements.
  - Following criteria for R posting were considered for downstate and upstate bridges:
    - Downstate bridges that do not have a RF $\geq$ 1.0 for the NYP-11 permit.
    - Upstate bridges that do not have a RF $\geq$ 1.0 for the NYP-6 permit.

Related live load models are shown in Figure 2.2:

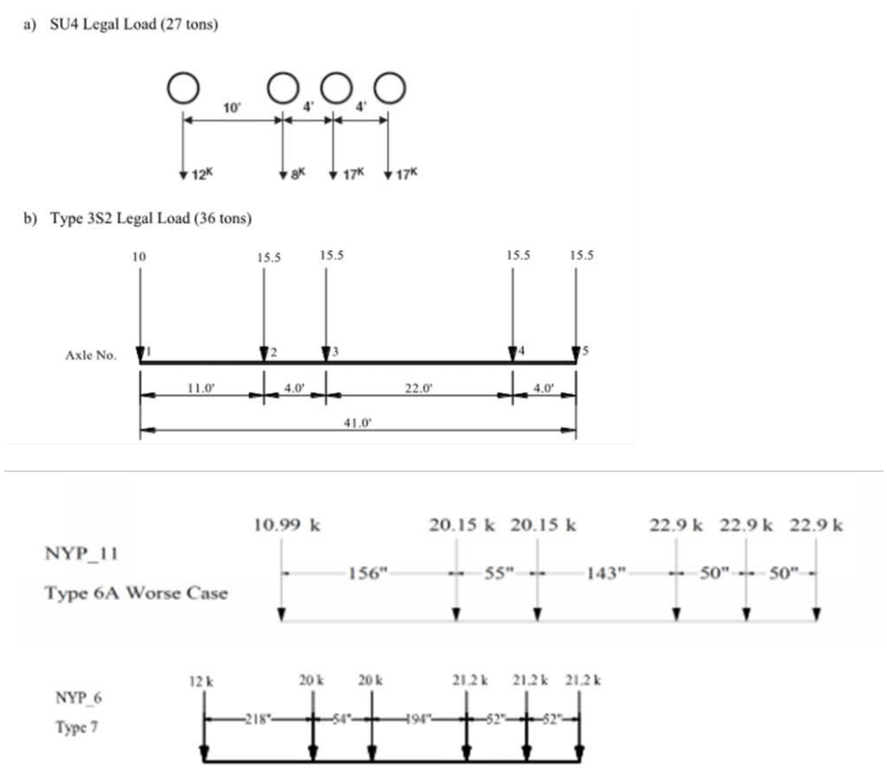



**Figure 2.2** – Legal and Permit Live load models used in Level I load ratings.

## 2.3 LFR / LRFR Rating Factor Comparisons

### *2.3.1 Design Load Rating (HL-93 vs. HS-20)*

Comparative results from design load ratings for steel and concrete bridges are shown in Figure 2.3 – Figure 2.6.

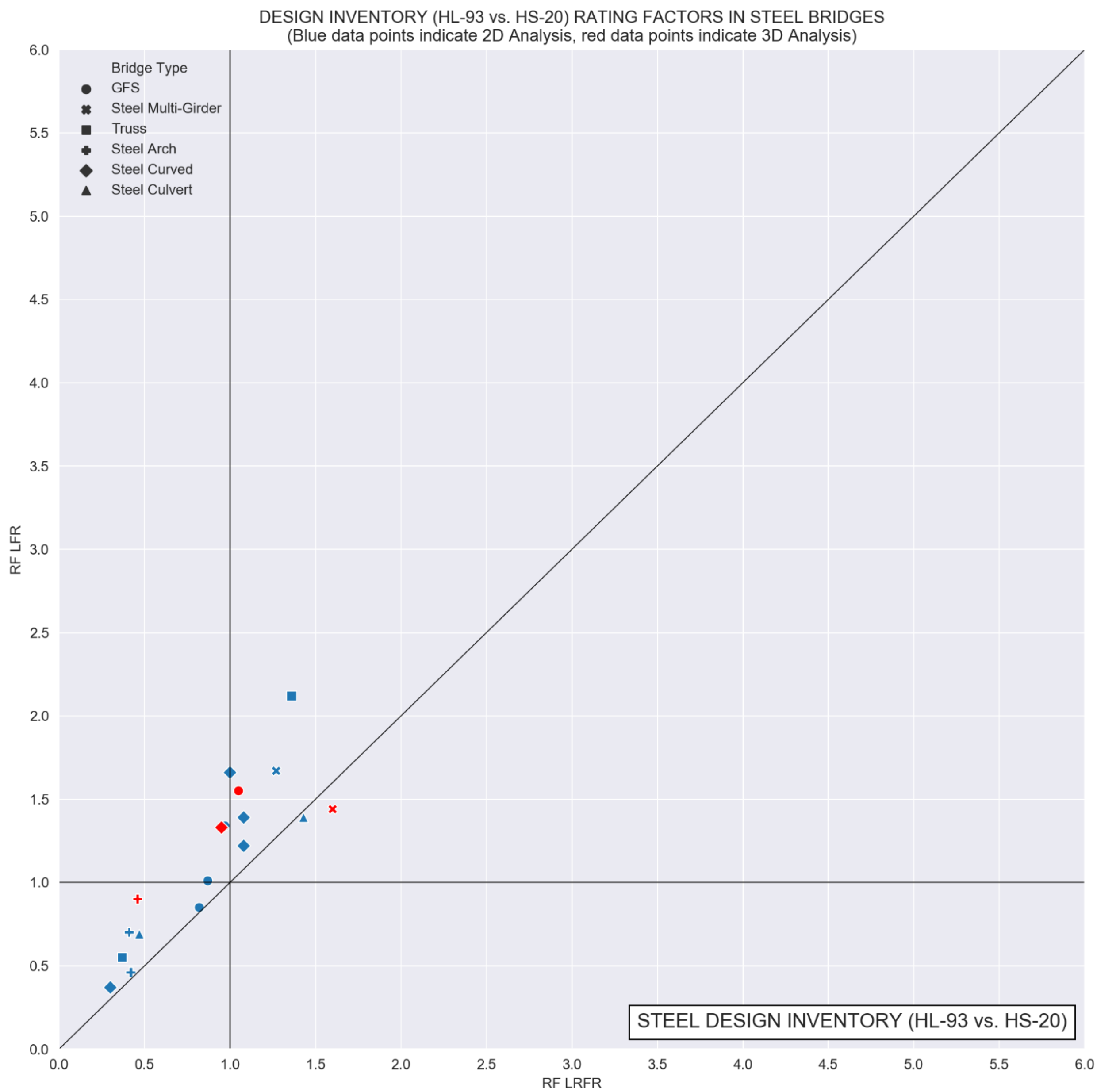



**Figure 2.3** – Design inventory rating factors in steel bridges (HL-93 vs. HS-20).

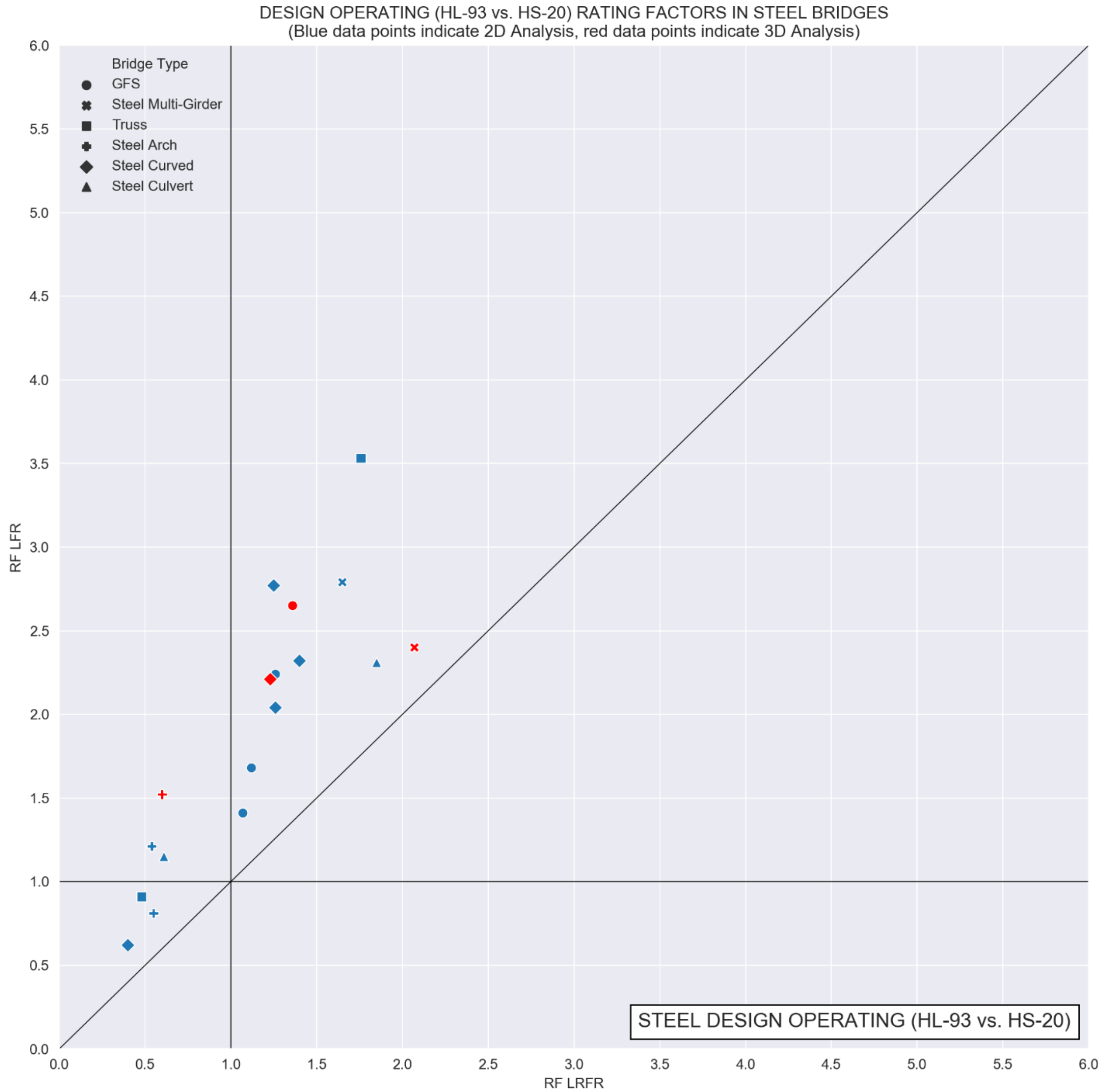



**Figure 2.4** – Design operating rating factors in steel bridges (HL-93 vs. HS-20).

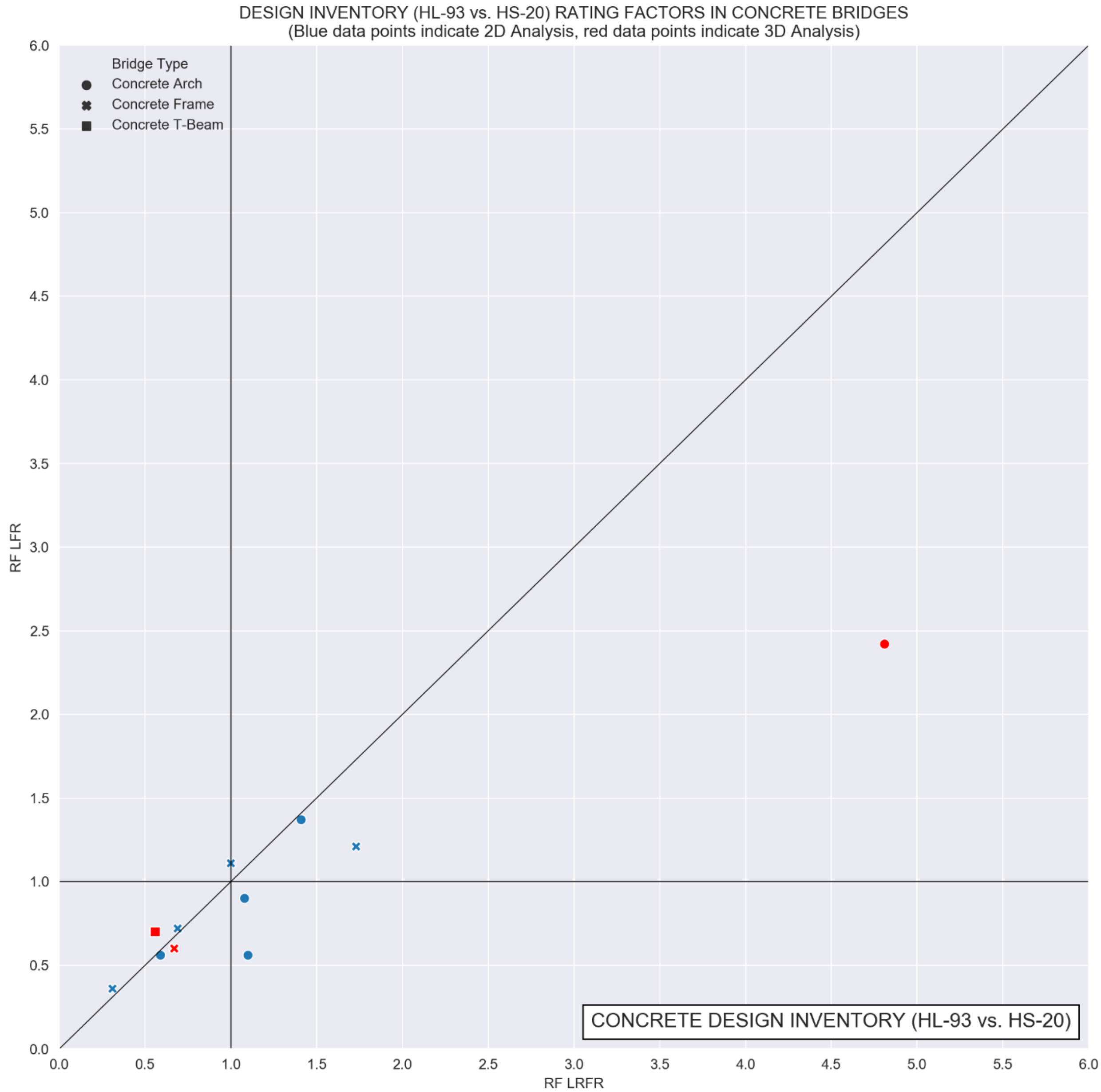



**Figure 2.5** – Design inventory rating factors in concrete bridges (HL-93 vs. HS-20).

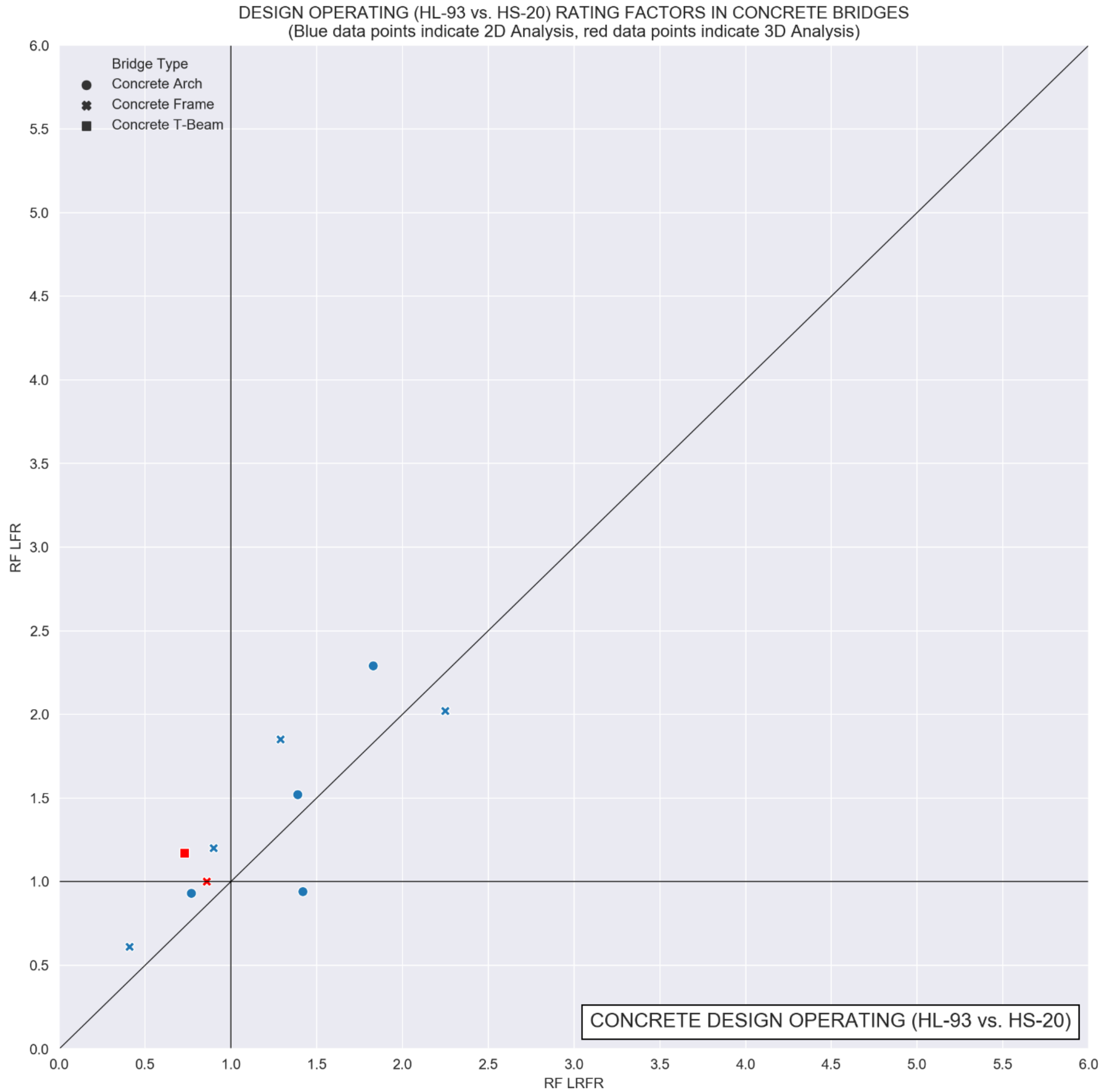



**Figure 2.6** – Design operating rating factors in concrete bridges (HL-93 vs. HS-20).

### *2.3.2 Design Load Rating (H20 / HL-93)*

Comparative results from design load ratings for steel and concrete bridges are shown in Figure 2.7 – Figure 2.10.

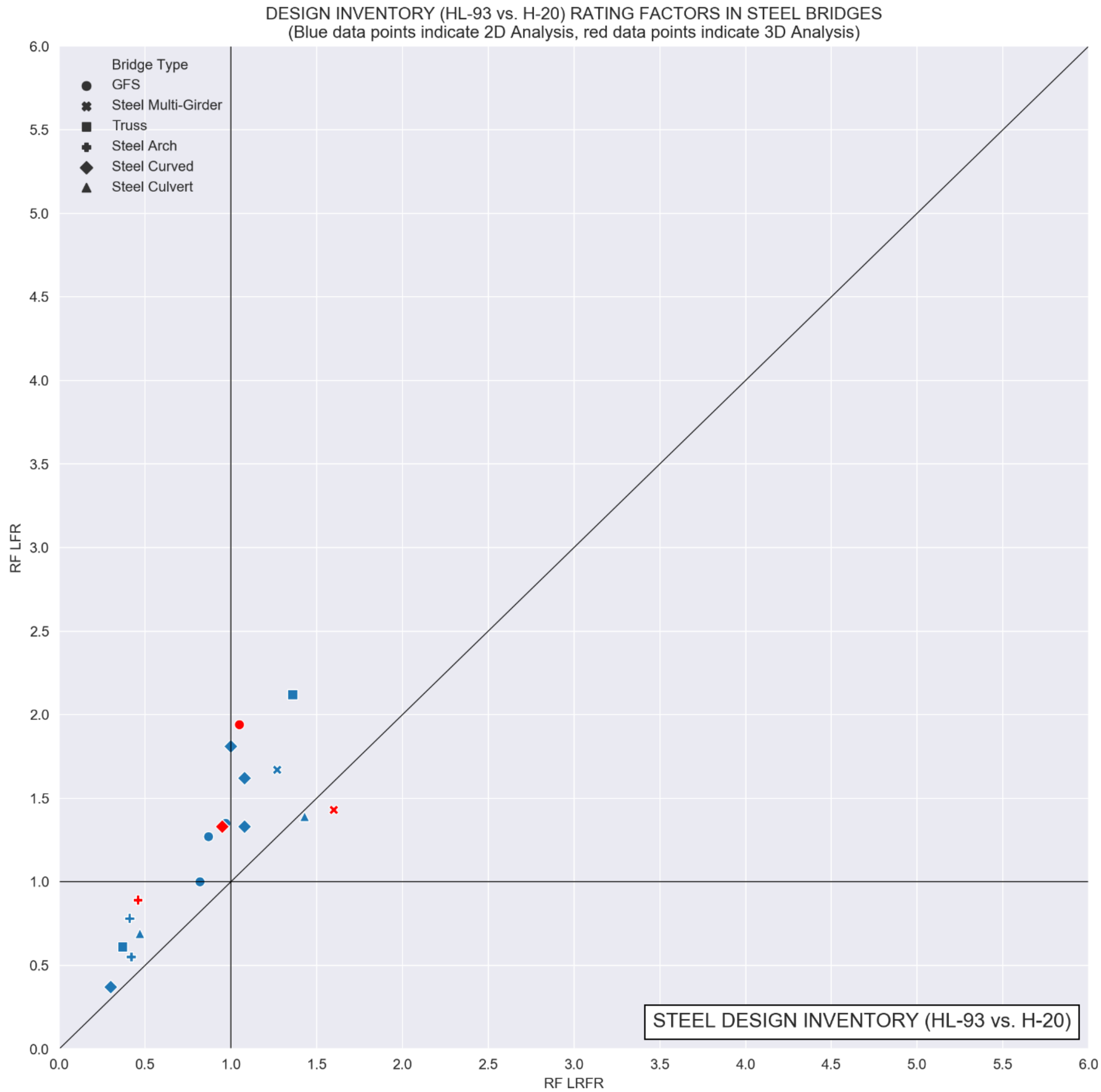



**Figure 2.7** – Design inventory rating factors in steel bridges (HL-93 vs. H-20).

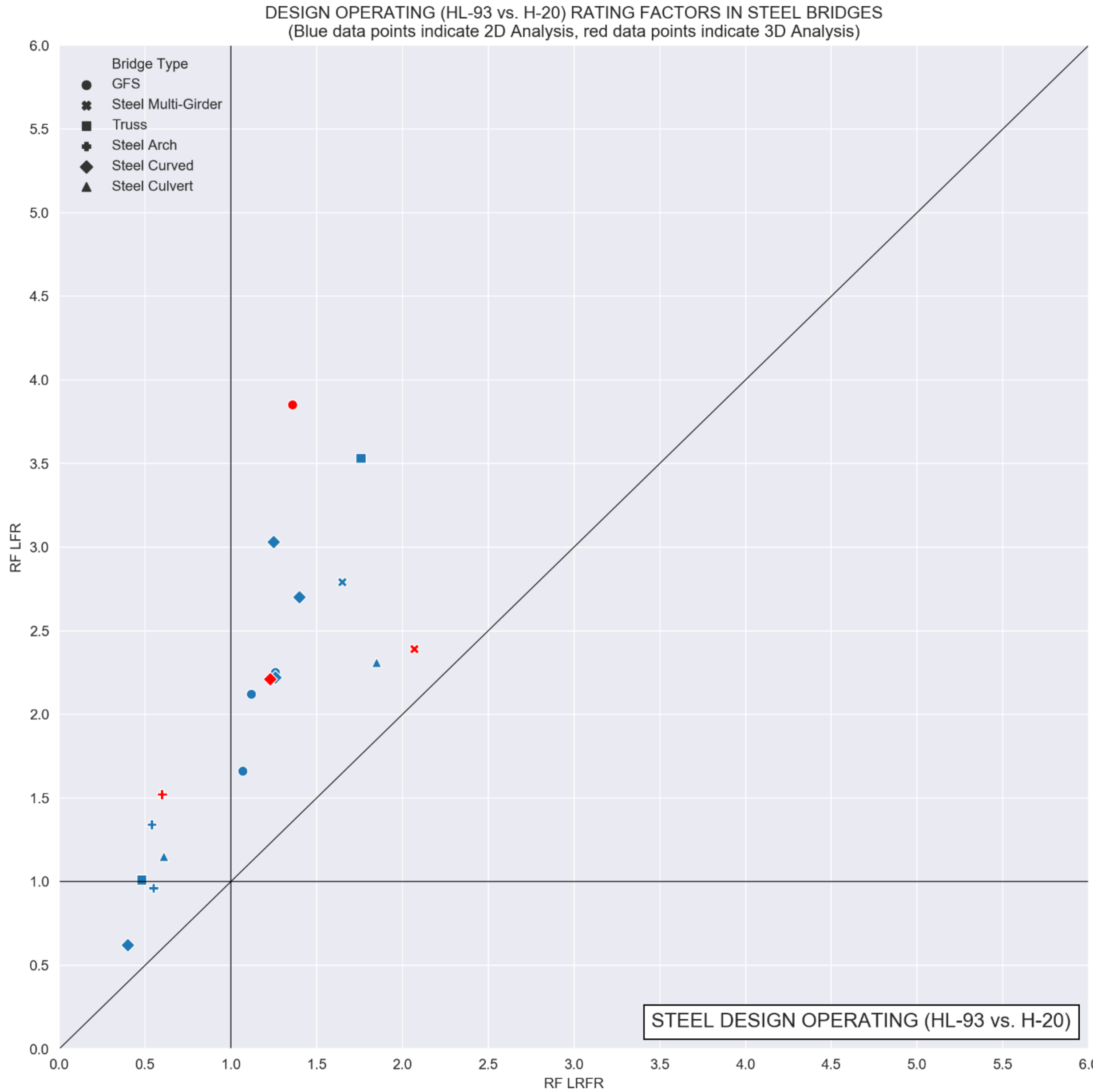



**Figure 2.8** – Design operating rating factors in steel bridges (HL-93 vs. H-20).

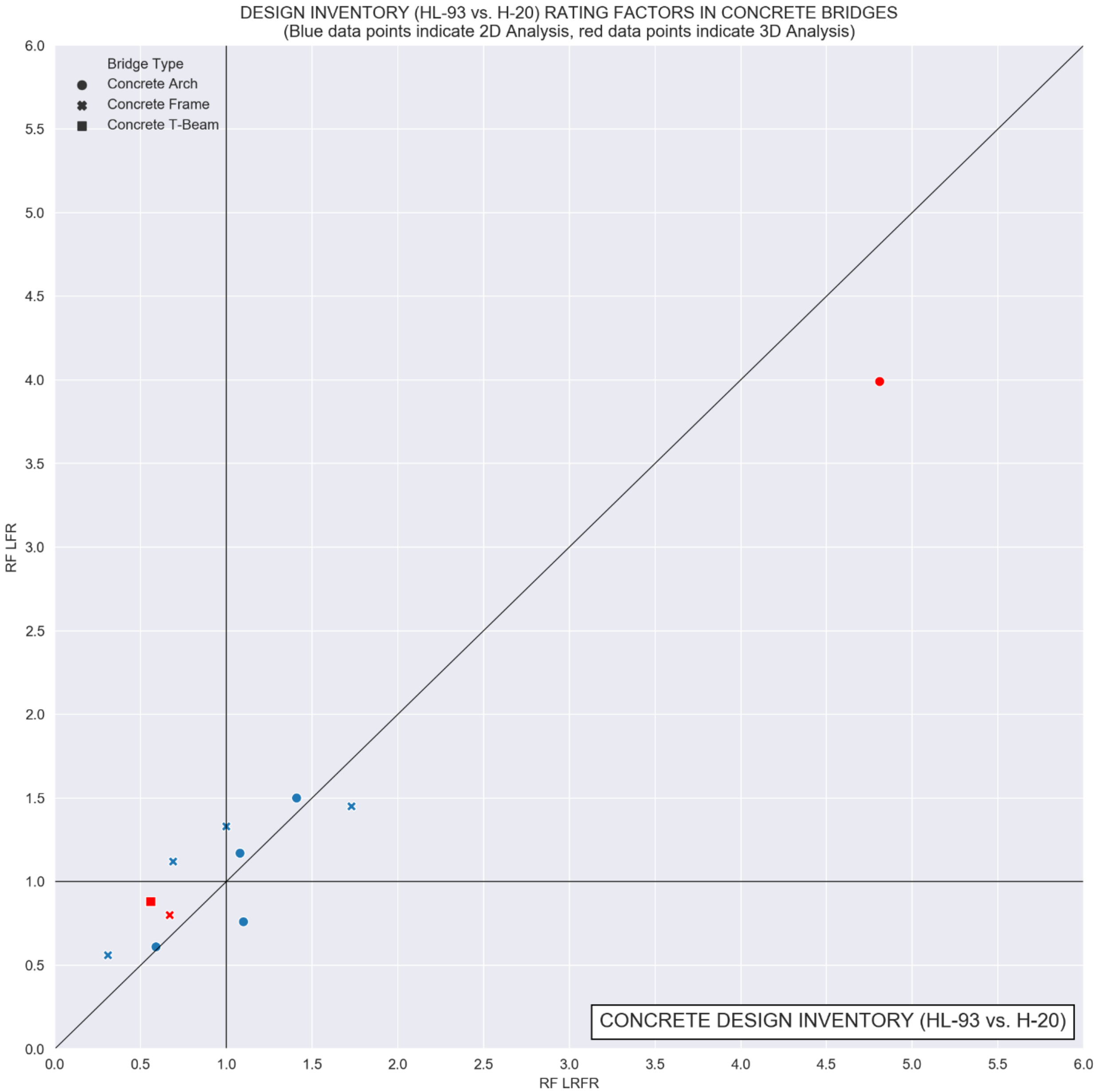



**Figure 2.9** – Design inventory rating factors in concrete bridges (HL-93 vs. H-20).

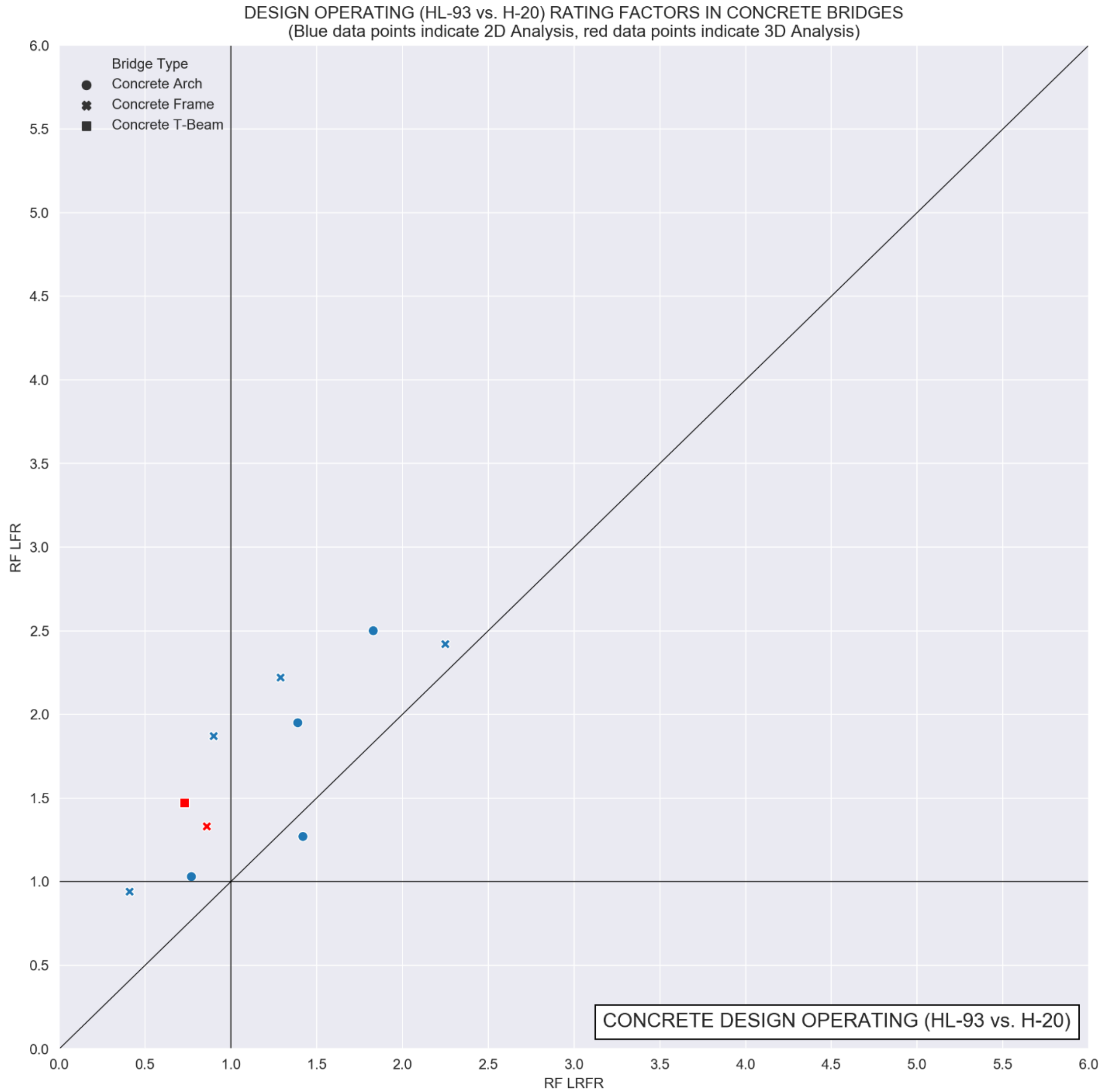



**Figure 2.10** – Design operating rating factors in concrete bridges (HL-93 vs. H-20).

### *2.3.3 Legal Load Rating (SU4)*

Comparative results from legal load ratings (SU4) for steel and concrete bridges are shown in Figure 2.11 – Figure 2.14.

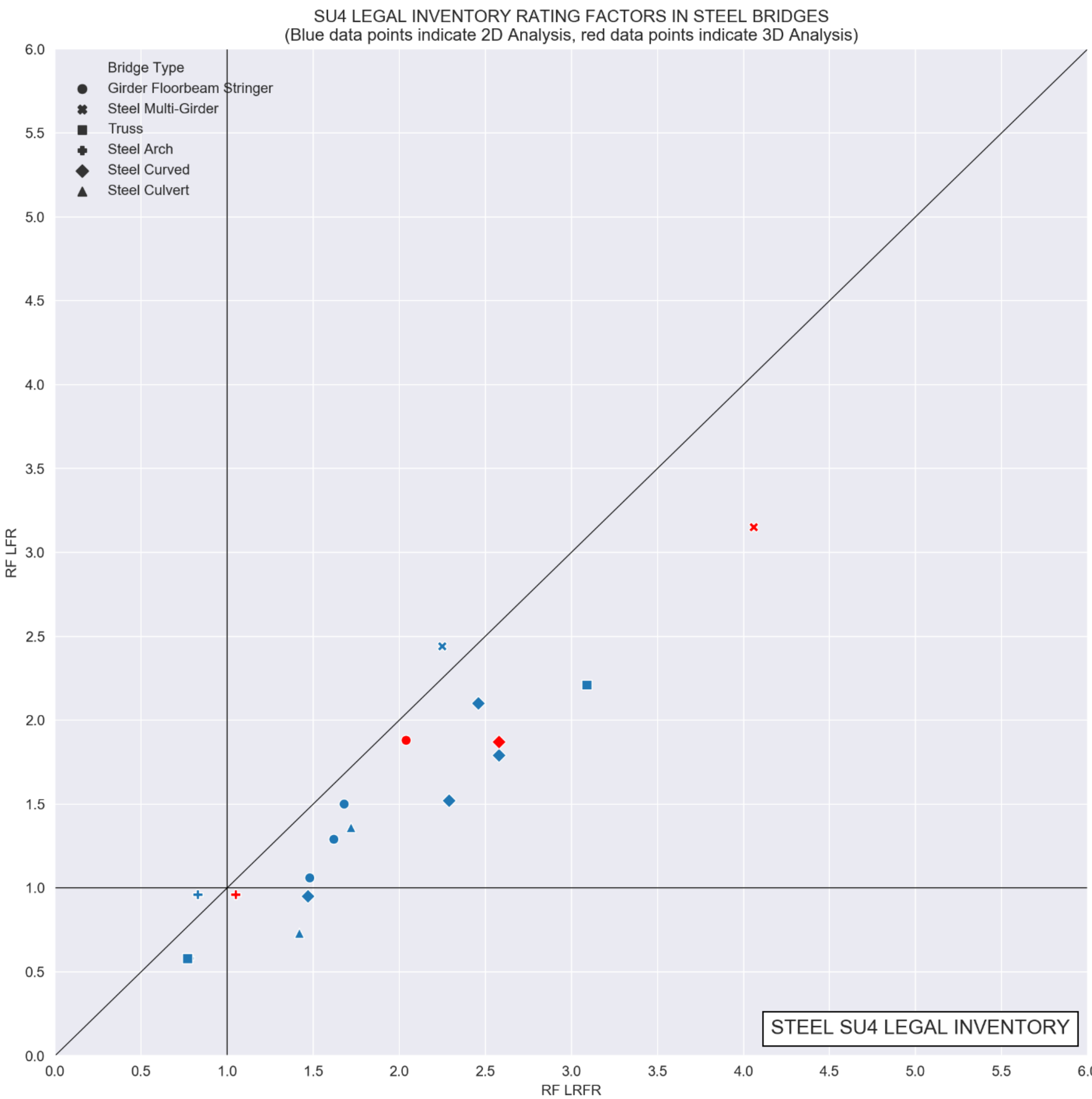



**Figure 2.11** – Legal (SU4) inventory rating factors in steel bridges.

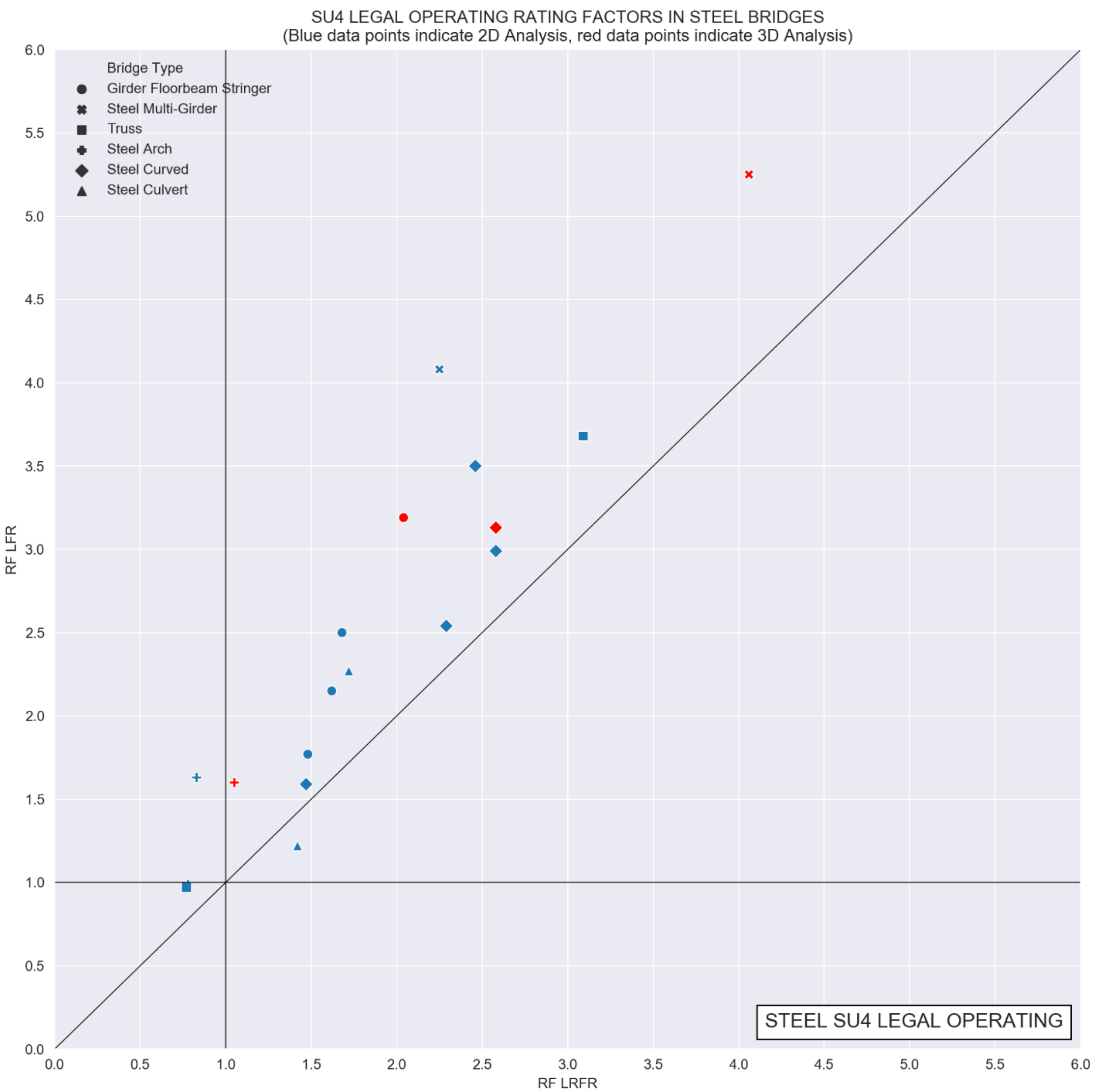



**Figure 2.12** – Legal (SU4) operating rating factors in steel bridges.

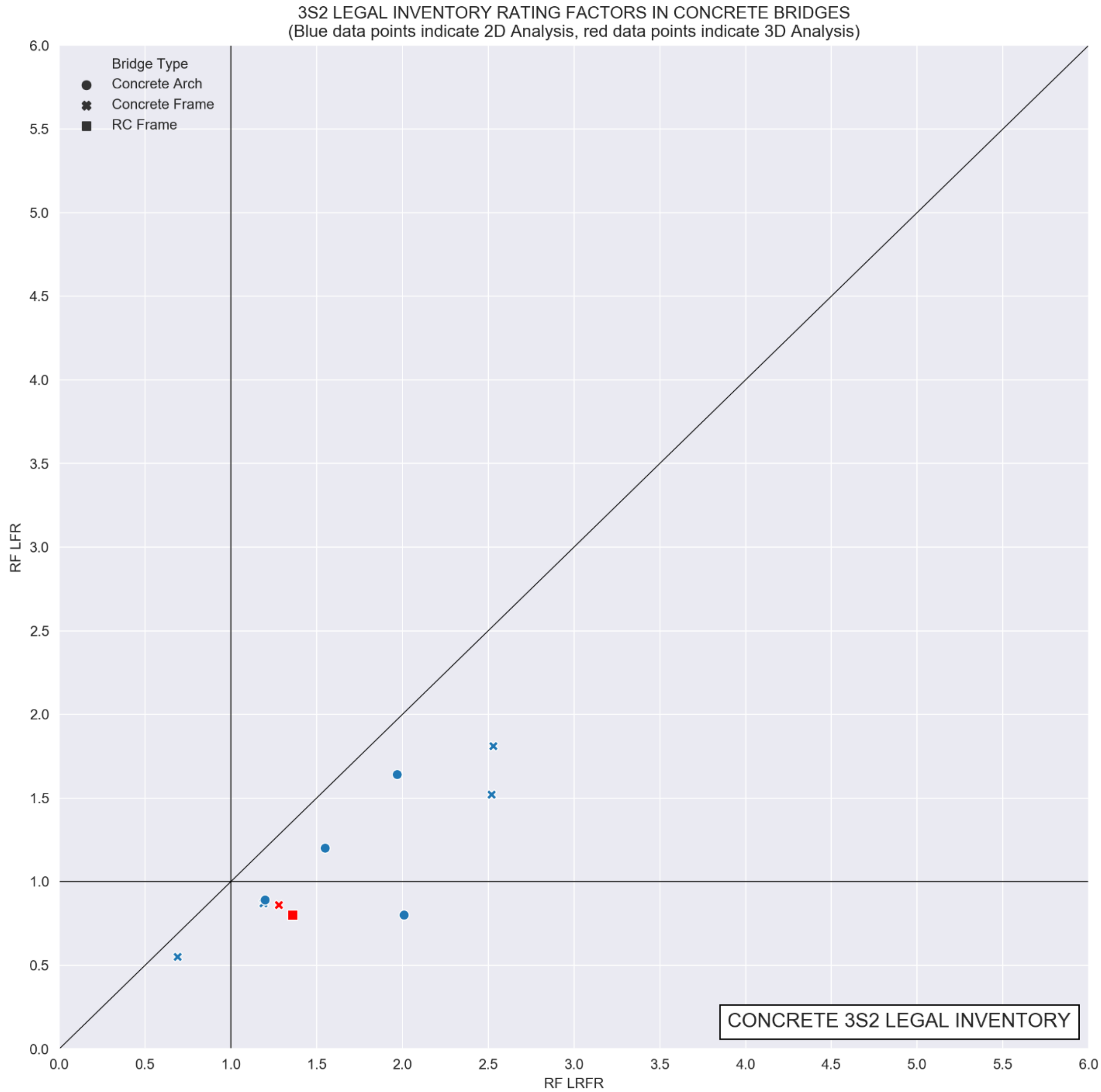



**Figure 2.13** – Legal (SU4) inventory rating factors in concrete bridges.

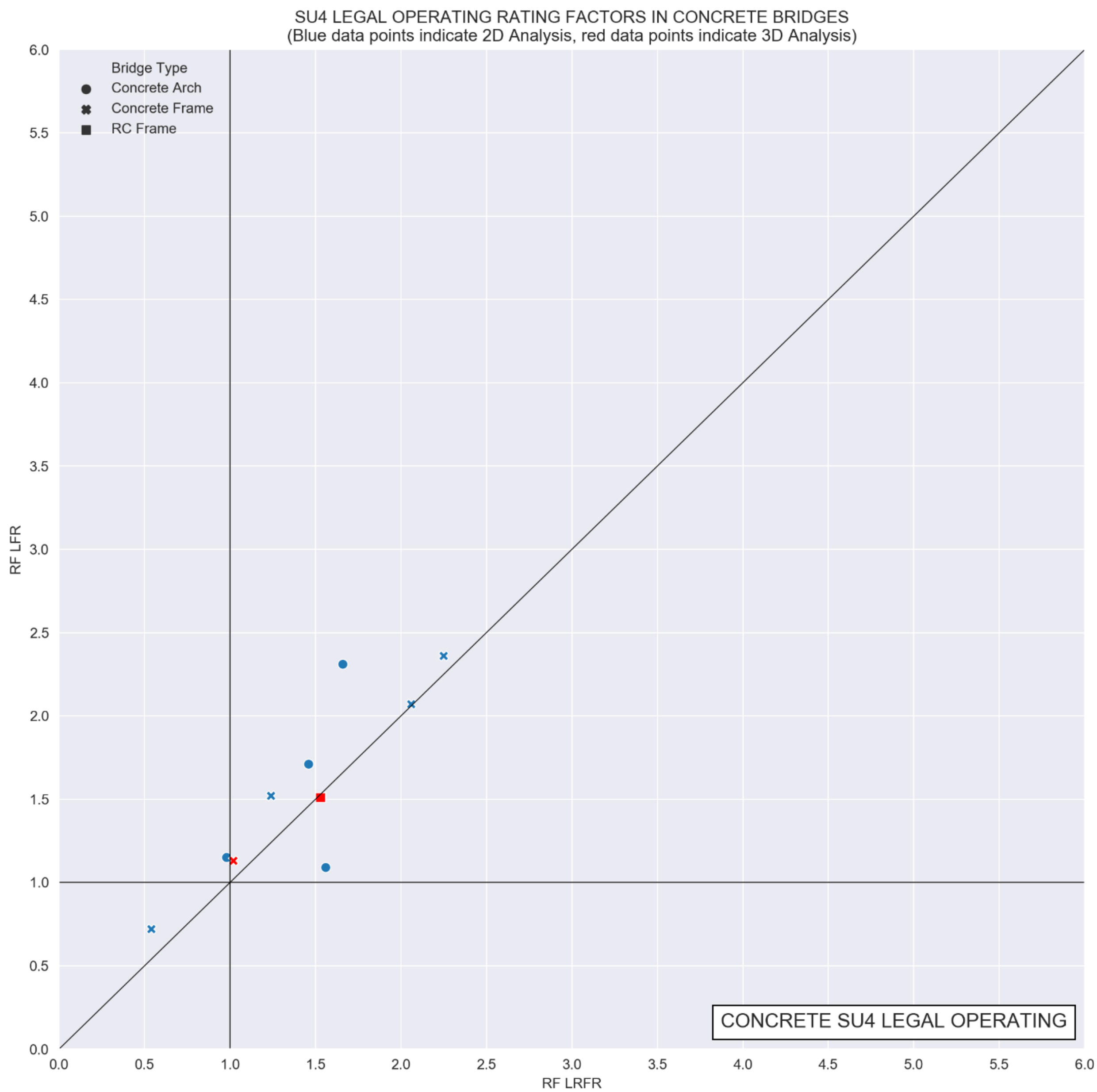



**Figure 2.14** – Legal (SU4) operating rating factors in concrete bridges.

### *2.3.4 Legal Load Rating (3S2)*

Comparative results from legal load ratings (3S2) for steel and concrete bridges are shown in Figure 2.15 – Figure 2.18.

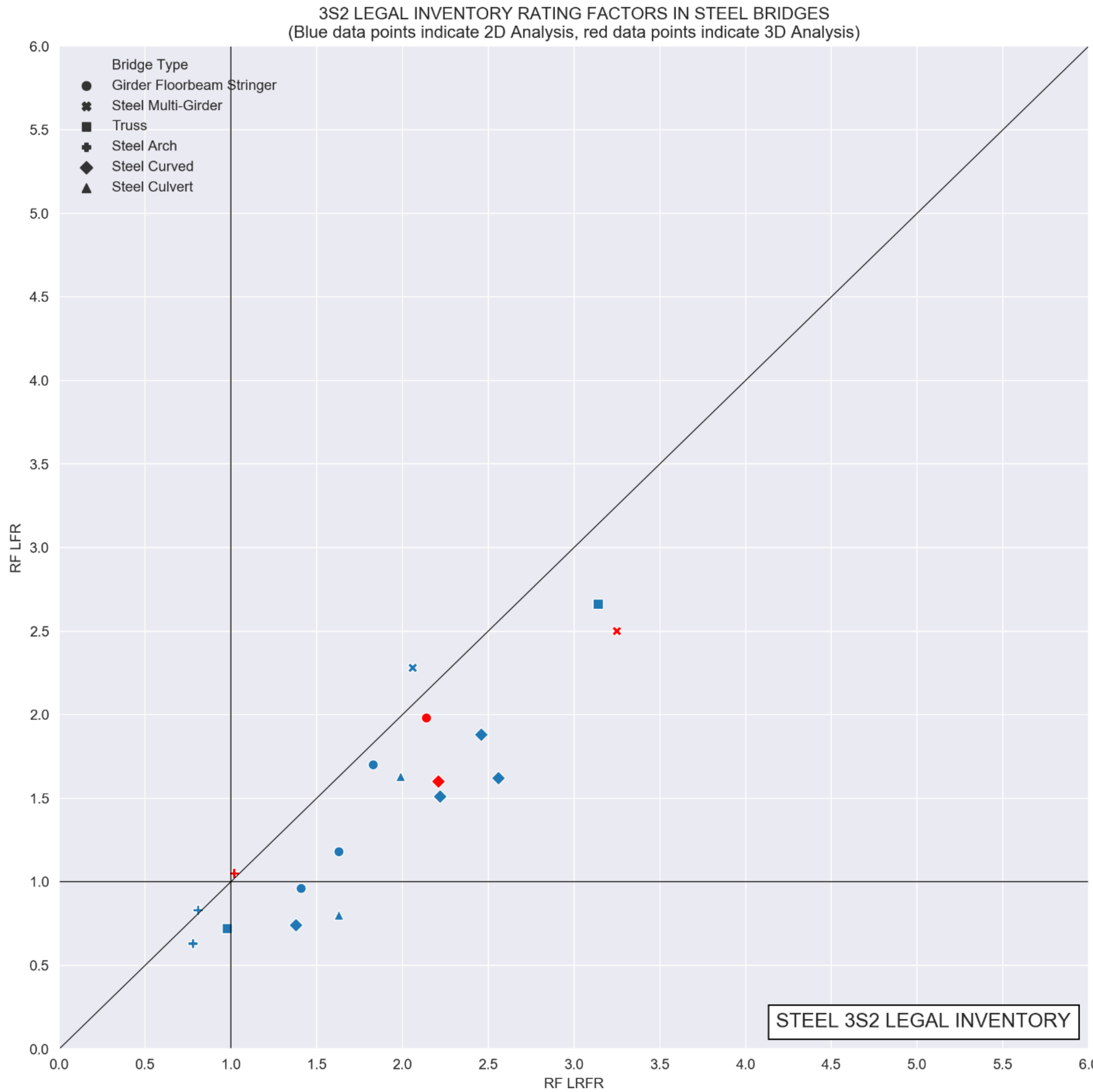



**Figure 2.15** – Legal (3S2) inventory rating factors in steel bridges.

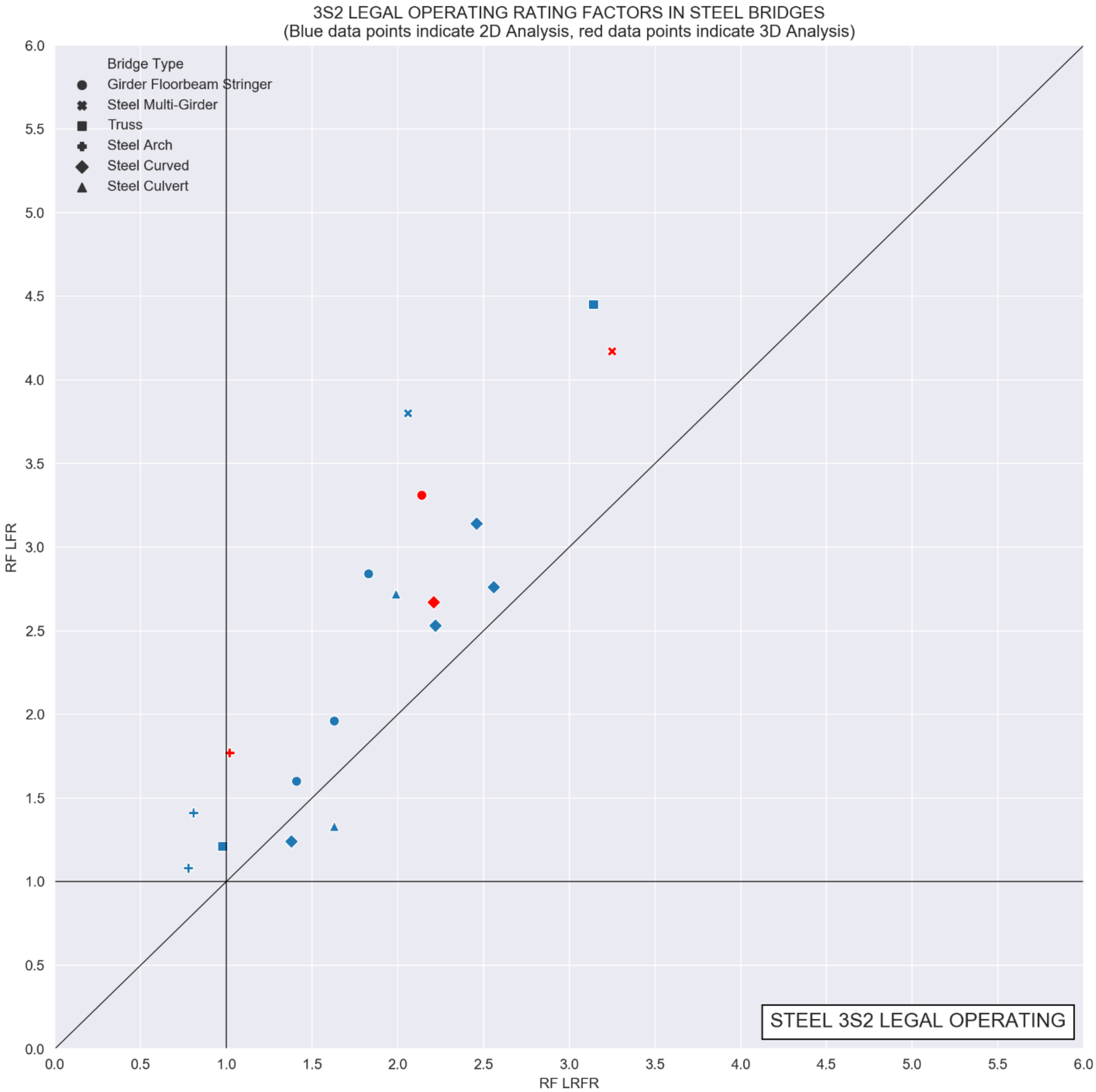



**Figure 2.16** – Legal (3S2) operating rating factors in steel bridges.

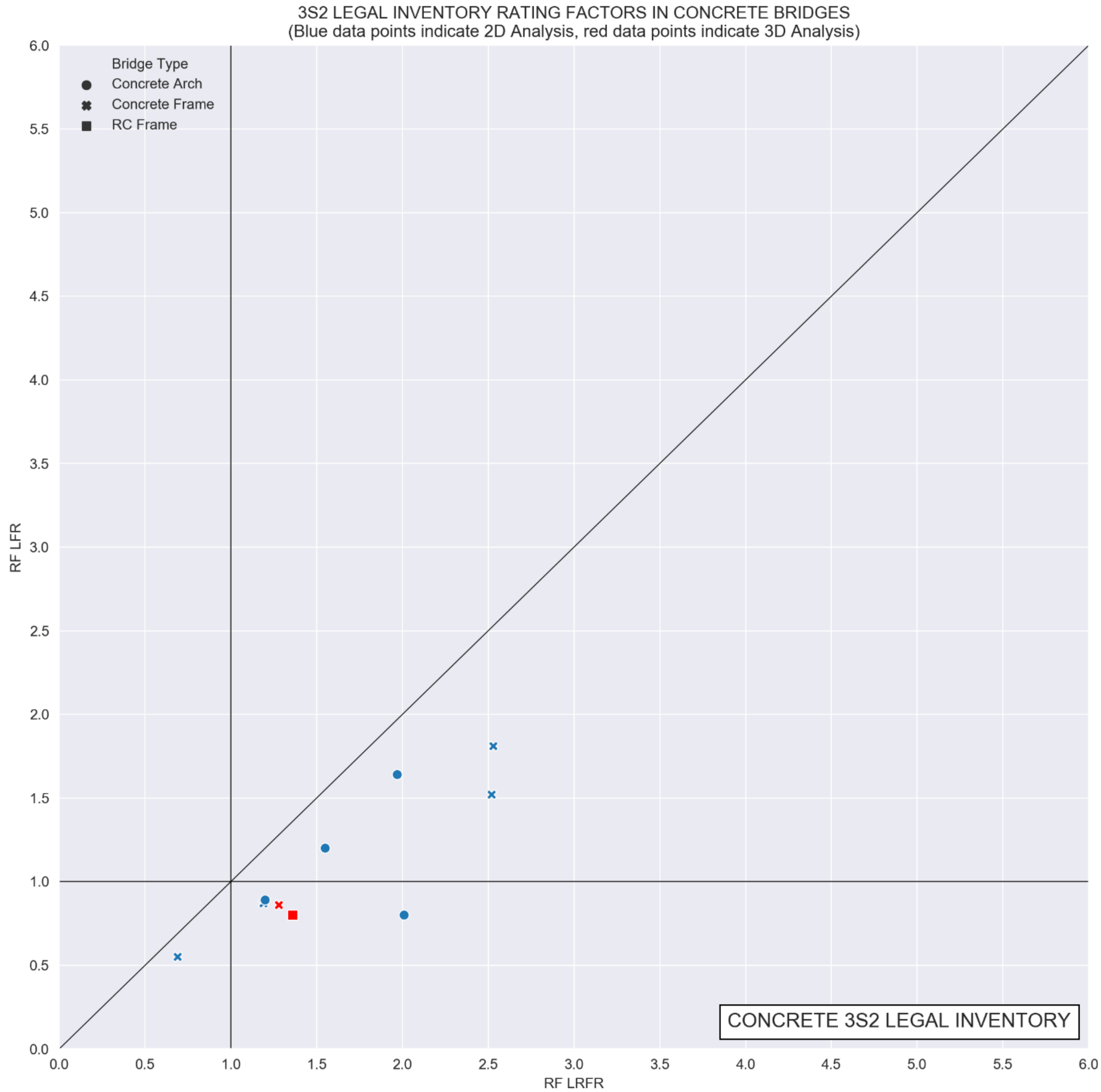



**Figure 2.17** – Legal (3S2) inventory rating factors in concrete bridges.

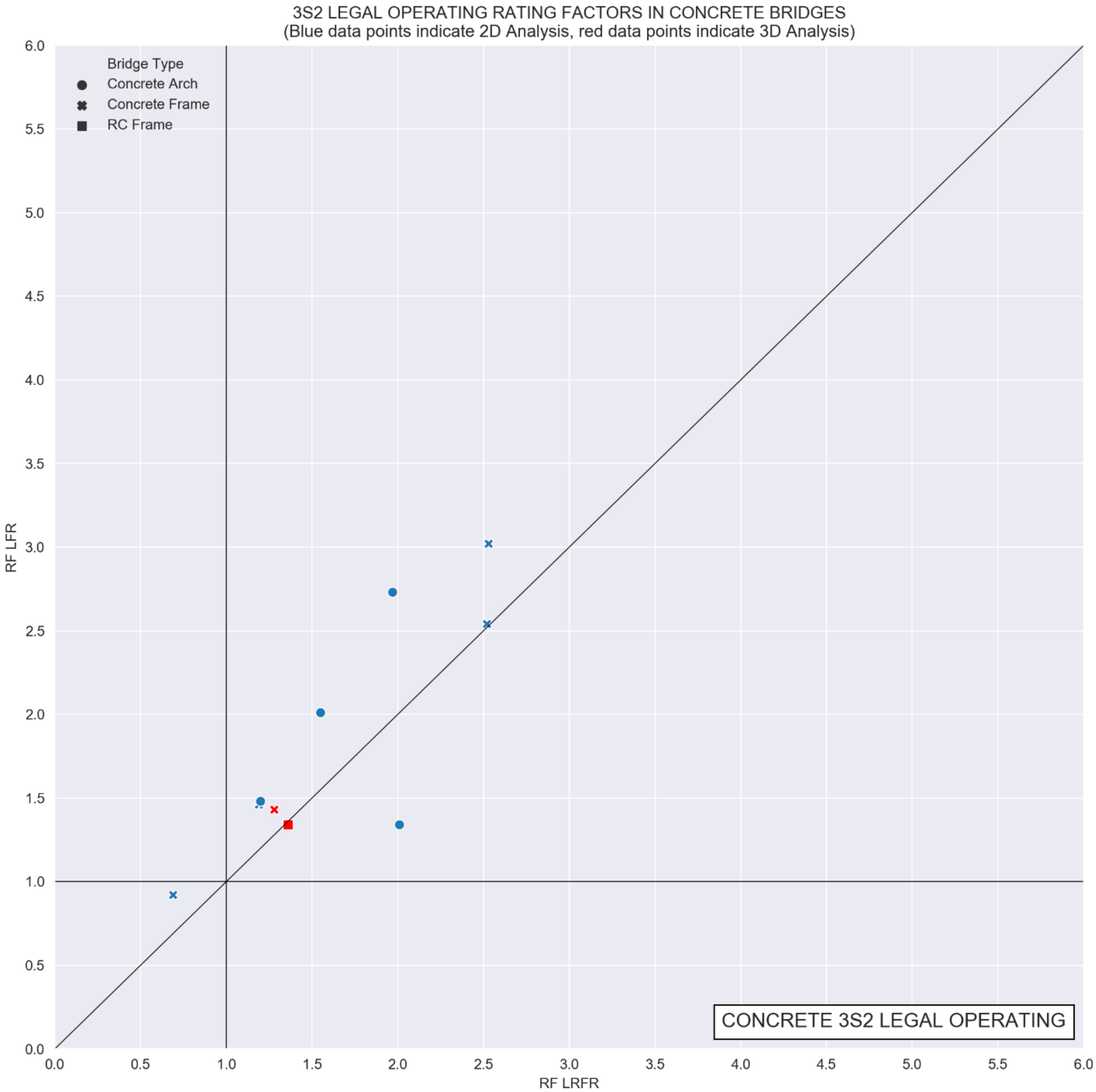



**Figure 2.18** – Legal (3S2) operating rating factors in concrete bridges.

### *2.3.5 Permit Load Rating (NYP6 and NYP11)*

Comparative results from permit load ratings (NYP6 and NYP11) for steel and concrete bridges are shown in Figure 2.19 – Figure 2.22.

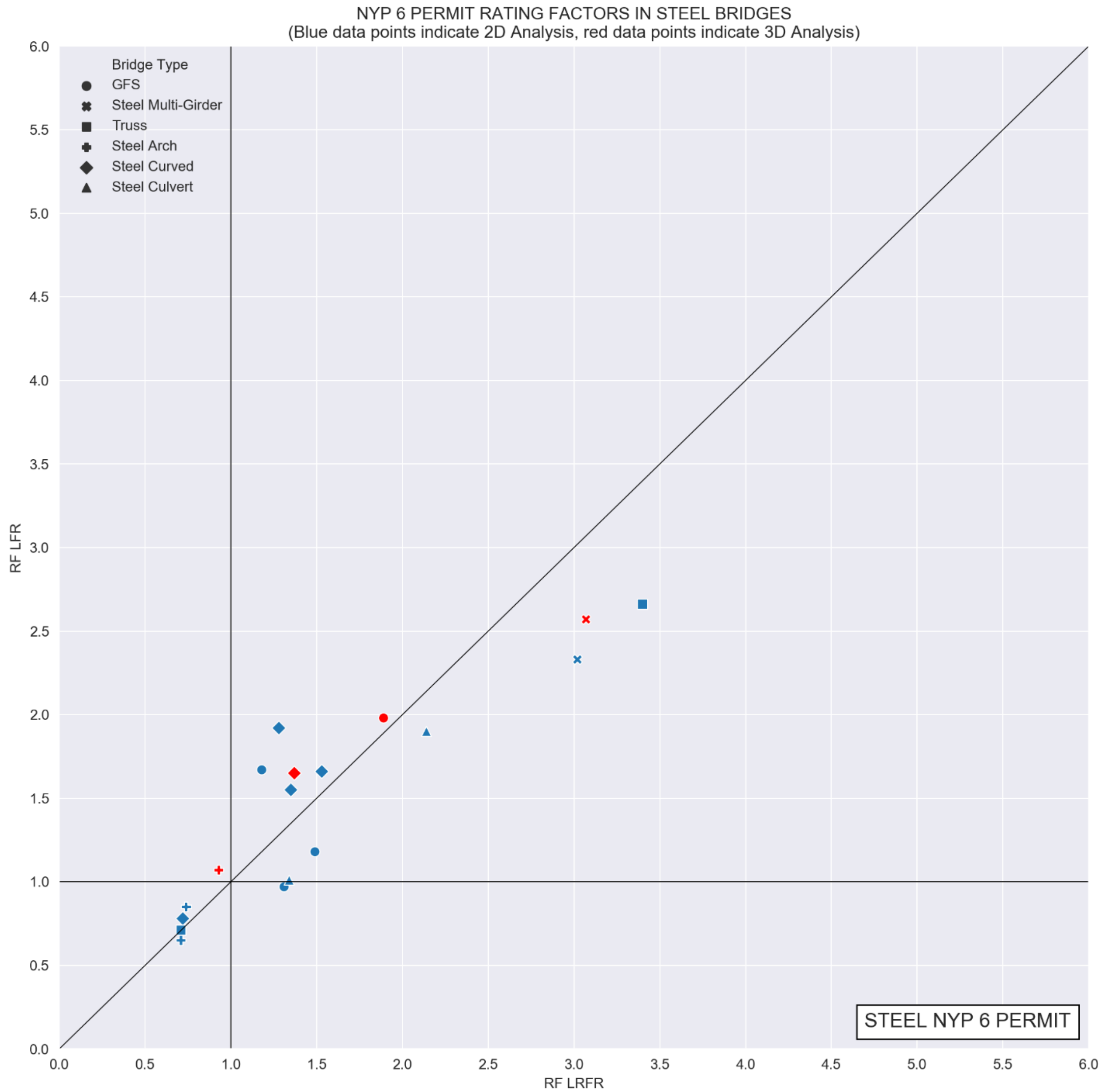



**Figure 2.19** – Permit (NYP6) rating factors in steel bridges.

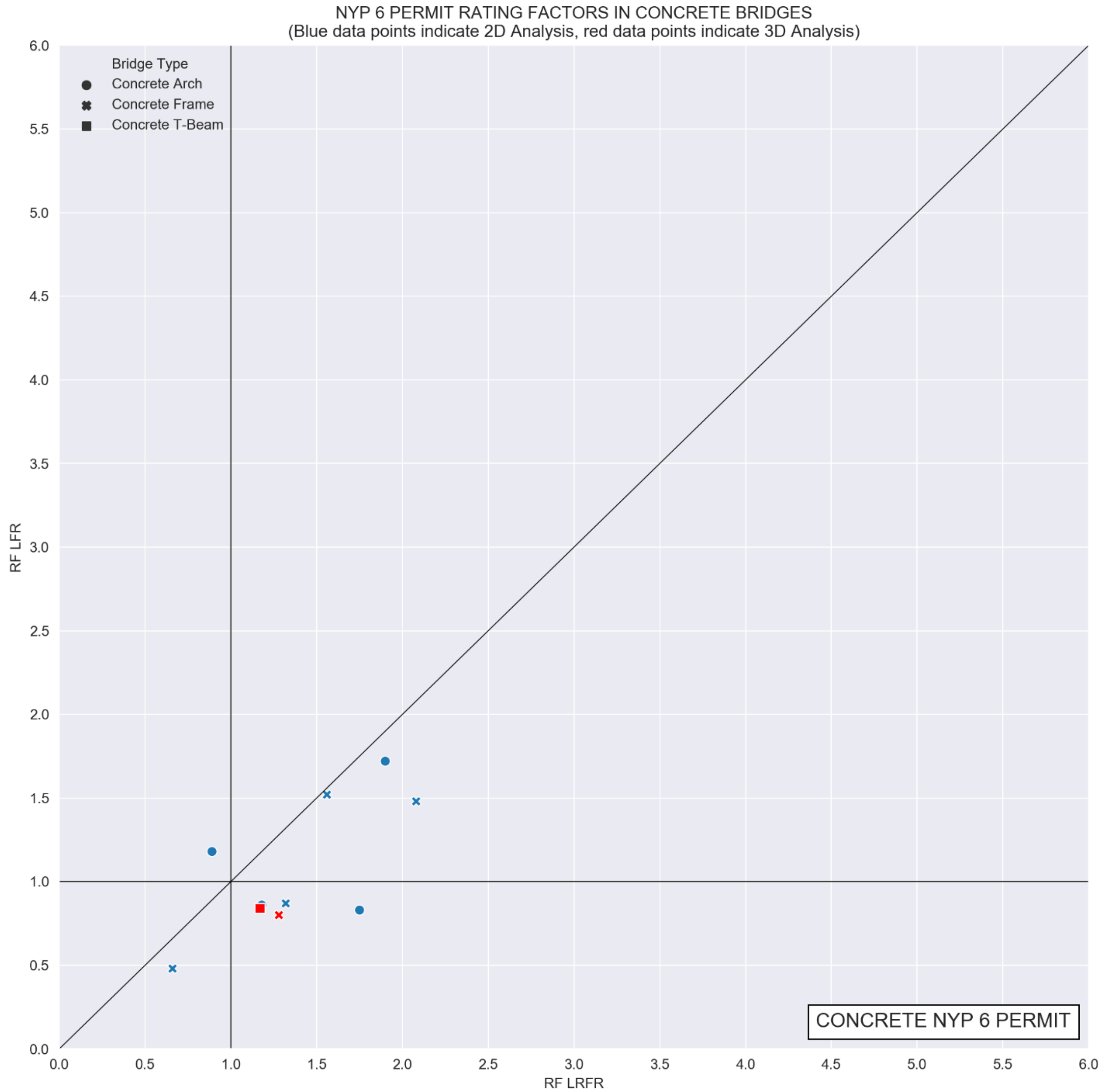



**Figure 2.20** – Permit (NYP6) rating factors in concrete bridges.

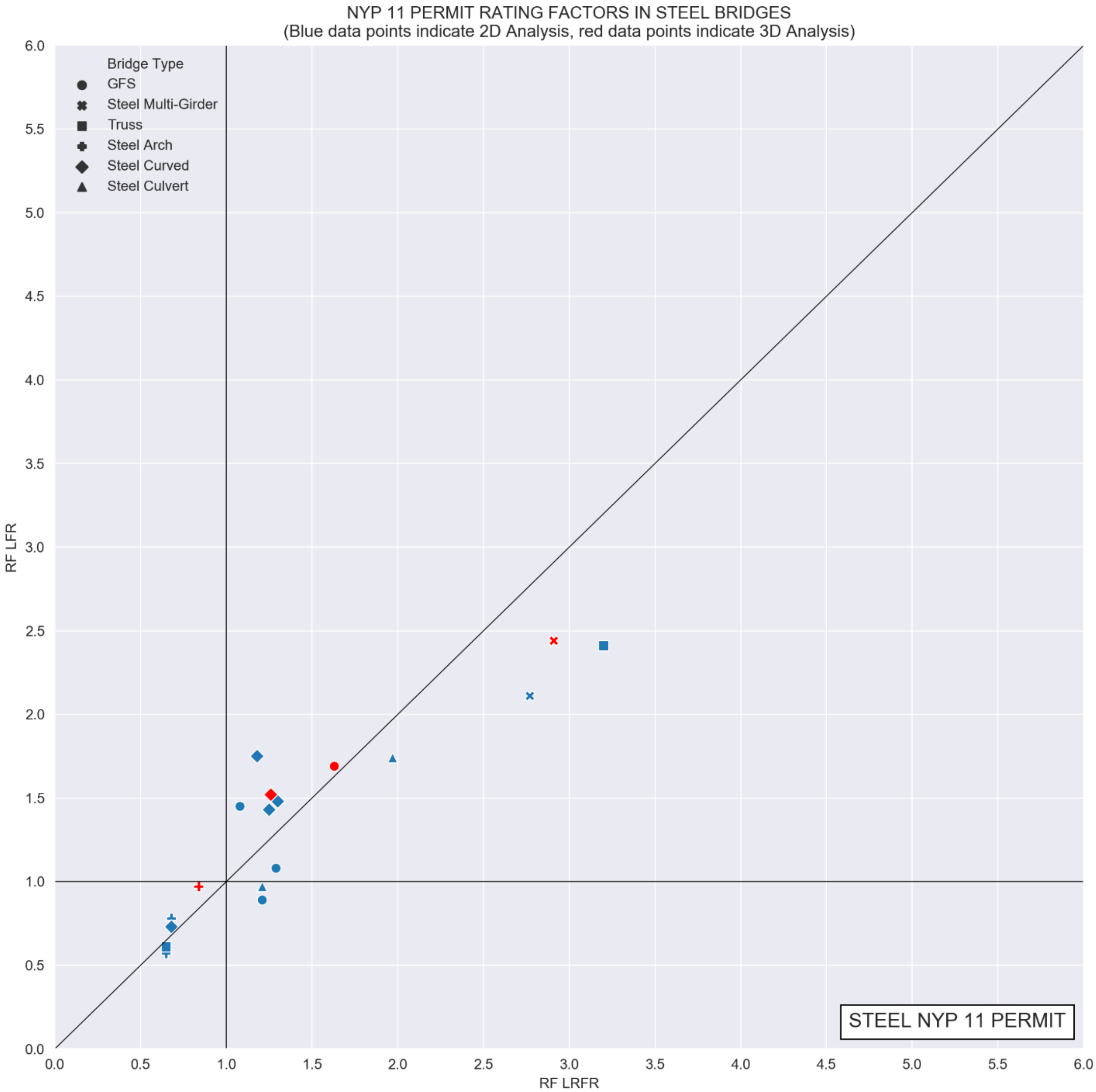



**Figure 2.21** – Permit (NYP11) rating factors in steel bridges.

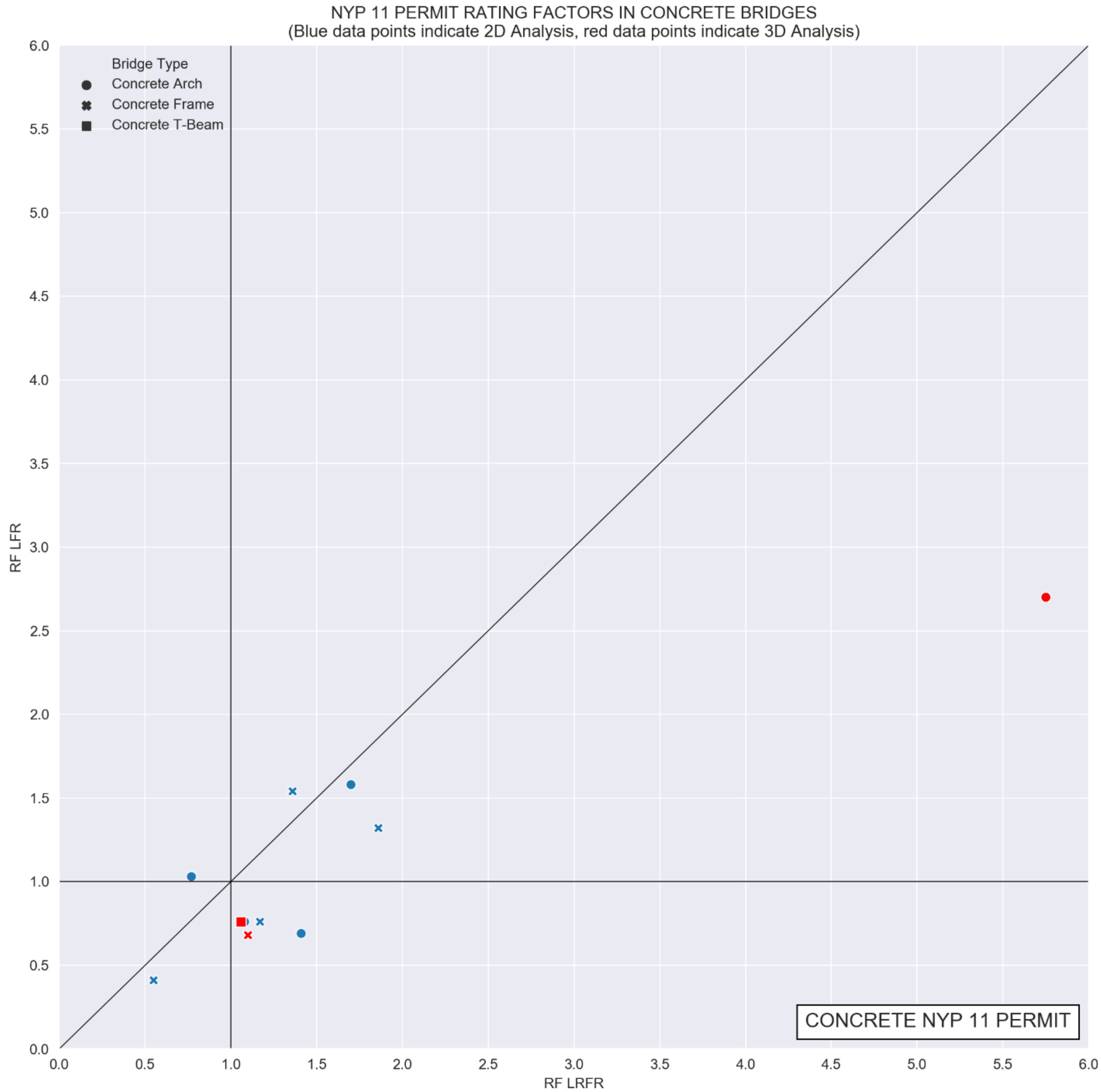



**Figure 2.22** – Permit (NYP11) rating factors in concrete bridges.

## 2.4 Statistical Comparative Results

Statistical comparative results expressed as a ratio of LRFR to LFR rating factors are presented in Tables 2.2 and 2.3, for steel and concrete bridges, respectively. Design Inventory and Operating (HL-93 vs. HS-20, HL-93 vs. H-20), Legal Inventory and Operating (SU4 and 3S2), and Permit (NYP6 and NYP11) cases are compared for the minimum, maximum and average rating factor ratios ($RF_{LRFR}/RF_{LFR}$). LRFR Blue Pages propose two different sets of live load factors for legal loads, depending on whether the bridge is on an Interstate/State Route (State) or on a Local Route (Local). It should be noted that this is a departure from the Draft LRFR EI, where only a single set of legal live load factors were provided, without classifying bridges as State or Local. Per the LRFR Blue Pages, bridges on an Interstate/State Route, the legal live load factors were calibrated using WIM data, and can range from 1.65 to 1.95, depending on the Average Daily Truck Traffic (ADTT) at the bridge (LRFR Blue Pages Section 6A.4.1.7.2a). On the other hand, for bridges on Local Routes, the LRFR Blue Pages recommend AASHTO MBE legal load factors to be used, which range from 1.30 to 1.45, again, as a function of the ADTT (LRFR Blue Pages Section 6A.4.1.7.2a). To reflect the difference in load factors for these two cases, the legal load rating comparisons were made separately for State and Local bridges. For Design and Permit rating levels, both State and Local bridges are included in the same data set, since there is no locality based distinction in live load factors for these rating levels. Lastly, since this is a direct comparison of LRFR and LFR rating results, both 2D and 3D analysis cases are included in the data sets.

**Table 2.2** – Statistical Comparison of Controlling Rating Factors in Steel Bridges

| Number of Analyses in Data Set | Load Rating Level | $RF_{LRFR}/RF_{LFR}$ | | |
|---|---|---|---|---|
| | | Min | Max | Average |
| 18 | Steel Design Inventory (HL-93 vs. HS-20) | 0.51 | 1.11 | 0.77 |
| 18 | Steel Design Operating (HL-93 vs. HS-20) | 0.40 | 0.86 | 0.59 |
| 18 | Steel Design Inventory (HL-93 vs. H-20) | 0.52 | 1.12 | 0.72 |
| 18 | Steel Design Operating (HL-93 vs. H-20) | 0.35 | 0.87 | 0.55 |
| 16 | Steel SU4 Legal Inventory (State) | 0.86 | 1.55 | 1.26 |
| 2 | Steel SU4 Legal Inventory (Local) | 1.33 | 1.95 | 1.63 |
| 16 | Steel SU4 Legal Operating (State) | 0.51 | 0.93 | 0.75 |
| 2 | Steel SU4 Legal Operating (Local) | 0.79 | 1.16 | 0.98 |
| 16 | Steel 3S2 Legal Inventory (State) | 0.90 | 1.86 | 1.28 |
| 2 | Steel 3S2 Legal Inventory (Local) | 1.36 | 2.04 | 1.70 |
| 16 | Steel 3S2 Legal Operating (State) | 0.54 | 1.11 | 0.76 |
| 2 | Steel 3S2 Legal Operating (Local) | 0.81 | 1.23 | 1.02 |
| 18 | Steel NYP 6 Permit | 0.67 | 1.35 | 1.03 |
| 18 | Steel NYP 11 Permit | 0.67 | 1.36 | 1.03 |

For steel bridges:

- LRFR HL-93 inventory design rating factors were 23% lower than LFR HS-20 inventory design rating factors, on average.
- LRFR HL-93 operating design rating factors were 41% lower than LFR HS-20 operating design rating factors, on average.
- LRFR HL-93 inventory design rating factors were 28% lower than LFR H-20 inventory design rating factors, on average.
- LRFR HL-93 operating design rating factors were 45% lower than LFR H-20 operating design rating factors, on average.
- LRFR SU4 legal rating factors were 26% and 63% higher than LFR SU4 inventory legal rating factors, for State and Local bridges, respectively, on average.
- LRFR SU4 legal rating factors were 25% and 2% lower than LFR SU4 operating legal rating factors, for State and Local bridges, respectively, on average.
- LRFR 3S2 legal rating factors were 28% and 70% higher than LFR 3S2 inventory legal rating factors, for State and Local bridges, respectively, on average.
- LRFR 3S2 legal rating factors were 24% lower but 2% higher than LFR 3S2 operating legal rating factors for State and Local bridges, respectively, on average.
- LRFR NYP 6 permit rating factors were 3% higher than LFR NYP 6 permit rating factors, on average.
- LRFR NYP 11 permit rating factors were 3% higher than LFR NYP 11 permit rating factors, on average.

In steel bridges, LRFR inventory and operating design rating factors were consistently lower than their LFR counterparts. This can be attributed to higher LRFR load effects when HL-93 is compared to HS-20 and H-20, as well as the constant 33% design dynamic allowance (impact) used in LRFR methodology, although both methodologies yielded similar nominal resistances. In LFR, the maximum dynamic allowance (impact) is 30%, and this factor decreases as the span length increases. It should also be noted that the LRFR system and condition factors may decrease the LRFR capacities by up to 15%, compared to LFR, where such factors are not implemented.

LRFR Legal Load rating factors (both SU4 and 3S2) in State and Local steel bridges were found to be higher than LFR Inventory legal rating factors. As expected, this was found to be more pronounced in Local bridges, compared to State bridges, due to difference in live load factor magnitudes. For State bridges, the LFR Inventory level live load factor can be up to 1.31 (2.17/1.65) times higher than the LRFR legal live load factor. For Local bridges, the same difference can be up to 1.67 (2.17/1.30) times. This is also reflected in the LRFR to LFR rating factor ratios given in Table 2.2. In State bridges, LFR Operating legal rating factors were consistently found to be higher than LRFR legal rating factors, again, which can be attributed to the difference in live load factor magnitudes, where the LRFR State bridge legal load factors can be up to 1.50 (1.95/1.30) times higher than the LFR Operating live load factor. For Local bridges, both methodologies yielded similar results at the Operating level. Other parameters affecting the results are the differences in the calculation of dynamic allowance and the application of system and condition factors in the LRFR methodology.

LRFR and LFR Permit Load rating factors (NYP 6 and NYP 11) were found to be similar in steel bridges. This can be attributed to higher LRFR live load effects due to dynamic allowance and lower resistances due to system and condition factors, being balanced by higher LFR Operating level live load factor used in permit load ratings, compared to the LRFR permit live load factors.

**Table 2.3** – Statistical Comparison of Controlling Rating Factors in Concrete Bridges

| **Number of Analyses in Data Set** | **Load Rating Level** | **$RF_{LRFR}/RF_{LFR}$** | | |
|---|---|---|---|---|
| | | **Min** | **Max** | **Average** |
| 11 | Concrete Design Inventory (HL-93 vs. HS-20) | 0.80 | 1.99 | 1.21 |
| 11 | Concrete Design Operating (HL-93 vs. HS-20) | 0.62 | 1.55 | 0.94 |
| 11 | Concrete Design Inventory (HL-93 vs. H-20) | 0.92 | 1.45 | 0.92 |
| 11 | Concrete Design Operating (HL-93 vs. H-20) | 0.44 | 1.12 | 0.71 |
| 7 | Concrete SU4 Legal Inventory (State) | 1.19 | 2.40 | 1.53 |
| 4 | ConcreteSU4 Legal Inventory (Local) | 1.43 | 2.96 | 1.93 |
| 7 | Concrete SU4 Legal Operating (State) | 0.72 | 1.43 | 0.92 |
| 4 | Concrete SU4 Legal Operating (Local) | 0.85 | 1.77 | 1.16 |
| 7 | Concrete 3S2 Legal Inventory (State) | 1.20 | 2.51 | 1.51 |
| 4 | Concrete 3S2 Legal Inventory (Local) | 1.29 | 2.93 | 1.90 |
| 7 | Concrete 3S2 Legal Operating (State) | 0.72 | 1.50 | 0.90 |
| 4 | Concrete 3S2 Legal Operating (Local) | 0.77 | 1.76 | 1.13 |
| 11 | Concrete NYP 6 Permit | 0.75 | 2.18 | 1.44 |
| 11 | Concrete NYP 11 Permit | 0.75 | 2.13 | 1.42 |

For concrete bridges:

- LRFR HL-93 inventory design rating factors were 21% higher than LFR HS-20 inventory design rating factors, on average.
- LRFR HL-93 operating design rating factors were 6% lower than LFR HS-20 operating design rating factors, on average.
- LRFR HL-93 inventory design rating factors were 8% lower than LFR H-20 inventory design rating factors, on average.

- LRFR HL-93 operating design rating factors were 29% lower than LFR H-20 operating design rating factors, on average.
- LRFR SU4 legal rating factors were 53% and 93% higher than LFR SU4 inventory legal rating factors, for State and Local bridges, respectively, on average.
- LRFR SU4 legal rating factors were 8% lower but 16% higher than LFR SU4 operating legal rating factors, for State and Local bridges, respectively, on average.
- LRFR 3S2 legal rating factors were 51% and 90% higher than LFR SU4 inventory legal rating factors, for State and Local bridges, respectively, on average.
- LRFR 3S2 legal rating factors were 10% lower, but 13% higher than LFR SU4 operating legal rating factors, for State and Local bridges, respectively, on average.
- LRFR NYP 6 permit rating factors were 44% higher than LFR NYP 6 permit rating factors, on average.
- LRFR NYP 11 permit rating factors were 42% higher than LFR NYP 11 permit rating factors, on average.

The data set for concrete bridges in this project contains 4 reinforced concrete arches, 4 reinforced concrete frames and one reinforced concrete T-beam structure. Unlike steel bridges, concrete bridges have more pronounced differences in the computation of LRFR and LFR resistances and live load distributions.

Most notably, for reinforced concrete arches, constituting 44% of the concrete bridges rated in this study, the LRFR live load distribution through earth fill generally results in a lower live load pressure on the arch, compared to the LFR live load distribution. This is due to the tire area based load application in LRFR, opposed to point loads used in the LFR methodology. In addition, the LRFR dynamic allowance (impact) is linearly decreased based on the depth of the fill, whereas a constant impact factor is used in the LFR methodology. Reduced live load effects computed per the LRFR methodology result in significantly high rating factors compared to the LFR methodology.

Other differences in live load factors, dynamic load allowance, and system and condition factors as described in detail for steel bridges, also apply to concrete bridges. A similar trend to steel bridges was observed when the design level load ratings are considered. In legal load ratings, for Local bridges, it was possible to have higher LRFR rating factors even at the LFR Operating level. LRFR Permit rating factors were found to be significantly higher than LFR Permit rating factors, on average. However, this was mostly due to high LRFR rating factors observed in reinforced concrete arch structures, taking a large portion of the concrete bridge dataset.

## 2.5 Level I Load Posting & R-Posting Summary

Level I Load Posting & R-Posting Summary is given in Table 2.4. A total of 6 bridges required load posting in LFR analysis, whereas 3 bridges required posting for Type 3S2 and 4 bridges for SU4 when the LRFR methodology is used, when the best rating outcome was taken into account from 2D and 3D analyses (if available). It should be noted that in two of the bridges (1051960 and 1041200) it was possible to avoid posting when the analysis methodology was switched from 2D to 3D, when using the LRFR methodology (both 2D and 3D analyses were performed for 6 bridges). Although no such change in the posting outcome was observed when the LFR methodology was used, it can be stated that 3D finite element analysis can help posted bridges in both methodologies, due to the increased rating factors observed for both. This is also supported by data for bridges where no posting is required, since 3D analysis based rating factors were generally higher than their 2D counterparts.

Six bridges needed R posting in both LFR and LRFR methodologies. It was possible to avoid R-postings when the analysis methodology was switched to 3D from 2D, one in LFR (1041200) and two in LRFR (1046510 and 1051960).

**Table 2.4** – Level I Load Posting & R-Posting Summary[1]

| NO | BIN | MATERIAL | TYPE | ANALYSIS | LFR POSTING (tons) | LRFR POSTING (tons) | | R-PERMIT POSTING | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | TYPE 3S2 | SU4 | LFR | LRFR |
| 1 | 1059320 | Concrete | Concrete Frame | 3D | N | N | N | N | N |
| 2 | 1075059 | Concrete | RC Arch | 3D | N | N | N | N/A[2] | N/A[2] |
| 3 | 4443160 | Steel | Steel Truss | 2D | 16 | 35 | 18 | Y | Y |
| 4 | 1016990 | Steel | Steel Truss | 2D | N | N | N | N | N |
| 5 | 1044220 | Concrete | RC Arch | 2D | N | N | N | N | N |
| 6 | 1075880 | Concrete | RC Arch | 2D | 18 | N | 26 | N/A[2] | N/A[2] |
| 7 | 1046510 | Concrete | RC Arch | 2D | N | N | N | N | Y |
| | 1046510 | Concrete | RC Arch | 3D | N | N | N | N | N |
| 8 | 1051960 | Concrete | Concrete Frame | 2D | 15 | 22 | 11 | Y | Y |
| | 1051960 | Concrete | Concrete Frame | 3D | 22 | N | N | Y | N |
| 9 | 1050180 | Concrete | Concrete Frame | 2D | N | N | N | N | N |
| 10 | 1045360 | Concrete | Concrete Frame | 2D | N | N | N | N | N |
| 11 | 5521680 | Steel | Steel Culvert | 2D | 13 | 21 | 13 | Y | Y |
| 12 | 1091510 | Steel | Steel Culvert | 2D | N | N | N | N | N |
| 13 | 1076419 | Concrete | Concrete Frame | 2D | N | N | N | N | N |
| 14 | 1069090 | Steel | Steel Curved | 2D | 12 | N | N | Y | Y |
| 15 | 1069610 | Steel | Steel Curved | 2D | N | N | N | N | N |
| 16 | 1090530 | Steel | Steel Curved | 2D | N | N | N | N | N |
| 17 | 1053060 | Steel | Steel Curved | 2D | N | N | N | N | N |
| | 1053060 | Steel | Steel Curved | 3D | N | N | N | N | N |
| 18 | 1041200 | Steel | Steel Arch | 2D | N | 35 | 26 | Y | Y |
| | 1041200 | Steel | Steel Arch | 3D | N | N | N | N | Y |
| 19 | 1023380 | Steel | Steel Arch | 2D | 22 | 33 | 24 | Y | Y |
| 20 | 1001360 | Steel | GFS | 2D | N | N | N | N | N |
| 21 | 1046790 | Steel | GFS | 2D | N | N | N | Y | N |
| 22 | 1004540 | Steel | GFS | 2D | N | N | N | N | Y |
| | 1004540 | Steel | GFS | 3D | N | N | N | N | Y |
| 23 | 1004279 | Steel | Steel Multi-Girder | 2D | N | N | N | N | N |
| | 1004279 | Steel | Steel Multi-Girder | 3D | N | N | N | N | N |
| **TOTAL[3]** | | | | | **6** | **3** | **4** | **6** | **6** |
| **CHANGE IN POSTING DECISION WHEN 3D ANALYSIS IS USED[3]** | | | | | **0** | **2** | **2** | **1** | **2** |

[1]: Y: Posting Required; N: Posting Not Required; N/A: Analysis Not Available

[2]: R-Posting analysis was not performed due to bridge location (NYC).

[3]: The counts reflect the best outcome (no-posting), if a bridge has both 2D and 3D analysis results.

## 2.6 Level I Load Rating Results by Bridge

In this section, detailed level 1 load rating results are given bridge by bridge.

