AASHTOWare™ BRIDGE
DESIGN AND RATING

Developing a State-Specific Legal Load Rating Procedure

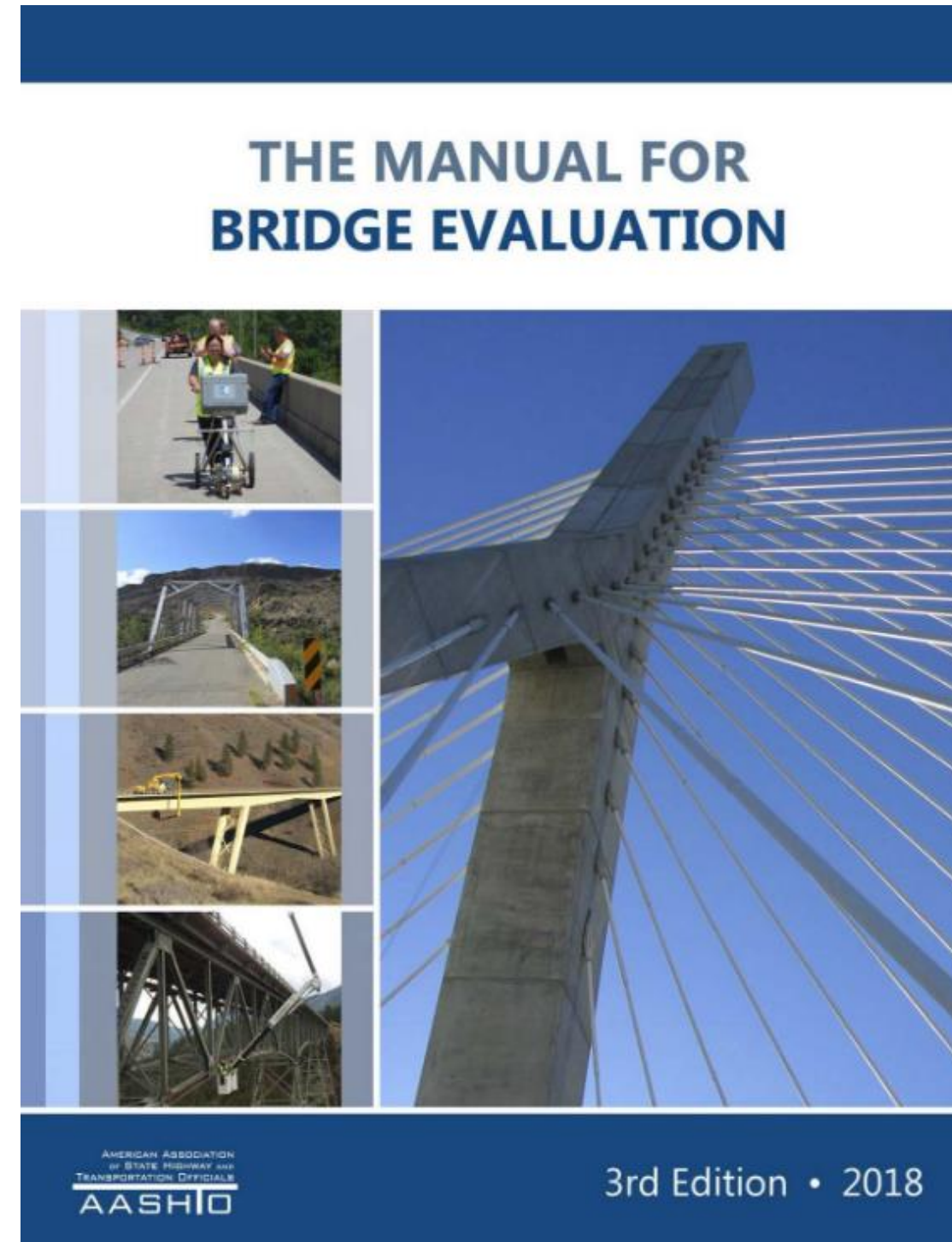Sylwia Stawska, PhD, PE

Rachel Mertz, PE, SE

Thomas Murphy, PhD, PE, SE

MODJESKI and MASTERS

TRANSPORTATION & PUBLIC FACILITIES · STATE OF ALASKA

2025 Rating and Design User Group Meeting
Boise, ID | August 12-13, 2025

Bridge Evaluation

- What is the goal?
  - Encompass traffic-induced load effects, and
  - Establish Bridge Safe Live Load Carrying Capacity

- What checks are required at operating rating level?
  - Design Trucks (HS-20 and HL-93)
  - Legal Trucks (Type 3, Type 3S2, Type 3-3)
  - Specialized Hauling Vehicles (SU4 to SU6)
  - Emergency Vehicles (EV2, EV3)
  - Permit Trucks
  - State-Specific Legal Trucks

THE MANUAL FOR
BRIDGE EVALUATION

AMERICAN ASSOCIATION of STATE HIGHWAY and TRANSPORTATION OFFICIALS
AASHTO

3rd Edition • 2018