### *2.6.1 BIN 1059320*

- **General Description**

| | | |
|---|---|---|
| Type: **Reinforced Concrete T-beam** | Year Built: 1934 | Total length: 89 ft |
| Number of spans: 1 | Feature carried: Elmont Road | Feature crossed: 908M03011002 |
| Location: Town of Hempstead, Nassau | Owner: Local | ADTT: 568 |
| NYSDOT Condition Factor: 4.88 | Posted Load: No Posting | |

- **Analysis Methods:**

LFR and LRFR: STAAD 3-D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.56 | Girder G4 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.73 | Girder G4 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.70 | Girder G4 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.17 | Girder G4 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.88 | Girder G4 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.47 | Girder G4 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.36 | Girder G4 | Flexure | 0.80 | Girder G4 | Flexure | 1.70 |
| | Type 3S2 (OPR) | 1.36 | Girder G4 | Flexure | 1.34 | Girder G4 | Flexure | 1.02 |
| | SU4 (INV) | 1.53 | Girder G4 | Flexure | 0.91 | Girder G4 | Flexure | 1.69 |
| | SU4 (OPR) | 1.53 | Girder G4 | Flexure | 1.51 | Girder G4 | Flexure | 1.01 |
| **Permit** | NYP 6 | 1.17 | Girder G4 | Flexure | 0.84 | Girder G4 | Flexure | 1.40 |
| | NYP 11 | 1.06 | Girder G4 | Flexure | 0.76 | Girder G4 | Flexure | 1.40 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1059320 | N/A | 1.47 | Girder G4 | N/A | 1.36 | Girder G4 | N/A | 1.53 | Girder G4 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1059320 | N | 1.47 | Girder G4 | N | 1.17 | Girder G4 |

### *2.6.2 BIN 1075059*

- **General Description**

| | | |
|---|---|---|
| Type: **Reinforced Concrete Arch** | Year Built: 1951 | Total length: 67 ft |
| Number of spans: 1 | Feature carried: Bronx River Pkwy | Feature crossed: Bronx River |
| Location: City of New York | Owner: State | ADTT: 4805 |
| NYSDOT Condition Factor: 5.09 | Posted Load: No Posting | |

- 
- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.10 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.42 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.56 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.94 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.76 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.27 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.01 | Arch Ring | Flexure | 0.80 | Arch Ring | Flexure | 2.51 |
| | Type 3S2 (OPR) | 2.01 | Arch Ring | Flexure | 1.34 | Arch Ring | Flexure | 1.50 |
| | SU4 (INV) | 1.56 | Arch Ring | Flexure | 0.65 | Arch Ring | Flexure | 2.40 |
| | SU4 (OPR) | 1.56 | Arch Ring | Flexure | 1.09 | Arch Ring | Flexure | 1.43 |
| **Permit** | NYP 6 | 1.75 | Arch Ring | Flexure | 0.83 | Arch Ring | Flexure | 2.11 |
| | NYP 11 | 1.41 | Arch Ring | Flexure | 0.69 | Arch Ring | Flexure | 2.04 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1075059 | 22 | 1.27 | Arch Ring | N/A | 2.01 | Arch Ring | N/A | 1.56 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 11 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1075059 | N/A | N/A | N/A | N/A | N/A | N/A |

No R-Posting due to bridge location (New York City)

### *2.6.3 BIN 4443160*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Truss** | Year Built: 1909 | Total length: 192 ft |
| Number of spans: 3 | Feature carried: Trimmer Road | Feature crossed: Erie Canal |
| Location: Town of OGDEN, Monroe County | Owner: Local | ADTT: 33 |
| NYSDOT Condition Factor: 5.78 | Posted Load: 13 Tons | |

- **Analysis Methods:**
  LFR: VIRTIS 6.4.1; LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.37 | Stringer | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.48 | Stringer | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.55 | Floorbeam | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.91 | Floorbeam | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.61 | Floorbeam | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.01 | Floorbeam | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 0.98 | Stringer | Flexure | 0.72 | Floorbeam | Flexure | 1.36 |
| | Type 3S2 (OPR) | 0.98 | Stringer | Flexure | 1.21 | Floorbeam | Flexure | 0.81 |
| | SU4 (INV) | 0.77 | Stringer | Flexure | 0.58 | Floorbeam | Flexure | 1.33 |
| | SU4 (OPR) | 0.77 | Stringer | Flexure | 0.97 | Floorbeam | Flexure | 0.79 |
| **Permit** | NYP 6 | 0.71 | Stringer - FB | Shear | 0.71 | Floorbeam | Flexure | 1.00 |
| | NYP 11 | 0.65 | Stringer - FB | Shear | 0.61 | Floorbeam | Flexure | 1.07 |

## Truss Members

| Rating Level | Vehicle | Failure Mode | LRFR Rating Factor | Controlling Member | LFR Rating Factor | Controlling Member | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | Tension | 0.45 | U01L02 | N/A | N/A | N/A |
| | HL-93 (OPR) | Tension | 0.58 | U01L02 | N/A | N/A | N/A |
| | HS20 (INV) | Tension | N/A | N/A | 0.68 | U01L02 | N/A |
| | HS20 (OPR) | Tension | N/A | N/A | 1.13 | U01L02 | N/A |
| | H20 (INV) | Tension | N/A | N/A | 0.95 | L06U07 | N/A |
| | H20(OPR) | Tension | N/A | N/A | 1.58 | L06U07 | N/A |
| Legal | Type 3S2 (INV) | Tension | 1.02 | U01L02 | 0.76 | L06U07 | 1.35 |
| | Type 3S2 (OPR) | Tension | 1.02 | U01L02 | 1.26 | L06U07 | 0.81 |
| | SU4 (INV) | Tension | 1.11 | U01L02 | 0.82 | L06U07 | 1.35 |
| | SU4 (OPR) | Tension | 1.11 | U01L02 | 1.37 | L06U07 | 0.81 |
| Permit | NYP 6 | Tension | 0.96 | U01L02 | 0.84 | L06U07 | 1.15 |
| | NYP 11 | Tension (LRFR) Compression (LFR) | 0.91 | U01L02 | 0.78 | U04U05 | 1.17 |

## Stringers

| Rating Level | Vehicle | Failure Mode | LRFR Rating Factor | Controlling Member | LFR Rating Factor | Controlling Member | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | Flexure | 0.37 | U2S2 | N/A | N/A | N/A |
| | HL-93 (OPR) | Flexure | 0.48 | U2S2 | N/A | N/A | N/A |
| | HS20 (INV) | Shear | N/A | N/A | 0.73 | U2S2 | N/A |
| | HS20 (OPR) | Shear | N/A | N/A | 1.23 | U2S2 | N/A |
| | H20 (INV) | Flexure | N/A | N/A | 0.84 | U2S2 | N/A |
| | H20(OPR) | Flexure | N/A | N/A | 1.40 | U2S2 | N/A |
| Legal | Type 3S2 (INV) | Flexure (LRFR) Shear (LFR) | 0.98 | U2S2 | 0.99 | U2S2 | 0.99 |
| | Type 3S2 (OPR) | Flexure (LRFR) Shear (LFR) | 0.98 | U2S2 | 1.65 | U2S2 | 0.59 |
| | SU4 (INV) | Flexure (LRFR) Shear (LFR) | 0.77 | U2S2 | 0.83 | U2S2 | 0.93 |
| | SU4 (OPR) | Flexure (LRFR) Shear (LFR) | 0.77 | U2S2 | 1.39 | U2S2 | 0.55 |
| Permit | NYP 6 | Flexure (LRFR) Shear (LFR) | 0.77 | U2S2 | 1.00 | U2S2 | 0.77 |
| | NYP 11 | Flexure (LRFR) Shear (LFR) | 0.70 | U2S2 | 0.92 | U2S2 | 0.76 |

### Floorbeams

| Rating Level | Vehicle | Failure Mode | LRFR Rating Factor | Controlling Member | LFR Rating Factor | Controlling Member | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | Flexure | 0.63 | FB8 | N/A | N/A | N/A |
| | HL-93 (OPR) | Flexure | 0.82 | FB8 | N/A | N/A | N/A |
| | HS20 (INV) | Flexure | N/A | N/A | 0.55 | FB8 | N/A |
| | HS20 (OPR) | Flexure | N/A | N/A | 0.91 | FB8 | N/A |
| | H20 (INV) | Flexure | N/A | N/A | 0.61 | FB8 | N/A |
| | H20(OPR) | Flexure | N/A | N/A | 1.01 | FB8 | N/A |
| Legal | Type 3S2 (INV) | Flexure | 1.60 | FB8 | 0.72 | FB8 | 2.21 |
| | Type 3S2 (OPR) | Flexure | 1.60 | FB8 | 1.21 | FB8 | 1.32 |
| | SU4 (INV) | Flexure | 1.28 | FB8 | 0.58 | FB8 | 2.21 |
| | SU4 (OPR) | Flexure | 1.28 | FB8 | 0.97 | FB8 | 1.33 |
| Permit | NYP 6 | Flexure | 1.12 | FB8 | 0.71 | FB8 | 1.57 |
| | NYP 11 | Flexure | 0.97 | FB8 | 0.61 | FB8 | 1.58 |

### Floorbeam to Truss Connection

| Rating Level | Vehicle | Failure Mode | LRFR Rating Factor | Controlling Member | LFR Rating Factor | Controlling Member | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | Shear | 0.61 | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | Shear | 0.79 | N/A | N/A | N/A | N/A |
| | HS20 (INV) | Shear | N/A | N/A | 0.72 | N/A | N/A |
| | HS20 (OPR) | Shear | N/A | N/A | 1.21 | N/A | N/A |
| | H20 (INV) | Shear | N/A | N/A | 0.80 | N/A | N/A |
| | H20(OPR) | Shear | N/A | N/A | 1.34 | N/A | N/A |
| Legal | Type 3S2 (INV) | Shear | 1.54 | N/A | 0.96 | N/A | 1.60 |
| | Type 3S2 (OPR) | Shear | 1.54 | N/A | 1.59 | N/A | 0.97 |
| | SU4 (INV) | Shear | 1.23 | N/A | 0.77 | N/A | 1.60 |
| | SU4 (OPR) | Shear | 1.23 | N/A | 1.28 | N/A | 0.96 |
| Permit | NYP 6 | Shear | 1.08 | N/A | 0.94 | N/A | 1.15 |
| | NYP 11 | Shear | 0.93 | N/A | 0.81 | N/A | 1.15 |

### Stringer to Floorbeam Connection

| Rating Level | Vehicle | Failure Mode | LRFR Rating Factor | Controlling Member | LFR Rating Factor | Controlling Member | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | Shear | 0.40 | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | Shear | 0.52 | N/A | N/A | N/A | N/A |
| | HS20 (INV) | Shear | N/A | N/A | 0.55 | N/A | N/A |
| | HS20 (OPR) | Shear | N/A | N/A | 0.92 | N/A | N/A |
| | H20 (INV) | Shear | N/A | N/A | 0.64 | N/A | N/A |
| | H20(OPR) | Shear | N/A | N/A | 1.06 | N/A | N/A |
| Legal | Type 3S2 (INV) | Shear | 0.99 | N/A | 0.73 | N/A | 1.36 |
| | Type 3S2 (OPR) | Shear | 0.99 | N/A | 1.22 | N/A | 0.81 |
| | SU4 (INV) | Shear | 0.83 | N/A | 0.61 | N/A | 1.36 |
| | SU4 (OPR) | Shear | 0.83 | N/A | 1.02 | N/A | 0.81 |
| Permit | NYP 6 | Shear | 0.71 | N/A | 0.74 | N/A | 0.96 |
| | NYP 11 | Shear | 0.65 | N/A | 0.68 | N/A | 0.96 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 4443160 | 16 | 1.01 | Floorbeam FB8 | 35 | 0.98 | Stringer U2S2 | 18 | 0.77 | Stringer U2S2 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 4443160 | Y | 1.01 | Floorbeam FB8 | Y | 0.71 | Stringer - FB |

### *2.6.4 BIN 1016990*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Truss** | Year Built: 1909 | Total length: 192 ft |
| Number of spans: 3 | Feature carried: Trimmer Road | Feature crossed: Erie Canal |
| Location: Town of OGDEN, Monroe County | Owner: State | ADTT: 33 |
| NYSDOT Condition Factor: 5.78 | Posted Load: 13 Tons | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 3-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| **Design** | HL-93 (INV) | 1.36 | FB8 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.76 | FB8 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.12 | U8U9 | Compression | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 3.53 | U8U9 | Compression | N/A |
| | H20 (INV) | N/A | N/A | N/A | 2.12 | U8U9 | Compression | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.53 | U8U9 | Compression | N/A |
| Legal | Type 3S2 (INV) | 3.14 | L2U3 | Compression | 2.66 | U7U8 | Compression | 1.18 |
| | Type 3S2 (OPR) | 3.14 | L2U3 | Compression | 4.45 | U7U8 | Compression | 0.71 |
| | SU4 (INV) | 3.09 | FB8 | Flexure | 2.21 | FB8 | Flexure | 1.40 |
| | SU4 (OPR) | 3.09 | FB8 | Flexure | 3.68 | FB8 | Flexure | 0.84 |
| Permit | NYP 6 | 3.40 | U11L12 | Compression | 2.66 | U7U8 | Compression | 1.28 |
| | NYP 11 | 3.20 | U5L6 | Tension | 2.41 | FB8 | Flexure | 1.33 |

## Truss Members

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 1.47 | U7U8 | Compression | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.91 | U7U8 | Compression | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.12 | U8U9 | Compression | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 3.53 | U8U9 | Compression | N/A |
| | H20 (INV) | N/A | N/A | N/A | 2.12 | U8U9 | Compression | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.53 | U8U9 | Compression | N/A |
| **Legal** | Type 3S2 (INV) | 3.14 | L2U3 | Compression | 2.66 | U7U8 | Compression | 1.18 |
| | Type 3S2 (OPR) | 3.14 | L2U3 | Compression | 4.45 | U7U8 | Compression | 0.71 |
| | SU4 (INV) | 3.58 | L8U9 | Tension | 2.98 | L8U9 | Tension | 1.20 |
| | SU4 (OPR) | 3.58 | L8U9 | Tension | 4.98 | L8U9 | Tension | 0.72 |
| **Permit** | NYP 6 | 3.40 | U11L12 | Compression | 2.66 | U11L12 | Compression | 1.28 |
| | NYP 11 | 3.20 | U5L6 | Tension | 2.44 | U5L6 | Tension | 1.31 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 1.36 | FB8 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.76 | FB8 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.41 | FB8 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 4.03 | FB8 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 2.59 | FB8 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 4.32 | FB8 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 3.91 | FB8 | Flexure | 2.79 | FB8 | Flexure | 1.40 |
| | Type 3S2 (OPR) | 3.91 | FB8 | Flexure | 4.65 | FB8 | Flexure | 0.84 |
| | SU4 (INV) | 3.09 | FB8 | Flexure | 2.21 | FB8 | Flexure | 1.40 |
| | SU4 (OPR) | 3.09 | FB8 | Flexure | 3.68 | FB8 | Flexure | 0.84 |
| **Permit** | NYP 6 | 4.07 | FB8 | Flexure | 2.66 | FB8 | Flexure | 1.53 |
| | NYP 11 | 3.70 | FB8 | Flexure | 2.41 | FB8 | Flexure | 1.53 |

### Gusset Plates

| Rating Level | Vehicle | LRFR Rating Factor | LRFR Member Type | LRFR Failure Mode | LFR Rating Factor | LFR Member Type | LFR Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 1.82 | L10 | Strength | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.36 | L10 | Strength | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 3.85 | L8 | Strength | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 6.41 | L8 | Strength | N/A |
| | H20 (INV) | N/A | N/A | N/A | 3.90 | L10 | Strength | N/A |
| | H20(OPR) | N/A | N/A | N/A | 6.50 | L10 | Strength | N/A |
| **Legal** | Type 3S2 (INV) | 4.20 | L10 | Strength | 4.13 | L10 | Strength | 1.02 |
| | Type 3S2 (OPR) | 4.20 | L10 | Strength | 6.89 | L10 | Strength | 0.61 |
| | SU4 (INV) | 4.50 | L10 | Strength | 4.14 | L10 | Strength | 1.09 |
| | SU4 (OPR) | 4.50 | L10 | Strength | 6.90 | L10 | Strength | 0.65 |
| **Permit** | NYP 6 | 3.91 | L10 | Strength | 4.05 | L8 | Strength | 0.97 |
| | NYP 11 | 3.70 | L10 | Strength | 3.81 | L8 | Strength | 0.97 |

- ### Load Posting Summary

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1016990 | N/A | 3.53 | U8U9 | N/A | 3.14 | L2U3 | N/A | 3.09 | FB8 |

- ### R – Posting Summary

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1016990 | N/A | 3.53 | U8U9 | N/A | 3.40 | U11L12 |

### *2.6.5 BIN 1044220*

- **General Description**

| | | |
|---|---|---|
| Type: **Reinforced Concrete Arch** | Year Built: 1929 | Total length: 102 ft |
| Number of spans: 2 | Feature carried: Union Road | Feature crossed: Cazenovia Cr. |
| Location: Town of West Seneca | Owner: State | ADTT: 1254 |
| NYSDOT Condition Factor: 4.76 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR: VIRTIS 6.4.1; LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.41 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.83 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.37 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.29 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.50 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.50 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.97 | Arch Ring | Flexure | 1.64 | Arch Ring | Flexure | 1.20 |
| | Type 3S2 (OPR) | 1.97 | Arch Ring | Flexure | 2.73 | Arch Ring | Flexure | 0.72 |
| | SU4 (INV) | 1.66 | Arch Ring | Flexure | 1.39 | Arch Ring | Flexure | 1.19 |
| | SU4 (OPR) | 1.66 | Arch Ring | Flexure | 2.31 | Arch Ring | Flexure | 0.72 |
| **Permit** | NYP 6 | 1.90 | Arch Ring | Flexure | 1.72 | Arch Ring | Flexure | 1.10 |
| | NYP 11 | 1.70 | Arch Ring | Flexure | 1.58 | Arch Ring | Flexure | 1.08 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1044220 | N/A | 2.50 | Arch Ring | N/A | 1.97 | Arch Ring | N/A | 1.66 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1044220 | N | 2.50 | Arch Ring | N | 1.90 | Arch Ring |

### *2.6.6 BIN 1075880*

- **General Description**

| Type: **Reinforced Concrete Arch** | Year Built: 1963 | Total length: 70 ft |
|---|---|---|
| Number of spans: 1 | Feature carried: Union Turnpike | Feature crossed: 907MX5M13084 |
| Location: City of New York | Owner: State | ADTT: 2360 |
| NYSDOT Condition Factor: 4.52 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.59 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.77 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.56 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.93 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.61 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.03 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.20 | Arch Ring | Flexure | 0.89 | Arch Ring | Flexure | 1.35 |
| | Type 3S2 (OPR) | 1.20 | Arch Ring | Flexure | 1.48 | Arch Ring | Flexure | 0.81 |
| | SU4 (INV) | 0.98 | Arch Ring | Flexure | 0.69 | Arch Ring | Flexure | 1.42 |
| | SU4 (OPR) | 0.98 | Arch Ring | Flexure | 1.15 | Arch Ring | Flexure | 0.85 |
| **Permit** | NYP 6 | 1.18 | Arch Ring | Flexure | 0.86 | Arch Ring | Flexure | 1.37 |
| | NYP 11 | 1.08 | Arch Ring | Flexure | 0.76 | Arch Ring | Flexure | 1.42 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1075880 | 18 | 1.03 | Arch Ring | N/A | 1.20 | Arch Ring | 26 | 0.98 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 11 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1075880 | N/A | N/A | Arch Ring | N/A | N/A | Arch Ring |

No R-Posting due to bridge location (New York City)

### *2.6.7 BIN 1046510 (2D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Reinforced Concrete Arch** | Year Built: 1947 | Total length: 70 ft |
| Number of spans: 1 | Feature carried: 354 53012156 | Feature crossed: Gayuga Creek |
| Location: Town of Marilla, Erie County | Owner: Local | ADTT: 105 |
| NYSDOT Condition Factor: 4.50 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.08 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.39 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.90 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.52 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.17 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.95 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.55 | Arch Ring | Flexure | 1.20 | Arch Ring | Flexure | 1.29 |
| | Type 3S2 (OPR) | 1.55 | Arch Ring | Flexure | 2.01 | Arch Ring | Flexure | 0.77 |
| | SU4 (INV) | 1.46 | Arch Ring | Flexure | 1.02 | Arch Ring | Flexure | 1.43 |
| | SU4 (OPR) | 1.46 | Arch Ring | Flexure | 1.71 | Arch Ring | Flexure | 0.85 |
| **Permit** | NYP 6 | 0.89 | Arch Ring | Flexure | 1.18 | Arch Ring | Flexure | 0.75 |
| | NYP 11 | 0.77 | Arch Ring | Flexure | 1.03 | Arch Ring | Flexure | 0.75 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1046510 | N/A | 1.95 | Arch Ring | N/A | 1.55 | Arch Ring | N/A | 1.46 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1046510 | N | 1.95 | Arch Ring | Y | 0.89 | Arch Ring |

### *2.6.8 BIN 1046510 (3D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Reinforced Concrete Arch** | Year Built: 1947 | Total length: 70 ft |
| Number of spans: 1 | Feature carried: 354 53012156 | Feature crossed: Gayuga Creek |
| Location: Town of Marilla, Erie County | Owner: Local | ADTT: 105 |
| NYSDOT Condition Factor: 4.50 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 3-D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 4.81 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 6.24 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.42 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 4.04 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 3.99 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 6.66 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 9.36 | Arch Ring | Flexure | 3.19 | Arch Ring | Flexure | 1.99 |
| | Type 3S2 (OPR) | 9.36 | Arch Ring | Flexure | 5.32 | Arch Ring | Flexure | 1.19 |
| | SU4 (INV) | 8.93 | Arch Ring | Flexure | 3.02 | Arch Ring | Flexure | 1.87 |
| | SU4 (OPR) | 8.93 | Arch Ring | Flexure | 5.05 | Arch Ring | Flexure | 1.12 |
| **Permit** | NYP 6 | 6.56 | Arch Ring | Flexure | 3.01 | Arch Ring | Flexure | 1.38 |
| | NYP 11 | 5.75 | Arch Ring | Flexure | 2.70 | Arch Ring | Flexure | 1.39 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1046510 | N/A | 6.66 | Arch Ring | N/A | 9.36 | Arch Ring | N/A | 8.93 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1046510 | N | 6.66 | Arch Ring | N | 6.56 | Arch Ring |

### *2.6.9 BIN 1051960 (2D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Concrete Frame** | Year Built: 1932 | Total length: 47 ft |
| Number of spans: 1 | Feature carried: 920V (28B26011046) | Feature crossed: Cincinnati Creek |
| Location: Village of Remsen, Oneida Ct. | Owner: State | ADTT: 15 |
| NYSDOT Condition Factor: 5.14 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.31 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.41 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.36 | Ext. Strip | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.61 | Ext. Strip | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.56 | Ext. Strip | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 0.94 | Ext. Strip | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 0.69 | Ext. Strip | Flexure | 0.55 | Ext. Strip | Flexure | 1.26 |
| | Type 3S2 (OPR) | 0.69 | Ext. Strip | Flexure | 0.92 | Ext. Strip | Flexure | 0.75 |
| | SU4 (INV) | 0.54 | Ext. Strip | Flexure | 0.43 | Ext. Strip | Flexure | 1.26 |
| | SU4 (OPR) | 0.54 | Ext. Strip | Flexure | 0.72 | Ext. Strip | Flexure | 0.76 |
| **Permit** | NYP 6 | 0.66 | Ext. Strip | Flexure | 0.48 | Ext. Strip | Flexure | 1.38 |
| | NYP 11 | 0.55 | Ext. Strip | Flexure | 0.41 | Ext. Strip | Flexure | 1.34 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1051960 | 15 | 0.94 | Ext. Strip | 22 | 0.69 | Ext. Strip | 11 | 0.54 | Ext. Strip |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1051960 | Y | 0.94 | Ext. Strip | Y | 0.66 | Ext. Strip |

### *2.6.10 BIN 1051960 (3D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Concrete Frame** | Year Built: 1932 | Total length: 47 ft |
| Number of spans: 1 | Feature carried: 920V (28B26011046) | Feature crossed: Cincinnati Creek |
| Location: Village of Remsen, Oneida Ct. | Owner: State | ADTT: 15 |
| NYSDOT Condition Factor: 5.14 | Posted Load: No Posting | |

- **Analysis Methods:**
LFR and LRFR: STAAD 3-D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.67 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.86 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.60 | Ext. Strip | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.00 | Ext. Strip | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.80 | Ext. Strip | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.33 | Ext. Strip | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.28 | Ext. Strip | Flexure | 0.86 | Ext. Strip | Flexure | 1.48 |
| | Type 3S2 (OPR) | 1.28 | Ext. Strip | Flexure | 1.43 | Ext. Strip | Flexure | 0.89 |
| | SU4 (INV) | 1.02 | Ext. Strip | Flexure | 0.68 | Ext. Strip | Flexure | 1.49 |
| | SU4 (OPR) | 1.02 | Ext. Strip | Flexure | 1.13 | Ext. Strip | Flexure | 0.77 |
| **Permit** | NYP 6 | 1.28 | Ext. Strip | Flexure | 0.80 | Ext. Strip | Flexure | 1.60 |
| | NYP 11 | 1.10 | Ext. Strip | Flexure | 0.68 | Ext. Strip | Flexure | 1.62 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1051960 | 22 | 1.33 | Ext. Strip | N/A | 1.28 | Ext. Strip | N/A | 1.02 | Ext. Strip |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1051960 | Y | 1.33 | Ext. Strip | N | 1.28 | Ext. Strip |

### *2.6.11 BIN 1050180*

- **General Description**

| | | |
|---|---|---|
| Type: **Concrete Frame** | Year Built: 1962 | Total length: 64 ft |
| Number of spans: 1 | Feature carried: Carpenter Ave | Feature crossed: South Street |
| Location: City of Newburgh, Orange Ct. | Owner: Local | ADTT: 54 |
| NYSDOT Condition Factor: 4.83 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.00 | Int. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.29 | Int. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.11 | Int. Strip | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.85 | Int. Strip | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.33 | Int. Strip | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.22 | Int. Strip | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.52 | Int. Strip | Flexure | 1.52 | Int. Strip | Flexure | 1.66 |
| | Type 3S2 (OPR) | 2.52 | Int. Strip | Flexure | 2.54 | Int. Strip | Flexure | 0.99 |
| | SU4 (INV) | 2.06 | Int. Strip | Flexure | 1.24 | Int. Strip | Flexure | 1.66 |
| | SU4 (OPR) | 2.06 | Int. Strip | Flexure | 2.07 | Int. Strip | Flexure | 0.99 |
| **Permit** | NYP 6 | 2.08 | Int. Strip | Flexure | 1.48 | Int. Strip | Flexure | 1.41 |
| | NYP 11 | 1.86 | Int. Strip | Flexure | 1.32 | Int. Strip | Flexure | 1.41 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1050180 | N/A | 2.22 | Int. Strip | N/A | 2.52 | Int. Strip | N/A | 2.06 | Int. Strip |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1050180 | N | 2.22 | Int. Strip | N | 2.08 | Int. Strip |

### *2.6.12 BIN 1045360*

- **General Description**

| | | |
|---|---|---|
| Type: **Concrete Frame** | Year Built: 1958 | Total length: 184 ft |
| Number of spans: 2 (Results from L=70.5' Span) | Feature carried: 303 85011014 | Feature crossed: 987C(987C85011026) |
| Location: Town of Orangetown, Rockland Ct | Owner: State | ADTT: 526 |
| NYSDOT Condition Factor: 5.02 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.69 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.90 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.72 | Ext. Strip | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.20 | Ext. Strip | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.12 | Ext. Strip | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.87 | Ext. Strip | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.19 | Ext. Strip | Flexure | 0.87 | Ext. Strip | Flexure | 1.37 |
| | Type 3S2 (OPR) | 1.19 | Ext. Strip | Flexure | 1.46 | Ext. Strip | Flexure | 0.82 |
| | SU4 (INV) | 1.24 | Ext. Strip | Flexure | 0.91 | Ext. Strip | Flexure | 1.36 |
| | SU4 (OPR) | 1.24 | Ext. Strip | Flexure | 1.52 | Ext. Strip | Flexure | 0.82 |
| | Lane-Type LL | 2.22 | Ext. Strip | Flexure | N/A | N/A | N/A | N/A |
| **Permit** | NYP 6 | 1.32 | Ext. Strip | Flexure | 0.87 | Ext. Strip | Flexure | 1.52 |
| | NYP 11 | 1.17 | Ext. Strip | Flexure | 0.76 | Ext. Strip | Flexure | 1.54 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1045360 | N/A | 1.87 | Ext. Strip | N/A | 1.19 | Ext. Strip | N/A | 1.24 | Ext. Strip |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1045360 | N | 1.87 | Ext. Strip | N | 1.32 | Ext. Strip |

### *2.6.13 BIN 5521680*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Culvert** | Year Built: 1966 | Total length: 7 ft |
| Number of spans: 3 | Feature carried: EHPA DPW Access Road | Feature crossed: Hutchinson River |
| Location: City of New Rochelle, Westchester Ct | Owner: Local | ADTT: 5 |
| NYSDOT Condition Factor: 3.00 | Posted Load: N/A (Not rated before) | |

- **Analysis Methods:**
  LFR and LRFR: CANDE-2013 & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.47 | Arch Ring | Thrust | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.61 | Arch Ring | Thrust | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.69 | Arch Ring | Thrust | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.15 | Arch Ring | Thrust | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.69 | Arch Ring | Thrust | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.15 | Arch Ring | Thrust | N/A |
| **Legal** | Type 3S2 (INV) | 1.63 | Arch Ring | Thrust | 0.80 | Arch Ring | Thrust | 2.67 |
| | Type 3S2 (OPR) | 1.63 | Arch Ring | Thrust | 1.33 | Arch Ring | Thrust | 1.59 |
| | SU4 (INV) | 1.42 | Arch Ring | Thrust | 0.73 | Arch Ring | Thrust | 2.68 |
| | SU4 (OPR) | 1.42 | Arch Ring | Thrust | 1.22 | Arch Ring | Thrust | 1.57 |
| **Permit** | NYP 6 | 1.34 | Arch Ring | Thrust | 1.01 | Arch Ring | Thrust | 2.00 |
| | NYP 11 | 1.21 | Arch Ring | Thrust | 0.97 | Arch Ring | Thrust | 1.98 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 5521680 | 13 | 1.02 | Arch Ring | 21.4 | 1.63 | Arch Ring | 13.5 | 13 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 11 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 5521680 | Y | 1.02 | Arch Ring | Y | 0.97 | Arch Ring |

### *2.6.14 BIN 1091510*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Culvert** | Year Built: 1974 | Total length: 8.58 ft |
| Number of spans: 1 | Feature carried: State Route 22 | Feature crossed: Roeliff Jansen Kil |
| Location: Town of Hillsdale, Columbia Ct | Owner: State | ADTT: 79 |
| NYSDOT Condition Factor: 4.00 | Posted Load: N/A (Not rated before) | |

- **Analysis Methods:**
  LFR and LRFR: CANDE-2013 & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.43 | Arch Ring | Thrust | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.85 | Arch Ring | Thrust | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.39 | Arch Ring | Thrust | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.31 | Arch Ring | Thrust | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.39 | Arch Ring | Thrust | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.31 | Arch Ring | Thrust | N/A |
| **Legal** | Type 3S2 (INV) | 1.99 | Arch Ring | Thrust | 1.63 | Arch Ring | Thrust | 1.22 |
| | Type 3S2 (OPR) | 1.99 | Arch Ring | Thrust | 2.72 | Arch Ring | Thrust | 0.73 |
| | SU4 (INV) | 1.72 | Arch Ring | Thrust | 1.36 | Arch Ring | Thrust | 1.26 |
| | SU4 (OPR) | 1.72 | Arch Ring | Thrust | 2.27 | Arch Ring | Thrust | 0.76 |
| **Permit** | NYP 6 | 2.14 | Arch Ring | Thrust | 1.9 | Arch Ring | Thrust | 1.13 |
| | NYP 11 | 1.97 | Arch Ring | Thrust | 1.74 | Arch Ring | Thrust | 1.13 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1091510 | N/A | 2.31 | Arch Ring | N/A | 1.99 | Arch Ring | N/A | 1.72 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1091510 | N/A | 2.31 | Arch Ring | N/A | 2.14 | Arch Ring |

### *2.6.15 BIN 1076419*

- **General Description**

| | | |
|---|---|---|
| Type: **Concrete Frame** | Year Built: 1951 | Total length: 68 ft |
| Number of spans: 1 | Feature carried: 907HX1M11038 | Feature crossed: Bronx River |
| Location: City of New York | Owner: State | ADTT: 3135 |
| NYSDOT Condition Factor: 5.10 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.73 | Int. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.25 | Int. Strip | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.21 | Int. Strip | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.02 | Int. Strip | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.45 | Int. Strip | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.42 | Int. Strip | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.53 | Int. Strip | Flexure | 1.81 | Int. Strip | Flexure | 1.40 |
| | Type 3S2 (OPR) | 2.53 | Int. Strip | Flexure | 3.02 | Int. Strip | Flexure | 0.84 |
| | SU4 (INV) | 2.25 | Int. Strip | Flexure | 1.41 | Int. Strip | Flexure | 1.59 |
| | SU4 (OPR) | 2.25 | Int. Strip | Flexure | 2.36 | Int. Strip | Flexure | 0.95 |
| **Permit** | NYP 6 | 1.56 | Int. Strip | Flexure | 1.52 | Int. Strip | Flexure | 1.02 |
| | NYP 11 | 1.36 | Int. Strip | Flexure | 1.54 | Int. Strip | Flexure | 0.88 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1076419 | N/A | 2.42 | Int. Strip | N/A | 2.53 | Int. Strip | N/A | 2.25 | Int. Strip |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1076419 | N/A | N/A | N/A | N/A | N/A | N/A |

### *2.6.16 BIN 1069090*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Curved Bridge** | Year Built: 1980 | Total length: 785 ft |
| Number of spans: 5 | Feature carried: I-481 Ramp | Feature crossed: I-81 |
| Location: City of Syracuse, Onondaga County | Owner: State | ADTT: 607 |
| NYSDOT Condition Factor: 4.78 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: MDX

- **Level I Load Rating Summary:**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.30 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.40 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.37 | Girder G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.62 | Girder G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.37 | Girder G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 0.62 | Girder G1 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.38 | Girder G1 | Flexure | 0.74 | Girder G1 | Flexure | 1.86 |
| | Type 3S2 (OPR) | 1.38 | Girder G1 | Flexure | 1.24 | Girder G1 | Flexure | 1.11 |
| | SU4 (INV) | 1.47 | Girder G1 | Flexure | 0.95 | Girder G1 | Flexure | 1.55 |
| | SU4 (OPR) | 1.47 | Girder G1 | Flexure | 1.59 | Girder G1 | Flexure | 0.92 |
| | Lane Type LL | 0.66 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| **Permit** | NYP 6 | 0.72 | Girder G1 | Flexure | 0.78 | Girder G1 | Flexure | 0.92 |
| | NYP 11 | 0.68 | Girder G1 | Flexure | 0.73 | Girder G1 | Flexure | 0.93 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1069090 | 12 | 0.62 | Girder G1 | N/A | 1.38 | Girder G1 | N/A | 1.47 | Girder G1 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1069090 | Y | 0.62 | Girder G1 | Y | 0.72 | Girder G1 |

### *2.6.17 BIN 1069610*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Curved Bridge** | Year Built: 1980 | Total length: 307 ft |
| Number of spans: 2 | Feature carried: I-991 Ramp | Feature crossed: I-88 |
| Location: Town of Maryland, Otsego County | Owner: State | ADTT: 607 |
| NYSDOT Condition Factor: 5.10 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: MDX

- **Level I Load Rating Summary:**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.00 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.25 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.66 | Girder G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.77 | Girder G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.81 | Girder G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.03 | Girder G1 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.46 | Girder G1 | Flexure | 1.88 | Girder G1 | Flexure | 1.31 |
| | Type 3S2 (OPR) | 2.46 | Girder G1 | Flexure | 3.14 | Girder G1 | Flexure | 0.78 |
| | SU4 (INV) | 2.46 | Girder G1 | Flexure | 2.10 | Girder G1 | Flexure | 1.17 |
| | SU4 (OPR) | 2.46 | Girder G1 | Flexure | 3.50 | Girder G1 | Flexure | 0.70 |
| | Lane Type LL | 2.03 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| **Permit** | NYP 6 | 1.28 | Girder G1 | Flexure | 1.92 | Girder G1 | Flexure | 0.67 |
| | NYP 11 | 1.18 | Girder G1 | Flexure | 1.75 | Girder G1 | Flexure | 0.67 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1069610 | N/A | 3.03 | Girder G1 | N/A | 2.46 | Girder G1 | N/A | 2.46 | Girder G1 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1069610 | N | 3.03 | Girder G1 | N | 1.28 | Girder G1 |

### *2.6.18 BIN 1090530*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Curved Bridge** | Year Built: 1975 | Total length: 182 ft |
| Number of spans: 3 | Feature carried: Ramp to N/S Arterial | Feature crossed: NY Susquehanna |
| Location: City of Utica, Oneida County | Owner: State | ADTT: 423 |
| NYSDOT Condition Factor: 5.00 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: MDX

- **Level I Load Rating Summary:**

**Controlling Ratings**

| Rating Level | Vehicle | LRFR Rating Factor (LRFR) | LRFR Member Type | LRFR Failure Mode | LFR Rating Factor (LFR) | LFR Member Type | LFR Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 1.08 | Girder G4 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.26 | Girder G3 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.22 | Girder G2 | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.04 | Girder G2 | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.33 | Girder G2 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.22 | Girder G2 | Flexure | N/A |
| Legal | Type 3S2 (INV) | 2.56 | Girder G4 | Flexure | 1.62 | Girder G2 | Shear | 1.58 |
| | Type 3S2 (OPR) | 2.56 | Girder G4 | Flexure | 2.76 | Girder G2 | Shear | 0.93 |
| | SU4 (INV) | 2.29 | Girder G4 | Flexure | 1.52 | Girder G2 | Shear | 1.51 |
| | SU4 (OPR) | 2.29 | Girder G4 | Flexure | 2.54 | Girder G2 | Shear | 0.90 |
| | Lane Type LL | 2.25 | Girder G4 | Flexure | N/A | N/A | N/A | N/A |
| Permit | NYP 6 | 1.53 | Girder G4 | Flexure | 1.66 | Girder G2 | Shear | 0.92 |
| | NYP 11 | 1.30 | Girder G4 | Flexure | 1.48 | Girder G2 | Shear | 0.88 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1090530 | N/A | 2.22 | Girder G3 | N/A | 2.56 | Girder G4 | N/A | 2.29 | Girder G4 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1090530 | N | 2.22 | Girder G3 | N | 1.53 | Girder G4 |

### *2.6.19 BIN 1053060 (2D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Curved Bridge** | Year Built: 1971 | Total length: 243 ft |
| Number of spans: 2 | Feature carried: Chestnut Ridge Rd | Feature crossed: I-684 |
| Location: Town of Bedford, Westchester Ct | Owner: State | ADTT: 21 |
| NYSDOT Condition Factor: 4.96 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: MDX

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.08 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.40 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.39 | Girder G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.32 | Girder G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.62 | Girder G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.70 | Girder G1 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.22 | Girder G1 | Flexure | 1.51 | Girder G1 | Flexure | 1.47 |
| | Type 3S2 (OPR) | 2.22 | Girder G1 | Flexure | 2.53 | Girder G1 | Flexure | 0.88 |
| | SU4 (INV) | 2.58 | Girder G1 | Flexure | 1.79 | Girder G1 | Flexure | 1.44 |
| | SU4 (OPR) | 2.58 | Girder G1 | Flexure | 2.99 | Girder G1 | Flexure | 0.86 |
| **Permit** | NYP 6 | 1.35 | Girder G1 | Flexure | 1.55 | Girder G1 | Flexure | 0.87 |
| | NYP 11 | 1.25 | Girder G1 | Flexure | 1.43 | Girder G1 | Flexure | 0.87 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1053060 | N/A | 2.70 | Girder G1 | N/A | 2.22 | Girder G1 | N/A | 2.58 | Girder G1 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 11 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1053060 | N | 2.70 | Girder G1 | N | 1.25 | Girder G1 |

### *2.6.20 BIN 1053060 (3D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Curved Bridge** | Year Built: 1971 | Total length: 243 ft |
| Number of spans: 2 | Feature carried: Chestnut Ridge Rd | Feature crossed: I-684 |
| Location: Town of Bedford, Westchester Ct | Owner: State | ADTT: 21 |
| NYSDOT Condition Factor: 4.96 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 3D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.95 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.23 | Girder G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.33 | Girder G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.21 | Girder G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.33 | Girder G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.21 | Girder G1 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.21 | Girder G1 | Flexure | 1.60 | Girder G1 | Flexure | 1.38 |
| | Type 3S2 (OPR) | 2.21 | Girder G1 | Flexure | 2.67 | Girder G1 | Flexure | 0.83 |
| | SU4 (INV) | 2.58 | Girder G1 | Flexure | 1.87 | Girder G1 | Flexure | 1.38 |
| | SU4 (OPR) | 2.58 | Girder G1 | Flexure | 3.13 | Girder G1 | Flexure | 0.83 |
| **Permit** | NYP 6 | 1.37 | Girder G1 | Flexure | 1.65 | Girder G1 | Flexure | 0.83 |
| | NYP 11 | 1.26 | Girder G1 | Flexure | 1.52 | Girder G1 | Flexure | 0.83 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1053060 | N/A | 2.21 | Girder G1 | N/A | 2.21 | Girder G1 | N/A | 2.58 | Girder G1 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 11 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1053060 | N | 2.21 | Girder G1 | N | 1.37 | Girder G1 |

### *2.6.21 BIN 1041200 (2D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Arch** | Year Built: 1957 | Total length: 340 ft |
| Number of spans: 1 | Feature carried: 213 (213 86011238) | Feature crossed: Rondout Cr. |
| Location: Town of Esopus, Ulster County | Owner: State | ADTT: 57 |
| NYSDOT Condition Factor: 4.00 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.41 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.54 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.70 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.21 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.78 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.34 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 0.81 | Arch Ring | Flexure | 0.83 | Arch Ring | Flexure | 0.98 |
| | Type 3S2 (OPR) | 0.81 | Arch Ring | Flexure | 1.41 | Arch Ring | Flexure | 0.57 |
| | SU4 (INV) | 0.83 | Arch Ring | Flexure | 0.96 | Arch Ring | Flexure | 0.86 |
| | SU4 (OPR) | 0.83 | Arch Ring | Flexure | 1.63 | Arch Ring | Flexure | 0.51 |
| **Permit** | NYP 6 | 0.74 | Arch Ring | Flexure | 0.85 | Arch Ring | Flexure | 0.87 |
| | NYP 11 | 0.68 | Arch Ring | Flexure | 0.78 | Arch Ring | Flexure | 0.87 |

## Arch Ring

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.41 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.54 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.70 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.21 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.78 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.34 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 0.81 | Arch Ring | Flexure | 0.83 | Arch Ring | Flexure | 0.98 |
| | Type 3S2 (OPR) | 0.81 | Arch Ring | Flexure | 1.41 | Arch Ring | Flexure | 0.57 |
| | SU4 (INV) | 0.83 | Arch Ring | Flexure | 0.96 | Arch Ring | Flexure | 0.86 |
| | SU4 (OPR) | 0.83 | Arch Ring | Flexure | 1.63 | Arch Ring | Flexure | 0.51 |
| **Permit** | NYP 6 | 0.74 | Arch Ring | Flexure | 0.85 | Arch Ring | Flexure | 0.87 |
| | NYP 11 | 0.68 | Arch Ring | Flexure | 0.78 | Arch Ring | Flexure | 0.87 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.36 | Int. FB | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.76 | Int. FB | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.28 | Int. FB | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.13 | Int. FB | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.67 | Int. FB | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.78 | Int. FB | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.74 | Int. FB | Flexure | 1.76 | Int. FB | Flexure | 1.55 |
| | Type 3S2 (OPR) | 2.74 | Int. FB | Flexure | 2.94 | Int. FB | Flexure | 0.93 |
| | SU4 (INV) | 2.15 | Int. FB | Flexure | 1.38 | Int. FB | Flexure | 1.56 |
| | SU4 (OPR) | 2.15 | Int. FB | Flexure | 2.31 | Int. FB | Flexure | 0.93 |
| **Permit** | NYP 6 | 2.23 | Int. FB | Flexure | 1.60 | Int. FB | Flexure | 1.39 |
| | NYP 11 | 1.89 | Int. FB | Flexure | 1.35 | Int. FB | Flexure | 1.40 |

### Stringers

| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| | | LRFR | | | LFR | | | |
| Design | HL-93 (INV) | 0.97 | S6 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.26 | S6 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.22 | S6 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.03 | S6 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.22 | S6 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.03 | S6 | Flexure | N/A |
| Legal | Type 3S2 (INV) | 2.07 | S6 | Flexure | 1.53 | S6 | Flexure | 1.35 |
| | Type 3S2 (OPR) | 2.07 | S6 | Flexure | 2.55 | S6 | Flexure | 0.81 |
| | SU4 (INV) | 1.61 | S6 | Flexure | 1.19 | S6 | Flexure | 1.35 |
| | SU4 (OPR) | 1.61 | S6 | Flexure | 1.99 | S6 | Flexure | 0.81 |
| Permit | NYP 6 | 1.70 | S6 | Flexure | 1.40 | S6 | Flexure | 1.21 |
| | NYP 11 | 1.55 | S6 | Flexure | 1.28 | S6 | Flexure | 1.21 |

### Hangers

| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| | | LRFR | | | LFR | | | |
| Design | HL-93 (INV) | 2.16 | Hanger 8 | Tension | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.80 | Hanger 8 | Tension | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.05 | Hanger 8 | Tension | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 3.42 | Hanger 8 | Tension | N/A |
| | H20 (INV) | N/A | N/A | N/A | 2.69 | Hanger 8 | Tension | N/A |
| | H20(OPR) | N/A | N/A | N/A | 4.49 | Hanger 8 | Tension | N/A |
| Legal | Type 3S2 (INV) | 4.32 | Hanger 8 | Tension | 2.84 | Hanger 8 | Tension | 1.52 |
| | Type 3S2 (OPR) | 4.32 | Hanger 8 | Tension | 4.74 | Hanger 8 | Tension | 0.91 |
| | SU4 (INV) | 3.43 | Hanger 8 | Tension | 2.26 | Hanger 8 | Tension | 1.52 |
| | SU4 (OPR) | 3.43 | Hanger 8 | Tension | 3.77 | Hanger 8 | Tension | 0.91 |
| Permit | NYP 6 | 3.81 | Hanger 8 | Tension | 2.79 | Hanger 8 | Tension | 1.37 |
| | NYP 11 | 3.11 | Hanger 8 | Tension | 2.28 | Hanger 8 | Tension | 1.36 |

### Connections

| Rating Level | Vehicle | LRFR: LRFR Rating Factor | LRFR: Member Type | LRFR: Failure Mode | LFR: LFR Rating Factor | LFR: Member Type | LFR: Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 1.13 | Connection | Shear | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.46 | Connection | Shear | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.52 | Connection | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.54 | Connection | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.88 | Connection | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.13 | Connection | Shear | N/A |
| Legal | Type 3S2 (INV) | 2.15 | Connection | Shear | 2.10 | Connection | Shear | 1.02 |
| | Type 3S2 (OPR) | 2.15 | Connection | Shear | 3.51 | Connection | Shear | 0.61 |
| | SU4 (INV) | 1.77 | Connection | Shear | 1.73 | Connection | Shear | 1.02 |
| | SU4 (OPR) | 1.77 | Connection | Shear | 2.89 | Connection | Shear | 0.61 |
| Permit | NYP 6 | 1.98 | Connection | Shear | 2.15 | Connection | Shear | 0.92 |
| | NYP 11 | 1.81 | Connection | Shear | 1.96 | Connection | Shear | 0.92 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1041200 | N/A | 1.34 | Arch Ring | 35 | 0.81 | Arch Ring | 26 | 0.83 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1041200 | Y | 1.34 | Arch Ring | Y | 0.74 | Arch Ring |

### *2.6.22 BIN 1041200 (3D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Arch** | Year Built: 1957 | Total length: 340 ft |
| Number of spans: 1 | Feature carried: 213 (213 86011238) | Feature crossed: Rondout Cr. |
| Location: Town of Esopus, Ulster County | Owner: State | ADTT: 57 |
| NYSDOT Condition Factor: 4.00 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 3-D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.46 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.60 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.90 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.52 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.89 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.52 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.02 | Arch Ring | Flexure | 1.05 | Arch Ring | Flexure | 0.97 |
| | Type 3S2 (OPR) | 1.02 | Arch Ring | Flexure | 1.77 | Arch Ring | Flexure | 0.58 |
| | SU4 (INV) | 1.05 | Arch Ring | Flexure | 0.96 | Stringer S6 | Flexure | 1.09 |
| | SU4 (OPR) | 1.05 | Arch Ring | Flexure | 1.60 | Stringer S6 | Flexure | 0.66 |
| **Permit** | NYP 6 | 0.93 | Arch Ring | Flexure | 1.07 | Arch Ring | Flexure | 0.87 |
| | NYP 11 | 0.84 | Arch Ring | Flexure | 0.97 | Arch Ring | Flexure | 0.87 |

## Arch Ring

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| **Design** | HL-93 (INV) | 0.46 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.60 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.90 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.52 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.89 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.52 | Arch Ring | Flexure | N/A |
| Legal | Type 3S2 (INV) | 1.02 | Arch Ring | Flexure | 1.05 | Arch Ring | Flexure | 0.97 |
| | Type 3S2 (OPR) | 1.02 | Arch Ring | Flexure | 1.77 | Arch Ring | Flexure | 0.58 |
| | SU4 (INV) | 1.05 | Arch Ring | Flexure | 1.22 | Arch Ring | Flexure | 0.86 |
| | SU4 (OPR) | 1.05 | Arch Ring | Flexure | 2.04 | Arch Ring | Flexure | 0.51 |
| Permit | NYP 6 | 0.93 | Arch Ring | Flexure | 1.07 | Arch Ring | Flexure | 0.87 |
| | NYP 11 | 0.84 | Arch Ring | Flexure | 0.97 | Arch Ring | Flexure | 0.87 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 2.07 | Int. FB | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.68 | Int. FB | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.36 | Int. FB | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 3.94 | Int. FB | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 2.36 | Int. FB | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.94 | Int. FB | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 5.31 | Int. FB | Shear | 3.57 | Int. FB | Shear | 1.49 |
| | Type 3S2 (OPR) | 5.31 | Int. FB | Shear | 5.96 | Int. FB | Shear | 0.89 |
| | SU4 (INV) | 4.19 | Int. FB | Shear | 2.81 | Int. FB | Shear | 1.49 |
| | SU4 (OPR) | 4.19 | Int. FB | Shear | 4.68 | Int. FB | Shear | 0.90 |
| **Permit** | NYP 6 | 4.42 | Int. FB | Shear | 3.20 | Int. FB | Flexure | 1.38 |
| | NYP 11 | 3.65 | Int. FB | Shear | 2.65 | Int. FB | Flexure | 1.38 |

## Stringers

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.80 | S6 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.03 | S6 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.04 | S6 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.73 | S6 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.06 | S6 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.77 | S6 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.61 | S6 | Flexure | 1.27 | S6 | Flexure | 1.27 |
| | Type 3S2 (OPR) | 1.61 | S6 | Flexure | 2.13 | S6 | Flexure | 0.76 |
| | SU4 (INV) | 1.22 | S6 | Flexure | 0.96 | S6 | Flexure | 1.27 |
| | SU4 (OPR) | 1.22 | S6 | Flexure | 1.60 | S6 | Flexure | 0.76 |
| **Permit** | NYP 6 | 1.31 | S6 | Flexure | 1.15 | S6 | Flexure | 1.14 |
| | NYP 11 | 1.17 | S6 | Flexure | 1.03 | S6 | Flexure | 1.14 |

## Hangers

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 2.24 | Hanger 8 | Tension | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.91 | Hanger 8 | Tension | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.37 | Hanger 8 | Tension | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 3.96 | Hanger 8 | Tension | N/A |
| | H20 (INV) | N/A | N/A | N/A | 2.88 | Hanger 8 | Tension | N/A |
| | H20(OPR) | N/A | N/A | N/A | 4.81 | Hanger 8 | Tension | N/A |
| **Legal** | Type 3S2 (INV) | 5.67 | Hanger 8 | Tension | 3.73 | Hanger 8 | Tension | 1.52 |
| | Type 3S2 (OPR) | 5.67 | Hanger 8 | Tension | 6.22 | Hanger 8 | Tension | 0.91 |
| | SU4 (INV) | 4.08 | Hanger 8 | Tension | 2.68 | Hanger 8 | Tension | 1.52 |
| | SU4 (OPR) | 4.08 | Hanger 8 | Tension | 4.48 | Hanger 8 | Tension | 0.91 |
| **Permit** | NYP 6 | 4.47 | Hanger 8 | Tension | 3.27 | Hanger 8 | Tension | 1.37 |
| | NYP 11 | 3.66 | Hanger 8 | Tension | 2.68 | Hanger 8 | Tension | 1.37 |

### Connections

| Rating Level | Vehicle | LRFR Rating Factor | LRFR Member Type | LRFR Failure Mode | LFR Rating Factor | LFR Member Type | LFR Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 1.85 | Connection | Shear | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.40 | Connection | Shear | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 3.42 | Connection | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 5.71 | Connection | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 3.13 | Connection | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 5.22 | Connection | Shear | N/A |
| Legal | Type 3S2 (INV) | 4.22 | Connection | Shear | 3.66 | Connection | Shear | 1.15 |
| | Type 3S2 (OPR) | 4.22 | Connection | Shear | 6.10 | Connection | Shear | 0.69 |
| | SU4 (INV) | 4.63 | Connection | Shear | 3.15 | Connection | Shear | 1.47 |
| | SU4 (OPR) | 4.63 | Connection | Shear | 5.26 | Connection | Shear | 0.88 |
| Permit | NYP 6 | 3.73 | Connection | Shear | 3.60 | Connection | Shear | 1.04 |
| | NYP 11 | 3.51 | Connection | Shear | 3.38 | Connection | Shear | 1.04 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1041200 | N/A | 1.52 | Arch Ring | N/A | 1.02 | Arch Ring | N/A | 1.05 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1041200 | N | 1.52 | Arch Ring | Y | 0.93 | Arch Ring |

### *2.6.23 BIN 1023380*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Arch** | Year Built: 1930 | Total length: 502 ft |
| Number of spans: 3 | Feature carried: 34B (34B36011018) | Feature crossed: Salmon Creek |
| Location: Town of Lansing, Tompkins Ct. | Owner: State | ADTT: 336 |
| NYSDOT Condition Factor: 3.61 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.42 | Arch Ring | Flexure | N/A | N/A | N/A | 0.73 |
| | HL-93 (OPR) | 0.55 | Arch Ring | Flexure | N/A | N/A | N/A | 0.95 |
| | HS20 (INV) | N/A | N/A | N/A | 0.46 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.81 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.55 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 0.96 | Arch Ring | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 0.78 | Arch Ring | Flexure | 0.63 | Arch Ring | Flexure | 1.24 |
| | Type 3S2 (OPR) | 0.78 | Arch Ring | Flexure | 1.08 | Arch Ring | Flexure | 0.72 |
| | SU4 (INV) | 0.78 | Arch Ring | Flexure | 0.58 | Arch Ring | Flexure | 1.34 |
| | SU4 (OPR) | 0.78 | Arch Ring | Flexure | 0.99 | Arch Ring | Flexure | 0.79 |
| **Permit** | NYP 6 | 0.71 | Arch Ring | Flexure | 0.65 | Arch Ring | Flexure | 1.09 |
| | NYP 11 | 0.65 | Arch Ring | Flexure | 0.57 | Arch Ring | Flexure | 1.14 |

## Arch Ring

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| **Design** | HL-93 (INV) | 0.42 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 0.55 | Arch Ring | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.46 | Arch Ring | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 0.81 | Arch Ring | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 0.55 | Arch Ring | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 0.96 | Arch Ring | Flexure | N/A |
| Legal | Type 3S2 (INV) | 0.78 | Arch Ring | Flexure | 0.63 | Arch Ring | Flexure | 1.24 |
| | Type 3S2 (OPR) | 0.78 | Arch Ring | Flexure | 1.08 | Arch Ring | Flexure | 0.72 |
| | SU4 (INV) | 0.78 | Arch Ring | Flexure | 0.58 | Arch Ring | Flexure | 1.34 |
| | SU4 (OPR) | 0.78 | Arch Ring | Flexure | 0.99 | Arch Ring | Flexure | 0.79 |
| Permit | NYP 6 | 0.71 | Arch Ring | Flexure | 0.65 | Arch Ring | Flexure | 1.09 |
| | NYP 11 | 0.65 | Arch Ring | Flexure | 0.57 | Arch Ring | Flexure | 1.14 |

## Columns

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 0.87 | Int. Column | Axial | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.13 | Int. Column | Axial | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.65 | Int. Column | Axial | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.75 | Int. Column | Axial | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.65 | Int. Column | Axial | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.75 | Int. Column | Axial | N/A |
| **Legal** | Type 3S2 (INV) | 1.81 | Int. Column | Axial | 1.86 | Int. Column | Axial | 0.97 |
| | Type 3S2 (OPR) | 1.81 | Int. Column | Axial | 3.10 | Int. Column | Axial | 0.58 |
| | SU4 (INV) | 1.44 | Int. Column | Axial | 1.48 | Int. Column | Axial | 0.97 |
| | SU4 (OPR) | 1.44 | Int. Column | Axial | 2.47 | Int. Column | Axial | 0.58 |
| **Permit** | NYP 6 | 1.55 | Int. Column | Axial | 1.73 | Int. Column | Axial | 0.90 |
| | NYP 11 | 1.41 | Int. Column | Axial | 1.58 | Int. Column | Axial | 0.89 |

## Floorbeams

| Rating Level | Vehicle | LRFR Rating Factor | LRFR Member Type | LRFR Failure Mode | LFR Rating Factor | LFR Member Type | LFR Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 0.82 | Int. FB | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.07 | Int. FB | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.22 | Int. FB | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.04 | Int. FB | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.22 | Int. FB | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.04 | Int. FB | Flexure | N/A |
| Legal | Type 3S2 (INV) | 1.70 | Int. FB | Flexure | 1.52 | Int. FB | Flexure | 1.12 |
| | Type 3S2 (OPR) | 1.70 | Int. FB | Flexure | 2.54 | Int. FB | Flexure | 0.67 |
| | SU4 (INV) | 1.32 | Int. FB | Flexure | 1.18 | Int. FB | Flexure | 1.12 |
| | SU4 (OPR) | 1.32 | Int. FB | Flexure | 1.97 | Int. FB | Flexure | 0.67 |
| Permit | NYP 6 | 1.41 | Int. FB | Flexure | 1.38 | Int. FB | Flexure | 1.02 |
| | NYP 11 | 1.29 | Int. FB | Flexure | 1.26 | Int. FB | Flexure | 1.02 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1023380 | 22 | 0.96 | Arch Ring | 33 | 0.78 | Arch Ring | 24 | 0.78 | Arch Ring |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1023380 | Y | 0.96 | Arch Ring | Y | 0.71 | Arch Ring |

### *2.6.24 BIN 1001360*

- **General Description**

| | | |
|---|---|---|
| Type: **Girder-Floorbeam-Stringer** | Year Built: 1975 | Total length: 95 ft |
| Number of spans: 1 | Feature carried: 5 553021075 | Feature crossed: Big Sister Creek |
| Location: Town of Evans, Erie County | Owner: State | ADTT: 369 |
| NYSDOT Condition Factor: 4.85 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.82 | G1 | Shear | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.07 | G1 | Shear | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.85 | G1 | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.41 | G1 | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.00 | G1 | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.66 | G1 | Shear | N/A |
| **Legal** | Type 3S2 (INV) | 1.41 | G1 | Shear | 0.96 | G1 | Shear | 1.47 |
| | Type 3S2 (OPR) | 1.41 | G1 | Shear | 1.60 | G1 | Shear | 0.88 |
| | SU4 (INV) | 1.48 | Int. FB | Shear | 1.06 | Int. FB | Shear | 1.40 |
| | SU4 (OPR) | 1.48 | Int. FB | Shear | 1.77 | Int. FB | Shear | 0.84 |
| **Permit** | NYP 6 | 1.31 | G1 | Shear | 0.97 | G1 | Shear | 1.35 |
| | NYP 11 | 1.21 | G1 | Shear | 0.89 | G1 | Shear | 1.36 |

## Girders

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| **Design** | HL-93 (INV) | 0.82 | G1 | Shear | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.07 | G1 | Shear | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 0.85 | G1 | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.41 | G1 | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.00 | G1 | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.66 | G1 | Shear | N/A |
| Legal | Type 3S2 (INV) | 1.41 | G1 | Shear | 0.96 | G1 | Shear | 1.47 |
| | Type 3S2 (OPR) | 1.41 | G1 | Shear | 1.60 | G1 | Shear | 0.88 |
| | SU4 (INV) | 1.61 | G1 | Shear | 1.09 | G1 | Shear | 1.48 |
| | SU4 (OPR) | 1.61 | G1 | Shear | 1.82 | G1 | Shear | 0.89 |
| Permit | NYP 6 | 1.31 | G1 | Shear | 0.97 | G1 | Shear | 1.35 |
| | NYP 11 | 1.21 | G1 | Shear | 0.89 | G1 | Shear | 1.36 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 0.96 | Int. FB | Shear | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.25 | Int. FB | Shear | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.01 | Int. FB | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.69 | Int. FB | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.11 | Int. FB | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 1.84 | Int. FB | Shear | N/A |
| **Legal** | Type 3S2 (INV) | 1.85 | Int. FB | Shear | 1.32 | Int. FB | Shear | 1.40 |
| | Type 3S2 (OPR) | 1.85 | Int. FB | Shear | 2.20 | Int. FB | Shear | 0.84 |
| | SU4 (INV) | 1.48 | Int. FB | Shear | 1.06 | Int. FB | Shear | 1.40 |
| | SU4 (OPR) | 1.48 | Int. FB | Shear | 1.77 | Int. FB | Shear | 0.84 |
| **Permit** | NYP 6 | 1.67 | Int. FB | Shear | 1.30 | Int. FB | Shear | 1.29 |
| | NYP 11 | 1.46 | Int. FB | Shear | 1.13 | Int. FB | Shear | 1.29 |

### Stringers

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.18 | S2 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.53 | S2 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.22 | S2 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.04 | S2 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.22 | S2 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.04 | S2 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.17 | S2 | Flexure | 1.62 | S2 | Flexure | 1.34 |
| | Type 3S2 (OPR) | 2.17 | S2 | Flexure | 2.71 | S2 | Flexure | 0.80 |
| | SU4 (INV) | 1.69 | S2 | Flexure | 1.27 | S2 | Flexure | 1.33 |
| | SU4 (OPR) | 1.69 | S2 | Flexure | 2.12 | S2 | Flexure | 0.80 |
| **Permit** | NYP 6 | 1.86 | S2 | Flexure | 1.51 | S2 | Flexure | 1.23 |
| | NYP 11 | 1.69 | S2 | Flexure | 1.38 | S2 | Flexure | 1.23 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1001360 | N/A | 1.66 | G1 | N/A | 1.41 | G1 | N/A | 1.48 | Int. FB |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1001360 | N | 1.66 | G1 | N | 1.31 | G1 |

### *2.6.25 BIN 1046790*

- **General Description**

| | | |
|---|---|---|
| Type: **Girder Floorbeam Stringer** | Year Built: 1932 | Total length: 95 ft |
| Number of spans: 1 | Feature carried: 366 36011075 | Feature crossed: Fall Creek |
| Location: Town of Dryden, Tompkins Ct. | Owner: State | ADTT: 176 |
| NYSDOT Condition Factor: 4.52 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.87 | G2 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.12 | G2 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.01 | G2 | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.68 | G2 | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.27 | G2 | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.12 | G2 | Shear | N/A |
| **Legal** | Type 3S2 (INV) | 1.63 | G2 | Flexure | 1.18 | G2 | Shear | 1.39 |
| | Type 3S2 (OPR) | 1.63 | G2 | Flexure | 1.96 | G2 | Shear | 0.83 |
| | SU4 (INV) | 1.62 | G2 | Flexure | 1.29 | G2 | Shear | 1.26 |
| | SU4 (OPR) | 1.62 | G2 | Flexure | 2.15 | G2 | Shear | 0.75 |
| **Permit** | NYP 6 | 1.49 | G2 | Flexure | 1.18 | G2 | Shear | 1.26 |
| | NYP 11 | 1.29 | G2 | Flexure | 1.08 | G2 | Shear | 1.20 |

## Girders

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| **Design** | HL-93 (INV) | 0.87 | G2 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.12 | G2 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.01 | G2 | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 1.68 | G2 | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.27 | G2 | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.12 | G2 | Shear | N/A |
| Legal | Type 3S2 (INV) | 1.63 | G2 | Flexure | 1.18 | G2 | Shear | 1.39 |
| | Type 3S2 (OPR) | 1.63 | G2 | Flexure | 1.96 | G2 | Shear | 0.83 |
| | SU4 (INV) | 1.62 | G2 | Flexure | 1.29 | G2 | Shear | 1.26 |
| | SU4 (OPR) | 1.62 | G2 | Flexure | 2.15 | G2 | Shear | 0.75 |
| Permit | NYP 6 | 1.49 | G2 | Flexure | 1.18 | G2 | Shear | 1.26 |
| | NYP 11 | 1.29 | G2 | Flexure | 1.08 | G2 | Shear | 1.20 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 1.50 | FB3 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.94 | FB3 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.90 | FB3 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 3.17 | FB3 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.90 | FB3 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.17 | FB3 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.84 | FB3 | Flexure | 2.48 | FB3 | Flexure | 1.15 |
| | Type 3S2 (OPR) | 2.84 | FB3 | Flexure | 4.14 | FB3 | Flexure | 0.69 |
| | SU4 (INV) | 2.20 | FB3 | Flexure | 1.92 | FB3 | Flexure | 1.15 |
| | SU4 (OPR) | 2.20 | FB3 | Flexure | 3.20 | FB3 | Flexure | 0.69 |
| **Permit** | NYP 6 | 2.35 | FB3 | Flexure | 2.27 | FB3 | Flexure | 1.04 |
| | NYP 11 | 2.14 | FB3 | Flexure | 2.07 | FB3 | Flexure | 1.04 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1046790 | N/A | 2.12 | G2 | N/A | 1.63 | G2 | N/A | 1.62 | G2 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1046790 | Y | 2.12 | G2 | N | 1.49 | G2 |

### *2.6.26 BIN 1004540 (2D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Girder Floorbeam Stringer** | Year Built: 1936 | Total length: 66 ft |
| Number of spans: 1 | Feature carried: 8 8 92031150 | Feature crossed: Great Brook |
| Location: Town of New Berlin, Chenango Ct. | Owner: State | ADTT: 117 |
| NYSDOT Condition Factor: 3.92 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 2-D & MathCAD

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 0.97 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.26 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.34 | G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.24 | G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.35 | S3 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.25 | S3 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 1.83 | G1 | Flexure | 1.70 | G1 | Flexure | 1.08 |
| | Type 3S2 (OPR) | 1.83 | G1 | Flexure | 2.84 | G1 | Flexure | 0.65 |
| | SU4 (INV) | 1.68 | FB1 | Flexure | 1.50 | S3 | Flexure | 1.12 |
| | SU4 (OPR) | 1.68 | FB1 | Flexure | 2.50 | S3 | Flexure | 0.67 |
| **Permit** | NYP 6 | 1.18 | FB1 | Flexure | 1.67 | G1 | Flexure | 0.71 |
| | NYP 11 | 1.08 | FB1 | Flexure | 1.45 | G1 | Flexure | 0.75 |

## Girders

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 0.97 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.26 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.34 | G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.24 | G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.95 | G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.25 | G1 | Flexure | N/A |
| Legal | Type 3S2 (INV) | 1.83 | G1 | Flexure | 1.70 | G1 | Flexure | 1.08 |
| | Type 3S2 (OPR) | 1.83 | G1 | Flexure | 2.84 | G1 | Flexure | 0.65 |
| | SU4 (INV) | 1.78 | G1 | Flexure | 1.58 | G1 | Flexure | 1.09 |
| | SU4 (OPR) | 1.78 | G1 | Flexure | 2.65 | G1 | Flexure | 0.65 |
| Permit | NYP 6 | 1.66 | G1 | Flexure | 1.67 | G1 | Flexure | 0.98 |
| | NYP 11 | 1.43 | G1 | Flexure | 1.45 | G1 | Flexure | 0.97 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 1.12 | FB1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.46 | FB1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.64 | FB1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.74 | FB1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.64 | FB1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.74 | FB1 | Flexure | N/A |
| Legal | Type 3S2 (INV) | 2.06 | FB1 | Flexure | 1.98 | FB1 | Flexure | 1.21 |
| | Type 3S2 (OPR) | 2.06 | FB1 | Flexure | 3.31 | FB1 | Flexure | 0.72 |
| | SU4 (INV) | 1.68 | FB1 | Flexure | 1.62 | FB1 | Flexure | 1.06 |
| | SU4 (OPR) | 1.68 | FB1 | Flexure | 2.70 | FB1 | Flexure | 0.63 |
| Permit | NYP 6 | 1.18 | FB1 | Flexure | 1.90 | FB1 | Flexure | 0.71 |
| | NYP 11 | 1.08 | FB1 | Flexure | 1.74 | FB1 | Flexure | 0.75 |

**Stringers**

| Rating Level | Vehicle | LRFR Rating Factor | LRFR Member Type | LRFR Failure Mode | LFR Rating Factor | LFR Member Type | LFR Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 1.17 | S3 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.51 | S3 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.35 | S3 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.25 | S3 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.35 | S3 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.25 | S3 | Flexure | N/A |
| Legal | Type 3S2 (INV) | 2.19 | S3 | Flexure | 1.89 | S3 | Flexure | 1.16 |
| | Type 3S2 (OPR) | 2.19 | S3 | Flexure | 3.16 | S3 | Flexure | 0.69 |
| | SU4 (INV) | 1.74 | S3 | Flexure | 1.50 | S3 | Flexure | 1.16 |
| | SU4 (OPR) | 1.74 | S3 | Flexure | 2.50 | S3 | Flexure | 0.69 |
| Permit | NYP 6 | 1.91 | S3 | Flexure | 1.83 | S3 | Flexure | 1.04 |
| | NYP 11 | 1.73 | S3 | Flexure | 1.66 | S3 | Flexure | 1.04 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1046790 | N/A | 2.25 | S3 | N/A | 1.83 | G1 | N/A | 1.68 | FB1 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1046790 | Y | 2.25 | S3 | N/A | 1.18 | FB1 |

### *2.6.27 BIN 1004540 (3D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Girder Floorbeam Stringer** | Year Built: 1936 | Total length: 66 ft |
| Number of spans: 1 | Feature carried: 8 8 92031150 | Feature crossed: Great Brook |
| Location: Town of New Berlin, Chenango Ct. | Owner: State | ADTT: 117 |
| NYSDOT Condition Factor: 3.92 | Posted Load: No Posting | |

- **Analysis Methods:**
  LFR and LRFR: STAAD 3-D & MathCAD

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.05 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.36 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.55 | G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.65 | G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.94 | G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.85 | G1 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.14 | G1 | Flexure | 1.98 | G1 | Flexure | 1.08 |
| | Type 3S2 (OPR) | 2.14 | G1 | Flexure | 3.31 | G1 | Flexure | 0.65 |
| | SU4 (INV) | 2.04 | G1 | Flexure | 1.88 | G1 | Flexure | 1.09 |
| | SU4 (OPR) | 2.04 | G1 | Flexure | 3.19 | G1 | Flexure | 0.65 |
| **Permit** | NYP 6 | 1.89 | G1 | Flexure | 1.98 | G1 | Flexure | 0.97 |
| | NYP 11 | 1.63 | G1 | Flexure | 1.69 | G1 | Flexure | 0.98 |

## Girders

| | | **LRFR** | | | **LFR** | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| **Design** | HL-93 (INV) | 1.05 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.36 | G1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.55 | G1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.65 | G1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.94 | G1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 3.85 | G1 | Flexure | N/A |
| Legal | Type 3S2 (INV) | 2.14 | G1 | Flexure | 1.98 | G1 | Flexure | 1.08 |
| | Type 3S2 (OPR) | 2.14 | G1 | Flexure | 3.31 | G1 | Flexure | 0.65 |
| | SU4 (INV) | 2.04 | G1 | Flexure | 1.88 | G1 | Flexure | 1.09 |
| | SU4 (OPR) | 2.04 | G1 | Flexure | 3.19 | G1 | Flexure | 0.65 |
| Permit | NYP 6 | 1.89 | G1 | Flexure | 1.98 | G1 | Flexure | 0.97 |
| | NYP 11 | 1.63 | G1 | Flexure | 1.69 | G1 | Flexure | 0.98 |

## Floorbeams

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| Rating Level | Vehicle | LRFR Rating Factor | Member Type | Failure Mode | LFR Rating Factor | Member Type | Failure Mode | RF Ratio (LRFR/LFR) |
| Design | HL-93 (INV) | 1.98 | FB1 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.56 | FB1 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 2.52 | FB1 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 4.21 | FB1 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 3.55 | FB1 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 5.93 | FB1 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 3.48 | FB1 | Flexure | 3.46 | FB1 | Flexure | 1.01 |
| | Type 3S2 (OPR) | 3.48 | FB1 | Flexure | 5.77 | FB1 | Flexure | 0.60 |
| | SU4 (INV) | 2.76 | FB1 | Flexure | 2.74 | FB1 | Flexure | 1.01 |
| | SU4 (OPR) | 2.76 | FB1 | Flexure | 4.58 | FB1 | Flexure | 0.60 |
| **Permit** | NYP 6 | 2.93 | FB1 | Flexure | 3.24 | FB1 | Flexure | 0.91 |
| | NYP 11 | 2.53 | FB1 | Flexure | 2.79 | FB1 | Flexure | 0.91 |

## Stringers

| Rating Level | Vehicle | LRFR Rating Factor | LRFR Member Type | LRFR Failure Mode | LFR Rating Factor | LFR Member Type | LFR Failure Mode | RF Ratio (LRFR/LFR) |
|---|---|---|---|---|---|---|---|---|
| Design | HL-93 (INV) | 1.98 | S3 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.57 | S3 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 3.44 | S3 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 5.74 | S3 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 3.43 | S3 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 5.72 | S3 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 4.59 | S3 | Flexure | 3.86 | S3 | Flexure | 1.19 |
| | Type 3S2 (OPR) | 4.59 | S3 | Flexure | 6.44 | S3 | Flexure | 0.71 |
| | SU4 (INV) | 3.74 | S3 | Flexure | 3.14 | S3 | Flexure | 1.19 |
| | SU4 (OPR) | 3.74 | S3 | Flexure | 5.25 | S3 | Flexure | 0.71 |
| **Permit** | NYP 6 | 4.11 | S3 | Flexure | 3.84 | S3 | Flexure | 1.07 |
| | NYP 11 | 3.70 | S3 | Flexure | 3.45 | S3 | Flexure | 1.07 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1004540 | N/A | 3.23 | G1 | N/A | 2.14 | G1 | N/A | 2.04 | G1 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1004540 | Y | 3.23 | G1 | N | 1.89 | G1 |

### *2.6.28 BIN 1004279 (2D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Multi-Girder Bridge** | Year Built: 1969 | Total length: 1424 ft |
| Number of spans: 8 | Feature carried: Route 2 | Feature crossed: Hudson River |
| Location: City of Watervliet, Albany County | Owner: State | ADTT: 351 |
| NYSDOT Condition Factor: 4.78 | Posted Load: No Posting | |

- **Analysis Methods:**
LFR and LRFR: AASHTOWARE BrR (Only Spans 1, 2, 3 and 4)

- **Level I Load Rating Summary (2D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.27 | Span 2 G5 | Flexure | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 1.65 | Span 2 G5 | Flexure | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.67 | Span 3-4 G5 | Flexure | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.79 | Span 3-4 G5 | Flexure | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.67 | Span 3-4 G5 | Flexure | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.79 | Span 3-4 G5 | Flexure | N/A |
| **Legal** | Type 3S2 (INV) | 2.06 | Span 2 G5 | Flexure | 2.28 | Span 2 G1 | Flexure | 0.90 |
| | Type 3S2 (OPR) | 2.06 | Span 2 G5 | Flexure | 3.80 | Span 2 G1 | Flexure | 0.54 |
| | SU4 (INV) | 2.25 | Span 2 G5 | Flexure | 2.44 | Span 2 G1 | Flexure | 0.92 |
| | SU4 (OPR) | 2.25 | Span 2 G5 | Flexure | 4.08 | Span 2 G1 | Flexure | 0.55 |
| **Permit** | NYP 6 | 3.02 | Span 2 G5 | Flexure | 2.33 | Span 2 G1 | Flexure | 1.30 |
| | NYP 11 | 2.77 | Span 2 G5 | Flexure | 2.11 | Span 2 G1 | Flexure | 1.31 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1004279 | N/A | 2.79 | Span 3-4 G5 | N/A | 2.06 | Span 2 G5 | N/A | 2.25 | Span 2 G5 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1004279 | N | 2.79 | Span 3-4 G5 | N | 3.02 | Span 2 G5 |

### *2.6.29 BIN 1004279 (3D)*

- **General Description**

| | | |
|---|---|---|
| Type: **Steel Multi-Girder Bridge** | Year Built: 1969 | Total length: 1424 ft |
| Number of spans: 8 | Feature carried: Route 2 | Feature crossed: Hudson River |
| Location: City of Watervliet, Albany County | Owner: State | ADTT: 351 |
| NYSDOT Condition Factor: 4.78 | Posted Load: No Posting | |

- **Analysis Methods:**
LFR and LRFR: STAAD 3-D (Only Spans 1 and 5-8)

- **Level I Load Rating Summary (3D):**

**Controlling Ratings**

| | | LRFR | | | LFR | | | |
|---|---|---|---|---|---|---|---|---|
| **Rating Level** | **Vehicle** | **LRFR Rating Factor** | **Member Type** | **Failure Mode** | **LFR Rating Factor** | **Member Type** | **Failure Mode** | **RF Ratio (LRFR/LFR)** |
| **Design** | HL-93 (INV) | 1.60 | Span 5-7 G9 | Shear | N/A | N/A | N/A | N/A |
| | HL-93 (OPR) | 2.07 | Span 5-7 G9 | Shear | N/A | N/A | N/A | N/A |
| | HS20 (INV) | N/A | N/A | N/A | 1.44 | Span 5-7 G9 | Shear | N/A |
| | HS20 (OPR) | N/A | N/A | N/A | 2.40 | Span 5-7 G9 | Shear | N/A |
| | H20 (INV) | N/A | N/A | N/A | 1.43 | Span 5-7 G9 | Shear | N/A |
| | H20(OPR) | N/A | N/A | N/A | 2.39 | Span 5-7 G9 | Shear | N/A |
| **Legal** | Type 3S2 (INV) | 3.25 | Span 5-7 G9 | Shear | 2.50 | Span 5-7 G9 | Shear | 1.30 |
| | Type 3S2 (OPR) | 3.25 | Span 5-7 G9 | Shear | 4.17 | Span 5-7 G9 | Shear | 0.78 |
| | SU4 (INV) | 4.06 | Span 8 G9 | Flexure | 3.15 | Span 5-7 G9 | Shear | 1.29 |
| | SU4 (OPR) | 4.06 | Span 8 G9 | Flexure | 5.25 | Span 5-7 G9 | Shear | 0.77 |
| **Permit** | NYP 6 | 3.07 | Span 5-7 G9 | Shear | 2.57 | Span 5-7 G9 | Shear | 1.19 |
| | NYP 11 | 2.91 | Span 5-7 G9 | Shear | 2.44 | Span 5-7 G9 | Shear | 1.19 |

- **Load Posting Summary**

| NBI Structure ID | LFR Posting | | | LRFR Posting | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | H20 | | | Type 3S2 | | | SU4 | | |
| | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member | Posting Load (tons) | Rating Factor | Controlling Member |
| 1004279 | N/A | 2.39 | Span 5-7 G9 | N/A | 3.25 | Span 5-7 G9 | N/A | 4.06 | Span 8 G9 |

- **R – Posting Summary**

| NBI Structure ID | LFR R-Posting | | | LRFR R-Posting | | |
|---|---|---|---|---|---|---|
| | R-Posting Vehicle: H20 | | | R-Posting Vehicle: NYP 6 | | |
| | R-Posted | Rating Factor | Controlling Member | R-Posted | Rating Factor | Controlling Member |
| 1004279 | N | 2.39 | Span 5-7 G9 | N | 3.07 | Span 5-7 G9 |

# 3 Special Studies to Support LRFR Implementation

## 3.1 Evaluation of the impact of individual AASHTO Specialized Hauling Vehicles (SHV) on LFR and LRFR Postings in New York State

### *3.1.1 Task Scope*

The scope of this task was to investigate two related issues pertaining to the use of Specialized Hauling Vehicles (SHVs) in load ratings and postings:

1. Update EI 05-034 and LFR posting to include SHVs
2. Rerun Level II ratings to ascertain impact of using SU5, SU6 & SU7, in addition to SU4 in LRFR postings.

The goal of the study was to assess the impact of SHVs on the NYSDOT bridge inventory. Currently ratings and postings are performed using EI 05-034 which utilizes the LFR method and the H-20 truck. SU4 is the only single unit truck that was used in initial Level II load rating study. Including all SHV trucks will have an impact on both LFR and LRFR postings. Revisions to EI 05-034 and the draft LRFR EI, developed to follow bridge LRFR methodology as specified in the AASHTO Manual for Bridge Evaluation, have been developed based on this study results.

Level II ratings were initially performed on 314 bridges without including all SHVs, using the AASHTOWare BrR software. Each bridge was analyzed for live loads including HL-93, HS-20, H-20, AASHTO Type 3S2, AASHTO SU4, and NYP 1 thru NYP 13 permits. The AASHTO SU4 vehicle is the most critical vehicle for rating and posting among the AASHTO SHVs. As NYSDOT posts bridges for a single tonnage for all vehicles, it became evident that SU4 alone would suffice to determine the lowest posting value. However, there could be bridges that do not need posting for SU4 but may need posting for one of the other SHVs. This could expand the number of posted bridges for SHVs. After evaluation of all the SHV trucks and their load effects it became apparent that the influence of the other SHVs (SU5, SU6, and SU7) should also be considered. Task 4-6 reran the 314 Level II bridges in BrR with the SU4, SU5, SU6, and SU7 vehicles for LRFR and the H-20 for LFR. The SU4 and H-20 were rerun to ensure that consistent results are compared since the version of BrR has changed (from 6.4 to 6.5). Incorporating the three heavier SHVs and testing the draft EIs for posting using those results provided the most accurate information for NYSDOT in its policy evaluation and implementation.

### *3.1.2 Evaluation of Rating and Posting Updates*

HNTB has completed several Level I and Level II ratings for the project to date to develop comparisons between LFR and LRFR evaluations. The single largest global difference between LFR Operating and

LRFR (single reliability level for Legal Loads) is the different live load factors that are applied. Since the live load factors for LRFR are a function of the traffic at the bridge site (through ADTT) there is not a single relationship between the two. However, beyond this difference, there are a number of other differences between the two approaches that also vary such as live load distribution and available capacity for live load (resistance minus factored dead load). Because there are many variables that cause differences in the results the best approach to evaluating the change from LFR to LRFR and implications for posting policy is by using a sample data set.

Level II ratings were performed on 314 bridges using both Load Factor Rating and Load and Resistance Factor Rating. The Level II ratings were performed using BrR and the resulting postings using existing and proposed NYSDOT EIs were evaluated in Excel spreadsheets. Three different posting values were calculated for LFR to match 1) the current EI, 2) the proposed EI with SU4 and SU5 only included, and 3) the proposed EI with all four SHVs included.

The AASHTO SU4 vehicle is the most critical vehicle for rating and posting using the AASHTO SHVs. Here critical has the meaning that the posting load based on a SU4 vehicle will be lower than the posting load based on any of the other three SHVs. Using a single SHV for rating is appropriate as NYSDOT uses a single tonnage for posting. However, this posting practice can be conservative for the other SHVs, which can be safely allowed to cross at a higher tonnage as the loads are distributed over more axles. SU4 vehicle has a legal weight of 27 tons and SU7 is more than 10 tons heavier. Both the LFR posting evaluation and the LRFR posting evaluation has found that a significant percentage of the NYSDOT data set would require postings above 27 tons for the heavier SHVs. This is because SU5, SU6 and SU7 will have lower Rating Factors than SU4 which may drop below 1.0 even when the SU4 RF is higher than 1.0, triggering the posting of more number of bridges. The SU7 vehicle requires posting on the largest number of bridges. For this data set, any bridge that requires posting for any of the SHVs requires posting for the SU7. It was noted that as the posting load exceeds the weight of a legal SU4 (27 Tons) other bridges that were previously un-posted would require posting for the other SHVs. For the 314 Level II bridges the number of additional posting when all SHVs are included is as follows:

- 154 of 314 bridges require posting for SU7,
- 142 bridges require posting for SU6,
- 119 bridges require posting for SU5
- 102 bridges require posting for SU4.

### *3.1.3 Evaluation of SHV Loading on LFR Posting*

New York State currently has its own methodology for legal load posting of bridges using the Load Factor Rating (LFR) method. New York State posts bridges using signs with a single tonnage value. NYSDOT EI 05-034 explains the step by step procedures and requirements for load posting. Current NY load posting procedures consider AASHTO Type 3, 3-S2 and 3-3 legal loads. Studies have found that this selection of trucks is not representative of all legal loads. It is shown that NYSDOT load posting procedures are insufficient in developing adequate posting weights. Per NCHRP Project 12-63 (Report 575, 2007), there is an immediate need to incorporate SHVs into a State's load rating and posting process.

Figure 3.1 below outlines a total of 7 legal vehicles that will serve as the new required basis for load posting. To account for this new load posting criteria, EI 05-034 Tables 1 and 3 should be revised.

| LEGAL LOADS | |
|---|---|
| **Typical Legal Loads** | **SPECIALIZED HAULING VEHICLES (SHV)** |
| Type 3 | SU4 |
| Type 3S2 | SU5 |
| Type 3-3 | SU6 |
| | SU7 |

**Figure 3.1** – New Legal Load Vehicle Library

### *3.1.4 H Equivalent Calculation*

Table 1 of EI 05-034 has been revised by replacing it with two tables (see Figure 3.2 below). These tables show H equivalent loads with the incorporation of SHVs. Table 1a provides the H equivalents for all 7 legal vehicles defined above. Table1b provides H equivalents for 5 of the legal loads defined above in Figure 3.1 (excluded vehicles are SU6 and SU7).

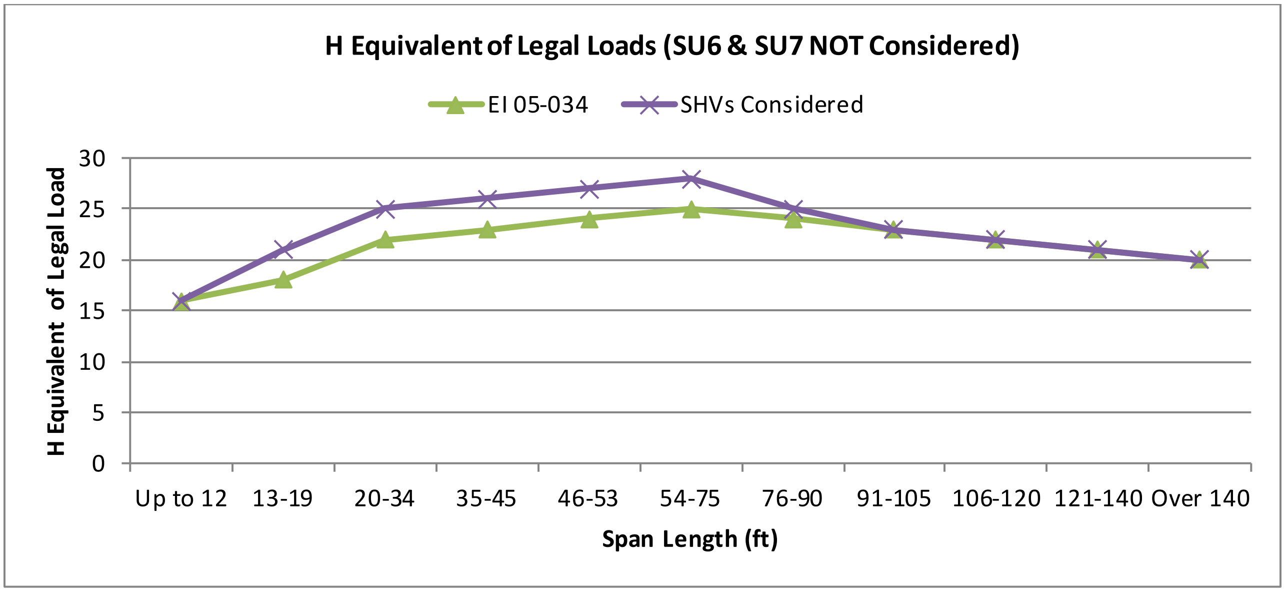
| TABLE 1a | |
|---|---|
| "H" - LOADING EQUIVALENT TO LEGAL LOADS | |
| Effective Span Length (ft.) | H Equivalent Legal Load |
| Up to 12 | H16 |
| 13-19 | H22 |
| 20-34 | H29 |
| 35-45 | H31 |
| 46-53 | H33 |
| 54-75 | H32 |
| 76-90 | H30 |
| 91-105 | H28 |
| 106-120 | H26 |
| 121-140 | H25 |
| Over 140 | H23 |

| TABLE 1b | |
|---|---|
| "H" - LOADING EQUIVALENT TO LEGAL LOADS (EXCLUDING SU6 & SU7) | |
| Effective Span Length (ft.) | H Equivalent Legal Load |
| Up to 12 | H16 |
| 13-19 | H21 |
| 20-34 | H25 |
| 35-45 | H26 |
| 46-53 | H27 |
| 54-75 | H27 |
| 76-90 | H25 |
| 91-105 | H23 |
| 106-120 | H22 |
| 121-140 | H21 |
| Over 140 | H19 |

**Figure 3.2** – Revised EI 05-034 Table 1.

Fig. 3.3 shows a side by side comparison of the original H equivalent values in EI 05-034 vs. new values that consider SHVs. Table 1a and Table 1b in Figure 3.3 are based on the maximum moment effect of the legal loads compared to the maximum moment effect of the H loading for simple spans. EI 05-034 provides modifications to the actual span length to determine the effective span length to account for continuity. The table is developed by comparing the moment effect of each legal load to the H configuration and computing the H vehicle tonnage to match the largest of each of the legal load moments. It should be noted that the SU5 truck controls for Table 1a and that the SU7 truck controls for Table 1b. This is because SU5 and SU7 trucks have higher legal moment to H moment ratios than SU4 and SU 6 trucks respectively. Although this is the case it is not also necessarily true that they would have the lowest posting load. Table 1a and Table 1b in Figure 3.2 are a decision step in the posting process flow. If the H Operating rating is greater than the H Equivalent Legal Load for the span of the bridge then no posting is required and the process stops. If the H Operating rating is lower than the H Equivalent Legal Load for the span of the bridge then the posting process continues. The EI Table 1 value does not enter any of the following steps. The relationship between EI Table 1 and EI Table 3 is discussed later.

Among all the SHVs, SU6 and SU7 have a considerably greater impact on increasing the H equivalent values than SU4 and SU5 trucks. Also, at this time, the SU6 and SU7 vehicles are not as common in New York as the AASHTO legal load configurations and the SU4 and SU5 vehicles. For these reasons, Table 1b has been provided as a way for NYSDOT to evaluate the differential impact of SHVs. It is expected that either one of the two sets of tables will be finally retained for the revised EI 05-034 using the LFR method or that a mapping to regions and/or routes will be provided to determine which table to use.



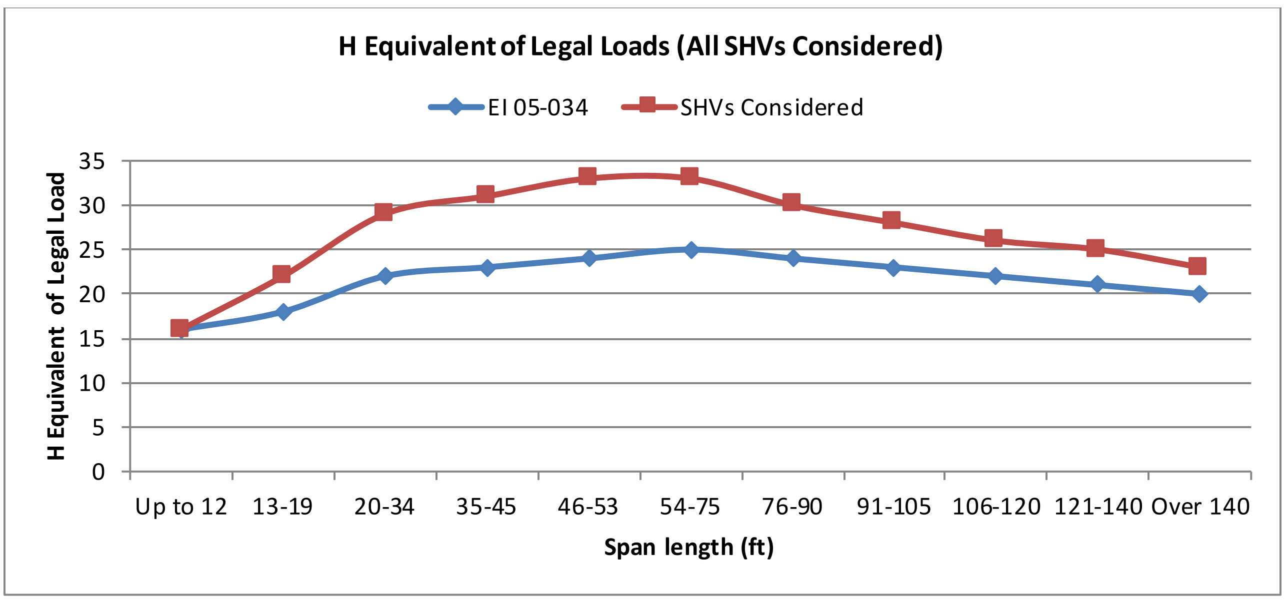




**Figure 3.3** – H Loading Equivalent Plot Comparison

### *3.1.5 Adjusting the H Equivalent of Legal Load for Different Legal Truck Variations:*

EI 05-034 states that the Safe Load Capacity (SLC) may be used directly as the posting value. However, this may be over-conservative for legal loads (including SHV vehicles). The SLC is based on a 2-axle truck with axles spaced 14' apart (H-Type axle configuration). Legal trucks (including SHVs) have spacings both greater than and less than an H-type truck. Legal spacings range from 4 ft. to 22 ft. When calculating legal posting loads, differing axle configurations need to be considered to adjust the single valued tonnage capacity.

In terms of converting SLC values to posting values, if the legal weight limit is not considered:

- Type 3 axle configuration will always control for typical legal trucks (3, 3S2, and 3-3)
- SU4 axle configuration will always control for SHVs (SU4, SU5, and SU6)
- SU4 axle configuration will always control for all legal trucks (3, 3S2, 3-2, SU4, SU5, SU6, and SU7)

If the legal weight limit of the vehicle is also considered, then the SU4 will govern postings except where the posting weight is greater than the legal SU4 weight. The governing vehicle then switches to the SU5 until the posting load is greater than the legal SU5 weight and so forth.

Converting all SHV SLCs to posting values using an SU4 configuration would be a conservative method for load posting. This would take the governing axle configuration and apply it to all trucks. Under this method, SU4 will have an exact posting. SU5, SU6, and SU7 trucks will post conservatively in an order following the scale shown below:

**Using Revised Table 3:**

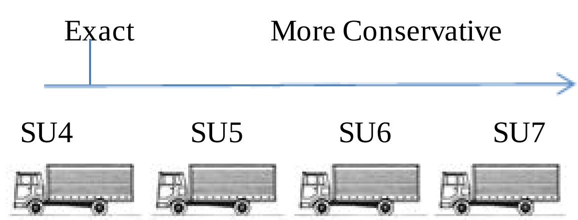



**Figure 3.4** – Conservativeness of SHV Posting Using Revised Table 3.

The conservatism in using SU6 and SU7 posting can however be partially accounted for and reduced by applying the following methodology:

SU6 and SU7 vehicles require posting over a larger range of SLC's than SU4 and SU5 trucks (see revised EI Table 1). In other words, yellow values in the revised EI Table 3 (see Fig. 3.6) do not apply SU4 or SU5 trucks. SLCs for these instances can be converted to posting values using the governing SU6 truck configuration (instead of SU4). This reduces the conservativeness of load postings for SU6 and SU 7 trucks having relatively high SLC. For these values, SU6 trucks will post exactly and SU7 trucks will be slightly conservative. SU6 and SU7 trucks on trucks with low SLC (green area on the revised EI Table 3) will still post more conservatively based on an SU4 configuration. There is no way to reduce this conservatism without instituting separate posting tonnages for separate vehicles.

Figure 3.5 below outlines how legal loads were grouped in our analysis. It also shows the corresponding controlling axle configuration for each grouping.

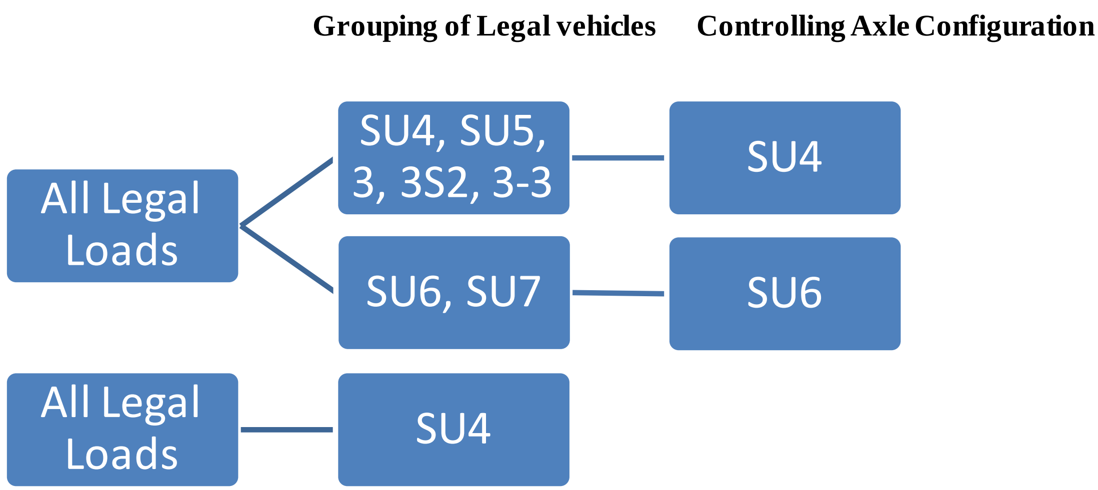



**Figure 3.5** – Grouping of Legal Trucks for Table 3 and Controlling Axle Configurations.

One table replaces Table 3 of EI 05-034. The revised table 3 is proposed in Figure 3.6. This table incorporates SHV vehicles. The safe posting load for SHVs was found by applying the equation:

$$SHV\ Posting\ Load\ (tons) = \frac{H20\ Moment\ (kip\ ft) \times H20\ R.F.\ x\ SHV\ Legal\ Gross\ Weight(tons)}{SHV\ Legal\ Moment\ (kip\ ft)}$$

## TABLE 3

### MAXIMUM POSTING VALUE (TONS)

| | | "Safe Load Capacity" (Based on H Type Truck) | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Bound | >10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 |
| Up to 12 | | 12 | 15 | 16 | 18 | 20 | 22 | | | | | | | | | | | | | | | | | | | | |
| 13-19 | | 10 | 12 | 14 | 15 | 16 | 18 | 20 | 22 | 24 | 26 | 27 | 34 | | | | | | | | | | | | | | |
| 20-34 | | 10 | 12 | 12 | 14 | 15 | 16 | 16 | 18 | 18 | 20 | 22 | 22 | 25 | 27 | 28 | 32 | 34 | 37 | 38 | | | | | | | |
| 35-45 | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 | 18 | 20 | 20 | 22 | 22 | 25 | 26 | 29 | 31 | 32 | 33 | 36 | 37 | | | | | |
| 46-53 | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 22 | 24 | 26 | 27 | 30 | 31 | 32 | 33 | 36 | 37 | 38 | | | |
| 54-64 | Use SLC | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 22 | 24 | 25 | 27 | 29 | 30 | 32 | 33 | 34 | 37 | 38 | | | |
| 65-75 | | 10 | 12 | 12 | 14 | 15 | 16 | 16 | 18 | 20 | 20 | 22 | 22 | 24 | 25 | 25 | 29 | 31 | 32 | 33 | 34 | 36 | 38 | | | | |
| 76-90 | | 10 | 12 | 14 | 15 | 16 | 18 | 18 | 20 | 20 | 22 | 24 | 25 | 25 | 25 | 30 | 31 | 32 | 34 | 36 | 37 | | | | | | |
| 91-105 | | 10 | 12 | 15 | 16 | 16 | 18 | 20 | 22 | 22 | 24 | 25 | 25 | 28 | 31 | 32 | 34 | 36 | 37 | | | | | | | | |
| 106-120 | | 12 | 14 | 15 | 18 | 18 | 20 | 22 | 22 | 25 | 25 | 28 | 28 | 32 | 33 | 35 | 37 | | | | | | | | | | |
| 121-140 | | 12 | 16 | 18 | 20 | 20 | 22 | 25 | 25 | 28 | 28 | 30 | 33 | 34 | 36 | 38 | | | | | | | | | | | |
| 141 | | 12 | 16 | 18 | 20 | 20 | 22 | 25 | 25 | 28 | 30 | 34 | 36 | 38 | | | | | | | | | | | | | |

(green) = Based on SU4 or SU5 Axle Configuration

(yellow) = Based on SU6 or SU7 Axle Configuration

**Figure 3.6** – Revised EI 05-034 Table 3.

This table would be used in the same manner as the existing Table 3 in EI 05-034 except that the table illustrates the change in controlling vehicles from the SU4 and SU5 to the range with the SU6 and SU7.

The overall shape of EI Table 3 is dictated by the magnitude of the H equivalent values from EI Table 1. The rows of EI Table 3 extend out to a SLC equal to the value given in Table 1a and Table 1b. A single Table 3 can represent both versions of Table 1 by demarking the change between results based on the two tables. Table 3 gives posting values for only for span ranges that have an SLC less than the H Equivalent rating of a legal load. For example, per Table 1a, a SU7 truck on a 46ft span bridge has an H equivalent for legal load of 33 Tons. This would mean that posting tonnages need to be generated for SLCs less than 33 tons. Because H equivalent values have increased to up to 33 tons in Table 1, Table 3 should be expanded up to 32 tons.

### *3.1.6 General Comments*

The proposed EI Table 1a or EI Table 1b values are compared to the H Operating rating. If the H Operating rating exceeds the table value, then no posting is needed. If the H Operating rating does not exceed the EI Table 1a/1b value, then a SLC is determined. The factors in the existing EI Table 2 are applied to the H Operating rating to determine the SLC. After determining the SLC from EI Table 2 the matching version of EI Table 3 is used to determine the maximum single value posting load in tons that can be applied to the bridge.

The original Table 3 in EI 05-034 has some conservative load posting values based on objectives such as lower limits for lower SLC values. This approach is consistent with the LRFR approach where posting values are determined by a formula that reduces the posting for lower rating bridges. To keep this intact, the values in the proposed Table 3 were limited to a maximum of the value in the current EI 05-034 Table 3. This is only the case for lower SLC values. In addition, to keep results conservative, values in the revised EI Table 3 are rounded down to the nearest integer value and results in EI Table 1 are rounded up to the nearest integer value. Conservative rounding in combination with conservatism in using controlling axle configurations is a consistent basis for ensuring safety in our analysis.

If posting values were calculated to be higher than the maximum permissible GVW for a given truck, the posting values were omitted from EI Table 3. The next governing vehicle in terms of axle configuration would then be used for converting SLC to a posting load. Trucks with weights greater than their maximum GVW incorrectly skew the results by lowering posting loads. These trucks are not allowed on NY roadways and should not be considered for posting.

By enveloping all trucks into a single posting value, it is an unavoidable predicament that certain trucks are forced to adhere to a posting value intended for a different governing truck. As stated before, SU5 and SU7 trucks control for EI Table 1 results. SU4 and SU6 are considered controlling weights/axle configurations for calculation of EI Table 3 results. It was in our interests to match the controlling truck from EI Table 1 with the controlling truck from EI Table 2 to be conservative. With this method, there may be a few cases where EI Table 1 suggests SU4 or SU6 trucks are required to be posted when really it is only necessary for the SU5 or SU7 trucks to be posted. At these instances, posting tonnages are sometimes returned higher than their maximum GVW. For these instances SU5 or SU7 posting values can be substituted. This process serves as a correction for the conservatism of EI Table 1. The example below outlines the processes for removing posting values returned greater than the maximum GVW:

Example:

Consider a 45ft bridge with an SLC of H25. The two tables were first constructed in Fig 3.7 below. Figure 3.7a shows posting values for an SU4 truck only. Figure 3.7b shows posting values for a SU5 truck only. As expected, SU4 always controls. However, the cell in the table at a span of 45 ft and SLC of H25 indicates 28 Tons. This is greater than the maximum GVW of 27 tons for a SU4. This suggests that Table 1a instructed us to overly conservatively post for a SU4 truck. To correct for this, we use Figure 3.7b and pick out the posting value of 29 tons for an SU5 truck. The same process is repeated for SU 6 and SU7 trucks using another set of two tables. Finally, these 4 tables were combined into Table 3 that is shown in Figure 3.6.

**Figure 3.7a. SU4 TRUCK MAXIMUM POSTING VALUE (TONS)**

| | | "Safe Load Capacity" (Based on H Type Truck) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Bound | >10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Up to 12 | Use SLC | 16 | 18 | 20 | 21 | 23 | 25 | | | | | | | | | | | | |
| 13-19 | | 13 | 15 | 16 | 17 | 19 | 20 | 21 | 23 | 24 | 26 | 27 | | | | | | | |
| 20-34 | | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 20 | 21 | 22 | 23 | 24 | 25 | 27 | 28 | | | |
| 35-45 | | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 28 | | |
| 46-53 | | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | |
| 54-64 | | 10 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 29 |
| 65-75 | | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 76-90 | | 12 | 13 | 14 | 15 | 17 | 18 | 19 | 20 | 21 | 23 | 24 | 25 | 26 | 28 | 29 | | | |
| 91-105 | | 13 | 14 | 15 | 17 | 18 | 19 | 21 | 22 | 23 | 25 | 26 | 27 | 29 | | | | | |
| 106-120 | | 14 | 15 | 17 | 18 | 20 | 21 | 23 | 24 | 25 | 27 | 28 | 30 | | | | | | |
| 121-140 | | 15 | 16 | 18 | 20 | 21 | 23 | 24 | 26 | 27 | 29 | 30 | | | | | | | |
| 141 | | 16 | 18 | 20 | 22 | 23 | 25 | 27 | 28 | 30 | 32 | | | | | | | | |

**Figure 3.7b. SU5 TRUCK MAXIMUM POSTING VALUE (TONS)**

| | | "Safe Load Capacity" (Based on H Type Truck) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Bound | >10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| Up to 12 | Use SLC | 19 | 21 | 23 | 25 | 27 | 29 | | | | | | | | | | | | |
| 13-19 | | 13 | 15 | 16 | 17 | 19 | 20 | 21 | 23 | 24 | 26 | 27 | | | | | | | |
| 20-34 | | 11 | 12 | 14 | 15 | 16 | 17 | 18 | 20 | 21 | 22 | 23 | 24 | 25 | 27 | 28 | | | |
| 35-45 | | 11 | 13 | 14 | 15 | 16 | 17 | 19 | 20 | 21 | 22 | 23 | 25 | 26 | 27 | 28 | 29 | | |
| 46-53 | | 11 | 12 | 13 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 30 | |
| 54-64 | | 11 | 12 | 13 | 14 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 65-75 | | 11 | 13 | 14 | 15 | 16 | 17 | 19 | 20 | 21 | 22 | 23 | 25 | 26 | 27 | 28 | 29 | 31 | 32 |
| 76-90 | | 12 | 13 | 15 | 16 | 17 | 18 | 20 | 21 | 22 | 23 | 25 | 26 | 27 | 28 | 30 | | | |
| 91-105 | | 13 | 14 | 16 | 17 | 19 | 20 | 21 | 23 | 24 | 25 | 27 | 28 | 29 | | | | | |
| 106-120 | | 14 | 16 | 17 | 19 | 20 | 22 | 23 | 25 | 26 | 27 | 29 | 30 | | | | | | |
| 121-140 | | 15 | 17 | 18 | 20 | 22 | 23 | 25 | 26 | 28 | 29 | 31 | | | | | | | |
| 141 | | 17 | 19 | 20 | 22 | 24 | 25 | 27 | 29 | 31 | 32 | | | | | | | | |

**Figure 3.7** – SU4 and SU5 Truck Maximum Posting Values (tons)

### *3.1.7 Evaluation of SHV Loading on LRFR Posting*

Unlike the LFR method using EI 05-034, the LRFR method requires comparisons of the rating results for the different load rating vehicles. The draft LRFR EI requires load ratings be performed for all appropriate vehicles but still keeps the New York single tonnage signing for posting.

154 of 314 bridges require posting for the SU7, 142 bridges require posting for the SU6, 119 bridges require posting for the SU5, and 102 bridges require posting for the SU4. The number of bridges by each type that have a rating factor less than 1.0 for each of the four SHVs are shown in Tables 3.1 to 3.4.

**Table 3.1 –** Bridges with LRFR SU4 RF < 1.0

| BRIDGE TYPES | LOCAL | STATE | TOTAL |
|---|---|---|---|
| Reinforced Concrete Slab | 6 | 2 | 8 |
| Reinforced Concrete T-Beam | 2 | 10 | 12 |
| PS Box Beam | 0 | 0 | 0 |
| Simple Span PS Multi Girder | 2 | 0 | 2 |
| Continuous Span PS Multi Girder | 0 | 0 | 0 |
| Simple Span Steel Multi Girder | 66 | 12 | 78 |
| Continuous Span Steel Multi Girder | 0 | 2 | 2 |
| TOTAL | 76 | 26 | 102 |

**Table 3.2 –** Bridges with LRFR SU5 RF < 1.0

| BRIDGE TYPES | LOCAL | STATE | TOTAL |
|---|---|---|---|
| Reinforced Concrete Slab | 6 | 4 | 10 |
| Reinforced Concrete T-Beam | 3 | 11 | 14 |
| PS Box Beam | 1 | 0 | 1 |
| Simple Span PS Multi Girder | 2 | 0 | 2 |
| Continuous Span PS Multi Girder | 0 | 0 | 0 |
| Simple Span Steel Multi Girder | 73 | 15 | 88 |
| Continuous Span Steel Multi Girder | 1 | 3 | 4 |
| TOTAL | 86 | 33 | 119 |

**Table 3.3 –** Bridges with LRFR SU6 RF < 1.0

| BRIDGE TYPES | LOCAL | STATE | TOTAL |
|---|---|---|---|
| Reinforced Concrete Slab | 8 | 6 | 14 |
| Reinforced Concrete T-Beam | 4 | 11 | 15 |
| PS Box Beam | 1 | 0 | 1 |
| Simple Span PS Multi Girder | 2 | 1 | 3 |
| Continuous Span PS Multi Girder | 0 | 0 | 0 |
| Simple Span Steel Multi Girder | 83 | 19 | 102 |
| Continuous Span Steel Multi Girder | 2 | 5 | 7 |
| TOTAL | 100 | 42 | 142 |

**Table 3.4 –** Bridges with LRFR SU7 RF < 1.0

| BRIDGE TYPES | LOCAL | STATE | TOTAL |
|---|---|---|---|
| Reinforced Concrete Slab | 9 | 6 | 15 |
| Reinforced Concrete T-Beam | 4 | 12 | 16 |
| PS Box Beam | 1 | 1 | 2 |
| Simple Span PS Multi Girder | 3 | 2 | 5 |
| Continuous Span PS Multi Girder | 0 | 0 | 0 |
| Simple Span Steel Multi Girder | 86 | 23 | 109 |
| Continuous Span Steel Multi Girder | 2 | 5 | 7 |
| TOTAL | 105 | 49 | 154 |

The NYSDOT draft EI for LRFR ratings requires that the 3S2 and the SU4 vehicles be considered for the posting load analysis. Prior to Task 4-6 the number of bridges requiring posting using LRFR for the 3S2 legal load was determined. Tables 3.5 and 3.6 show the number of bridges requiring posting for all SHVs (which is the same as bridges requiring posting for SU7) and the number of bridges requiring posting for 3S2. As expected posting for SHV loads requires a much greater number of bridge postings than posting for 3S2 alone.

**Table 3.5 –** Bridges Requiring LRFR Posting for SHVs

| BRIDGE TYPES | LOCAL | STATE | TOTAL |
|---|---|---|---|
| Reinforced Concrete Slab | 9 | 6 | 15 |
| Reinforced Concrete T-Beam | 4 | 12 | 16 |
| PS Box Beam | 1 | 1 | 2 |
| Simple Span PS Multi Girder | 3 | 2 | 5 |
| Continuous Span PS Multi Girder | 0 | 0 | 0 |
| Simple Span Steel Multi Girder | 86 | 23 | 109 |
| Continuous Span Steel Multi Girder | 2 | 5 | 7 |
| TOTAL | 105 | 49 | 154 |

**Table 3.6 –** Bridges Requiring LRFR Posting for 3S2

| BRIDGE TYPES | LOCAL | STATE | TOTAL |
|---|---|---|---|
| Reinforced Concrete Slab | 4 | 0 | 4 |
| Reinforced Concrete T-Beam | 1 | 7 | 8 |
| PS Box Beam | 0 | 0 | 0 |
| Simple Span PS Multi Girder | 2 | 0 | 2 |
| Continuous Span PS Multi Girder | 0 | 0 | 0 |
| Simple Span Steel Multi Girder | 40 | 8 | 48 |
| Continuous Span Steel Multi Girder | 0 | 3 | 3 |
| TOTAL | 47 | 18 | 65 |

The study here has shown that while the SU4 is the most critical posting load that it does not conservatively indicate posting loads for bridges that should be posted for loads above 27 tons. One way this can be resolved is by using a higher rating factor than 1.0 as the basis for posting using the SU4. Based on the 314 bridges, using a rating factor of 1.32 as the basis to post bridges using the SU4 rating factor would capture all bridges that would need to be posted for any of the SHVs. This recommendation has been incorporated in the draft EI for LRFR Section 6A.8.2. Since using the SU4 in this manner is conservative it results in posting loads for 171 bridges instead of the 154 based off of considering each of the four SHVs as posting loads. Rounding the limit to 1.3 would result in two bridges in the data set that would have a high posting for SU7 (both 38 tons instead of the 38.75 ton legal limit) that would instead be unposted for any loads using SU4 only. This would appear to be reasonable and more consistent with the general level of precision that should be inferred with the posting factors.

LFR results based on H20 loading using the current EI would require posting 81 bridges. If the SU4 and SU5 loads are included the number of bridges requiring posting increases to 118. If the SU6 and SU7 loads are included the number of bridges requiring posting increases to 163. In both these increased cases the rating does not explicitly include the SHVs through the rating process but includes them through modified versions of the tables in EI 05-034 which ratio the H20 load effect to determine a Safe Load Capacity (SLC) that indirectly includes the SHVs.

A histogram of ratios of LFR Operating H20 ratings to LRFR SU4 ratings is given in Figure 3.8. The histogram displays the anticipated shape which reasonably follows a normal distribution. On average H20 ratings using LFR at Operating are higher than SU4 ratings using LRFR by a factor of 1.43. It is not surprising that the distribution is a random function with a fairly high relative standard deviation. The update to the LRFR approach with new rating and posting vehicles should not have a deterministic correlation to the prior LFR approach. If it did, the revisions could be achieved by just rescaling the LFR results instead of updating the methodology.

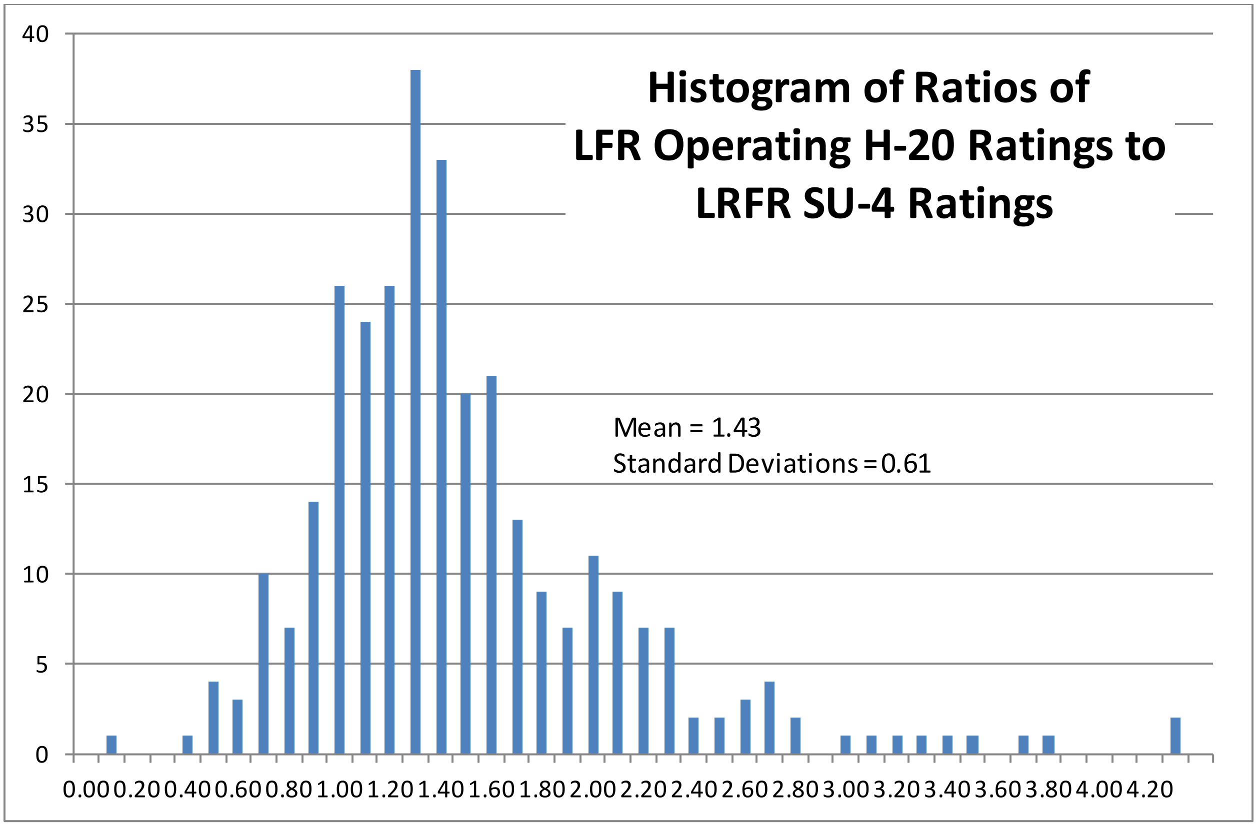



**Figure 3.8** – Histogram of Ratios of LFR Operating H20 Ratings to LRFR SU4 Ratings

The set of bridges are characterized by the type of superstructure. Figure 3.9 shows the frequency of load postings using the three variations of LFR EI 05-034 in Table 2 and the frequency of load posting for each of the SHVs using the draft LRFR EI for all structure types. Same frequency of load postings is shown in Figure 3.10 in closer view for each structure type. With every bridge type the number of postings increases as the larger SHVs are included for both the LFR and LRFR postings. The base LFR method does not include any SHVs and therefore it has the lowest frequencies for any bridge type except for the Continuous Span Steel Multi Girder bridges.

| Code | Definition |
|---|---|
| RCS | Reinforced Concrete Slab |
| RCT | Reinforced Concrete T-Beam |
| PSB | PS Box Beam |
| PMGS | Simple Span PS Multi Girder |
| PMGC | Continuous Span PS Multi Girder |
| SMGS | Simple Span Steel Multi Girder |
| SMGC | Continuous Span Steel Multi Girder |

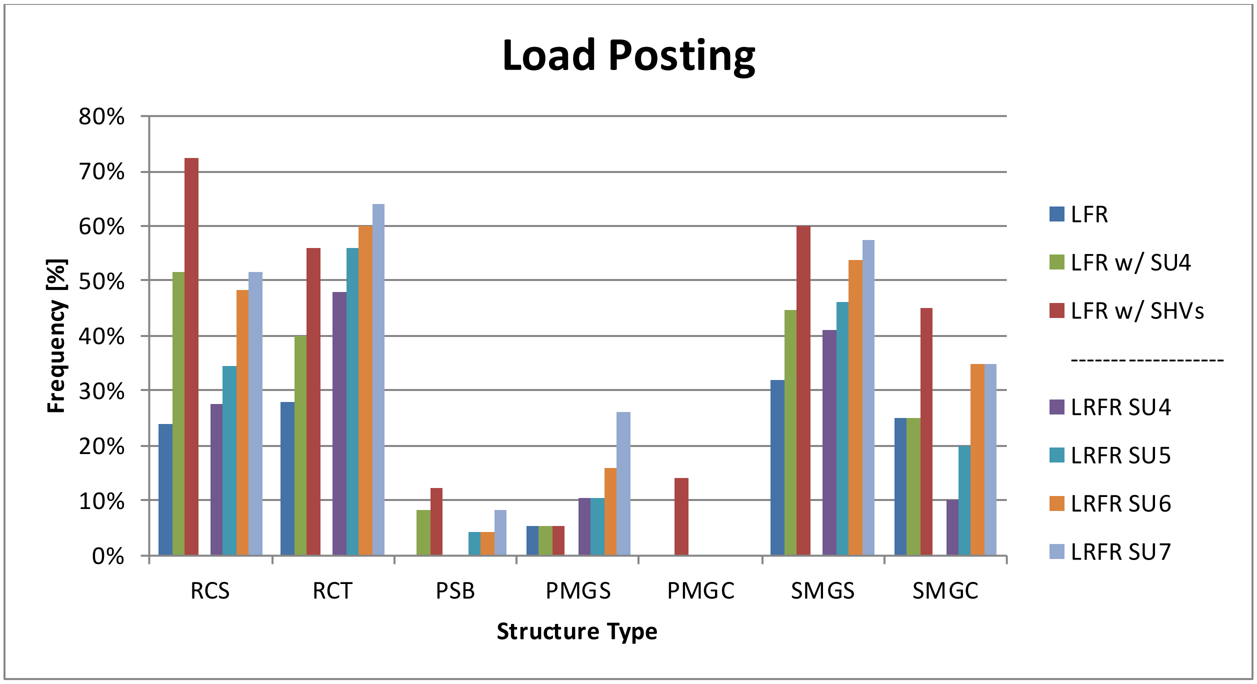
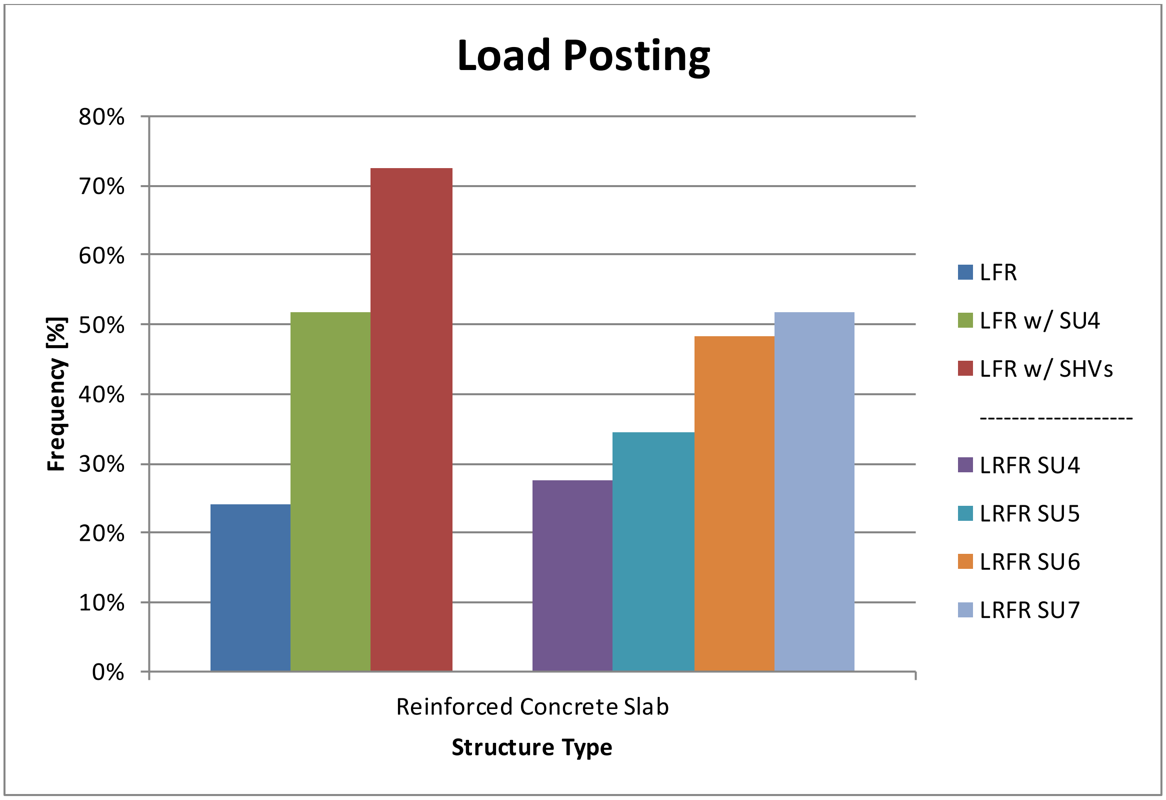



**Figure 3.9** – Load Postings for different bridge types.



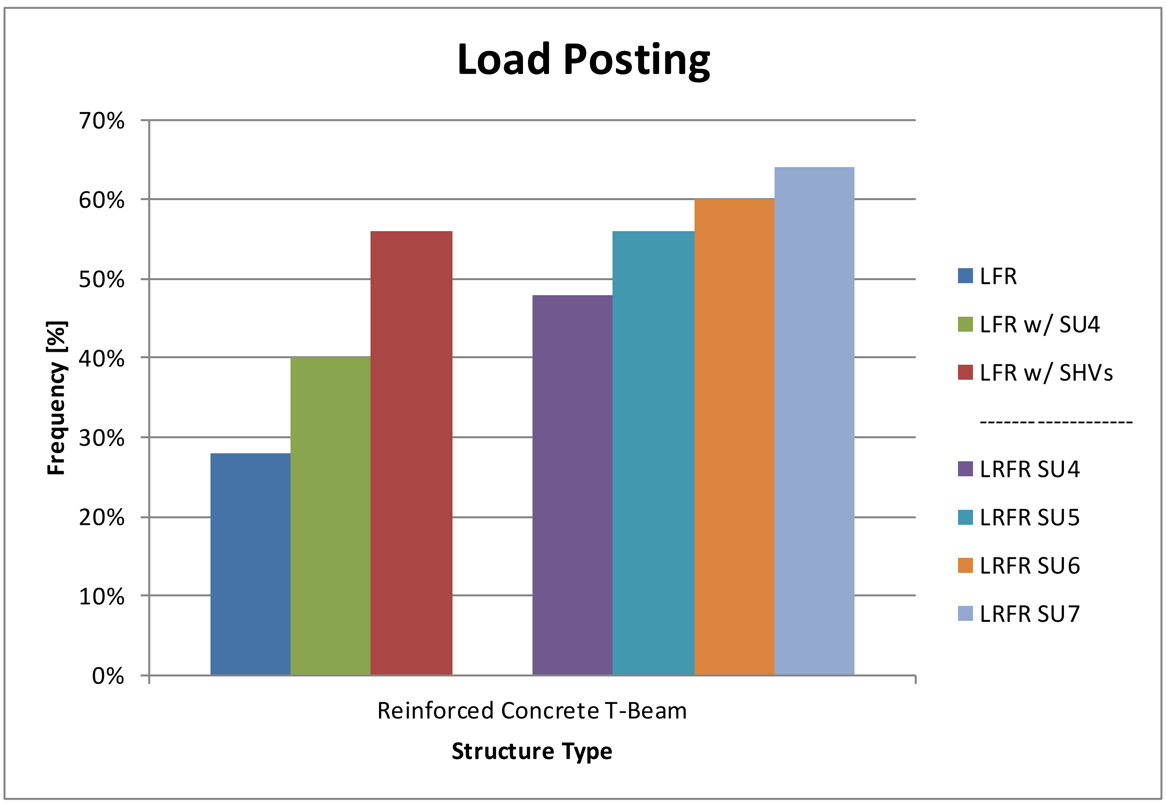
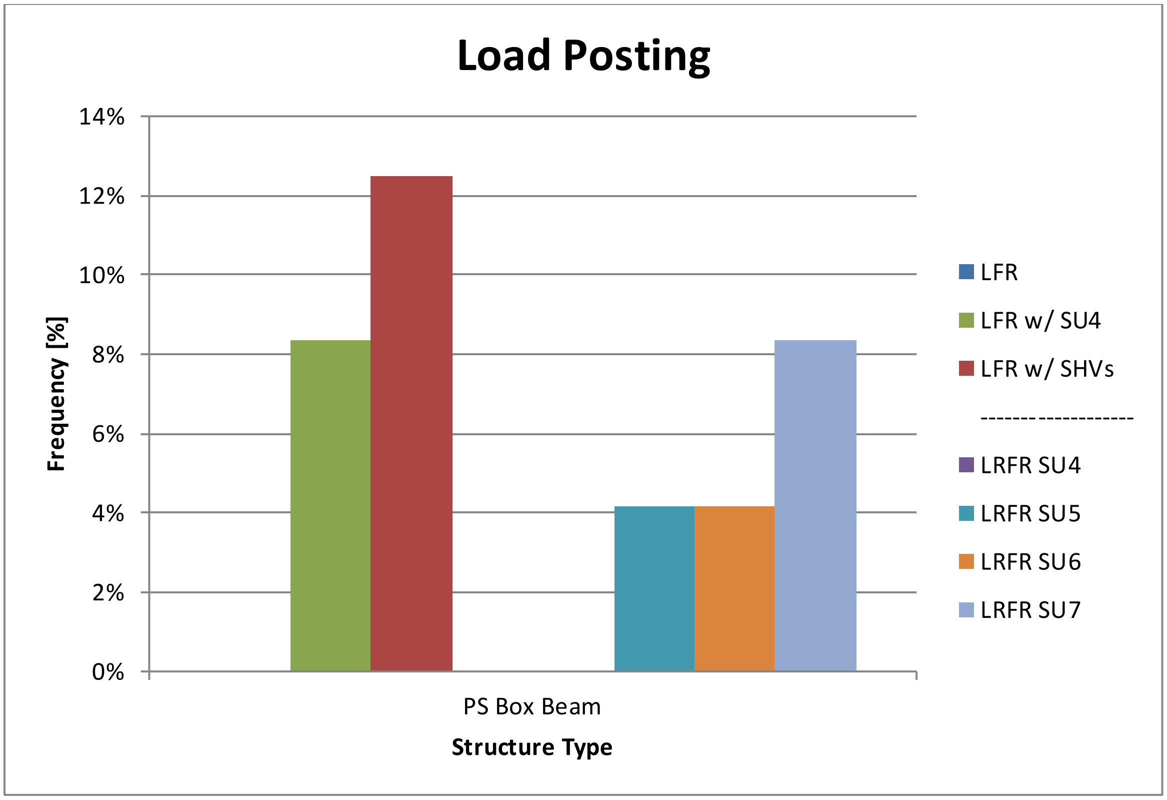




**Figure 3.10 -** Frequency of load posting by bridge types.



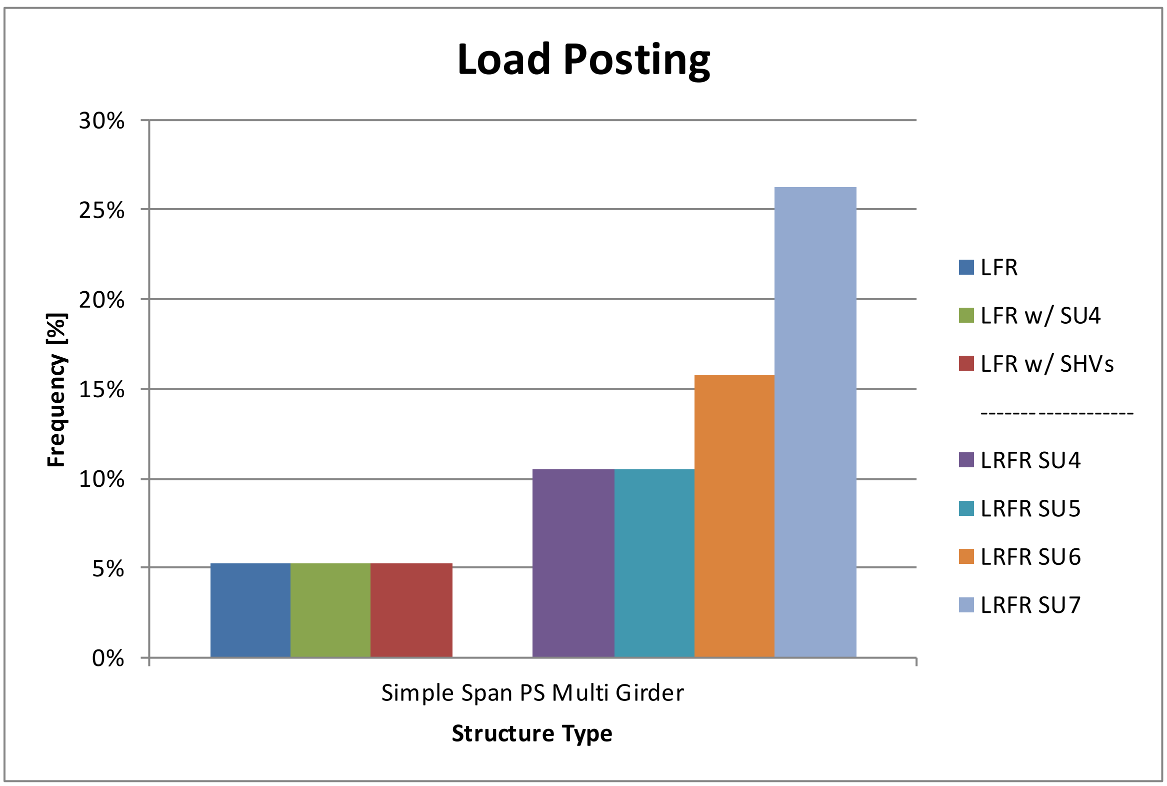
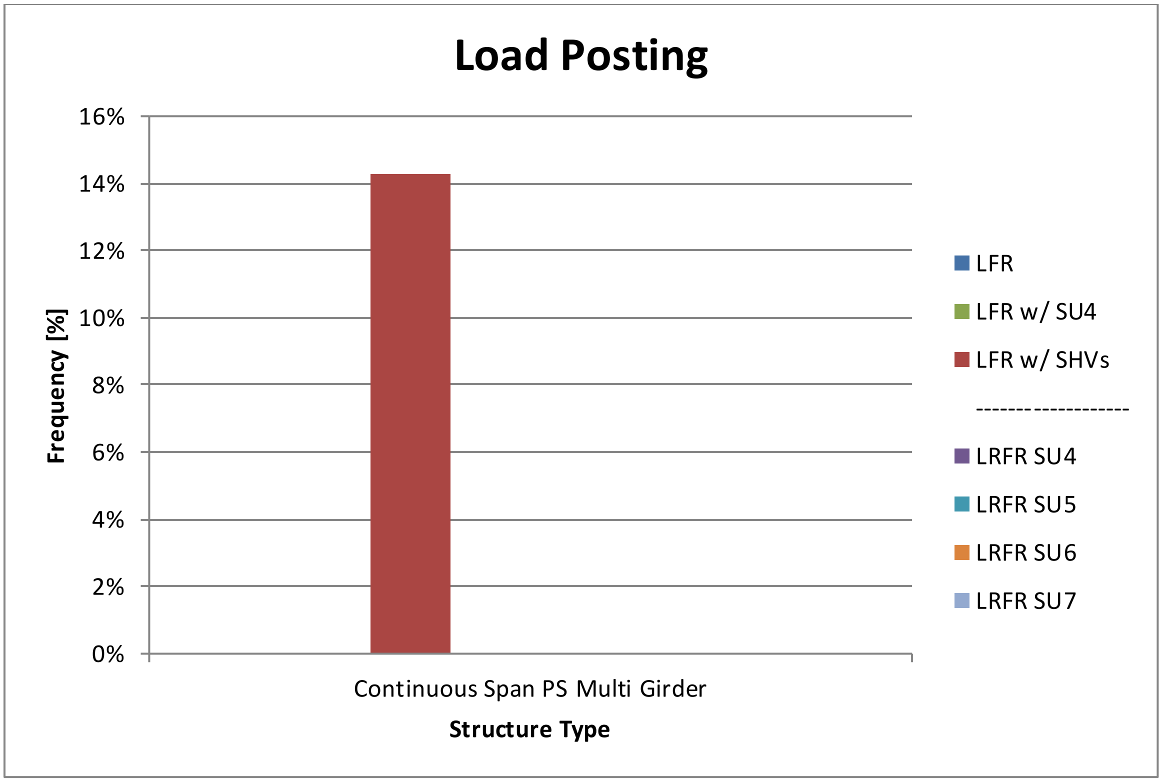




**Figure 3.10 -** Frequency of load posting by bridge types. *(continued)*



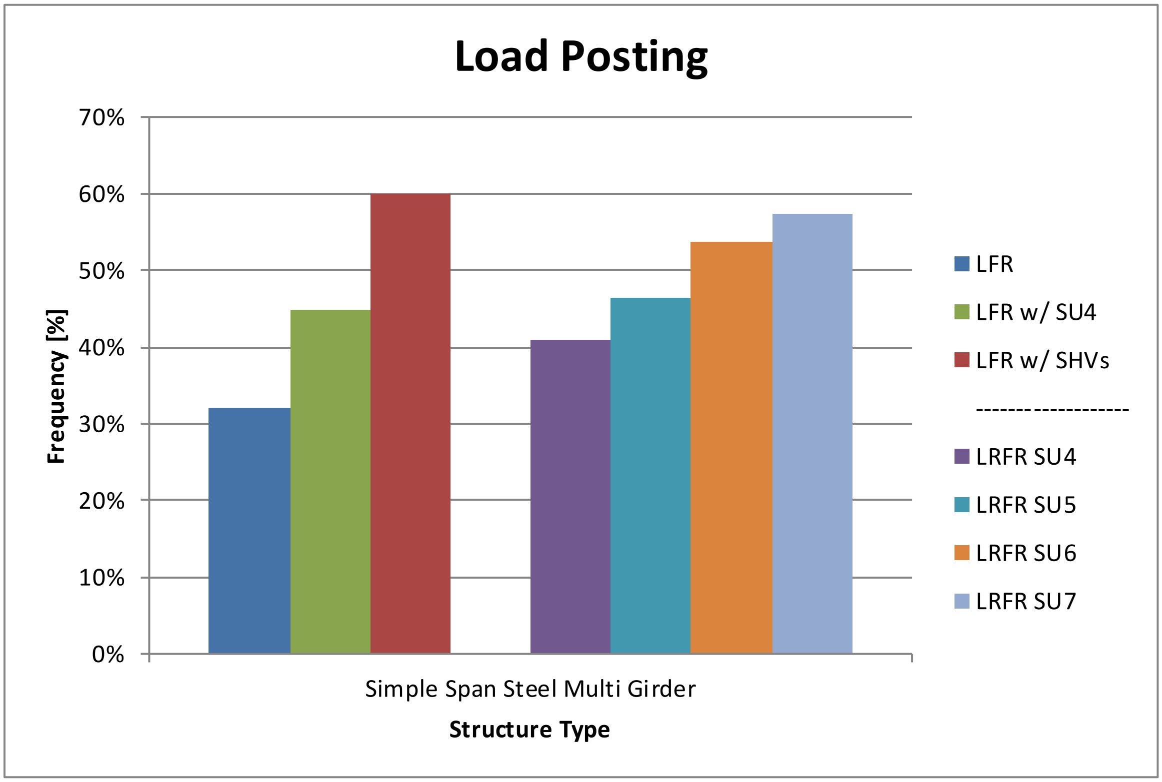




**Figure 3.10 -** Frequency of load posting by bridge types. *(continued)*

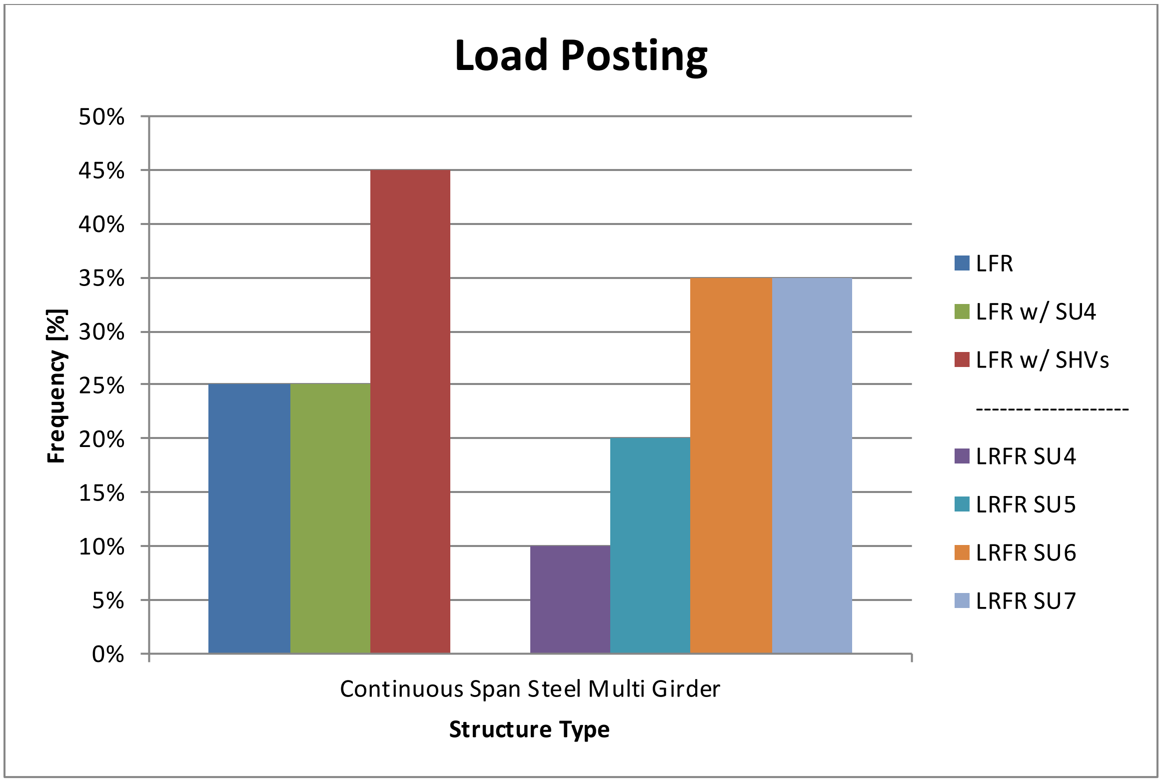



**Figure 3.10 -** Frequency of load posting by bridge types. *(continued)*

Illustrative Posting Evaluation – Bridge 12254:

An example of following the posting evaluation for bridge 12254 is given here to highlight the case where the SU4 rating is the most critical in terms of resulting in the lowest posting load, but its rating factor is above 1.0.

Bridge 12254 is a Simple Span Steel Multi Girder. The bridge has the following rating factors:

| LRFR | | | | LFR |
|---|---|---|---|---|
| SU4 | SU5 | SU6 | SU7 | H20 (OPR) Rating Factor |
| 1.073 | 0.974 | 0.886 | 0.836 | 0.99 |

This bridge was selected as an illustrative case where the SU4 rating factor is slightly above 1.0. Since this is the case this bridge does not require posting for SU4 vehicles and they would be limited to their usual legal weight of 27 tons. The rating factors for the remaining SHVs are below 1.0 and the bridge should therefore have limits for their use. Using the posting approach in the draft LRFR EI and the draft revisions to EI 05-034 results in the following posting loads.

| LRFR Posting (tons) | | | | LFR Posting (tons) | | |
|---|---|---|---|---|---|---|
| SU4 (27) | SU5 (31) | SU6 (34.75) | SU7 (38.75) | current EI 05-034 | revised (SU4 & SU5) | revised (all 4 SHVs) |
| N | 30 | 29 | 30 | 16 | 16 | 16 |

The posting loads include the modification for effective length and weights are rounded down to the nearest ton. By multiplying each of the four posting vehicle weights by the rating factors (and rounding down) we get values of 28 tons for SU4 (which is above its 27 ton legal limit), 30 tons for SU5, 30 tons for SU6, and 32 tons for SU7. If the SU4 rating is used together with the posting modification formula, then the posting increases from 28 tons to 29 tons. This illustrates that for these bridges that have relatively high rating factors that the SU4 can still be used as the single SHV posting load but that it needs to have a posting calculated for rating factors above 1.0 but less than 1.3.

This bridge is an example where the LRFR postings are significantly higher than the LFR postings by either the current method or revisions to the current method. Results are mixed for this comparison as shown previously by the histogram of rating ratios.

## 3.2 LRFR Condition Factors Using Element Inspection Data

### *3.2.1 Introduction*

In 2016 NYSDOT retired the 1 thru 7 rating scale for NBIS bridge inspections, and all inspections are now performed using the AASHTO element methodology. This requires that Table 2 in the Draft LRFR EI needs to be revised to incorporate AASHTO Element Condition Ratings. and the Condition Factor referred to in the LRFR Draft EI - Section 2.7.1 – Table 2 should be revised to include the AASHTO element. It is thus necessary to redesign Table 2, incorporating AASHTO Element Condition State ratings. A study was initiated in Task 4-10 and recommendations were developed to make the transition to element data in LRFR condition factors.

The general rating equation in LRFR (MBE Eq. 6A.4.2.1-1) is given as:

$$RF = \frac{\phi_c \phi_s \phi R_n - \gamma_{DC} DC - \gamma_{DW} DW \pm \gamma_P P}{\gamma_{LL}(LL + IM)}$$

In the LRFR Rating Factor equation:

| | |
|---|---|
| $RF$ | : Rating Factor |
| $R_n$ | : Nominal member resistance (as inspected) |
| $\phi$ | : Condition Factor (EI Section 2.7.2) |
| $\phi_c$ | : System Factor (EI Section 2.7.3) |
| $\phi_s$ | : LRFD Resistance Factor |
| $DC$ | : Dead load effect due to structural components and attachments |
| $DW$ | : Dead load effect due to wearing surface and utilities |
| $P$ | : Permanent loads other than dead loads (secondary prestressing effects, etc.) |
| $LL$ | : Live load effect of the rating vehicle |
| $IM$ | : Dynamic load allowance (EI Section 2.8.5) |
| $\gamma_{DC}$ | : LRFD load factor for structural components and attachments |
| $\gamma_{DW}$ | : LRFD load factor for wearing surfaces and utilities |
| $\gamma_P$ | : LRFD load factor for permanent loads other than dead loads |
| $\gamma_{LL}$ | : Evaluation live load factor for the rating vehicle (EI Section 2.81., 2.8.2, 2.8.3) |

Where, the following lower limit shall apply:

$$\phi_c \phi_s \geq 0.85$$

Additionally, for all non-strength limit states, $\phi = 1.0$, $\phi_c = 1.0$, $\phi_s = 1.0$

If the member experiences deterioration and begins to degrade the uncertainties and resistance variability are greatly increased or scatter is larger. And the resistance factor for new design would not be reflective of the increased resistance uncertainties. The condition factor specifies an estimated reduction to account for the increased uncertainty in the resistance of deteriorated members and the likely increased future deterioration of these members during the period between inspection cycles. In AASHTO LRFR the Condition factor varies from 0.85 for members in poor condition to 1.0 for members in good or satisfactory condition. The condition factor does not account for the observed changes in the actual physical dimensions of a member due to deterioration. The specified approach is to take the present as-inspected member information and apply it in finding the nominal member resistance and then apply the condition factor to decrease the resistance for reasons previously noted.

**Table 3.1 –** NYSDOT LRFR EI: Table 2 Condition Factor: $\phi_c$**.**

| Structural Condition of Member | Condition Rating | $\phi_c$ |
|---|---|---|
| Fair, satisfactory or good | $\geq 4$ | 1.0 |
| Poor | $\leq 3$ | 0.95 |

In the draft LRFR EI Table 2 shown above, a reduction factor based on member condition as evaluated using the New York condition rating system that rates the condition on a scale of 1 through 7 was included. The Condition Factor $\phi_C$ is applied to the resistance of degraded members. The Condition Factor in LRFR does not account for section loss, but is used in addition to section loss. An increased reliability index is maintained for deteriorated and non-redundant bridges by using Condition and System Factors in the load rating equation. The NYSDOT condition rating scale ranges from 1 to 7, with 7 being in new condition and a rating of 5 or greater considered as good condition. NYSDOT condition ratings were converted to the AASHTO MBE LRFR condition factor as shown in the draft EI Table 2.

As NYSDOT has implemented inspection data collection using AASHTO Elements in 2016, Table 2 in the Draft LRFR EI needs to be revised to incorporate AASHTO Element Condition Ratings. AASHTO element set includes two element types identified as National Bridge Elements (NBE) or Bridge Management Elements. The National Bridge Elements represent the primary structural components of bridges necessary to determine the overall condition and safety of the primary load carrying members. The NBEs are a refinement of the deck, superstructure, substructure, and culvert condition ratings defined in the Federal Highway Administration's Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges. The NBEs are designed to remain consistent from agency to agency across the country to facilitate and standardize the capture of bridge element condition at the national level. These elements are central to load rating applications. All elements have four defined condition states.

Two issues that need to be investigated and addressed regarding load rating are; 1) The loss in load capacity because deterioration; 2) the reduction in the Condition Factor to account for the increased uncertainties or variabilities in the calculated resistance. For primary load carrying elements in Condition State 4, indicates that the condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed. Condition State 3 represents that section loss is evident or pack rust is present. Connections may have missing bolts, rivets or broken welds. The general interpretation is that such deteriorations do not impact structural strength and does not warrant structural review even when there are measurable losses. The assumptions used for the Condition States need to be thoroughly vetted regarding their impact on element load capacity and on the Condition Factors when used in conjunction with LRFR and NYSDOT element inspections.

Under this subtask, a consistent approach to developing Condition Factors is proposed. In order to quantify the Condition Factor for an element, the first step is to review the condition state language for the element. The element condition requires the inspector to evaluate defects and also quantify the defect's impact to the element or possibly the bridge. A defect evaluation may result in element quantities in CS1, CS2, CS3, or CS4 depending on the location, size, structural importance or element units. To maintain the intent and purpose of using the Condition Factors (CF) for load rating, the CF should capture the increased uncertainty in the resistance of deteriorated members and the likely increased future deterioration of these members during the period between inspection cycles. This goes beyond only including defects that directly reduce load capacity. Condition States 3 and 4 and associated quantities for each of these Condition States should be considered for CF determination. How these element data could be considered in a uniform manner across various primary elements needs to be evaluated and an approach derived that works for NYSDOT bridges. The influence of the quantities of element defects could depend on the Condition States, the type of element, and the type of defect. Defects such as damage from impact, distress or steel cracking due to fatigue should not be the basis for selecting Condition Factors but addressed as repair and maintenance issues. Defects associated with deterioration with age, environmental exposure and traffic exposure should be captured in the load ratings / Condition Factors.

### *3.2.2 Condition States*

The inspector is responsible for evaluating each element and assigning to it a descriptive Condition State (CS) assessment of "good", "fair", "poor", "severe", or "unknown". Detailed descriptions of these condition states are given in Table 3.2. Prior to inspecting an element, its total quantity should be established and verified through contract plans and/or field measurements. The total quantity and condition state quantity of each element should be rounded to the nearest whole number. When several condition states are assessed for one element, the inspector should ensure the sum of the individual condition state quantities equals the total quantity for that element.

**Table 3.2 –** AASHTO Element Condition States

| Condition State | Condition Type | General Condition Guideline |
|---|---|---|
| CS-1 | Good | That portion of the element that has either no deterioration or the deterioration is insignificant to the management of the element, meaning that portion of the element has no condition based preventive maintenance needs or repairs. Areas of an element that have received long lasting structural repairs that restore the full capacity of the element with an expected life equal to the original element may be coded as good condition. |
| CS-2 | Fair | That portion of the element that has minor deficiencies that signify a progression of the deterioration process. This portion of the element may need condition based preventive maintenance. Areas of the element that have received repairs that improve the element, but the repair is not considered equal to the original member may be coded as fair. |
| CS-3 | Poor | That portion of the element that has advanced deterioration but does not warrant structural review. This portion of the element may need condition based preventative maintenance or other remedial action. |
| CS-4 | Severe | That portion of the element that warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge; OR a condition where that portion of the element is no longer effective for its intended purpose. |
| CS-5 | Unknown | That portion of the element not assessable due to lack of access. |

### *3.2.3 National Bridge Elements and Defects*

National Bridge Elements that could impact load ratings are decks, slabs, superstructure elements and certain substructure elements. The element represents the aggregate condition of the defined element inclusive of all defined defects. Element defects are used to break down the overall element condition into one or more specific observed problems. Elements with a portion or all of the quantity in state 4 may often have load capacity implications warranting a structural review. The term structural review is defined as a review by a person qualified to evaluate the field observed conditions and make a determination of the impacts of the conditions on the performance of the element.

The elements are organized by major groupings such as Decks and Slabs, Superstructure, Substructure, Joints, and Bearings. *Decks and Slabs, Superstructure, and some Substructure elements could influence load capacity evaluation.*

## Decks and Slabs

Deck elements transmit the loads into superstructure elements. Slab elements transmit the load into the substructure elements. Structures that include slab elements typically do not have superstructure elements. These elements transmit traffic loads directly into the substructure.

Element 12— Reinforced Concrete Deck

Element 13— Prestressed Concrete Deck

Element 38— Reinforced Concrete Slab

Element 39— Prestressed Concrete Slab

Element 15— Prestressed Concrete Top Flange

Element 16— Reinforced Concrete Top Flange

## Superstructure Elements

Superstructure elements described in this section transmit load from decks into the substructure. These elements include girders, trusses, arches, and floor systems. The floor systems include floor beams and stringers.

Element 102—Steel Closed Web/Box Girder

Element 107—Steel Open Girder/Beam

Element 113—Steel Stringer

Element 120—Truss, Steel

Element 141—Arch, Steel

Element 152—Steel Floor Beam

Element 105—Reinforced Concrete Closed Web/Box Girder

Element 110—Reinforced Concrete Open Girder/Beam

Element 116—Reinforced Concrete Stringer

Element 155—Reinforced Concrete Floor Beam

Element 104—Prestressed Concrete Closed Web/Box Girder

Element 109—Prestressed Concrete Open Girder/Beam

Element 115—Prestressed Concrete Stringer

Element 154—Prestressed Concrete Floor Beam

### *3.2.4 Defects and Condition factors*

Defects that influence the Condition Factor (CF) determination need to be categorized in a uniform manner for ease of implementation. As noted, only Condition States 3 and 4 and associated quantities should be considered for CF determination. Only defects that directly impact load capacity should be considered in CF determination. These defects for concrete and steel bridges are identified in the tables below. The influence of the quantities of these element defects could depend on the Condition States, the type of element, and the type of defect. Defects associated with deterioration with age, environmental exposure and traffic exposure should be captured in the load ratings / Condition Factors. These are the qualifying defects for CF determination. (Defects such as damage from impact or steel cracking should be addressed as repair and maintenance issues and not used in CF determination).

**Table 3.3 –** Reinforced Concrete Elements Defects

| Defect | Element | Condition States | | |
|---|---|---|---|---|
| | | 1/2 | 3 | 4 |
| | | Good / Fair | Poor | Severe |
| Delamination/Spall/Patched Area (1080) | 12,16,38, 105, 110, 116, 155 | N.A. | Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review. | The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge |
| Exposed Rebar (1090) | 12,16,38, 105, 110, 116, 144, 155 | N.A. | Present with measurable section loss, but does not warrant structural review. | |
| Efflorescence/Rust Staining (1120) | 12,16,38, 105, 110, 116, 144, 155 | N.A. | Heavy build-up with rust staining. | |
| Cracking (RC and Other) (1130) | 12,16,38, 105, 110, 116, 144, 155 | N.A. | Wide cracks or heavy pattern (map) cracking. Cracks greater than 0.05 inches wide. | |

**Table 3.4 –** Prestressed Concrete Elements Defects

| Defect | Element | Condition States | | |
|---|---|---|---|---|
| | | **1/2** | **3** | **4** |
| | | **Good / Fair** | **Poor** | **Severe** |
| Delamination/Spall/Patched Area (1080) | 13, 15,39, 104, 109, 115, 154 | N.A. | Spall greater than 1 in. deep or greater than 6 in. diameter. Patched area that is unsound or showing distress. Does not warrant structural review | The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge |
| Exposed Rebar (1090) | 13, 15,39, 104, 109, 115, 154 | N.A. | Present with measurable section loss, but does not warrant structural review. | |
| Exposed Prestressing (1100) | 13, 15,39, 104, 109, 115, 154 | N.A. | Present with section loss, but does not warrant structural review | |
| Cracking (PSC) (1110) | 13, 15,39, 104, 109, 115, 154 | N.A. | Wide cracks or heavy pattern (map) cracking. Cracks greater than 0.009 inches wide. | |
| Efflorescence/Rust Staining (1120) | 13, 15,39, 104, 109, 115, 154 | N.A. | Heavy build-up with rust staining | |

**Table 3.5 –** Steel Elements Defects

| Defect | Element | Condition States | | |
|---|---|---|---|---|
| | | **1/2** | **3** | **4** |
| | | **Good / Fair** | **Poor** | **Severe** |
| Corrosion (1000) | 102, 107,113, 120, 141, 152 | N.A. | Section loss is evident or pack rust is present but does not warrant structural review. | The condition warrants a structural review to determine the effect on strength or serviceability of the element or bridge; OR a structural review has been completed and the defects impact strength or serviceability of the element or bridge |

### *3.2.5 NYSDOT Guidance for Condition States (NYSDOT Bridge Inspection Manual 2016)*

The new Manual requires that NYSDOT bridge inspection element level data collection shall be performed in accordance with the AMBEI. Section 3 provides NYSDOT guidance for the National Bridge Elements (NBE), Bridge Management Elements (BME), and Agency Defined Elements (ADE). This section includes general guidance, element determination sketches, and condition state examples. Element data collection is expected to begin in April 2016. Examples provided in the Inspection Manual for CS-3 and CS-4 are shown in Figures 3.11 through 3.17 as they provide a visual illustration of the state of deterioration for assessing the Condition Factors, as defined by NYSDOT.

**Figure 3.11 -** Element 12: Reinforced Concrete Deck CS-3.

**Figure 3.12 -** Element 12: Reinforced Concrete Deck CS-4.

**Figure 3.13 -** Element 107: Girder, Steel CS-3.

**Figure 3.14-** Element 107: Girder, Steel CS-4

**Figure 3.15 -** Element 104: Box Girder, Prestressed Concrete CS-3

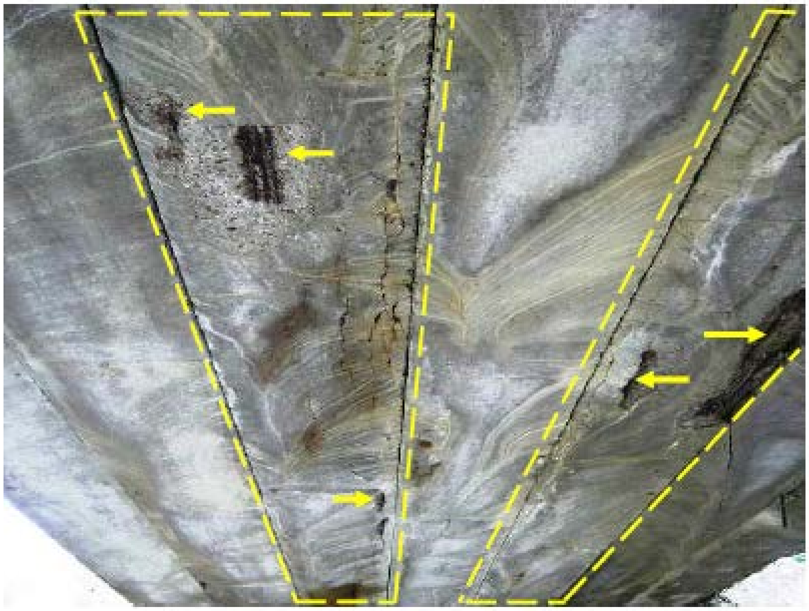


**Figure 3.16 -** Element 104: Box Girder, Prestressed Concrete CS-4

**Figure 3.17 -** Element 110: T-Beam, Reinforced Concrete CS-3

### *3.2.6 Selecting Condition Factors Using Elements Data*

The Condition Factor in LRFR specifies an estimated reduction to account for the increased uncertainty in the resistance of deteriorated members and the likely increased future deterioration of these members during the period between inspection cycles. This reduction is applied on top of the reduced member resistance calculated from as-inspection member sections. From pictures seen in the previous section (taken from NYSDOT Inspection Manual) bridge elements in CS-3 or CS-4 are in a stage of moderate to advanced deterioration. Members in CS-3 or CS-4 impose greater resistance uncertainties and can be expected to experience on-going active corrosion in the years following the inspection that will further degrade member safety.

In the previous sections, it was noted that:

1. Only certain deck, slab and superstructure (and some substructure) elements directly influence load ratings.
2. Only certain element defects have a direct bearing on load ratings. For instance, member damage, distress, fatigue cracking are issues that should be addressed by repairs and not be made part of member load ratings or selecting Condition Factors.
3. Only condition states 3 and 4 are likely to impact current or future load ratings.

National Bridge Elements represent the primary structural components of bridges necessary to determine the overall condition and safety of the primary load carrying members. National Bridge Elements that could impact load ratings are decks, slabs, superstructure elements and certain substructure elements.

The Condition Factor $\phi_c$, is applied to the resistance of degraded members. The Condition Factor $\phi_c$, does not account for section loss, but is used in addition to section loss. An increased reliability index is maintained for deteriorated and non-redundant bridges by using condition and system factors in the load rating equation. A reduction factor $\phi_c$ based on member condition, as evaluated using the AASHTO Element Condition Ratings, provides a uniform way to select Condition factors using the latest inspection findings. Element inspection evaluates defects and assigns Condition State quantities for each element. National Bridge Elements represent the primary load carrying members.

### *3.2.7 Proposed Modification to the draft LRFR EI to include only Condition States*

In the previous sections, it was noted that:At a meeting with NYSDOT on Jan 17, 207 the modifications to Condition Factor was discussed. NYSDOT recommended that only condition states CS3 and CS4 of primary members, as defined by national bridge elements, factor into selecting the condition factor. This would be consistent with element data collection procedures being implemented by NYSDOT.

The selection of the condition factor is based on primary members that are in condition states 3 and 4 and is stated as follows:

- CS-4 > 10% for a primary member, or
- CS-3 + CS-4 > 20% for a primary member should trigger a manual review for determining the condition factor.

If the reviewer considers the member conditions to increase the uncertainty or variability in the structural resistance and increased future deterioration, a reduced condition factor $\phi_c = 0.95$ should be assigned for load rating.

Proposed modification to the draft LRFR EI to include element data will be revised using this methodology as recommended by NYSDOT. This modification will also be reflected in the AASHTO MBE Blue Pages.

### 3.3 NYSDOT LRFR "Blue Pages"

NYSDOT LRFR "Blue Pages" issue guidance for prioritizing and submitting load rating calculations, posting bridges for load restrictions, and documenting and reporting load tests on state-owned and locally owned highway bridges. NYSDOT LRFR Blue Pages are contained in Appendix B. Ratings should be calculated following the guidelines contained in the latest edition of the AASHTO MBE and this document. This document provides guidance to load rating engineers for performing and submitting load rating calculations, posting bridges for load restrictions, and checking overweight permits using the Load and Resistance Factor Rating (LRFR) methodology. This document serves as a supplement to the AASHTO MBE and deals primarily with NYSDOT specific load rating requirements, interpretations, and policy decisions.

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# 4 Screening of NY Bridges for Specialized Hauling Vehicles and Emergency Vehicles

## 4.1 Introduction

Under Task 4 Subtask 11 of Contract D031028 – Bridge Load and Resistance Factor Rating (LRFR) Assessment – Statewide, a screening study was performed on the New York State bridge Inventory for the AASHTO Specialized Hauling Vehicles (SHVs) and the FAST Act's Emergency Vehicles (EV). Screening criteria that are given in the 2013 and 2016 Federal Highway Administration (FHWA) memorandums, as well as those refinements adopted in 2014 in the AASHTO Manual of Bridge Evaluation constitute the basis for this investigation (See Section 3). The screening is intended to promote efficiency in load rating analysis for these load models so that spans that are most susceptible to overstress from SHVs and EVs are load rated first.

The study investigated all NYS highway bridges with available load ratings in the database (13988 bridges). The screening was performed on a database provided by NYSDOT that include up-to-date (11/30/2018) load rating results. Bridges that do not satisfy the screening criteria were tabulated by bridge owners and by NYSDOT regions. Geographic locations of such bridges were determined using a geographic information system (GIS) software, ArcGIS, and marked on state maps, which are included in this report.

## 4.2 New York State Bridge Inventory

Total bridge counts in the New York State by primary owner and by NYSDOT region are listed in Table 4.3. The extract file contains records for 7732 NYSDOT owned bridges and 12178 bridges owned by other entities, totaling to 19910 bridges. Per NYSDOT's request, **the screening study was performed for highway bridges only (RC01 "Type of Service on" codes 1, 4, 5 and 6)**. The database was further filtered for bridges with available load rating results. The following scheme was followed for determining the available ratings:

- Use Level I Inventory and Operating HS20 ratings where available
- If Level I HS20 ratings are not available, use Level II HS20 ratings
- If results from both rating tiers are not available, filter out the bridge in consideration.

The initial bridge inventory was filtered for highway bridges and for availability of rating results, and the bridge counts from the filtered database are listed in Table 4.4. This brings down the bridge counts to 6342 NYSDOT owned bridges (82% of the initial count) and 7656 bridges owned by other entities (62.9% of the initial count), totaling to 13998 bridges (70.3% of the initial count). The ratios of filtered bridge counts to the initial bridge counts as a percentage are given in Table 4.5.

**Table 4.1** – New York State Bridge Owners

| Owner Code | Owner Name |
|---|---|
| 10 | NYSDOT |
| 20 | State - Other |
| 21 | Authority or Commission - Other |
| 22 | Alleghany State Park Authority |
| 23 | Nassau County Bridge Authority |
| 24 | Peace Bridge Authority |
| 25 | Capital District State Park Commission |
| 26 | Central NY State Park Commission |
| 27 | City of NY State Park Commission |
| 29 | Finger Lakes Parks and Recreation Commission |
| 30 | County |
| 40 | Town |
| 41 | Village |
| 42 | City |
| 43 | NYC Department of Water Supply, Gas, and Electric |
| 50 | Federal (Other than those listed below) |
| 53 | National Park Service |
| 56 | Military Reservation / Corps of Engineers |
| 60 | Railroad |
| 61 | Long Island Railroad |
| 62 | Retired (use to be Conrail - converted to 60) |
| 70 | Private - Industrial |
| 71 | Private - Utility |
| 72 | Other |
| 2A | Genesee State Parks and Recreation Commission |
| 2B | Interstate Bridge Commission |
| 2C | NYS Department of Environmental Conservation |
| 2G | Metropolitan Transportation Authority |
| 2H | Monroe County Water Authority |
| 2I | Niagara Falls Bridge Commission |
| 2J | Niagara Frontier State Park Commission |
| 2K | NYS Bridge Authority |
| 2L | NYS Thruway Authority |
| 2M | Ogdensburg Bridge and Port Authority |
| 2N | Palisades Interstate Park Commission |
| 2P | NYS Power Authority |
| 2Q | Seaway International Bridge Authority |
| 2S | Thousand Islands Bridge Authority |
| 2T | Transit Authority |
| 2U | MTA Tunnels & Bridges (aka TBTA) |
| 2W | Port Authority of NY & NJ |

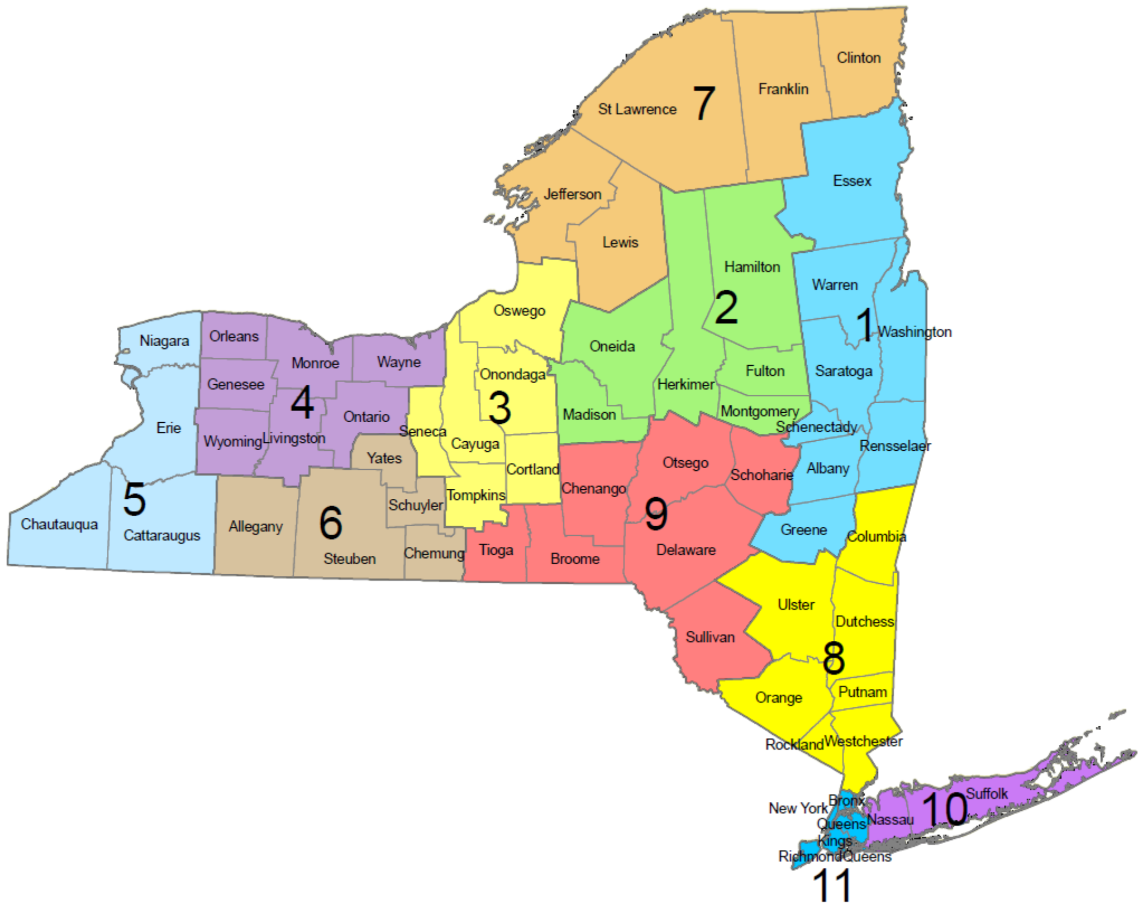


**Figure 4.1** – NYSDOT Regions

**Table 4.2** – NYSDOT Regions

| CODE | REGION (OFFICE) |
|---|---|
| 1 | Capital Region (Albany) |
| 2 | Mohawk Valley (Utica) |
| 3 | Central New York (Syracuse) |
| 4 | Finger Lakes (Rochester) |
| 5 | Western New York (Buffalo) |
| 6 | Central Southern Tier (Hornell) |
| 7 | North Country (Watertown) |
| 8 | Hudson Valley (Poughkeepsie) |
| 9 | Southern Tier (Binghamton) |
| 0 (10) | Long Island (Hauppauge) |
| N (11) | New York City (LIC, Queens) |

**Table 4.3** – New York State Bridge Inventory Bridge Counts

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| **10** | **NYSDOT** | 547 | 822 | 487 | 612 | 783 | 817 | 538 | 408 | 1094 | 944 | 680 | **7732** |
| **20** | **State - Other** | 1 | 22 | 9 | 1 | 3 | 14 | 1 | 1 | 26 | 2 | | **80** |
| **21** | **Authority or Commission - Other** | | 3 | 1 | | | 2 | | | | 2 | 1 | **9** |
| **22** | **Alleghany State Park Authority** | | | | | | 18 | | | | | | **18** |
| **23** | **Nassau County Bridge Authority** | 1 | | | | | | | | | | | **1** |
| **24** | **Peace Bridge Authority** | | | | | | 1 | | | | | | **1** |
| **25** | **Capital District State Park Commission** | | | 1 | | | | | | | | | **1** |
| **26** | **Central NY State Park Commission** | | | | 1 | | | | | | 1 | | **2** |
| **27** | **City of NY State Park Commission** | | | | | | | | | | | 3 | **3** |
| **29** | **Finger Lakes Parks and Recreation Commission** | | | | 6 | | | 2 | | | | | **8** |
| **30** | **County** | 117 | 691 | 459 | 442 | 556 | 947 | 540 | 687 | 827 | 1037 | 1 | **6304** |
| **40** | **Town** | 37 | 101 | 178 | 112 | 43 | 120 | 337 | 103 | 212 | 181 | | **1424** |
| **41** | **Village** | 10 | 6 | 15 | 13 | 9 | 10 | 26 | 5 | 52 | 17 | | **163** |
| **42** | **City** | 5 | 48 | 66 | 100 | 41 | 91 | 31 | 15 | 84 | 19 | 721 | **1221** |
| **43** | **NYC Department of Water Supply, Gas, and Electric** | | | | | | | | | 28 | 22 | | **50** |
| **50** | **Federal (Other than those listed below)** | | | | | | | 1 | 1 | | | 2 | **4** |
| **53** | **National Park Service** | | 4 | | | | | | | 6 | 1 | | **11** |
| **56** | **Military Reservation / Corps of Engineers** | | | | | | 1 | | | | | | **1** |
| **60** | **Railroad** | 1 | 134 | 21 | 51 | 110 | 214 | 32 | 23 | 193 | 63 | 118 | **960** |
| **61** | **Long Island Railroad** | 51 | | | | | | | | | | 156 | **207** |
| **62** | **Retired (use to be Conrail - converted to 60)** | | | 2 | 3 | 11 | 27 | | | | | | **43** |
| **70** | **Private - Industrial** | | 9 | 1 | 4 | 5 | 7 | | 2 | 11 | 5 | 17 | **61** |
| **71** | **Private - Utility** | | | | 1 | 6 | | | 1 | 2 | | 9 | **19** |
| **72** | **Other** | 3 | 6 | 1 | 7 | 10 | 6 | 2 | 4 | 8 | 4 | 61 | **112** |
| **2A** | **Genesee State Parks and Recreation Commission** | | | | | 5 | | | | | | | **5** |
| **2B** | **Interstate Bridge Commission** | | | | | | | | | 1 | 4 | | **5** |
| **2C** | **NYS Department of Environmental Conservation** | | 5 | 14 | | 3 | | 1 | 21 | | | | **44** |
| **2G** | **Long Island State Parks & Recreation Commission** | 2 | | | | | | | | | | | **2** |
| **2F** | **Metropolitan Transportation Authority** | 127 | | | | | | | | | | 50 | **177** |
| **2H** | **Monroe County Water Authority** | | | | | 2 | | | | | | | **2** |
| **2I** | **Niagara Falls Bridge Commission** | | | | | | 5 | | | | | | **5** |
| **2J** | **Niagara Frontier State Park Commission** | | | | | | 36 | | | | | | **36** |
| **2K** | **NYS Bridge Authority** | | 1 | | | | | | | 8 | | | **9** |
| **2L** | **NYS Thruway Authority** | | 90 | 115 | 68 | 88 | 211 | | | 210 | | 12 | **794** |
| **2M** | **Ogdensburg Bridge and Port Authority** | | | | | | | | 2 | | | | **2** |
| **2N** | **Palisades Interstate Park Commission** | | | | | | | | | 65 | | | **65** |
| **2P** | **NYS Power Authority** | | | | | | 16 | | 1 | | | | **17** |
| **2Q** | **Seaway International Bridge Authority** | | | | | | | | 1 | | | | **1** |
| **2S** | **Thousand Islands Bridge Authority** | | | | | | | | 5 | | | | **5** |
| **2T** | **Transit Authority** | | | | | | | | | | | 120 | **120** |
| **2U** | **MTA Tunnels & Bridges (aka TBTA)** | | | | | | | | | | | 51 | **51** |
| **2W** | **Port Authority of NY & NJ** | | | | | | | | | | | 135 | **135** |
| | **SUBTOTAL FOR NON-NYSDOT BRIDGES** | **355** | **1120** | **883** | **809** | **892** | **1726** | **973** | **872** | **1733** | **1358** | **1457** | **12178** |
| | **TOTAL INCLUDING NYSDOT BRIDGES** | **902** | **1942** | **1370** | **1421** | **1675** | **2543** | **1511** | **1280** | **2827** | **2302** | **2137** | **19910** |

**Table 4.4** – New York State Bridge Inventory Bridge Counts (Highway Bridges with Available Load Ratings)

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| 10 | NYSDOT | 329 | 666 | 392 | 470 | 619 | 693 | 510 | 349 | 914 | 843 | 557 | **6342** |
| 20 | State - Other | 1 | 12 | 5 | | | 3 | 1 | | 9 | 1 | | **32** |
| 21 | Authority or Commission - Other | | 1 | 1 | | | | | | | 2 | | **4** |
| 22 | Alleghany State Park Authority | | | | | | 10 | | | | | | **10** |
| 23 | Nassau County Bridge Authority | 1 | | | | | | | | | | | **1** |
| 24 | Peace Bridge Authority | | | | | | 1 | | | | | | **1** |
| 25 | Capital District State Park Commission | | | | | | | | | | | | **0** |
| 26 | Central NY State Park Commission | | | | | | | | | | | | **0** |
| 27 | City of NY State Park Commission | | | | | | | | | | | 2 | **2** |
| 29 | Finger Lakes Parks and Recreation Commission | | | | 2 | | | | | | | | **2** |
| 30 | County | 100 | 528 | 330 | 267 | 379 | 712 | 474 | 558 | 667 | 888 | 1 | **4904** |
| 40 | Town | 19 | 68 | 127 | 51 | 19 | 38 | 298 | 45 | 144 | 106 | | **915** |
| 41 | Village | 3 | 4 | 8 | 6 | 8 | 2 | 20 | 3 | 33 | 13 | | **100** |
| 42 | City | 4 | 28 | 34 | 56 | 22 | 68 | 21 | 12 | 38 | 8 | 337 | **628** |
| 43 | NYC Department of Water Supply, Gas, and Electric | | | | | | | | | 15 | 16 | | **31** |
| 50 | Federal (Other than those listed below) | | | | | | | 1 | | | | | **1** |
| 53 | National Park Service | | 2 | | | | | | | 1 | | | **3** |
| 56 | Military Reservation / Corps of Engineers | | | | | | | | | | | | **0** |
| 60 | Railroad | | 12 | 1 | | 3 | 1 | 1 | | 53 | 2 | | **73** |
| 61 | Long Island Railroad | | | | | | | | | | | | **0** |
| 62 | Retired (use to be Conrail - converted to 60) | | | | | | | | | | | | **0** |
| 70 | Private - Industrial | | | | | | | | | | | | **0** |
| 71 | Private - Utility | | | | | | | | | 1 | | | **1** |
| 72 | Other | | 1 | | 2 | | 1 | 1 | | 2 | | | **7** |
| 2A | Genesee State Parks and Recreation Commission | | | | | | | | | | | | **0** |
| 2B | Interstate Bridge Commission | | | | | | | | | | | | **0** |
| 2C | NYS Department of Environmental Conservation | | 2 | 9 | | | | 1 | 17 | | | | **29** |
| 2G | Long Island State Parks & Recreation Commission | | | | | | | | | | | | **0** |
| 2F | Metropolitan Transportation Authority | 1 | | | | | | | | | | 18 | **19** |
| 2H | Monroe County Water Authority | | | | | | | | | | | | **0** |
| 2I | Niagara Falls Bridge Commission | | | | | | 1 | | | | | | **1** |
| 2J | Niagara Frontier State Park Commission | | | | | | 23 | | | | | | **23** |
| 2K | NYS Bridge Authority | | 1 | | | | | | | 4 | | | **5** |
| 2L | NYS Thruway Authority | | 74 | 101 | 65 | 83 | 198 | | | 169 | | 6 | **696** |
| 2M | Ogdensburg Bridge and Port Authority | | | | | | | | | | | | **0** |
| 2N | Palisades Interstate Park Commission | | | | | | | | | 25 | | | **25** |
| 2P | NYS Power Authority | | | | | | 9 | | 1 | | | | **10** |
| 2Q | Seaway International Bridge Authority | | | | | | | | 1 | | | | **1** |
| 2S | Thousand Islands Bridge Authority | | | | | | | | 2 | | | | **2** |
| 2T | Transit Authority | | | | | | | | | | | 37 | **37** |
| 2U | MTA Tunnels & Bridges (aka TBTA) | | | | | | | | | | | 47 | **47** |
| 2W | Port Authority of NY & NJ | | | | | | | | | | | 46 | **46** |
| | **SUBTOTAL FOR NON-NYSDOT BRIDGES** | **129** | **733** | **616** | **449** | **514** | **1067** | **818** | **639** | **1161** | **1036** | **494** | **7656** |
| | **TOTAL INCLUDING NYSDOT BRIDGES** | **458** | **1399** | **1008** | **919** | **1133** | **1760** | **1328** | **988** | **2075** | **1879** | **1051** | **13998** |

**Table 4.5** – New York State Bridge Inventory Bridge Counts (Percentages of Highway Bridges with Available Load Ratings)

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| 10 | NYSDOT | 60% | 81% | 80% | 77% | 79% | 85% | 95% | 86% | 84% | 89% | 82% | **82%** |
| 20 | State - Other | 100% | 55% | 56% | | | 21% | 100% | | 35% | 50% | | **40%** |
| 21 | Authority or Commission - Other | | 33% | 100% | | | | | | | 100% | | **44%** |
| 22 | Alleghany State Park Authority | | | | | | 56% | | | | | | **56%** |
| 23 | Nassau County Bridge Authority | 100% | | | | | | | | | | | **100%** |
| 24 | Peace Bridge Authority | | | | | | 100% | | | | | | **100%** |
| 25 | Capital District State Park Commission | | | | | | | | | | | | |
| 26 | Central NY State Park Commission | | | | | | | | | | | | |
| 27 | City of NY State Park Commission | | | | | | | | | | | 67% | **67%** |
| 29 | Finger Lakes Parks and Recreation Commission | | | | 33% | | | | | | | | **25%** |
| 30 | County | 85% | 76% | 72% | 60% | 68% | 75% | 88% | 81% | 81% | 86% | 100% | **78%** |
| 40 | Town | 51% | 67% | 71% | 46% | 44% | 32% | 88% | 44% | 68% | 59% | | **64%** |
| 41 | Village | 30% | 67% | 53% | 46% | 89% | 20% | 77% | 60% | 63% | 76% | | **61%** |
| 42 | City | 80% | 58% | 52% | 56% | 54% | 75% | 68% | 80% | 45% | 42% | 47% | **51%** |
| 43 | NYC Department of Water Supply, Gas, and Electric | | | | | | | | | 54% | 73% | | **62%** |
| 50 | Federal (Other than those listed below) | | | | | | | 100% | | | | | **25%** |
| 53 | National Park Service | | 50% | | | | | | | 17% | | | **27%** |
| 56 | Military Reservation / Corps of Engineers | | | | | | | | | | | | |
| 60 | Railroad | | 9% | 5% | | 3% | 0% | 3% | | 27% | 3% | | **8%** |
| 61 | Long Island Railroad | | | | | | | | | | | | |
| 62 | Retired (use to be Conrail - converted to 60) | | | | | | | | | | | | |
| 70 | Private - Industrial | | | | | | | | | | | | |
| 71 | Private - Utility | | | | | | | | | 50% | | | **5%** |
| 72 | Other | | 17% | | 29% | | 17% | 50% | | 25% | | | **6%** |
| 2A | Genesee State Parks and Recreation Commission | | | | | | | | | | | | |
| 2B | Interstate Bridge Commission | | | | | | | | | | | | |
| 2C | NYS Department of Environmental Conservation | | 40% | 64% | | | | 100% | 81% | | | | **66%** |
| 2G | Long Island State Parks & Recreation Commission | | | | | | | | | | | | |
| 2F | Metropolitan Transportation Authority | 1% | | | | | | | | | | 36% | **11%** |
| 2H | Monroe County Water Authority | | | | | | | | | | | | |
| 2I | Niagara Falls Bridge Commission | | | | | | 20% | | | | | | **20%** |
| 2J | Niagara Frontier State Park Commission | | | | | | 64% | | | | | | **64%** |
| 2K | NYS Bridge Authority | | 100% | | | | | | | 50% | | | **56%** |
| 2L | NYS Thruway Authority | | 82% | 88% | 96% | 94% | 94% | | | 80% | | 50% | **88%** |
| 2M | Ogdensburg Bridge and Port Authority | | | | | | | | | | | | |
| 2N | Palisades Interstate Park Commission | | | | | | | | | 38% | | | **38%** |
| 2P | NYS Power Authority | | | | | | 56% | | 100% | | | | **59%** |
| 2Q | Seaway International Bridge Authority | | | | | | | | 100% | | | | **100%** |
| 2S | Thousand Islands Bridge Authority | | | | | | | | 40% | | | | **40%** |
| 2T | Transit Authority | | | | | | | | | | | 31% | **31%** |
| 2U | MTA Tunnels & Bridges (aka TBTA) | | | | | | | | | | | 92% | **92%** |
| 2W | Port Authority of NY & NJ | | | | | | | | | | | 34% | **34%** |
| | **SUBTOTAL FOR NON-NYSDOT BRIDGES** | **36%** | **65%** | **70%** | **56%** | **58%** | **62%** | **84%** | **73%** | **67%** | **76%** | **34%** | **63%** |
| | **TOTAL INCLUDING NYSDOT BRIDGES** | **51%** | **72%** | **74%** | **65%** | **68%** | **69%** | **88%** | **77%** | **73%** | **82%** | **49%** | **70%** |

## 4.3 Screening for Specialized Hauling Vehicles

On November 15, 2013, Federal Highway Administration (FHWA) issued a memorandum titled "Load Rating of Specialized Hauling Vehicles" to clarify FHWA's position on the analysis of Specialized Hauling Vehicles (SHVs) as defined in the AASHTO Manual for Bridge Evaluation (MBE) during bridge load rating and posting to comply with the requirements of the National Bridge Inspection Standards (NBIS). The intent of the load rating and posting provisions of the NBIS is to ensure that all bridges are appropriately evaluated to determine their safe live load carrying capacity considering all unrestricted legal loads, including State routine permits, and that bridges are appropriately posted if required, in accordance with the MBE. The memorandum requires the SU4, SU5, SU6, SU7 or the Notional Rating Load (NRL), which envelopes individual SHV live load models, to be used in load ratings and the consequent posting analyses per Article 6B.7.2 of the MBE 2nd Edition, unless the state verifies that State laws preclude SHV use or the state has its own rating vehicle models for legal loads and verifies that the State legal load models envelope the applicable AASHTO SHV loading models. Per the memorandum, FHWA also recognizes that it may not be feasible to include SHVs in ratings for the entire inventory at once. Thus, a screening criteria was provided to prioritize load ratings with the following time lines:

**Group 1:** Bridges with the shortest span not greater than 200 feet should be re-rated after their next NBIS inspection, but no later than December 31, 2017, that were last rated by:

- either Allowable Stress Rating (ASR) or Load Factor Rating (LFR) method and have an operating rating for the AASHTO Routine Commercial Vehicle either Type 3, Type 3S2, or Type 3-3 less than 33 tons, 47 tons or 52 tons respectively; or
- Load and Resistance Factor Rating (LRFR) method and have a legal load rating factor for the AASHTO Routine Commercial Vehicle, either Type 3, Type 3S2 or Type 3-3, less than 1.3.

**Group 2**: Rate those bridges not in Group 1 no later than December 31, 2022.

Later, AASHTO Manual of Bridge Evaluation 2nd Edition extended the screening criteria above in its 2014 interims based on a study executed by the AASHTO T-18 Technical Committee for Bridge Management, Evaluation and Rehabilitation. Per AASHTO MBE Article 6B.7.2, the screening criteria is as follows:

- Bridges having an HL-93 Operating RF > 1.0 need not be rated for SHVs.
- **Bridges having an HS20 Operating RF > 1.20 need not be rated for SHVs. [selected criterion]**
- Bridges with a minimum Operating RF > 1.35 for the AASHTO legal trucks under ASR or LFR, or a RF > 1.35 for these trucks using LRFR, would have adequate load capacity for the SHVs as follows: SU4 and SU5 for all spans; SU6 for spans above 70 ft; and SU7 for spans above 80 ft.

In this SHV screening study, the criterion provided for utilizing existing HS20 ratings is used, since H and HS ratings are most commonly reported for bridges in the New York State inventory. The bridge counts for bridges that does not satisfy the screening criteria are summarized by region for NYSDOT bridges and other bridges in Table 4.6. In addition, results in more detail are listed in Table 4.7. Based on the bridge counts, 121 NYSDOT owned bridges out 6342 screened) and 799 bridges (out of 7656 screened) owned by other entities do not satisfy the screening criteria, and would require SHV load ratings. Based on the GPS coordinates included in the database, locations of these bridges are overlaid on a map of New York State using the ArcGIS software, as shown in Figure 4.2.

**Table 4.6** – Summary of Bridge Counts Not Satisfying the SHV Screening Criteria

| CODE | REGION (OFFICE) | NYSDOT BRIDGES | OTHER BRIDGES | TOTAL |
|---|---|---|---|---|
| 1 | Capital Region (Albany) | 10 | 51 | 61 |
| 2 | Mohawk Valley (Utica) | 10 | 89 | 99 |
| 3 | Central New York (Syracuse) | 8 | 53 | 61 |
| 4 | Finger Lakes (Rochester) | 35 | 51 | 86 |
| 5 | Western New York (Buffalo) | 7 | 82 | 89 |
| 6 | Central Southern Tier (Hornell) | 4 | 75 | 79 |
| 7 | North Country (Watertown) | 2 | 113 | 115 |
| 8 | Hudson Valley (Poughkeepsie) | 20 | 119 | 139 |
| 9 | Southern Tier (Binghamton) | 17 | 136 | 153 |
| 0 (10) | Long Island (Hauppauge) | 5 | 13 | 18 |
| N (11) | New York City (LIC, Queens) | 3 | 17 | 20 |
| **TOTAL** | | **121** | **799** | **920** |

**Table 4.7** – New York State Bridges Not Satisfying SHV Screening Criteria (HS20 OPR RF < 1.2)

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| 10 | NYSDOT | 5 | 10 | 10 | 8 | 35 | 7 | 4 | 2 | 20 | 17 | 3 | 121 |
| 20 | State - Other | | | | | | | | | | | | |
| 21 | Authority or Commission - Other | | | | | | | | | | 2 | | 2 |
| 22 | Alleghany State Park Authority | | | | | | 1 | | | | | | 1 |
| 23 | Nassau County Bridge Authority | | | | | | | | | | | | |
| 24 | Peace Bridge Authority | | | | | | | | | | | | |
| 25 | Capital District State Park Commission | | | | | | | | | | | | |
| 26 | Central NY State Park Commission | | | | | | | | | | | | |
| 27 | City of NY State Park Commission | | | | | | | | | | | | |
| 29 | Finger Lakes Parks and Recreation Commission | | | | 1 | | | | | | | | 1 |
| 30 | County | 8 | 33 | 41 | 24 | 40 | 68 | 32 | 83 | 59 | 104 | | 492 |
| 40 | Town | 4 | 15 | 35 | 21 | 3 | 1 | 38 | 21 | 23 | 28 | | 189 |
| 41 | Village | 1 | | 2 | 3 | 4 | | 2 | 2 | 5 | 1 | | 20 |
| 42 | City | | 1 | 4 | 1 | | 7 | 2 | | 3 | 1 | 11 | 30 |
| 43 | NYC Department of Water Supply, Gas, and Electric | | | | | | | | | 3 | | | 3 |
| 50 | Federal (Other than those listed below) | | | | | | | 1 | | | | | 1 |
| 53 | National Park Service | | 1 | | | | | | | 1 | | | 2 |
| 56 | Military Reservation / Corps of Engineers | | | | | | | | | | | | |
| 60 | Railroad | | | | | | 1 | | | 16 | | | 17 |
| 61 | Long Island Railroad | | | | | | | | | | | | |
| 62 | Retired (use to be Conrail - converted to 60) | | | | | | | | | | | | |
| 70 | Private - Industrial | | | | | | | | | | | | |
| 71 | Private - Utility | | | | | | | | | | | | |
| 72 | Other | | | | | | 1 | | | | | | 1 |
| 2A | Genesee State Parks and Recreation Commission | | | | | | | | | | | | |
| 2B | Interstate Bridge Commission | | | | | | | | | | | | |
| 2C | NYS Department of Environmental Conservation | | | 2 | | | | | 7 | | | | 9 |
| 2G | Long Island State Parks & Recreation Commission | | | | | | | | | | | | |
| 2F | Metropolitan Transportation Authority | | | | | | | | | | | | |
| 2H | Monroe County Water Authority | | | | | | | | | | | | |
| 2I | Niagara Falls Bridge Commission | | | | | | | | | | | | |
| 2J | Niagara Frontier State Park Commission | | | | | | 2 | | | | | | 2 |
| 2K | NYS Bridge Authority | | | | | | | | | | | | |
| 2L | NYS Thruway Authority | | 1 | 5 | 3 | 4 | 1 | | | 9 | | | 23 |
| 2M | Ogdensburg Bridge and Port Authority | | | | | | | | | | | | |
| 2N | Palisades Interstate Park Commission | | | | | | | | | | | | |
| 2P | NYS Power Authority | | | | | | | | | | | | |
| 2Q | Seaway International Bridge Authority | | | | | | | | | | | | |
| 2S | Thousand Islands Bridge Authority | | | | | | | | | | | | |
| 2T | Transit Authority | | | | | | | | | | | | |
| 2U | MTA Tunnels & Bridges (aka TBTA) | | | | | | | | | | | 2 | 2 |
| 2W | Port Authority of NY & NJ | | | | | | | | | | | 4 | 4 |
| | SUBTOTAL FOR NON-NYSDOT BRIDGES | 13 | 51 | 89 | 53 | 51 | 82 | 75 | 113 | 119 | 136 | 17 | 799 |
| | TOTAL INCLUDING NYSDOT BRIDGES | 18 | 61 | 99 | 61 | 86 | 89 | 79 | 115 | 139 | 153 | 20 | 920 |

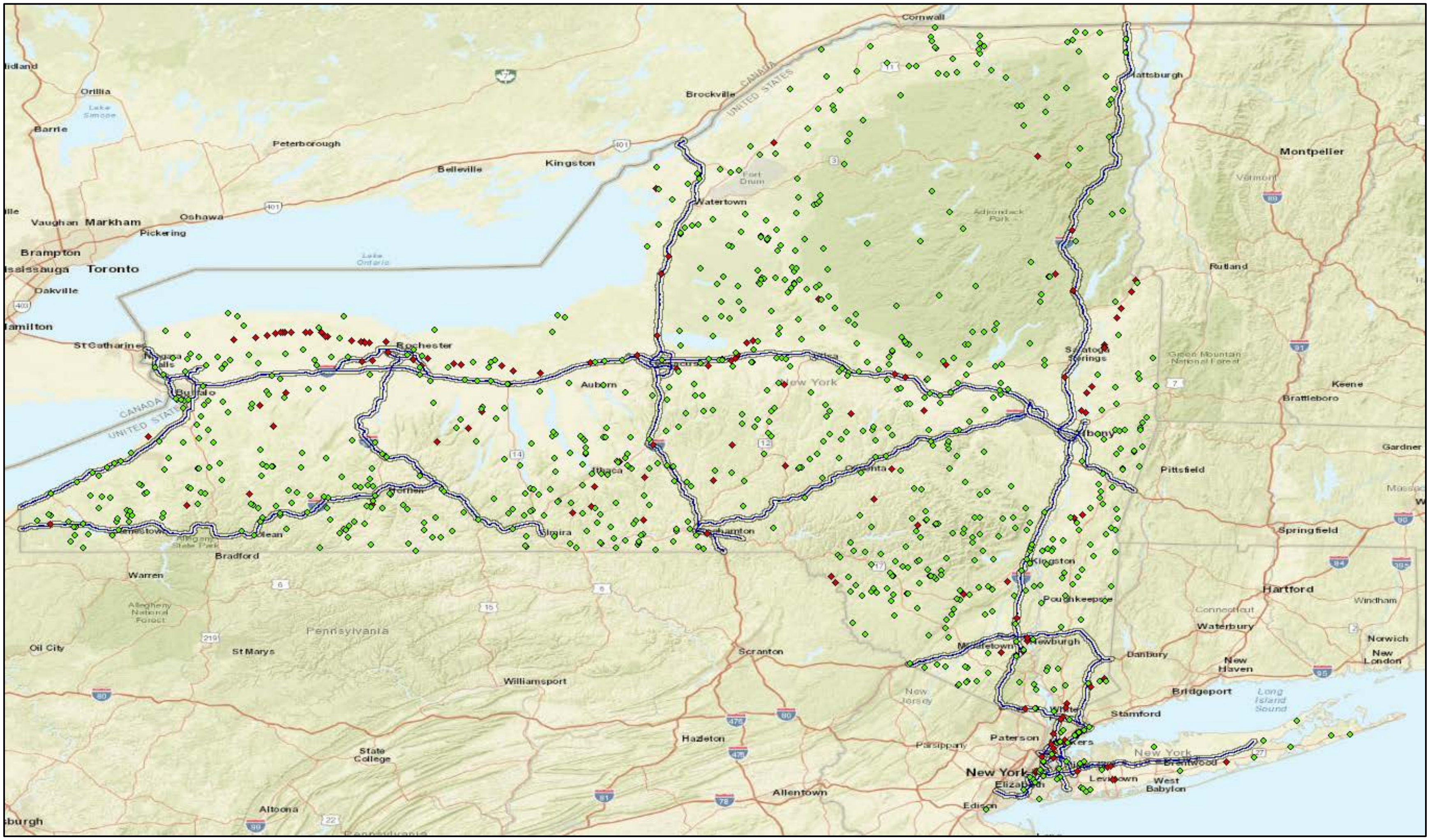


**Figure 4.2** – New York State Highway Bridges Not Satisfying SHV Screening Criteria (Red: NYSDOT Bridges, Green: Other Bridges).

### 4.4 Screening for Emergency Vehicles

On November 3, 2016, Federal Highway Administration (FHWA) issued a memorandum titled "Load Rating for the FAST Act's Emergency Vehicles" to provide guidance on maintaining compliance with the load rating and posting requirements of 23 CFR Part 650 – specifically for the amended weight limits in 23 U.S.C. 127(r), Emergency Vehicles, for bridges on the Interstate System and within reasonable access to the Interstate System. An emergency vehicle is defined in the FAST Act is designed to be used under emergency conditions to transport personnel and equipment to support the suppression of fires and mitigation of other hazardous situations. The gross vehicle weight limit for emergency vehicles is 86,000 pounds under section 127(r). The statute imposes the following additional limits, depending upon vehicle configuration:

- 24,000 pounds on a single steering axle
- 33,500 pounds on a single drive axle
- 62,000 pounds on a tandem axle
- 52,000 ponds on a tandem rear drive steer axle

The Federal Highway Administration has determined that, for the purpose of load rating, two emergency vehicle configurations produce load effects in typical bridges that envelop the effects resulting from the family of typical emergency vehicles that is covered by the FAST Act:

1. **Type EV2** – for single rear axle emergency vehicles
   Front Single Axle: 24,000 pounds

   Rear Single Axle: 33,500 pounds

   Wheelbase: 15 ft
2. **Type EV3** – for tandem rear axle emergency vehicles
   Front Single Axle: 24,000 pounds

   Rear Tandem Axle: 62,000 pounds (two 31,000 pound axles spaced at 4 ft)

   Wheelbase: 17 ft (distance from front axle to the centerline of rear tandem axle)

Per 23 CFR 650.313(c), all highway bridges must be load rated and, if necessary, posted in accordance with the MBE. Per the memorandum, FHWA recognizes that it may not be possible to load rate every Interstate System bridge and bridges within reasonable access to the Interstate. Thus, a screening criteria was provided to prioritize load ratings with the following time lines:

> **Group 1**: Bridges that meet any one of the following criteria do not need to be immediately load rated for emergency vehicles.
>
> - An operating or legal load rating factor for the AASHTO Type 3 vehicle of at least 1.85.

- **An inventory rating factor for the HS 20 design load of at least 1.0 using the LFR method.** [selected criterion]
- An inventory rating factor for the HL-93 design load of at least 0.9 using the LRFR method.

**Group 2**: Bridges not in Group 1 should be rated for the emergency vehicles following their next inspection to incorporate the latest condition of the bridge, but no later than December 31, 2019. Emergency vehicles should be included in any new load ratings for these bridges when the load ratings occur before December 31, 2019.

In this EV screening study, the criterion provided for utilizing existing HS20 ratings is used, since H and HS ratings are most commonly reported for bridges in the New York State inventory. Since the screening procedure also includes bridges with reasonable distance to Interstates, in addition to Interstate Bridges, a proximity analysis was performed using the ArcGIS software. First, all highway bridges not satisfying the screening criteria was plotted. Second, a buffer zone based geoprocessing methodology was employed to determine if a bridge not satisfying the screening criteria falls within a 1-mile and a 2-mile buffer zone centered along the Interstate Highways, again using the ArcGIS software, as shown in Figure 4.3. It should be noted that bridges that are on Interstates were grouped and counted separately.

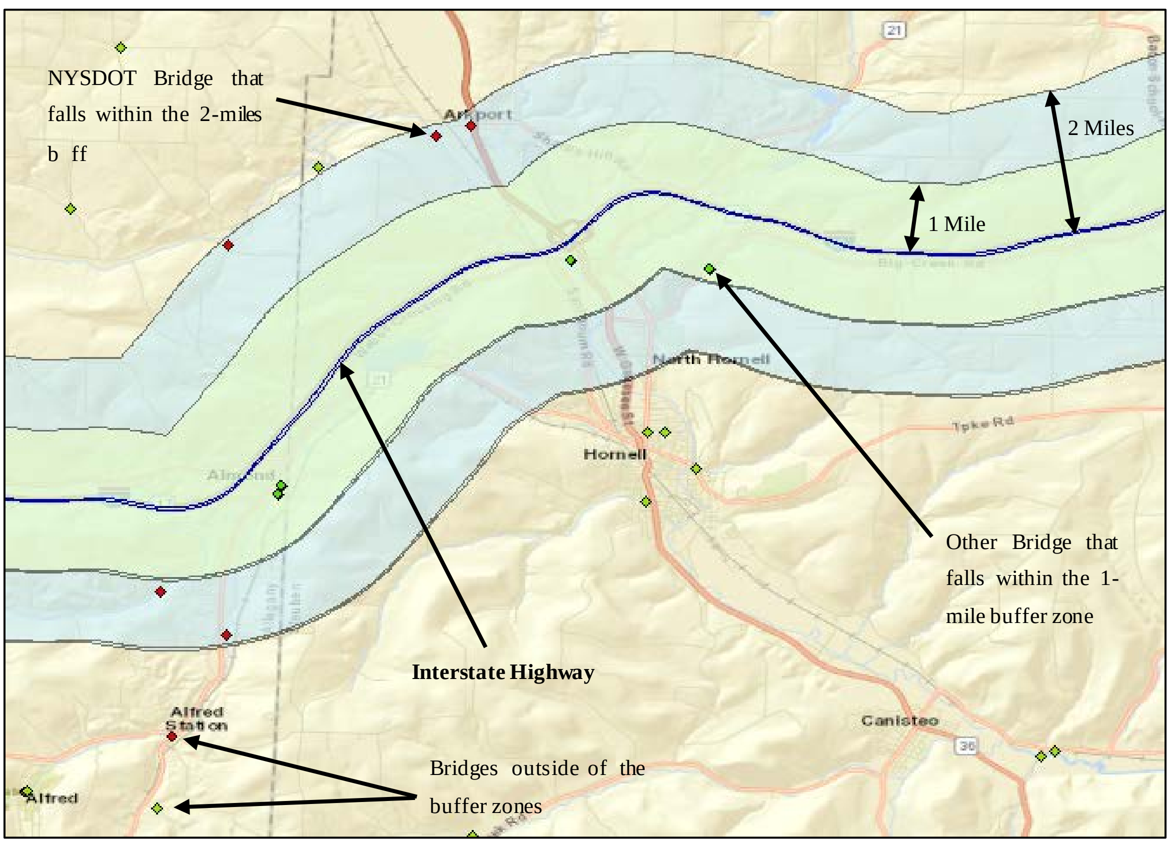


**Figure 4.3** – Proximity analysis based on buffer zone based geoprocessing.

The bridge counts for Interstate bridges that does not satisfy the EV screening criteria (HS 20 INV RF < 1.0) are summarized region by region for NYSDOT bridges and other bridges in Table 4.8. In addition, results in more detail are listed in Table 4.11. Based on the bridge counts, 70 NYSDOT owned bridges and 64 bridges owned by other entities that are on Interstates do not satisfy the screening criteria, and require EV load ratings performed no later than December 31, 2009. Based on the GPS coordinates included in the database, locations of these bridges are overlaid on a map of New York State using the ArcGIS software, as shown in Figure 4.4.

**Table 4.8** – Summary of Interstate Bridge Counts Not Satisfying the EV Screening Criteria

| CODE | REGION (OFFICE) | NYSDOT BRIDGES | OTHER BRIDGES | TOTAL |
|---|---|---|---|---|
| 1 | Capital Region (Albany) | 2 | 2 | 4 |
| 2 | Mohawk Valley (Utica) | 0 | 11 | 11 |
| 3 | Central New York (Syracuse) | 12 | 9 | 21 |
| 4 | Finger Lakes (Rochester) | 4 | 13 | 17 |
| 5 | Western New York (Buffalo) | 7 | 8 | 15 |
| 6 | Central Southern Tier (Hornell) | 13 | 0 | 13 |
| 7 | North Country (Watertown) | 1 | 0 | 1 |
| 8 | Hudson Valley (Poughkeepsie) | 5 | 10 | 15 |
| 9 | Southern Tier (Binghamton) | 4 | 0 | 4 |
| 0 (10) | Long Island (Hauppauge) | 5 | 0 | 5 |
| N (11) | New York City (LIC, Queens) | 17 | 11 | 28 |
| | **TOTAL** | **70** | **64** | **134** |

Per the proximity analysis performed, bridge counts that are within a 1-mile and 2-mile buffer zones are summarized in Tables 4.9 and 4.10, respectively. It should be noted that that bridges that are within the 2-mile buffer zone already includes those within the 1-mile buffer zone. Results in more detail are listed in Tables 4.12 and 4.13. Also, locations of the bridges that are within 2-mile proximity of Interstates are shown in Figure 5. Based on the results, within a 1-mile buffer zone, 245 NYSDOT owned and 297 other Non-Interstate bridges do not satisfy the screening criteria for EVs. When the buffer zone is increased to 2 miles, the bridge counts for NYSDOT owned and other Non-Interstate bridges increase to 297 and 393 bridges, respectively.

**Table 4.9** – Summary of Non-Interstate Bridge Counts Not Satisfying the EV Screening Criteria (1-Mile)

| CODE | REGION (OFFICE) | NYSDOT BRIDGES | OTHER BRIDGES | TOTAL |
|---|---|---|---|---|
| 1 | Capital Region (Albany) | 17 | 11 | 28 |
| 2 | Mohawk Valley (Utica) | 14 | 27 | 41 |
| 3 | Central New York (Syracuse) | 28 | 19 | 47 |
| 4 | Finger Lakes (Rochester) | 17 | 16 | 33 |
| 5 | Western New York (Buffalo) | 17 | 61 | 78 |
| 6 | Central Southern Tier (Hornell) | 3 | 21 | 24 |
| 7 | North Country (Watertown) | 11 | 10 | 21 |
| 8 | Hudson Valley (Poughkeepsie) | 28 | 67 | 95 |
| 9 | Southern Tier (Binghamton) | 17 | 18 | 35 |
| 0 (10) | Long Island (Hauppauge) | 10 | 2 | 12 |
| N (11) | New York City (LIC, Queens) | 83 | 45 | 128 |
| | **TOTAL** | **245** | **297** | 542 |

**Table 4.10** – Summary of Non-Interstate Bridge Counts Not Satisfying the EV Screening Criteria (2-Miles)

| CODE | REGION (OFFICE) | NYSDOT BRIDGES | OTHER BRIDGES | TOTAL |
|---|---|---|---|---|
| 1 | Capital Region (Albany) | 17 | 14 | 31 |
| 2 | Mohawk Valley (Utica) | 16 | 37 | 53 |
| 3 | Central New York (Syracuse) | 32 | 24 | 56 |
| 4 | Finger Lakes (Rochester) | 22 | 21 | 43 |
| 5 | Western New York (Buffalo) | 26 | 82 | 108 |
| 6 | Central Southern Tier (Hornell) | 5 | 30 | 35 |
| 7 | North Country (Watertown) | 13 | 17 | 30 |
| 8 | Hudson Valley (Poughkeepsie) | 48 | 85 | 133 |
| 9 | Southern Tier (Binghamton) | 19 | 28 | 47 |
| 0 (10) | Long Island (Hauppauge) | 10 | 4 | 14 |
| N (11) | New York City (LIC, Queens) | 89 | 51 | 140 |
| | **TOTAL** | **297** | **393** | 690 |

**Table 4.11** – New York State Interstate Bridges Not Satisfying EV Screening Criteria (HS20 INV RF < 1.0)

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| 10 | NYSDOT | 5 | 2 | | 12 | 4 | 7 | 13 | 1 | 5 | 4 | 17 | 70 |
| 20 | State - Other | | | | | | | | | | | | |
| 21 | Authority or Commission - Other | | | | | | | | | | | | |
| 22 | Alleghany State Park Authority | | | | | | | | | | | | |
| 23 | Nassau County Bridge Authority | | | | | | | | | | | | |
| 24 | Peace Bridge Authority | | | | | | | | | | | | |
| 25 | Capital District State Park Commission | | | | | | | | | | | | |
| 26 | Central NY State Park Commission | | | | | | | | | | | | |
| 27 | City of NY State Park Commission | | | | | | | | | | | | |
| 29 | Finger Lakes Parks and Recreation Commission | | | | | | | | | | | | |
| 30 | County | | | | | | | | | | | | |
| 40 | Town | | | | | | | | | | | | |
| 41 | Village | | | | | | | | | | | | |
| 42 | City | | | | | | | | | | | 5 | 5 |
| 43 | NYC Department of Water Supply, Gas, and Electric | | | | | | | | | | | | |
| 50 | Federal (Other than those listed below) | | | | | | | | | | | | |
| 53 | National Park Service | | | | | | | | | | | | |
| 56 | Military Reservation / Corps of Engineers | | | | | | | | | | | | |
| 60 | Railroad | | | | | | | | | | | | |
| 61 | Long Island Railroad | | | | | | | | | | | | |
| 62 | Retired (use to be Conrail - converted to 60) | | | | | | | | | | | | |
| 70 | Private - Industrial | | | | | | | | | | | | |
| 71 | Private - Utility | | | | | | | | | | | | |
| 72 | Other | | | | | | | | | | | | |
| 2A | Genesee State Parks and Recreation Commission | | | | | | | | | | | | |
| 2B | Interstate Bridge Commission | | | | | | | | | | | | |
| 2C | NYS Department of Environmental Conservation | | | | | | | | | | | | |
| 2G | Long Island State Parks & Recreation Commission | | | | | | | | | | | | |
| 2F | Metropolitan Transportation Authority | | | | | | | | | | | | |
| 2H | Monroe County Water Authority | | | | | | | | | | | | |
| 2I | Niagara Falls Bridge Commission | | | | | | | | | | | | |
| 2J | Niagara Frontier State Park Commission | | | | | | | | | | | | |
| 2K | NYS Bridge Authority | | | | | | | | | | | | |
| 2L | NYS Thruway Authority | | 2 | 11 | 9 | 13 | 8 | | | 10 | | | 53 |
| 2M | Ogdensburg Bridge and Port Authority | | | | | | | | | | | | |
| 2N | Palisades Interstate Park Commission | | | | | | | | | | | | |
| 2P | NYS Power Authority | | | | | | | | | | | | |
| 2Q | Seaway International Bridge Authority | | | | | | | | | | | | |
| 2S | Thousand Islands Bridge Authority | | | | | | | | | | | | |
| 2T | Transit Authority | | | | | | | | | | | | |
| 2U | MTA Tunnels & Bridges (aka TBTA) | | | | | | | | | | | 4 | 4 |
| 2W | Port Authority of NY & NJ | | | | | | | | | | | 2 | 2 |
| | SUBTOTAL FOR NON-NYSDOT BRIDGES | | 2 | 11 | 9 | 13 | 8 | | | 10 | | 11 | 64 |
| | TOTAL INCLUDING NYSDOT BRIDGES | 5 | 4 | 11 | 21 | 17 | 15 | 13 | 1 | 15 | 4 | 28 | 134 |


**Figure 4.4** – New York State Interstate Bridges Not Satisfying EV Screening Criteria (Red: NYSDOT Bridges, Green: Other Bridges).

**Table 4.12** – New York State Non-Interstate Bridges Not Satisfying EV Screening Criteria (HS20 INV RF < 1.0) – 1-Mile Proximity

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| 10 | NYSDOT | 10 | 17 | 14 | 28 | 17 | 17 | 3 | 11 | 28 | 17 | 83 | **245** |
| 20 | State - Other | | | 1 | | | 1 | | | | | | **2** |
| 21 | Authority or Commission - Other | | | | | | | | | | | | |
| 22 | Alleghany State Park Authority | | | | | | | | | | | | |
| 23 | Nassau County Bridge Authority | | | | | | | | | | | | |
| 24 | Peace Bridge Authority | | | | | | | | | | | | |
| 25 | Capital District State Park Commission | | | | | | | | | | | | |
| 26 | Central NY State Park Commission | | | | | | | | | | | | |
| 27 | City of NY State Park Commission | | | | | | | | | | | | |
| 29 | Finger Lakes Parks and Recreation Commission | | | | | | | | | | | | |
| 30 | County | 2 | 7 | 7 | 4 | 11 | 20 | 9 | 7 | 18 | 12 | | **97** |
| 40 | Town | | | 5 | 4 | 1 | 1 | 8 | 1 | 4 | 3 | | **27** |
| 41 | Village | | | 2 | | | | 3 | | 6 | 3 | | **14** |
| 42 | City | | 1 | 1 | 3 | 1 | 10 | | 1 | 5 | | 34 | **56** |
| 43 | NYC Department of Water Supply, Gas, and Electric | | | | | | | | | | | | |
| 50 | Federal (Other than those listed below) | | | | | | | 1 | | | | | **1** |
| 53 | National Park Service | | | | | | | | | | | | |
| 56 | Military Reservation / Corps of Engineers | | | | | | | | | | | | |
| 60 | Railroad | | | | | | | | | 9 | | | **9** |
| 61 | Long Island Railroad | | | | | | | | | | | | |
| 62 | Retired (use to be Conrail - converted to 60) | | | | | | | | | | | | |
| 70 | Private - Industrial | | | | | | | | | | | | |
| 71 | Private - Utility | | | | | | | | | | | | |
| 72 | Other | | | | | | | | | | | | |
| 2A | Genesee State Parks and Recreation Commission | | | | | | | | | | | | |
| 2B | Interstate Bridge Commission | | | | | | | | | | | | |
| 2C | NYS Department of Environmental Conservation | | | | | | | | 1 | | | | **1** |
| 2G | Long Island State Parks & Recreation Commission | | | | | | | | | | | | |
| 2F | Metropolitan Transportation Authority | | | | | | | | | | | | |
| 2H | Monroe County Water Authority | | | | | | | | | | | | |
| 2I | Niagara Falls Bridge Commission | | | | | | | | | | | | |
| 2J | Niagara Frontier State Park Commission | | | | | | | | | | | | |
| 2K | NYS Bridge Authority | | | | | | | | | | | | |
| 2L | NYS Thruway Authority | | 3 | 11 | 8 | 3 | 28 | | | 25 | | | **78** |
| 2M | Ogdensburg Bridge and Port Authority | | | | | | | | | | | | |
| 2N | Palisades Interstate Park Commission | | | | | | | | | | | | |
| 2P | NYS Power Authority | | | | | | 1 | | | | | | **1** |
| 2Q | Seaway International Bridge Authority | | | | | | | | | | | | |
| 2S | Thousand Islands Bridge Authority | | | | | | | | | | | | |
| 2T | Transit Authority | | | | | | | | | | | | |
| 2U | MTA Tunnels & Bridges (aka TBTA) | | | | | | | | | | | 4 | **4** |
| 2W | Port Authority of NY & NJ | | | | | | | | | | | 7 | **7** |
| | **SUBTOTAL FOR NON-NYSDOT BRIDGES** | **2** | **11** | **27** | **19** | **16** | **61** | **21** | **10** | **67** | **18** | **45** | **297** |
| | **TOTAL INCLUDING NYSDOT BRIDGES** | **12** | **28** | **41** | **47** | **33** | **78** | **24** | **21** | **95** | **35** | **128** | **542** |

**Table 4.13** – New York State Non-Interstate Bridges Not Satisfying EV Screening Criteria (HS20 INV RF < 1.0) – 2-Mile Proximity

| OWNER CODE | OWNER NAME | REGION | | | | | | | | | | | SUM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| **10** | **NYSDOT** | 10 | 17 | 16 | 32 | 22 | 26 | 5 | 13 | 48 | 19 | 89 | **297** |
| **20** | **State - Other** | | | 1 | | | 1 | | | | | | **2** |
| **21** | **Authority or Commission - Other** | | | | | | | | | | | | |
| **22** | **Alleghany State Park Authority** | | | | | | | | | | | | |
| **23** | **Nassau County Bridge Authority** | | | | | | | | | | | | |
| **24** | **Peace Bridge Authority** | | | | | | | | | | | | |
| **25** | **Capital District State Park Commission** | | | | | | | | | | | | |
| **26** | **Central NY State Park Commission** | | | | | | | | | | | | |
| **27** | **City of NY State Park Commission** | | | | | | | | | | | | |
| **29** | **Finger Lakes Parks and Recreation Commission** | | | | | | | | | | | | |
| **30** | **County** | 2 | 9 | 12 | 6 | 15 | 36 | 11 | 13 | 25 | 21 | | **150** |
| **40** | **Town** | 2 | | 8 | 7 | 1 | 3 | 14 | 1 | 5 | 3 | | **44** |
| **41** | **Village** | | | 3 | | 1 | | 4 | | 7 | 3 | | **18** |
| **42** | **City** | | 1 | 2 | 3 | 1 | 13 | | 2 | 9 | 1 | 40 | **72** |
| **43** | **NYC Department of Water Supply, Gas, and Electric** | | | | | | | | | | | | |
| **50** | **Federal (Other than those listed below)** | | | | | | | 1 | | | | | **1** |
| **53** | **National Park Service** | | | | | | | | | | | | |
| **56** | **Military Reservation / Corps of Engineers** | | | | | | | | | | | | |
| **60** | **Railroad** | | | | | | | | | 14 | | | **14** |
| **61** | **Long Island Railroad** | | | | | | | | | | | | |
| **62** | **Retired (use to be Conrail - converted to 60)** | | | | | | | | | | | | |
| **70** | **Private - Industrial** | | | | | | | | | | | | |
| **71** | **Private - Utility** | | | | | | | | | | | | |
| **72** | **Other** | | | | | | | | | | | | |
| **2A** | **Genesee State Parks and Recreation Commission** | | | | | | | | | | | | |
| **2B** | **Interstate Bridge Commission** | | | | | | | | | | | | |
| **2C** | **NYS Department of Environmental Conservation** | | | | | | | | 1 | | | | **1** |
| **2G** | **Long Island State Parks & Recreation Commission** | | | | | | | | | | | | |
| **2F** | **Metropolitan Transportation Authority** | | | | | | | | | | | | |
| **2H** | **Monroe County Water Authority** | | | | | | | | | | | | |
| **2I** | **Niagara Falls Bridge Commission** | | | | | | | | | | | | |
| **2J** | **Niagara Frontier State Park Commission** | | | | | | | | | | | | |
| **2K** | **NYS Bridge Authority** | | | | | | | | | | | | |
| **2L** | **NYS Thruway Authority** | | 4 | 11 | 8 | 3 | 28 | | | 25 | | | **79** |
| **2M** | **Ogdensburg Bridge and Port Authority** | | | | | | | | | | | | |
| **2N** | **Palisades Interstate Park Commission** | | | | | | | | | | | | |
| **2P** | **NYS Power Authority** | | | | | | 1 | | | | | | **1** |
| **2Q** | **Seaway International Bridge Authority** | | | | | | | | | | | | |
| **2S** | **Thousand Islands Bridge Authority** | | | | | | | | | | | | |
| **2T** | **Transit Authority** | | | | | | | | | | | | |
| **2U** | **MTA Tunnels & Bridges (aka TBTA)** | | | | | | | | | | | 4 | **4** |
| **2W** | **Port Authority of NY & NJ** | | | | | | | | | | | 7 | **7** |
| | **SUBTOTAL FOR NON-NYSDOT BRIDGES** | **4** | **14** | **37** | **24** | **21** | **82** | **30** | **17** | **85** | **28** | **51** | **393** |
| | **TOTAL INCLUDING NYSDOT BRIDGES** | **14** | **31** | **53** | **56** | **43** | **108** | **35** | **30** | **133** | **47** | **140** | **690** |

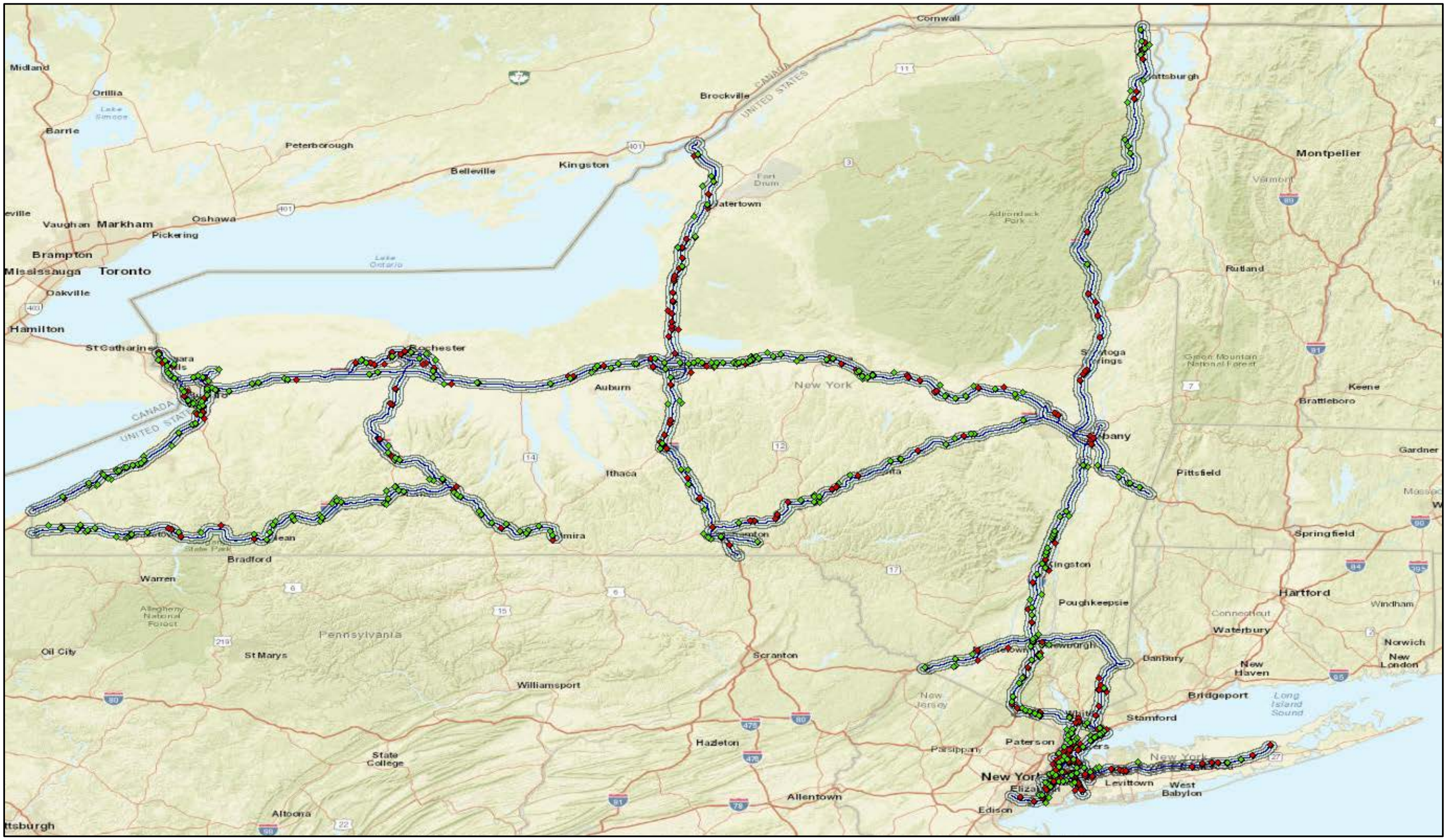


**Figure 4.5** – New York State Non-Interstate Bridges Not Satisfying EV Screening Criteria (Red: NYSDOT Bridges, Green: Other Bridges).

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# 5 CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The goal of this task was "To validate and test the draft LRFR EI developed to follow the LRFR methodology as specified in the AASHTO MBE using Level I ratings". The work completed under this task consists of Level I load ratings of 23 bridges and culverts not ratable by AASHTOWare BrR and Special studies to support LRFR Implementation in New York State.

**Design Load Ratings:**

- As seen in the previously submitted Level II Load Rating Report, direct comparisons of LRFR and LFR load ratings generally yielded scattered results. This was mainly due to the differences in the live loads (HS-20/H-20 vs HL-93), live load distribution, dynamic load allowance, and sometimes due to differences in resistance calculations.
- Overall, the LRFR methodology produced lower rating factors than the LFR methodology for the design load in steel bridges. This is likely due to the heavier HL-93 design load and the application of the dynamic allowance (impact).
- For T-beam and RC Frame type concrete bridges, LRFR and LFR results were less distinct. However, in reinforced concrete arch bridges, significantly higher LRFR rating factors were observed due to the less conservative distribution of wheel loads through earth fill. This resulted in LRFR Inventory level design ratings to be higher than HS-20 LFR Inventory level design ratings on average, for the bridges in consideration.

**Legal Load Ratings:**

- For steel bridges, LRFR Legal Load ratings were higher than LFR legal load ratings at the Inventory level, but lower than LFR legal load ratings at the Operating level, for both State and Local bridges.
- For concrete bridges, LRFR Legal Load ratings were higher than LFR legal load ratings at the Inventory level, for both State and Local bridges. However, for Local bridges, it was possible to achieve higher LRFR ratings than LFR even at the Operating level, due to the use of reduced live load factors for Local bridges. For State bridges, LRFR ratings were lower than LFR ratings at the Operating level.

**Permit Load Ratings:**

- For steel bridges, LRFR and LFR permit load ratings were similar, where LRFR resulted in only 3% lower ratings on average.
- For concrete bridges, LRFR permit load ratings were significantly higher than LFR ratings (44% higher on average). This can mostly be attributed to high LRFR ratings observed for the reinforced concrete arch bridges, which constitute 4 out of 9 concrete bridges that were load rated.

**Load Posting and R-Posting:**

Level I Load Posting & R-Posting Summary is given in Table 2.4. A total of 6 bridges required load posting in LFR analysis, whereas 3 bridges required posting for Type 3S2 and 4 bridges for SU4 when the LRFR methodology is used, when the best rating outcome was taken into account from 2D and 3D analyses (if available). It should be noted that in two of the bridges (1051960 and 1041200) it was possible to avoid posting when the analysis methodology was switched to 3D from 2D, when using the LRFR methodology (both 2D and 3D analyses were performed for 6 bridges). Although no such change in the posting outcome was observed when the LFR methodology was used, it can be stated that 3D finite element analysis can help posted bridges in both methodologies, due to the increased rating factors observed for both. This is also supported by data for bridges with no posting is required, where 3D analysis based rating factors were generally higher than their 2D counterparts.

Six bridges needed R posting in both LFR and LRFR methodologies. It was possible to avoid R-postings when the analysis methodology was switched to 3D from 2D, one in LFR (1041200) and two in LRFR (1046510 and 1051960).

## 5.2 Recommendations

- Currently ratings and postings are performed using EI 05-034 which utilizes the LFR method and the H truck. NYSDOT LRFR procedures are based on the SU4 truck as the representative single unit rating vehicle as it would provide the lowest posting load compared to SU5, SU6, and SU7 vehicles. As the SHV loads exceeds the weight of a legal SU4 configuration that a significant number of other bridge that were previously unposted would require posting for the other SHVs.

- Revisions to EI 05-034 for LFR posting using SHVs and revisions to the draft LRFR EI, developed to follow bridge LRFR methodology as specified in the AASHTO Manual for Bridge Evaluation, have been developed based on this study results. “Load and Resistance Factor Rating (LRFR)

Blue Pages" document has also been created. This is analogous to the NYSDOT LRFD Blue Pages. See Appendix B.

- An approach to deriving LRFR Condition Factors using element inspection data has been recommended and included in the LRFR Blue Pages. EI 05-034 Table 2 has been updated incorporating AASHTO Element Condition State ratings.

- Per the latest FHWA directive, and the MBE refinements, SHV ratings and Emergency Vehicles ratings required by the FAST Act were applied for the screenings of state and locally owned bridges. This study has identified **bridges that are at risk** of being controlled by SHV ratings and EV ratings and may require posting. The screening will promote efficiency in load rating analysis for these load models. The study investigated all NYS highway bridges with available load ratings in the database (13988 bridges).

- Other recommendations from this study include:
  - ➢ For the LRFR methodology, two criteria for R-Posting bridges were recommended in the draft EI. Recommended methodology was developed based on the load rating results.
  - ➢ For bridges on the local system the use of LRFR legal load factors provided in the AASHTO MBE 3rd Edition (2018) is recommended. This would be a departure from the Draft EI and has been incorporated in the LRFR Blue Pages. State owned and Interstate bridges should be rated with NY specific legal load factors given in the Draft EI.
  - ➢ Guidance on the use of all SHVs in load ratings and postings has been added to the LFR and LRFR EI and Blue Pages.

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# APPENDIX A

## Results of Task 4-6 Level II SHV Load Ratings

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# Appendix A - Results of Task 4-6 Level II SHV Load Ratings

| Bridge ID | NBI Structure ID | Superstructure Type Code | LRFR Legal Load Rating Factor | | | | H20 (OPR) LFR Rating Factor |
|---|---|---|---|---|---|---|---|
| | | | SU4 | SU5 | SU6 | SU7 | |
| 28112 | 1047720 | SMGS | 1.15 | 1.08 | 0.97 | 0.90 | 1.39 |
| 31019 | 1055740 | SMGS | 1.98 | 1.77 | 1.60 | 1.46 | 2.67 |
| 41505 | 3203640 | SMGS | 1.00 | 0.93 | 0.83 | 0.77 | 2.28 |
| 26389 | 3221950 | PSB | 2.81 | 2.59 | 2.42 | 2.30 | 4.53 |
| 01513 | 3344660 | RCS | 1.31 | 1.20 | 1.11 | 1.09 | 1.20 |
| 04505 | 1000610 | RCS | 1.00 | 0.92 | 0.86 | 0.85 | 1.43 |
| 13363 | 1001370 | RCS | 1.16 | 1.07 | 1.00 | 1.00 | 1.55 |
| 19483 | 1001830 | SMGS | 1.16 | 1.07 | 0.96 | 0.88 | 1.96 |
| 03046 | 1002450 | RCT | 0.98 | 0.88 | 0.86 | 0.85 | 2.28 |
| 42897 | 1002730 | PMGS | 0.71 | 0.62 | 0.57 | 0.53 | 1.91 |
| 25708 | 1003330 | PMGC | 2.87 | 2.61 | 2.41 | 2.25 | 2.58 |
| 00413 | 1003720 | SMGS | 1.07 | 1.00 | 0.91 | 0.87 | 1.38 |
| 17700 | 1003930 | RCT | 0.70 | 0.67 | 0.60 | 0.57 | 1.85 |
| 17704 | 1003940 | RCT | 0.69 | 0.64 | 0.58 | 0.56 | 1.76 |
| 19731 | 1004010 | SMGS | 1.11 | 1.04 | 0.94 | 0.88 | 1.79 |
| 24094 | 1004440 | RCS | 1.33 | 1.23 | 1.14 | 1.13 | 1.65 |
| 24688 | 1006250 | RCS | 1.20 | 1.13 | 1.07 | 1.07 | 1.55 |
| 18285 | 1007710 | RCS | 1.11 | 1.03 | 0.95 | 0.94 | 1.55 |
| 27457 | 1007850 | RCS | 1.00 | 0.94 | 0.89 | 0.89 | 1.31 |
| 06481 | 1007880 | PSB | 1.25 | 1.19 | 1.13 | 1.08 | 1.49 |
| 06483 | 1007900 | PSB | 1.35 | 1.18 | 1.19 | 1.17 | 2.09 |
| 13403 | 1008000 | SMGS | 1.29 | 1.19 | 1.07 | 0.99 | 2.03 |
| 02728 | 1008130 | RCS | 0.92 | 0.87 | 0.79 | 0.75 | 1.30 |
| 04510 | 1008610 | SMGS | 1.44 | 1.31 | 1.18 | 1.08 | 1.88 |
| 04487 | 1008930 | SMGS | 1.22 | 1.14 | 1.03 | 0.96 | 2.14 |
| 20177 | 1009210 | SMGS | 0.84 | 0.79 | 0.71 | 0.68 | 1.92 |
| 04119 | 1009530 | SMGS | 2.51 | 2.25 | 2.02 | 1.84 | 1.96 |
| 04862 | 1010160 | SMGS | 1.32 | 1.18 | 1.08 | 0.99 | 2.96 |
| 17981 | 1010250 | PMGS | 1.21 | 1.11 | 1.01 | 0.94 | 2.49 |
| 18310 | 1010260 | PMGS | 1.08 | 1.03 | 0.94 | 0.89 | 2.18 |
| 18730 | 1010660 | RCT | 0.71 | 0.63 | 0.62 | 0.62 | 2.22 |
| 07462 | 1012510 | SMGS | 1.19 | 1.09 | 0.98 | 0.90 | 1.93 |
| 10065 | 1012720 | PSB | 1.78 | 1.70 | 1.63 | 1.58 | 2.63 |
| 29305 | 1014580 | SMGS | 1.94 | 1.79 | 1.61 | 1.49 | 2.55 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 20683 | 1014730 | RCT | 1.37 | 1.28 | 1.16 | 1.11 | 2.66 |
| 19519 | 1015080 | SMGS | 1.36 | 1.27 | 1.15 | 1.07 | 2.16 |
| 14118 | 1015590 | RCS | 1.62 | 1.54 | 1.47 | 1.47 | 2.05 |
| 05781 | 1016030 | RCS | 1.36 | 1.28 | 1.15 | 1.07 | 2.01 |
| 14122 | 1016080 | PSB | 1.33 | 1.23 | 1.16 | 1.14 | 2.85 |
| 05415 | 1016590 | RCT | 0.55 | 0.52 | 0.47 | 0.45 | 1.22 |
| 16253 | 1017520 | PSB | 2.13 | 1.93 | 1.76 | 1.62 | 2.39 |
| 40070 | 1018000 | PSB | 2.37 | 2.14 | 1.96 | 1.83 | 3.35 |
| 15447 | 1018730 | SMGS | 0.65 | 0.62 | 0.56 | 0.53 | 1.65 |
| 07840 | 1019830 | RCS | 1.20 | 1.20 | 1.20 | 1.20 | 1.42 |
| 28969 | 1019990 | SMGS | 0.79 | 0.74 | 0.67 | 0.63 | 1.42 |
| 05614 | 1020370 | SMGC | 1.23 | 1.09 | 0.98 | 0.90 | 1.00 |
| 18843 | 1020870 | RCT | 0.80 | 0.75 | 0.67 | 0.63 | 1.44 |
| 23728 | 1021380 | RCT | 1.20 | 1.15 | 1.04 | 0.98 | 2.46 |
| 01302 | 1022290 | SMGS | 0.70 | 0.65 | 0.59 | 0.57 | 0.91 |
| 38106 | 1022380 | SMGS | 2.13 | 2.01 | 1.81 | 1.70 | 2.31 |
| 02843 | 1023210 | SMGS | 1.84 | 1.73 | 1.56 | 1.46 | 2.33 |
| 30203 | 1024080 | SMGS | 1.53 | 1.40 | 1.26 | 1.16 | 1.99 |
| 18602 | 1024320 | SMGS | 0.58 | 0.52 | 0.47 | 0.42 | 1.53 |
| 14390 | 1024840 | SMGS | 1.14 | 1.07 | 0.97 | 0.93 | 3.11 |
| 44332 | 1025270 | PSB | 3.44 | 3.26 | 3.12 | 3.02 | 4.48 |
| 38337 | 1025390 | SMGS | 1.96 | 1.86 | 1.68 | 1.57 | 2.12 |
| 28526 | 1025480 | RCS | 1.12 | 1.03 | 0.95 | 0.94 | 2.20 |
| 24635 | 1027580 | SMGS | 0.98 | 0.92 | 0.83 | 0.80 | 1.59 |
| 27682 | 1028000 | RCS | 1.19 | 1.15 | 1.11 | 1.11 | 1.46 |
| 42979 | 1028030 | RCT | 0.80 | 0.74 | 0.67 | 0.62 | 1.42 |
| 02614 | 1030320 | SMGS | 0.11 | 0.10 | 0.09 | 0.09 | 0.20 |
| 35598 | 1031740 | PMGC | 5.39 | 4.73 | 4.23 | 3.80 | 2.75 |
| 04830 | 1032050 | SMGS | 3.57 | 3.32 | 2.98 | 2.77 | 2.17 |
| 21487 | 1034440 | PSB | 2.29 | 2.15 | 2.02 | 1.94 | 3.89 |
| 24797 | 1035450 | RCT | 1.38 | 1.27 | 1.16 | 1.07 | 1.42 |
| 24003 | 1035460 | RCT | 0.89 | 0.84 | 0.75 | 0.70 | 1.50 |
| 20753 | 1035869 | SMGS | 1.76 | 1.57 | 1.41 | 1.28 | 1.94 |
| 27713 | 1036080 | PMGC | 3.39 | 2.89 | 2.56 | 2.29 | 2.07 |
| 06535 | 1037720 | RCS | 0.96 | 0.89 | 0.84 | 0.84 | 1.46 |
| 04515 | 1038980 | PMGS | 2.78 | 2.52 | 2.33 | 2.18 | 2.86 |
| 04540 | 1039010 | PMGS | 2.61 | 2.39 | 2.22 | 2.10 | 3.11 |
| 24671 | 1039480 | SMGC | 2.51 | 2.20 | 1.97 | 1.77 | 1.09 |
| 06003 | 1039830 | PMGS | 2.11 | 1.97 | 1.77 | 1.65 | 4.46 |
| 42323 | 1039969 | SMGS | 1.33 | 1.22 | 1.19 | 1.18 | 2.03 |
| 04968 | 1040140 | RCT | 1.02 | 0.96 | 0.87 | 0.83 | 2.31 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 30930 | 1040380 | SMGS | 1.74 | 1.65 | 1.49 | 1.42 | 3.21 |
| 07847 | 1041330 | SMGS | 0.43 | 0.39 | 0.36 | 0.35 | 1.58 |
| 42691 | 1041660 | SMGS | 1.02 | 0.95 | 0.87 | 0.83 | 1.90 |
| 14946 | 1041670 | SMGS | 1.43 | 1.35 | 1.21 | 1.14 | 2.03 |
| 03321 | 1041830 | SMGS | 1.44 | 1.30 | 1.16 | 1.06 | 2.02 |
| 06989 | 1041890 | RCT | 0.52 | 0.46 | 0.43 | 0.41 | 2.23 |
| 20706 | 1043520 | SMGS | 1.22 | 1.15 | 1.03 | 0.97 | 1.86 |
| 03216 | 1043720 | RCS | 1.90 | 1.90 | 1.88 | 1.88 | 1.62 |
| 30225 | 1045640 | SMGS | 2.05 | 1.90 | 1.70 | 1.58 | 2.03 |
| 04750 | 1046720 | PMGS | 2.66 | 2.43 | 2.26 | 2.13 | 3.11 |
| 42737 | 1049420 | SMGS | 3.44 | 3.10 | 2.78 | 2.54 | 2.76 |
| 06207 | 1050490 | SMGS | 1.07 | 0.99 | 0.99 | 0.98 | 1.62 |
| 44642 | 1051360 | RCS | 2.28 | 2.11 | 1.97 | 1.97 | 2.52 |
| 04776 | 1054630 | SMGC | 2.29 | 2.04 | 1.83 | 1.67 | 1.46 |
| 30115 | 1055650 | SMGC | 2.32 | 2.11 | 1.92 | 1.80 | 2.22 |
| 00837 | 1058059 | SMGS | 2.13 | 1.91 | 1.71 | 1.56 | 2.33 |
| 44461 | 1059412 | SMGS | 0.77 | 0.72 | 0.65 | 0.60 | 1.72 |
| 22304 | 1061050 | SMGS | 0.59 | 0.54 | 0.50 | 0.49 | 1.54 |
| 00056 | 1061371 | PMGS | 3.09 | 2.72 | 2.50 | 2.33 | 2.17 |
| 00061 | 1061391 | PMGS | 3.51 | 3.10 | 2.81 | 2.55 | 2.32 |
| 07298 | 1061392 | PMGS | 1.80 | 1.63 | 1.50 | 1.40 | 2.32 |
| 00062 | 1061421 | PMGS | 3.01 | 2.65 | 2.45 | 2.30 | 2.13 |
| 02569 | 1061672 | SMGS | 2.62 | 2.35 | 2.10 | 1.91 | 3.57 |
| 07421 | 1061852 | PMGS | 1.94 | 1.76 | 1.62 | 1.50 | 2.77 |
| 18619 | 1063319 | SMGS | 1.99 | 1.77 | 1.60 | 1.46 | 2.55 |
| 33301 | 1066140 | SMGC | 4.46 | 4.06 | 3.67 | 3.42 | 2.10 |
| 35654 | 1066990 | SMGC | 3.22 | 2.95 | 2.69 | 2.53 | 1.63 |
| 36168 | 1067089 | SMGC | 0.67 | 0.61 | 0.55 | 0.50 | 2.03 |
| 00989 | 1069431 | PSB | 1.76 | 1.57 | 1.45 | 1.35 | 2.45 |
| 17071 | 1069890 | PSB | 1.24 | 1.14 | 1.04 | 0.97 | 2.16 |
| 20143 | 1071482 | PMGS | 1.75 | 1.58 | 1.45 | 1.37 | 2.16 |
| 37285 | 1072970 | SMGC | 2.04 | 1.79 | 1.60 | 1.45 | 2.43 |
| 14646 | 1074392 | SMGS | 3.18 | 2.81 | 2.56 | 2.35 | 3.61 |
| 32955 | 1075930 | SMGC | 1.69 | 1.60 | 1.45 | 1.38 | 2.53 |
| 26641 | 1076460 | SMGS | 2.02 | 1.89 | 1.70 | 1.58 | 2.16 |
| 33927 | 1076710 | SMGC | 1.40 | 1.26 | 1.14 | 1.04 | 2.20 |
| 21454 | 1078630 | SMGS | 0.86 | 0.81 | 0.76 | 0.76 | 1.59 |
| 21761 | 1091370 | SMGS | 1.58 | 1.45 | 1.32 | 1.22 | 2.04 |
| 07666 | 1093681 | SMGS | 1.84 | 1.64 | 1.47 | 1.34 | 3.29 |
| 04824 | 1094890 | SMGS | 3.14 | 2.93 | 2.64 | 2.45 | 2.05 |
| 06266 | 1096040 | SMGS | 2.01 | 1.87 | 1.68 | 1.57 | 2.15 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 41541 | 2200580 | SMGS | 0.93 | 0.85 | 0.79 | 0.78 | 1.78 |
| 42936 | 2201730 | PSB | 1.68 | 1.59 | 1.45 | 1.39 | 2.37 |
| 45375 | 2201980 | SMGS | 1.38 | 1.26 | 1.17 | 1.15 | 1.21 |
| 41483 | 2203810 | SMGS | 0.97 | 0.91 | 0.84 | 0.79 | 1.46 |
| 39872 | 2204590 | SMGS | 0.57 | 0.51 | 0.46 | 0.42 | 0.70 |
| 40216 | 2204780 | SMGS | 0.86 | 0.80 | 0.72 | 0.67 | 0.62 |
| 42887 | 2205570 | SMGS | 0.94 | 0.84 | 0.75 | 0.68 | 0.98 |
| 43675 | 2205650 | SMGS | 0.82 | 0.77 | 0.72 | 0.72 | 0.95 |
| 43845 | 2206220 | SMGS | 0.63 | 0.59 | 0.53 | 0.49 | 1.15 |
| 44649 | 2206380 | SMGS | 0.68 | 0.63 | 0.58 | 0.54 | 0.59 |
| 20299 | 2206780 | SMGS | 0.76 | 0.73 | 0.66 | 0.62 | 1.67 |
| 40030 | 2207300 | SMGS | 1.08 | 1.00 | 0.90 | 0.83 | 1.24 |
| 39297 | 2209550 | SMGS | 1.31 | 1.21 | 1.09 | 1.01 | 1.46 |
| 41078 | 2209610 | SMGS | 1.07 | 0.97 | 0.89 | 0.82 | 1.48 |
| 21141 | 2210640 | SMGS | 1.95 | 1.80 | 1.62 | 1.50 | 2.26 |
| 45799 | 2210730 | RCS | 0.51 | 0.48 | 0.46 | 0.46 | 0.77 |
| 45884 | 2210950 | SMGS | 1.05 | 0.98 | 0.92 | 0.92 | 1.42 |
| 43355 | 2212480 | SMGS | 0.86 | 0.81 | 0.76 | 0.76 | 1.79 |
| 42963 | 2213050 | PMGS | 2.03 | 1.90 | 1.75 | 1.65 | 3.06 |
| 05183 | 2213990 | SMGS | 0.92 | 0.89 | 0.81 | 0.81 | 3.23 |
| 14766 | 2214400 | SMGS | 0.56 | 0.51 | 0.46 | 0.42 | 0.69 |
| 09214 | 2216220 | PSB | 2.62 | 2.30 | 2.05 | 1.85 | 3.14 |
| 10306 | 2217300 | SMGS | 0.43 | 0.40 | 0.37 | 0.35 | 1.59 |
| 10281 | 2217940 | SMGS | 1.29 | 1.22 | 1.13 | 1.06 | 1.83 |
| 44697 | 2218260 | SMGS | 0.88 | 0.83 | 0.75 | 0.70 | 0.40 |
| 43276 | 2218480 | SMGS | 0.30 | 0.27 | 0.25 | 0.25 | 0.99 |
| 43278 | 2218800 | SMGS | 0.69 | 0.65 | 0.58 | 0.54 | 1.06 |
| 40693 | 2219070 | SMGS | 0.46 | 0.44 | 0.41 | 0.41 | 1.16 |
| 40675 | 2219150 | SMGS | 2.06 | 1.83 | 1.65 | 1.50 | 2.73 |
| 13150 | 2219330 | RCS | 1.12 | 1.07 | 0.96 | 0.91 | 1.54 |
| 20117 | 2221880 | PMGS | 1.71 | 1.60 | 1.51 | 1.45 | 2.09 |
| 21484 | 2223120 | SMGS | 0.68 | 0.63 | 0.57 | 0.53 | 0.61 |
| 25536 | 2224900 | RCS | 0.90 | 0.85 | 0.80 | 0.80 | 1.10 |
| 25639 | 2225070 | RCT | 0.79 | 0.72 | 0.72 | 0.70 | 1.14 |
| 26024 | 2225260 | RCT | 1.27 | 1.17 | 1.07 | 1.03 | 1.79 |
| 43001 | 2225780 | RCT | 3.53 | 3.25 | 3.20 | 3.06 | 3.25 |
| 39568 | 2225790 | SMGS | 1.62 | 1.50 | 1.35 | 1.25 | 1.73 |
| 47146 | 2227040 | SMGS | 0.91 | 0.85 | 0.77 | 0.75 | 1.18 |
| 41381 | 2227370 | SMGS | 0.86 | 0.81 | 0.73 | 0.69 | 1.63 |
| 43882 | 2227620 | SMGS | 0.93 | 0.83 | 0.75 | 0.69 | 1.79 |
| 43655 | 2228670 | SMGS | 1.13 | 1.04 | 0.94 | 0.87 | 1.52 |

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|---|---|---|---|---|---|---|---|
| 43241 | 2228800 | SMGS | 0.29 | 0.27 | 0.25 | 0.24 | 0.41 |
| 43225 | 2228960 | SMGS | 0.73 | 0.67 | 0.62 | 0.62 | 0.91 |
| 30622 | 2230890 | SMGC | 4.15 | 3.79 | 3.43 | 3.14 | 4.03 |
| 29984 | 2240660 | SMGC | 2.65 | 2.38 | 2.13 | 1.94 | 2.83 |
| 33240 | 2241080 | SMGS | 2.07 | 1.96 | 1.77 | 1.68 | 2.02 |
| 04029 | 2254590 | SMGS | 0.64 | 0.59 | 0.53 | 0.49 | 1.24 |
| 40220 | 2255580 | SMGS | 1.34 | 1.27 | 1.14 | 1.07 | 1.28 |
| 43579 | 2255910 | RCS | 0.80 | 0.74 | 0.68 | 0.67 | 0.72 |
| 21701 | 2257710 | SMGS | 0.31 | 0.29 | 0.26 | 0.24 | 0.48 |
| 44992 | 2257930 | SMGS | 0.42 | 0.39 | 0.38 | 0.38 | 0.51 |
| 37854 | 2260030 | SMGS | 2.27 | 2.13 | 2.14 | 2.14 | 3.37 |
| 24705 | 2262150 | PMGC | 1.30 | 1.25 | 1.20 | 1.17 | 2.46 |
| 27446 | 2265300 | SMGS | 1.85 | 1.69 | 1.52 | 1.40 | 2.21 |
| 40620 | 2266840 | SMGS | 1.16 | 1.05 | 0.96 | 0.88 | 0.80 |
| 46931 | 2266890 | SMGS | 4.01 | 3.65 | 3.27 | 3.01 | 3.79 |
| 10738 | 2267080 | SMGS | 1.02 | 0.95 | 0.86 | 0.80 | 1.04 |
| 11480 | 2267900 | SMGS | 0.25 | 0.23 | 0.21 | 0.21 | 0.64 |
| 41598 | 2270600 | SMGS | 4.20 | 3.84 | 3.53 | 3.46 | 5.57 |
| 43406 | 2308750 | SMGS | 1.02 | 0.93 | 0.83 | 0.76 | 1.44 |
| 42814 | 2309090 | SMGS | 1.53 | 1.40 | 1.25 | 1.15 | 2.04 |
| 43324 | 2309130 | SMGS | 0.63 | 0.57 | 0.51 | 0.46 | 0.57 |
| 43491 | 2309280 | SMGS | 2.10 | 1.92 | 1.72 | 1.59 | 2.18 |
| 43336 | 3034720 | PSB | 1.47 | 1.32 | 1.25 | 1.20 | 2.56 |
| 32011 | 3043630 | SMGS | 0.83 | 0.77 | 0.70 | 0.68 | 1.90 |
| 39769 | 3201100 | SMGS | 1.58 | 1.48 | 1.35 | 1.32 | 1.49 |
| 39192 | 3209160 | SMGS | 1.27 | 1.16 | 1.06 | 1.03 | 1.72 |
| 08915 | 3210170 | SMGS | 1.27 | 1.19 | 1.12 | 1.12 | 1.72 |
| 08824 | 3219300 | SMGS | 0.38 | 0.36 | 0.32 | 0.31 | 0.78 |
| 09723 | 3221340 | SMGS | 1.52 | 1.40 | 1.28 | 1.24 | 1.18 |
| 14754 | 3221850 | SMGS | 1.71 | 1.60 | 1.44 | 1.34 | 2.60 |
| 11749 | 3222490 | SMGS | 1.30 | 1.19 | 1.07 | 0.98 | 1.85 |
| 25704 | 3222510 | SMGS | 0.25 | 0.23 | 0.21 | 0.19 | 0.57 |
| 26391 | 3222650 | SMGS | 0.59 | 0.54 | 0.48 | 0.44 | 0.99 |
| 29315 | 3222770 | SMGS | 1.86 | 1.69 | 1.52 | 1.39 | 1.65 |
| 29296 | 3222870 | PSB | 1.95 | 1.79 | 1.69 | 1.61 | 2.47 |
| 43724 | 3300272 | PSB | 1.92 | 1.76 | 1.62 | 1.51 | 2.94 |
| 44091 | 3300520 | PMGC | 2.83 | 2.55 | 2.32 | 2.14 | 3.01 |
| 42748 | 3300689 | RCT | 1.49 | 1.41 | 1.27 | 1.19 | 1.37 |
| 42791 | 3300740 | RCT | 1.65 | 1.50 | 1.38 | 1.34 | 1.99 |
| 37261 | 3301660 | SMGS | 1.40 | 1.29 | 1.17 | 1.11 | 1.91 |
| 44359 | 3301760 | SMGS | 2.01 | 1.80 | 1.61 | 1.47 | 1.94 |

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|---|---|---|---|---|---|---|---|
| 28426 | 3302460 | SMGS | 2.78 | 2.55 | 2.30 | 2.12 | 3.81 |
| 45092 | 3302520 | SMGS | 1.37 | 1.25 | 1.12 | 1.03 | 1.64 |
| 44301 | 3303680 | SMGS | 0.84 | 0.80 | 0.72 | 0.68 | 1.04 |
| 44481 | 3303780 | SMGS | 1.33 | 1.22 | 1.12 | 1.10 | 1.22 |
| 42866 | 3303880 | SMGS | 2.93 | 2.72 | 2.47 | 2.32 | 2.66 |
| 05437 | 3304310 | PMGS | 3.92 | 3.62 | 3.40 | 3.25 | 4.10 |
| 44591 | 3305330 | SMGS | 0.65 | 0.60 | 0.55 | 0.53 | 0.54 |
| 03441 | 3306670 | SMGS | 0.84 | 0.79 | 0.71 | 0.66 | 1.70 |
| 40226 | 3307900 | SMGS | 0.87 | 0.80 | 0.72 | 0.67 | 1.66 |
| 40264 | 3307960 | SMGS | 0.61 | 0.55 | 0.50 | 0.46 | 0.97 |
| 42866 | 3308330 | SMGS | 0.31 | 0.27 | 0.25 | 0.24 | 0.16 |
| 42822 | 3308420 | SMGS | 1.61 | 1.47 | 1.31 | 1.21 | 1.61 |
| 44020 | 3308470 | PSB | 1.64 | 1.51 | 1.41 | 1.33 | 2.30 |
| 40638 | 3309970 | SMGS | 0.93 | 0.87 | 0.78 | 0.73 | 0.00 |
| 43483 | 3310560 | SMGS | 1.20 | 1.11 | 1.00 | 0.92 | 2.29 |
| 39292 | 3313930 | SMGS | 0.83 | 0.74 | 0.68 | 0.62 | 0.94 |
| 44869 | 3315180 | SMGS | 1.42 | 1.31 | 1.22 | 1.21 | 1.30 |
| 45056 | 3318070 | PSB | 2.73 | 2.46 | 2.27 | 2.11 | 3.22 |
| 32362 | 3318910 | PMGS | 1.18 | 1.12 | 1.03 | 0.98 | 2.48 |
| 45274 | 3319660 | RCS | 0.64 | 0.59 | 0.54 | 0.52 | 0.79 |
| 45593 | 3320620 | SMGS | 0.26 | 0.24 | 0.22 | 0.22 | 1.07 |
| 42292 | 3323080 | SMGS | 0.84 | 0.77 | 0.71 | 0.69 | 1.76 |
| 44092 | 3323220 | SMGS | 1.43 | 1.36 | 1.23 | 1.16 | 2.31 |
| 45006 | 3324670 | SMGS | 0.86 | 0.81 | 0.73 | 0.70 | 1.88 |
| 45000 | 3325010 | PSB | 2.68 | 2.42 | 2.23 | 2.08 | 2.20 |
| 44186 | 3325250 | PSB | 1.26 | 1.17 | 1.08 | 1.01 | 1.72 |
| 40877 | 3325510 | RCS | 1.19 | 1.12 | 1.01 | 0.97 | 1.48 |
| 40511 | 3325610 | PMGC | 2.70 | 2.40 | 2.17 | 1.98 | 1.66 |
| 45604 | 3326880 | SMGS | 3.29 | 2.94 | 2.65 | 2.44 | 2.26 |
| 44130 | 3327130 | PMGC | 2.85 | 2.66 | 2.50 | 2.38 | 2.65 |
| 44247 | 3327470 | SMGS | 0.61 | 0.57 | 0.52 | 0.49 | 1.41 |
| 44990 | 3327510 | SMGS | 1.32 | 1.24 | 1.12 | 1.04 | 1.50 |
| 45107 | 3327540 | SMGS | 1.98 | 1.80 | 1.61 | 1.47 | 2.54 |
| 45107 | 3327870 | SMGS | 1.74 | 1.62 | 1.48 | 1.42 | 2.43 |
| 45190 | 3328050 | SMGS | 2.04 | 1.92 | 1.73 | 1.62 | 2.11 |
| 44260 | 3328180 | SMGS | 1.04 | 0.97 | 0.88 | 0.85 | 1.49 |
| 44046 | 3328460 | RCS | 0.14 | 0.13 | 0.13 | 0.13 | 0.24 |
| 43274 | 3328790 | PSB | 1.18 | 1.12 | 1.09 | 1.07 | 1.90 |
| 44208 | 3329140 | SMGS | 0.55 | 0.50 | 0.46 | 0.45 | 1.36 |
| 44197 | 3329510 | PSB | 1.07 | 1.00 | 0.91 | 0.85 | 1.50 |
| 10340 | 3330320 | SMGS | 0.50 | 0.47 | 0.43 | 0.41 | 1.47 |

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|---|---|---|---|---|---|---|---|
| 05189 | 3330420 | SMGS | 3.23 | 3.08 | 2.78 | 2.62 | 4.22 |
| 14793 | 3331750 | SMGS | 0.25 | 0.24 | 0.22 | 0.21 | 0.50 |
| 04033 | 3332400 | SMGS | 1.17 | 1.09 | 0.99 | 0.95 | 1.50 |
| 03972 | 3332450 | SMGS | 2.50 | 2.35 | 2.11 | 1.97 | 3.17 |
| 24190 | 3335910 | SMGS | 1.37 | 1.26 | 1.15 | 1.11 | 1.41 |
| 13296 | 3335920 | SMGS | 1.11 | 1.03 | 0.92 | 0.85 | 1.22 |
| 12622 | 3336500 | SMGS | 0.91 | 0.85 | 0.79 | 0.77 | 0.89 |
| 12254 | 3336520 | SMGS | 1.07 | 0.97 | 0.89 | 0.84 | 0.99 |
| 11786 | 3337200 | SMGS | 0.62 | 0.59 | 0.53 | 0.51 | 0.69 |
| 15923 | 3338770 | SMGS | 1.42 | 1.35 | 1.22 | 1.16 | 2.94 |
| 21524 | 3339350 | SMGS | 1.12 | 1.04 | 0.95 | 0.91 | 1.25 |
| 25319 | 3339560 | SMGS | 1.59 | 1.45 | 1.33 | 1.29 | 2.14 |
| 10735 | 3339660 | SMGS | 0.55 | 0.50 | 0.44 | 0.41 | 0.89 |
| 25333 | 3340010 | SMGS | 0.58 | 0.52 | 0.48 | 0.44 | 1.03 |
| 09579 | 3340190 | SMGS | 0.88 | 0.84 | 0.75 | 0.71 | 1.24 |
| 11814 | 3340220 | SMGS | 2.57 | 2.35 | 2.11 | 1.94 | 2.39 |
| 12119 | 3340280 | SMGS | 0.36 | 0.33 | 0.31 | 0.30 | 0.57 |
| 19642 | 3341800 | SMGS | 0.78 | 0.70 | 0.63 | 0.58 | 1.03 |
| 01453 | 3342300 | SMGS | 1.72 | 1.55 | 1.39 | 1.27 | 1.54 |
| 29201 | 3342420 | RCT | 1.08 | 1.03 | 0.93 | 0.87 | 1.18 |
| 29338 | 3342430 | RCT | 0.62 | 0.57 | 0.54 | 0.54 | 0.65 |
| 12485 | 3342530 | RCS | 0.94 | 0.88 | 0.83 | 0.83 | 1.25 |
| 29186 | 3342660 | SMGS | 1.46 | 1.31 | 1.19 | 1.10 | 1.50 |
| 15085 | 3342720 | PSB | 2.61 | 2.40 | 2.25 | 2.14 | 2.98 |
| 07492 | 3343530 | SMGS | 0.72 | 0.66 | 0.62 | 0.61 | 1.29 |
| 16435 | 3343730 | SMGS | 0.94 | 0.88 | 0.79 | 0.74 | 1.19 |
| 27747 | 3343870 | SMGS | 1.76 | 1.63 | 1.56 | 1.54 | 2.16 |
| 05402 | 3343920 | SMGS | 2.28 | 2.16 | 1.94 | 1.82 | 2.58 |
| 26385 | 3343930 | SMGS | 2.29 | 2.08 | 2.02 | 1.98 | 2.40 |
| 09953 | 3345210 | SMGS | 1.62 | 1.51 | 1.36 | 1.26 | 1.45 |
| 26033 | 3345930 | RCT | 3.43 | 3.19 | 2.87 | 2.66 | 4.22 |
| 05008 | 3346070 | RCT | 1.38 | 1.31 | 1.18 | 1.11 | 1.85 |
| 24261 | 3347440 | SMGS | 2.48 | 2.27 | 2.03 | 1.87 | 1.54 |
| 26154 | 3348420 | SMGS | 1.85 | 1.67 | 1.50 | 1.37 | 1.78 |
| 26030 | 3348910 | SMGS | 0.38 | 0.36 | 0.35 | 0.35 | 1.23 |
| 43375 | 3349140 | RCS | 1.43 | 1.35 | 1.22 | 1.14 | 1.49 |
| 43906 | 3351420 | SMGS | 0.89 | 0.82 | 0.76 | 0.72 | 1.45 |
| 41411 | 3352610 | RCS | 1.72 | 1.63 | 1.63 | 1.63 | 2.70 |
| 47238 | 3353780 | RCT | 1.00 | 0.94 | 0.85 | 0.82 | 1.54 |
| 43307 | 3354260 | SMGS | 0.99 | 0.93 | 0.87 | 0.87 | 1.23 |
| 43924 | 3354600 | SMGC | 1.14 | 1.02 | 0.92 | 0.84 | 0.47 |

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|---|---|---|---|---|---|---|---|
| 43592 | 3354700 | SMGS | 0.66 | 0.62 | 0.56 | 0.53 | 0.65 |
| 43211 | 3354710 | PMGS | 0.06 | 0.06 | 0.05 | 0.05 | 0.14 |
| 43736 | 3354960 | SMGS | 0.83 | 0.82 | 0.82 | 0.82 | 1.63 |
| 45259 | 3355200 | SMGS | 0.89 | 0.84 | 0.75 | 0.70 | 1.07 |
| 43596 | 3356140 | SMGS | 0.92 | 0.85 | 0.77 | 0.71 | 1.16 |
| 43238 | 3357040 | SMGC | 1.05 | 1.00 | 0.92 | 0.88 | 1.58 |
| 05097 | 3358430 | PSB | 1.85 | 1.68 | 1.57 | 1.47 | 2.38 |
| 03038 | 3361500 | RCS | 1.53 | 1.43 | 1.35 | 1.35 | 1.32 |
| 44736 | 3362320 | PMGS | 2.72 | 2.48 | 2.30 | 2.16 | 2.74 |
| 42884 | 3367070 | SMGS | 1.08 | 1.01 | 0.95 | 0.95 | 1.04 |
| 41362 | 3367240 | SMGS | 0.78 | 0.74 | 0.70 | 0.70 | 1.09 |
| 43337 | 3367370 | RCS | 1.14 | 1.06 | 1.00 | 1.00 | 1.33 |
| 02335 | 4002311 | SMGC | 2.90 | 2.62 | 2.38 | 2.24 | 2.55 |
| 05442 | 4045180 | SMGC | 1.23 | 1.09 | 0.98 | 0.90 | 1.16 |
| 29561 | 4051011 | SMGC | 1.04 | 0.92 | 0.83 | 0.75 | 1.46 |
| 07794 | 4053701 | SMGC | 2.13 | 1.89 | 1.69 | 1.53 | 1.43 |
| 20681 | 4060680 | SMGC | 1.67 | 1.48 | 1.33 | 1.21 | 1.22 |
| 02609 | 4417010 | SMGS | 7.56 | 6.80 | 6.42 | 6.11 | 2.28 |
| 44325 | 4417050 | SMGS | 1.48 | 1.34 | 1.21 | 1.13 | 2.15 |
| 10824 | 4424050 | SMGS | 1.94 | 1.79 | 1.63 | 1.58 | 2.36 |
| 01918 | 4424070 | RCT | 1.24 | 1.14 | 1.05 | 1.04 | 1.49 |
| 10059 | 4424110 | SMGS | 0.91 | 0.85 | 0.80 | 0.80 | 1.03 |
| 11421 | 4424160 | SMGS | 1.07 | 1.00 | 0.94 | 0.94 | 1.34 |
| 21807 | 4426150 | SMGS | 1.16 | 1.06 | 0.95 | 0.89 | 1.92 |
| 21532 | 4426200 | SMGS | 1.21 | 1.14 | 1.03 | 0.96 | 1.82 |
| 12401 | 4426230 | SMGS | 1.75 | 1.63 | 1.46 | 1.36 | 1.48 |
| 23857 | 4426240 | SMGS | 1.28 | 1.18 | 1.06 | 0.98 | 1.93 |
| 10890 | 4426440 | SMGS | 1.79 | 1.68 | 1.56 | 1.47 | 1.92 |
| 23618 | 4433110 | SMGS | 3.68 | 3.26 | 2.92 | 2.64 | 2.85 |
| 04335 | 4433240 | RCS | 1.46 | 1.37 | 1.28 | 1.28 | 1.44 |
| 36166 | 5500089 | RCT | 0.36 | 0.33 | 0.30 | 0.30 | 0.77 |
| 01697 | 5500779 | SMGS | 1.26 | 1.17 | 1.07 | 1.03 | 1.45 |
| 11803 | 5500799 | SMGS | 0.69 | 0.68 | 0.65 | 0.64 | 1.45 |
| 19356 | 5502439 | SMGC | 0.86 | 0.77 | 0.73 | 0.69 | 1.64 |

# APPENDIX B

**NYSDOT LRFR Blue Pages**

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| To: | New York State Department of Transportation<br>ENGINEERING INSTRUCTION | EI<br>00-000 |
|---|---|---|
| **Title: LOAD RATING/POSTING GUIDELINES FOR STATE-OWNED HIGHWAY BRIDGES** | | |
| Distribution: | Approved: | |

## ADMINISTRATIVE INFORMATION:

- Effective Date: This Engineering Instruction (EI) is effective upon signature.
- Superseded Issuances: The Information transmitted by this EI supersedes Engineering Instructions 88-004, 88-005, 88-006, 94-004 and 05-034.
- Disposition of Issued Materials: The information included in this EI is intended to stand alone outside of any other document.

## PURPOSE:

This EI officially adopts the “NYSDOT LRFR Blue Pages” dated __ ___ that issue guidance for prioritizing and submitting load rating calculations, posting bridges for load restrictions, and documenting and reporting load tests on state-owned and locally owned highway bridges.

## TECHNICAL INFORMATION:

- The AASHTO *Manual for Bridge Evaluation, Third Edition 2018,* together with the latest Interim Revisions and the “NYSDOT LRFR Blue Pages” dated __ __ constitute the NYSDOT Load Rating / Posting Guidelines for State and Locally Owned Bridges.

- The language used in this EI to describe personnel, entities and functions is in accordance with NYSDOT’s present organizational structure, with the anticipated Program Support Division organizational entity in parenthesis where appropriate.

- Bridge load rating is the determination of the live load carrying capacity of a newly designed or existing bridge. Load ratings are typically determined by analytical methods based on information taken from bridge plans supplemented by information gathered from field inspections or field testing. This task is vital for several reasons, including (but not limited to) the following:

    - To determine which structures have substandard load capacities that may require posting or other remedial action.
    - To assist in the most effective use of available resources for rehabilitation or replacement.
    - Mandated by the Code of Federal Regulations – Highways, Title 23. Chapter 1 – Federal Highway Administration (FHWA), DOT, Part 650 – Bridges, Structures and Hydraulics.
    - Mandated by New York State Highway Law, §230, §231, §232, & §233. NY Code of Rules and Regulations, 17 (17NYCRR), Chapter V – Uniform Code of Bridge Inspection (UCBI).
    - To assist in the overload permit review process.

- The New York State regulations regarding bridge load ratings are part of the UCBI, which is contained in the current NYSDOT Bridge Inspection Manual.
- The Federal Highway Administration (FHWA) requires that bridge load rating results be submitted to them annually. These results are used in conjunction with other bridge inventory and inspection information to determine the Federal Bridge Sufficiency Rating, which, in turn, is a factor used to determine the eligibility of a project for the Highway Bridge Replacement and Rehabilitation (HBRR) Program. Inaccurate bridge ratings may result in incorrect eligibility determinations under the program. This document provides guidance for prioritizing and submitting load rating calculations, posting bridges for load restrictions, and documenting and reporting load tests.

## DEFINITIONS AND TERMINOLOGY

*AASHTO* - American Association of State Highway and Transportation Officials.

*AASHTO MBE* - AASHTO Manual for Bridge Evaluation.

*BDMS* - Bridge Data Management System.

*Divisible Loads:* Are overweight trucks which are issued permits to carry loads that can be broken down.

*FHWA* - Federal Highway Administration, U.S. Department of Transportation.

*Internally Redundant* - Supporting primary members made up of three or more elements that are mechanically fastened together so that if one should fail the other elements will be able to internally transfer the load and still support the main structure. An example would be a riveted girder.

*Inventory Level Rating (LRFR)* - Generally corresponds to the rating at the design level of reliability for new bridges in the *AASHTO LRFD Bridge Design Specifications*, but reflects the existing bridge and material conditions with regard to deterioration and loss of section.

*Limit State* - A condition beyond which the bridge or component ceases to satisfy the criteria for which it was designed.

*Load Effect* - The response (axial force, shear force, bending moment, etc.) in a member or an element due to externally applied loads.

*Load Factor* - A load multiplier accounting for the variability of loads, the lack of accuracy in analysis, and the probability of simultaneous occurrence of different loads.

*Load Path Redundant* - A structure that has multiple paths between substructure units to distribute the load in the event of failure of one of the supporting members. Examples are steel multi-girder or prestressed concrete multi-girder bridge types. NYSDOT considers a structure to be load path redundant if it has four or more load paths.

*Load Posting* - Live load weight restriction placed on a structure, by the owner, when a bridge is incapable of carrying the maximum legal live load. Load postings are done after an analysis that accounts for the current condition of the structure.

*Load Rating Engineer (LRE)* - Engineer responsible for the accuracy and quality control of load rating data for a given bridge inventory in accordance with this EI, State and Federal requirements.

*Load Rating Levels* - Bridge load ratings in New York State are grouped into three distinct levels of accuracy, Level 1, Level 2, and Level 3. Load Rating Levels are discussed in detail in subsequent sections.

*Load Rating Unit* - Functional unit responsible for statewide implementation, operations, and quality assurance of the NYSDOT load rating program, including management of the Statewide load rating database.

*MBE* -- AASHTO Manual for Bridge Evaluation

*National Bridge Inspection Standards (NBIS)* - Federal regulations establishing requirements for inspection procedures, frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of bridge inventory records.

Nondivisible Loads – Are overweight trucks issued permits to carry loads that cannot be broken down.

Operating Level Rating *(LRFR)*—Maximum load level to which a structure may be subjected. Generally corresponds to the same reliability as that of the Operating Level Rating in past load rating practice.

*Quality Assurance* - The use of sampling to verify or measure the level of the entire bridge inspection and load rating program.

*Quality Control* - System that is intended to maintain the quality of a bridge inspection and load rating at or above a certain level.

*R-Posting* - A load restriction for a bridge, which based on design or condition, does not have the reserve capacity to accommodate most vehicles over legal loads but, can still safely carry legal loads. Vehicles operating pursuant to an overweight permit with structure use restrictions (known as "R" Permits) are not allowed to cross. Originally established for NYSDOT's divisible load permit program, R-Postings are also used to restrict other non-divisible overload permit classifications. These bridges are identified with signage stating "No Trucks with R Permits."

*Reliability Index: $\beta$*—A computed quantity defining the relative safety of a structural element or structure expressed as the number of standard deviations that the mean of the margin of safety falls on the safe side. A reliability index $\beta$=3.5 imply that, based on available statistical data, there is a $2.3\times 10^{-4}$ chance that the limit state being investigated will be exceeded. $\beta$=2.5 imply a $6.2\times 10^{-3}$ probability of exceedance, $\beta$=2.0 imply a $2.3\times 10^{-2}$ probability of exceedance and $\beta$=1.5 imply a $6.7\times 10^{-2}$ probability of exceedance.

*Resistance Factor* - A resistance multiplier accounting for the variability of material properties, structural dimensions, workmanship, and the uncertainty in the prediction of resistance.

*Serviceability* - A term that denotes restrictions on stress, deformation, and crack opening under regular service conditions.

*Service Limit State* - Limit state relating to stress deformation and cracking.

*Specialized Hauling Vehicle (SHV)*—Short wheelbase multi-axle trucks used in construction, waste management, bulk cargo and commodities hauling industries.

*Strength Limit State* - Safety limit state relating to strength and stability.

*Substantial Structural Alteration* - Any work that modifies the live load capacity, load distribution or load paths or structural behavior of the bridge (UCBI).

*UCBI* - Uniform Code of Bridge Inspection - NY Code of Rules and Regulations, 17, Chapter V.

## IMPLEMENTATION:

This Engineering Instruction (EI) is effective immediately for all load ratings, postings and permit reviews in New York State.

## TRANSMITTED MATERIALS:

The NYSDOT "LRFR Blue Pages" dated ____ can be found at the following web address: https://www.dot.ny.gov/divisions/engineering/structures/xxxxx

**CONTACT:** Direct questions regarding this EI to xxxx of the Office of Structures at xxx-xxx-xxxx or by email to xxxxx

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The following is a list of articles that have been created as "Load and Resistance Factor Rating (LRFR) Blue Pages" and are incorporated into the AASHTO Manual for Bridge Evaluation – Third Edition and latest Interims:


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| 6A.4.1 | 6A.4.1.8.2 |
| 6A.4.1.1 | 6A.4.1.9 |
| 6A.4.1.2 | 6A.4.2 |
| 6A.4.1.3 | 6A.4.2 .1 |
| 6A.4.1.4 | 6A.4.2 .2 |
| 6A.4.1.5 | 6A.4.2 .3 |
| 6A.4.1.6 | 6A.4.3 |
| 6A.4.1.6.1 | 6A.8 |
| 6A.4.1.6.2 | 6A.8.1 |
| 6A.4.1.6.3 | 6A.8.2 |
| 6A.4.1.7 | 6A.8.3 |
| 6A.4.1.7.1 | 6A.8.4 |
| 6A.4.1.7.2 | 6A.8.4.1 |
| 6A.4.1.7.3 | 6A.9 |
| 6A.4.1.7.4 | 6A.9.3 |
| 6A.4.1.7.5 | 6A.9.3.1 |
| 6A.4.1.8 | |

## 6A.4 LOAD RATING PROCEDURES

Delete this Article and the Commentary to this Article in their entirety and replace it with the following:

## 6A.4 LRFR RATING PROCESS FOR NYSDOT OWNED BRIDGES

### 6A.4.1 Level 1 Load Rating Guidelines

*"A Level 1 rating refers to any fully documented analysis or capacity evaluation that is signed and certified by a professional engineer, licensed by the State of New York, as being complete and correct in its computation of bridge load capacity. Generally, a Level 1 analysis shall be in conformance with the analysis assumptions and provisions of the AASHTO Manual."* – UCBI 165.8 (a) (1). Rating results from Level 1 calculations are used to determine need for member strengthening, load posting, or if a structure should be closed.

A complete Level 1 load rating will include analyses of the following items:

- All elements defined as "primary members" in the NYSDOT Bridge Inspection Manual, as well as all stringer-floorbeam, girder-floorbeam, and truss connections.
- Timber and metal bridge decks.
- Timber and metal pier elements.

It is not necessary to analyze concrete bridge decks, concrete and masonry substructure elements, or foundation elements unless there are unusual circumstances which, in the load rating engineer's judgment, will affect the load carrying capacity of the bridge. Secondary members subject to impact damage or deterioration shall also be investigated if the capacity of a primary member is affected.

Level 1 load ratings are required for all new and replacement bridges, and for all rehabilitation and repair designs involving a substantial structural alteration. Level 1 rating calculations shall be performed as part of the structural analysis process used for design and reflect the bridge as-built or as-rehabilitated construction and configuration. As an example, a new bridge design will account for a future wearing surface, but the Level 1 load rating does not include this future wearing surface as a dead load because it is not part of the as-built condition. This rule also applies to a Level 2 analysis which accounts for the current conditions of the structure.

Ratings shall be calculated following the guidelines contained in the latest edition of the AASHTO MBE and this document. This document provides guidance to load rating engineers for performing and submitting load rating calculations, posting bridges for load restrictions, and checking overweight permits using the Load and Resistance Factor Rating (LRFR) methodology. This document serves as a supplement to the AASHTO MBE and deals primarily with NYSDOT specific load rating requirements, interpretations, and policy decisions.

Load and Resistance Factor Rating is consistent with the LRFD Specifications in using a reliability-based limit states philosophy and extends the provisions of the LRFD Specifications to the areas of inspection, load rating, posting and permit rules, fatigue evaluation, and load testing of existing bridges. The LRFR methodology has been developed to provide uniform reliability in bridge load ratings, load postings and permit decisions. LRFR provisions allow for calibrating load factors based on statewide vehicle load data. This provides an opportunity to refine the LRFR process while meeting an acceptable index of structural reliability and provide results that are reasonably compatible with current NYSDOT procedures based on LFD/ASD rating methods. The LRFR procedures provide live load factors for load rating that have been calibrated using statewide vehicle load data to provide a uniform and acceptable level of reliability reasonably consistent with NYSDOT LFD/ASD rating practices.

#### 6A.4.1.1 Analysis Frequency

Level 1 calculations eventually become outdated. Member deterioration, rehabilitation, redecking, and repaving of the wearing course are just a few of the occurrences that may force a reanalysis of the bridge. Therefore, the required frequency of Level 1 calculations can vary widely. A new bridge designed to current standards may not need another Level 1 for some time if it is maintained properly. However, for example, an old truss that is deteriorating steadily should be reanalyzed as conditions change every few years.

The Load Rating Engineer (LRE) or other qualified person should review any existing Level 1 data during or after each inspection to see if a reanalysis is needed. A new Level 1 analysis may be necessary if any of the following have occurred since the last Level 1 analysis was completed.

- The primary member condition rating on the inspection report has changed by more than one point, if the initial rating was 5 or lower.
- Dead load has changed significantly due to resurfacing or other nonstructural alterations.
- Section properties have changed due to rehabilitation, redecking, deterioration, or other alterations.

If Level 1 load ratings stored in NYSDOT's statewide database are invalid, these ratings shall be deleted from the database by the LRE or other designated qualified personnel.

The Priorities for Level 1 analysis may be set in the following order:

1 Bridges which appear to require R posting or load posting.
2 Bridges with primary member ratings less than 4 (using NYSDOT's 1-7 rating scale) that are not ratable by NYSDOT's standard load rating system.
3 Bridges that are ratable by NYSDOT's standard load rating system with primary member ratings less than 4.

#### 6A.4.1.2 Live Loads for LRFR Ratings

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 Table 6A.4.1.8-1:

1) **Design load Rating**: Design load rating is a first-level rating performed for all bridges using the HL-93 loading at the Inventory (Design) and Operating levels.
2) **Legal Load Rating**: Bridges that have an HL-93 Rating Factor < 1.0 at the Operating Level shall be load rated for the AASHTO posting load SU4 and Type 3S-2 to determine posting needs
3) **Permit load Rating**: Bridges that do not need load or “R” posting may be evaluated for Overload Permits. Bridges that have an HL-93 RF < 1.0 at the Operating level shall be evaluated for R-posting as specified in Section 6A.8.4.

#### 6A.4.1.3 Reporting LRFR Ratings to the NBI

For all new 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 loadings.

#### 6A.4.1.4 Truck Traffic Conditions at Bridge Site

LRFR live load factors appropriate for use with legal loads and permit loads are defined based upon the Average Daily Truck Traffic (ADTT) available or estimated for the bridge site. FHWA requires an ADTT to be recorded on the Structural Inventory and Appraisal (SI&A) form for all bridges. In cases where site traffic conditions are unavailable from the bridge file, the NYSDOT Traffic Data Services should be contacted for current ADTT information.

#### 6A.4.1.5 Selection of Surface Roughness Rating

LRFD dynamic load allowance of 33% reflects conservative conditions that may prevail under certain distressed approach and bridge deck conditions. For load rating of legal and permit vehicles for bridges with less severe approach and deck surface conditions, the dynamic load allowance (IM) may be decreased based on field observations in accordance with Section 6A.4.1.7.5. Inspection should carefully note these and other surface discontinuities in order to benefit from a reduced dynamic load allowance.

To ensure proper and consistent selection of dynamic load allowance values in all load ratings, NYSDOT should consider a new data item in the Bridge Inspection Forms for documenting the surface roughness of the bridge riding surface, with clear guidelines for inspectors on how to assign a rating for this item. Surface Roughness is defined as follows:

**Table 6A.4.1.5-1 Surface Roughness Rating**

| Surface Roughness Rating | Description |
|---|---|
| 3 = Smooth | Smooth riding surface at approaches, bridge deck, and expansion joints |
| 2 = Average | Minor surface deviations or depressions |
| 1 = Poor | Significant deviations in riding surface at approaches, bridge deck, and expansion joints |

### 6A.4.1.6 LRFR Load Rating Equation and Factors

The general rating equation in LRFR (MBE Eq. 6A.4.2.1-1) is given as:

$$RF = \frac{\phi_c \ \phi_s \ \phi \ R_n - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_p)(P)}{(\gamma_L)(LL + IM)}$$

In the LRFR Rating Factor equation:

- RF = Rating Factor
- $R_n$ = Nominal member resistance (as inspected)
- $\phi_c$ = Condition Factor (Section 6A.4.1.6.2)
- $\phi_s$ = System Factor (Section 6A.4.1.6.3)
- $\phi$ = LRFD Resistance Factor
- DC = Dead load effect due to structural components and attachments
- DW = Dead load effect due to wearing surface and utilities
- P = Permanent loads other than dead loads (secondary prestressing effects, etc.)
- LL = Live load effect of the rating vehicle
- IM = Dynamic load allowance (Section 6A.4.1.7.1; Section 6A.4.1.7.5)
- $\gamma_{DC}$ = LRFD load factor for structural components and attachments
- $\gamma_{DW}$ = LRFD load factor for wearing surfaces and utilities
- $\gamma_p$ = LRFD load factor for permanent loads other than dead loads
- $\gamma_L$ = Evaluation live load factor for the rating vehicle (Section 6A.4.1.7.1; 6A.4.1.7.2; 6A.4.1.7.3)

Where, the following lower limit shall apply:

$$\phi_c \ \phi_s \ \geq \ 0.85$$

Additionally, for all non-strength limit states, $\phi = 1.0$, $\phi_c = 1.0$, $\phi_s = 1.0$

The NYSDOT LRFR methodology presented in this document is based on a recalibration of the live load factors performed to provide reliability levels consistent with those implied in NYSDOT load rating, posting and permitting practices based on load factor and working stress analyses that have been known to provide adequate levels of safety. A target reliability index $\beta$=2.0 was intentionally chosen to be slightly higher than that observed in current rating methods to account for the expected growth in truck volumes over time. This target reliability index was extracted based on current and past NYSDOT rating methods and truck loads and multiple presence frequencies observed from recent New York Weigh-In-Motion (WIM) data.

The Dead Load factors are the same as those provided in the AASHTO LRFD. The dead load factors in the AASHTO LRFD were calibrated to provide uniform levels of reliability at the design and inventory rating levels and should be maintained to ensure consistency between bridge load rating and design.

#### 6A.4.1.6.1 Resistance Factor $\phi$

Resistance factor $\varphi$ has the same value for new design and for load rating. Resistance factors, $\varphi$, shall be taken as specified in the LRFD Specifications for new construction. The resistance factors in the AASHTO LRFD were calibrated to provide uniform levels of reliability and should be maintained to ensure consistency between bridge load rating and design.

The nominal resistance used for load rating shall be the as-inspected member resistance accounting for measured section losses and deterioration.

#### 6A.4.1.6.2 Condition Factor $\phi_c$

The Condition Factor $\phi_c$, is applied to the resistance of degraded members. The Condition Factor $\phi_c$, does not account for section loss, but is used in addition to section loss. An increased reliability index is maintained for deteriorated and non-redundant bridges by using condition and system factors in the load rating equation.

The condition factor is a reduction factor based on member condition as evaluated using the New York element condition ratings. National Bridge Elements represent the primary structural components of bridges necessary to determine the overall condition and safety of the primary load carrying members. National Bridge Elements that could impact load ratings are decks, slabs, superstructure elements and certain substructure elements. Only condition states CS3 and CS4 of primary members, as defined by national bridge elements, factor into selecting the condition factor.

The selection of the condition factor is based on primary members that are in Condition States 3 and 4, based on the following criteria:

- CS-4 > 10% for a primary member, or
- CS-3 + CS-4 > 20% for a primary member should trigger a manual review for determining the condition factor.

If the reviewer considers the member conditions to increase the uncertainty or variability in the structural resistance and/or increased future deterioration, a reduced Condition Factor $\phi_c = 0.95$ should be assigned for load rating.

#### 6A.4.1.6.3 System Factor $\phi_s$

System factors are multipliers applied to the nominal resistance to reflect the level of redundancy of the complete superstructure system. Bridges that are less redundant will have their factor member capacities reduced, and, accordingly, will have lower ratings. The aim of the system factor is to provide additional reserve capacity for bridges with primary members that are both internally and load path non-redundant. Subsystems that have redundant members should not be penalized if the overall system is non-redundant (i.e. multi stringer deck framing members on a two-girder or truss bridge). System Factor is used with all live load models.

Current NYSDOT policy is to use the system factors provided in Table MBE 6A.4.2.4-1 when load rating for Flexural and Axial Effects for steel members and non-segmental concrete members for Legal Load Ratings only. The system factor is set equal to 1.0 when checking shear. The load modifiers provided in LRFD shall be used for Design Load Inventory and Operating Ratings and for Permit Load Ratings (Annual Divisible, Non-Divisible and Special Hauling)

**Table MBE 6A.4.2.4-1 System Factor: $\phi_S$ for Flexural and Axial Effects**

| Superstructure Type | $\phi_S$ |
|---|---|
| Welded Members in Two-Girder/Truss/Arch Bridges | 0.85 |
| Riveted Members in Two-Girder/Truss/Arch Bridges | 0.90 |
| Multiple Eyebar Members in Truss Bridges | 0.90 |
| Three-Girder Bridges with Girder Spacing 6ft | 0.85 |
| Four-Girder Bridges with Girder Spacing ≤ 4ft | 0.95 |
| All Other Girder Bridges and Slab Bridges | 1.00 |
| Floorbeams with Spacing >12ft. and Non-Continuous Stringers | 0.85 |
| Redundant Stringer Subsystems Between Floorbeams | 1.00 |

**Definitions**

Floorbeam – A horizontal flexural member located transversely to the bridge alignment.
Stringer – A longitudinal beam supporting the bridge deck.
Girder – A large flexural member, usually built-up, which is the main or primary support for the structure, and which usually receives load from floorbeams, stringers, or in some cases directly from the deck.

### 6A.4.1.7 LRFR Live Loads and Load Factors

#### 6A.4.1.7.1 Design Load Rating

The design-load rating (or HL-93 rating) assesses 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. The evaluation live-load factors for the Strength I limit state shall be taken as given in MBE Table MBE 6A.4.3.2.2-1.

**Table MBE 6A.4.3.2.2-1 Load Factors for Design Load: $\gamma_L$**

| Evaluation Level | Load Factor |
|---|---|
| Inventory | 1.75 |
| Operating | 1.35 |

The dynamic load allowance specified in the LRFD Specifications for new bridge design (LRFD Article 3.6.2) shall apply. For design load rating, regardless of the riding surface condition or the span length, always use 33% for the dynamic load allowance (IM).The results of the HL-93 rating are to be reported to the NBI as a Rating Factor.

#### 6A.4.1.7.2a Legal Load Rating of State Owned Bridges

In LRFR, load rating for legal loads determines a single safe load capacity of a bridge. The previously existing distinction of Operating and Inventory level ratings is no longer maintained when load rating for legal loads.

The live load to be used in the NYSDOT LRFR rating for posting considerations shall be the governing loading from the legal loads given in Figure 6A.4.1.7.2-1. For example, for simple spans less than 200 ft, the governing load effect from either the SU4 or the Type 3S2 loading shall be used in the load rating.

It is unnecessary to place more than one vehicle in a lane for spans up to 200 ft. because the LRFR live load factors provided have been modeled for this possibility (no lane load to be used). For negative moments and for span lengths greater than 200 ft., critical load effects shall be obtained by lane-type legal load models shown in Figure 6A.4.1.7.2-1.

A reliability index $\beta_{target} = 2.0$ was chosen for target during the recalibration of the live load factors for ratings. This target is slightly more conservative than the average reliability value implicit in New York State DOT Load Factor Rating procedures and loading projected from New York WIM data. The SU-4 vehicle and the AASHTO legal 3-S2 trucks for the NYSDOT LRFR ratings are recommended as these two trucks provide a good envelope of the live load effects by reducing the spread in the reliability index values for the range of spans considered.

The live load factors for multi-lane bridges were calibrated based on the weight histograms and probability of multiple presence of trucks assembled from New York WIM data to provide a uniform reliability index $\beta = 2.0$ within a 5-year rating period. Bridges with higher ADTT have a higher probability of being loaded by heavy trucks and require higher live load factors.

The NYSDOT live load factors are higher than those of the AASHTO LRFR because of the heavier truck loadings observed in the State using WIM data collected from State routes and Interstates. These higher live load factors apply only to state-owned bridges. The multi-lane live load factors were calibrated to also provide an envelope to multi-lane bridges loaded by a single lane of trucks. This implies that the single lane loading with the higher live load factor in Table 6A.4.1.7.2 -1 does not need to be checked for multi-lane bridges.

Higher live load factors are used for single lane bridges because of the higher probability of having one heavy truck in one lane bridges than having multiple heavy trucks in multi-lane bridges. The multiple presence factor included in the current AASHTO LRFD single-lane distribution factor does not sufficiently reflect the current truck load intensities in the State, requiring the adoption of higher live load factors for single lane bridges.

The rating live-load factors for legal loads for the Strength I limit state shall be taken as given in Table 6A.4.1.7.2 -1

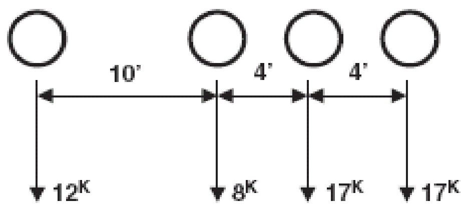
**Table 6A.4.1.7.2a -1 NYSDOT Live-Load Factors, $\gamma_L$ for Legal Loads**

| Traffic Volume (one direction)[1] | Load Factor for Multi-lane bridges (use LRFD load distribution factor for multi-lanes) | Load Factor for Single-lane bridges (use LRFD load distribution factor for a single lane without removing the multiple presence factor)[2] |
|---|---|---|
| ADTT $\geq$ 5000 | 1.95 | 2.65 |
| ADTT=1000 | 1.85 | 2.50 |
| ADTT $\leq$ 100 | 1.65 | 2.20 |

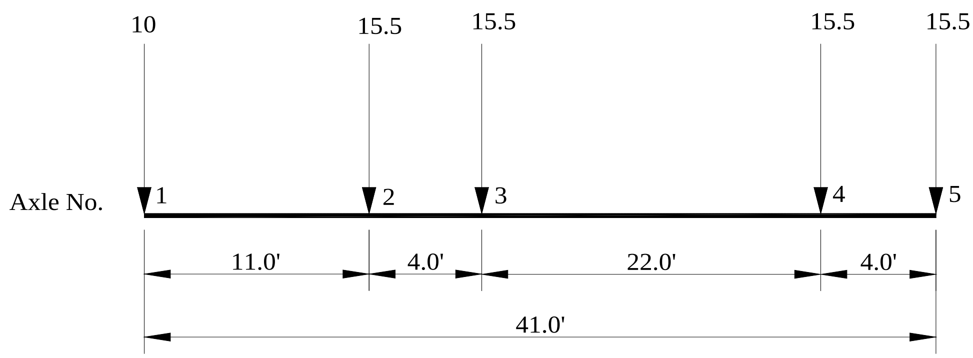
[1] Linear interpolation is permitted for other ADTT
[2] The AASHTO LRFD load distribution factor tables for single loaded lanes already includes a multiple presence factor MP=1.2. This factor must be included when the analysis employs other

methods for determining the load on a bridge member. For instance, when the lever rule is used for live load distribution to longitudinal or transverse members, the 1.2 multiple presence factor shall be included in the distribution analysis.

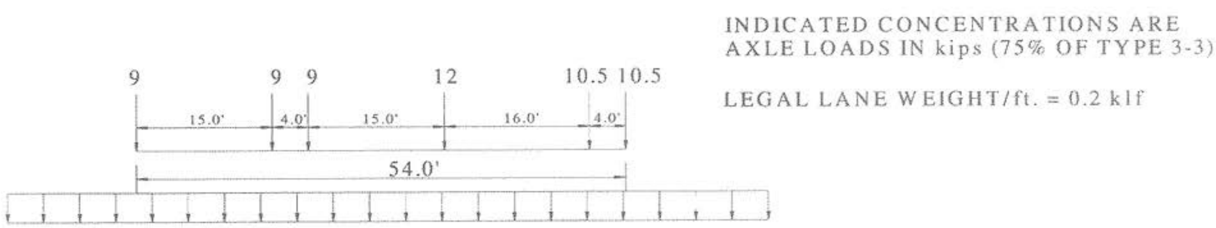
a) SU4 Legal Load (27 tons)




b) Type 3S2 Legal Load (36 tons)

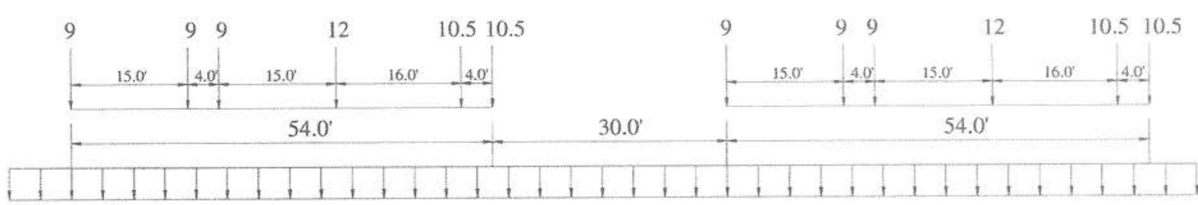



c) Lane-Type Legal Load Model—Apply for spans greater than 200 ft. and all load effects.




MBE APPENDIX A-6A.4, Figure A-6A.4-4

d) Lane-Type Legal Load Model—Apply for negative moment and interior reaction for all span lengths.




MBE APPENDIX A-6A.4, Figure A-6A.4-5

**Figure 6A.4.1.7.2-1 Legal Load Models for NYSDOT LRFR Ratings**

### 6A.4.1.7.2b Legal Load Rating of Local Bridges using Live Load Factors in the MBE

In the 2012 Interims to the AASHTO MBE, reduced live load factors for AASHTO legal loads and SHVs have been introduced. The reduced load factors listed in Table 6A.4.4.2.3a-1were developed under the NCHRP 12-78 project. The LRFR load factors in the MBE for legal loads are considerably lower than that derived for NYSDOT using recent WIM data from NY sites, which were all located on the state and Interstate highways. It is recommended that these reduced LRFR live load factors in the MBE be applied for rating for legal loads and SHVs of bridges on the local system where the truck traffic exposure is lower than that on the Interstate and state system.

**MBE Table 6A.4.4.2.3a-1—Generalized Live Load Factors, $\gamma_L$ for Routine Commercial Traffic & SHVs**

| Traffic Volume (one direction) | Load Factor |
|---|---|
| Unknown | 1.45 |
| ADTT ≥ 5,000 | 1.45 |
| ADTT ≤ 1,000 | 1.30 |

Linear interpolation is permitted for ADTT values between 5,000 and 1,000.

### 6A.4.1.7.3 Permit Load Rating

NYSDOT has a set of established procedures to allow the passage of vehicles that exceed the legally established weight limits. Special Hauling Permits and Divisible Load Overweight Permits are issued by NYSDOT to protect public safety and preserve the State's infrastructure. Special Hauling Permits are required to allow the movement on New York State highways of vehicles or loads that exceed the legal dimensions or weights specified in Section 385 of the New York State Vehicle and Traffic Law. If the permit application is for self-propelled construction equipment or for vehicles with a gross weight of 140,000 lbs or greater, a structural review by the Office of Structures must be performed. Loads with gross weights that are 200,000 lbs. or greater are classified as superloads and are subject to special requirements.

New York State has several different Permit classifications depending on the permit loading type and number of trips allowed. For the purposes of LRFR evaluations the permit loading types have been grouped into two categories, those carrying divisible loads and those carrying non-divisible loads. Non-divisible load permits are assumed to be controlled so that the truck weights are known and taken to be to be equal to the permitted weight. Divisible load permits are allowed unlimited crossings over an unrestricted bridge for a year’s period, with a probability of exceeding the permit weight limits. Permit configurations belonging to each permit type used as calibration trucks are shown in Figures 6A.4.1.7.4-1 and. 6A.4.1.7.4-2

In terms of trip categories, the permits in this report will be divided into single-crossing (single-trip) and unlimited crossing (multi-trip) permits. Single Trip Overweight Permit load analysis assumes only one permit load on the bridge, which allows the use of the single-lane distribution. As stated in Table 6A.4.1.7.3, when using a single-lane LRFD distribution factor, the 1.2 multiple-presence factor should be divided out from the distribution factor equations. For single trip permit vehicles, it is important to note that the vehicle could traverse the bridge in any lane, making it necessary to investigate whether the interior or exterior girder controls the load rating.

For continuous spans one permit truck is applied.

A reliability index $\beta_{target}$ = 2.0 was chosen for target during the recalibration of the live load factors for permits. This target is slightly more conservative than the average reliability value implicit in current New York State DOT practice and loading projected from New York WIM data. Calibration studies demonstrate that using a live load factor $\gamma_L$ = 1.10 for non-divisible permit loads, where the vehicles operate at the permitted weight, will provide average reliability index values greater than the target $\beta_{target}$ = 2.0. For the cases of divisible loads where some data shows that Permit loads may exceed the Permit weight limits, the load factors have been increased accordingly.

For Multi-lane bridges, the Permit live load factors account for the probability of having a permit truck alongside a random overweight truck in the adjacent lane. These permit live load factors are lower than those for legal load rating reflecting the lower probability of having both trucks exceed the permit load limits as compared to the probability of having two random trucks exceed the legal truck weights.

Lower live load factors are used for non-divisible loads and special hauling permits because these trucks are less likely to exceed the authorized permit weight.

Similar divisible live load factors are used for single lane bridges to those of multi-lane bridges to envelope the reliability of continuous span single lane bridges.

The rating live-load factors for permits for the Strength II limit state shall be taken as given in Table 6A.4.1.7.3.

**Table 6A.4.1.7.3 NYSDOT Permit Load Factors, $\gamma_L$**

| Permit Type | Frequency | Loading Condition | DF | ADTT (one direction) | Permit Load Factor, $\gamma_L$ |
|---|---|---|---|---|---|
| Annual Divisible Load | Unlimited trips | Multi-lane bridges Mix with traffic | Multi-lane | ADTT $\geq$ 5,000 | 1.20 |
| | | | | ADTT=1,000 | 1.15 |
| | | | | ADTT $\leq$ 100 | 1.10 |
| Annual Divisible load | Unlimited trips | Single lane bridges | Single Lane DF after dividing out MP=1.2 | ADTT $\geq$ 5,000 | 1.20 |
| | | | | ADTT=1,000 | 1.15 |
| | | | | ADTT $\leq$ 100 | 1.10 |
| Non-divisible loads | Unlimited trips | Multi-lane bridges Mix with traffic | Multi-lane | All ADTT | 1.10 |
| Non-Divisible loads | Unlimited trips | Single lane bridges | Single Lane DF after dividing out MP=1.2 | All ADTT | 1.10 |
| Special Hauling and Superloads | Single Crossing | Multi-lane bridges Mix with traffic | Single Lane DF after dividing out MP=1.2 | All ADTT | 1.10 |
| Special Hauling and Superloads | Single Crossing | Single lane bridges | Single Lane DF after dividing out MP=1.2 | All ADTT | 1.10 |

Linear interpolation is permitted for other ADTT

### 6A.4.1.7.4 Use of HL-93 Ratings for Screening Bridges

The first level load rating in LRFR is the HL-93 design load check at the Inventory and Operating levels. This check can serve as an effective technique to identify bridges that can safely carry legal load ratings and/or permit loads, thus reducing the number of bridges needed further analysis for other load models.

Analysis of factored load effects (moment and shear) for NY divisible load permits, non-divisible load permits and legal loads used in the calibration (see Appendix A) were generated and compared to the factored HL93 loads at the Inventory and Operating levels for simple and continuous spans from 20 ft to 200 ft. The load effects were normalized by dividing by HL-93 load effects. Moment and shear ratios obtained are shown in the charts given in Appendix A. The results show the following rules regarding screening to be valid:

1. HL-93 rating at the Operating level (LF=1.35) is appropriate for screening multi-lane bridges for AASHTO and NY legal loads. That is multi-lane bridges that pass HL-93 rating (RF ≥ 1.0) at the Operating level will have adequate load capacity for legal loads.
2. HL-93 rating at the Inventory level (LF=1.75) is appropriate for screening single lane bridges for AASHTO and NY legal loads. That is single-lane bridges that pass HL-93 rating (RF ≥ 1.0) at the Inventory level will have adequate load capacity for legal loads.
3. HL-93 rating at the Operating level (LF=1.35) is appropriate for screening bridges for NY divisible load permits (LF = 1.2) similar to the NYP6 thru NYP 13 configurations shown in Fig 6A.4.1.7.4-2. That is bridges that pass HL-93 rating (RF ≥ 1.0) at the Operating level will have adequate load capacity for the class of divisible load permits.
4. HL-93 rating at the Inventory level (LF=1.75) is appropriate for screening bridges for NY non-divisible load permits (LF=1.1) similar to the NYP1 thru NYP 5 configurations shown in Fig 6A.4.1.7.4-1. That is bridges that pass HL-93 rating (RF ≥ 1.0) at the Inventory level will have adequate load capacity for the class of non-divisible load permits.

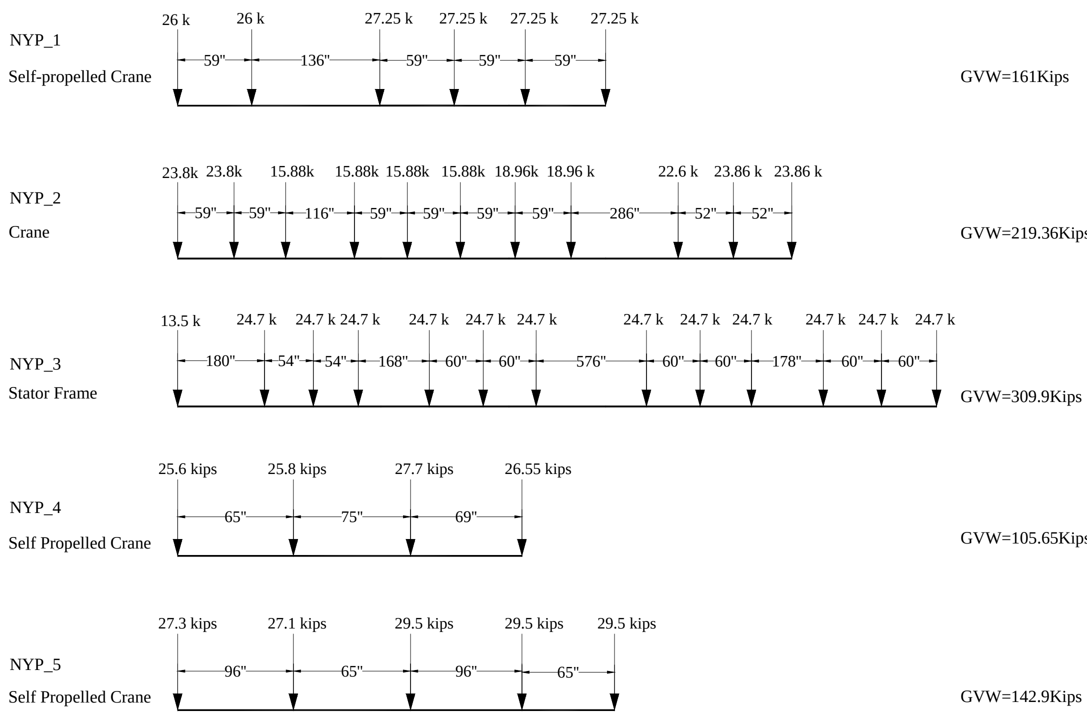



**Fig. 6A.4.1.7.4-1 Calibration Trucks --NY Non-Divisible Load Permits**

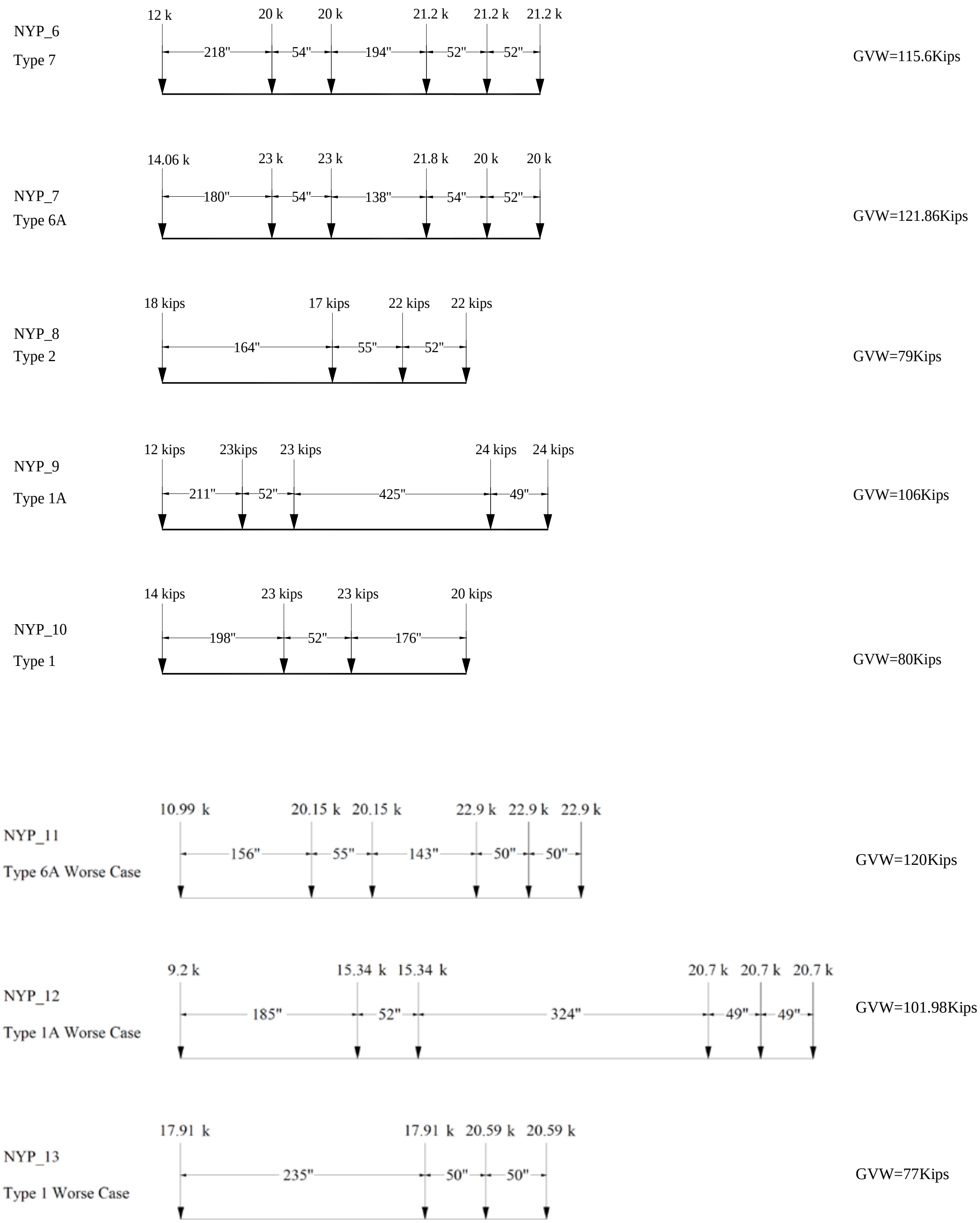



**Fig. 6A.4.1.7.4-2 Calibration Trucks -- NY Divisible Load Permits**

#### 6A.4.1.7.5 Reduced Dynamic Load Allowance for Rating (Legal and Permit Loads)

For legal and permit vehicles rating, of longitudinal members having spans greater than 40 ft. with less severe approach and deck surface conditions, the Dynamic Load Allowance (IM) may be decreased from the LRFD design value of 33%, as given below in Table 6A.4.1.7.5-1, for the Strength and Service limit states. Dynamic load allowance shall be applied to the state legal vehicles and not the lane loads. Selection of IM shall be in accordance with the requirements of Section 6A.4.1.5 and the Surface Roughness rating noted in the inspection report. State or document what value of IM was used for the load rating in the Load Rating Summary Form. If the permit vehicle proceeds at a crawl speed, no more than 5 miles per hour, then the impact can be assumed to be 5%.

**Table 6A.4.1.7.5-1 Dynamic Load Allowance for Rating: IM.**

| Riding Surface Rating | IM |
|---|---|
| 3 | 10% |
| 2 | 20% |
| 1 | 33% |

Regardless of riding surface condition, always use 33% for spans 40 ft or less and for transverse members.

### 6A.4.1.8 LRFR Limit States for Evaluation

Live load models described in Section 6A.4.1.7 shall be evaluated for the Strength, Service and Fatigue limit states in accordance with Table 6A.4.1.8-1:

**Table 6A.4.1.8-1 LRFR Limit States**

| Bridge Type | Limit State | Design | Legal | Permits |
|---|---|---|---|---|
| | | HL-93 | SU4, Type 3-S2, Lane Loads, SHV Loads | Divisible, Non-Divisible Special Hauling Superloads |
| 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 | ● | ● | |
| | Strength II | | | ● |

#### 6A.4.1.8.1 Concrete Bridges

For non-segmental prestressed concrete bridges, 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 during design load ratings. The allowable tensile stress in precompressed tensile zone for the Inventory level design load check shall be $0.095\sqrt{f'c}$ in KSI units. Service III need not be checked for design load Operating ratings.

Service I and Service III limit states are mandatory for load rating of segmental concrete box girder bridges (MBE 6A.5.11.5).

A new 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 (MBE 6A.5.4.2.2b). 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 reserve ductility in the member.

#### 6A.4.1.8.2 Steel Bridges

Steel structures shall satisfy the overload permanent deflection check under the SERVICE II load combination for design load and legal load ratings using load factors as given in Table MBE 6A.4.2.2-1. Maximum steel stress is limited to 95% and 80% of the yield stress for composite and non-composite compact girders respectively. Service II checks for permit loads are recommended but optional. During an overweight permit review the actual truck weight is available, so a 1.0 live load factor is specified.

In situations where fatigue-prone details are present (category D or lower) a Fatigue limit state Rating Factor for infinite fatigue life may be computed for Level I load ratings. If directed by NYSDOT, bridge details that fail the infinite-life check can be subject to the more complex finite-life fatigue evaluation using evaluation procedures given in the AASHTO MBE (Section 7).

### 6A.4.1.9 Documentation and Submissions

All Level 1 calculations must be certified as accurate by a professional engineer currently licensed in New York State. They must be performed and checked according to standard structural engineering practice. If using a computer program, note the program name and version. Also, all input information must be documented. Both Allowable Stress and Load Factor are acceptable analysis methods but, Load and Resistance Factor is the preferred rating method. Load ratings may be submitted in English or metric units.

The attached flowchart at the end of this section (Fig 6A.4.1.9-1) shows the proper work flow for the Level 1 calculations. When a new Level 1 analysis is done, a copy of all pertinent documentation should be kept in the responsible Region office

Each NYSDOT Region (or Program Support Center responsible for Regional load rating engineering services) shall provide new Level 1 summaries to the NYSDOT Load Rating Unit after completion. For each bridge, Level 1 data should be summarized in terms of structure rating units. A structure rating unit is defined as a single simple span or a continuous series of spans that are analyzed as a single structural unit. Thus, a bridge with three simple spans will have three rating units, but a bridge with four continuous spans will have only one rating unit.

Level 1 load rating documentation shall be incorporated into a comprehensive package to facilitate updating of the information and calculations in the future, as well as documenting the assumptions that were used. For new, replacement, or rehabilitation projects, the Level 1 load rating package shall be transmitted as part of the Plans Specifications and Estimate (PS&E).

The following information shall be included in the Level 1 Load Rating package. Additional information may be required as part of the scope of services.

- Cover sheet with BIN; feature carried/feature crossed; political unit and county; rating summary table; analysis method and controlling member; engineers responsible for Level 1 load rating calculations (done by, checked by), approving PE signature, license number, and date.

- Table of contents.

- Level 1 Load Rating Summary Sheets for each unique member type to include 'HL-93' inventory and operating ratings. Legal Load ratings shall also be included if the 'HL-93' operating rating is less 1.0.

- General Information Sheet:

1) Bridge Identification Number (BIN)
2) Date load rating performed:
3) Political Unit:
4) Feature carried:
5) Feature crossed:
6) Superstructure type
7) Number of spans
8) Skew:
9) Total length:
10) Out-to-out width:
11) Bridge width curb-to-curb
12) Number of actual travel lanes
13) Number of lanes used in rating
14) Type of deck
15) Type of wearing surface
16) Type of sidewalks
17) Barrier or railing type
18) Year built:
19) Rehabilitation year(s)
20) Design live load
21) Existing posted load
22) List of plans or sketches referenced should be provided for an existing structure
23) Date of most recent inspection should be provided for an existing structure

- Drawings or sketches of Superstructure Framing Plan, Typical Cross Section and Girder Elevation. For new or rehabilitation designs, also include Moment and Shear Tables and Design Load Table.
- General description and comments affecting the Load Rating, such as structure

condition, flags, posting history, etc.
    - Assumptions and analysis methods
    - Live load distribution method used (AASHTO Standard Bridge Specifications, lever rule, AASHTO Guide Specification, 3D analysis, etc.)
    - Dead load distribution (tributary area, simple beam distribution, continuous transverse beam distribution, 3D analysis, etc.)
    - Analysis method, assumptions and design criteria

- Analysis
    - Section properties: As-built and deteriorated section properties as applicable; composite section properties
    - Material properties and any assumptions.
    - Copy of any hand calculations.
    - Dead load effects, with distribution method stated. This may be taken from computer output, assuming it is easy to follow
    - All hand calculations for all dead loads or those needed for dead load inputs shall be included.
    - Dead load assumptions, such as the weight of barriers/railings, utility lines, etc., shall be included.
    - Live loads effects, with distribution method stated and impact factor calculation
    - All required hand calculations shall be included.
    - If alternative distribution factors are used, an explanation of why an alternative method was used and all necessary calculations shall be included
    - Member capacities for controlling section and limit state.
    - A listing of what software was utilized including version number.
    - Copy of software input where applicable.
    - At a minimum, a printout of the summarized output
    - Safe load and load posting calculations if applicable

- Rating Results: Tabulated by structural rating unit with controlling member for controlling unit with controlling limit state.

<u>Notes:</u>

All input sheets and calculation sheets shall show both the rater and checker.

All inspection reports, manuals, textbooks, and articles referenced as part of the load rating package shall be documented.

Typically, the substructure is not analyzed as part of a load rating; however there are cases where the substructure shall be analyzed, such as steel cap beams and steel columns. In these cases, those calculations shall be included in the load rating of the structure. At the LRE's discretion, other substructure elements not normally included in a Level 1 may need to be analyzed on an existing structure. This may be necessary in cases of extreme concrete deterioration or other mitigating circumstances.

Note: As previously stated, All Level 1 calculations must be certified as accurate by a professional engineer currently licensed in New York State.

## RECORDING AND TRANSFERRING LEVEL 1 LOAD RATING DATA

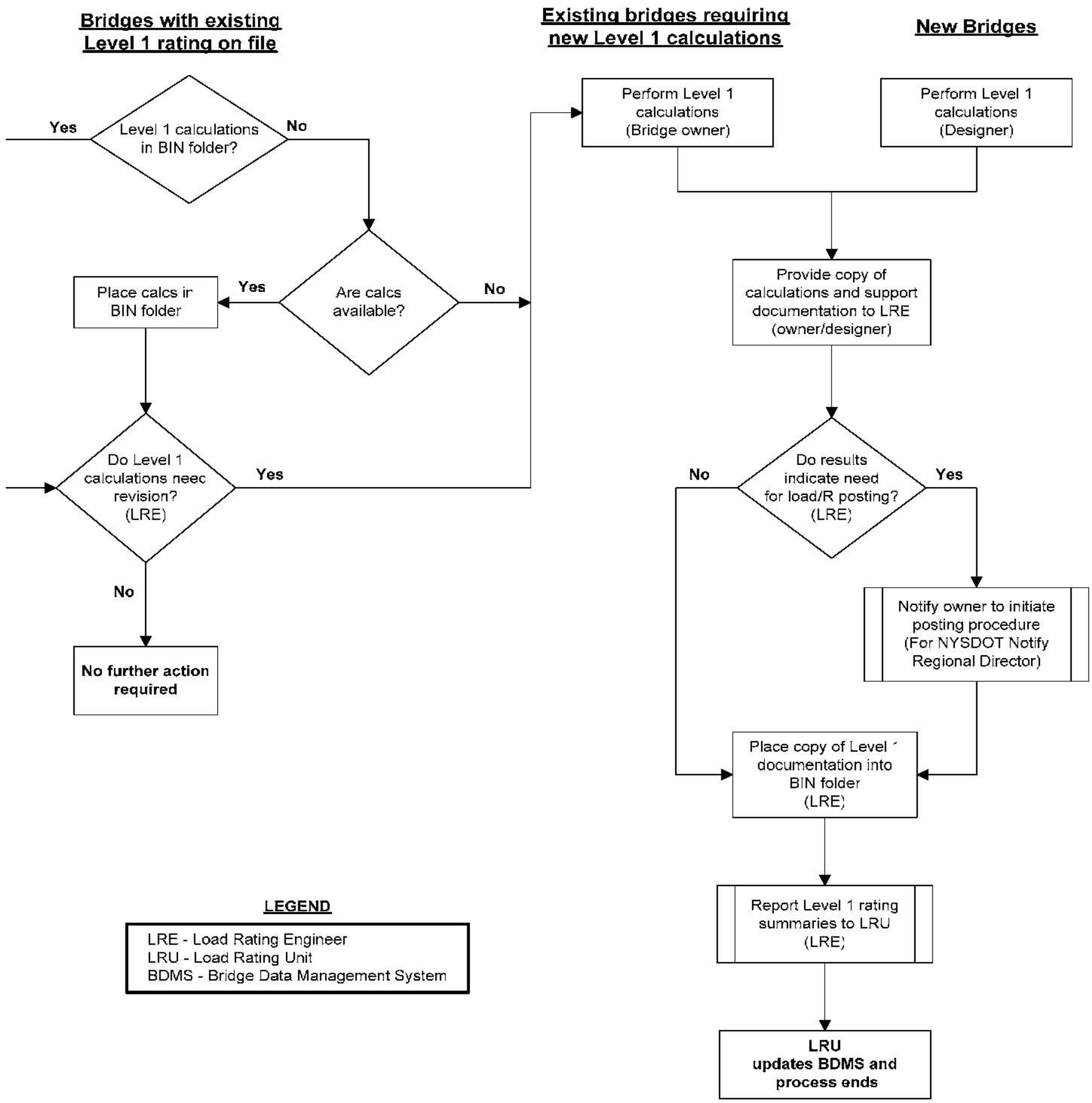



**Fig. 6A.4.1.9-1 Level 1 Flowchart**

### 6A.4.2 Level 2 Load Rating Guidelines

#### 6A.4.2.1 Introduction

Level 2 load ratings are computer generated analyses of bridges produced by NYSDOT using its current bridge load rating computer system – AASHTOWare BrR (BrR). The Load Rating Engineer is responsible for collection and Quality Control of Level 2 data for their assigned bridge inventory. The Load Rating Unit is responsible for Quality Assurance of all load rating work and management of the statewide load rating database. Input data for Level 2 ratings is generally collected as part of the NYSDOT bridge inspection program. Level 2 load rating work that is performed by consultants as part of their general bridge inspection agreements for the NYSDOT shall conform to NYSDOT specifications and standards before it is submitted to NYSDOT.

#### 6A.4.2.2 Analysis Frequency

All bridges ratable by the current NYSDOT Level 2 Load Rating System shall be entered for analysis. As part of each Biennial bridge inspection, Level 2 load rating information shall be updated and the load ratings subsequently regenerated and submitted. An analysis shall be completed whether or not there has been any change to the input data. Specification changes, which are incorporated in each release of BrR, may affect previous load rating results as well as new analysis modules that could analyze previously un-ratable structures. The Bridge Data Management System (BDMS) will also record an analysis date in the inventory database for processed ratings. By updating the analysis there will be a time stamp verification that the load rating for a particular structure was evaluated as part of its biennial inspection and is still valid.

Consultants performing a Level 2 load rating analysis shall submit their results to the respective LRE. The LRE shall be responsible for transferring this data into BDMS. The Load Rating Unit is responsible for all Level 2 Quality Assurance activities. This includes final approval of submitted Level 2 load ratings in BDMS.

#### 6A.4.2.3 Analysis and Submission Procedure

The flowchart at the end of this section (Fig 6A.4.2.3-1) outlines the updating, recording, and transferring of Level 2 load rating data.

The inspector shall verify in the field the information in the BIN folder needed for the Level 2 load rating analysis. This is the Level 2 field data and may include existing bridge plans that are marked up by the Inspector or spreadsheet forms prepared by the LRE. The Level 2 field data required to perform a Level 2 analysis is at the discretion of the LRE and may vary. If there are changes, the LRE or designated staff or consultant will update the information in the BIN folder with the new data. The LRE or consultant will regenerate the Level 2 Load Rating analysis with the current data and report the new results.

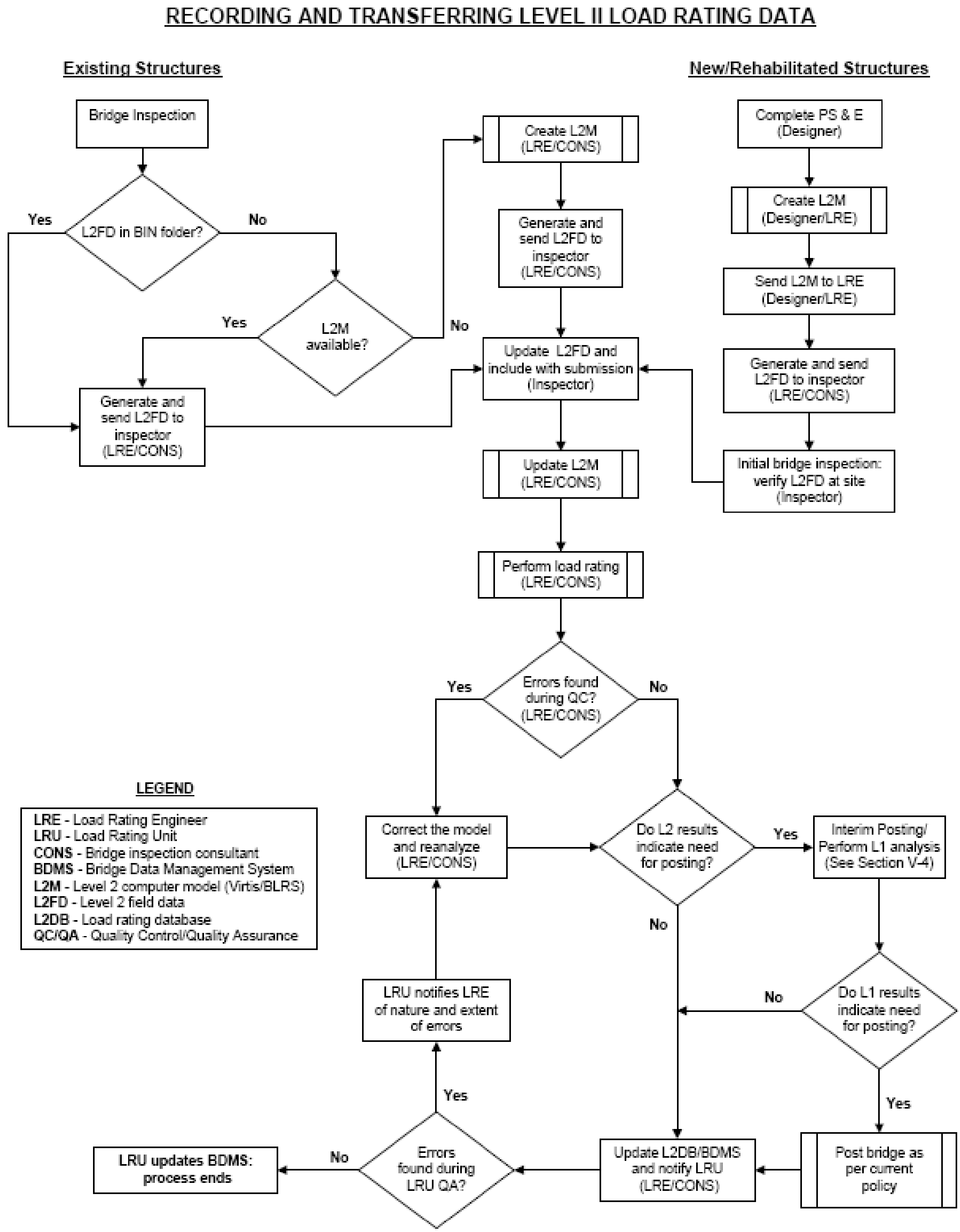



**Fig. 6A.4.2.3-1 Level 2 Flowchart**

### 6A.4.3 Level 3 Load Rating

When no Level 1 or Level 2 load rating exists, BDMS will generate a Level 3 load rating for the structure based on existing general inventory and inspection information such as design load, condition rating, existing posting values, etc. These ratings are not based on an analysis of the structure but on an estimate of the probable capacity of the bridge from the parameters mentioned.

These ratings are only to be used to report rating values to the FHWA when better information is not available. These ratings are not to be used for any type of structural evaluation or overload permit review

## 6A.8 POSTING OF BRIDGES

Delete this Article and the Commentary to this Article in their entirety and replace it with the following:

### 6A.8.1 Load Posting Requirements for Bridges

This section provides guidance for load posting of NYSDOT-owned highway bridges. Because of the varying nature of structural systems, materials, frequency of loadings, and other factors which may affect a load posting, no rigid set of rules can be adopted that would be appropriate in every case.

The Region initiating the posting or change in posting must immediately give written notification to the Regional (or assigned Program Support Center) Structural Engineering Unit Manager, who will update the inventory database to reflect the change. Copies of all documentation related to posting decisions, including calculations, inspection reports, load test reports, etc., will be kept in the state BIN folder or other permanent bridge file location.

The bridge owner is responsible for the decision to post a bridge and setting posting values. However, the following minimum standards must always be followed, according to Section 233 and 234 of the Highway Law, and the UCBI. Load posting signs shall conform to the standards for regulatory signs under the current NYSDOT (17NYCRR), Chapter V, a.k.a Manual of Uniform Traffic Control Devices (MUTCD).

NBIS regulations (23 CFR Part 650) require the rating of each bridge as to its safe loading capacity in accordance with the AASHTO MBE and the posting of the bridge in accordance with this document or in accordance with state law, when the maximum unrestricted legal loads or state routine permit loads exceed that allowed under the Operating rating. If a bridge is not capable of carrying statutory loads, it is posted for a lesser load limit.

Strength limit state is used for checking the ultimate capacity of structural members and is the primary limit state utilized by NYSDOT for determining posting needs. Service and fatigue limit states are utilized to limit stresses, deformations, and cracking under regular service conditions. In LRFR, Service and Fatigue limit state checks are optional 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 process.

A concrete bridge with unknown details need not be posted for restricted loading if it has been carrying normal unrestricted traffic and shows no distress. knowledge of the live load used in the original design, the current condition of the structure and live load history may be used to provide a basis for assigning a safe load capacity. Nondestructive proof load tests can be helpful in establishing the safe load capacity for such structures.

### 6A.8.2 Posting Analysis

The goal of the LRFR methodology is to maintain target uniform reliabilities in all load ratings and load postings. Unlike past practice, it should be noted that in a reliability-based evaluation the relationship between posting values and rating factors is not proportional. For a posted bridge there is a greater probability of vehicles exceeding the posted limit compared to numbers exceeding the legal limit on an un-posted bridge

A reliability calibration procedure has been performed to calibrate posting load levels for bridges with rating factor R.F. <1.0. The calibration is performed to ensure that posted bridges will still meet the target reliability level $\beta_{target} = 2.0$ set during the calibration of the live load factors for rating. Because posting is normally used for bridges with low ADTT levels, the calculations were performed based on sites with ADTT=100. The calibration process involved conservative assumptions on the loading of posted bridges due to unavailability of WIM data at posted bridge sites.

According to the calibration results, two-lane bridges with low truck volumes should be posted if the rating analysis performed for the SU-4 single unit truck, the 3-S2 semi-trailer truck, or the Legal Lane Load lead to Rating Factors R.F.<1.0. The rating also envelopes the effects on multi-lane bridges loaded by a single line of trucks. Single-lane bridges should be posted based on a rating analysis using the single lane live load factors and maximum effects from the NYSDOT Legal Loads. The rating equation should also include the System Factor $\phi_s$ and the condition factor $\phi_c$.

When for any Legal Load the RF is between 0.3 and 1.0, then the following equation should be used to establish the LRFR posting load for each posting vehicle type:

LRFR Safe Posting Load Equation:

$$\text{Safe Posting Load} = W[RF + 0.00375(L - 110)(1 - RF)]$$

Where W = Weight of Posting Vehicle
RF= Legal Load Rating Factor
L = Effective span length in feet as defined below

When the lane load model governs the load rating, W shall be taken as 80 Kips (40 tons). Table 6A.8.2-1 shows the safe posting load using the equation for various rating factors and span lengths.

**Table 6A.8.2-1 Safe Posting Load**

| **a) Posting weights in Tons for single unit trucks (W = 27 Tons)** | | | | | | | |
|---|---|---|---|---|---|---|---|
| SPAN | R.F.=0.3 | R.F.=0.4 | R.F.=0.5 | R.F.=0.6 | R.F.=0.7 | R.F.=0.8 | R.F.=0.9 |
| 40 ft | 3 | 7 | 10 | 14 | 17 | 20 | 24 |
| 100 ft | 8 | 10 | 13 | 16 | 19 | 22 | 24 |
| 200 ft | 15 | 17 | 18 | 20 | 22 | 24 | 25 |
| **b) Posting weights in Tons for semi-trailer trucks (W=36 Tons)** | | | | | | | |
| SPAN | R.F.=0.3 | R.F.=0.4 | R.F.=0.5 | R.F.=0.6 | R.F.=0.7 | R.F.=0.8 | R.F.=0.9 |
| 40 ft | 4 | 9 | 14 | 18 | 23 | 27 | 32 |
| 100 ft | 10 | 14 | 18 | 21 | 25 | 29 | 33 |
| 200 ft | 20 | 22 | 24 | 27 | 29 | 31 | 34 |

In a departure from current NYSDOT practice, two posting vehicles are specified, as using only one single unit truck for posting would be unnecessarily restrictive on the longer semi-trailer trucks. If only a single tonnage is to be used for posting, then the lowest safe load value shall be used. The higher posting loads for the longer spans are reflective of the higher reliability indices inherent in longer spans, when compared to the shorter spans. Posting is more restrictive on the shorter spans also due to their lower reliability indices. When the RF for any vehicle type falls below 0.3, then a recommendation should be made to not allow that particular vehicle type on the bridge. Other vehicle types with RF > 0.3 may continue to use the bridge.

Bridges that are determined not capable of carrying 3 tons shall be closed.

<u>Definition of Effective Span Length</u>

| Member Type | Effective Span |
|---|---|
| 1. Simple span stri8ngers or girders | Span length |
| 2. Continuous stringers or girders | |
| a) Positive moment or shear | Span length |
| b) Negative moment | Average of adjacent span lengths |
| 3. Floorbeams | |
| a) End floorbeam | Adjacent stringer or panel length |
| b) Intermediate floorbeam | Sum of two adjacent stringer spans or panel lengths |
| 4. Trusses | |
| a) Chords and end posts | Total span length |
| b) Interior diagonals | Panel length + sum of panel lengths to far support |
| c) Vertical hangers or posts | Same as intermediate floorbeam |
| d) Vertical part of truss web | Same as interior diagonal |

**Posting for SHVs**

The AASHTO SU4 vehicle is the most critical vehicle for posting for AASHTO SHVs as it results in the lowest posted value among all SHVs. As NYSDOT posts bridges for a single tonnage for all vehicles, the SU4 vehicle alone would suffice to determine the lowest posting value. However, there could be bridges that don’t need posting for SU4 but may need posting for one of the other SHVs. Considering all SHVs in load ratings could expand the number of posted bridges for SHVs. A study of 314 NY bridges has shown that while the SU4 is the most critical posting load that it does not conservatively indicate posting loads for bridges that should be posted for loads above 27 tons.  One way this can be resolved is by using a higher rating factor than 1.0 for SU4 as the basis for determining posting needs.  Based on this study, using a SU4 rating factor of 1.32 as the basis for screening would capture all bridges that would need to be posted for any of the AASHTO SHVs. This would increase the number of bridges to be posted.

### 6A.8.3 Examples

A single span rolled beam bridge with four stringers has a span length of 65 ft. Carries two lanes of traffic with an ADTT = 5000. There is significant deterioration and the primary member rating is 3. Dynamic load allowance = 20% (used only for legal load and permit load ratings). This bridge will be evaluated for three cases: 1) the as-built condition, 2) the as-inspected condition and 3) Condition that would require R-posting, to illustrate the use of the LRFR procedures.

$M_{DC1}$ = 480.0 K-ft

$M_{DC2}$ = 0.00 K-ft

$\varphi R_n$ = 2125.0 K-ft (As-built)

$\varphi R_n$ = 1738.9 K-ft (As-inspected)

Distributed two-lane live load moments:

$M_{LL+I}$ (HL-93) = 952.6 K ft

$M_{LL+I}$ (Type 3S2) = 531.2 K ft

$M_{LL+I}$ (Type SU4) = 559.4 K ft

$M_{LL+I}$ (Permit Type 6A) = 1028.8 K ft

$M_{LL+I}$ (Permit Type 7) = 889.1 K ft

**<u>Case 1 -- As-Built Ratings</u>**

Condition Factor = 1.00

Load modifiers: importance factor $\eta_I$=1.0, ductility factor $\eta_D$=1.0, and redundancy factor $\eta_R$=1.0

HL-93 Ratings: Inv. Rating = 0.91 (LF =1.75)

Opr. Rating = 1.19 (LF =1.35)

As the HL-93 Operating Rating > 1.0 the bridge would have had adequate load capacity for NY legal loads (Section 6A.4.1.7.2) and for NY divisible load permits (Section 6A.4.1.7.3), as shown below:

System Factor = 1.00 (redundant system)

Type 3S2 Rating: RF = 1.47 (LF = 1.95)

Type SU4 Rating: RF = 1.40 (LF = 1.95)

Permit Type 6A Rating: RF = 1.24 (LF = 1.20)

Permit Type 7 Rating: RF = 1.43 (LF = 1.20)

In the as-built condition, the bridge would not have had to be load posted or R-posted (RF > 1.0). All load ratings are based on multi-lane distribution factors.

**<u>Case 2 --As-Inspected Ratings</u>**

Condition Factor = 0.95

Load modifiers: importance factor $\eta_I$=1.0, ductility factor $\eta_D$=1.0, and redundancy factor $\eta_R$=1.0

HL-93 Ratings: Inv. Rating = 0.63 (LF =1.75)

Opr. Rating = 0.82 (LF =1.35)

As the HL-93 Operating Rating < 1.0 the bridge may not have adequate load capacity for NY legal loads (Section 6A.4.1.7.2) and for NY divisible load permits (Section 6A.4.1.7.3). Perform legal load ratings:

System Factor = 1.00 (redundant system)

Type 3S2 Rating: RF = 1.02 (LF = 1.95)

Type SU4 Rating: RF = 0.96 (LF = 1.95)

As the legal load ratings are less than 1.0, the bridge will need to be load posted and permit loads should not be allowed on the bridge. All load ratings are based on multi-lane distribution factors.

**Posting Analysis (Section 6A.8.2)**

$$\text{Safe Posting Load} = W[RF + 0.00375(L - 110)(1 - RF)]$$

Where W = Weight of Posting Vehicle
RF= Legal Load Rating Factor
L = Effective span length in

Governing Rating Factor RF = 0.96

Posting load for Type 3S2:

L = 65 ft., W = 36 Tons, RF = 0.96

Safe Posting Load = 34.5 Tons

Posting load for Type SU4:

L = 65 ft., W = 27 Tons, RF = 0.96

Safe Posting Load = 25.7 Tons

**Case 3 – R-Posting Analysis (Section 6A.8.4)**

To illustrate the R-Posting analysis, assume that the as-inspected resistance is $R_n$ = 1785.0 K-ft

Condition Factor = 0.95

Load modifiers: importance factor $\eta_I$=1.0, ductility factor $\eta_D$=1.0, and redundancy factor $\eta_R$=1.0

HL-93 Ratings: Inv. Rating = 0.66 (LF =1.75)

Opr. Rating = 0.86 (LF =1.35)

As the HL-93 Operating Rating < 1.0 the bridge may not have adequate load capacity for NY legal loads (Section 6A.4.1.7.2) and for NY divisible load permits (Section 6A.4.1.7.3). Perform legal load ratings:

System Factor = 1.00 (redundant system)

Type 3S2 Rating: RF = 1.06 (LF = 1.95)

Type SU4 Rating: RF = 1.00 (LF = 1.95)

As the NY legal load ratings are ≥ 1.0, the bridge need not be load posted.

The bridge should then be evaluated for divisible loads to check if it has adequate reserve capacity for permits and if an R-Posting may be required.

For R-Posting, check either the governing divisible load for downstate bridges (Type 6A) or Type 7 for upstate bridges --- depending on where the bridge is located. If the bridge does not rate out for these trucks, an R-posted would be required. For the subject bridge the permit ratings are:

System Factor = 1.00 (redundant system)

Permit Type 6A Rating: RF = 0.89 (LF = 1.20)

Permit Type 7 Rating: RF = 1.03 (LF = 1.20)

The results indicate that only if the bridge was located downstate an R-Posting would be required, based on the rating factor (< 1.0) for Type 6A downstate permit.

### 6A.8.4 Criteria for Posting Bridges for R-Permit Restrictions

#### 6A.8.4.1 Introduction

The posting methodology also includes posting for divisible load restrictions, referred to as "R"-posting, as per NYS regulations for divisible permit loads. R-Postings are intended to keep most overloads from using bridges that, through design or deterioration, do not have the reserve capacity to accommodate most overload permit vehicles, but are still capable of safely carrying legal loads. These bridges have signage stating "No Trucks with R Permits."

#### 6A.8.4.1 R-Posting Evaluation

Downstate bridges that do not have a Rating Factor ≥ 1.0 for the NYP 11 (Type 6A) Divisible Load permit and upstate bridges that do not have a Rating Factor ≥ 1.0 for the NYP 6 (Type 7) Divisible Load permit following the LRFR procedures shall be R - posted. NYP 11 and NYP 6 were shown to be the governing divisible permit load models with the highest moment and shear effects on a series of simple and continuous spans (See Appendix A).

HL-93 ratings can be used as a simplified but more conservative approach to screening bridges for R posting requirements. Bridges that have a Rating Factor ≥ 1.0 for HL-93 at the Operating Level will not require R posting for NY divisible load permits.

The loading configurations and live load factors for NYP 11 and NYP 6 are as given below in Fig 6A.8.4.1-1 and Table 6A.4.1.7.5-1. Reduced Dynamic Load Allowance may be used as provided in Section 6A.4.1.7.5.

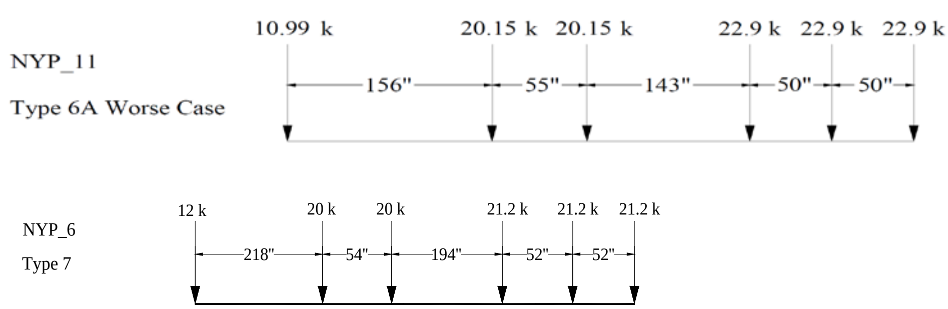



**Fig. 6A.8.4.1-1 NYP 11 and NYP 6 -- Governing Divisible Load Permits for R-posting Evaluation**

**Table 6A.8.4.1-1 NYP 11 Permit Load Factors, $\gamma_L$**

| Permit Type | Frequency | Loading Condition | DF | ADTT (one direction) | Permit Load Factor $\gamma_L$ |
|---|---|---|---|---|---|
| Annual Divisible Load | Unlimited trips | Multi-lane bridges Mix with traffic | Multi-lane | ADTT ≥ 5000 | 1.20 |
| | | | | ADTT=1000 | 1.15 |
| | | | | ADTT ≤ 100 | 1.10 |
| Annual Divisible load | Unlimited trips | Single lane bridges | Single Lane DF after dividing out MP=1.2 | ADTT ≥ 5000 | 1.20 |
| | | | | ADTT=1000 | 1.15 |
| | | | | ADTT ≤ 100 | 1.10 |

Linear interpolation is permitted for other ADTT

## 6A.9 SPECIAL TOPICS

Add the following Articles at the end of this Section after Article 6A.9.2:

### 6A.9.3 Field Load testing

#### 6A.9.3.1 Introduction

The actual performance of most bridges is more favorable than conventional theory dictates. Safe load capacity for a structure can be determined from full scale non-destructive field load tests, which may be desirable to establish a higher 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.

There are many bridges for which common analytical methods are not adequate to determine a load rating. The following are some examples:

- Bridges that cannot be realistically modeled using routine analytical methods.
- Bridges with unavailable or incomplete plans and structural components that cannot be measured. Examples include (but are not limited to) steel beams encased in concrete and concrete structures with unknown reinforcement or prestressing.

For cases like these, alternate methods of load rating, such as a non-destructive load test, may need to be used to generate realistic load rating results.

Field load testing, also referred to as nondestructive load testing, is an experimental determination of a structure’s load capacity by measuring the actual structural response to known loads. The measured response of the bridge under the field load test is then compared to the analytical predicted response. Load testing can be a useful part of a load rating calculation for a bridge that is difficult to load rate using conventional analytical methods. Load testing may also provide a more accurate and at times higher rating, which can be very helpful when the theoretical safe live load capacity is lower than desirable. Load testing is typically separated into two types; diagnostic and proof testing.

Diagnostic load testing involves measuring the load effects (such as moment, shear, axial force, stresses, and deflection caused by known loads, such as a specific vehicle or vehicles of known weight, axle loads, and spacings). The results of the load tests are then compared to those predicted using analytical calculations. The difference between the theoretical and measured load effects will then be reviewed and calibrated to the standard AASHTO rating vehicles. The results will then be used to establish the new load rating. Load testing typically involves measurements of load effects of several bridge members at critical locations.

Proof load testing involves loading the bridge with incremental loads until a targeted load level is safely reached. This level is then used to set the level of the new load rating. Loading should be done incrementally while the bridge is carefully monitored. The loading should be discontinued at any sign of distress or damage. Proof load testing requires careful preparation and experienced personnel. Care is required to avoid damage to the structure as well as to prevent injuries to personnel and to the public.

If done incorrectly, field load testing can lead to inaccurate load rating results. In addition, incorrect testing procedures can lead to permanent damage and even possible collapse of the bridge structure. Sound engineering judgment and analytical principles need to be taken into consideration before load testing is performed. See the AASHTO MBE Section 8 and references.

### 6A.9.3.1 Documentation of Results

Every test report must include certain information, regardless of test procedure. At a minimum, provide the following:

- Truck weights, axle spacing, and axle loadings.
- Exact location of truck(s) on the bridge for all strain or deflection measurements.
- Types of measuring instruments used (strain gauges, survey rods, etc.)
- Location of measuring instruments.
- Conversion calculations to legal load ratings.
- Reasons for increased capacity above the analytical predicted load rating.

The report shall be signed by the responsible professional engineer licensed by the State of New York, and filed with NYSDOT using the same procedures as for an in-depth Level 1 load rating. All load test documentation and results should be kept in the Region (or responsible Program Support Center) office. If used to generate a Level 1 load rating, the actual results of the load test are only a portion of the Level 1 documentation. In addition to the load testing documentation, the procedures in the preceding Level 1 guidelines shall be followed.

## REFERENCES


1. *Load and Resistance Factor Rating Methodology in New York State*, C-06-13: Final Report The City College of New York, 2011.

2. ASHTO *Manual for Bridge Evaluation* Third Edition, 2018, including all subsequent interim revisions.

3. AASHTO LRFD *Bridge Design Specifications*, 8th Edition (2017) including all subsequent interim revisions.

4. NCHRP Report 575; *Legal Truck Loads and AASHTO Legal Loads for Posting.*

5. NCHRP Report 454; *Calibration of Load Factors for LRFR Evaluation*

6. NYSDOT Research Report 163 "Highway Bridge Rating by Nondestructive Proof-Load Testing for Consistent Safety." NYSDOT Transportation Research and Development Bureau.

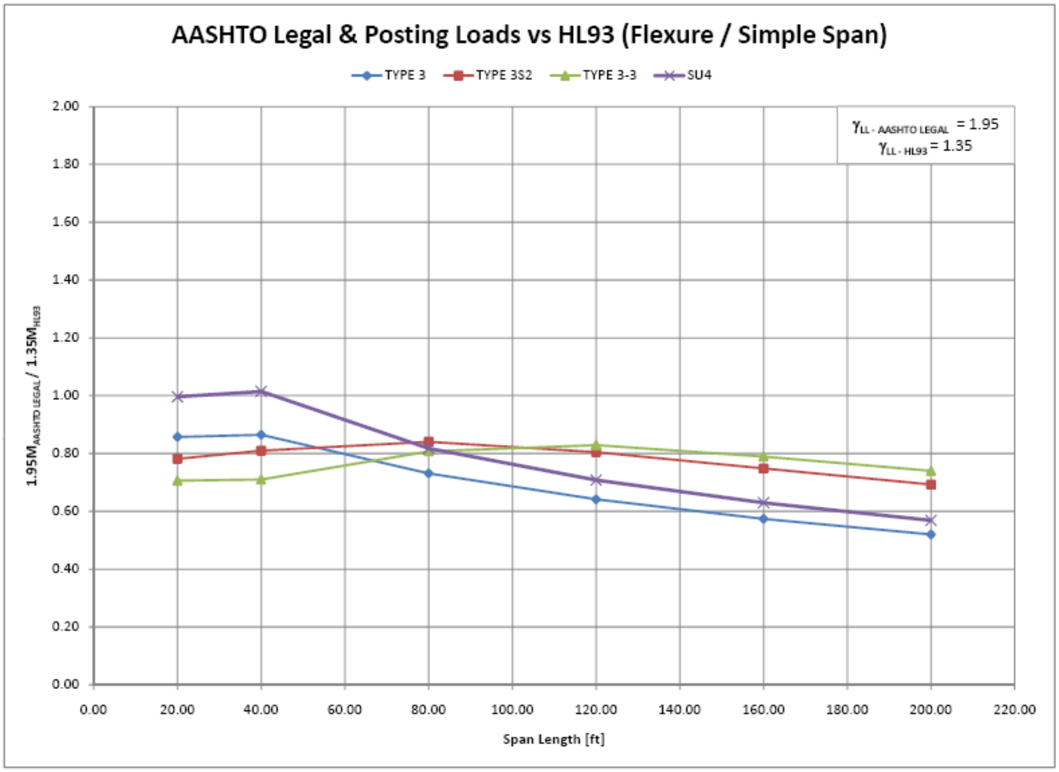
7. NYSDOT Research Report 153 "Proof Testing of Highway Bridges" NYSDOT Transportation Research and Development Bureau.

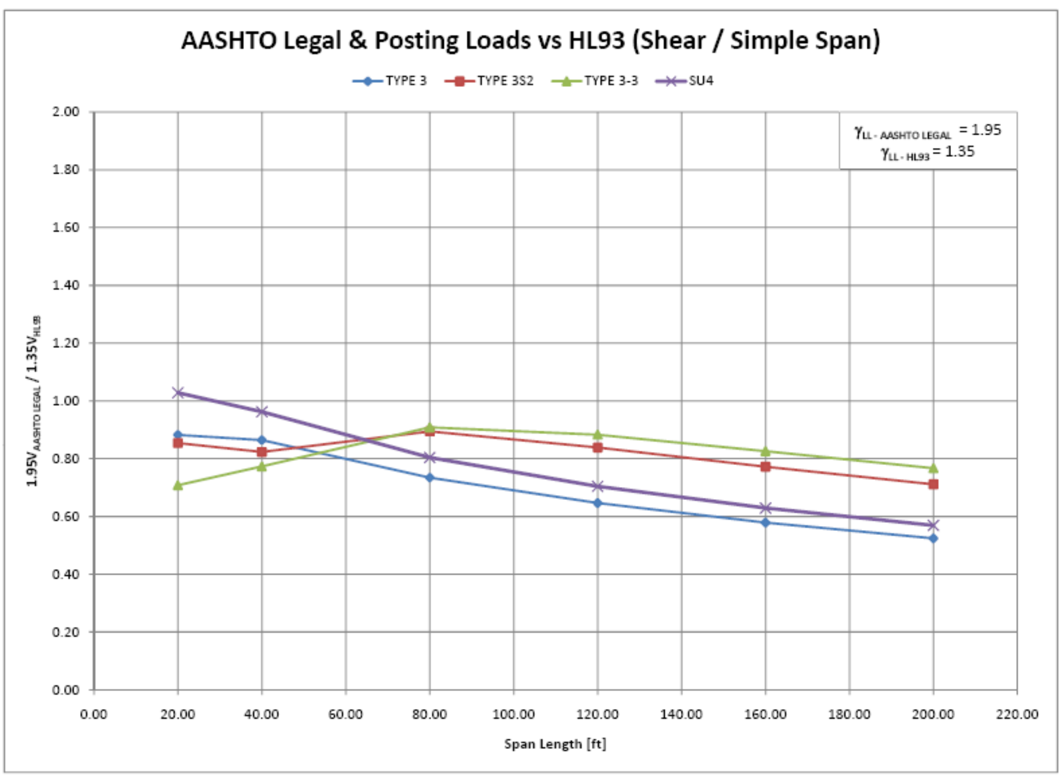
# APPENDIX A

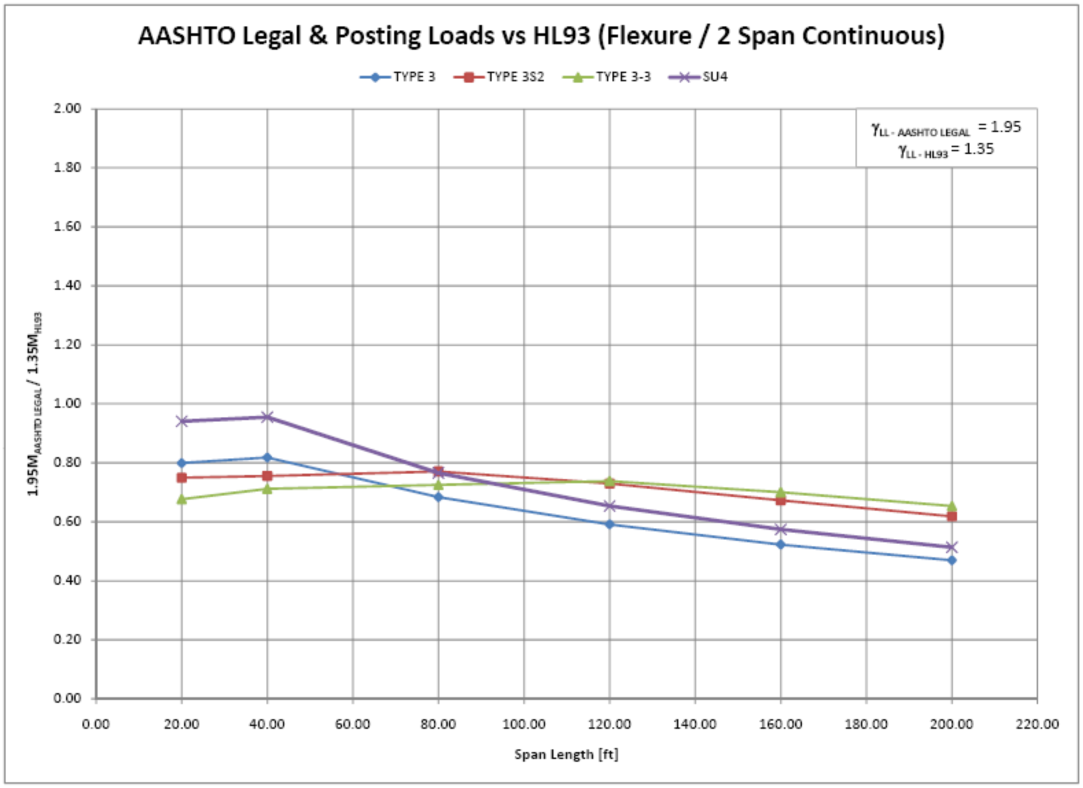
## Moment & Shear Effects

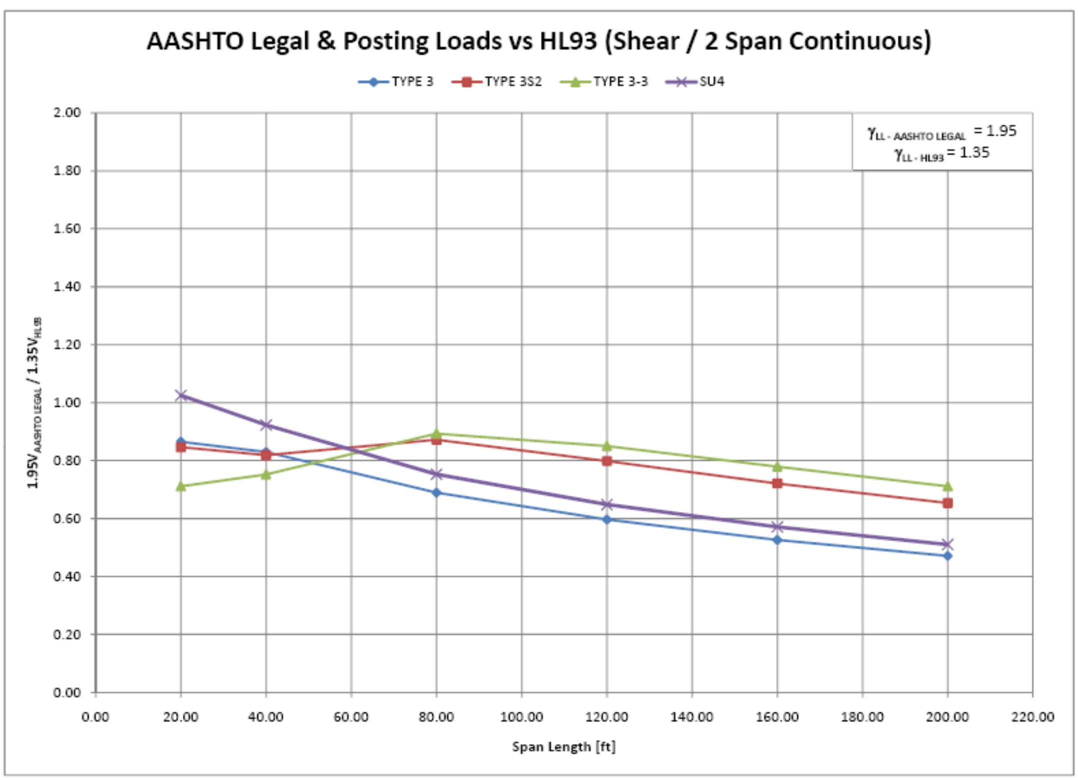
## For

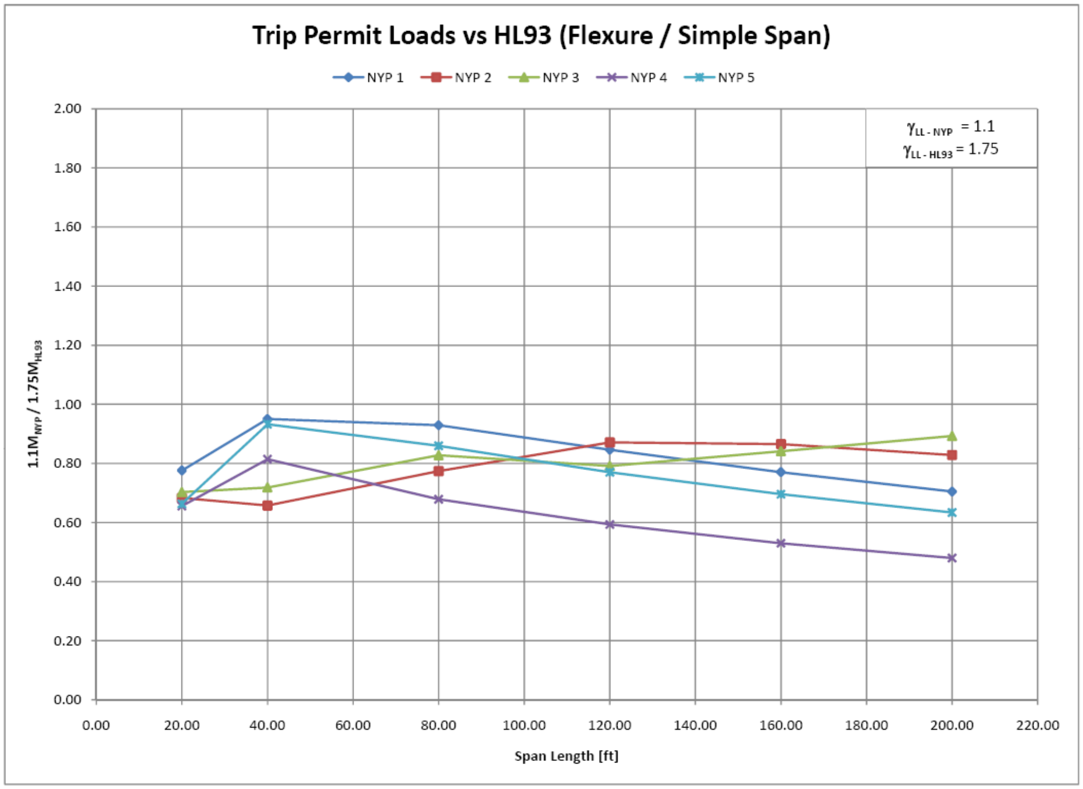
## NYSDOT Legal Loads & Permit Loads


AASHTO Legal & Posting Loads vs HL93 (Flexure / Simple Span)
TYPE 3
TYPE 3S2
TYPE 3-3
SU4
γLL - AASHTO LEGAL = 1.95
γLL - HL93 = 1.35
1.95MAASHTO LEGAL / 1.35MHL93
Span Length [ft]
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00

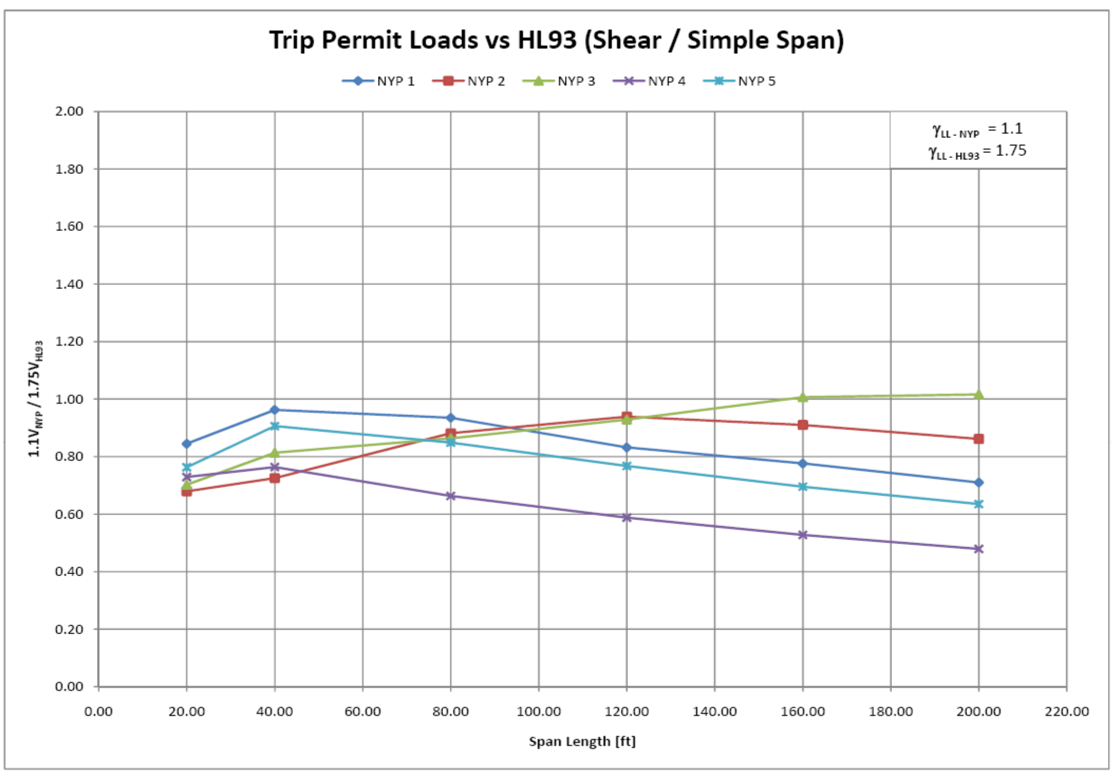

AASHTO Legal & Posting Loads vs HL93 (Shear / Simple Span)
TYPE 3
TYPE 3S2
TYPE 3-3
SU4
γLL - AASHTO LEGAL = 1.95
γLL - HL93 = 1.35
1.95VAASHTO LEGAL / 1.35VHL93
Span Length [ft]
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00


AASHTO Legal & Posting Loads vs HL93 (Flexure / 2 Span Continuous)
TYPE 3
TYPE 3S2
TYPE 3-3
SU4
γLL - AASHTO LEGAL = 1.95
γLL - HL93 = 1.35
1.95M AASHTO LEGAL / 1.35M HL93
Span Length [ft]

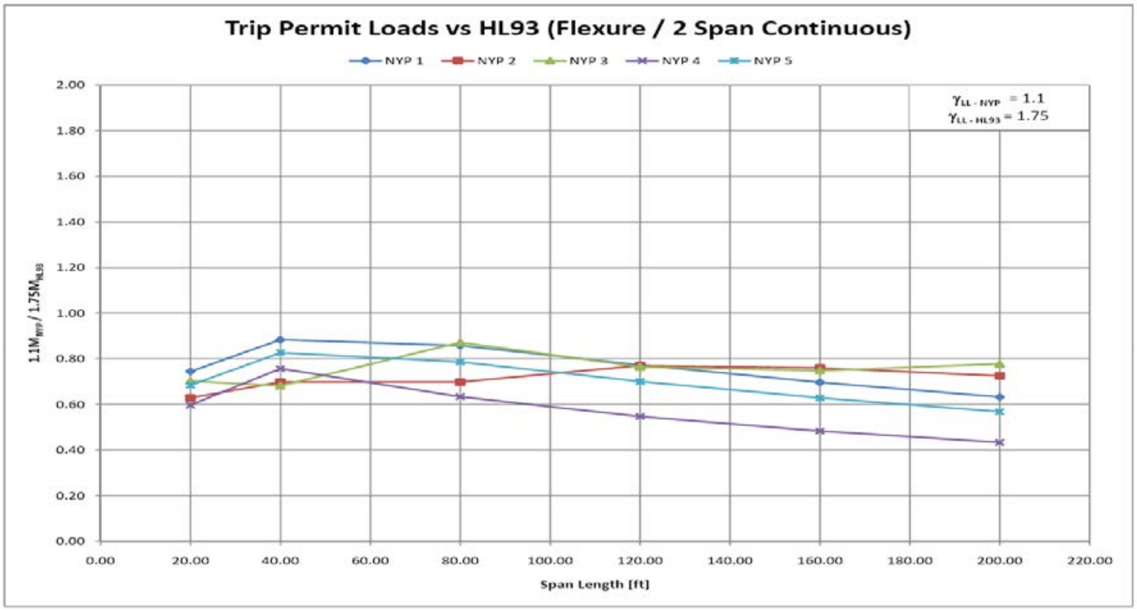

AASHTO Legal & Posting Loads vs HL93 (Shear / 2 Span Continuous)
TYPE 3
TYPE 3S2
TYPE 3-3
SU4
γLL - AASHTO LEGAL = 1.95
γLL - HL93 = 1.35
1.95V AASHTO LEGAL / 1.35V HL93
Span Length [ft]



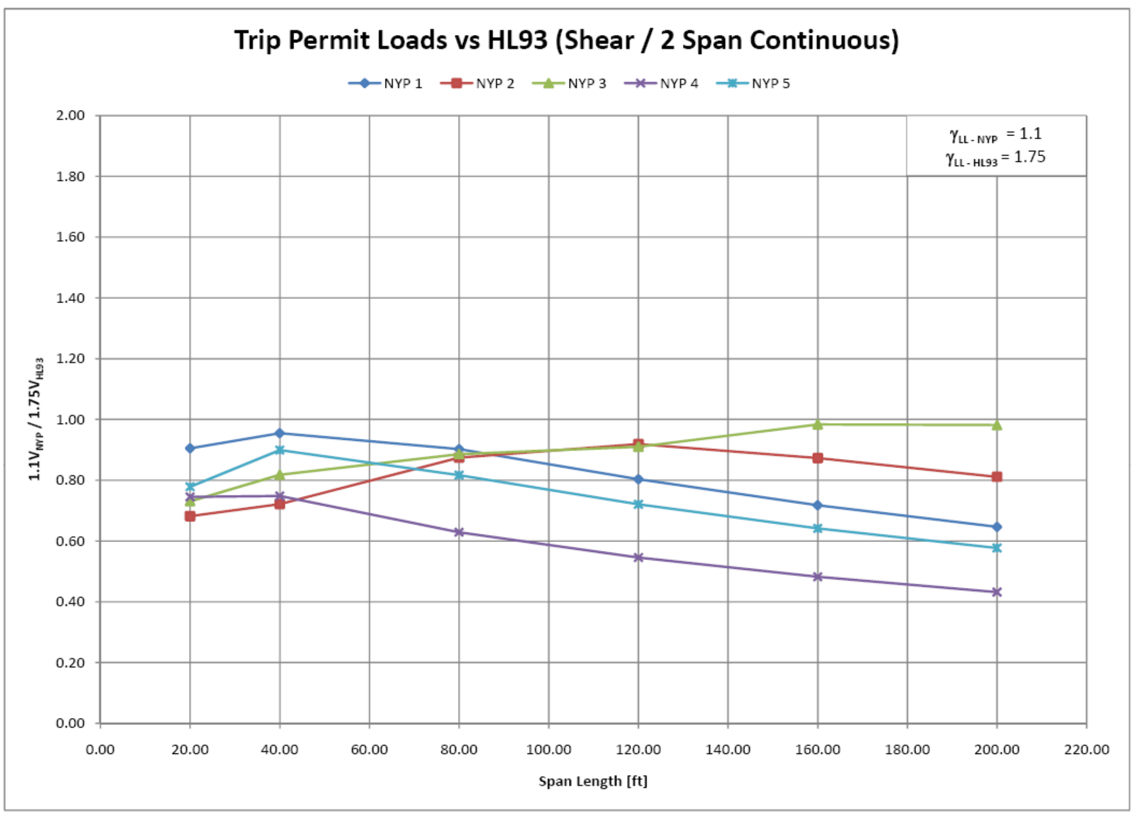
Trip Permit Loads vs HL93 (Flexure / Simple Span)
NYP 1
NYP 2
NYP 3
NYP 4
NYP 5
γLL - NYP = 1.1
γLL - HL93 = 1.75
1.1MNYP / 1.75MHL93
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
Span Length [ft]

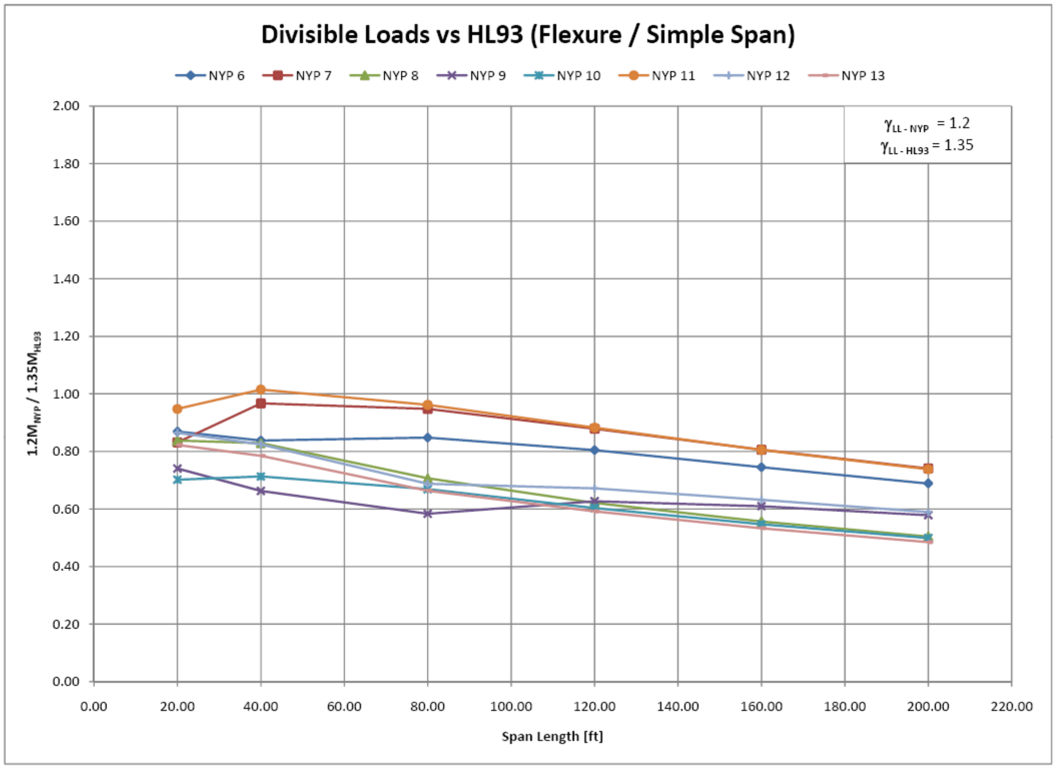
Trip Permit Loads vs HL93 (Shear / Simple Span)
NYP 1
NYP 2
NYP 3
NYP 4
NYP 5
γLL - NYP = 1.1
γLL - HL93 = 1.75
1.1VNYP / 1.75VHL93
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00
Span Length [ft]

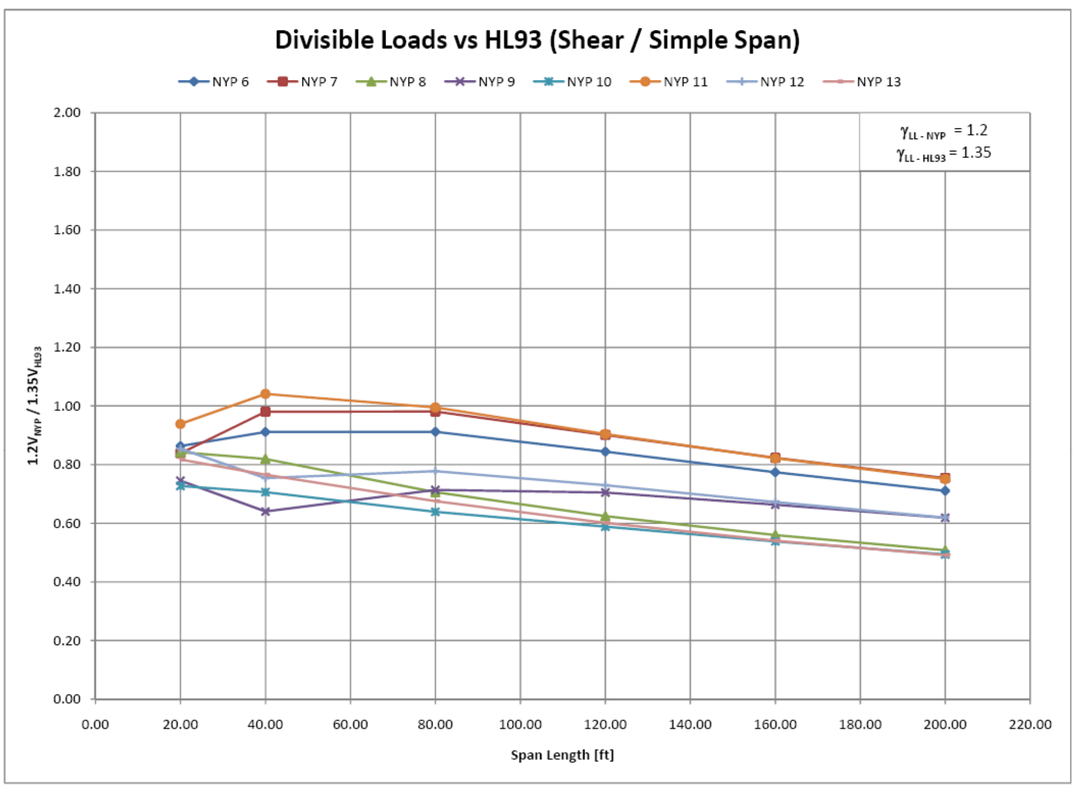


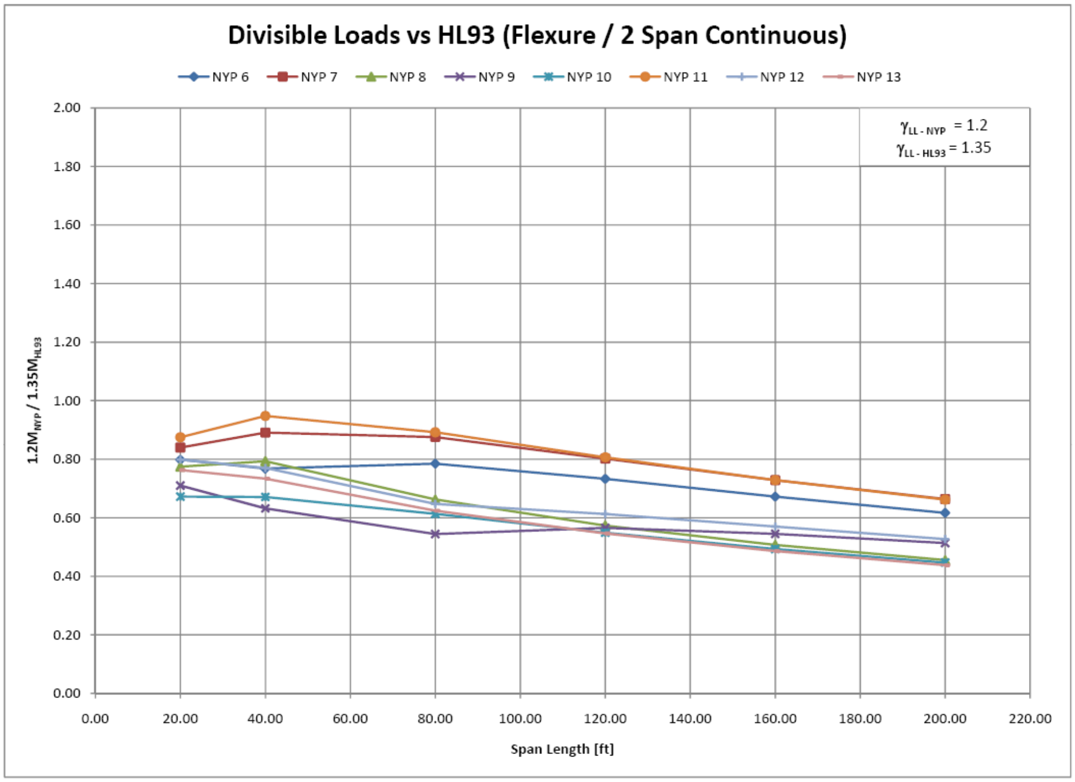
Trip Permit Loads vs HL93 (Flexure / 2 Span Continuous)
NYP 1
NYP 2
NYP 3
NYP 4
NYP 5
γLL - NYP = 1.1
γLL - HL93 = 1.75
1.1MNYP / 1.75MHL93
Span Length [ft]

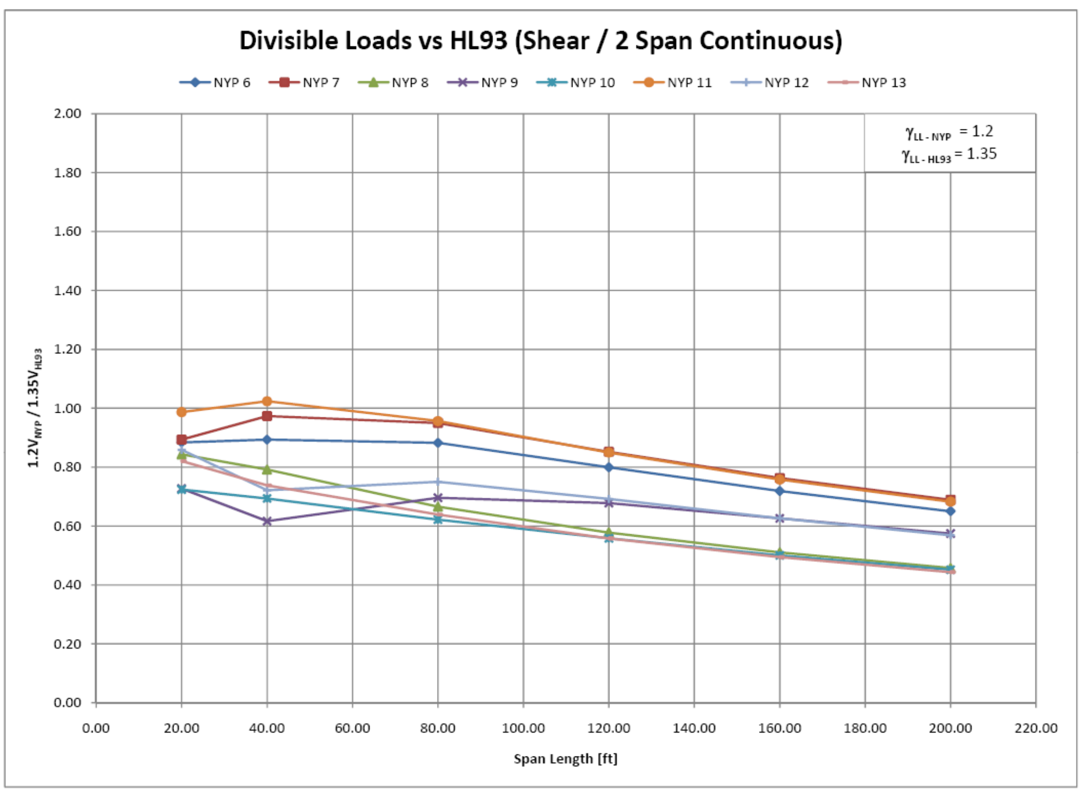
Trip Permit Loads vs HL93 (Shear / 2 Span Continuous)
NYP 1
NYP 2
NYP 3
NYP 4
NYP 5
γLL - NYP = 1.1
γLL - HL93 = 1.75
1.1VNYP / 1.75VHL93
Span Length [ft]


Divisible Loads vs HL93 (Flexure / Simple Span)
NYP 6
NYP 7
NYP 8
NYP 9
NYP 10
NYP 11
NYP 12
NYP 13
$\gamma_{LL-NYP}$ = 1.2
$\gamma_{LL-HL93}$ = 1.35
$1.2M_{NYP} / 1.35M_{HL93}$
Span Length [ft]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00


Divisible Loads vs HL93 (Shear / Simple Span)
NYP 6
NYP 7
NYP 8
NYP 9
NYP 10
NYP 11
NYP 12
NYP 13
$\gamma_{LL-NYP}$ = 1.2
$\gamma_{LL-HL93}$ = 1.35
$1.2V_{NYP} / 1.35V_{HL93}$
Span Length [ft]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00



Divisible Loads vs HL93 (Flexure / 2 Span Continuous)
NYP 6
NYP 7
NYP 8
NYP 9
NYP 10
NYP 11
NYP 12
NYP 13
$\gamma_{LL-NYP}$ = 1.2
$\gamma_{LL-HL93}$ = 1.35
$1.2M_{NYP} / 1.35M_{HL93}$
Span Length [ft]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00

Divisible Loads vs HL93 (Shear / 2 Span Continuous)
NYP 6
NYP 7
NYP 8
NYP 9
NYP 10
NYP 11
NYP 12
NYP 13
$\gamma_{LL-NYP}$ = 1.2
$\gamma_{LL-HL93}$ = 1.35
$1.2V_{NYP} / 1.35V_{HL93}$
Span Length [ft]
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
2.00
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
160.00
180.00
200.00
220.00

**TABLE A.1** Moment and Shear Tables for Simple Span and 2-Span Continuous Cases (NY Legal Loads)

| | **LOADING** | **SPAN LENGTH** | **SIMPLE SPAN** | | **2-SPAN CONTINUOUS** | |
|---|---|---|---|---|---|---|
| | | | **MOMENT** | **SHEAR** | **MOMENT** | **SHEAR** |
| | | | kip-ft | kip | kip-ft | kip |
| **NY LEGAL LOADS** | **TYPE 3S2** | 20 FT | 126 | 30.4 | 102 | 32.1 |
| | | 40 FT | 324 | 38.8 | 260 | 42.4 |
| | | 80 FT | 973 | 55.3 | 773 | 59.4 |
| | | 120 FT | 1689 | 60.8 | 1354 | 64.5 |
| | | 160 FT | 2407 | 63.6 | 1942 | 66.7 |
| | | 200 FT | 3126 | 65.3 | 2533 | 67.9 |
| | **SU4** | 20 FT | 160 | 36.6 | 128 | 38.9 |
| | | 40 FT | 406 | 45.3 | 328 | 47.8 |
| | | 80 FT | 946 | 49.7 | 769 | 51.3 |
| | | 120 FT | 1486 | 51.1 | 1213 | 52.3 |
| | | 160 FT | 2026 | 51.8 | 1658 | 52.8 |
| | | 200 FT | 2566 | 52.3 | 2103 | 53.0 |

*Moment and shear values given in the table do not include load factors, distribution factors or dynamic load allowance.

**TABLE A.2** Moment and Shear Tables for Simple Span and 2-Span Continuous Cases (Non-Divisible Permits)

| | LOADING | SPAN LENGTH | SIMPLE SPAN | | 2-SPAN CONTINUOUS | |
|---|---|---|---|---|---|---|
| | | | MOMENT | SHEAR | MOMENT | SHEAR |
| | | | kip-ft | kip | kip-ft | kip |
| NY NON-DIVISIBLE PERMITS | NYP_1 | 20 FT | 286 | 69.1 | 232 | 78.9 |
| | | 40 FT | 874 | 104.2 | 699 | 113.6 |
| | | 80 FT | 2472 | 132.7 | 1979 | 141.4 |
| | | 120 FT | 4082 | 138.7 | 3294 | 149.0 |
| | | 160 FT | 5696 | 146.9 | 4617 | 152.4 |
| | | 200 FT | 7308 | 149.8 | 5942 | 154.4 |
| | NYP_2 | 20 FT | 252 | 55.5 | 196 | 59.4 |
| | | 40 FT | 604 | 78.5 | 551 | 85.8 |
| | | 80 FT | 2058 | 125.0 | 1609 | 136.9 |
| | | 120 FT | 4202 | 156.6 | 3282 | 170.5 |
| | | 160 FT | 6398 | 172.3 | 5037 | 185.5 |
| | | 200 FT | 8593 | 181.8 | 6820 | 193.7 |
| | NYP_3 | 20 FT | 259 | 57.4 | 219 | 63.7 |
| | | 40 FT | 661 | 88.0 | 539 | 97.2 |
| | | 80 FT | 2201 | 122.6 | 2010 | 138.8 |
| | | 120 FT | 3816 | 154.8 | 3257 | 168.8 |
| | | 160 FT | 6220 | 190.5 | 4958 | 209.0 |
| | | 200 FT | 9260 | 214.4 | 7315 | 234.3 |
| | NYP_4 | 20 FT | 242 | 59.6 | 186 | 65.0 |
| | | 40 FT | 748 | 82.6 | 598 | 89.0 |
| | | 80 FT | 1805 | 94.1 | 1460 | 98.5 |
| | | 120 FT | 2861 | 98.0 | 2329 | 101.2 |
| | | 160 FT | 3918 | 99.9 | 3200 | 102.4 |
| | | 200 FT | 4974 | 101.0 | 4071 | 103.1 |
| | NYP_5 | 20 FT | 245 | 62.4 | 213 | 67.9 |
| | | 40 FT | 857 | 98.0 | 653 | 106.9 |
| | | 80 FT | 2286 | 120.5 | 1813 | 127.9 |
| | | 120 FT | 3715 | 127.9 | 2986 | 133.7 |
| | | 160 FT | 5144 | 131.7 | 4163 | 136.3 |
| | | 200 FT | 6573 | 133.9 | 5341 | 137.8 |

*Moment and shear values given in the table do not include load factors, distribution factors or dynamic load allowance.

**TABLE A.3a** Moment and Shear Tables for Simple Span and 2-Span Continuous Cases (Divisible Permits)

| | LOADING | SPAN LENGTH | SIMPLE SPAN | | 2-SPAN CONTINUOUS | |
|---|---|---|---|---|---|---|
| | | | MOMENT | SHEAR | MOMENT | SHEAR |
| | | | kip-ft | kip | kip-ft | kip |
| NY NON-DIVISIBLE PERMITS | NYP_6 | 20 FT | 227 | 49.9 | 176 | 54.5 |
| | | 40 FT | 545 | 69.7 | 429 | 75.1 |
| | | 80 FT | 1595 | 91.5 | 1280 | 97.7 |
| | | 120 FT | 2744 | 99.6 | 2209 | 104.8 |
| | | 160 FT | 3896 | 103.6 | 3152 | 108.0 |
| | | 200 FT | 5050 | 106.0 | 4100 | 109.8 |
| | NYP_7 | 20 FT | 217 | 48.5 | 185 | 55.1 |
| | | 40 FT | 629 | 75.0 | 498 | 81.8 |
| | | 80 FT | 1782 | 98.4 | 1428 | 105.2 |
| | | 120 FT | 2997 | 106.3 | 2418 | 111.8 |
| | | 160 FT | 4214 | 110.2 | 3416 | 114.7 |
| | | 200 FT | 5432 | 112.5 | 4418 | 116.3 |
| | NYP_8 | 20 FT | 219 | 48.7 | 171 | 52.0 |
| | | 40 FT | 539 | 62.7 | 443 | 66.6 |
| | | 80 FT | 1329 | 70.8 | 1080 | 73.8 |
| | | 120 FT | 2119 | 73.6 | 1728 | 75.7 |
| | | 160 FT | 2909 | 74.9 | 2378 | 76.7 |
| | | 200 FT | 3699 | 75.7 | 3029 | 77.2 |
| | NYP_9 | 20 FT | 193 | 43.1 | 157 | 44.8 |
| | | 40 FT | 431 | 49.0 | 353 | 51.8 |
| | | 80 FT | 1097 | 71.6 | 888 | 77.1 |
| | | 120 FT | 2138 | 83.1 | 1705 | 88.9 |
| | | 160 FT | 3189 | 88.8 | 2555 | 94.1 |
| | | 200 FT | 4243 | 92.2 | 3415 | 97.0 |
| | NYP_10 | 20 FT | 183 | 42.1 | 148 | 44.6 |
| | | 40 FT | 464 | 54.0 | 375 | 58.3 |
| | | 80 FT | 1258 | 64.1 | 1001 | 68.8 |
| | | 120 FT | 2058 | 69.4 | 1655 | 73.2 |
| | | 160 FT | 2858 | 72.0 | 2313 | 75.2 |
| | | 200 FT | 3658 | 73.6 | 2972 | 76.3 |

*Moment and shear values given in the table do not include load factors, distribution factors or dynamic load allowance.

**TABLE A.3b** Moment and Shear Tables for Simple Span and 2-Span Continuous Cases (Divisible Permits)

| | LOADING | SPAN LENGTH | SIMPLE SPAN | | 2-SPAN CONTINUOUS | |
|---|---|---|---|---|---|---|
| | | | MOMENT | SHEAR | MOMENT | SHEAR |
| | | | kip-ft | kip | kip-ft | kip |
| NY NON-DIVISIBLE PERMITS | NYP_11 | 20 FT | 247 | 54.3 | 193 | 60.8 |
| | | 40 FT | 660 | 79.6 | 530 | 86.1 |
| | | 80 FT | 1809 | 99.9 | 1455 | 106.0 |
| | | 120 FT | 3010 | 106.6 | 2432 | 111.4 |
| | | 160 FT | 4211 | 110.0 | 3417 | 113.9 |
| | | 200 FT | 5412 | 112.0 | 4404 | 115.3 |
| | NYP_12 | 20 FT | 226 | 49.4 | 176 | 53.0 |
| | | 40 FT | 536 | 57.7 | 431 | 60.7 |
| | | 80 FT | 1294 | 78.1 | 1056 | 83.1 |
| | | 120 FT | 2290 | 86.0 | 1847 | 90.7 |
| | | 160 FT | 3303 | 90.0 | 2672 | 94.1 |
| | | 200 FT | 4319 | 92.4 | 3505 | 96.0 |
| | NYP_13 | 20 FT | 215 | 47.3 | 168 | 50.6 |
| | | 40 FT | 510 | 58.5 | 410 | 62.1 |
| | | 80 FT | 1248 | 67.8 | 1018 | 70.8 |
| | | 120 FT | 2017 | 70.8 | 1647 | 73.2 |
| | | 160 FT | 2787 | 72.4 | 2279 | 74.3 |
| | | 200 FT | 3557 | 73.3 | 2913 | 74.9 |

*Moment and shear values given in the table do not include load factors, distribution factors or dynamic load allowance.

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# APPENDIX C

**Proposed Revisions to NYSDOT EI 05-034 (06/24/2016)**

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PROPOSED REVISIONS 6/24/16

| To: | | *New York State Department of Transportation* **ENGINEERING INSTRUCTION** | **EI** **05-034** |
|---|---|---|---|

**Title: LOAD RATING/POSTING GUIDELINES FOR STATE-OWNED HIGHWAY BRIDGES**

Distribution:
- ❑ Manufacturers (18)
- ☒ Local Govt. (31)
- ☒ Agencies (32)
- ❑ Surveyors (33)
- ☒ Consultants (34)
- ❑ Contractors (39)
- ❑ ____________( )

Approved:

/s/ G. A. Christian — 10/18/05
George A. Christian, Deputy Chief Engineer (Structures) — Date

**ADMINISTRATIVE INFORMATION:**

- Effective Date: This Engineering Instruction (EI) is effective upon signature.
- Superseded Issuances: The Information transmitted by this EI supersedes Engineering Instructions 88-004, 88-005, 88-006, and 94-004.
- Disposition of Issued Materials: The information included in this EI is intended to stand alone outside of any other document.

**PURPOSE:** To issue guidance for prioritizing and submitting load rating calculations, posting bridges for load restrictions, and documenting and reporting load tests on state-owned highway bridges.

**TECHNICAL INFORMATION:** The language used in this EI to describe personnel, entities and functions is in accordance with NYSDOT's present organizational structure, with the anticipated Program Support Division organizational entity in parenthesis where appropriate.

## 1) INTRODUCTION

Bridge load rating is the determination of the live load carrying capacity of a newly designed or existing bridge. Load ratings are typically determined by analytical methods based on information taken from bridge plans supplemented by information gathered from field inspections or field testing. This task is vital for several reasons, including (but not limited to) the following:

- To determine which structures have substandard load capacities that may require posting or other remedial action.
- To assist in the most effective use of available resources for rehabilitation or replacement.
- Mandated by the Code of Federal Regulations – Highways, Title 23. Chapter 1 – Federal Highway Administration (FHWA), DOT, Part 650 – Bridges, Structures and Hydraulics.
- Mandated by New York State Highway Law, §230, §231, §232, & §233. NY Code of Rules and Regulations, 17 (17NYCRR), Chapter V – Uniform Code of Bridge Inspection (UCBI).
- To assist in the overload permit review process.

The New York State regulations regarding bridge load ratings are part of the UCBI, which is contained in the current NYSDOT Bridge Inspection Manual.

The Federal Highway Administration (FHWA) requires that bridge load rating results be submitted to them annually. These results are used in conjunction with other bridge inventory and inspection information to determine the Federal Bridge Sufficiency Rating, which, in turn, is a factor used to determine the eligibility of a project for the Highway Bridge Replacement and Rehabilitation (HBRR) Program. Inaccurate bridge ratings may result in incorrect eligibility determinations under the program. This document provides guidance for prioritizing and submitting load rating calculations, posting bridges for load restrictions, and documenting and reporting load tests.

**1.1 DEFINITIONS and TERMINOLOGY:**

*AASHTO* - American Association of State Highway and Transportation Officials.

*AASHTO Manual* - AASHTO Manual for Condition Evaluation of Bridges (MCEB). In 2006 the MCEB will be replaced by the Manual for Evaluation of Bridges.

*BDMS* - Bridge Data Management System.

*FHWA* - Federal Highway Administration, U.S. Department of Transportation.

*Internally Redundant* - Supporting primary members made up of three or more elements that are mechanically fastened together so that if one should fail the other elements will be able to internally transfer the load and still support the main structure. An example would be a riveted girder.

*Inventory Rating Level* - The inventory rating level generally corresponds to the customary design level of stresses but reflects the existing bridge and material conditions with regard to deterioration and loss of section. Load ratings based on the inventory level allow comparisons with the capacity for new structures and, therefore, results in a live load which can safely utilize an existing structure for an indefinite period of time. (MCEB)

*Limit State* - A condition beyond which the bridge or component ceases to satisfy the criteria for which it was designed.

*Load Effect* - The response (axial force, shear force, bending moment, etc.) in a member or an element due to externally applied loads.

*Load Factor* - A load multiplier accounting for the variability of loads, the lack of accuracy in analysis, and the probability of simultaneous occurrence of different loads.

*Load Path Redundant* - A structure that has multiple paths between substructure units to distribute the load in the event of failure of one of the supporting members. Examples are steel multi-girder or prestressed concrete multi-girder bridge types. NYSDOT considers a structure to be load path redundant if it has four or more load paths.

*Load Posting* - Live load weight restriction placed on a structure, by the owner, when a bridge is incapable of carrying the maximum legal live load. Load postings are done after an analysis that accounts for the current condition of the structure.

*Load Rating Engineer (LRE)* - Engineer responsible for the accuracy and quality control of load rating data for a given bridge inventory in accordance with this EI, State and Federal requirements.

*Load Rating Levels* - Bridge load ratings in New York State are grouped into three distinct levels of accuracy, Level 1, Level 2, and Level 3. Load Rating Levels are discussed in detail in subsequent sections.

*Load Rating Unit* - Functional unit responsible for statewide implementation, operations, and quality assurance of the NYSDOT load rating program, including management of the Statewide load rating database.

*National Bridge Inspection Standards (NBIS)* - Federal regulations establishing requirements for inspection procedures, frequency of inspections, qualifications of personnel, inspection reports, and preparation and maintenance of bridge inventory records.

*Operating Rating Level* - Load ratings based on the operating rating level generally describe the maximum permissible live load to which the structure may be subjected. Allowing unlimited numbers of vehicles to use the bridge at operating level may shorten the life of the bridge (MCEB).

*Quality Assurance* - The use of sampling to verify or measure the level of the entire bridge inspection and load rating program.

*Quality Control* - System that is intended to maintain the quality of a bridge inspection and load rating at or above a certain level.

*R-Posting* - A load restriction for a bridge, which based on design or condition, does not have the reserve capacity to accommodate most vehicles over legal loads but, can still safely carry legal loads. Vehicles operating pursuant to an overweight permit with structure use restrictions (known as “R” Permits) are not allowed to cross. Originally established for NYSDOT’s divisible load permit program, R-Postings are also used to restrict other non-divisble overload permit classifications. These bridges are identified with signage stating “No Trucks with R Permits.”

*Resistance Factor* - A resistance multiplier accounting for the variability of material properties, structural dimensions, workmanship, and the uncertainty in the prediction of resistance.

*Serviceability* - A term that denotes restrictions on stress, deformation, and crack opening under regular service conditions.

*Service Limit State* - Limit state relating to stress deformation and cracking.

*Strength Limit State* - Safety limit state relating to strength and stability.

*Substantial Structural Alteration* - Any work that modifies the live load capacity, load distribution or load paths or structural behavior of the bridge (UCBI).

*UCBI* - Uniform Code of Bridge Inspection - NY Code of Rules and Regulations, 17, Chapter V.

## 2) LEVEL 1 LOAD RATING GUIDELINES

### 2.1 INTRODUCTION:

*"A Level 1 rating refers to any fully documented analysis or capacity evaluation that is signed and certified by a professional engineer, licensed by the State of New York, as being complete and correct in its computation of bridge load capacity. Generally, a Level 1 analysis shall be in conformance with the analysis assumptions and provisions of the AASHTO Manual."* – UCBI 165.8 (a) (1). Rating results from Level 1 calculations are used to determine need for member strengthening, load posting, or if a structure should be closed.

A complete Level 1 load rating will include analyses of the following items:

- All elements defined as "primary members" in the NYSDOT Bridge Inspection Manual, as well as all stringer-floorbeam, girder-floorbeam, and truss connections.
- Timber and metal bridge decks.
- Timber and metal pier elements.

It is not necessary to analyze concrete bridge decks, concrete and masonry substructure elements, or foundation elements unless there are unusual circumstances which, in the load rating engineer's judgment, will affect the load carrying capacity of the bridge. Secondary members subject to impact damage or deterioration shall also be investigated if the capacity of a primary member is affected.

Level 1 load ratings are required for all new and replacement bridges, and for all rehabilitation and repair designs involving a substantial structural alteration. Level 1 rating calculations shall be performed as part of the structural analysis process used for design and reflect the bridge as-built or as-rehabilitated construction and configuration. As an example, a new bridge design will account for a future wearing surface, but the Level 1 load rating does not include this future wearing surface as a dead load because it is not part of the as-built condition. This rule also applies to a Level 2 analysis which accounts for the current conditions of the structure.

Ratings shall be calculated following the guidelines contained in the latest edition of the AASHTO Manual adopted by NYSDOT.

### 2.2) ANALYSIS FREQUENCY:

Level 1 calculations eventually become outdated. Member deterioration, rehabilitation, redecking, and repaving of the wearing course are just a few of the occurrences that may force a reanalysis of the bridge. Therefore, the required frequency of Level 1 calculations can vary widely. A new bridge designed to current standards may not need another Level 1 for some time if it is maintained properly. However, for example, an old truss that is deteriorating steadily should be reanalyzed as conditions change every few years.

The Load Rating Engineer (LRE) or other qualified person should review any existing Level 1 data during or after each inspection to see if a reanalysis is needed. A new Level 1 analysis may be necessary if any of the following have occurred since the last Level 1 analysis was completed.

- The primary member condition rating on the inspection report has changed by more than one point, if the initial rating was 5 or lower.
- Dead load has changed significantly due to resurfacing or other nonstructural alterations.
- Section properties have changed due to rehabilitation, redecking, deterioration, or other alterations.

If Level 1 load ratings stored in NYSDOT's statewide database are invalid, these ratings shall be deleted from the database by the LRE or other designated qualified personnel.

The Priorities for Level 1 analysis may be set in the following order:

1. Bridges which appear to require R posting or load posting.
2. Bridges with primary member ratings less than 4 (using NYSDOT's 1-7 rating scale) that are not ratable by NYSDOT's standard load rating system.
3. Bridges that are ratable by NYSDOT's standard load rating system with primary member ratings less than 4.

### 2.3) DOCUMENTATION AND SUBMISSIONS:

All Level 1 calculations must be certified as accurate by a professional engineer currently licensed in New York State. They must be performed and checked according to standard structural engineering practice. If using a computer program, note the program name and version. Also, all input information must be documented. Both Allowable Stress and Load Factor are acceptable analysis methods but, Load Factor is the preferred rating method. Load ratings may be submitted in English or metric units.

The attached flowchart shows the proper work flow for the Level 1 calculations. When a new Level 1 analysis is done, a copy of all pertinent documentation should be kept in the responsible Region office.

Each NYSDOT Region (or Program Support Center responsible for Regional load rating engineering services) shall provide new Level 1 summaries to the NYSDOT Load Rating Unit after completion. For each bridge, Level 1 data should be summarized in terms of structure rating units. A structure rating unit is defined as a single simple span or a continuous series of spans that are analyzed as a single structural unit. Thus, a bridge with three simple spans will have three rating units, but a bridge with four continuous spans will have only one rating unit.

Level 1 load rating documentation shall be incorporated into a comprehensive package to facilitate updating of the information and calculations in the future, as well as documenting the assumptions that were used. For new, replacement, or rehabilitation projects, the Level 1 load rating package shall be transmitted as part of the Plans Specifications and Estimate (PS&E).

The following information shall be included in the Level 1 Load Rating package. Additional information may be required as part of the scope of services.

- Cover sheet with BIN; feature carried/feature crossed; political unit and county; rating summary table; analysis method and controlling member; engineers responsible for Level 1 load rating calculations (done by, checked by), approving PE signature, license number, and date.
- Table of contents.
- Level 1 Load Rating Summary Sheets for each unique member type to include 'HS' inventory and operating ratings. 'H' ratings shall also be included if the 'HS' inventory rating is less than 36 tons.
- General Information Sheet:

1) Bridge Identification Number (BIN):
2) Date load rating performed:
3) Political Unit:
4) Feature carried:
5) Feature crossed:
6) Superstructure type:
7) Number of spans:
8) Skew:
9) Total length:
10) Out-to-out width:
11) Bridge width curb-to-curb:
12) Number of actual travel lanes:
13) Number of lanes used in rating:
14) Type of deck:
15) Type of wearing surface:
16) Type of sidewalks:
17) Barrier or railing type:
18) Year built:
19) Rehabilitation year(s):
20) Design live load:
21) Existing posted load:
22) List of plans or sketches referenced should be provided for an existing structure:
23) Date of most recent inspection should be provided for an existing structure:

- Drawings or sketches of Superstructure Framing Plan, Typical Cross Section and Girder Elevation. For new or rehabilitation designs, also include Moment and Shear Tables and Design Load Table.
- General description and comments affecting the Load Rating, such as structure condition, flags, posting history, etc.
- Assumptions and analysis methods

    - Live load distribution method used (AASHTO Standard Bridge Specifications, lever rule, AASHTO Guide Specification, 3D analysis, etc.)
    - Dead load distribution (tributary area, simple beam distribution, continuous transverse beam distribution, 3D analysis, etc.)
    - Analysis method (ASD, LFD and/or, LRFD), assumptions and design criteria
- Analysis
    - Section properties: As-built and deteriorated section properties as applicable; composite section properties.
    - Material properties and any assumptions.
    - Copy of any hand calculations.
    - Dead load effects, with distribution method stated. This may be taken from computer output, assuming it is easy to follow.
        - All hand calculations for all dead loads or those needed for dead load inputs shall be included.
        - Dead load assumptions, such as the weight of barriers/railings, utility lines, etc., shall be included.
    - Live loads effects, with distribution method stated and impact factor calculation.
        - All required hand calculations shall be included.
        - If alternative distribution factors are used, an explanation of why an alternative method was used and all necessary calculations shall be included.
    - Member capacities for controlling section and limit state.
    - A listing of what software was utilized including version number.
    - Copy of software input where applicable.
    - At a minimum, a printout of the summarized output.
    - Safe load and load posting calculations if applicable.
- Rating Results: Tabulated by structural rating unit with controlling member for controlling unit with controlling limit state.

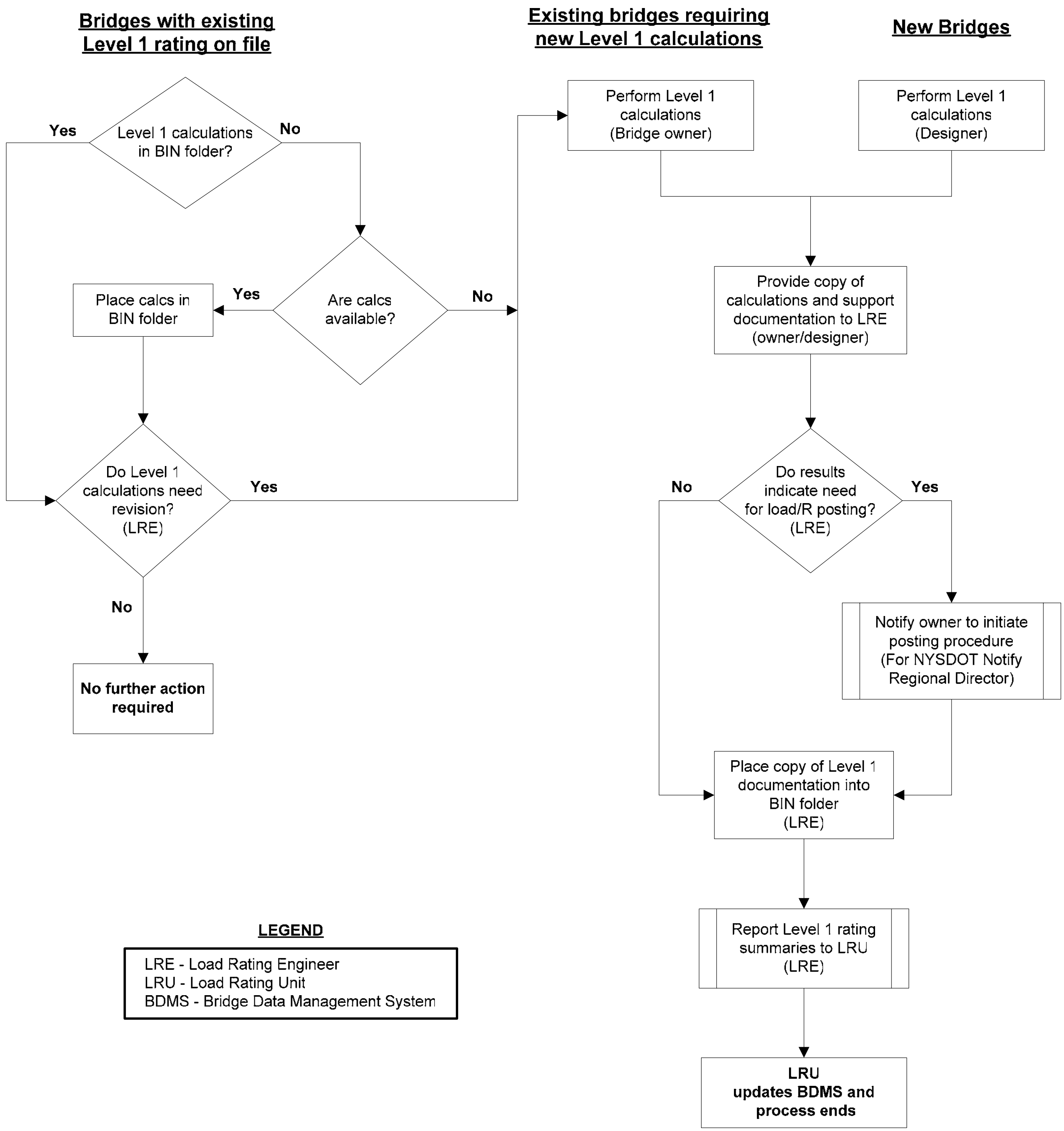
Notes:

All input sheets and calculation sheets shall show both the rater and checker.

All inspection reports, manuals, textbooks, and articles referenced as part of the load rating package shall be documented.

Typically, the substructure is not analyzed as part of a load rating; however there are cases where the substructure shall be analyzed, such as steel cap beams and steel columns. In these cases, those calculations shall be included in the load rating of the structure. At the LRE’s discretion, other substructure elements not normally included in a Level 1 may need to be analyzed on an existing structure. This may be necessary in cases of extreme concrete deterioration or other mitigating circumstances.

## RECORDING AND TRANSFERRING LEVEL 1 LOAD RATING DATA




Note: As previously stated, All Level 1 calculations must be certified as accurate by a professional engineer currently licensed in New York State.

## 3) LEVEL 2 LOAD RATING GUIDELINES

### 3.1) INTRODUCTION:

Level 2 load ratings are computer generated analyses of bridges produced by NYSDOT using its current bridge load rating computer systems - AASHTO Virtis and the New York Bridge Load Rating System (NYBLRS). The Load Rating Engineer is responsible for collection and Quality Control of Level 2 data for their assigned bridge inventory. The Load Rating Unit is responsible for Quality Assurance of all load rating work and management of the statewide load rating database. Input data for Level 2 ratings is generally collected as part of the NYSDOT bridge inspection program. Level 2 load rating work that is performed by consultants as part of their general bridge inspection agreements for the NYSDOT shall conform to NYSDOT specifications and standards before it is submitted to NYSDOT.

### 3.2) ANALYSIS FREQUENCY:

All bridges ratable by the current NYSDOT Level 2 Load Rating System shall be entered for analysis. As part of each Biennial bridge inspection, Level 2 load rating information shall be updated and the load ratings subsequently regenerated and submitted. An analysis shall be completed whether or not there has been any change to the input data. Specification changes, which are incorporated in each release of Virtis, may affect previous load rating results as well as new analysis modules that could analyze previously unratable structures. The Bridge Data Management System (BDMS) will also record an analysis date in the inventory database for processed ratings. By updating the analysis there will be a time stamp verification that the load rating for a particular structure was evaluated as part of its biennial inspection and is still valid.

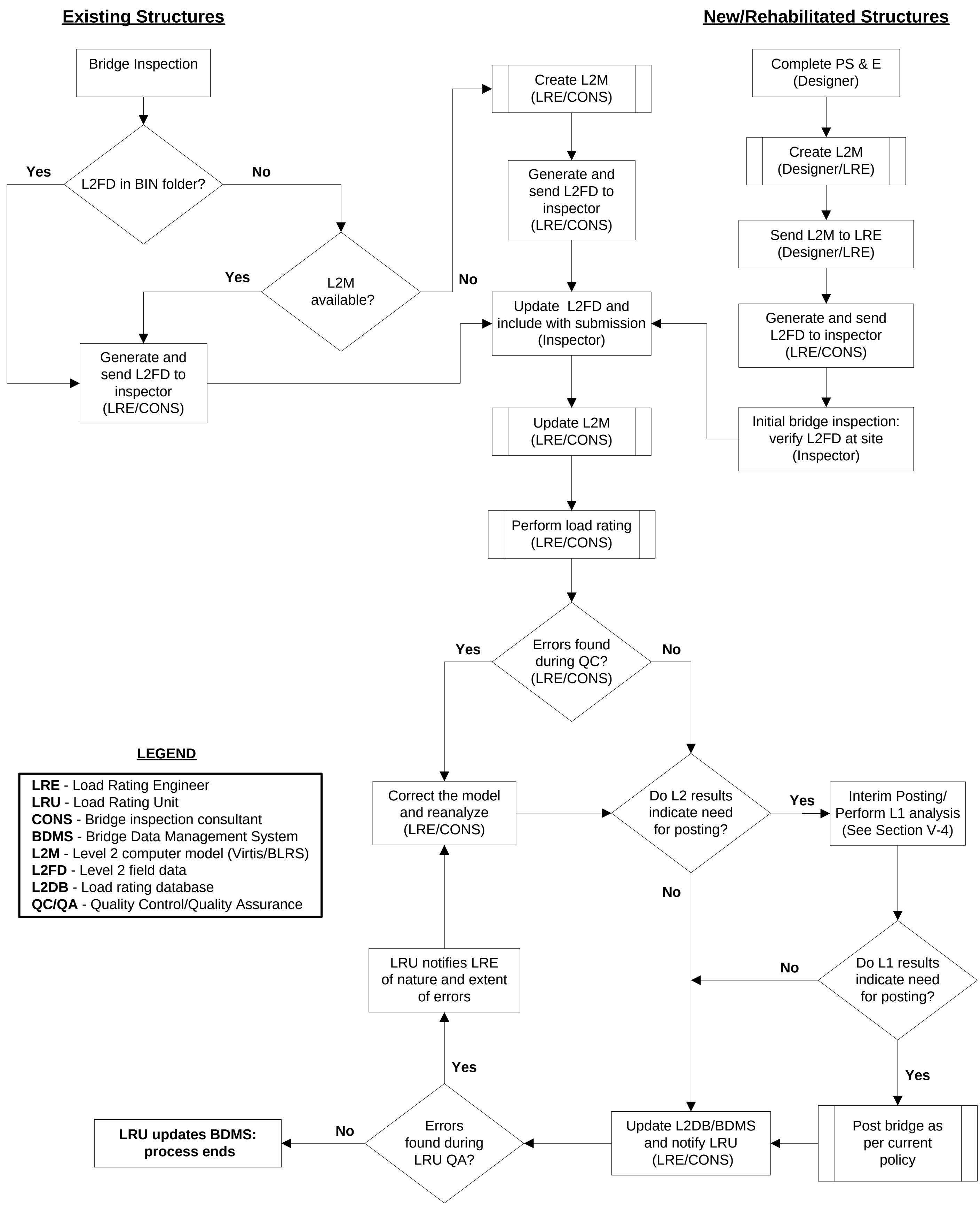
Consultants performing a Level 2 load rating analysis shall submit their results to the respective LRE. The LRE shall be responsible for transferring this data into BDMS. The Load Rating Unit is responsible for all Level 2 Quality Assurance activities. This includes final approval of submitted Level 2 load ratings in BDMS.

### 3.3) ANALYSIS AND SUBMISSION PROCEDURE:

The flowchart at the end of this section outlines the updating, recording, and transferring of Level 2 load rating data.

The inspector shall verify in the field the information in the BIN folder needed for the Level 2 load rating analysis. This is the Level 2 field data and may include existing bridge plans that are marked up by the Inspector or spreadsheet forms prepared by the LRE. The Level 2 field data required to perform a Level 2 analysis is at the discretion of the LRE and may vary. If there are changes, the LRE or designated staff or consultant will update the information in the BIN folder with the new data. The LRE or consultant will regenerate the Level 2 Load Rating analysis with the current data and report the new results.

## RECORDING AND TRANSFERRING LEVEL II LOAD RATING DATA



## 4) LEVEL III LOAD RATING

When no Level 1 or Level 2 load rating exists, BDMS will generate a Level 3 load rating for the structure based on existing general inventory and inspection information such as design load, condition rating, existing posting values, etc. These ratings are not based on an analysis of the structure but on an estimate of the probable capacity of the bridge from the parameters mentioned.

These ratings are only to be used to report rating values to the FHWA when better information is not available. These ratings are not to be used for any type of structural evaluation or overload permit review.

## 5) BRIDGE LOAD POSTING GUIDELINES

### 5.1) INTRODUCTION:

This section provides guidance for load posting of NYSDOT-owned highway bridges. Because of the varying nature of structural systems, materials, frequency of loadings, and other factors which may affect a load posting, no rigid set of rules can be adopted that would be appropriate in every case.

The Region initiating the posting or change in posting must immediately give written notification to the Regional (or assigned Program Support Center) Structural Engineering Unit Manager, who will update the inventory database to reflect the change. Copies of all documentation related to posting decisions, including calculations, inspection reports, load test reports, etc., will be kept in the state BIN folder or other permanent bridge file location.

### 5.2) GENERAL:

The bridge owner is responsible for the decision to post a bridge and setting posting values. However, the following minimum standards must always be followed, according to Section 233 and 234 of the Highway Law, and the UCBI:

- Bridges shall not be posted at a value that will cause the operating rating level to be exceeded. As stated in the AASHTO Manual; *"Load ratings based on the operating rating level generally describe the maximum permissible live load to which the structure may be subjected."*
- The **minimum** load posting value is three tons. If the bridge cannot safely carry that load, it must be closed.
- Load posting signs shall conform to the standards for regulatory signs under the current NYSDOT (17NYCRR), Chapter V, a.k.a <u>Manual of Uniform Traffic Control Devices</u> (MUTCD).

### 5.3) CONDITION EVALUATION:

Bridges being investigated for posting must be inspected for condition as per the requirements of the UCBI, the latest edition of the NYSDOT Bridge Inspection Manual and the AASHTO Manual. The inspector must verify the accuracy of existing plans or sketches in lieu of plans with field measurements. It is especially important to measure and document items that may affect the load capacity, such as overlay thickness and section deterioration.

### 5.4) STRENGTH EVALUATION:

All permanent posting decisions should be based on the results of a current Level 1 load rating and field investigation. However, *"Level 2 ratings may be used to assign interim load restrictions to a deficient bridge until a Level 1 load rating can be undertaken."* – UCBI 165.8 (a) (2). Level 2 ratings shall not to be used as the basis for a permanent posting decision. The applied live loads for load rating are the standard AASHTO H and HS vehicles. Both inventory and operating ratings must be calculated. For bridges being evaluated for load posting using the guidance provided herein, the H inventory and operating ratings are used in the determination of the Safe Load Capacity (SLC).

There are many bridges for which common analytical methods are not adequate to determine a load rating. The following are some examples:

- Bridges that cannot be realistically modeled using routine analytical methods.
- Bridges with unavailable or incomplete plans and structural components that cannot be measured. Examples include (but are not limited to) steel beams encased in concrete and concrete structures with unknown reinforcement or prestressing.
- Timber bridges with unknown material properties.

For cases like these, alternate methods of load rating may need to be used to generate realistic load rating results.

### 5.5) DETERMINATION OF SAFE LOAD CAPACITY (SLC) AND POSTING VALUES:

The SLC is a load rating value that corresponds to an acceptable stress level from actual traffic loads. **Load posting is required if the SLC for a given span is less than the H equivalent rating of a legal load.** A maximum legal load effect will be equivalent to different H rating values depending on the effective span length, as shown in Table 1. The effective span is the length of the live load influence line for the member action (moment or shear) that the member's rating is based on.

The SLC limits set forth in these guidelines are not intended to be entirely rigid. The evaluating engineer may exceed these limits based on engineering judgment or factors unique to the bridge, provided that the rationale for doing so is documented in the posting analysis. In no case, however, shall the SLC exceed the Operating Rating. Conversely, individual situations may warrant using lower SLC values than those presented in these guidelines.

| TABLE 1a | |
|---|---|
| "H" - LOADING EQUIVALENT TO LEGAL LOADS | |
| Effective Span Length (ft.) | H Equivalent Legal Load |
| Up to 12 | H16 |
| 13-19 | H22 |
| 20-34 | H29 |
| 35-45 | H31 |
| 46-53 | H33 |
| 54-75 | H32 |
| 76-90 | H30 |
| 91-105 | H28 |
| 106-120 | H26 |
| 121-140 | H25 |
| Over 140 | H23 |

| TABLE 1b | |
|---|---|
| "H" - LOADING EQUIVALENT TO LEGAL LOADS (EXCLUDING SU6 & SU7) | |
| Effective Span Length (ft.) | H Equivalent Legal Load |
| Up to 12 | H16 |
| 13-19 | H21 |
| 20-34 | H25 |
| 35-45 | H26 |
| 46-53 | H27 |
| 54-75 | H27 |
| 76-90 | H25 |
| 91-105 | H23 |
| 106-120 | H22 |
| 121-140 | H21 |
| Over 140 | H19 |

* Generally applies to stringers and floorbeams only

Note: R posting may be necessary for bridges where the SLC is above the threshold level required for load posting. See Section VI.

As an example, if the H SLC is 23 tons, and the maximum effective span is 32 feet, posting is not required. However, if the effective span is 64 feet, posting is required.

| **Member Type** | **Effective Span** |
|---|---|
| 1) Simple span stringers or girders | Span length |
| 2) Continuous stringers or girders | |
| a) Positive moment and shear | Span length |
| b) Negative moment | Average of adjacent span lengths |
| 3) Floorbeams | |
| a) End floorbeam | Adjacent stringer span or panel length |
| b) Intermediate floorbeam | Sum of two adjacent stringer spans or panel lengths |
| 4) Trusses | |
| a) Chords and end posts | Total span length |
| b) Interior diagonals | Panel length + sum of panel lengths to far support |
| c) Vertical hangers or posts | Same as intermediate floorbeam |
| d) Vertical part of truss web | Same as interior diagonals |

## TABLE 2

### SAFE LOAD CAPACITY DETERMINATION GUIDELINES

<table>
<tr><th>Bridge Type & Characteristics</th><th>Primary Member Rating</th><th>SLC</th></tr>
<tr><td rowspan="2">1. Steel primary members that are both internally and load path nonredundant:<br>• Two and three member welded plate girder bridges or rolled beams that have partial-length welded cover plates or other fatigue category D, E, or E’ details.<br>• Truss members with pinned eye bars or threaded rods.<br>• Welded truss members and truss members with welded connections.<br>• Floorbeams spaced at more than 12' that have timber or steel grating decks.<br>• Pin and hanger connections.<br>• Floorbeam hanger connections.<br><br>2. All primary members with extensive section loss that significantly affects the load rating of the structure.</td><td>≤3</td><td>0.60 HOR*</td></tr>
<tr><td>≥4</td><td>0.70 HOR</td></tr>
<tr><td rowspan="2">3. All load path redundant steel members including welded girders, riveted girders, and rolled stringers.<br>4. Rolled or welded truss members with riveted or bolted connections.<br>5. Rolled two girder bridges without fatigue category D, E, or E’ welds.<br><br>6. All internally redundant members (excluding floorbeams described in #1) regardless of load path redundancy including: Riveted truss members; Riveted through or deck main girders.<br><br>7. Floor system members;<br>• All floor system stringers.<br>• All steel floorbeams with concrete decks regardless of spacing.<br>• All steel floorbeams spaced 12’ or less regardless of deck type.<br><br>8. All concrete beam or slab members.</td><td>≤3</td><td>0.80 HOR</td></tr>
<tr><td>≥4</td><td>0.85 HOR</td></tr>
<tr><td>9. Load path redundant members and floor system members where it can be demonstrated that there is capacity above that computed by the normal load rating assumptions. This added capacity may be demonstrated by a greater roadway width than is required by the actual number of traffic lanes and also, excess redundant members.<br><br>10. Box or H shaped compression chords of trusses with adequate lateral support and no signs of lateral movement.</td><td colspan="2">Up to HOR</td></tr>
</table>

* HOR-H Operating Rating

Note: Connections for the above primary member types, excluding splices, shall be evaluated with the same criteria as the primary member.

The SLC recommendations in Table 2 are a function of the calculated operating rating of the controlling member, whether determined using Allowable Stress or Load Factor analysis methods. Operating rating results for both methods will generally be comparable for the same bridge. However, inventory ratings for both methods can differ greatly. The inventory rating for the Load Factor method is directly proportional to the operating rating (HIN=0.6HOP). Whereas, the inventory rating for Working Stress can fluctuate independent of the operating rating for different bridge types and for bridges with different dead load to live load ratios. Basing the SLC calculations on the inventory rating could significantly penalize a bridge with a low inventory but, high operating rating.

The SLC may be allowed up to the operating rating for load path redundant members in good condition and floor systems where it can be demonstrated that there is capacity above that computed by the Load Rating Specification assumptions. This added capacity is normally attributed to excess roadway widths in comparison to the actual number of travel lanes and/or sufficient redundant members. A posting decision for these members can be based on the operating rating if it can be shown that there is at least 125% of equivalent legal load capacity available due to excess roadway width or redundancy.

Decimal values resulting from these guidelines should be truncated to the nearest ton. For instance, a calculated result of 12.71 tons should be truncated to 12 tons.

The SLC may be used directly as the posting value. However, this may be over-conservative for some span lengths, since the H-type vehicle is not a legal weight and spacing configuration for two-axle trucks. To account for the different configurations of legal loads, Table 3 may be used to convert the SLC (which is based on the H vehicle) into a posting value.

## TABLE 3

### MAXIMUM POSTING VALUES (TONS)

| | | "Safe Load Capacity" (Based on H Type Truck) | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Low Bound | >10 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 |
| Up to 12 | | 12 | 15 | 16 | 18 | 20 | 22 | | | | | | | | | | | | | | | | | |
| 13-19 | | 10 | 12 | 14 | 15 | 16 | 18 | 20 | 22 | 24 | 26 | 27 | 34 | | | | | | | | | | | |
| 20-34 | | 10 | 12 | 12 | 14 | 15 | 16 | 16 | 18 | 18 | 20 | 22 | 22 | 25 | 27 | 28 | 32 | 34 | 37 | 38 | | | | |
| 35-45 | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 18 | 18 | 20 | 20 | 22 | 22 | 25 | 26 | 29 | 31 | 32 | 33 | 36 | 37 | | |
| 46-53 | | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 22 | 24 | 26 | 27 | 30 | 31 | 32 | 33 | 36 | 37 | 38 |
| 54-64 | Use SLC | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 22 | 22 | 24 | 25 | 27 | 29 | 30 | 32 | 33 | 34 | 37 | 38 |
| 65-75 | | 10 | 12 | 12 | 14 | 15 | 16 | 16 | 18 | 20 | 20 | 22 | 22 | 24 | 25 | 25 | 29 | 31 | 32 | 33 | 34 | 36 | 38 | |
| 76-90 | | 10 | 12 | 14 | 15 | 16 | 18 | 18 | 20 | 20 | 22 | 24 | 25 | 25 | 25 | 30 | 31 | 32 | 34 | 36 | 37 | | | |
| 91-105 | | 10 | 12 | 15 | 16 | 16 | 18 | 20 | 22 | 22 | 24 | 25 | 25 | 28 | 31 | 32 | 34 | 36 | 37 | | | | | |
| 106-120 | | 12 | 14 | 15 | 18 | 18 | 20 | 22 | 22 | 25 | 25 | 28 | 28 | 32 | 33 | 35 | 37 | | | | | | | |
| 121-140 | | 12 | 16 | 18 | 20 | 20 | 22 | 25 | 25 | 28 | 28 | 30 | 33 | 34 | 36 | 38 | | | | | | | | |
| 141 | | 12 | 16 | 18 | 20 | 20 | 22 | 25 | 25 | 28 | 30 | 34 | 36 | 38 | | | | | | | | | | |

= Based on SU4 or SU5 Axle Configuration (green)

= Based on SU6 or SU7 Axle Configuration (yellow)

**5.6) EXAMPLES:**

1.) A truss bridge has a primary member condition rating of 3, based on pitting of the lower chords and floorbeams. All components are rolled sections or riveted built up steel sections, except the bottom chord, which is composed of pinned eye bars. There are seven stringers in the floor system cross section. The bridge has an open steel grating deck. Main span is 141 ft., floorbeam spacing is 14 ft., and the overall width is 28ft. Effective span, H equivalent of legal load and HH operating ratings (Allowable Stress) are as follows:

| Component | Effective Span (ft.) | H Equivalent of Legal Load | H Operating (HOR) |
|---|---|---|---|
| Stringer (Rolled) | 14 | H22 | H25 |
| Floorbeam (Built-up) | 28 | H29 | H12 |
| Bottom Chord (eye bar) | 141 | H23 | H13 |
| Top Chord (built-up) | 141 | H23 | H22 |
| Diagonal (built-up) | 70 | H33 | H19 |

To find out the posting value for this truss, it is necessary to determine the SLC for all components. Each one will have a different SLC based on member type and rating.

The stringers in this floor system are load path redundant and the cross section consists of excess redundant members. Based on this, the stringer can be shown to fall under category 9 in table 2. The SLC in this grouping can be up to the HOR = H25. In this case it is acceptable to use the full operating rating for the SLC because the low primary member ratings are not based on the stringers, which are in good condition. If they were not in good condition, the engineer would have to use their discretion as to how close to the operating rating the SLC should be. We will assume that the engineer wants to post this bridge for all legal loads in Figure 1. Using table 1a, the H equivalent of legal load for an effective stringer span of 14 ft. is H22. This is less than the SLC of H25 therefore; the bridge does not need to be posted based on the stringer rating.

The H equivalent for a legal load over the floorbeam effective span of 28 ft. is H29 (table 1a). This is greater than the floorbeam operating rating of H21. Therefore, it is necessary to determine the SLC of the floorbeam. The floorbeam (w/ steel deck) falls under category 1 in Table 2. The SLC is 0.60HOR ≈ H12.6 ≈ H12.

For the diagonal, the operating rating (H24) is also less than the H equivalent of a legal load (H33) for the effective span. The diagonal is internally redundant but not load path redundant and, has riveted connections at its ends. This places it in category 6 in table 2. With a primary rating of 3 the SLC is 0.80HOR = H19.

The eye bar operating rating (H23) is equal to the H equivalent of a legal load for the effective span (H23). However, eye bars are vulnerable to stress corrosion and brittle fracture, since eye bars were often fabricated from steels with poor notch toughness. Also, eye bar connection details attract moisture, making further section loss likely. Using the guidelines in Table 2, category 1, results in an SLC value of 0.60HOR = H13.

The top chord falls into category 6 in Table 2. The SLC is 0.85HOR = H22, which is less than the H equivalent (H23) of a legal load.

The lowest SLC that is less than H equivalent belongs to the floor beam. To set the posting value, it is acceptable to directly use the floorbeam SLC value of 12 tons. This may be conservative and, some evaluating engineers may want to check the posting value against the posting that Table 3 would yield. If table 3 is used, the floorbeam, diagonal, bottom chord, and top chord must be evaluated. For the floorbeam, an SLC of H12 over an effective span of 28 ft. in Table 3 yields a posting value of 12 tons. For the diagonal SLC of H19 over an effective span of 70 ft., the Table 3 value is 20 tons. In Table 3, the posting value for the bottom chord SLC of H13 over an effective span of 141 ft. is 20 tons. The posting value for the top chord SLC of H22 over an effective span length of 141 ft. is 38 tons. The floorbeam still governs for the posting. Using Table 3 yields a posting value of 12 tons based on an SLC of H12 for the floorbeam.

2.) A Single-span rolled beam bridge with five stringers is originally designed for an H15 load. The primary member rating is 3 based on section loss on the fascia stringers. There is also deterioration on the interior stringers that is not as extensive. Main span equals 61 ft., with Level 1 H inventory and operating ratings of 14 and 24 tons, respectively.

Posting for this bridge will be required, since the operating rating is lower than the H equivalent for the legal load applied to a span of 61 ft. of H33 (Table 1a). The bridge was not designed for current legal loads, there are significant deteriorations and, with only five members in the cross section there is no excess redundant capacity. Using the SLC guideline for category 2 from Table 2, we can say that this bridge has an SLC value equal to 0.60HOR = H14.

As per Table 3, a SLC of H14 over a span of 61 ft. yields a posting value of 14 tons.

## 6) CRITERIA FOR POSTING BRIDGES FOR R - PERMIT RESTRICTIONS

### 6.1) INTRODUCTION

R-Postings are intended to keep most overloads from using bridges that, through design or deterioration, do not have the reserve capacity to accommodate most overload permit vehicles, but are still capable of safely carrying legal loads. These bridges have signage stating "No Trucks with R Permits." If any of the following apply, the bridge should be investigated to determine the need for posting for R restriction.

**Criteria used to determine R-Posting**:

- Low operating rating.
    - Below H29 Upstate
    - Below H33 Downstate *
- Design load below H20, with no level 1 or level 2 load rating available.
- Bridge width (curb-to-curb).
    - Below 24 feet Upstate
    - Below 28 feet Downstate *
- Primary member condition rating below 4.
- Structural deck condition rating of 1.
- Regional prerogative.

∗ Downstate includes the following:
Region 8
Dutchess, Putnam, Orange, Rockland and Westchester Counties
Region 10
Nassau and Suffolk Counties

Note: NYSDOT does not currently have permitting responsibilities in New York City, and is therefore not included as part of the R-Posting process.

The H29 and H33 thresholds were developed using multipresence reduction factors. This was based on the unlikelihood of two overload permit vehicles being situated at the most critical location of a bridge simultaneously. Bridges whose controlling ratings are governed by fascia girders not designed to current specifications, single-lane bridges, certain connections, and other controlling elements where multi-presence reduction is not applicable may need to be evaluated at a higher threshold. A Region may exercise their prerogative in cases such as these or others where a higher threshold for R-Posting can be justified.

The bridge width criterion was initially included when load ratings were not as widely available as they are now. It was intended to ensure that bridges that allow overloads were designed for two travel lanes. A bridge designed for two lanes provides some overload reserve capacity not available in a single lane structure. If a level 1 or level 2 load rating exists, the rating should be used to determine overload capacity for the structure and the width criterion may not be considered.

Regional prerogative may be used where circumstances warrant restricting overload vehicles from crossing a structure for reasons other than those listed above.

### 6.2) REEVALUATION OF POSTING STATUS

The presence of load or R posted bridges can be quite disruptive to users of the highway system. Whenever any remedial work is done on a posted bridge (including dead load reduction), an evaluation should be done as soon as possible to determine if it is still necessary to be R-Posted. If a bridge is posted based on a level 1 load rating, and a new Level 2 indicates a capacity above the R-Posting threshold, the level 1 calculations should be reviewed to insure the level 1 load rating and prior posting are still valid.

Conversely, reevaluation is also needed to ensure that any existing posting values are still adequately protecting the bridge. Every inspection report and updated level 2 rating should be examined closely to ensure that the initial posting determination is still applicable.

## 7) FIELD LOAD TESTING

### 7.1) INTRODUCTION

Field load testing, also referred to as nondestructive load testing, is an experimental determination of a structure's load capacity by measuring the actual structural response to known loads. The measured response of the bridge under the field load test is then compared to the analytical predicted response. Load testing can be a useful part of a load rating calculation for a bridge that is difficult to load rate using conventional analytical methods. Load testing may also provide a more accurate and at times higher rating, which can be very helpful when the theoretical safe live load capacity is lower than desirable. Load testing is typically separated into two types; diagnostic and proof testing.

Diagnostic load testing involves measuring the load effects (such as moment, shear, axial force, stresses, and deflection caused by known loads, such as a specific vehicle or vehicles of known weight, axle loads, and spacings). The results of the load tests are then compared to those predicted using analytical calculations. The difference between the theoretical and measured load effects will then be reviewed and calibrated to the standard AASHTO HS and/or H rating vehicles. The results will then be used to establish the new load rating. Load testing typically involves measurements of load effects of several bridge members at critical locations.

Proof load testing involves loading the bridge with incremental loads until a targeted load level is safely reached. This level is then used to set the level of the new load rating. Loading should be done incrementally while the bridge is carefully monitored. The loading should be discontinued at any sign of distress or damage. Proof load testing requires careful preparation and experienced personnel. Care is required to avoid damage to the structure as well as to prevent injuries to personnel and to the public.

If done incorrectly, field load testing can lead to inaccurate load rating results. In addition, incorrect testing procedures can lead to permanent damage and even possible collapse of the bridge structure. Sound engineering judgment and analytical principles need to be taken into consideration before load testing is performed. See the AASHTO Manual and, the references listed in 7.3 below for more additional information on conducting field load tests.

### 7.2) DOCUMENTATION OF RESULTS

Every test report must include certain information, regardless of test procedure. At a minimum, provide the following:

- Truck weights, axle spacing, and axle loadings.
- Exact location of truck(s) on the bridge for all strain or deflection measurements.
- Types of measuring instruments used (strain gauges, survey rods, etc.)
- Location of measuring instruments.
- Conversion calculations to HS equivalents (as well as H if applicable).
- Reasons for increased capacity above the analytical predicted load rating.

The report shall be signed by the responsible professional engineer licensed by the State of New York, and filed with NYSDOT using the same procedures as for an in-depth Level 1 load rating. All load test documentation and results should be kept in the Region (or responsible Program Support Center) office. If used to generate a Level 1 load rating, the actual results of the load test are only a portion of the Level 1 documentation. In addition to the load testing documentation, the procedures in the preceding Level 1 guidelines shall be followed.

### 7.3) REFERENCES


- NYSDOT Research Report 163 "Highway Bridge Rating by Nondestructive Proof-Load Testing for Consistent Safety." NYSDOT Transportation Research and Development Bureau.
- NYSDOT Research Report 153 "Proof Testing of Highway Bridges" NYSDOT Transportation Research and Development Bureau.
- “Manual for Bridge Rating Through Load Testing.” Research Results Digest, No. 234, Transportation Research Board, National Research Council, Washington, D.C., (1998).
- Barker, Michael G. “Quantifying Field-Test Behavior for Rating Steel Girder Bridges.” Journal of Bridge Engineering, July/August 2001, pp. 254-261.


**CONTACT:** For questions concerning this Engineering Instruction contact the Load Rating Unit at (518) 457-5498.

# APPENDIX D

**Level II Ratings Report (October 2013)**

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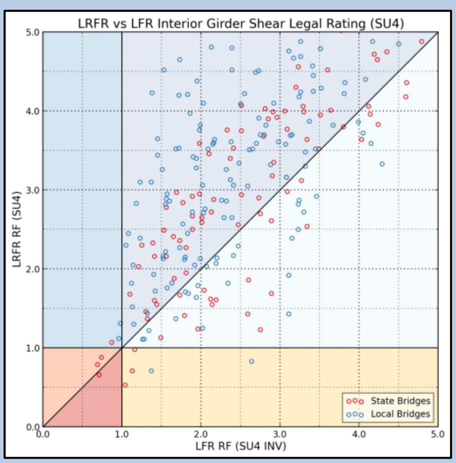
# BRIDGE LOAD AND RESISTANCE FACTOR RATING (LRFR) ASSESSMENT - STATEWIDE

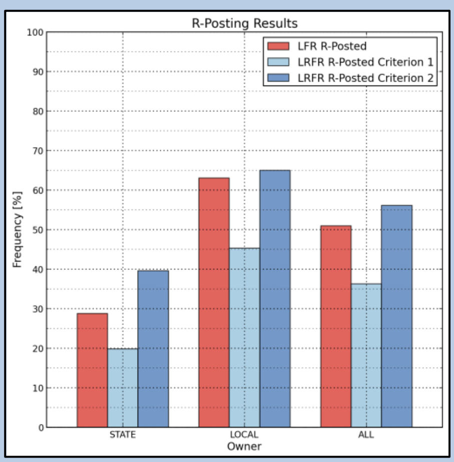
CONTRACT: D031028

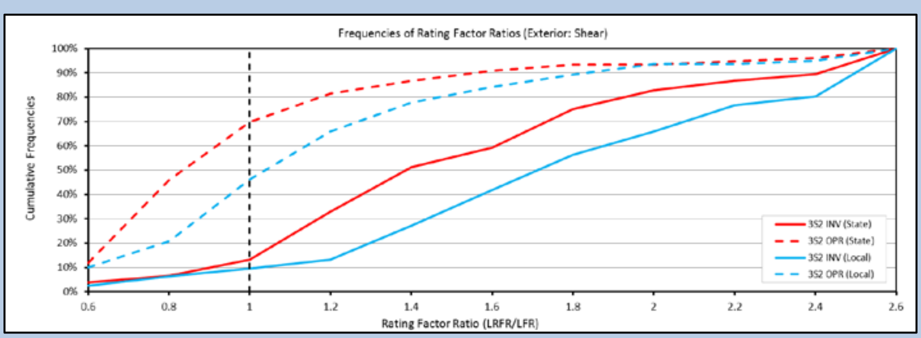
**DRAFT**

**LEVEL II RATINGS REPORT**

**OCTOBER 2013**

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# 1. INTRODUCTION & BACKGROUND

### 1.1 Introduction

The goal of this project is to validate and test the Department's draft Engineering Instruction (EI) developed to follow bridge LRFR methodology as specified in the AASHTO Manual for Bridge Evaluation. The draft EI recommends NYSDOT specific LRFR procedures for bridge Load Rating, Load Posting and R-Posting evaluations. 314 bridges (state and local), selected by NYSDOT in collaboration with HNTB, were rated using both Load Factor Rating (LFR) and Load Resistance and Factor Rating (LRFR) methodologies following the procedures outlined in the Draft EI document for LRFR ratings and the EI 05-034 document for LFR ratings. The selected bridges include concrete slab, simple span steel multi-girder, simple span prestressed concrete multi-girder, continuous span steel multi-girder, continuous span prestressed concrete multi-girder, prestressed box beam and concrete Tee-beam structures. The Department provided plans, inspection reports and current VIRTIS models for the selected bridges. HNTB Team checked the plans, as well as inspection reports, and updated existing VIRTIS models as necessary to reflect latest inspection findings and input the required parameters for LRFR load rating procedures.

This comparative study was performed on selected bridges at all three primary levels of LRFR rating: Design, Legal and Permit rating levels. The load models that were utilized in the rating analysis were the AASHTO design loads (HS-20 or HL-93), NY legal loads (SU4 and Type 3S2), NY divisible permits (NYP6 thru NYP 13), and NY non-divisible permits (NYP1 thru NYP 5). The bridges were modeled in the bridge load rating software AASHTO VIRTIS version 6.4.1. Flexural and shear load rating factors were extracted for the controlling exterior and interior girders for each bridge type, except reinforced concrete slab structures. Rating results were generated for interior and exterior girders of each bridge analyzed as well as for moment and shear load effects. Load Posting values and R-posting values in both methodologies were calculated. Load rating and posting results were collected in a summary spreadsheet for each bridge. This spreadsheet was capable of running the posting analysis automatically, based on the load rating results.

In order to facilitate the presentation of the results, data gathered from the comparative study has been subdivided into several sections based on the rating level considered. General procedures for level II load ratings are presented in Section 2. Results from the design, legal and permit load rating levels are presented in Sections 3, 4 and 5, respectively. Each section presents comparisons between the LRFR and the LFR methodologies with regards to flexure and shear rating factors for interior and exterior girders.

Tables and plots that allow quantitative and qualitative reviews of the rating results are provided in each section. Significant differences between LFR and LRFR results were investigated and the causes for such anomalies were identified. The resulting data presented in each of the sections follows a similar pattern.

The Load Posting and R-Posting results are presented in Section 6. All rated bridges were evaluated to determine if legal load posting or R-posting is required. The load posting criteria were based on the Draft EI document for LRFR ratings and the EI 05-034 document for LFR ratings. For bridges that require load posting, LRFR posting loads were determined for the 3S2 and SU-4 vehicles separately. R-posting requirements were checked for downstate and upstate bridges using the NYP 11 and NYP 6 vehicles, respectively, as given in the Draft EI document. Comparisons for the LFR and LRFR legal and R-posting results were made.

Section 7 presents a summary of the research findings as well as conclusions and recommendations based on the comparative study.

Appendix I contains the results of the LFR and LRFR ratings, load postings and R-postings for all bridges rated in this study.

Appendix II contains information regarding VIRTIS settings used in the load ratings, as well as information on possible VIRTIS issues pertaining to this study.

### 1.2 Selection of Bridges

It was important to select bridges that can highlight the differences between the new LRFR methodology and the current LFR methodology with regard to load rating, posting and permit evaluations. The bridges as shown in the tables below were selected by HNTB in collaboration with NYSDOT and represent a mix of state and locally owned bridges from various periods of construction. In the selection process, priority was given to including load posted bridges and R-Posted bridges with restricted capacity for overloads. The bridge types and distribution of bridges in the sample are aligned with that in the overall inventory. NYSDOT WINBOLTS bridge inventory database was used for initial screening. The number of bridges selected for each superstructure type, as well as the posting statuses are listed in Table 1.1. The distribution of bridges by the ownership status for each superstructure type is given in Table 1.2.

**Table 1.1 –** Bridge Inventory Used in the Comparative Study by Posting Status

| Superstructure Type | R-Posted Bridges | Load Posted Bridges | Closed Bridges | Not Posted Bridges | Total |
|---|---|---|---|---|---|
| Concrete Slab | 18 | 7 | 0 | 4 | 29 |
| Simple Span Steel Multi-Girder | 116 | 61 | 1 | 12 | 190 |
| Simple Span P/S Multi-Girder | 2 | 0 | 1 | 16 | 19 |
| Continuous Span Steel Multi-Girder | 7 | 6 | 0 | 7 | 20 |
| Continuous P/S Span Multi-Girder | 0 | 0 | 0 | 7 | 7 |
| Box Beam P/S Multi-Girder | 8 | 0 | 0 | 16 | 24 |
| Concrete T-Beam | 9 | 6 | 0 | 10 | 25 |
| **Total** | **160** | **80** | **2** | **72** | **314** |

**Table 1.2 –** Bridge Inventory Used in the Comparative Study by Owner

| Superstructure Type | State Owned | Locally Owned | Total |
|---|---|---|---|
| Concrete Slab | 15 | 14 | 29 |
| Simple Span Steel Multi-Girder | 47 | 143 | 190 |
| Simple Span P/S Multi-Girder | 12 | 7 | 19 |
| Continuous Span Steel Multi-Girder | 13 | 7 | 20 |
| Continuous P/S Span Multi-Girder | 0 | 7 | 7 |
| Box Beam P/S Multi-Girder | 10 | 14 | 24 |
| Concrete T-Beam | 14 | 11 | 25 |
| **Total** | **111** | **203** | **314** |

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# 2. LRFR PROCEDURES FOR LEVEL II LOAD RATINGS

## 2.1 Introduction

Level II load ratings were performed using the bridge load rating software AASHTO VIRTIS version 6.4.1. LRFR ratings in this study conform to the guidelines contained in the Department's draft Engineering Instruction (EI) developed in 2011. LFR ratings are in accordance with the EI 05-034 document. LFR and LRFR ratings were performed for the design loads (HS-20 or HL-93), NY legal loads (SU4 and 3S2), NY divisible permits (NYP6 thru NYP 13), and NY non-divisible permits (NYP1 thru NYP 5). Where required, Load Posting values and R-posting values for both methodologies were calculated. In this section, the procedures that were followed for the LRFR methodology are presented. Detailed descriptions for the procedures that were followed for the LFR methodology can be found in the EI 05-034 document.

## 2.2 LRFR Rating Parameters for New York State Bridges

The LRFR rating factor formula is as follows:

$$RF = \frac{\phi_c \phi_s \phi R_n - (\gamma_{DC})(DC) - (\gamma_{DW})(DW) \pm (\gamma_P)(P)}{(\gamma_{LL})(LL)}$$

where:

| | | |
|---|---|---|
| $RF$ | : | Rating Factor |
| $R_n$ | : | Nominal member resistance (as inspected) |
| $\phi_c$ | : | Condition Factor |
| $\phi_s$ | : | System Factor |
| $\phi$ | : | LRFD Resistance Factor |
| $DC$ | : | Dead load effect due to structural components and attachments |
| $DW$ | : | Dead load effect due to wearing surface and utilities |
| $P$ | : | Permanent loads other than dead loads (secondary prestressing effects, etc.) |
| $LL$ | : | Live load effect of the rating vehicle |
| $IM$ | : | Dynamic load allowance |
| $\gamma_{DC}$ | : | LRFD load factor for structural components and attachments |
| $\gamma_{DW}$ | : | LRFD load factor for wearing surfaces and utilities |
| $\gamma_p$ | : | LRFD load factor for permanent loads other than dead loads |
| $\gamma_L$ | : | Evaluation live load factor for the rating vehicle |

### *2.2.1 Condition Factor $\phi_c$*

Condition ratings for the load rated bridges were taken from the latest inspection reports. NYSDOT condition ratings were converted to the AASHTO MBE LRFR condition factor as shown in Table 2.1.

**Table 2.1 –** Conversion of NYSDOT Condition Ratings to the AASHTO MBE LRFR Condition Factor

| Structural Condition of Member | Condition Rating | Condition Factor $\phi_c$ |
|---|---|---|
| Fair, satisfactory or good | $\geq 4$ | 1.00 |
| Poor | $\leq 3$ | 0.95 |

### *2.2.2 System Factor $\phi_S$*

The system factor used in the LRFR analysis for flexural and axial effects was taken from AASHTO MBE 6A.4.2.4-1, as given in Table 2.2.

**Table 2.2 –** Conversion of NYSDOT Condition Ratings to the AASHTO MBE LRFR Condition Factor

| Superstructure Type | System Factor $\phi_s$ |
|---|---|
| Welded Members in Two-Girder/Truss/Arch Bridges | 0.85 |
| Riveted or Bolted Members in Two-Girder/Truss/Arch Bridges | 0.90 |
| Multiple Eyebar Members in Truss Bridges | 0.90 |
| All Other Girder Bridges and Slab Bridges | 1.00 |
| Floorbeams with Spacing >12ft. and Non-Continuous Stringers | 0.85 |
| Redundant Stringer Subsystems Between Floorbeams | 1.00 |

### *2.2.3 LRFR Live Loads and Load Factors*

Load ratings based on the LRFR methodology were performed at design, legal and permit levels. These load rating levels are described as follows:

**a) Design Load Rating of All Bridges**

Inventory and Operating level ratings were performed for the HL-93 loading using the live load factors given in AASHTO MBE 6A.4.3.2.2-1, as shown in Table 2.3.

**Table 2.3 –** Load Factors for Design Load Rating of All Bridges

| Evaluation Level | Load Factor |
|---|---|
| Inventory | 1.75 |
| Operating | 1.35 |

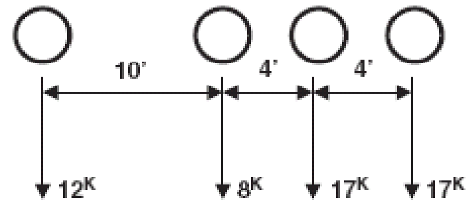
**b) Legal Load Rating of Bridges on the State and Interstate Highways**

For simple spans less than 200 ft, load ratings were performed for the SU4 and Type 3S2 vehicles. For spans greater than 200 ft, the lane type legal load model for long spans was also taken into consideration. For continuous spans, the special lane type legal load model was applied for negative moment and interior reactions for all span lengths.

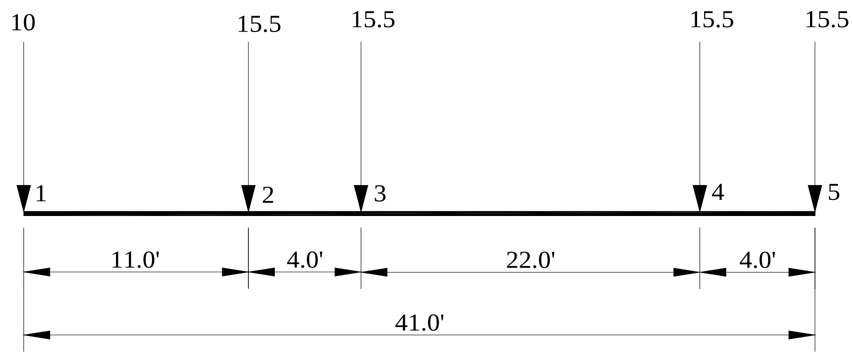
Live load factors, used in the legal load ratings are as shown in Table 2.4. Legal load models used in the analysis are shown in Fig. 2.1

**Table 2.4–** Load Factors for Legal Load Rating of Bridges on the State and Interstate Highways

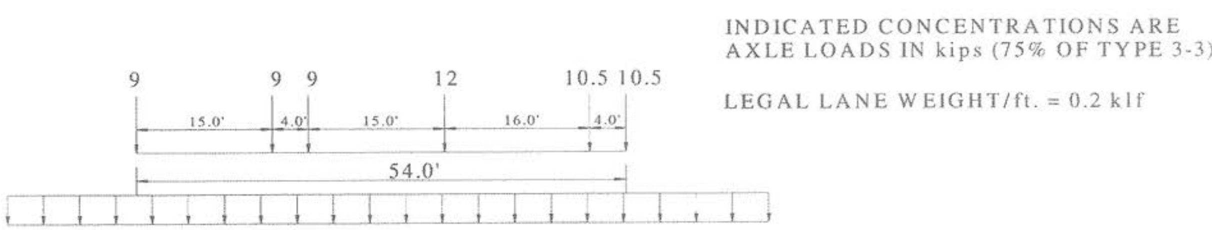
| **Traffic Volume** (one direction) | **Load Factor for Multi-lane bridges** (use LRFD load distribution factor for multi-lanes) | **Load Factor for Single-lane bridges** (use LRFD load distribution factor for a single lane without removing the multiple presence factor) |
|---|---|---|
| ADTT $\geq$ 5000 | 1.95 | 1.95 |
| ADTT=1000 | 1.85 | 1.85 |
| ADTT $\leq$ 100 | 1.65 | 1.65 |



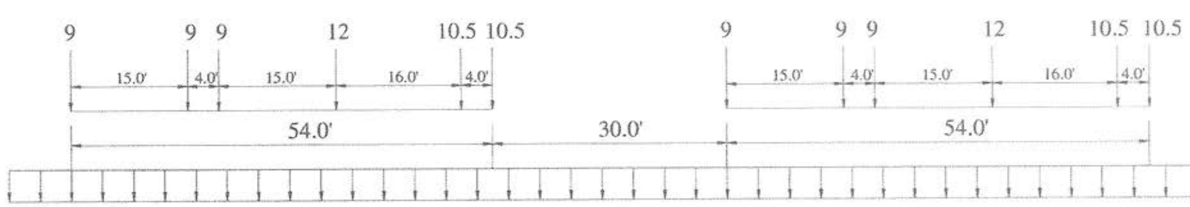

**SU4 Legal Load (27 tons)**




**Type 3S2 Legal Load (36 tons)**




**Lane-Type Legal Load Model** (applied for spans greater than 200 ft. and all load effects)




**Lane-Type Legal Load Model (applied for negative moment and interior reaction for all span lengths)**

**Figure 2.1 –** Legal Loads used in the analysis.

**c) Legal Load Rating of Local Bridges**

The LRFR load factors in the MBE for legal loads are considerably lower than that derived for NYSDOT using recent WIM data from NY sites, which were all located on the state and Interstate highways. In consultation with NYSDOT, it was considered appropriate that the reduced LRFR live load factors in the MBE be applied for rating of bridges on the local system where the truck traffic exposure is lower than that on the Interstate and state system. These reduced live load factors are based on the updated load factors in the AASHTO MBE 2012 Interims Table 6A.4.42.3a-1, as listed in Table 2.5.

**Table 2.5 –** Load Factors for Legal Load Rating of Local Bridges

| **Traffic Volume** (one direction) | **Load Factor** |
|---|---|
| ADTT ≥ 5000 | 1.45 |
| ADTT=1000 | 1.45 |
| ADTT ≤ 100 | 1.30 |

**d) Permit Load Rating of All Bridges using NYSDOT Permit Load Factors**

Permit load ratings were performed for 5 non-divisible (NYP_1 to NYP_5) and 8 divisible (NYP_6 to NYP_13) load permits. Live load factors used in the analysis are listed in Table 2.6. NYSDOT non-divisible and divisible permits are illustrated in Figs. 2.2 and 2.3.

**Table 2.6 –** Load Factors for Permit Load Rating of All Bridges

| **Permit Type** | **Frequency** | **Loading Condition** | **DF** | **ADTT (one direction)** | **Permit Load Factor, $\gamma_L$** |
|---|---|---|---|---|---|
| Annual Divisible Load | Unlimited Trips | Multi-lane bridges Mix with traffic | Multi-lane | ADTT ≥ 5000 | 1.20 |
| | | | | ADTT=1000 | 1.15 |
| | | | | ADTT ≤ 100 | 1.10 |
| Annual Divisible load | Unlimited Trips | Single lane bridges | Single Lane DF after dividing out MP=1.2 | ADTT ≥ 5000 | 1.20 |
| | | | | ADTT=1000 | 1.15 |
| | | | | ADTT ≤ 100 | 1.10 |
| Non-divisible loads | Unlimited Trips | Multi-lane bridges Mix with traffic | Multi-lane | All ADTT | 1.10 |
| Non-Divisible loads | Unlimited Trips | Single lane bridges | Single Lane DF after dividing out MP=1.2 | All ADTT | 1.10 |
| Special Hauling and Superloads | Single Crossing | Multi-lane bridges Mix with traffic | Single Lane DF after dividing out MP=1.2 | All ADTT | 1.10 |
| Special Hauling and Superloads | Single Crossing | Single lane bridges | Single Lane DF after dividing out MP=1.2 | All ADTT | 1.10 |

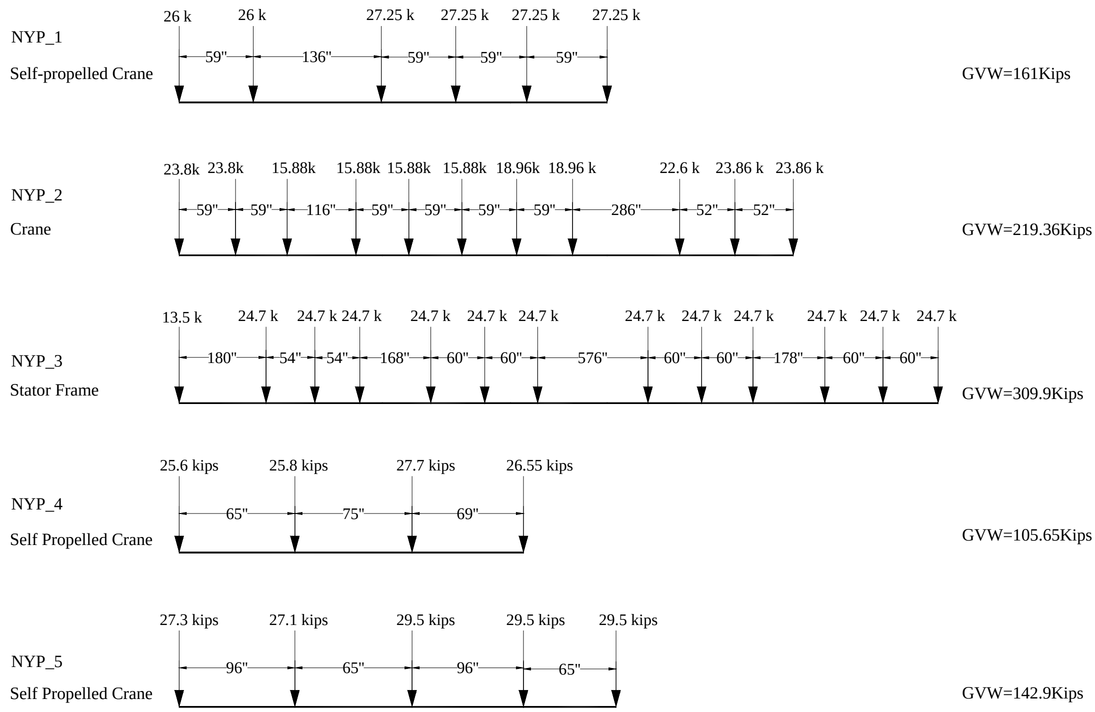



**Figure 2.2 –** NYSDOT non-divisible permit loads used in the analysis.

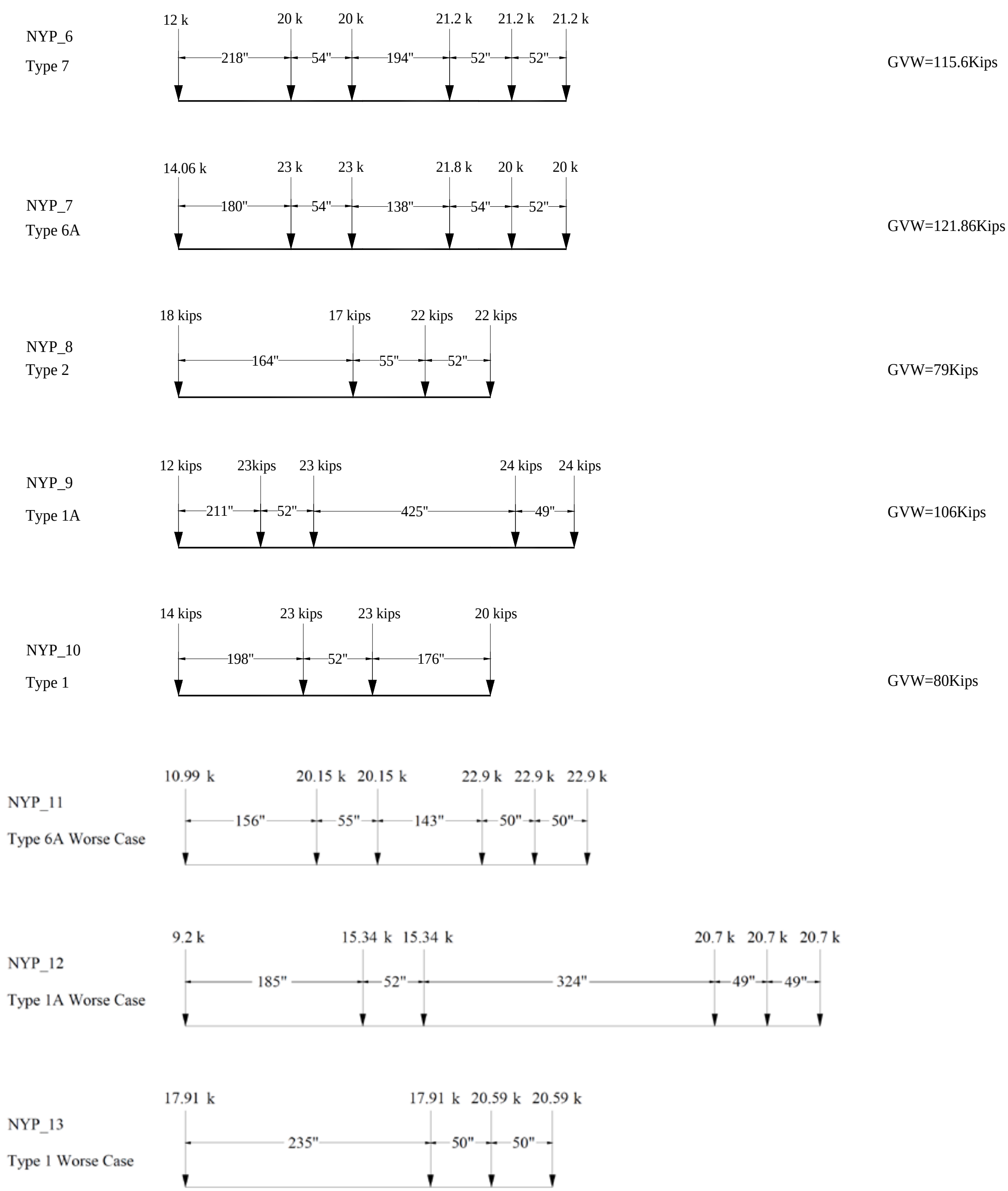



**Figure 2.3 –** NYSDOT divisible permit loads used in the analysis.

### *2.2.4 Reduced Dynamic Load Allowance for Rating*

For legal and permit load rating of longitudinal members having spans greater than 40 feet with less severe approach and deck surface conditions, the dynamic load allowance (IM) was decreased from the LRFD design value of 33%.

An LRFD dynamic load allowance of 33% reflects conservative conditions that may prevail under certain distressed approach and bridge deck conditions. For load rating of legal loads for bridges with less severe approach and deck surface conditions, the dynamic load allowance (IM) was decreased based on field observations in accordance with MBE Table C6A.4.4.3-1 and Tables 2.7 and 2.8.

Riding Surface Roughness for load rating purposes is defined as presented in Table 2.7. The Riding Surface Roughness was taken as the worst of the conditions for the bridge deck surface, the approach surface, and the expansion joints. NYSDOT inspection reports include the "wearing surface rating" item based on a scale from 1-7, where 1 is the worst and 7 is the brand new condition. Wearing surface rating values 8 and 9 are reserved for rare cases where the wearing surface does not exist, or could not be inspected, respectively. LRFD design value of 33% was used when the NYSDOT wearing surface rating is reported as 8 or 9.

**Table 2.7** – Riding Surface Roughness Descriptions

| **Riding Surface Roughness** | **Rating Description** |
|---|---|
| 6-7 = Smooth | Smooth riding surface at the approaches, bridge deck, and expansion joints.<br>Should only be applied to bridges with excellent riding surface condition and geometry. |
| 4-5 = Average | Minor surface deviations or depressions. |
| 1-3 = Poor | Significant deviations in the riding surface at the approaches, bridge deck surface (patchwork), and expansion joints. |

For a given Riding Surface Roughness, taken from the inspection reports, the dynamic load allowance was modified accordingly with Table 2.8, for legal and permit load ratings.

**Table 2.8** – Dynamic Load Allowance for Rating: IM

| Riding Surface Roughness | IM |
|---|---|
| 6-7 | 10% |
| 4-5 | 20% |
| 1-3 | 33% |

## 2.3 LRFR Limit States

Bridges were evaluated for the Strength and Service limit states in accordance with Table 2.9, per the LRFR methodology.

**Table 2.9** – LRFR Limit States Used in the Analysis

| Bridge Type | Limit State | Design | Legal | Permits |
|---|---|---|---|---|
| | | HL-93 | SU4, Type 3-S2, Lane Loads | Divisible, Non-Divisible |
| Steel | Strength I | ● | ● | |
| | Strength II | | | ● |
| | Service II | ● | ● | ● |
| Reinforced Concrete | Strength I | ● | ● | |
| | Strength II | | | ● |
| | Service I | | | ● |
| Prestressed Concrete (non-segmental) | Strength I | ● | ● | |
| | Strength II | | | ● |
| | Service III | ● | | |
| | Service I | | | ● |
| | Strength II | | | ● |

### 2.4 LRFR Load Posting Requirements

Safe posting loads were computed per the Draft EI document, using two posting vehicles, specified as the SU4 single truck unit, and the 3S2 semi-trailer truck. When for any legal load the rating factor is between 0.3 and 1.0, the following equation was used to establish the LRFR posting load.

$$\text{Safe Posting Load} = W[RF + 0.00375(L - 110)(1 - RF)]$$

where:

| | | |
|---|---|---|
| $W$ | : | Weight of the Posting Vehicle (SU4 = 27 tons, 3S2 = 36 tons) |
| $RF$ | : | Rating Factor |
| $L$ | : | Effective Span Length in feet |

### 2.5 LRFR Posting of Bridges for R-Permit Restrictions

The need for R-posting was determined for divisible loads per the Draft EI requirements. Posting methodology for divisible load restrictions, is referred to as "R"- posting. These bridges have signage stating "No Trucks with R Permits." In order to decide whether a bridge should be R-posted or not, the following criteria were considered for downstate and upstate bridges:

- Downstate bridges that do not have a RF ≥ 1.0 for the NYP_11 permit load.
- Upstate bridges that do not have a RF ≥ 1.0 for the NYP_6 permit load.

The permit load models used in the R-posting analysis are given in Fig. 2.3.

# 3. DESIGN LEVEL RATING RESULTS

## 3.1 Introduction

In order to investigate the design level rating results, the LRFR design inventory and operating rating factors computed for the AASHTO LRFD HL-93 design load model were compared with the LFR inventory and operating rating factors determined using the HS-20 truck or the lane loading from the AASHTO Standard Specifications. Load rating output data was investigated for the exterior and interior girders of each bridge separately, both for flexure and shear.

A summary of the rating factors used in the comparisons at the Design Inventory rating are provided in Tables 3.1 and 3.2. These tables list only a few of the rated bridges, as a small sample. Table 3.1 provides the moment and shear rating factors generated for both the interior and exterior girders for state bridges, determined through LRFR and LFR methodologies. Similar output data are shown in Table 3.2 for local bridges.

**Table 3.1** – Design Inventory Rating for State Bridges (example results)

| Bridge Information | | LRFR Rating Factors | | | | LFR Rating Factors | | | | LRFR/LFR Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bridge ID | Structure Type | Exterior Girder | | Interior Girder | | Exterior Girder | | Interior Girder | | Exterior Girder | | Interior Girder | |
| | | Moment | Shear | Moment | Shear | Moment | Shear | Moment | Shear | Moment | Shear | Moment | Shear |
| 1003720 | SMGS | 1.19 | 4.39 | 0.60 | 2.30 | 0.88 | 3.24 | 0.75 | 2.42 | 1.35 | 1.35 | 0.80 | 0.95 |
| 1001830 | SMGS | 0.71 | 4.07 | 1.28 | 3.35 | 0.81 | 4.16 | 1.15 | 4.30 | 0.88 | 0.98 | 1.11 | 0.78 |
| 1002450 | RCT | 0.74 | 0.86 | 1.00 | 0.59 | 2.65 | 3.70 | 1.34 | 0.97 | 0.28 | 0.23 | 0.75 | 0.61 |
| 1003930 | RCT | 8.33 | 15.12 | 0.46 | 0.85 | 3.23 | 5.01 | 0.91 | 2.17 | 2.58 | 3.02 | 0.51 | 0.39 |
| 1003940 | RCT | 9.28 | 15.46 | 0.45 | 0.98 | 2.14 | 2.69 | 0.95 | 2.47 | 4.33 | 5.74 | 0.47 | 0.40 |
| 1004010 | SMGS | NA | NA | 0.70 | 2.16 | 1.30 | 3.89 | 0.82 | 2.62 | NA | NA | 0.85 | 0.82 |
| 1004440 | RCS | NA | NA | 0.89 | 7.94 | NA | NA | 0.99 | 1.03 | NA | NA | 0.90 | 7.71 |

**Table 3.2** – Design Inventory Rating for Local Bridges (example results)

| Bridge Information | | LRFR Rating Factors | | | | LFR Rating Factors | | | | LRFR/LFR Ratio | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bridge ID | Structure Type | Exterior Girder | | Interior Girder | | Exterior Girder | | Interior Girder | | Exterior Girder | | Interior Girder | |
| | | Moment | Shear | Moment | Shear | Moment | Shear | Moment | Shear | Moment | Shear | Moment | Shear |
| 3342300 | SMGS | 0.79 | 4.67 | 0.67 | 4.19 | 0.73 | 4.17 | 0.67 | 4.08 | 1.08 | 1.12 | 1.00 | 1.03 |
| 3344660 | RCS | NA | NA | 0.66 | 2.17 | NA | NA | 0.69 | 1.94 | NA | NA | 0.96 | 1.12 |
| 4424070 | RCT | 0.62 | 3.07 | 0.71 | 1.49 | 1.05 | 2.20 | 0.88 | 1.30 | 0.59 | 1.40 | 0.81 | 1.15 |
| 4417010 | SMGS | 0.96 | 4.46 | 0.69 | 3.14 | 0.95 | 4.74 | 1.20 | 3.79 | 1.01 | 0.94 | 0.58 | 0.83 |
| 3361500 | RCS | NA | NA | 0.78 | 2.05 | NA | NA | 0.79 | 1.62 | NA | NA | 0.99 | 1.27 |
| 3306670 | SMGS | 1.59 | 6.89 | 0.44 | 2.03 | 0.85 | 3.52 | 0.77 | 2.34 | 1.87 | 1.96 | 0.57 | 0.87 |
| 3332450 | SMGS | 1.21 | 2.73 | 1.14 | 2.56 | 1.44 | 3.14 | 1.44 | 3.06 | 0.84 | 0.87 | 0.79 | 0.84 |
| 2254590 | SMGS | 0.33 | 3.17 | 0.42 | 2.97 | 0.52 | 4.51 | 0.56 | 3.67 | 0.63 | 0.70 | 0.75 | 0.81 |
| 3332400 | SMGS | 0.66 | 1.31 | 0.63 | 1.22 | 0.98 | 1.57 | 0.82 | 1.32 | 0.67 | 0.83 | 0.77 | 0.92 |

In order to perform a comparative analysis of the rating results, a region plot was developed, as shown in Fig 3.1. Each bridge was represented as a data point, where the (x, y) coordinate pairs correspond to the LFR and LRFR rating factors, resulting in a scatter plot. The horizontal, vertical and diagonal lines shown in Fig 3.1 subdivide the plot into six regions. Data falling into each of the shaded regions has a specific meaning.

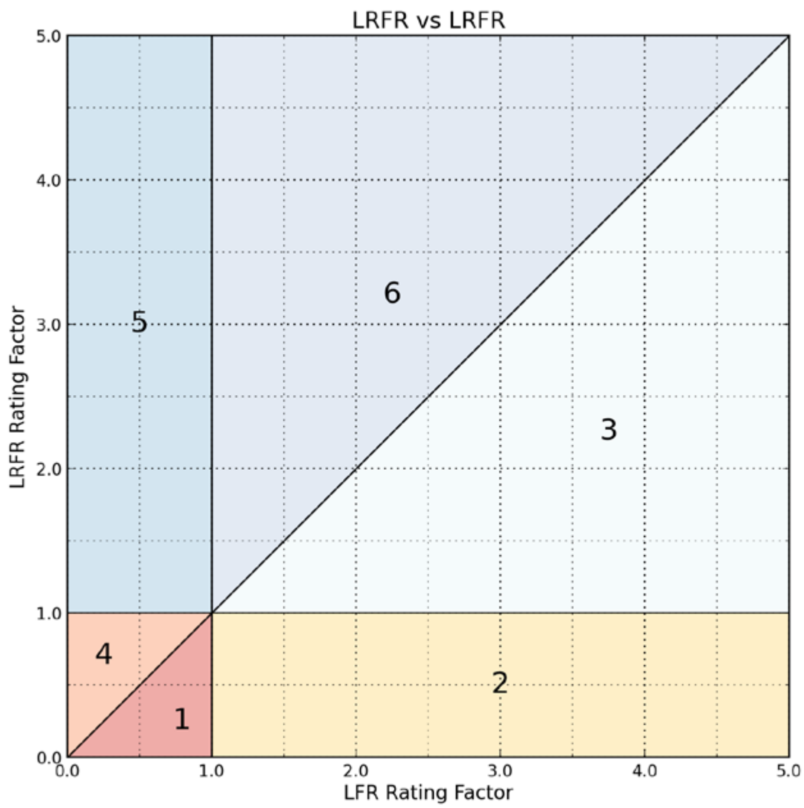



**Figure 3.1** – LRFR vs. LFR region plot.

The diagonal line serves as a convenient baseline for directly comparing LFR and LRFR ratings. Data points in regions 1, 2 and 3 (LRFR/LFR Ratio < 1.0) have lower LRFR rating factors than LFR rating factors. On contrary, data points in regions 4, 5, and 6 (LRFR/LFR Ratio > 1) have higher LRFR rating factors than LFR rating factors. Additionally:

- Data points in Region 1 have unsatisfactory rating factors for both the LRFR and the LFR (RF < 1.0), and lower LRFR rating factors than the LFR rating factors.

- Data points in Region 2 indicate unsatisfactory rating factors for the LRFR (RF < 1.0), however, satisfactory rating factors for the LFR (RF > 1.0).
- Data points in Region 3 indicate satisfactory rating factors for both the LRFR and the LFR (RF > 1.0), and lower LRFR rating factors than the LFR rating factors (RF LRFR < RF LFR).
- Data found in Region 4 indicates unsatisfactory rating factors for both the LRFR and the LFR (RF < 1.0), however, higher LRFR rating factors than the LFR rating factors (RF LRFR > RF LFR).
- Data points in Region 5 indicate satisfactory rating factors for the LRFR (RF > 1.0), however, unsatisfactory rating factors for the LFR (RF < 1.0).
- Data points in Region 6 indicate satisfactory rating factors for both the LRFR and the LFR (RF > 1.0), and higher LRFR rating factors than the LFR rating factors (RF LRFR > RF LFR)

Vertical and horizontal extends of the plots were fixed at RF = 5.0 for all region plots to make it easy to interpret and compare results, as well as to eliminate outlier points. State owned and locally owned bridges shown as two separate data groups.

**3.2 Flexural Design Rating Factors**

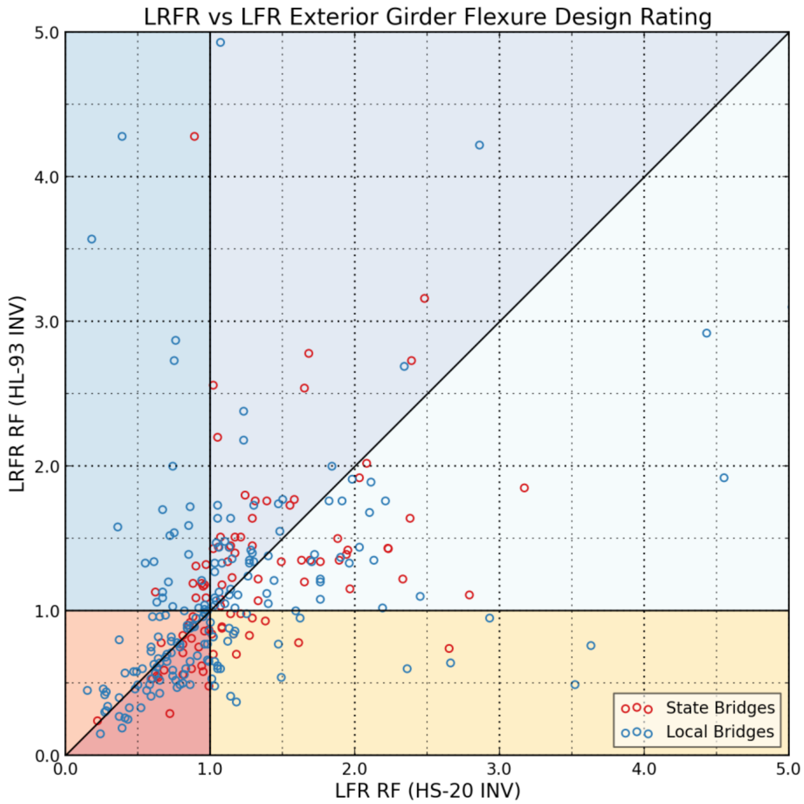
The comparison of flexural design rating factors of all bridges rated are shown in Fig 3.2 and Fig 3.3 at the inventory and operating levels, respectively. Distribution of flexural rating factors for different regions in the plots is summarized in Fig. 3.4.

Based on Figs 3.2 and 3.3 it can be stated that there is much more scatter in the rating results for exterior girders compared to interior girders for both at inventory and operating levels. This may be due to the discrepancies in the calculation methods for live load distribution factors in the AASHTO LRFD and the AASHTO Standard specifications, respectively used for the LRFR and the LFR methodologies. It was determined that for most of the outlier points, the wide discrepancies occur when the distribution factors were controlled by the lever-rule method for the LFR and the rigid body method for the LRFR. It was previously found out that LRFR distribution factors computed by the rigid body method are generally larger than those calculated by the lever rule method (Goodrich, 2002).

For interior girders, it was observed that the majority of the data points lie along the diagonal line, with less scatter. A downward shift was observed both at the inventory and operating levels, resulting in generally higher rating factors for the LFR methodology, compared to the LRFR methodology.

Fig. 3.4 allows a more refined look at the distribution of the rating factors. These plots also support the previous findings, where rating factors computed by the LFR methodology are observed to be generally higher than those computed by the LRFR methodology. This is due to significantly higher live load demands produced by the HL-93 load model, compared to the HS-20 truck.

It can be stated that the findings above apply for both state owned and locally owned bridges.



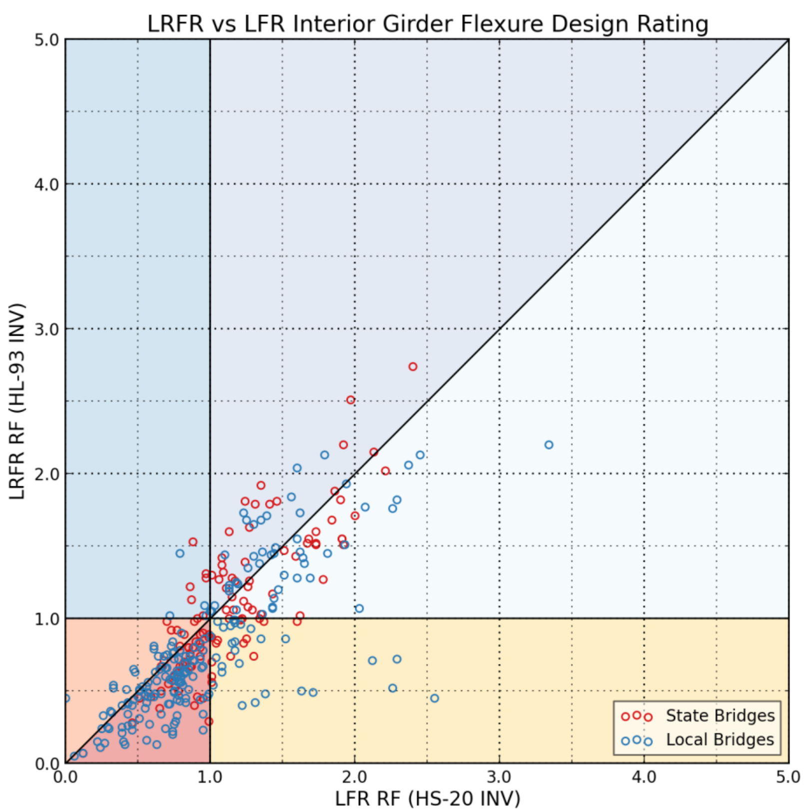




**Figure 3.2** – Flexural rating factors compared at the design inventory level.

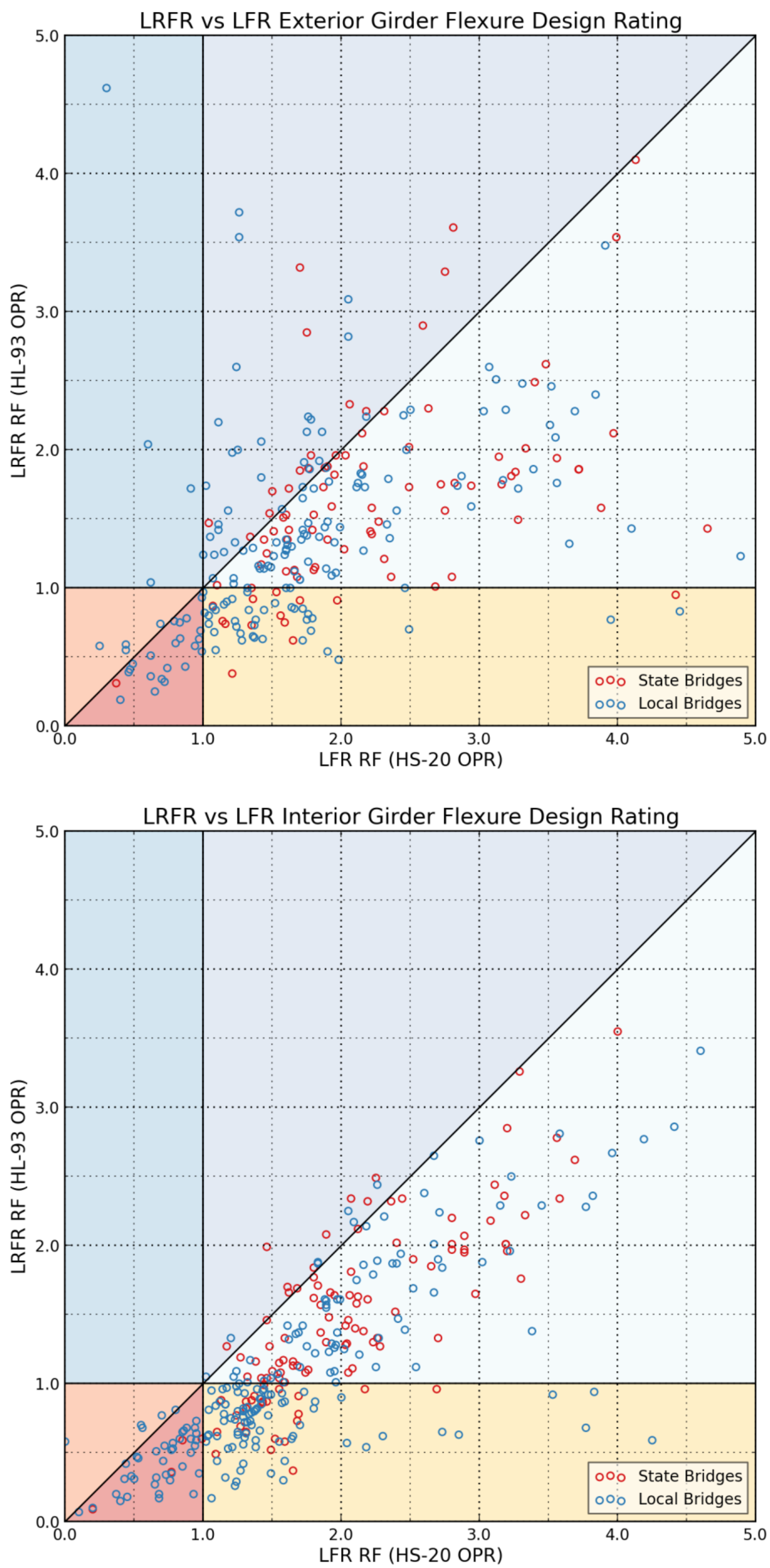
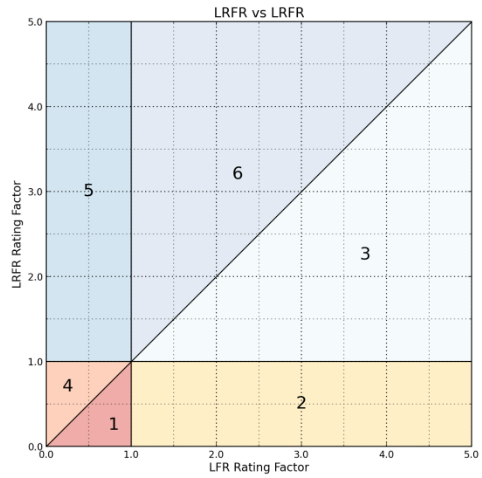



**Figure 3.3** – Flexural rating factors compared at the design operating level.



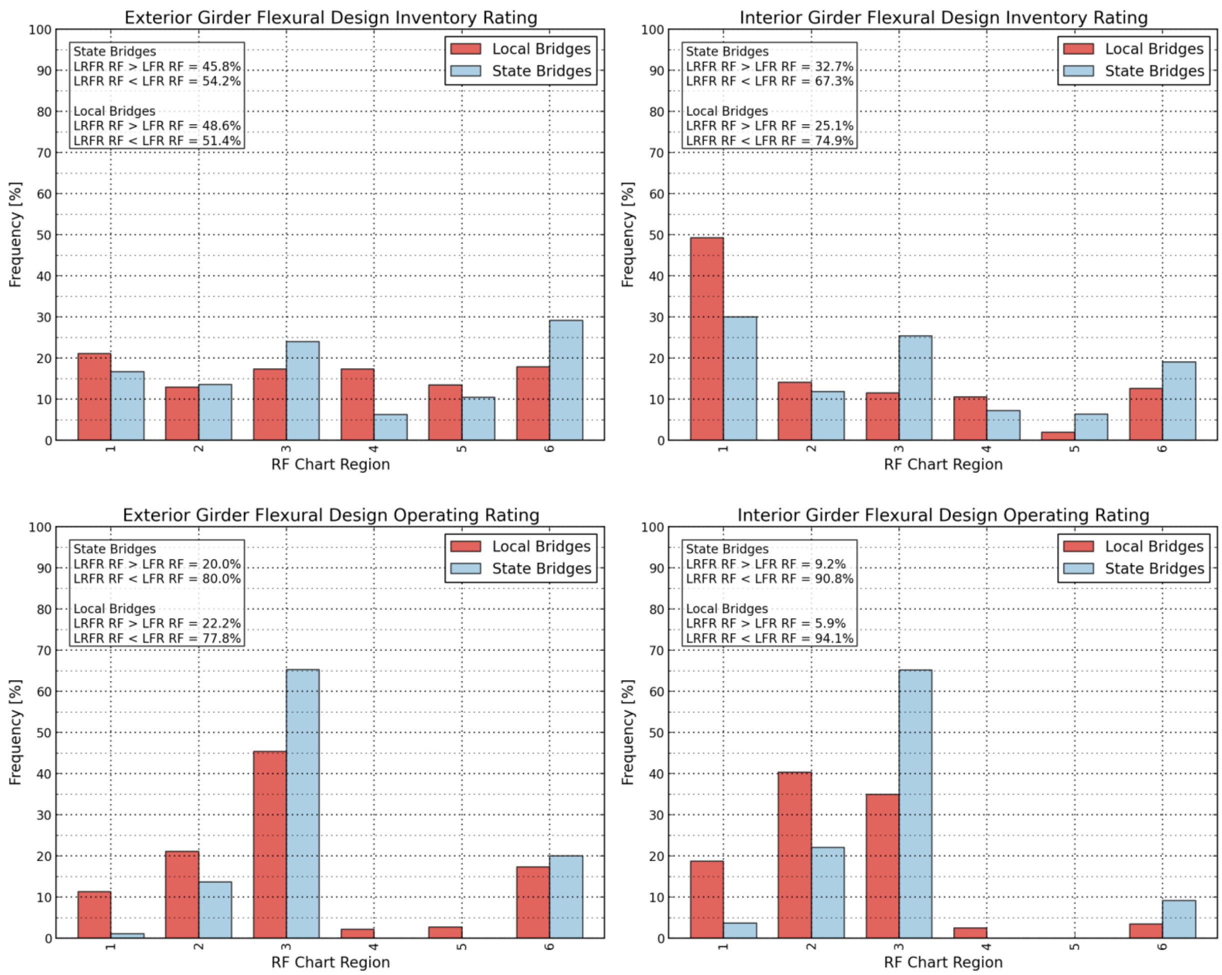



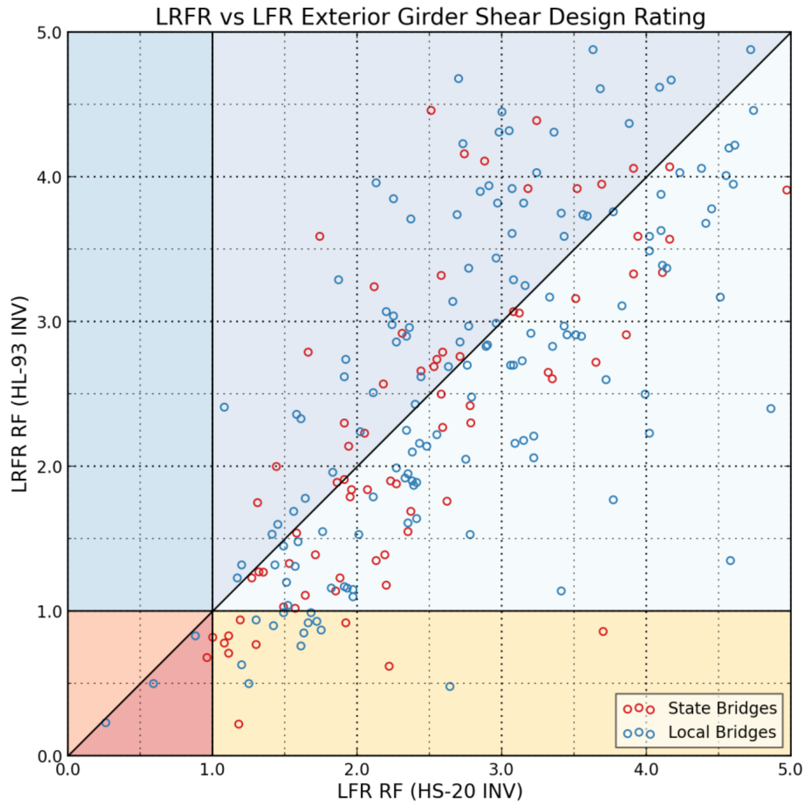

**Figure 3.4** – Distribution of flexural rating factors.

### 3.3 Shear Design Rating Factors

The comparison of shear design rating factors of all bridges rated are shown in Fig 3.5 and Fig 3.6 at the inventory and operating levels, respectively. Distribution of flexural rating factors for different regions in the plots is summarized in Fig. 3.7.

Based on Figs 3.2 and 3.3 it can be stated that the amount of scatter in the rating results was high in all of the cases, compared to the flexural design ratings, where this scatter was more pronounced in external girders. Again, this may be due to the discrepancies in the calculation methods for live load distribution factors in the AASHTO LRFD and the AASHTO Standard specifications, respectively used for the LRFR and the LFR methodologies. In addition, there are fundamental differences in the calculation of the shear capacity for reinforced concrete and prestressed concrete structures, which may be compounding the scatter seen in all of the plots.

For both interior and exterior girders, it was observed that the trend in the data points follow the diagonal line. A downward shift was observed both at the inventory and operating levels, resulting in generally higher rating factors for the LFR methodology, compared to the LRFR methodology, which can also be deducted from the plots given in Fig. 3.7. Similar to the flexural case, design shear loads produced by the HL-93 live load model are significantly higher than those produced by the HS-20 truck. In addition, the higher shear distribution factors in LRFR compared to LFR also contribute to the lower rating factors for the LRFR methodology.



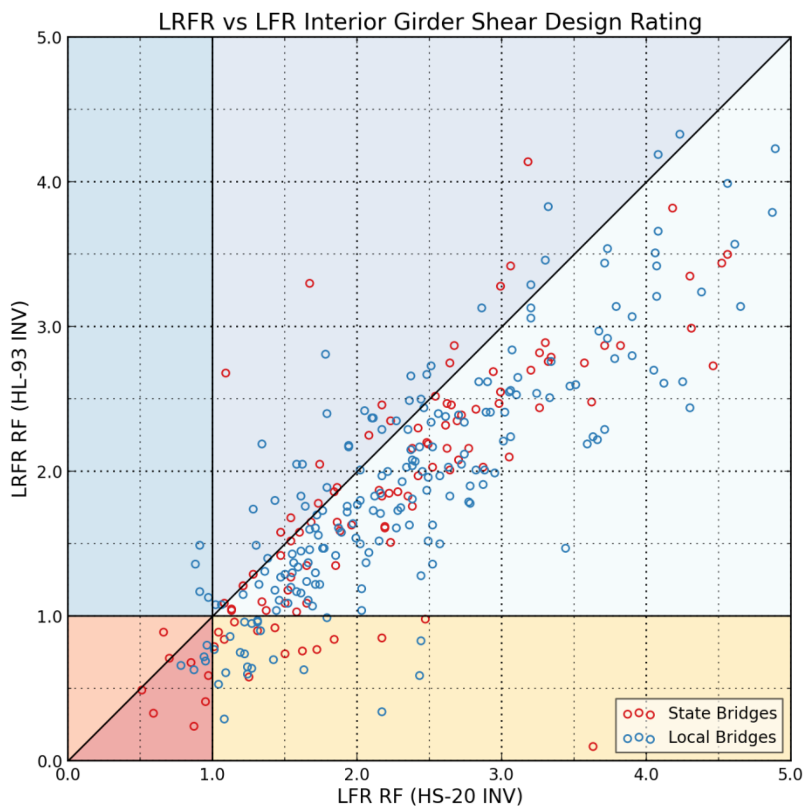
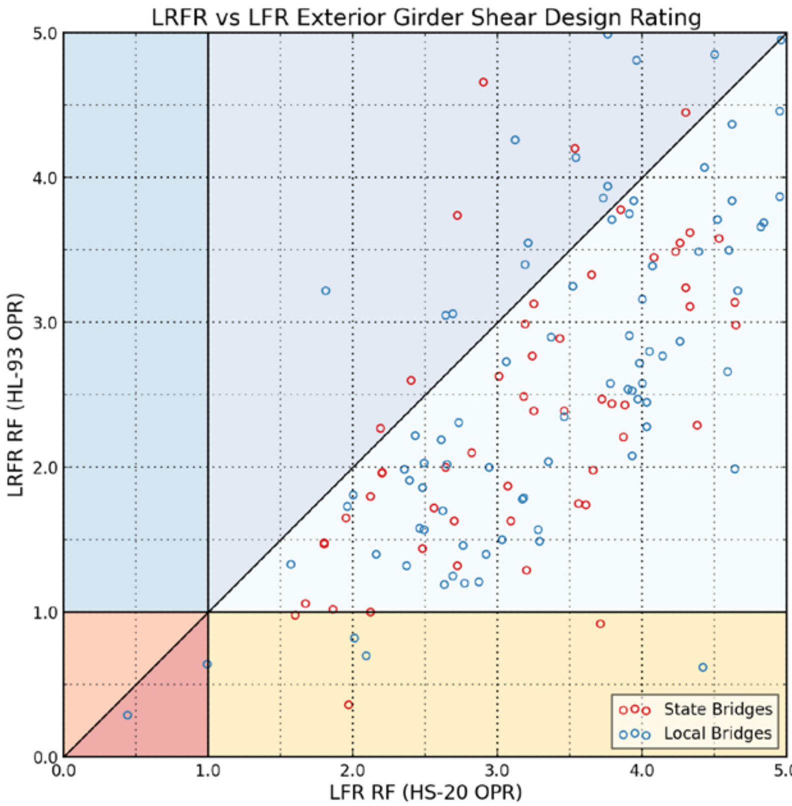




**Figure 3.5** – Shear rating factors compared at the design inventory level.



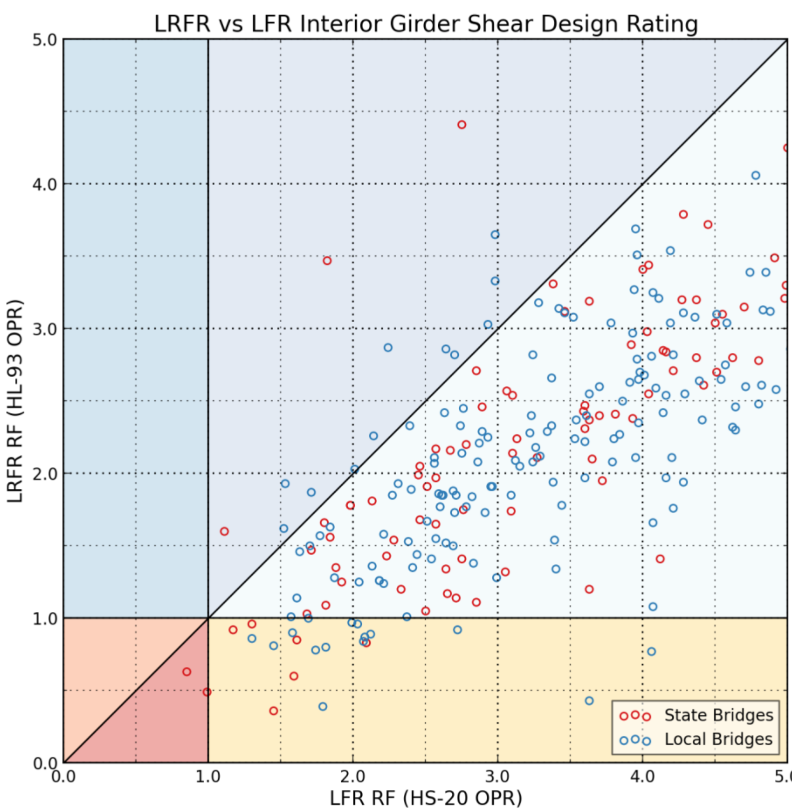




**Figure 3.6** – Shear rating factors compared at the design operating level.

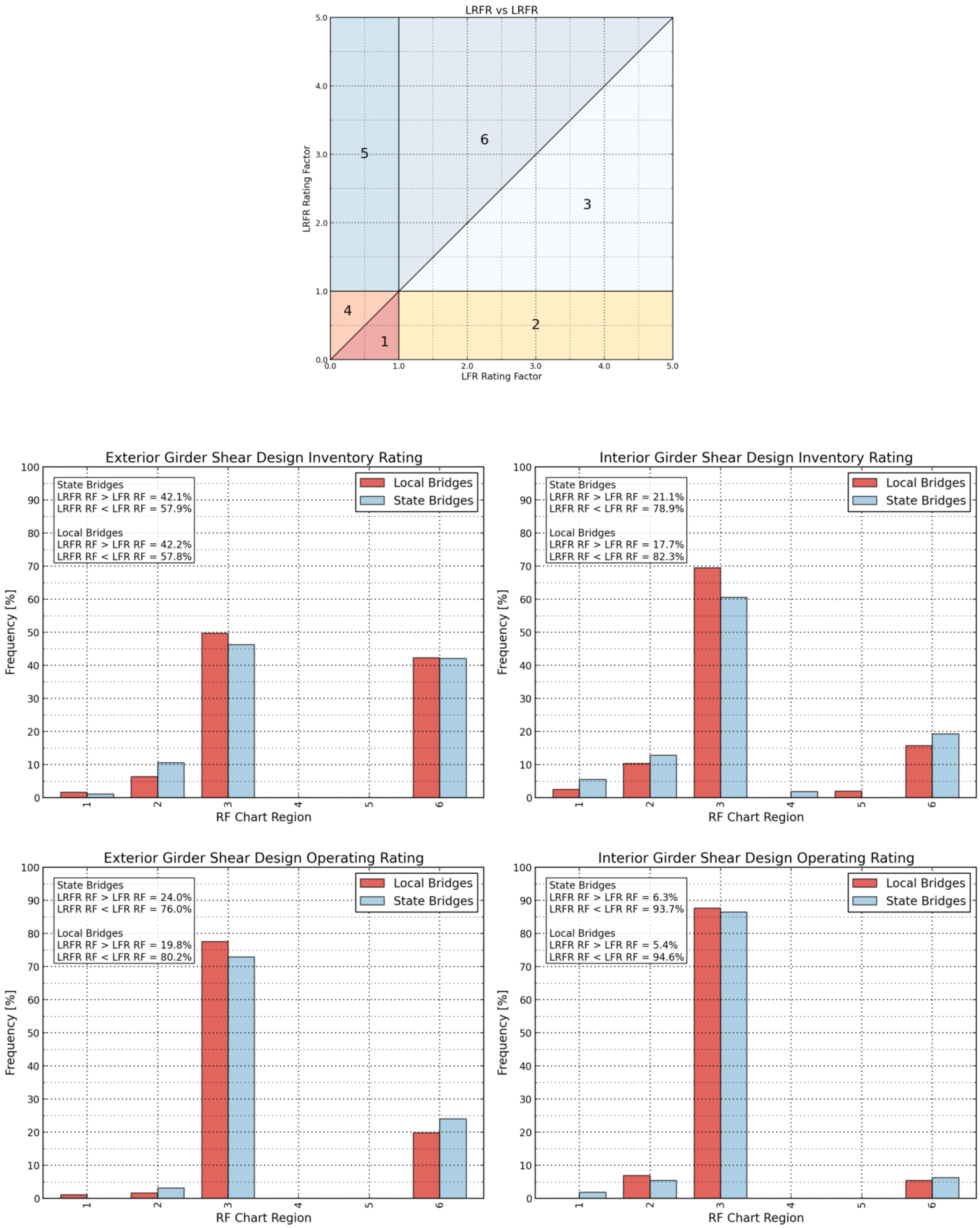



**Figure 3.7** – Distribution of shear rating factors.

### 3.4 Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions

Frequency distributions and cumulative frequency distributions of the rating factor ratios are listed in Tables 3.3 and 3.4, respectively. Tables include data from exterior and interior girders, moment and shear load effects, as well as the ownership information at both inventory and operating levels. In addition, the cumulative frequencies that correspond to the LRFR/LFR < 1.0 boundary is highlighted in Table 3.4. For example, 54.2% of the state owned bridges yielded higher LFR rating factors than LRFR rating factors for the exterior girders under moment load effects at the inventory level. A value less than 50.0% indicates the LRFR methodology yields higher rating factors than the LFR methodology for more than half of the bridges. The number of bridges in the inventory having a rating factor ratio less than 1.0 is given in Table 3.5.

It is possible to visualize the cumulative frequency tables using cumulative frequency plots for easier interpretation of the comparative rating results. Such plots were constructed for moment and shear load effects at the interior and exterior members, as shown in Figs. 3. 8 to 3.11.

**Table 3.3 –** Rating Factor Ratio (LRFR/LFR) Frequency Distributions

| Design Load RF Ratio Frequency Distributions | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | 10.4 | 29.2 | 11.8 | 29.9 | 7.2 | 21.6 | 21.7 | 40.4 | 7.3 | 18.8 | 13.4 | 25.1 | 9.9 | 27.9 | 9.4 | 36.0 |
| 0.6 - 0.8 | 19.8 | 27.1 | 21.9 | 26.2 | 21.6 | 49.5 | 25.1 | 38.9 | 21.9 | 34.4 | 16.6 | 33.7 | 29.7 | 45.0 | 37.4 | 45.8 |
| 0.8 - 1.0 | 24.0 | 25.0 | 18.2 | 20.9 | 38.7 | 18.0 | 28.6 | 14.8 | 29.2 | 24.0 | 27.8 | 21.4 | 39.6 | 20.7 | 35.5 | 12.8 |
| 1.0 - 1.2 | 16.7 | 10.4 | 20.9 | 7.0 | 15.3 | 9.9 | 15.8 | 3.9 | 15.6 | 12.5 | 16.0 | 8.0 | 14.4 | 0.9 | 12.8 | 3.9 |
| 1.2 - 1.4 | 16.7 | 1.0 | 8.0 | 6.4 | 12.6 | 0.9 | 5.9 | 1.0 | 11.5 | 3.1 | 10.7 | 4.3 | 1.8 | 0.9 | 3.0 | 1.5 |
| 1.4 -1.6 | 4.2 | 1.0 | 4.8 | 1.6 | 3.6 | 0.0 | 1.5 | 0.5 | 4.2 | 1.0 | 5.9 | 2.1 | 0.9 | 0.9 | 1.0 | 0.0 |
| 1.6 - 1.8 | 1.0 | 1.0 | 4.3 | 1.6 | 0.9 | 0.0 | 0.5 | 0.0 | 3.1 | 0.0 | 2.1 | 1.1 | 0.0 | 0.9 | 1.0 | 0.0 |
| 1.8 - 2.0 | 1.0 | 1.0 | 1.6 | 1.1 | 0.0 | 0.0 | 0.5 | 0.0 | 1.0 | 2.1 | 2.1 | 0.0 | 0.9 | 0.9 | 0.0 | 0.0 |
| 2.0 - 2.2 | 1.0 | 1.0 | 2.1 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.5 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 |
| 2.2 - 2.4 | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 0.5 | 0.5 | 0.0 | 0.9 | 0.0 | 0.0 |
| >2.40 | 5.2 | 3.1 | 6.4 | 4.3 | 0.0 | 0.0 | 0.5 | 0.5 | 6.3 | 3.1 | 4.3 | 2.7 | 2.7 | 0.9 | 0.0 | 0.0 |

**Table 3.4 –** Cumulative Frequencies of Rating Factor Ratios (LRFR/LFR)

| Design Load RF Cumulative Frequency Distributions | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | 10.4 | 29.2 | 11.8 | 29.9 | 7.2 | 21.6 | 21.7 | 40.4 | 7.3 | 18.8 | 13.4 | 25.1 | 9.9 | 27.9 | 9.4 | 36.0 |
| <= 0.8 | 30.2 | 56.3 | 33.7 | 56.1 | 28.8 | 71.2 | 46.8 | 79.3 | 29.2 | 53.1 | 29.9 | 58.8 | 39.6 | 73.0 | 46.8 | 81.8 |
| <= 1.0 | 54.2 | 81.3 | 51.9 | 77.0 | 67.6 | 89.2 | 75.4 | 94.1 | 58.3 | 77.1 | 57.8 | 80.2 | 79.3 | 93.7 | 82.3 | 94.6 |
| <= 1.2 | 70.8 | 91.7 | 72.7 | 84.0 | 82.9 | 99.1 | 91.1 | 98.0 | 74.0 | 89.6 | 73.8 | 88.2 | 93.7 | 94.6 | 95.1 | 98.5 |
| <= 1.4 | 87.5 | 92.7 | 80.7 | 90.4 | 95.5 | 100 | 97.0 | 99.0 | 85.4 | 92.7 | 84.5 | 92.5 | 95.5 | 95.5 | 98.0 | 100 |
| <= 1.6 | 91.7 | 93.8 | 85.6 | 92.0 | 99.1 | 100 | 98.5 | 99.5 | 89.6 | 93.8 | 90.4 | 94.7 | 96.4 | 96.4 | 99.0 | 100 |
| <=1.8 | 92.7 | 94.8 | 89.8 | 93.6 | 100 | 100 | 99.0 | 99.5 | 92.7 | 93.8 | 92.5 | 95.7 | 96.4 | 97.3 | 100 | 100 |
| <= 2.0 | 93.8 | 95.8 | 91.4 | 94.7 | 100 | 100 | 99.5 | 99.5 | 93.8 | 95.8 | 94.7 | 95.7 | 97.3 | 98.2 | 100 | 100 |
| <= 2.2 | 94.8 | 96.9 | 93.6 | 95.2 | 100 | 100 | 99.5 | 99.5 | 93.8 | 95.8 | 95.2 | 96.8 | 97.3 | 98.2 | 100 | 100 |
| <= 2.4 | 94.8 | 96.9 | 93.6 | 95.7 | 100 | 100 | 99.5 | 99.5 | 93.8 | 96.9 | 95.7 | 97.3 | 97.3 | 99.1 | 100 | 100 |
| >2.40 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 3.5 –** Number of Bridges with Design Rating Factor Ratio LRFR/LFR <=1.0

| Load Model | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| Design Load | 52 | 78 | 97 | 144 | 75 | 99 | 153 | 191 | 56 | 74 | 108 | 150 | 88 | 104 | 167 | 192 |

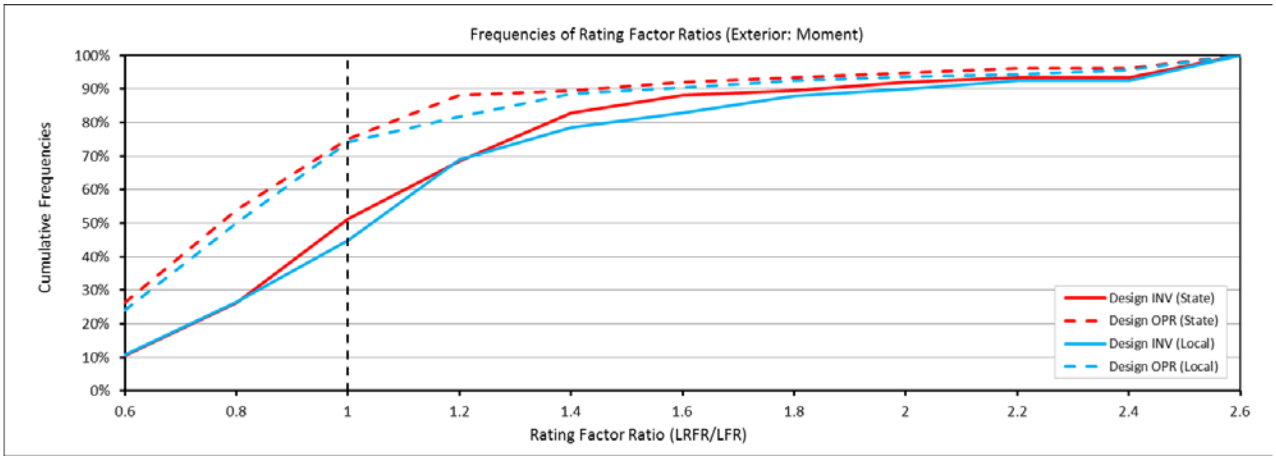



**Figure 3.8 –** Cumulative frequencies of flexural design rating factor ratios for exterior girders.

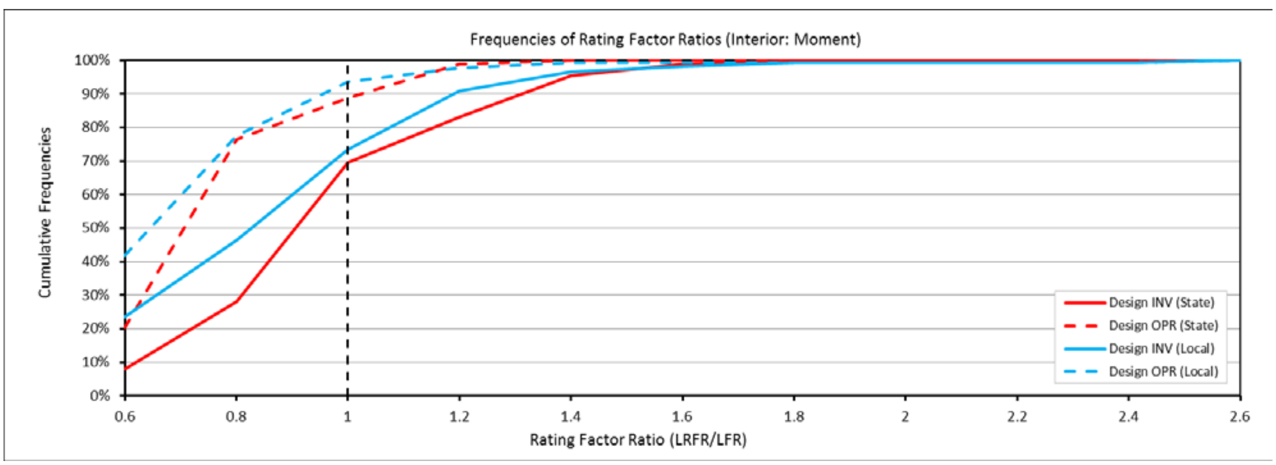



**Figure 3.9 –** Cumulative frequencies of flexural design rating factor ratios for interior girders.

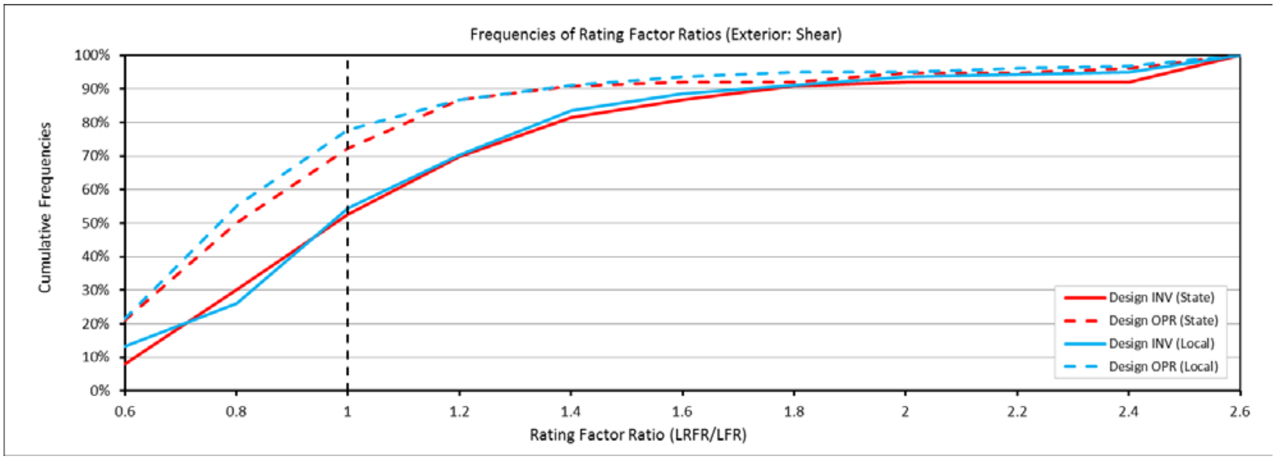



**Figure 3.10 –** Cumulative frequencies of flexural design rating factor ratios for exterior girders.

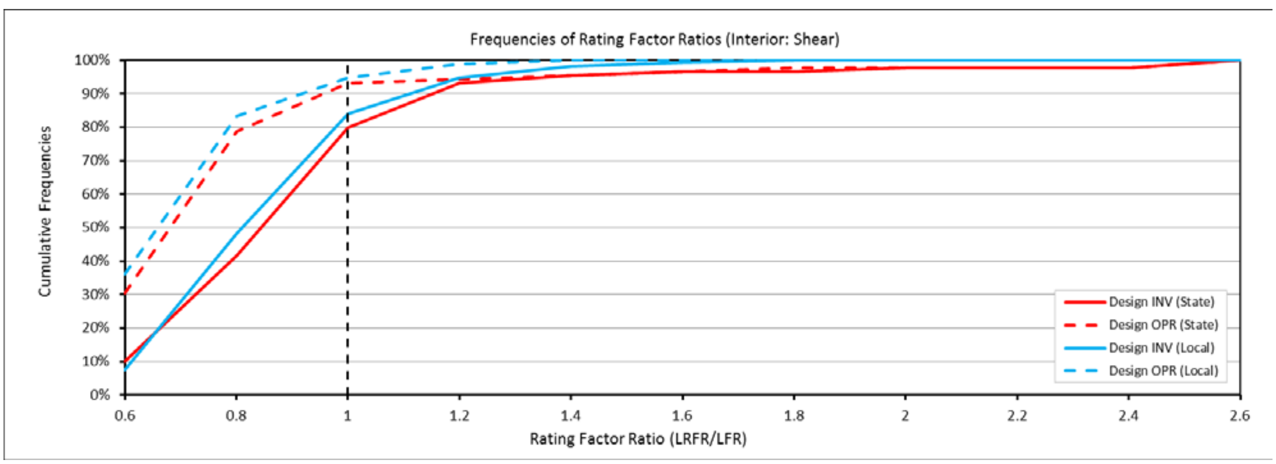



**Figure 3.11 –** Cumulative frequencies of shear design rating factor ratios for interior girders.

### 3.5 Summary of Analysis Results

Findings from the comparative analysis of design load ratings using LRFR and LFR methodologies can be summarized as:

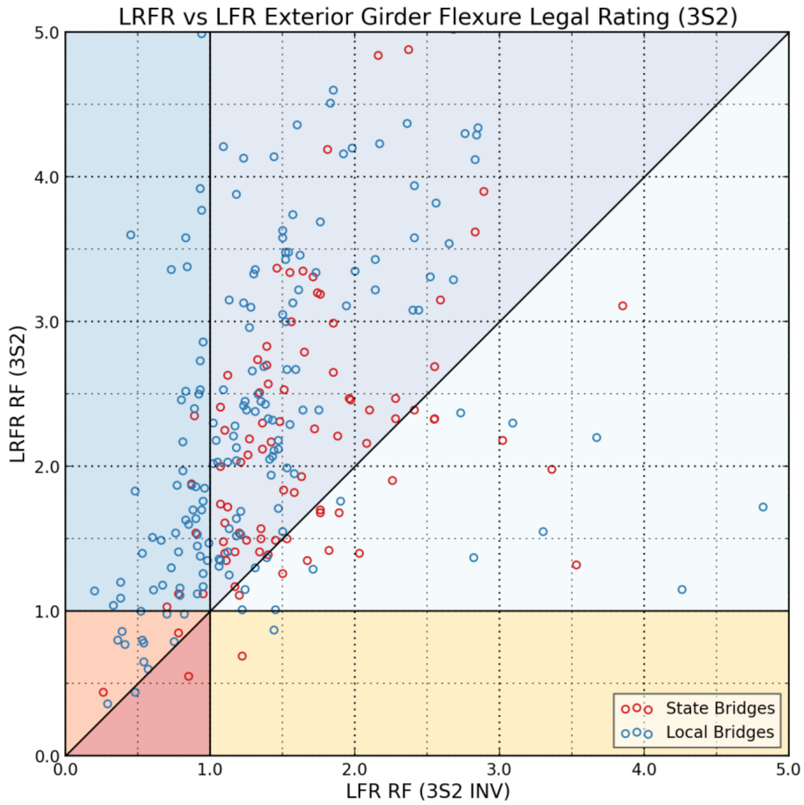
- As expected, direct comparisons of LRFR and LFR load ratings generally yielded scattered results. This was mainly due to the difference in the live load demand side of the load rating formula. Load models, load factors and differences in the application of live load distribution and dynamic load allowance result in scattered results.
- Overall, the LRFR methodology produced lower rating factors than the LFR methodology.
- State and local bridges produced similar trends based on the computed frequency distributions and the cumulative density functions.
- Exterior members yielded much scattered results compared to interior girders. A highly possible reason was determined to be the differences in the application of the distribution factors in each methodology.
- The state and local bridges produced similar results for LRFR and LFR methodologies.

# 4. LEGAL LEVEL RATING RESULTS

### 4.1 NY Legal Load Type 3S2

In LRFR only a single rating factor is derived for legal loads. This is a departure from LFR that includes two rating levels, inventory and operating. For the comparative study, for each bridge, the single LRFR legal load rating factor was compared to the LFR inventory and operating legal rating factors. The load models that were utilized in the rating analysis were NY legal loads Type 3S2 and SU4 as given in the LRFR draft EI document. To facilitate the presentation of the results, the data was divided into subsections based on the exterior and interior girders of each bridge. Those sections were further divided into results for flexure and shear. The results obtained for each bridge were compiled into tables and charts to better understand the trends and results, in a similar way that was performed for the design load ratings.

The comparison of flexural inventory and operating rating factors based on the Type 3S2 legal load model is shown in Fig 4.1 and 4.2, for exterior and interior girders, respectively. The plots show scatter for exterior girders when compared to interior girders. For flexural effects due to Type 3S2 effects, the LRFR methodology produces generally higher rating results than the LFR methodology at inventory level; the LRFR methodology in general produces equal or higher rating results than the LFR methodology at operating level. This trend is also evident in Fig 4.3, where distribution of rating results for each region is illustrated for exterior and interior girders, at inventory and operating levels.



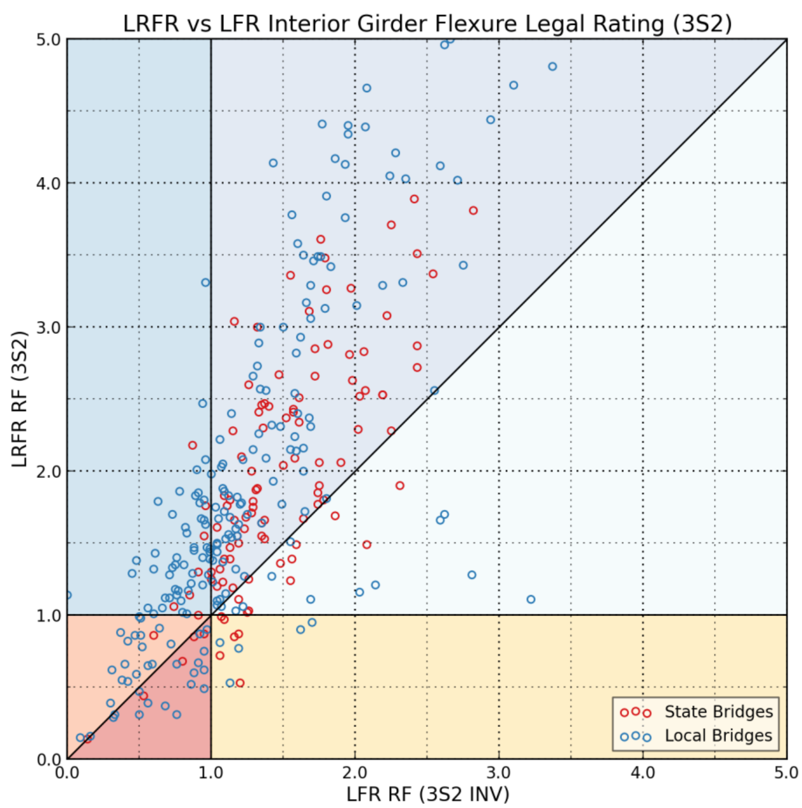
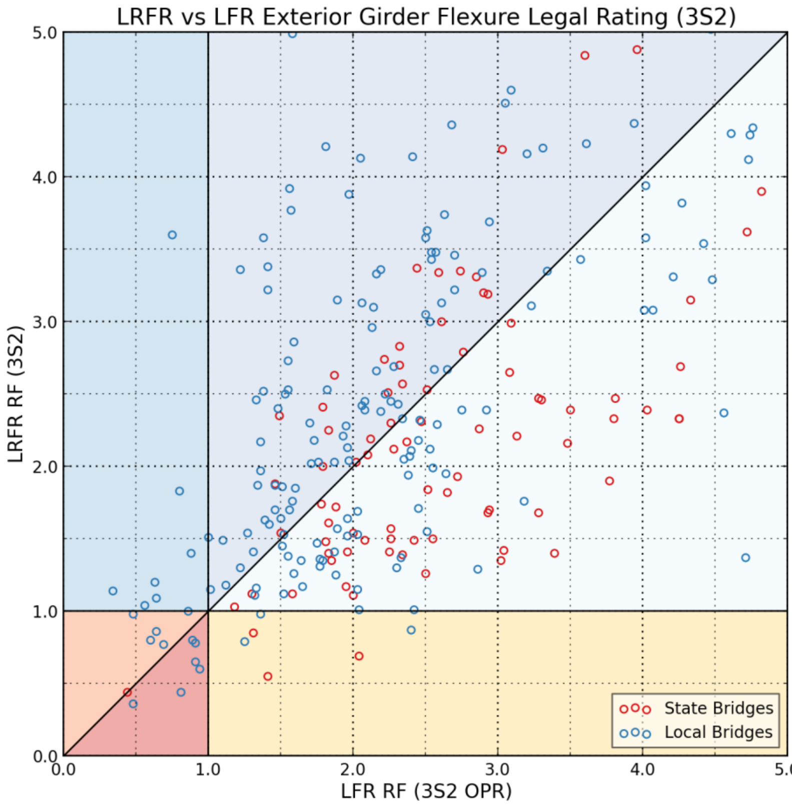




**Figure 4.1** – 3S2 Flexural rating factors compared at the legal inventory level (LFR INV).



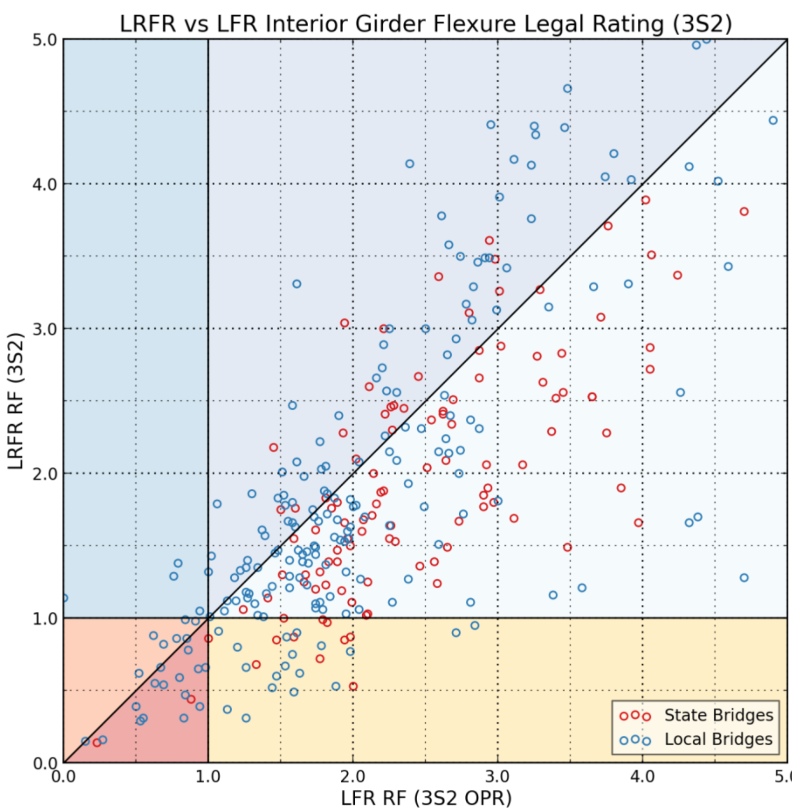




**Figure 4.2** – 3S2 Flexural rating factors compared at the legal inventory level (LFR OPR).

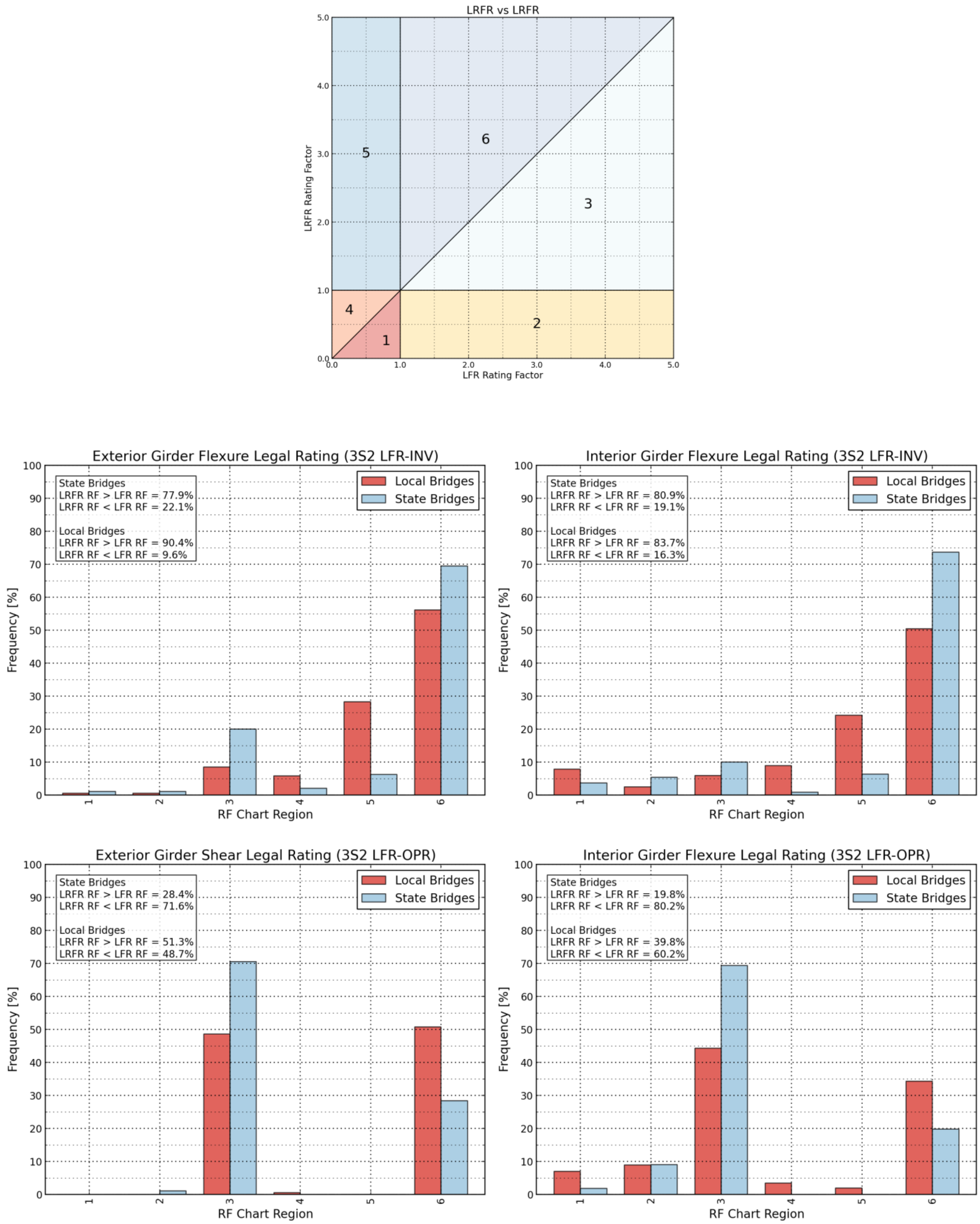
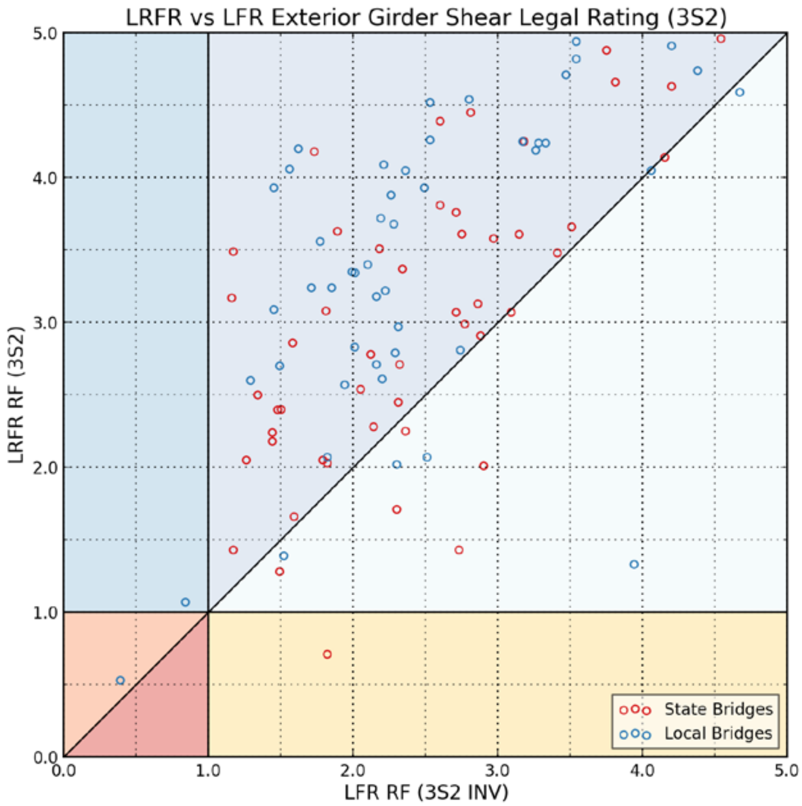



**Figure 4.3** – Distribution of 3S2 flexure legal rating factors.

Comparative plots of inventory and operating rating factors for shear effects for the Type 3S2 legal load model are shown in Fig. 4.4 and Fig. 4.5, respectively. The shear rating factors for LFR and LRFR methodologies exhibit much more scatter compared to the flexural rating factors. Similar to the flexural case, shear rating factors in LRFR were higher than LFR rating factors at the inventory level and generally lower at the operating level. This trend is also evident in Fig 4.6, where distribution of rating results for each region is illustrated for exterior and interior girders, at inventory and operating levels.



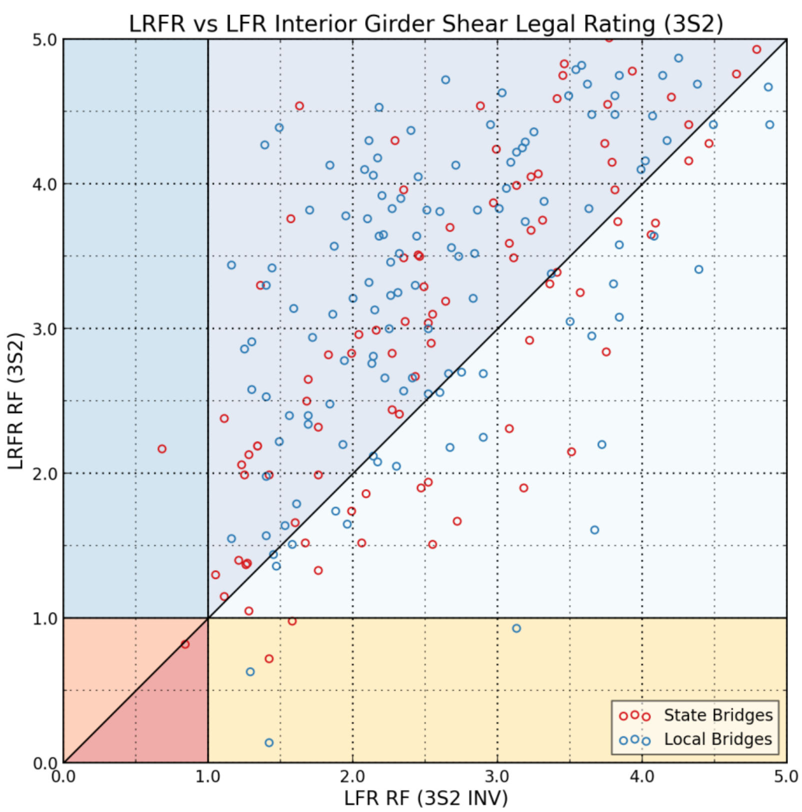
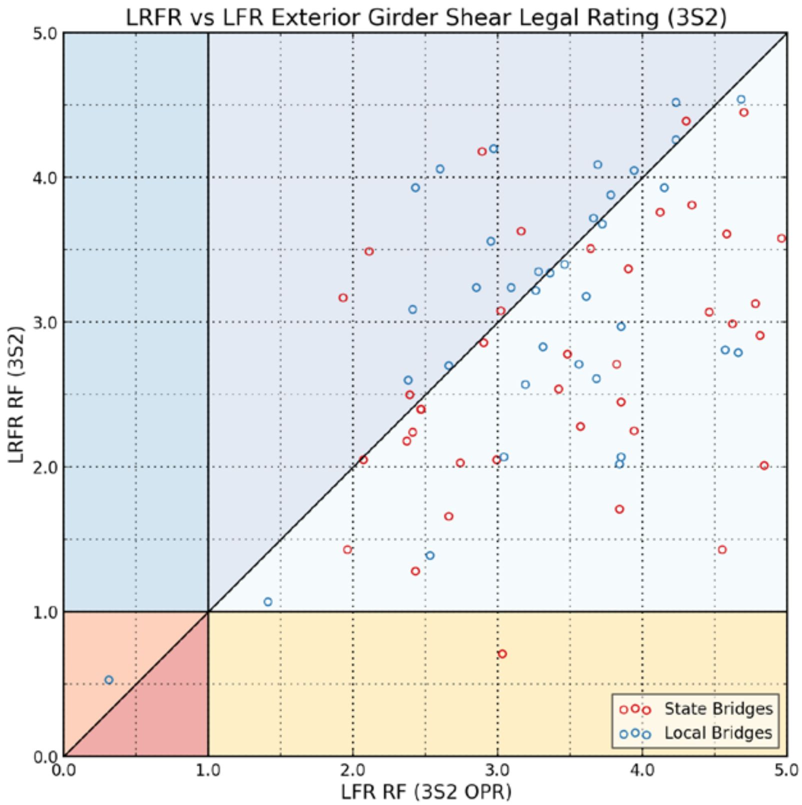




**Figure 4.4** – 3S2 Shear rating factors compared at the legal inventory level (LFR INV).



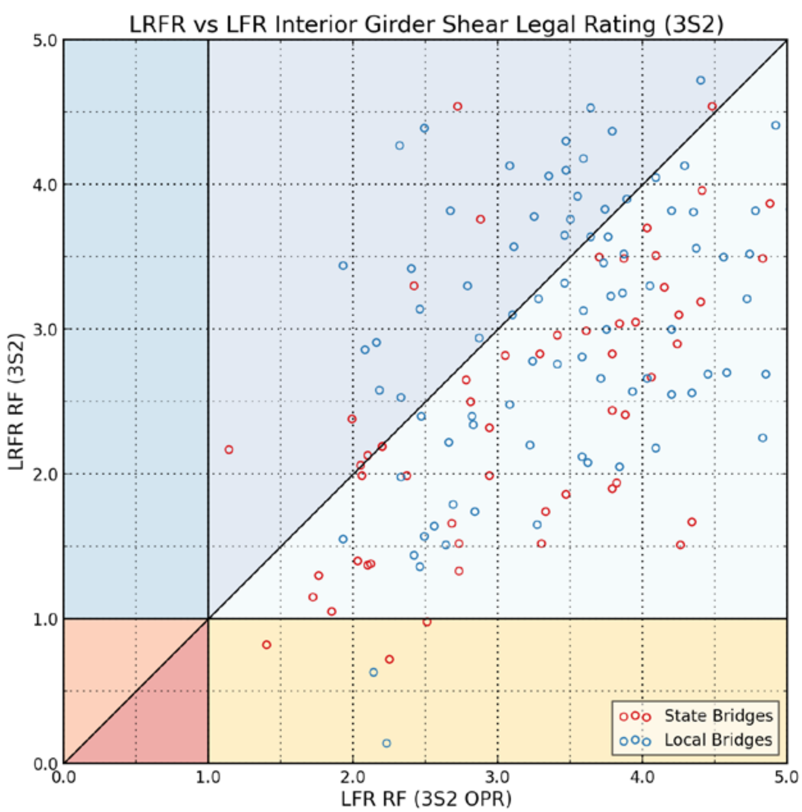




**Figure 4.5** – 3S2 Shear rating factors compared at the legal inventory level (LFR OPR).

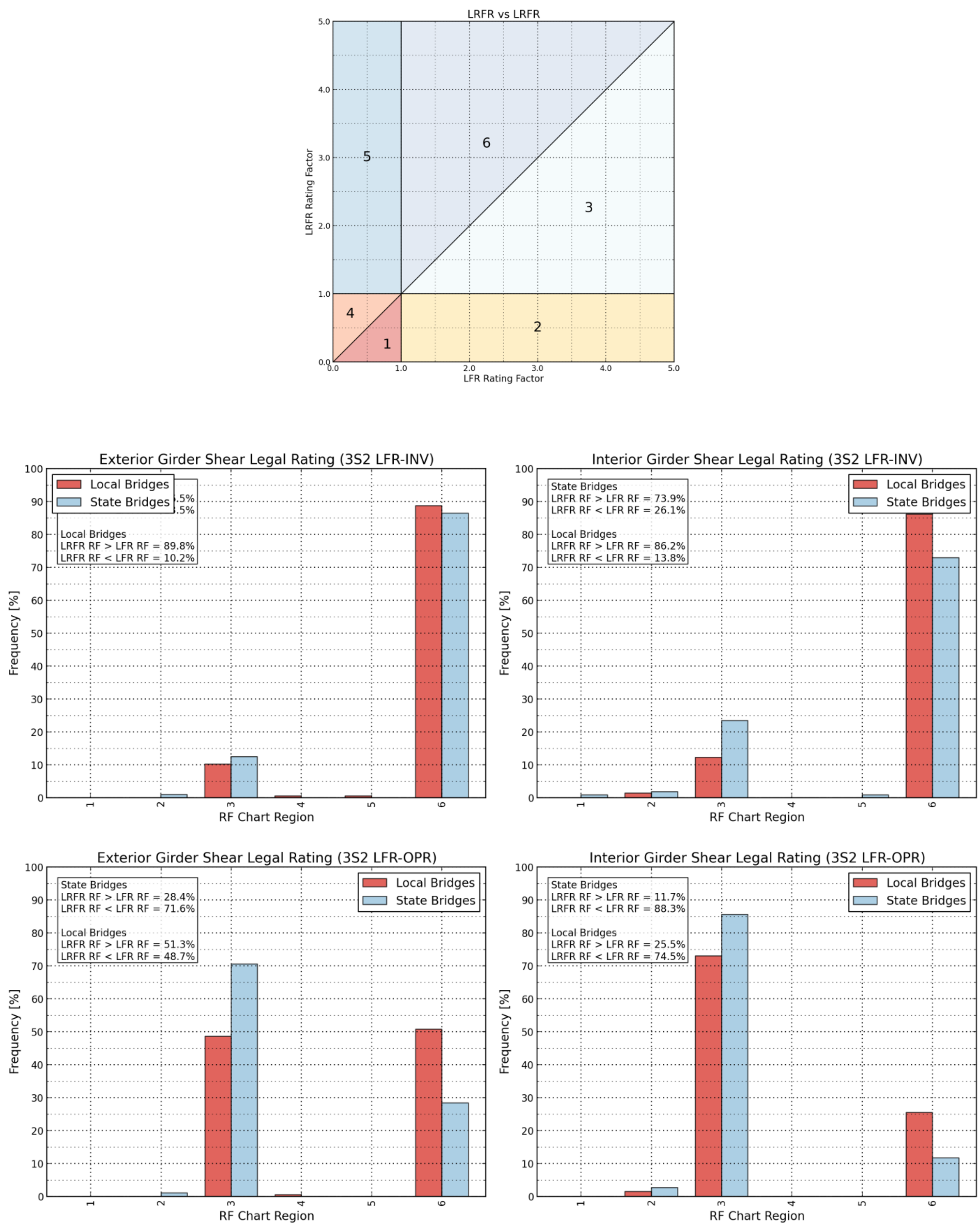
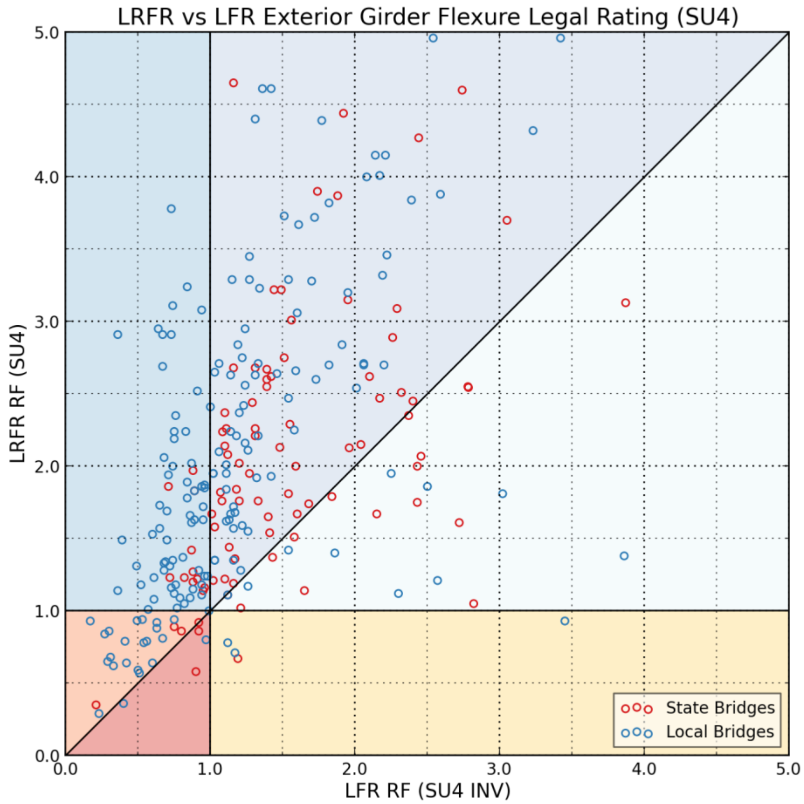



**Figure 4.6** – Distribution of 3S2 shear legal rating factors.

### 4.2 NY Legal Load SU4

Analysis of the rating factors for the SU4 legal load produced similar trends with the Type 3S2 rating results. The comparison of inventory and operating rating factors for flexural effects based on the SU4 legal load are shown in Fig. 4.7 and Fig. 4.8. Fig. 4.9 illustrates the distribution of SU4 flexural rating factor ratios in different regions of the comparative plots. The comparison of inventory and operating rating factors for shear effects based on the SU4 legal load are shown in Fig. 4.10 and Fig. 4.11. Fig. 4.12 illustrates the distribution of SU4 shear rating factor ratios in different regions of the comparative plots.



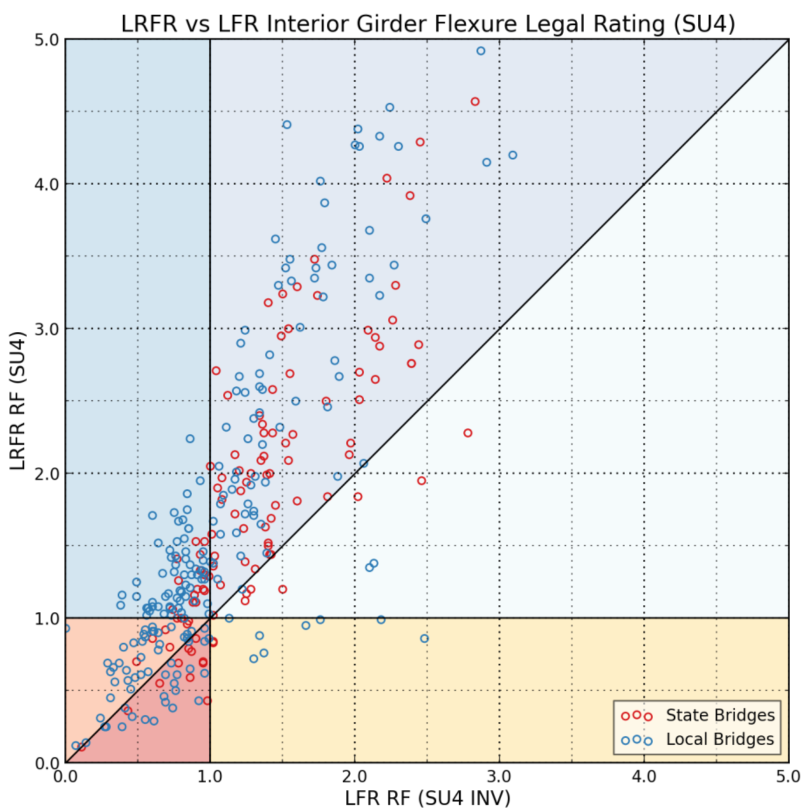
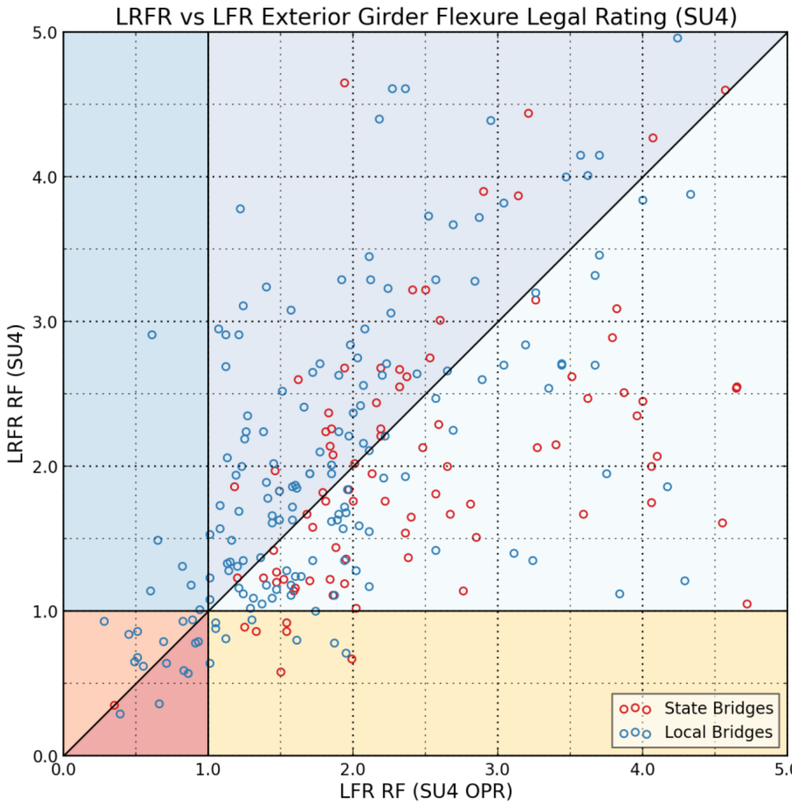




**Figure 4.7** – SU4 flexure rating factors compared at the legal inventory level (LFR INV).



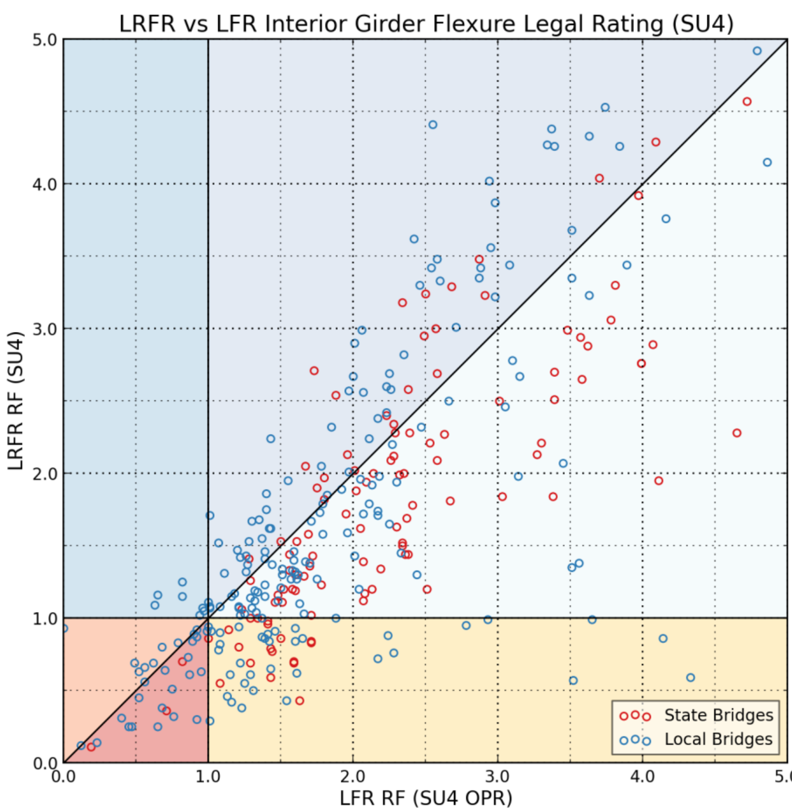




**Figure 4.8** – SU4 flexure rating factors compared at the legal inventory level (LFR OPR).

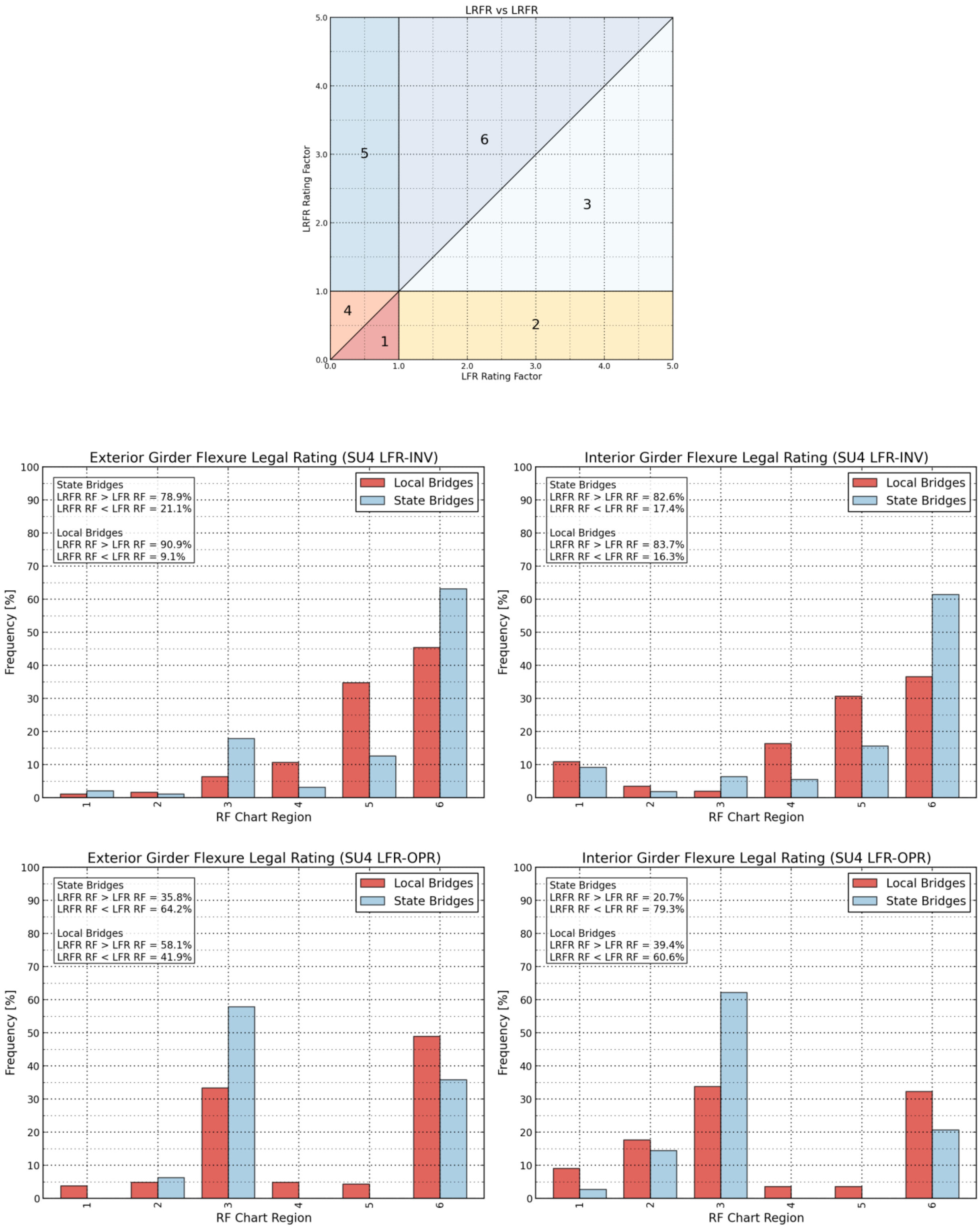
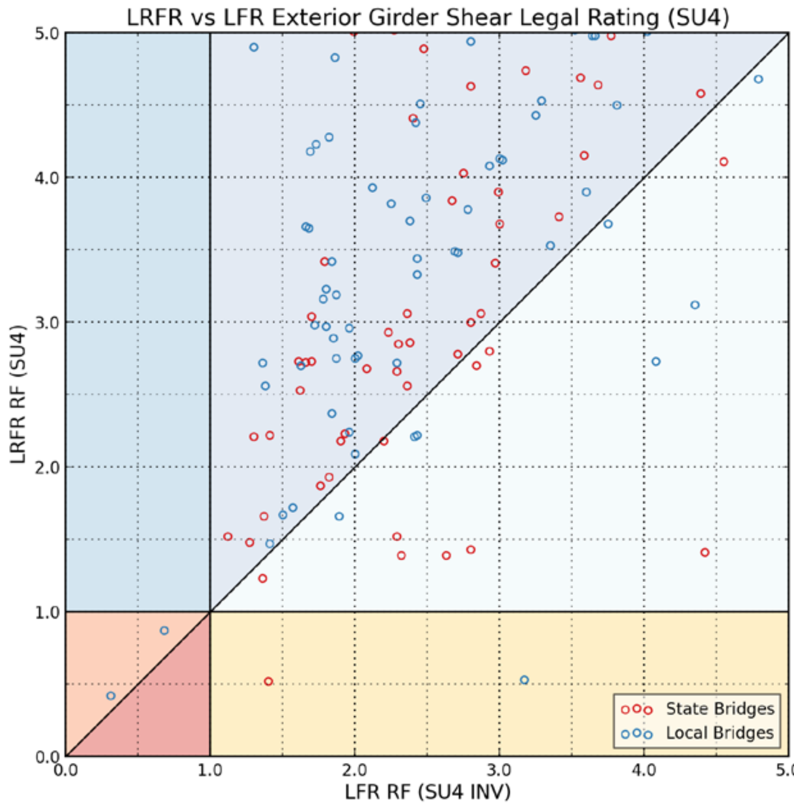



**Figure 4.9** – Distribution of SU4 flexure legal rating factors.



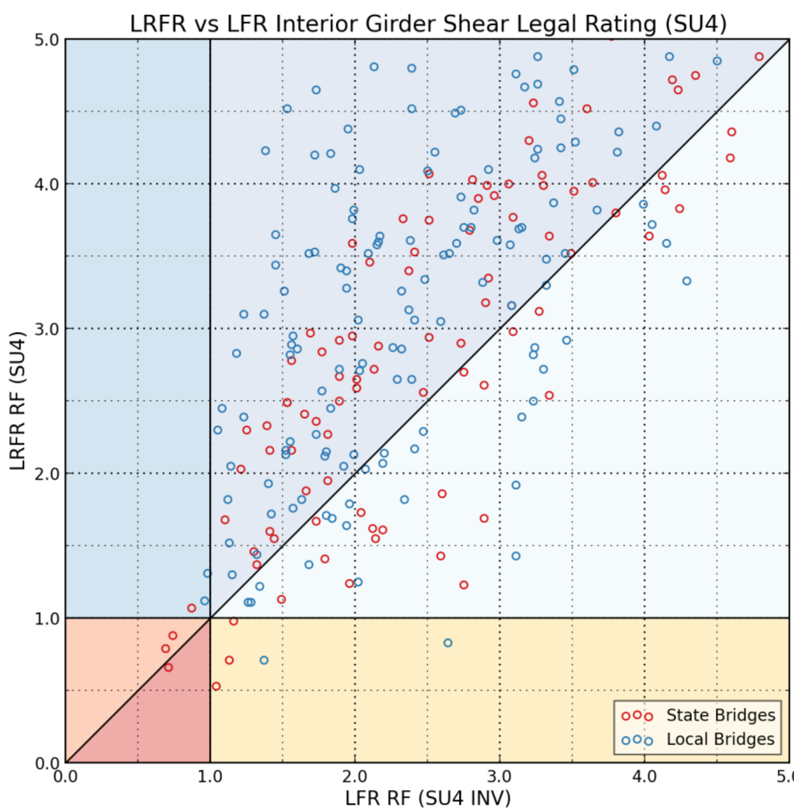
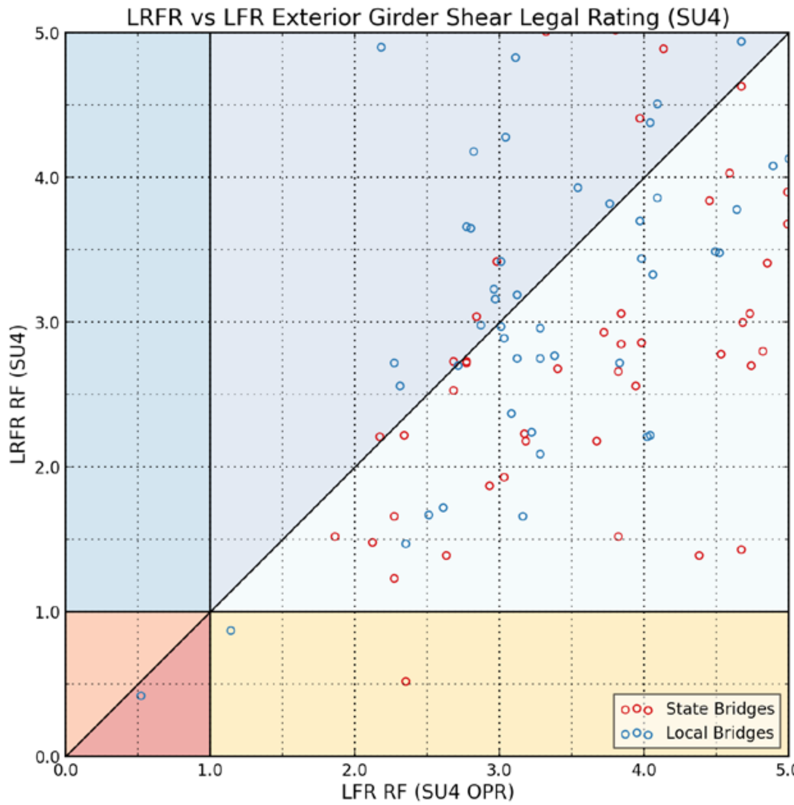




**Figure 4.10** – SU4 shear rating factors compared at the legal inventory level (LFR INV).



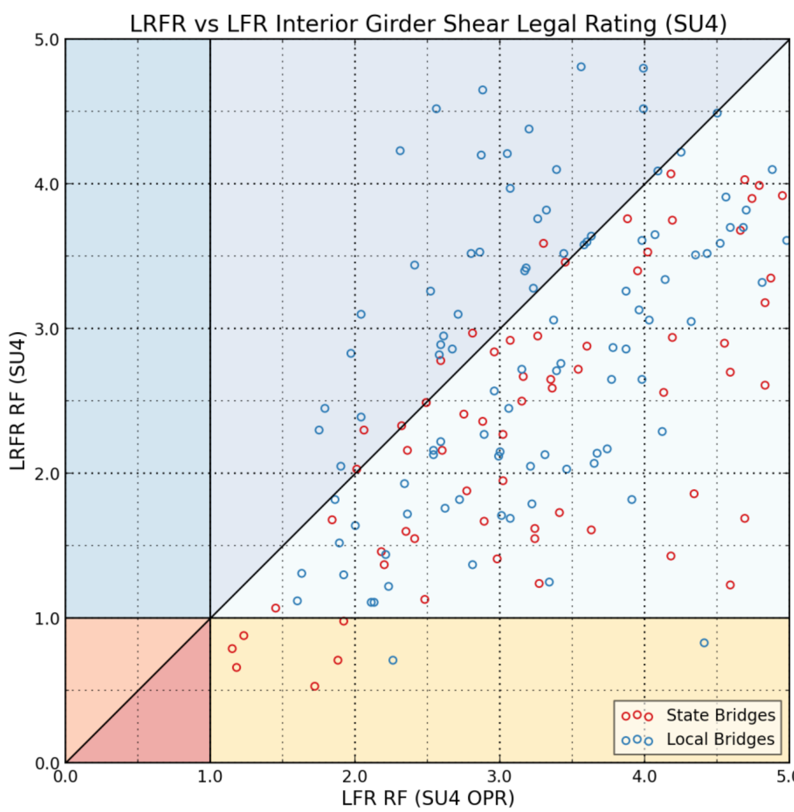




**Figure 4.11** – SU4 shear rating factors compared at the legal inventory level (LFR OPR).

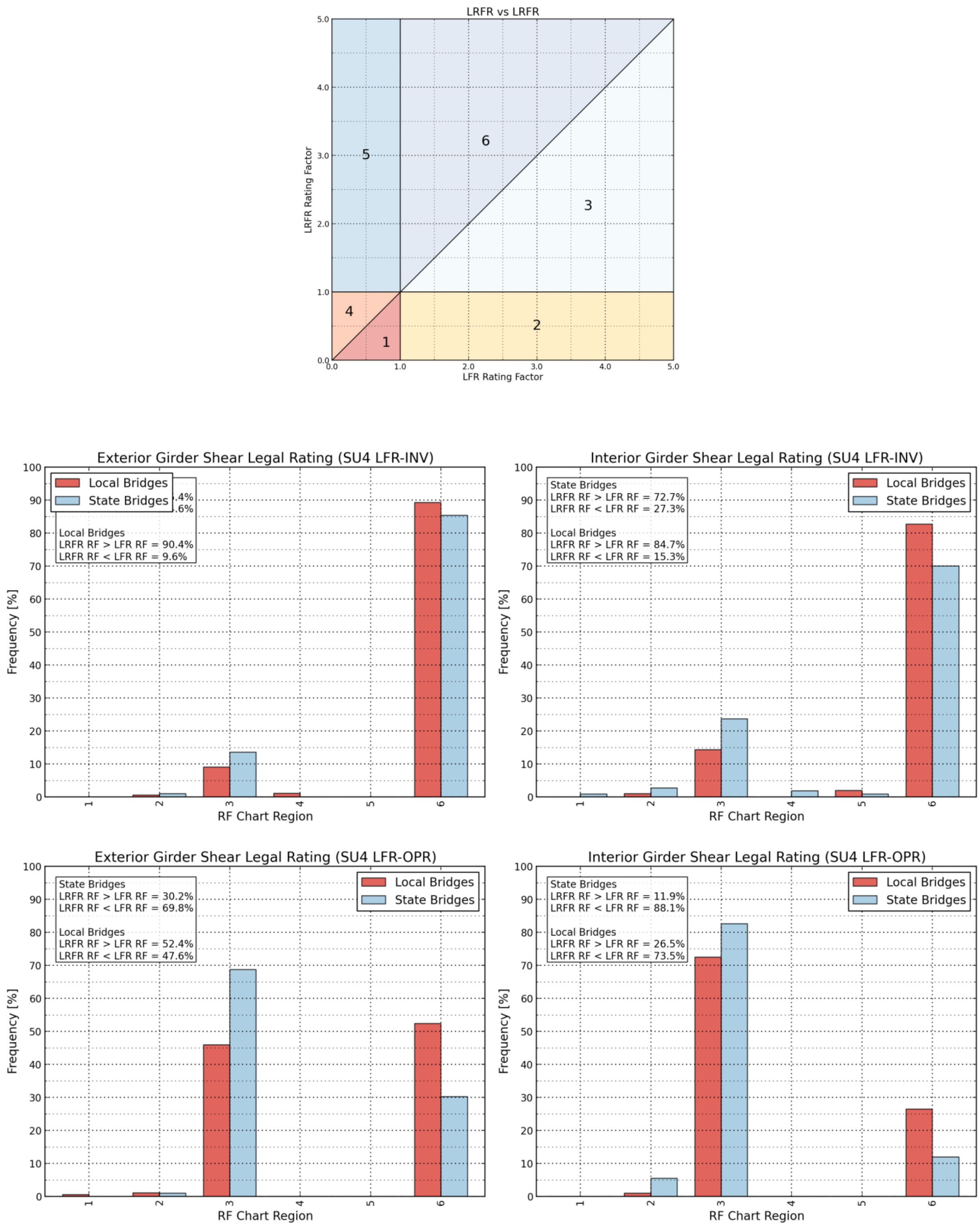



**Figure 4.12** – Distribution of SU4 flexure legal rating factors.

### 4.3 Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions

The legal rating factor ratio (LRFR/LFR) frequency distributions at the inventory and the operating levels (for LFR) for flexural and shear load effects are tabulated in Table 4.1 and Table 4.2, respectively for the Type 3S2 and SU4 legal load models. This is followed by the cumulative frequency distributions given in Table 4.3 and Table 4.4. In addition, the cumulative frequencies that correspond to the LRFR/LFR < 1.0 boundary is highlighted in Tables 4.3 and 4.4. At the highlighted row, a value less than 50.0% indicates the LRFR methodology yields higher rating factors than the LFR methodology for more than half of the bridges. The number of bridges in the inventory having a LRFR/LFR rating factor ratio less than 1.0 is given in Table 4.5.

It is possible to visualize the cumulative frequency tables using cumulative frequency plots for easier interpretation of the comparative rating results. Such plots were constructed for moment and shear load effects at the interior and exterior members, as shown in Figs. 4.13 to 4.20

**Table 4.1 –** Rating Factor Ratio (LRFR/LFR) Frequency Distributions for Type 3S2

| Legal Load RF Ratio Frequency Distributions (3S2) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | 4.2 | 21.9 | 2.7 | 9.6 | 0.9 | 20.7 | 4.9 | 16.7 | 3.1 | 12.5 | 3.2 | 11.2 | 2.7 | 27.0 | 2.5 | 13.3 |
| 0.6 - 0.8 | 3.1 | 28.1 | 3.2 | 13.4 | 4.5 | 30.6 | 5.9 | 13.8 | 3.1 | 34.4 | 3.2 | 11.8 | 9.0 | 41.4 | 1.0 | 29.1 |
| 0.8 - 1.0 | 14.6 | 13.5 | 3.7 | 17.6 | 14.4 | 28.8 | 5.9 | 29.6 | 7.3 | 26.0 | 4.3 | 25.7 | 14.4 | 19.8 | 10.3 | 32.0 |
| 1.0 - 1.2 | 17.7 | 17.7 | 3.7 | 21.4 | 17.1 | 14.4 | 6.4 | 22.7 | 20.8 | 11.5 | 4.3 | 19.3 | 25.2 | 3.6 | 17.2 | 13.3 |
| 1.2 - 1.4 | 12.5 | 11.5 | 13.9 | 11.2 | 22.5 | 3.6 | 14.3 | 11.3 | 16.7 | 4.2 | 15.5 | 11.2 | 22.5 | 3.6 | 19.2 | 4.4 |
| 1.4 -1.6 | 8.3 | 2.1 | 11.2 | 7.5 | 17.1 | 1.8 | 17.7 | 3.0 | 12.5 | 3.1 | 13.9 | 6.4 | 11.7 | 0.0 | 19.2 | 3.4 |
| 1.6 - 1.8 | 12.5 | 0.0 | 7.5 | 4.8 | 9.0 | 0.0 | 11.8 | 2.0 | 14.6 | 3.1 | 13.9 | 5.3 | 4.5 | 1.8 | 10.3 | 3.0 |
| 1.8 - 2.0 | 8.3 | 0.0 | 17.1 | 3.2 | 9.0 | 0.0 | 14.8 | 0.0 | 7.3 | 1.0 | 9.6 | 3.7 | 0.9 | 0.9 | 8.4 | 1.0 |
| 2.0 - 2.2 | 7.3 | 0.0 | 5.9 | 1.6 | 2.7 | 0.0 | 7.9 | 0.5 | 3.1 | 0.0 | 10.2 | 0.0 | 2.7 | 0.9 | 2.0 | 0.5 |
| 2.2 - 2.4 | 5.2 | 2.1 | 5.9 | 2.1 | 0.9 | 0.0 | 5.9 | 0.0 | 1.0 | 1.0 | 3.2 | 1.1 | 0.9 | 0.0 | 4.4 | 0.0 |
| >2.40 | 5.2 | 3.1 | 6.4 | 4.3 | 0.0 | 0.0 | 0.5 | 0.5 | 6.3 | 3.1 | 4.3 | 2.7 | 2.7 | 0.9 | 0.0 | 0.0 |

**Table 4.2 –** Rating Factor Ratio (LRFR/LFR) Frequency Distributions for SU4

| Legal Load RF Ratio Frequency Distributions (SU4) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | 4.2 | 20.8 | 3.2 | 10.2 | 0.9 | 18.0 | 4.9 | 18.2 | 5.2 | 15.6 | 3.2 | 10.2 | 4.5 | 27.9 | 1.5 | 14.8 |
| 0.6 - 0.8 | 3.1 | 27.1 | 2.7 | 13.4 | 5.4 | 30.6 | 5.9 | 11.8 | 2.1 | 36.5 | 3.2 | 12.8 | 9.0 | 40.5 | 3.0 | 29.6 |
| 0.8 - 1.0 | 13.5 | 15.6 | 3.2 | 18.7 | 12.6 | 29.7 | 5.9 | 31.0 | 7.3 | 18.8 | 3.2 | 24.6 | 15.3 | 19.8 | 10.8 | 29.6 |
| 1.0 - 1.2 | 19.8 | 16.7 | 4.3 | 20.9 | 17.1 | 14.4 | 6.4 | 21.2 | 20.8 | 16.7 | 7.0 | 21.4 | 25.2 | 6.3 | 16.7 | 12.3 |
| 1.2 - 1.4 | 10.4 | 12.5 | 13.4 | 10.7 | 21.6 | 5.4 | 12.3 | 10.8 | 17.7 | 5.2 | 14.4 | 11.2 | 19.8 | 1.8 | 19.2 | 6.9 |
| 1.4 -1.6 | 8.3 | 1.0 | 11.8 | 7.0 | 18.0 | 0.9 | 19.7 | 4.4 | 10.4 | 3.1 | 13.4 | 7.0 | 10.8 | 0.9 | 14.8 | 3.0 |
| 1.6 - 1.8 | 12.5 | 1.0 | 8.0 | 5.3 | 9.9 | 0.0 | 11.3 | 2.0 | 16.7 | 0.0 | 14.4 | 3.7 | 8.1 | 1.8 | 12.3 | 2.5 |
| 1.8 - 2.0 | 9.4 | 0.0 | 17.1 | 3.2 | 8.1 | 0.0 | 14.8 | 0.0 | 6.3 | 0.0 | 9.6 | 3.2 | 1.8 | 0.0 | 6.4 | 0.5 |
| 2.0 - 2.2 | 7.3 | 0.0 | 5.9 | 1.1 | 3.6 | 0.9 | 8.4 | 0.0 | 4.2 | 0.0 | 8.6 | 0.5 | 0.9 | 0.0 | 4.4 | 0.5 |
| 2.2 - 2.4 | 5.2 | 2.1 | 4.8 | 1.1 | 1.8 | 0.0 | 4.9 | 0.0 | 2.1 | 1.0 | 3.2 | 1.1 | 0.9 | 0.0 | 3.9 | 0.5 |
| >2.40 | 6.3 | 3.1 | 25.7 | 8.6 | 0.9 | 0.0 | 5.4 | 0.5 | 7.3 | 3.1 | 19.8 | 4.3 | 3.6 | 0.9 | 6.9 | 0.0 |

**Table 4.3 –** Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions for Type 3S2

| Legal Load RF Ratio Cumulative Frequency Distributions (3S2) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | 4.2 | 21.9 | 2.7 | 9.6 | 0.9 | 20.7 | 4.9 | 16.7 | 3.1 | 12.5 | 3.2 | 11.2 | 2.7 | 27.0 | 2.5 | 13.3 |
| 0.6 - 0.8 | 7.3 | 50.0 | 5.9 | 23.0 | 5.4 | 51.4 | 10.8 | 30.5 | 6.3 | 46.9 | 6.4 | 23.0 | 11.7 | 68.5 | 3.4 | 42.4 |
| 0.8 - 1.0 | 21.9 | 63.5 | 9.6 | 40.6 | 19.8 | 80.2 | 16.7 | 60.1 | 13.5 | 72.9 | 10.7 | 48.7 | 26.1 | 88.3 | 13.8 | 74.4 |
| 1.0 - 1.2 | 39.6 | 81.3 | 13.4 | 62.0 | 36.9 | 94.6 | 23.2 | 82.8 | 34.4 | 84.4 | 15.0 | 67.9 | 51.4 | 91.9 | 31.0 | 87.7 |
| 1.2 - 1.4 | 52.1 | 92.7 | 27.3 | 73.3 | 59.5 | 98.2 | 37.4 | 94.1 | 51.0 | 88.5 | 30.5 | 79.1 | 73.9 | 95.5 | 50.2 | 92.1 |
| 1.4 -1.6 | 60.4 | 94.8 | 38.5 | 80.7 | 76.6 | 100 | 55.2 | 97.0 | 63.5 | 91.7 | 44.4 | 85.6 | 85.6 | 95.5 | 69.5 | 95.6 |
| 1.6 - 1.8 | 72.9 | 94.8 | 46.0 | 85.6 | 85.6 | 100 | 67.0 | 99.0 | 78.1 | 94.8 | 58.3 | 90.9 | 90.1 | 97.3 | 79.8 | 98.5 |
| 1.8 - 2.0 | 81.3 | 94.8 | 63.1 | 88.8 | 94.6 | 100 | 81.8 | 99.0 | 85.4 | 95.8 | 67.9 | 94.7 | 91.0 | 98.2 | 88.2 | 99.5 |
| 2.0 - 2.2 | 88.5 | 94.8 | 69.0 | 90.4 | 97.3 | 100 | 89.7 | 99.5 | 88.5 | 95.8 | 78.1 | 94.7 | 93.7 | 99.1 | 90.1 | 100 |
| 2.2 - 2.4 | 93.8 | 96.9 | 74.9 | 92.5 | 98.2 | 100 | 95.6 | 99.5 | 89.6 | 96.9 | 81.3 | 95.7 | 94.6 | 99.1 | 94.6 | 100 |
| >2.40 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 4.4 –** Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions for SU4

| Legal Load RF Ratio Cumulative Frequency Distributions (SU4) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | 4.2 | 20.8 | 3.2 | 10.2 | 0.9 | 18.0 | 4.9 | 18.2 | 5.2 | 15.6 | 3.2 | 10.2 | 4.5 | 27.9 | 1.5 | 14.8 |
| 0.6 - 0.8 | 7.3 | 47.9 | 5.9 | 23.5 | 6.3 | 48.6 | 10.8 | 30.0 | 7.3 | 52.1 | 6.4 | 23.0 | 13.5 | 68.5 | 4.4 | 44.3 |
| 0.8 - 1.0 | 20.8 | 63.5 | 9.1 | 42.2 | 18.9 | 78.4 | 16.7 | 61.1 | 14.6 | 70.8 | 9.6 | 47.6 | 28.8 | 88.3 | 15.3 | 73.9 |
| 1.0 - 1.2 | 40.6 | 80.2 | 13.4 | 63.1 | 36.0 | 92.8 | 23.2 | 82.3 | 35.4 | 87.5 | 16.6 | 69.0 | 54.1 | 94.6 | 32.0 | 86.2 |
| 1.2 - 1.4 | 51.0 | 92.7 | 26.7 | 73.8 | 57.7 | 98.2 | 35.5 | 93.1 | 53.1 | 92.7 | 31.0 | 80.2 | 73.9 | 96.4 | 51.2 | 93.1 |
| 1.4 -1.6 | 59.4 | 93.8 | 38.5 | 80.7 | 75.7 | 99 | 55.2 | 97.5 | 63.5 | 95.8 | 44.4 | 87.2 | 84.7 | 97.3 | 66.0 | 96.1 |
| 1.6 - 1.8 | 71.9 | 94.8 | 46.5 | 86.1 | 85.6 | 99 | 66.5 | 99.5 | 80.2 | 95.8 | 58.8 | 90.9 | 92.8 | 99.1 | 78.3 | 98.5 |
| 1.8 - 2.0 | 81.3 | 94.8 | 63.6 | 89.3 | 93.7 | 99 | 81.3 | 99.5 | 86.5 | 95.8 | 68.4 | 94.1 | 94.6 | 99.1 | 84.7 | 99.0 |
| 2.0 - 2.2 | 88.5 | 94.8 | 69.5 | 90.4 | 97.3 | 100 | 89.7 | 99.5 | 90.6 | 95.8 | 77.0 | 94.7 | 95.5 | 99.1 | 89.2 | 100 |
| 2.2 - 2.4 | 93.8 | 96.9 | 74.3 | 91.4 | 99.1 | 100 | 94.6 | 99.5 | 92.7 | 96.9 | 80.2 | 95.7 | 96.4 | 99.1 | 93.1 | 100 |
| >2.40 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

**Table 4.5 –** Number of Bridges with Design Rating Factor Ratio LRFR/LFR <=1.0

| Load Model | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| Type 3S2 | 21 | 61 | 18 | 76 | 22 | 89 | 34 | 122 | 15 | 70 | 70 | 91 | 29 | 98 | 28 | 151 |
| SU4 | 20 | 61 | 17 | 79 | 21 | 87 | 34 | 124 | 16 | 68 | 18 | 89 | 32 | 98 | 31 | 150 |

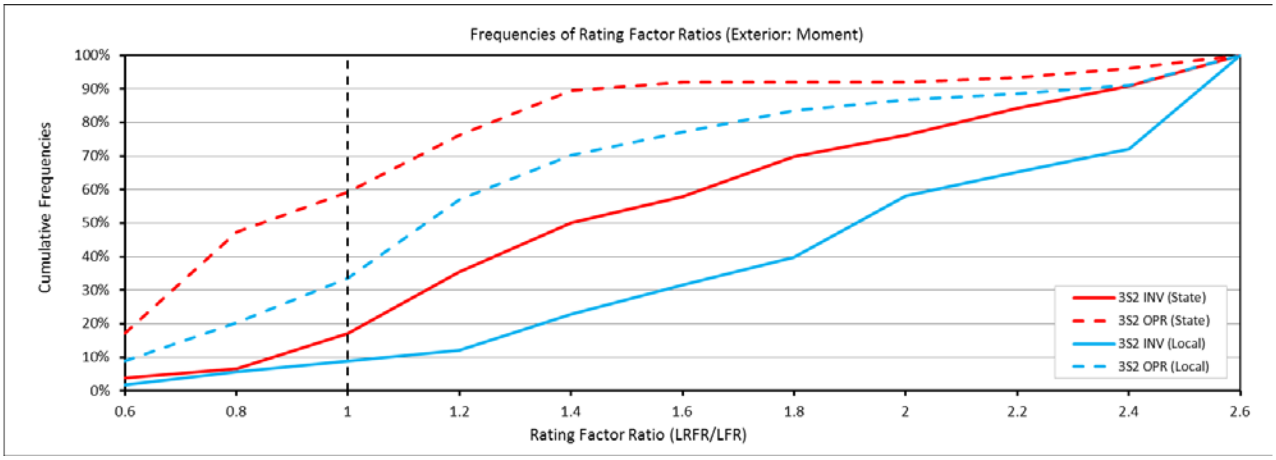



**Figure 4.13** - Cumulative frequencies of flexural legal rating factor ratios for exterior girders (Type 3S2).

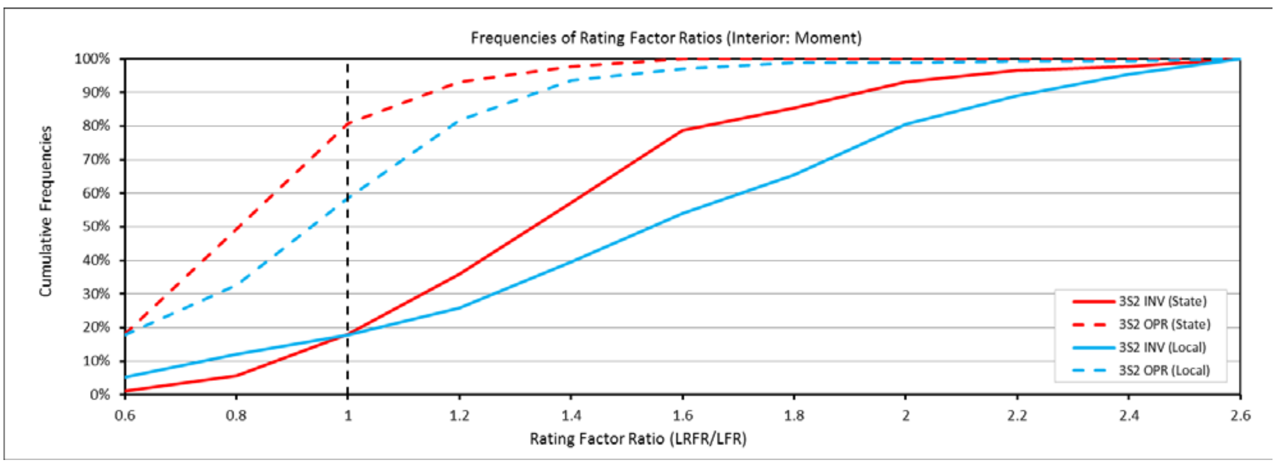



**Figure 4.14** - Cumulative frequencies of flexural legal rating factor ratios for interior girders (Type 3S2).

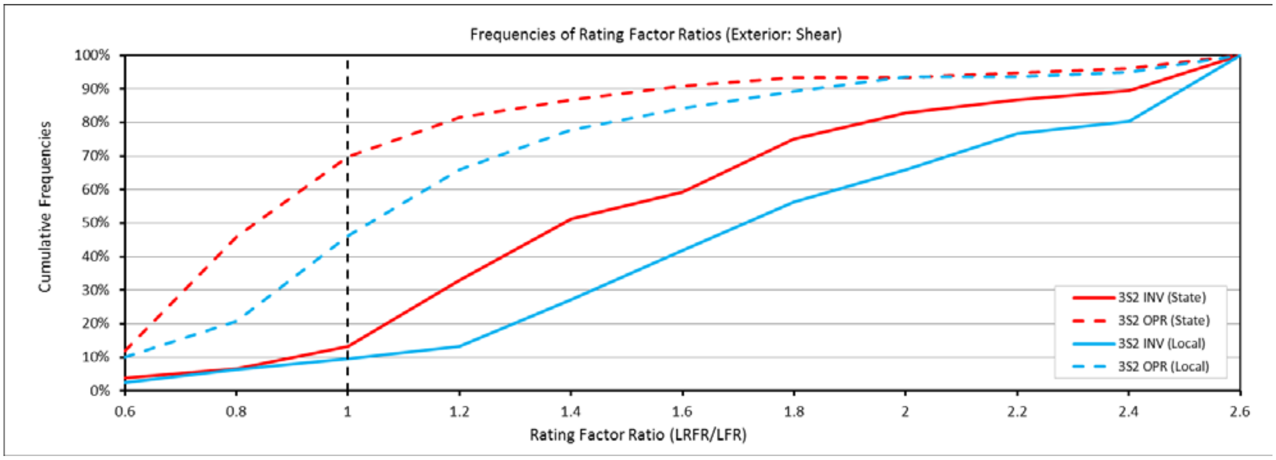



**Figure 4.15** - Cumulative frequencies of shear legal rating factor ratios for exterior girders (Type 3S2).

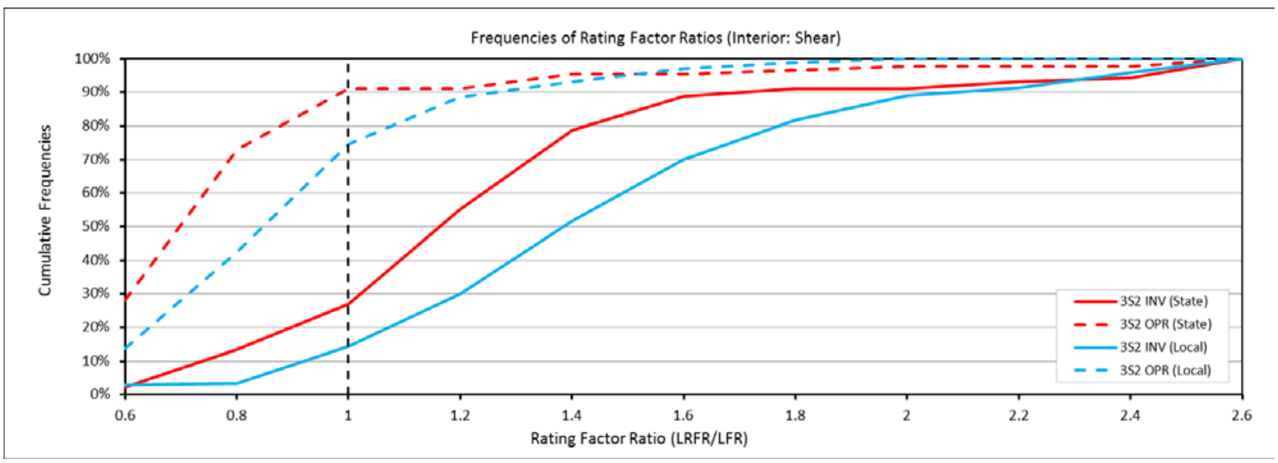



**Figure 4.16** - Cumulative frequencies of shear legal rating factor ratios for interior girders (Type 3S2).

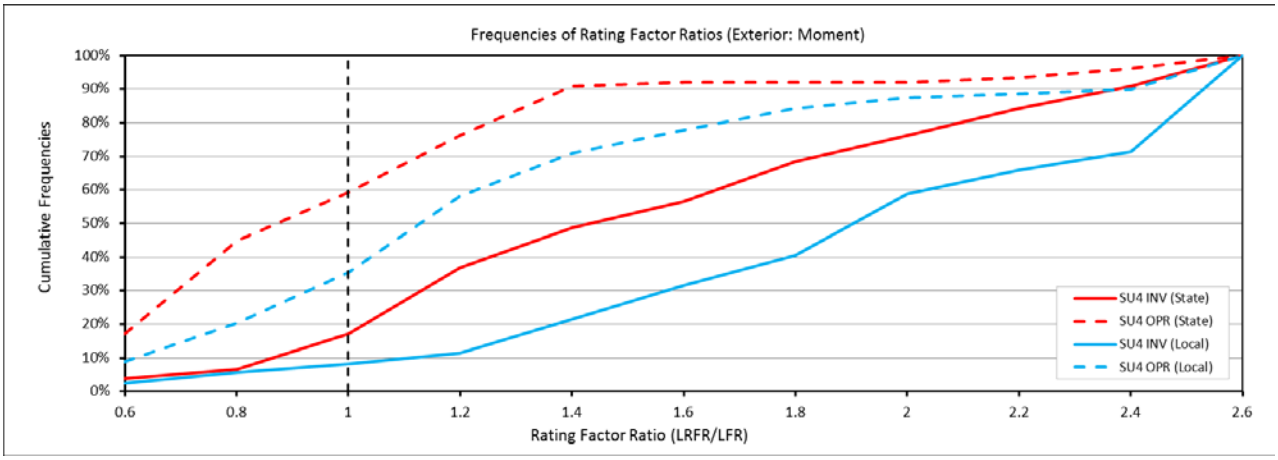



**Figure 4.17** - Cumulative frequencies of flexural legal rating factor ratios for exterior girders (SU4).

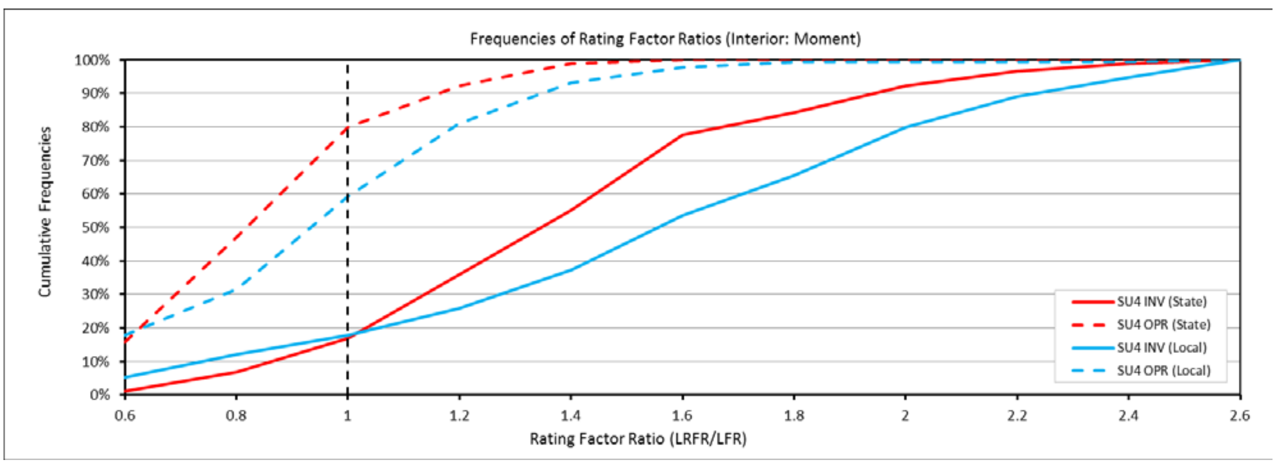



**Figure 4.18** - Cumulative frequencies of flexural legal rating factor ratios for interior girders (SU4).

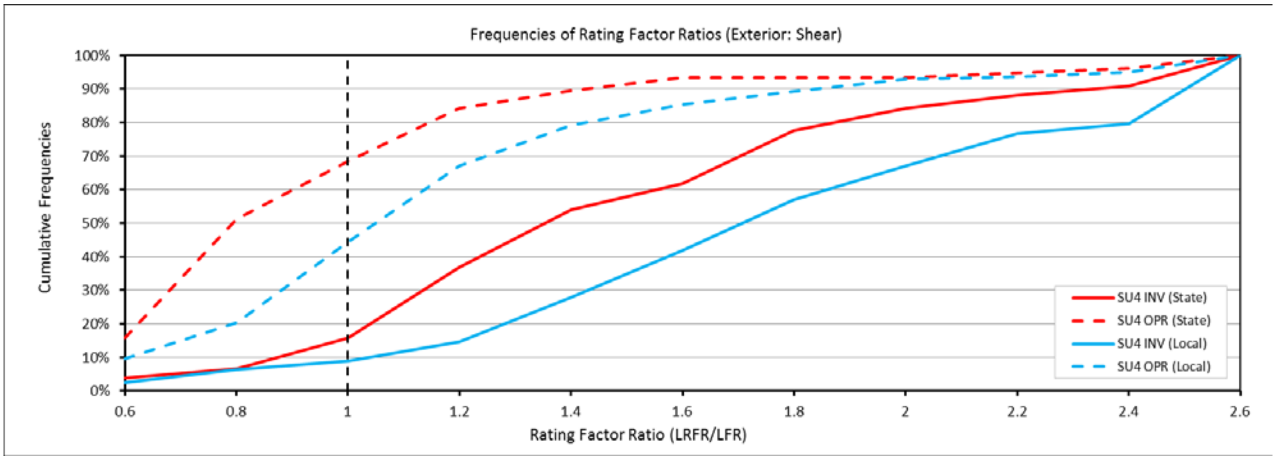



**Figure 4.19** - Cumulative frequencies of shear legal rating factor ratios for exterior girders (SU4).

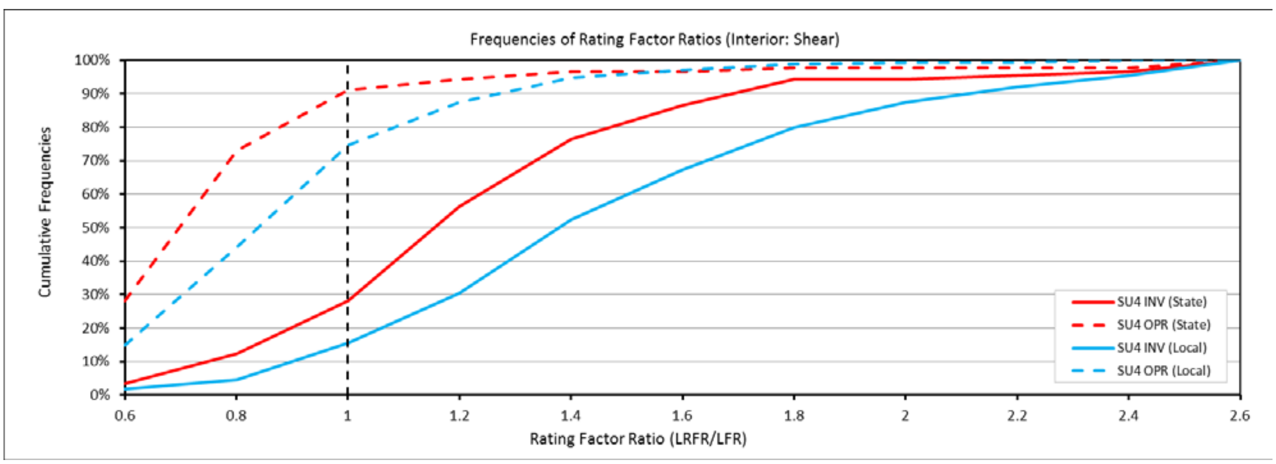



**Figure 4.20** - Cumulative frequencies of shear legal rating factor ratios for interior girders (SU4).

### 4.4 Summary of Analysis Results

Findings from the comparative analysis of legal load ratings using LRFR and LFR methodologies can be summarized as:

- For both 3S2 and SU4 legal loads, the LRFR ratings mostly yielded higher rating factors compared to the LFR inventory ratings. On contrary, at the operating level, it was observed that the LFR rating factors were generally higher than their LRFR counterparts. This result can be attributed to the higher live load factors used in the LFR methodology at the inventory level. At the operating level, the results from the local bridges were close to each other, due to similar rating factors used in both methodologies. However, for state bridges, the difference between both methodologies was more pronounced, due to higher load factors derived for state owned and interstate bridges in the LRFR methodology, reflecting the traffic patterns on these highways.
- The rating factors for exterior girders were more scattered than those for interior girders. As previously indicated in the design ratings section, this is probably a result of the application of different distribution factor methodologies.
- Moment rating factors for the Interior girders tend to control over moment rating factors for the exterior girders under the LRFR.
- Flexural rating factors predominantly controlled over shear rating factors for both LRFR and LFR methodologies.
- The ratings for shear strength were more widely scattered than those for flexure. This can be attributed to diverging shear capacity calculations in the LRFR and LFR methodologies, which especially applies to reinforced concrete and prestressed concrete bridges.
- Similar trends in the LRFR – LFR comparison were observed for both Type 3S2 and SU4 legal loads

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# 5. PERMIT LEVEL RATING RESULTS

In this section, a comparative analysis of rating results from the LRFR and LFR methodologies for NYSDOT permit loads are presented. Emphasis is given to results from the NYP 6 (Type 7) and the NYP 11 (Type 6A) vehicles since the NSYDOT R-posting analysis is based on these load models. According to the draft EI document, upstate bridges that do not have a rating factor greater than 1.0 for NYP 6 and Downstate bridges that do not have a rating factor greater than 1.0 for the NYP11 are required to be R-posted. Only a single rating factor is computed in both LFR and LRFR methodologies, where the permit analysis in the LFR methodology is based on the operating rating level. The LRFR methodology has its own set of live load factors for permit loads, calibrated for the New York State.

### 5.1 NY Permit Load NYP6

Permit load rating with the NYP6 load model determines if an upstate bridge should be R-rated or not based on the LRFR methodology. The comparison of permit rating factors based on the NYP6 load model is shown in Fig 5.1 and 5.2, for flexural and shear load effects, respectively. The plots show more scatter for exterior girders when compared to interior girders. It was observed that most of the data points lie on the left of the diagonal line, indicating that computed rating factors for LRFR are higher than the ones determined using the LFR methodology. This can be attributed to the permit live load factor used in the LRFR methodology being less than the LFR operating level live load factor used in the LFR permit analysis. The data points that lie above the vertical line shows the bridges that require R-posting. Comparing all four plots, it was observed that the bridges are more likely to require R-posting due to interior flexure load ratings. Although much more scattered compared to flexural rating results, shear ratings seem to be predominantly above the horizontal line, indicating a bridge that require R-posting due to a low shear rating is mostly unlikely. The state and local bridges produced similar results for both LRFR and LFR methodologies using the NYP6 load model.

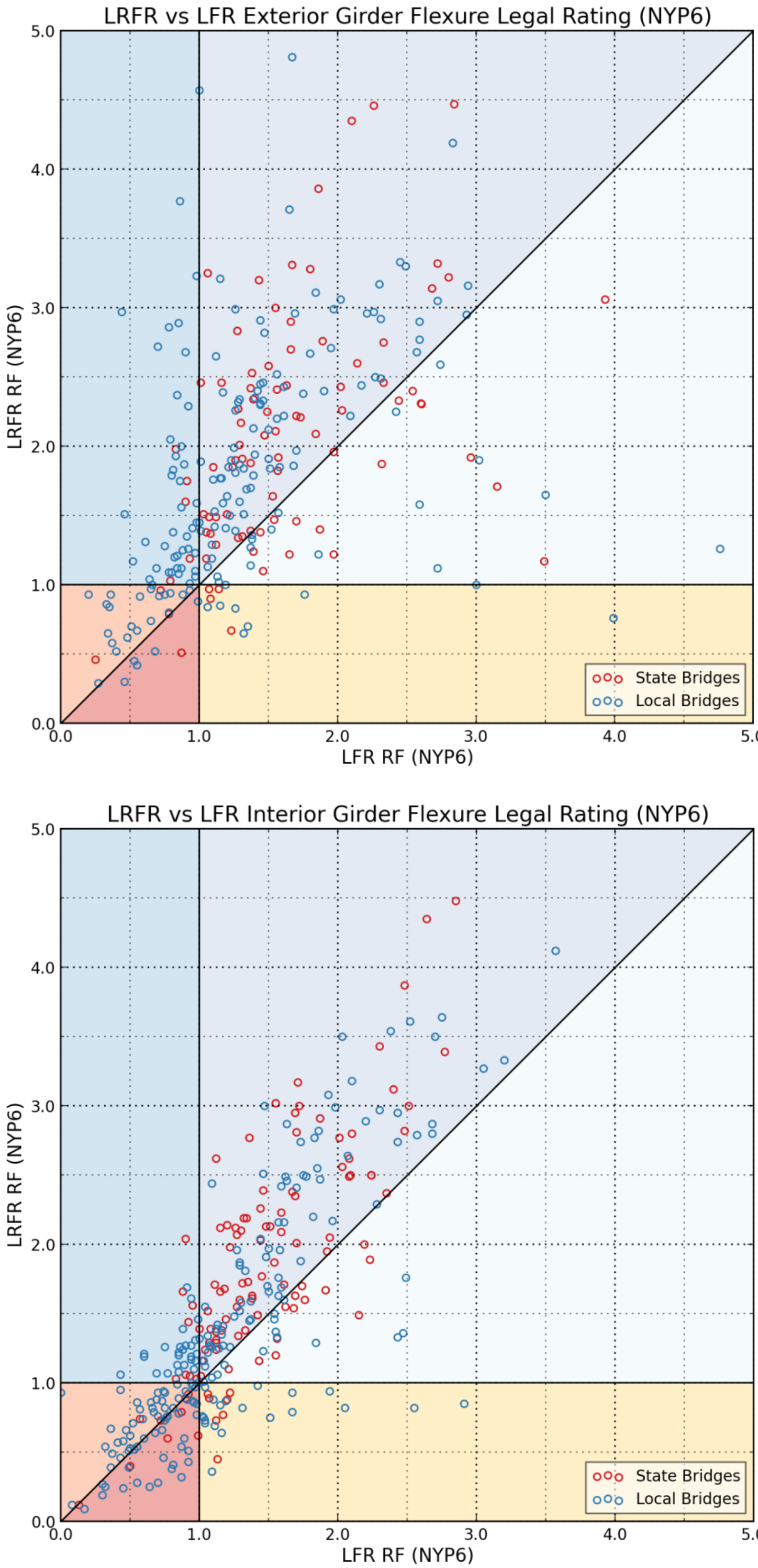
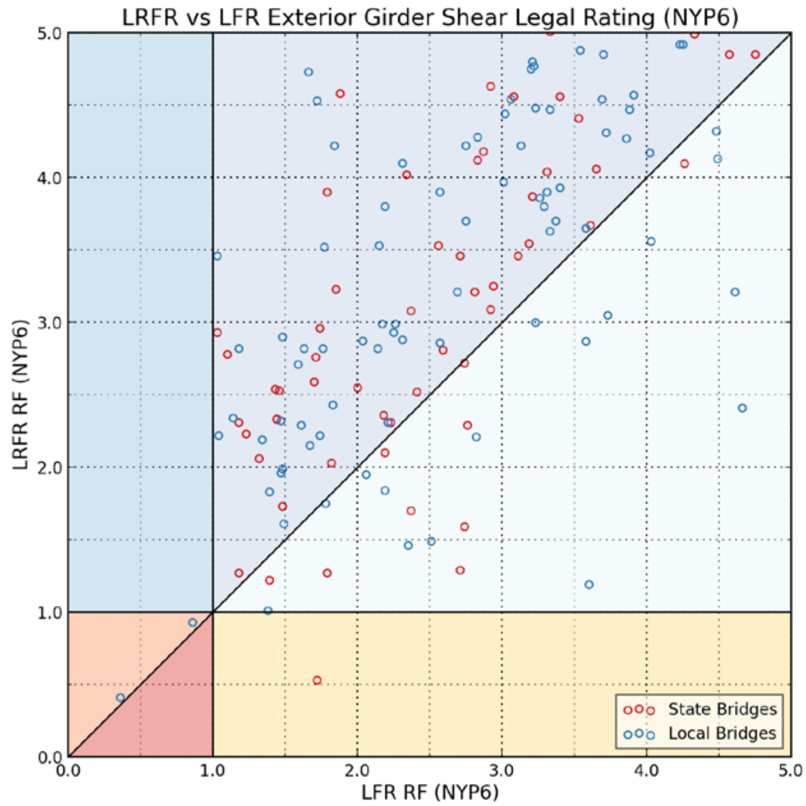



**Figure 5.1** – NYP6 Flexural rating factors compared at the permit load rating level.



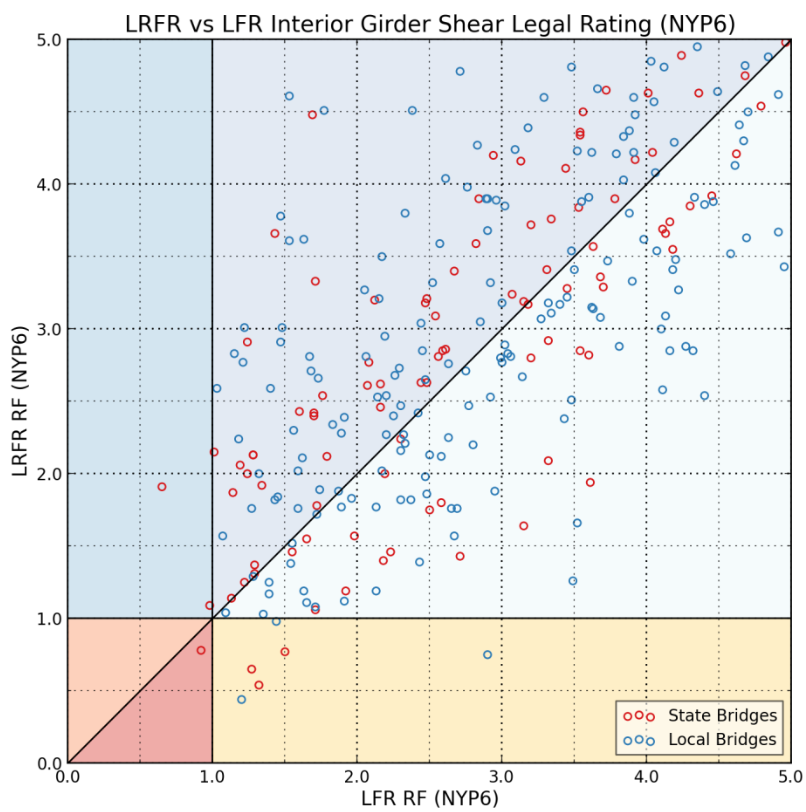
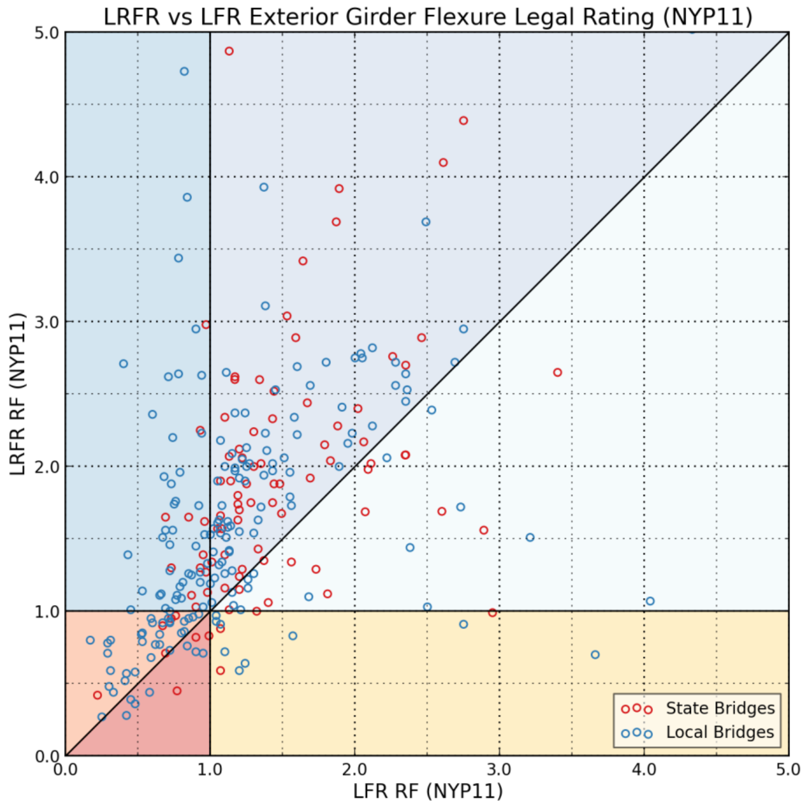




**Figure 5.2** – NYP6 Shear rating factors compared at the permit load rating level.

### 5.2 NY Permit Load NYP11

Permit load rating with the NYP11 load model determines if a downstate bridge should be R-rated or not based on the LRFR methodology. The comparison of permit rating factors based on the NYP11 load model is shown in Fig 5.3 and 5.4, for flexure and shear load effects, respectively. The plots show more scatter for exterior girders when compared to interior girders. Similar to the case in NYP6, it was observed that most of the data points lie on the left of the diagonal line, indicating that computed rating factors for LRFR are higher than the ones determined using the LFR methodology. This can be attributed to the permit live load factor used in the LRFR methodology being less than the LFR operating level live load factor used in the LFR permit analysis. The data points that lie above the vertical line shows the bridges that require R-posting. Comparing all four plots, it was observed that the bridges are more likely to require R-posting due to interior flexure load ratings. Although much more scattered compared to flexural rating results, shear ratings seem to be predominantly above the horizontal line, indicating a bridge that require R-posting due to a low shear rating is mostly unlikely. The state and local bridges produced similar results for both LRFR and LFR methodologies using the NYP11 load model.



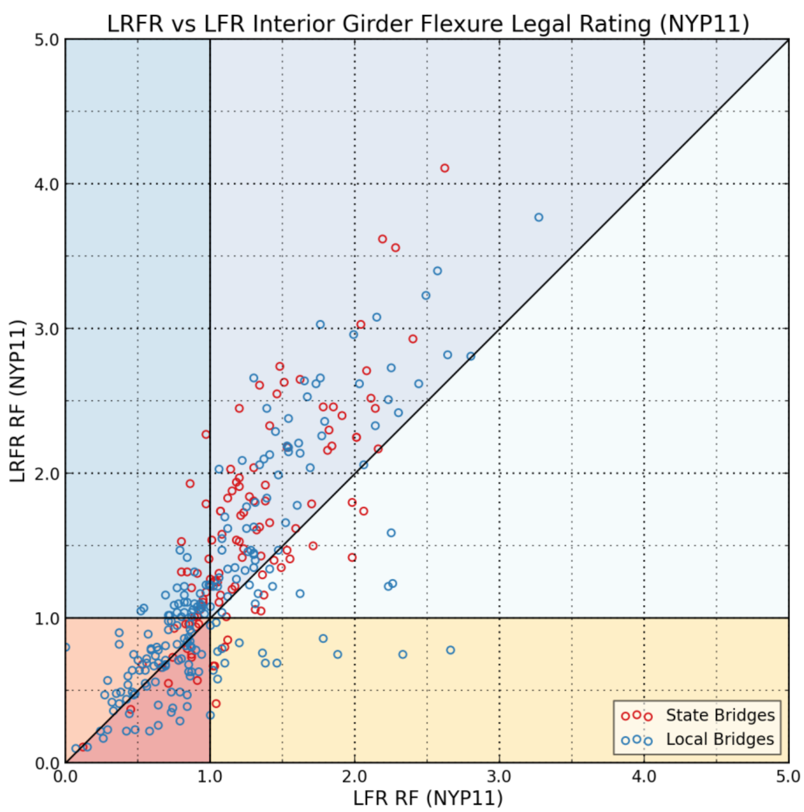
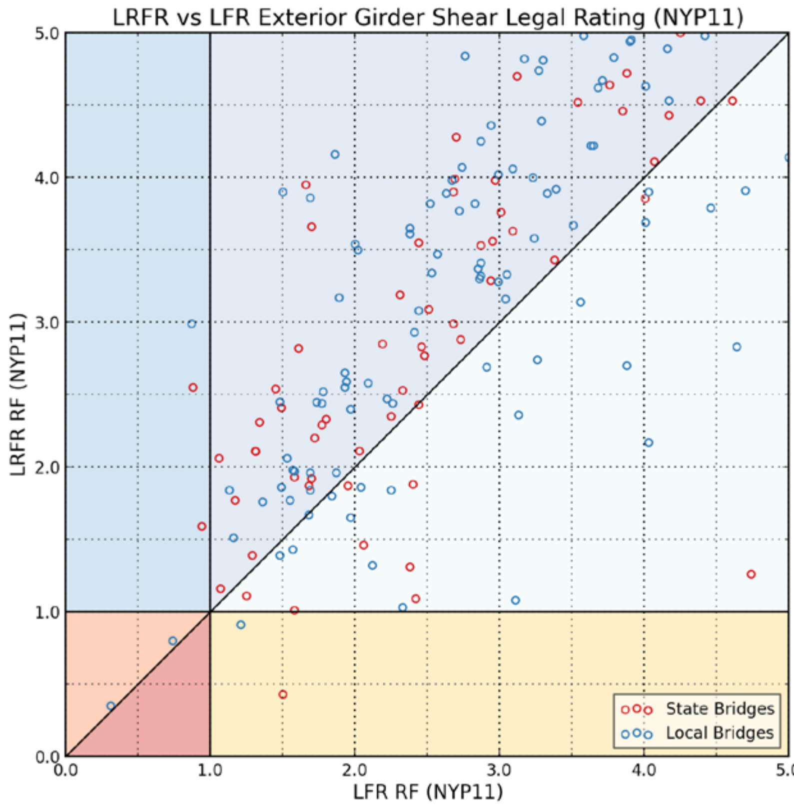




**Figure 5.3** – NYP11 Flexural rating factors compared at the permit load rating level.



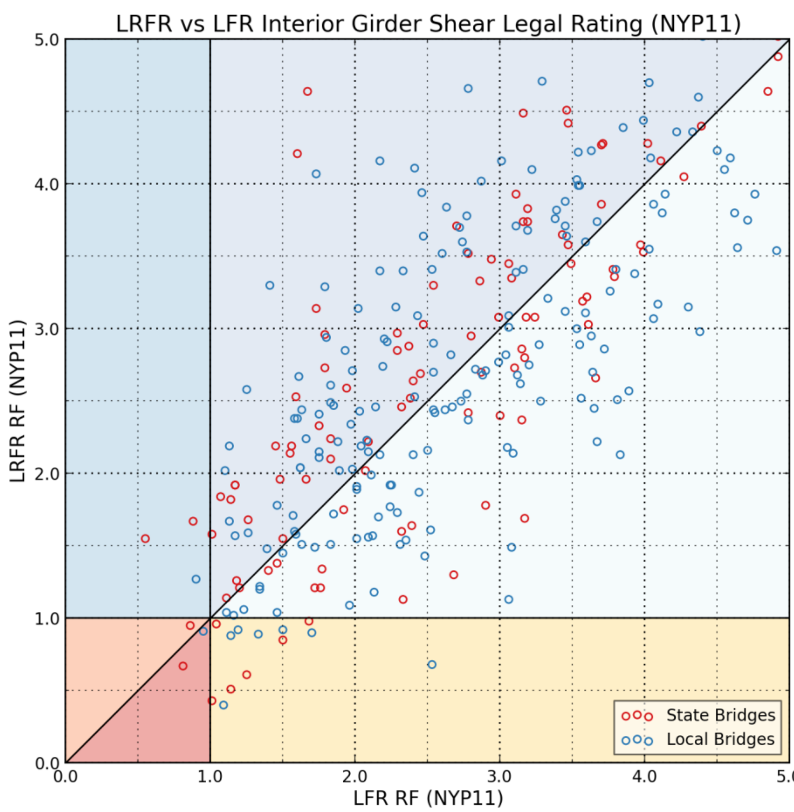




**Figure 5.4** – NYP11 Shear rating factors compared at the permit load rating level.

### 5.3 Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions

The legal rating factor ratio (LRFR/LFR) frequency distributions for flexural and shear load effects are tabulated in Table 5.1 and Table 5.2, respectively for the NYP6 and NYP11 legal load models. This is followed by the cumulative frequency distributions given in Table 5.3 and Table 5.4. In addition, the cumulative frequencies that correspond to the LRFR/LFR < 1.0 boundary is highlighted in Tables 5.3 and 5.4. At the highlighted row, a value less than 50.0% indicates the LRFR methodology yields higher rating factors than the LFR methodology for more than half of the bridges. The number of bridges in the inventory having a LRFR/LFR rating factor ratio less than 1.0 is given in Table 5.5.

It is possible to visualize the cumulative frequency tables using cumulative frequency plots for easier interpretation of the comparative rating results. Such plots were constructed for moment and shear load effects at the interior and exterior members, as shown in Figs. 5.5 to 5.10.

**Table 5.1 –** Rating Factor Ratio (LRFR/LFR) Frequency Distributions for NYP6

| Permit Load RF Ratio Frequency Distributions (NYP6) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | - | 5.2 | - | 4.8 | - | 0.9 | - | 10.3 | - | 4.2 | - | 5.3 | - | 5.4 | - | 4.4 |
| 0.6 - 0.8 | - | 5.2 | - | 5.9 | - | 8.1 | - | 9.4 | - | 4.2 | - | 4.3 | - | 9.9 | - | 14.8 |
| 0.8 - 1.0 | - | 15.6 | - | 7.0 | - | 15.3 | - | 12.8 | - | 6.3 | - | 8.0 | - | 21.6 | - | 27.6 |
| 1.0 - 1.2 | - | 14.6 | - | 15.5 | - | 25.2 | - | 23.6 | - | 21.9 | - | 18.7 | - | 27.0 | - | 24.1 |
| 1.2 - 1.4 | - | 16.7 | - | 20.3 | - | 19.8 | - | 21.2 | - | 19.8 | - | 20.9 | - | 14.4 | - | 13.3 |
| 1.4 -1.6 | - | 12.5 | - | 14.4 | - | 12.6 | - | 15.3 | - | 12.5 | - | 17.1 | - | 7.2 | - | 4.9 |
| 1.6 - 1.8 | - | 9.4 | - | 9.6 | - | 11.7 | - | 3.0 | - | 11.5 | - | 8.0 | - | 5.4 | - | 3.4 |
| 1.8 - 2.0 | - | 7.3 | - | 2.7 | - | 3.6 | - | 1.5 | - | 4.2 | - | 3.2 | - | 1.8 | - | 2.0 |
| 2.0 - 2.2 | - | 3.1 | - | 2.7 | - | 0.9 | - | 1.0 | - | 5.2 | - | 3.7 | - | 0.9 | - | 0.5 |
| 2.2 - 2.4 | - | 3.1 | - | 4.8 | - | 1.8 | - | 1.0 | - | 0.0 | - | 1.6 | - | 0.9 | - | 2.0 |
| >2.40 | - | 7.3 | - | 12.3 | - | 0.0 | - | 1.0 | - | 10.4 | - | 9.1 | - | 5.4 | - | 3.0 |

**Table 5.2 –** Rating Factor Ratio (LRFR/LFR) Frequency Distributions for NYP11

| Permit Load RF Ratio Frequency Distributions (NYP11) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | - | 5.2 | - | 4.8 | - | 0.9 | - | 9.9 | - | 4.2 | - | 5.3 | - | 7.2 | - | 4.4 |
| 0.6 - 0.8 | - | 5.2 | - | 5.9 | - | 7.2 | - | 9.9 | - | 4.2 | - | 4.3 | - | 9.9 | - | 16.3 |
| 0.8 - 1.0 | - | 14.6 | - | 7.0 | - | 17.1 | - | 12.8 | - | 6.3 | - | 9.6 | - | 22.5 | - | 28.1 |
| 1.0 - 1.2 | - | 14.6 | - | 16.6 | - | 23.4 | - | 23.6 | - | 21.9 | - | 19.3 | - | 27.0 | - | 24.1 |
| 1.2 - 1.4 | - | 16.7 | - | 18.7 | - | 20.7 | - | 22.2 | - | 22.9 | - | 22.5 | - | 15.3 | - | 13.3 |
| 1.4 -1.6 | - | 13.5 | - | 14.4 | - | 12.6 | - | 13.8 | - | 11.5 | - | 16.6 | - | 6.3 | - | 6.9 |
| 1.6 - 1.8 | - | 9.4 | - | 9.6 | - | 11.7 | - | 3.4 | - | 10.4 | - | 7.5 | - | 4.5 | - | 3.0 |
| 1.8 - 2.0 | - | 7.3 | - | 3.2 | - | 3.6 | - | 2.0 | - | 3.1 | - | 2.1 | - | 2.7 | - | 2.0 |
| 2.0 - 2.2 | - | 3.1 | - | 2.7 | - | 0.9 | - | 1.0 | - | 5.2 | - | 2.7 | - | 0.0 | - | 0.5 |
| 2.2 - 2.4 | - | 3.1 | - | 4.3 | - | 1.8 | - | 0.5 | - | 1.0 | - | 2.1 | - | 0.0 | - | 1.5 |
| >2.40 | - | 7.3 | - | 12.8 | - | 0.0 | - | 1.0 | - | 9.4 | - | 8.0 | - | 4.5 | - | 0.0 |

**Table 5.3 –** Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions for NYP6

| Permit Load RF Ratio Frequency Distributions (NYP6) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | - | 5.2 | - | 4.8 | - | 0.9 | - | 10.3 | - | 4.2 | - | 5.3 | - | 5.4 | - | 4.4 |
| 0.6 - 0.8 | - | 10.4 | - | 10.7 | - | 9.0 | - | 19.7 | - | 8.3 | - | 9.6 | - | 15.3 | - | 19.2 |
| 0.8 - 1.0 | - | 26.0 | - | 17.6 | - | 24.3 | - | 32.5 | - | 14.6 | - | 17.6 | - | 36.9 | - | 46.8 |
| 1.0 - 1.2 | - | 40.6 | - | 33.2 | - | 49.5 | - | 56.2 | - | 36.5 | - | 36.4 | - | 64.0 | - | 70.9 |
| 1.2 - 1.4 | - | 57.3 | - | 53.5 | - | 69.4 | - | 77.3 | - | 56.3 | - | 57.2 | - | 78.4 | - | 84.2 |
| 1.4 -1.6 | - | 69.8 | - | 67.9 | - | 82.0 | - | 92.6 | - | 68.8 | - | 74.3 | - | 85.6 | - | 89.2 |
| 1.6 - 1.8 | - | 79.2 | - | 77.5 | - | 93.7 | - | 95.6 | - | 80.2 | - | 82.4 | - | 91.0 | - | 92.6 |
| 1.8 - 2.0 | - | 86.5 | - | 80.2 | - | 97.3 | - | 97.0 | - | 84.4 | - | 85.6 | - | 92.8 | - | 94.6 |
| 2.0 - 2.2 | - | 89.6 | - | 82.9 | - | 98.2 | - | 98.0 | - | 89.6 | - | 89.3 | - | 93.7 | - | 95.1 |
| 2.2 - 2.4 | - | 92.7 | - | 87.7 | - | 100 | - | 99.0 | - | 89.6 | - | 90.9 | - | 94.6 | - | 97.0 |
| >2.40 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 |

**Table 5.4 –** Rating Factor Ratio (LRFR/LFR) Cumulative Frequency Distributions for NYP11

| Permit Load RF Ratio Frequency Distributions (NYP11) | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RF | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| <=0.60 | - | 5.2 | - | 4.8 | - | 0.9 | - | 9.9 | - | 4.2 | - | 5.3 | - | 7.2 | - | 4.4 |
| 0.6 - 0.8 | - | 10.4 | - | 10.7 | - | 8.1 | - | 19.7 | - | 8.3 | - | 9.6 | - | 17.1 | - | 20.7 |
| 0.8 - 1.0 | - | 25.0 | - | 17.6 | - | 25.2 | - | 32.5 | - | 14.6 | - | 19.3 | - | 39.6 | - | 48.8 |
| 1.0 - 1.2 | - | 39.6 | - | 34.2 | - | 48.6 | - | 56.2 | - | 36.5 | - | 38.5 | - | 66.7 | - | 72.9 |
| 1.2 - 1.4 | - | 56.3 | - | 52.9 | - | 69.4 | - | 78.3 | - | 59.4 | - | 61.0 | - | 82.0 | - | 86.2 |
| 1.4 -1.6 | - | 69.8 | - | 67.4 | - | 82.0 | - | 92.1 | - | 70.8 | - | 77.5 | - | 88.3 | - | 93.1 |
| 1.6 - 1.8 | - | 79.2 | - | 77.0 | - | 93.7 | - | 95.6 | - | 81.3 | - | 85.0 | - | 92.8 | - | 96.1 |
| 1.8 - 2.0 | - | 86.5 | - | 80.2 | - | 97.3 | - | 97.5 | - | 84.4 | - | 87.2 | - | 95.5 | - | 98.0 |
| 2.0 - 2.2 | - | 89.6 | - | 82.9 | - | 98.2 | - | 98.5 | - | 89.6 | - | 89.8 | - | 95.5 | - | 98.5 |
| 2.2 - 2.4 | - | 92.7 | - | 87.2 | - | 100 | - | 99.0 | - | 90.6 | - | 92.0 | - | 95.5 | - | 100 |
| >2.40 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 | - | 100 |

**Table 5.5 –** Number of Bridges with Design Rating Factor Ratio LRFR/LFR <=1.0

| Load Model | Exterior Moment [%] | | | | Interior Moment [%] | | | | Exterior Shear [%] | | | | Interior Shear [%] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | State | | Local | | State | | Local | | State | | Local | | State | | Local | |
| | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR | INV | OPR |
| NYP6 | - | 25 | - | 33 | - | 27 | - | 66 | - | 14 | - | 33 | - | 41 | - | 95 |
| NYP11 | - | 24 | - | 33 | - | 28 | - | 66 | - | 14 | - | 36 | - | 7 | - | 99 |

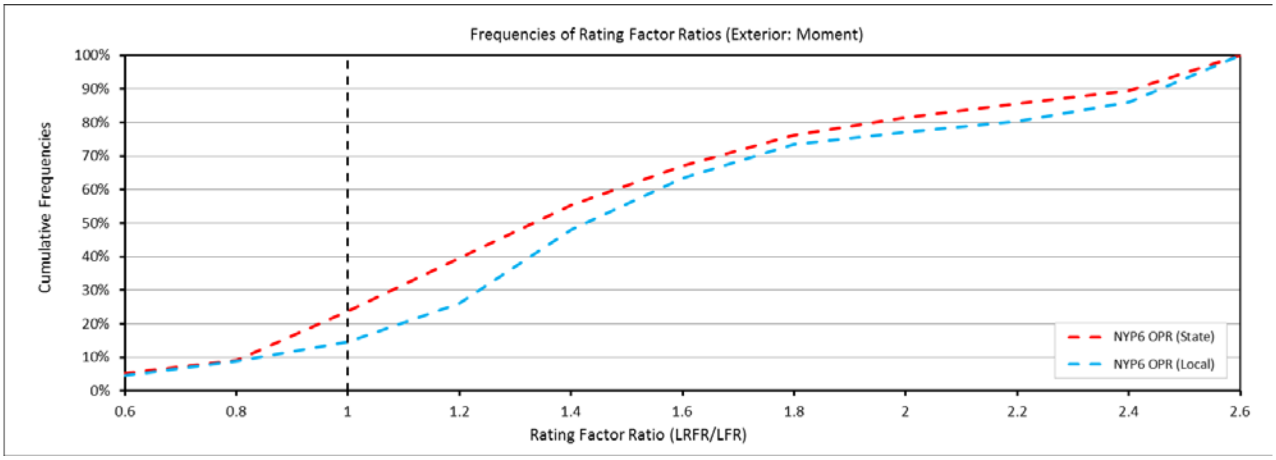



**Figure 5.5** - Cumulative frequencies of flexural permit rating factor ratios for exterior girders (NYP6).

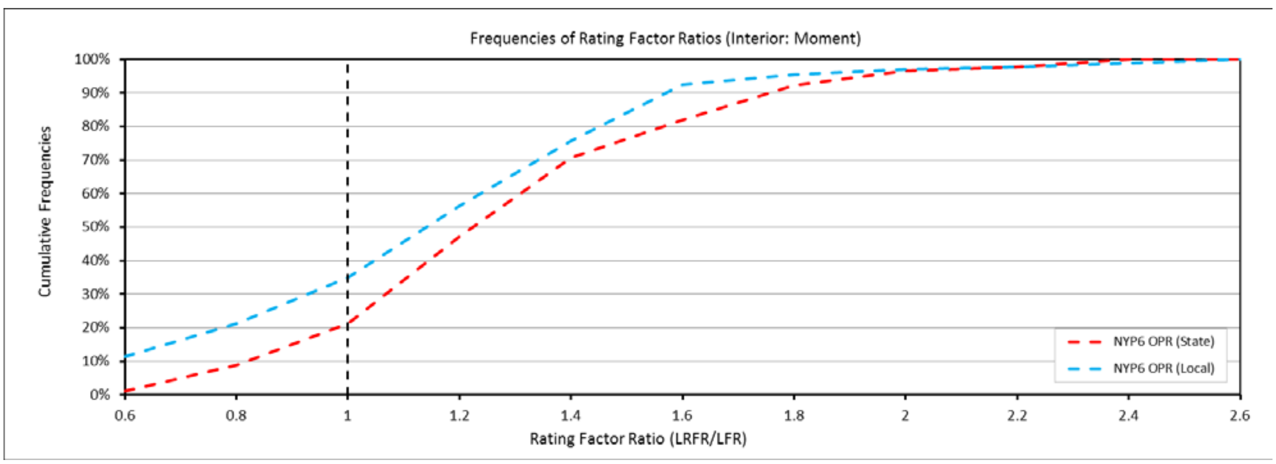



**Figure 5.6** - Cumulative frequencies of flexural permit rating factor ratios for interior girders (NYP6).

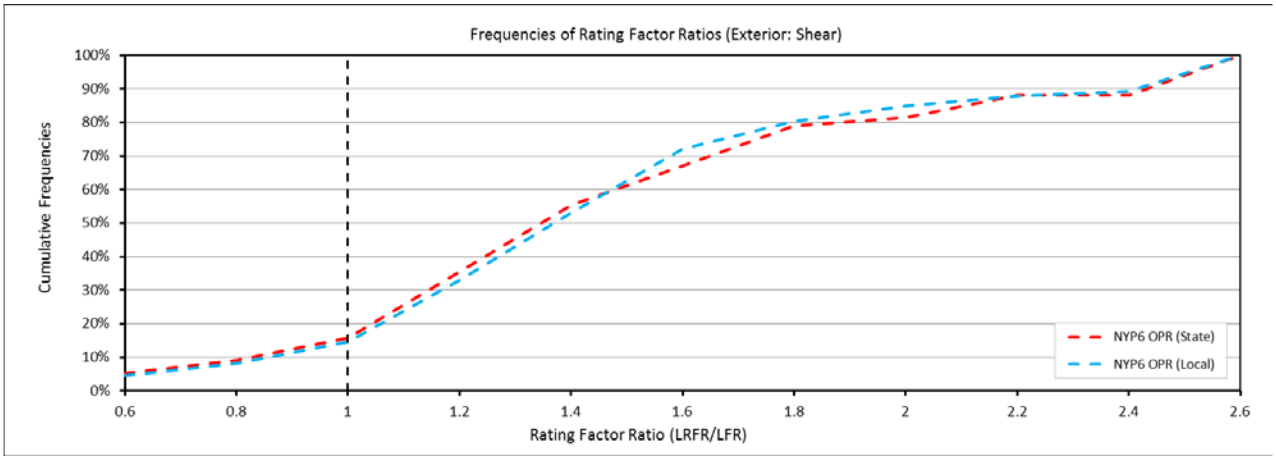



**Figure 5.7** - Cumulative frequencies of shear permit rating factor ratios for exterior girders (NYP6).

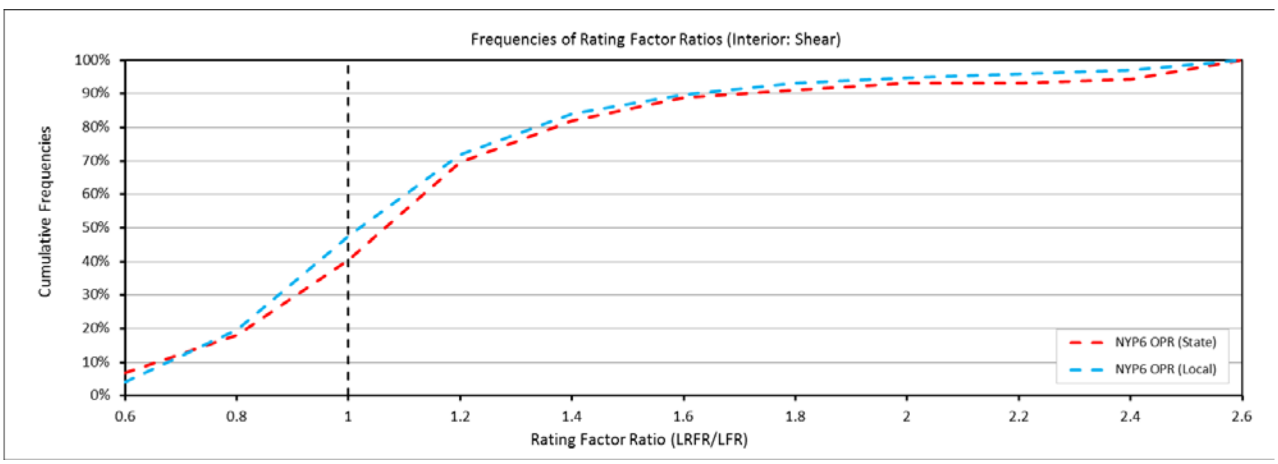



**Figure 5.8** - Cumulative frequencies of shear permit rating factor ratios for interior girders (NYP6).

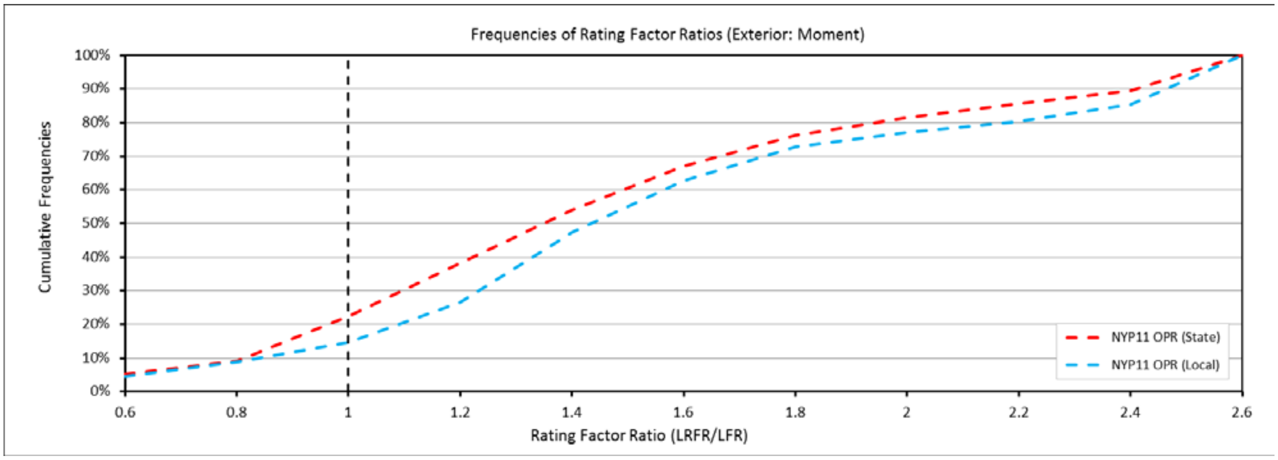



**Figure 5.9** - Cumulative frequencies of flexural permit rating factor ratios for exterior girders (NYP11).

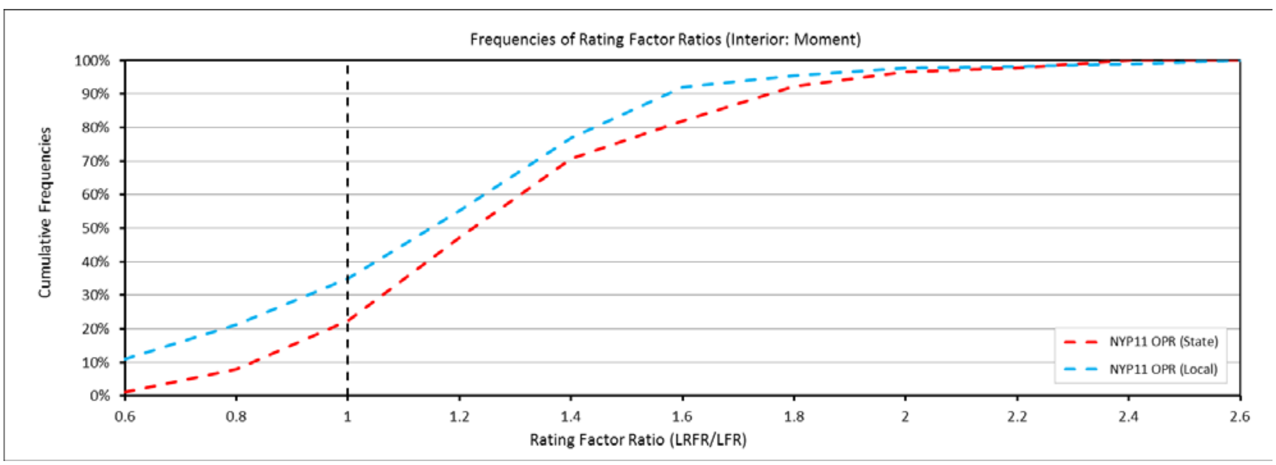



**Figure 5.10** - Cumulative frequencies of flexural permit rating factor ratios for interior girders (NYP11).

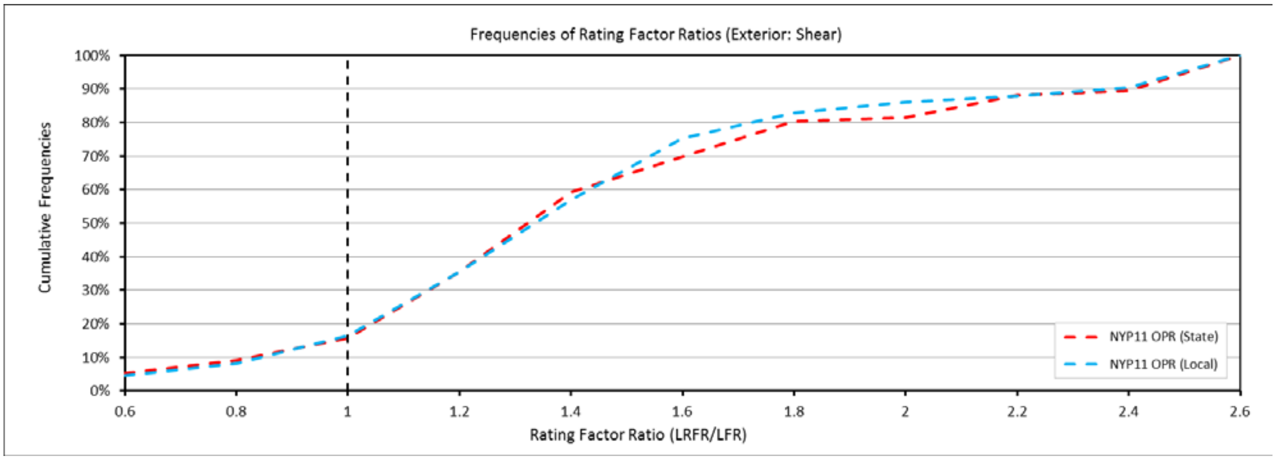



**Figure 5.10** - Cumulative frequencies of shear permit rating factor ratios for exterior girders (NYP11).

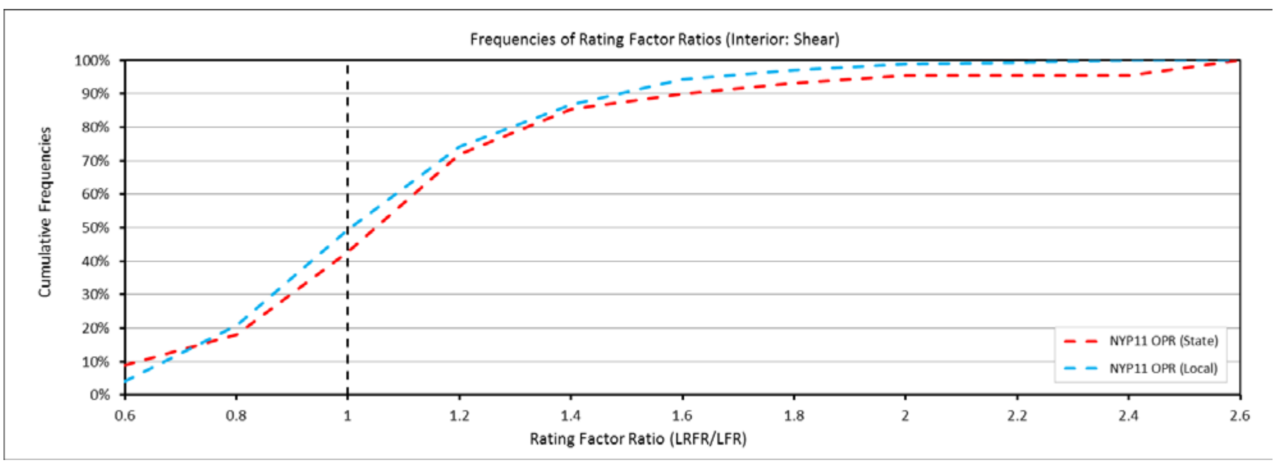



**Figure 5.10** - Cumulative frequencies of shear permit rating factor ratios for interior girders (NYP11).

### 5.4 Summary of Analysis Results

Findings from the comparative analysis of permit load ratings using LRFR and LFR methodologies can be summarized as:

- For both NYP6 and NYP11 legal loads, the LRFR permit ratings mostly yielded higher rating factors compared to the LFR permit ratings based on the operating level. This result can be attributed to the slightly higher live load factors used in the LFR methodology, as well as the allowance to decrease the LRFR impact factor in permit ratings.
- The rating factors for exterior girders were more scattered than those for interior girders. As previously indicated in the design and legal rating sections, this is probably a result of the differences in the distribution factor calculations.
- Moment rating factors for the Interior girders tend to control over moment rating factors for the exterior girders under the LRFR.
- Flexural rating factors predominantly controlled over shear rating factors for both LRFR and LFR methodologies. Thus, when a bridge requires R-posting, this is most likely due to flexure rather than shear.
- The ratings for shear strength were more widely scattered than those for flexure. This can be attributed to diverging shear capacity calculations in the LRFR and LFR methodologies, which especially applies to reinforced concrete and prestressed concrete bridges.
- Similar trends in the LRFR – LFR comparison were observed for both NYP6 and NYP11 permit loads.
- The state and local bridges produced similar results for the LRFR and the LFR methodologies.

# 6. LOAD POSTING AND R-POSTING ANALYSIS RESULTS

## 6.1 Introduction

This section compares load posting and R-posting analysis results based on the LFR and LRFR methodologies. The intention is to investigate NY bridges using current NYSDOT LFR procedures (EI 05-034) and the proposed LRFR procedures contained in the draft EI document. Current NYSDOT LFR procedures require Level 1 load rating and field investigation results for a permanent posting decision to be made. However, the EI 05-034 document indicates that "Level 2 ratings may be used to assign interim load restrictions to a deficient bridge until a Level 1 load rating can be undertaken." Load posting results presented in this section are all determined through Level 2 ratings using the VIRTIS software. R-postings are intended to keep most overloads from using bridges that, through design or deterioration, do not have the reserve capacity to accommodate most overload permit vehicles, but are still capable of safely carrying legal loads. R-posting results presented in this section are also determined through Level 2 ratings using the VIRTIS software.

## 6.2 Load Posting of NY Bridges

NBIS regulations (23 CFR Part 650) require the load rating of each bridge as to its safe loading capacity in accordance with the AASHTO MBE and the posting of the bridge in accordance with state law, when the maximum unrestricted legal loads or state routine permit loads exceed that allowed under the operating rating. When a bridge is found to be unsatisfactory for the LFR operating rating level or the LRFR legal load level, load posting of the bridge may be necessary. The procedure for load posting bridges differs between the LFR and LRFR philosophies.

For LFR, NYSDOT EI 05-034 recommends that Section 5 be followed for the determination of load posting. Under the guidance given in Section 5, the rating factor for a type of vehicle can be converted into equivalent H inventory and operating ratings, which in turn are used to determine the Safe Load Capacity (SLC). Load posting is required if the SLC for a given span is less than the H equivalent rating of a legal load. The maximum Legal Truck load effect on a bridge will produce different equivalent H rating values depending on the span length.

The LRFR methodology in the draft EI provides a more structured format for load posting than the LFR. The recommended posting procedure outlined in the LRFR calls for bridges to be rated at the legal load level under the legal load truck in question. The two recommended AASHTO legal loads are specified for NY bridges: SU-4 single unit truck or 3-S2 semi-trailer truck. As mentioned previously, if the legal load vehicle provides a rating factor greater than or equal to 1.0, the bridge does not need to be load posted. However when for any Legal Load the RF is between 0.3 and 1.0, then the following equation should be used to establish the LRFR posting load:

$$\text{Safe Posting Load} = W[RF + 0.00375(L - 110)(1 - RF)]$$

where:

$W$ : Weight of the Posting Vehicle (SU4 = 27 tons, 3S2 = 36 tons)

$RF$ : Rating Factor

$L$ : Effective Span Length in feet

When the RF for any vehicle type falls below 0.3, then a recommendation should be made to not allow that particular vehicle type on the bridge. Other vehicle types with RF > 0.3 may continue to use the bridge. Bridges that are determined not capable of carrying 3 tons shall be closed.

The naming convention used in the tables and plots for different superstructure types is tabulated in Table 6.1. Load Posting results for the bridge inventory used in this study, from the LRFR and the LFR methodologies are listed in Table 6.2. Table 6.2 also includes bridge closure information. Table 6.3 lists the load posting and bridge closure frequencies for different superstructure types.

**Table 6.1 –** Naming convention for Superstructure Types

| Superstructure Type | Abbreviation |
|---|---|
| Concrete Slab | RCS |
| Concrete T-Beam | RCT |
| Box Beam P/S Multi-Girder | PSB |
| Simple Span P/S Multi-Girder | PMGS |
| Continuous P/S Span Multi-Girder | PMGC |
| Simple Span Steel Multi-Girder | SMGS |
| Continuous Span Steel Multi-Girder | SMGC |

**Table 6.2 –** Load Posting/Closure Results for State and Local Bridges by Superstructure Type

| Bridge Type | Owner | LFR Load Rating | | LRFR Load Rating | | | | Total # of Bridges in the Inventory |
|---|---|---|---|---|---|---|---|---|
| | | | | Type 3S2 | | SU4 | | |
| | | Posting | Closed | Posting | Closed | Posting | Closed | |
| RCS | State | 0 | 0 | 0 | 0 | 2 | 0 | 15 |
| | Local | 7 | 0 | 3 | 1 | 5 | 1 | 14 |
| RCT | State | 4 | 0 | 7 | 0 | 10 | 0 | 14 |
| | Local | 2 | 0 | 1 | 0 | 2 | 0 | 11 |
| PSB | State | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| | Local | 0 | 0 | 0 | 0 | 0 | 0 | 14 |
| PMGS | State | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| | Local | 0 | 1 | 1 | 1 | 1 | 1 | 7 |
| PMGC | State | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | Local | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| SMGS | State | 2 | 0 | 7 | 1 | 11 | 1 | 47 |
| | Local | 59 | 1 | 39 | 1 | 57 | 6 | 143 |
| SMGC | State | 4 | 0 | 3 | 0 | 2 | 0 | 13 |
| | Local | 2 | 0 | 0 | 0 | 0 | 0 | 7 |
| **Total** | **State** | **10** | **0** | **17** | **1** | **25** | **1** | **111** |
| | **Local** | **70** | **2** | **44** | **3** | **65** | **8** | **203** |
| | **Total** | **80** | **2** | **61** | **4** | **90** | **9** | **314** |

**Table 6.3 –** Load Posting/Closure Percentages for State and Local Bridges by Superstructure Type

| Bridge Type | Owner | LFR Load Rating | | LRFR Load Rating | | | | Total # of Bridges in the Inventory |
|---|---|---|---|---|---|---|---|---|
| | | | | Type 3S2 | | SU4 | | |
| | | Posting % | Closed % | Posting % | Closed % | Posting % | Closed % | |
| RCS | State | 0.0 | 0.0 | 0.0 | 0.0 | 13.3 | 0.0 | 15 |
| | Local | 50.0 | 0.0 | 21.4 | 7.1 | 35.7 | 7.1 | 14 |
| RCT | State | 28.6 | 0.0 | 50.0 | 0.0 | 71.4 | 0.0 | 14 |
| | Local | 18.2 | 0.0 | 9.1 | 0.0 | 18.2 | 0.0 | 11 |
| PSB | State | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 10 |
| | Local | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 14 |
| PMGS | State | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 12 |
| | Local | 0.0 | 14.3 | 14.3 | 14.3 | 14.3 | 14.3 | 7 |
| PMGC | State | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | Local | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7 |
| SMGS | State | 4.3 | 0.0 | 14.9 | 2.1 | 23.4 | 2.1 | 47 |
| | Local | 41.3 | 0.7 | 27.3 | 0.7 | 39.9 | 4.2 | 143 |
| SMGC | State | 30.8 | 0.0 | 23.1 | 0.0 | 15.4 | 0.0 | 13 |
| | Local | 28.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 7 |
| **Total** | **State** | 9.0 | 0.0 | 15.3 | 0.9 | 22.5 | 0.9 | **111** |
| | **Local** | 34.5 | 1.0 | 21.7 | 1.5 | 32.0 | 3.9 | **203** |
| | **Total** | 25.5 | 0.6 | 19.4 | 1.3 | 28.7 | 2.9 | **314** |

The naming convention used in the tables and plots for different superstructure types is tabulated in Table 6.1. Load Posting results for the bridge inventory used in this study, from the LRFR and the LFR methodologies are listed in Table 6.2. Table 6.2 also includes bridge closure information. Table 6.3 lists the load posting and bridge closure frequencies for different superstructure types.

When both state and local bridges considered all together, it was seen that 25.5% of the bridges required load posting when rated using the LFR methodology, whereas 19.4% and 28.7% of the bridges required load posting when rated using the LRFR methodology, for Type 3S2 and SU4 loads, respectively.

When only state bridges were taken into consideration, it was seen that 9.0% of the bridges required load posting when rated using the LFR methodology, whereas 15.3% and 22.5% of the bridges required load posting when rated using the LRFR methodology, for Type 3S2 and SU4 loads, respectively. Similarly, when only local bridges were considered, it was seen that 34.5% of the bridges required load posting when rated using the LFR methodology, whereas 21.7% and 32.0% of the bridges required load posting when rated using the LRFR methodology, for Type 3S2 and SU4 loads, respectively. Posting analysis comparisons for local, state and all bridges is illustrated in Fig. 6.1.

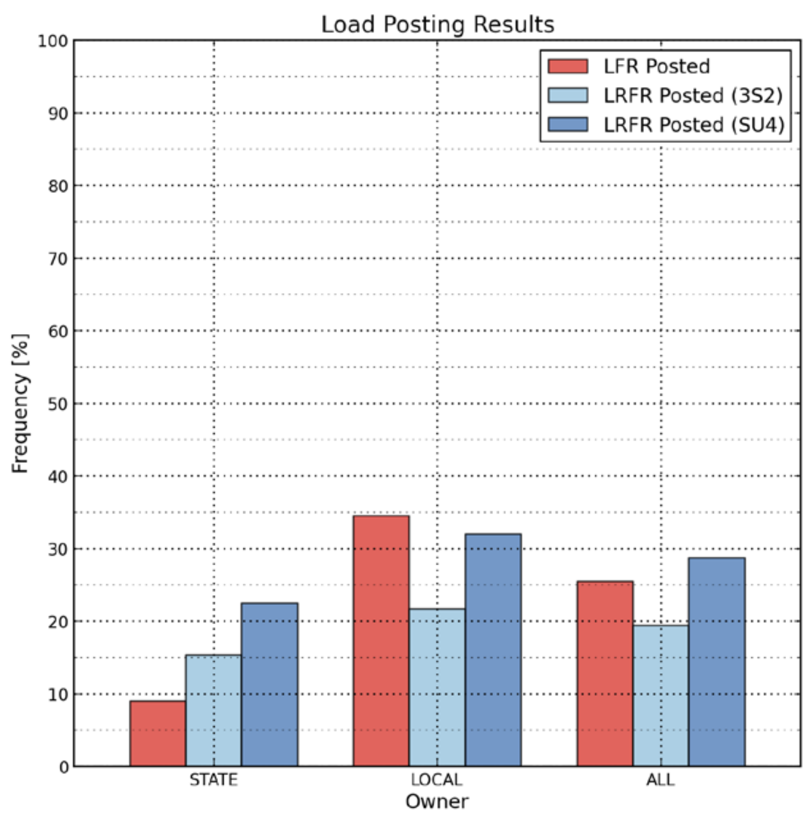



**Figure 6.1** – Load posting comparisons for state and local bridges.

Within the sample set of bridges, it can be stated that local bridges are more prone to load posting compared to state bridges. Using the LRFR methodology seems to increase the number of state bridges that require posting. For local bridges, it was observed that the number of bridges that needs posting slightly decreases when the LRFR methodology is used. For the LRFR methodology, bridges were more often posted for the SU4 vehicle than the Type 3S2 vehicle.

Based on the rating results as shown in Table 6.2, 2 bridges (both local) required closure per LFR, 4 bridges (1 state, 3 local) required closure due to Type 3S2 rating and 9 bridges (1 state, 8 local) required to closure due to SU4 rating per LRFR. Although the closed bridge data set is very limited, it can be specified that local bridges seem to be more prone to closures compared to state bridges.

When load postings for different superstructure types were investigated, it was observed that for state bridges, switching from the LFR to the LRFR methodology affected the reinforced concrete T-beam bridges the most: 28.6% posted in LFR, whereas 50% and 71% posted for Type 3S2 and SU4, respectively, in LRFR, as shown in Fig 6.2. This indicates that the Department may see an increase in the number of reinforced concrete T-beam bridges in the state highways and interstates that need load posting. The posting frequencies for simple span steel multi girder bridges seemed to increase and posting frequencies for continuous steel multi girder bridges seemed to decrease when the rating methodology was switched from LFR to LRFR.

For local bridges, a decrease in the load postings of the reinforced concrete slab structures was observed when the LRFR methodology was used: 50% posted in LFR, whereas 21% and 35% posted for Type 3S2 and SU4, respectively, in LRFR. In addition, the frequency of steel multi girder continuous bridges seem to decrease from 29% to 0% when the rating methodology was switched from LFR to LRFR, however, it should be noted that the sample set for this kind of structures was very limited.

Another finding from the posting analysis was that none of the local or state owned prestressed concrete box girder and prestressed concrete multi girder continuous bridges required load posting.

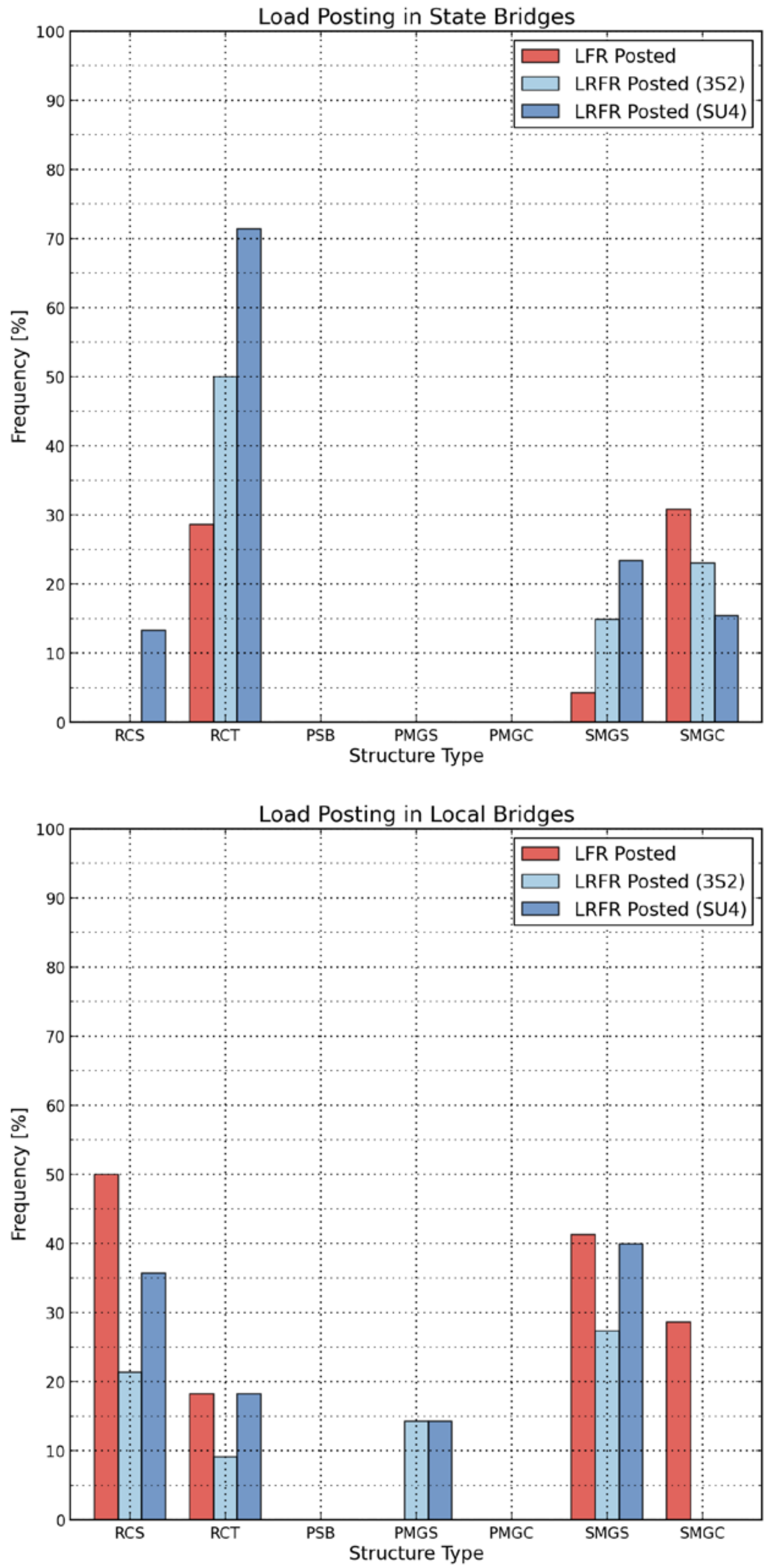



**Figure 6.2** – Load posting comparisons for state and local bridges by structure type.

### 6.3 Effect of Using Different Methodologies in Load Posting

Since LFR and LRFR are different rating philosophies that could result in significant differences in rating factors, posting status of a bridge may change when different rating methodologies are used. In order to investigate this potential issue, un-posted bridges rated by the LFR methodology were extracted, and compared with the posting results from the LRFR methodology. The same approach was repeated for a dataset consisting of un-posted bridges rated by the LRFR methodology. The change in number of posted bridges when different methodologies are used is listed in Table 6.4

**Table 6.4 –** Change in the number of posted bridges when different rating methodologies are used

| No Posting LFR | Only 3S2 Posting | Only SU4 Posting | Both 3S2 & SU4 Posting | Total New Posted Bridges LRFR |
|---|---|---|---|---|
| 232 | 1 | 19 | 21 | 41 |
| **No Posting LRFR (3S2)** | **Total New Posted Bridges with LFR** | | | |
| 249 | 38 | | | |
| **No Posting LRFR (SU4)** | **Total New Posted Bridges with LFR** | | | |
| 215 | 23 | | | |

When a dataset of 232 un-posted (LFR) bridges was used, it was seen that 0.4% of these bridges will be posted only for Type 3S2, 8.2% will be posted only for SU4, and 9.1% will be posted both for Type 3S2 and SU4, resulting in a total of approximately 18% of the previously un-posted bridges to require postings.

When the same investigation was performed for the 249 bridges un-posted (LRFR) for Type 3S2, it was observed that approximately 15% of these bridges will be posted per LFR. Similarly, for the 215 bridges un-posted (LRFR) for SU4, approximately 10.7% will be posted per the LFR methodology.

To further illustrate this phenomenon, 10 bridges for LFR and 10 bridges for LRFR were extracted, where the posting requirement changed when the rating methodology is switched from LFR to LRFR and vice versa, as listed in Table 6.5. It can be stated that there will be some reordering of the list of posted bridges with the change to LRFR. Additionally, in LRFR, there are two posting vehicles with different number of bridges that need posting for each vehicle with a specific posting value for each. This would affect posting signage.

**Table 6.5 –** Examples of bridges that changed load posting status

| Bridge ID | NBI Structure ID | Region | State/Local | Condition Rating | Construction Date | Structure Type | Span Length | LFR Posting (tons) | LRFR Posting (tons) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Type 3S2 | SU4 |
| 01513 | 3344660 | 8 | Local | 4.50 | 1938 | RCS | 26.5 | 22 | N | N |
| 42979 | 1028030 | 5 | State | 4.16 | 1934 | RCT | 46.0 | 22 | N | N |
| 45375 | 2201980 | 1 | Local | 4.27 | 1938 | SMGS | 26.4 | 20 | N | N |
| 40030 | 2207300 | 3 | Local | 3.60 | 1940 | SMGS | 51.0 | 19 | N | N |
| 40220 | 2255580 | 2 | Local | 4.49 | 1930 | SMGS | 40.0 | 22 | N | N |
| 40620 | 2266840 | 2 | Local | 3.86 | 1978 | SMGS | 55.5 | 13 | N | N |
| 09723 | 3221340 | 7 | Local | 4.51 | 1984 | SMGS | 29.5 | 22 | N | N |
| 44481 | 3303780 | 1 | Local | 4.33 | 1932 | SMGS | 27.0 | 22 | N | N |
| 05442 | 4045180 | 3 | State | 3.78 | 1960 | SMGC | 591.0 | 28 | N | N |
| 20681 | 4060680 | 4 | State | 4.33 | 1970 | SMGC | 95.0 | 25 | N | N |
| 42897 | 1002730 | 2 | Local | 4.27 | 1964 | PMGS | 81.00 | N | 21 | 18 |
| 15447 | 1018730 | 9 | Local | 4.98 | 1924 | SMGS | 35.10 | N | 27 | 14 |
| 18843 | 1020870 | 9 | State | 4.31 | 1933 | RCT | 41.50 | N | 35 | 20 |
| 18602 | 1024320 | 3 | State | 3.76 | 1959 | SMGS | 92.00 | N | 18 | 14 |
| 07847 | 1041330 | 8 | State | 4.63 | 1913 | SMGS | 27.00 | N | 13 | 6 |
| 06989 | 1041890 | 6 | State | 4.20 | 1955 | RCT | 48.00 | N | 22 | 11 |
| 20299 | 2206780 | 3 | Local | 4.37 | 1982 | SMGS | 36.00 | N | 33 | 18 |
| 10306 | 2217300 | 6 | Local | 5.00 | 1973 | SMGS | 30.75 | N | 14 | 7 |
| 11803 | 5500799 | 8 | State | 5.08 | 1933 | SMGS | 31.82 | N | 29 | 16 |
| 19356 | 5502439 | 8 | State | 4.01 | 1946 | SMGC | 72.00 | N | 29 | 22 |

**6.4 Posting of Bridges for R-Permit Restrictions**

R-Postings are intended to keep most overloads from using bridges that, through design or deterioration, do not have the reserve capacity to accommodate most overload permit vehicles, but are still capable of safely carrying legal loads. These bridges have signage stating "No Trucks with R Permits."

For the LFR methodology, per NYSDOT EI 05-034, if any of the following apply, the bridge should be investigated to determine the need for posting for R restriction:

- Low operating rating
  - Below H29 Upstate
  - Below H33 Downstate
- Design load below H20, with no level 1 or level 2 load rating available
- Bridge width (curb-to-curb)
  - Below 24 feet Upstate
  - Below 28 feet Downstate
- Primary member condition rating below 4
- Structural deck condition rating of 1
- Regional prerogative

For the LRFR methodology, two criteria for R-Posting bridges were recommended:

***Criterion 1***: Following bridges shall be R - Posted:

- Downstate bridges that do not have a RF ≥ 1.0 for the NYP 11 (Type 6A)
- Upstate bridges that do not have a RF ≥ 1.0 for the NYP 6 (Type 7)

***Criterion 2***: RF ≤ 1.0 for HL-93 at the Operating Level; a simpler, but more conservative approach that is to be verified in this study.

The R-posting analysis was performed using both methodologies for comparison purposes. R-posting results for the bridge inventory used in this study, from the LRFR and the LFR methodologies are listed in Table 6.6. Table 6.7 lists the load posting and bridge closure frequencies for different superstructure types.

**Table 6.6 –** R-Posting Results for State and Local Bridges by Superstructure Type

| Bridge Type | Owner | R Posting | | | Total # of Bridges in the Inventory |
|---|---|---|---|---|---|
| | | LFR | LRFR(1) | LRFR(2) | |
| RCS | State | 8 | 1 | 6 | 15 |
| | Local | 10 | 8 | 11 | 14 |
| RCT | State | 5 | 8 | 11 | 14 |
| | Local | 4 | 4 | 7 | 11 |
| PSB | State | 5 | 0 | 2 | 10 |
| | Local | 3 | 0 | 3 | 14 |
| PMGS | State | 0 | 0 | 0 | 12 |
| | Local | 2 | 1 | 2 | 7 |
| PMGC | State | 0 | 0 | 0 | N/A |
| | Local | 0 | 0 | 0 | 7 |
| SMGS | State | 9 | 10 | 19 | 47 |
| | Local | 107 | 78 | 107 | 143 |
| SMGC | State | 5 | 3 | 6 | 13 |
| | Local | 2 | 1 | 2 | 7 |
| **Total** | **State** | **32** | **22** | **44** | **111** |
| | **Local** | **128** | **92** | **132** | **203** |
| | **Total** | **160** | **114** | **176** | **314** |

(1): Based on criterion 1
(2): Based on criterion 2

**Table 6.7 –** R-Posting Percentages for State and Local Bridges by Superstructure Type

| Bridge Type | Owner | R Posting | | | Total # of Bridges in the Inventory |
|---|---|---|---|---|---|
| | | LFR % | LRFR(1) % | LRFR(2) % | |
| RCS | State | 53.3 | 6.7 | 40.0 | 15 |
| | Local | 71.4 | 57.1 | 78.6 | 14 |
| RCT | State | 35.7 | 57.1 | 78.6 | 14 |
| | Local | 36.4 | 36.4 | 63.6 | 11 |
| PSB | State | 50.0 | 0.0 | 20.0 | 10 |
| | Local | 21.4 | 0.0 | 21.4 | 14 |
| PMGS | State | 0.0 | 0.0 | 0.0 | 12 |
| | Local | 28.6 | 14.3 | 28.6 | 7 |
| PMGC | State | N/A | N/A | N/A | N/A |
| | Local | 0.0 | 0.0 | 0.0 | 7 |
| SMGS | State | 19.1 | 21.3 | 40.4 | 47 |
| | Local | 74.8 | 54.5 | 74.8 | 143 |
| SMGC | State | 38.5 | 23.1 | 46.2 | 13 |
| | Local | 28.6 | 14.3 | 28.6 | 7 |
| **Total** | **State** | 28.8 | 19.8 | 39.6 | **111** |
| | **Local** | 63.1 | 45.3 | 65.0 | **203** |
| | **Total** | 51.0 | 36.3 | 56.1 | **314** |

When both state and local bridges considered all together, it was seen that 51.0% of the bridges required R-posting when rated using the LFR methodology, whereas 36.3% and 56.1% of the bridges required load posting when rated using the LRFR methodology, based on criterion 1 and criterion 2, respectively. It should be noted that using LRFR R-posting criterion 2 results in 19.8% more bridges to require R-posting, compared to criterion 1.

When only state bridges were taken into consideration, it was seen that 28.8% of the bridges required R-posting when rated using the LFR methodology, whereas 19.8% and 39.6% of the bridges required R-posting when rated using the LRFR methodology, based on criterion 1 and criterion 2, respectively. Similarly, when only local bridges were considered, it was seen that 63.1% of the bridges required R-posting when rated using the LFR methodology, whereas 45.3% and 65.0% of the bridges required R-posting when rated using the LRFR methodology, based on criterion 1 and criterion 2, respectively. Posting analysis comparisons for local, state and all bridges is illustrated in Fig. 6.3.

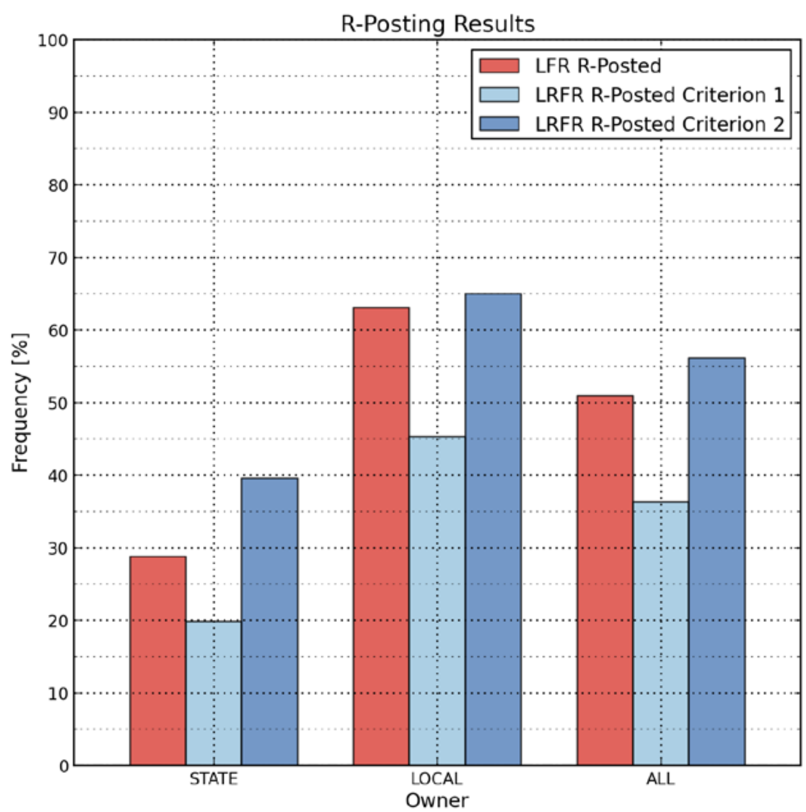


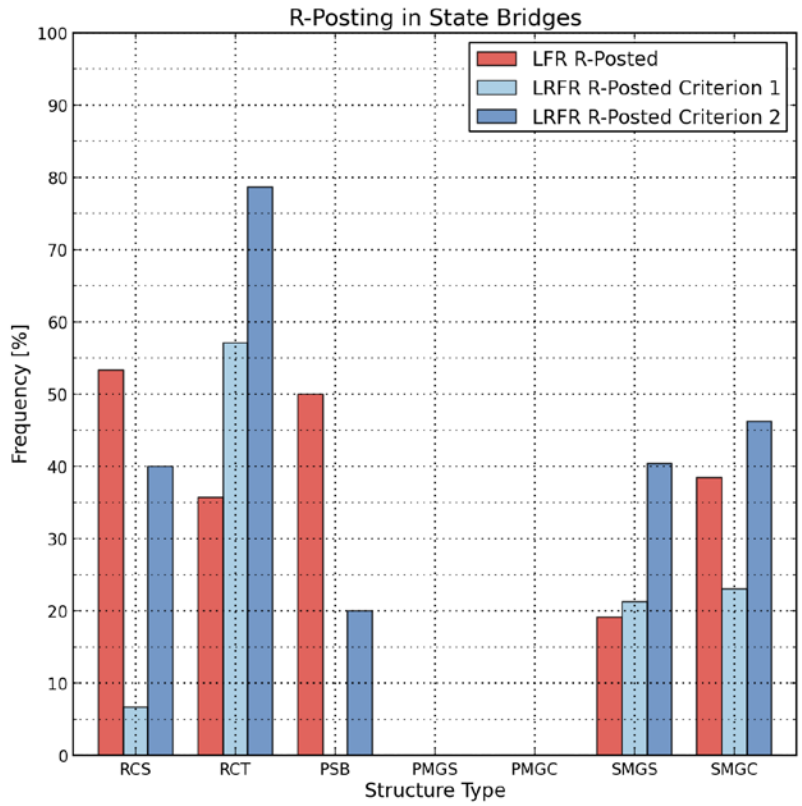

**Figure 6.3** – R-posting comparisons for state and local bridges.

Within the sample set of bridges, it can be stated that local bridges are more prone to R-posting compared to state bridges. Using the LRFR methodology seems to decrease the number of state bridges that require posting by 9%, compared to the LFR methodology, when NY permit trucks are used in the analysis (LRFR criterion 1). However, applying LRFR criterion 2 seems to increase the number of state bridges that require R-posting by 10.8%, compared to the LRFR methodology. For local bridges, it was observed that the number of bridges that need R-posting is similar when results from LFR and LRFR criterion 2 are compared (63.1% and 65.0%). However, applying LRFR criterion 1 with NY permit trucks result in 17.8% less bridges to require R-posting, when compared to the LFR methodology. Overall, LRFR criterion 2 was observed to be a simple, but conservative approach, which can be used for quick screening of the inventory to determine potential bridges that require R-postings. The final R-posting decision should be made using LRFR criterion 1 to prevent unnecessary conservatism.

When R-postings for different superstructure types were investigated, it was observed that for state bridges, switching from the LFR to the LRFR methodology affected the reinforced concrete T-beam bridges the most: 35.7% posted in LFR, whereas 57.1% and 78.6% R-posted, based on LRFR criterion 1 and criterion 2, respectively, as shown in Fig. 6.3. This indicates that the Department may see an increase in the number of reinforced concrete T-beam bridges in the state highways and interstates that need R-posting. The R-posting frequencies for reinforced concrete slab bridges, prestressed box girder and continuous steel multi girder bridges seem to decrease when the rating methodology was switched from LFR to LRFR.

For local bridges, decreases in R-posting frequencies were observed for almost all types of bridges when the rating methodology was switch from LFR to LRFR, as shown in Fig. 6.3.

Another finding from the R-posting analysis was that none of the local or state owned prestressed concrete multi girder continuous bridges required R-posting.



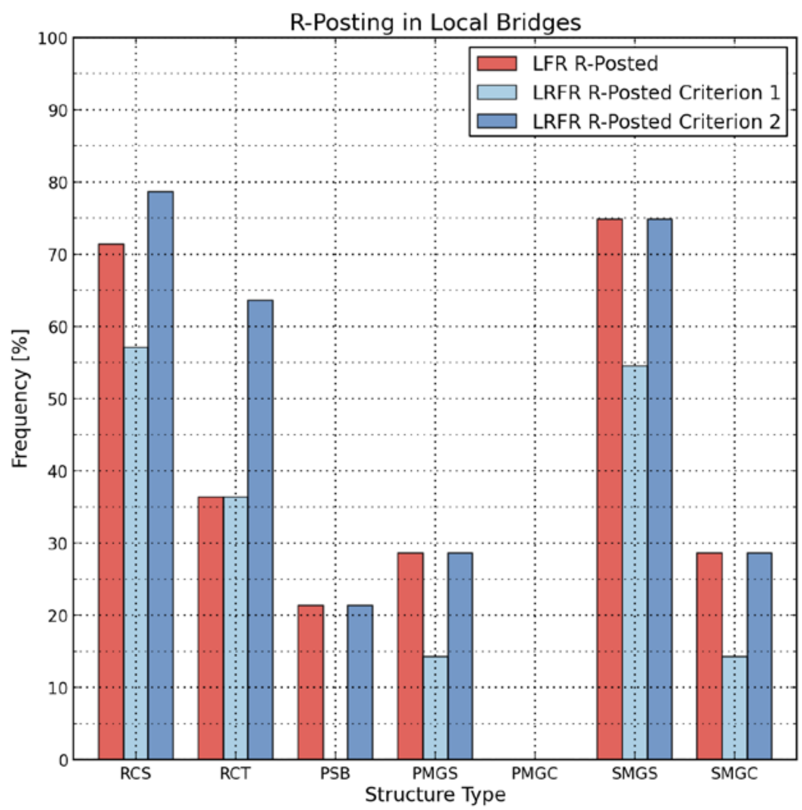




**Figure 6.4** – R-posting comparisons for state and local bridges by structure type.

### 6.5 Effect of Using Different Methodologies in R-Posting

Since LFR and LRFR are different rating philosophies that could result in significant differences in rating factors, R-posting status of a bridge may change when different rating methodologies are used. In order to investigate this potential issue, un-posted bridges rated by the LFR methodology were extracted, and compared with the posting results from the LRFR methodology, only using criterion 1. The same approach was repeated for a dataset consisting of un-posted bridges rated by the LRFR methodology. The change in number of posted bridges when different methodologies are used is listed in Table 6.8

**Table 6.8 –** Change in the number of R-posted bridges when different rating methodologies are used

| No R-Posting LFR | Total New R-Posted Bridges with LRFR |
|---|---|
| 150 | 22 |
| **No R-Posting LRFR (Criterion 1)** | **Total New R-Posted Bridges with LFR** |
| 196 | 68 |

When a dataset of 150 not R-posted (LFR) bridges was used, it was seen that 22 (approximately 15%) of these previously un-posted bridges may require R-postings.

When the same investigation was performed for the 196 not R-posted (LRFR) bridges based on criterion 1, it was observed that approximately 35% of these bridges will be R-posted per LFR.

To further illustrate this phenomenon, 10 bridges for LFR and 10 bridges for LRFR were extracted, where the posting requirement changed when the rating methodology is switched from LFR to LRFR and vice versa, as listed in Table 6.5. It can be stated that there will be some reordering of the list of R-posted bridges with the change to LRFR.

**Table 6.9 –** Examples of bridges that changed load posting status

| Bridge ID | NBI Structure ID | Region | State/Local | Condition Rating | Construction Date | Structure Type | Span Length | R-Posting | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | LFR | LRFR |
| 26389 | 3221950 | 8 | Local | 6.54 | 1954 | PSB | 52.6 | R | N |
| 04505 | 1000610 | 7 | State | 4.40 | 1950 | RCS | 25.4 | R | N |
| 00413 | 1003720 | 9 | State | 4.43 | 1927 | SMGS | 31.5 | R | N |
| 24094 | 1004440 | 9 | State | 5.49 | 1932 | RCS | 25.0 | R | N |
| 24688 | 1006250 | 8 | State | 5.17 | 1950 | RCS | 21.3 | R | N |
| 27457 | 1007850 | 9 | State | 5.37 | 1951 | RCS | 21.5 | R | N |
| 06483 | 1007900 | 9 | State | 4.32 | 1974 | PSB | 60.0 | R | N |
| 02728 | 1008130 | 9 | State | 4.69 | 1947 | RCS | 33.5 | R | N |
| 19519 | 1015080 | 4 | State | 3.76 | 1930 | SMGS | 44.0 | R | N |
| 40070 | 1018000 | 1 | State | 4.34 | 1985 | PSB | 90.0 | R | N |
| 42897 | 1002730 | 2 | Local | 4.27 | 1964 | PMGS | 81.0 | N | R |
| 17700 | 1003930 | 9 | State | 4.82 | 1933 | RCT | 36.0 | N | R |
| 17704 | 1003940 | 9 | State | 5.07 | 1933 | RCT | 30.0 | N | R |
| 20177 | 1009210 | 9 | State | 4.43 | 1928 | SMGS | 31.5 | N | R |
| 18730 | 1010660 | 3 | State | 3.35 | 1949 | RCT | 40.0 | N | R |
| 15447 | 1018730 | 9 | Local | 4.98 | 1924 | SMGS | 35.1 | N | R |
| 18602 | 1024320 | 3 | State | 3.76 | 1959 | SMGS | 92.0 | N | R |
| 06989 | 1041890 | 6 | State | 4.20 | 1955 | RCT | 48.0 | N | R |
| 10306 | 2217300 | 6 | Local | 5.00 | 1973 | SMGS | 30.8 | N | R |
| 22304 | 1061050 | 9 | State | 4.47 | 1925 | SMGS | 26.3 | N | R |

### 6.5 Verification of HL-93 Load Model as a Screening Load for Load Postings and R-Postings

The HL-93 design load check at the Inventory and Operating levels can serve as an effective technique to identify bridges that can safely carry legal load ratings and/or permit loads. The following rules regarding screening given in the Draft EI based on comparing load effects were checked using the rating results:

1. Bridges that pass HL-93 rating (RF ≥ 1.0) at the Operating level will have adequate load capacity for NY legal loads.

2. Bridges that pass HL-93 rating (RF ≥ 1.0) at the Operating level will have adequate load capacity for divisible and non-divisible load permits (NYP1 thru NYP 13).

In order to use HL-93 operating ratings as a screening load in the LRFR method, there should be no bridge in the inventory that requires postings or R-postings based on the analysis results. This criterion was verified as seen in Table 6.10.

**Table 6.10 –** Verification of the HL-93 Load Model as a Screening Load

| Design Load Operating Level RF ≥ 1.0 | Load Posted Bridges (LRFR) | | R-Posted Bridges (LRFR) |
|---|---|---|---|
| | Type 3S2 | SU4 | |
| State | 0 | 0 | 0 |
| Local | 0 | 0 | 0 |
| Total | 0 | 0 | 0 |

### 6.6 Summary of Analysis Results

Findings from the comparative analysis of posting and R-posting results using LRFR and LFR methodologies can be summarized as:

- Overall, LRFR methodology yields slightly more bridges to be load posted compared to the LFR methodology.
- For local bridges, the number of bridges to be load posted seemed decrease when the rating methodology is changed from LFR to LRFR.
- For local bridges, the number of bridges to be load posted seemed increase when the rating methodology is changed from LFR to LRFR.
- For the LRFR methodology, bridges were more often posted for the SU4 vehicle than the Type 3S2 vehicle.
- For state owned bridges, switching from the LFR to the LRFR methodology affected the reinforced concrete T-beam bridges the most by more bridges requiring postings.
- For local bridges, switching from the LFR to the LRFR methodology decreased the number of slab bridges to be load posted.
- None of the local or state owned prestressed concrete box girder and prestressed concrete multi girder continuous bridges required load posting.
- Overall, using the LRFR methodology Criterion 1 decreased the number of bridges to be R-posted, compared to the LFR methodology for both local and state bridges. So LRFR allows higher number of bridges to be considered for unrestricted permit crossings compared to the LFR.
- For state owned bridges, switching from the LFR to the LRFR methodology affected the reinforced concrete T-beam bridges the most by more bridges requiring postings.

- Applying LRFR Criterion 1 decreases the number of bridges to be R-rated, for almost all other structure types, where the most pronounced effect was seen in state owned reinforced concrete slab bridges.
- LRFR criterion 2 was observed to be a simple, but conservative approach, which can be used for quick screening of the inventory to determine potential bridges that require R-postings. However, the final R-posting decision should be made using LRFR criterion 1 to prevent unnecessary conservatism.
- Applicability of the HL-93 operating level rating results as a screening tool for posting and R-posting analysis was verified.

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# 7. CONCLUSIONS AND RECOMMENDATIONS

## 7.1 Introduction

The goal of this project was to validate/test the Department's draft Engineering Instruction (EI) developed to follow bridge LRFR methodology as specified in the AASHTO Manual for Bridge Evaluation. A group of 314 bridges that represents the various types and characteristics of bridges found in New York State were load rated with both Load Factor Rating (LFR) and LRFR methodologies using the VIRTIS software. Load ratings were performed at the Design Load, Legal Load and Permit Load levels. Posting and R-posting analyses were also performed for all bridges for comparing the results from each methodology.

## 7.2 Conclusions

**Design Load Level:**

- As expected, direct comparisons of LRFR and LFR load ratings generally yielded scattered results. This was mainly due to the difference in the live load demand side of the load rating formula. Load models, load factors and differences in the application of live load distribution and dynamic load allowance result in scattered results.
- Overall, the LRFR methodology produced lower rating factors than the LFR methodology.
- State and local bridges produced similar trends based on the computed frequency distributions and the cumulative density functions.
- Exterior members yielded much scattered results compared to interior girders. A highly possible reason was determined to be the differences in the application of the distribution factors in each methodology.
- The state and local bridges produced similar results for LRFR and LFR methodologies.

**Legal Load Level:**

- For both 3S2 and SU4 legal loads, the LRFR ratings mostly yielded higher rating factors compared to the LFR inventory ratings. On contrary, at the operating level, it was observed that the LFR rating factors were generally higher than their LRFR counterparts. This result can be attributed to the higher live load factors used in the LFR methodology at the inventory level. At the operating level, the results from the local bridges were close to each other, due to similar rating factors used in both methodologies. However, for state bridges, the difference between both methodologies was more pronounced, due to higher load factors derived for state owned and interstate bridges in the LRFR methodology, reflecting the traffic patterns on these highways.

- The rating factors for exterior girders were more scattered than those for interior girders. As previously indicated in the design ratings section, this is probably a result of the application of different distribution factor methodologies.
- Moment rating factors for the Interior girders tend to control over moment rating factors for the exterior girders under the LRFR.
- Flexural rating factors predominantly controlled over shear rating factors for both LRFR and LFR methodologies.
- The ratings for shear strength were more widely scattered than those for flexure. This can be attributed to diverging shear capacity calculations in the LRFR and LFR methodologies, which especially applies to reinforced concrete and prestressed concrete bridges.

**Permit Load Level:**

- For both NYP6 and NYP11 legal loads, the LRFR permit ratings mostly yielded higher rating factors compared to the LFR permit ratings based on the operating level. This result can be attributed to the slightly higher live load factors used in the LFR methodology, as well as the allowance to decrease the LRFR impact factor in permit ratings.
- The rating factors for exterior girders were more scattered than those for interior girders. As previously indicated in the design and legal rating sections, this is probably a result of the differences in the distribution factor calculations.
- Moment rating factors for the Interior girders tend to control over moment rating factors for the exterior girders under the LRFR.
- Flexural rating factors predominantly controlled over shear rating factors for both LRFR and LFR methodologies. Thus, when a bridge requires R-posting, this is most likely due to flexure rather than shear.

- The ratings for shear strength were more widely scattered than those for flexure. This can be attributed to diverging shear capacity calculations in the LRFR and LFR methodologies, which especially applies to reinforced concrete and prestressed concrete bridges.
- Similar trends in the LRFR – LFR comparison were observed for both NYP6 and NYP11 permit loads.
- The state and local bridges produced similar results for the LRFR and the LFR methodologies.

**Posting & R-Posting Analysis:**

- Overall, LRFR methodology yields slightly more bridges to be load posted compared to the LFR methodology.
- For local bridges, the number of bridges to be load posted seemed decrease when the rating methodology is changed from LFR to LRFR.
- For local bridges, the number of bridges to be load posted seemed increase when the rating methodology is changed from LFR to LRFR.
- For the LRFR methodology, bridges were more often posted for the SU4 vehicle than the Type 3S2 vehicle.
- For state owned bridges, switching from the LFR to the LRFR methodology affected the reinforced concrete T-beam bridges the most by more bridges requiring postings.
- For local bridges, switching from the LFR to the LRFR methodology decreased the number of slab bridges to be load posted.
- None of the local or state owned prestressed concrete box girder and prestressed concrete multi girder continuous bridges required load posting.
- Overall, using the LRFR methodology Criterion 1 decreased the number of bridges to be R-posted, compared to the LFR methodology for both local and state bridges. So LRFR allows higher number of bridges to be considered for unrestricted permit crossings compared to the LFR.
- For state owned bridges, switching from the LFR to the LRFR methodology affected the reinforced concrete T-beam bridges the most by more bridges requiring postings.
- Applying LRFR Criterion 1 decreases the number of bridges to be R-rated, for almost all other structure types, where the most pronounced effect was seen in state owned reinforced concrete slab bridges.

- LRFR criterion 2 was observed to be a simple, but conservative approach, which can be used for quick screening of the inventory to determine potential bridges that require R-postings. However, the final R-posting decision should be made using LRFR criterion 1 to prevent unnecessary conservatism.
- Applicability of the HL-93 operating level rating results as a screening tool for posting and R-posting analysis was verified.

**7.3 Recommendations**

Based on above observations the following recommendations are suggested to NYSDOT. From an implementation point of view:

- It is recommended that NYSDOT uses the LRFR for rating new bridges designed to the AASHTO LRFD at all rating levels
- It is recommended that NYSDOT uses both the LRFR and LFR methodologies for rating existing bridges at all rating levels. When RF > 1.0 for LRFR and for LFR, a bridge can be considered satisfactory. When RF < 1.0 for LRFR and for LFR, a bridge can be considered unsatisfactory. When RF < 1.0 for LRFR and RF > 1.0 for LFR, further investigation of the safety of the bridge is recommended according to NYSDOT current policies.
- Application of the HL-93 operating level results as a screening tool for detecting bridges that may require load posting and R-postings may aid in prioritization of the rating efforts.

In addition, the following recommendations for further investigations are also made:

- It is recommended that further research be conducted to understand and identify factors affecting the observed differences between the LRFR and the LFR methodologies. Factors to investigate may include, but are not limited to: the live load distribution factors, dynamic load allowance and live load factors on the rating results.
- This study was performed on a group of regular bridges that can be rated with the VIRTIS software. It is recommend that further research be conducted in complicated bridges, like Truss bridge, curved bridges, cable bridges and so on.

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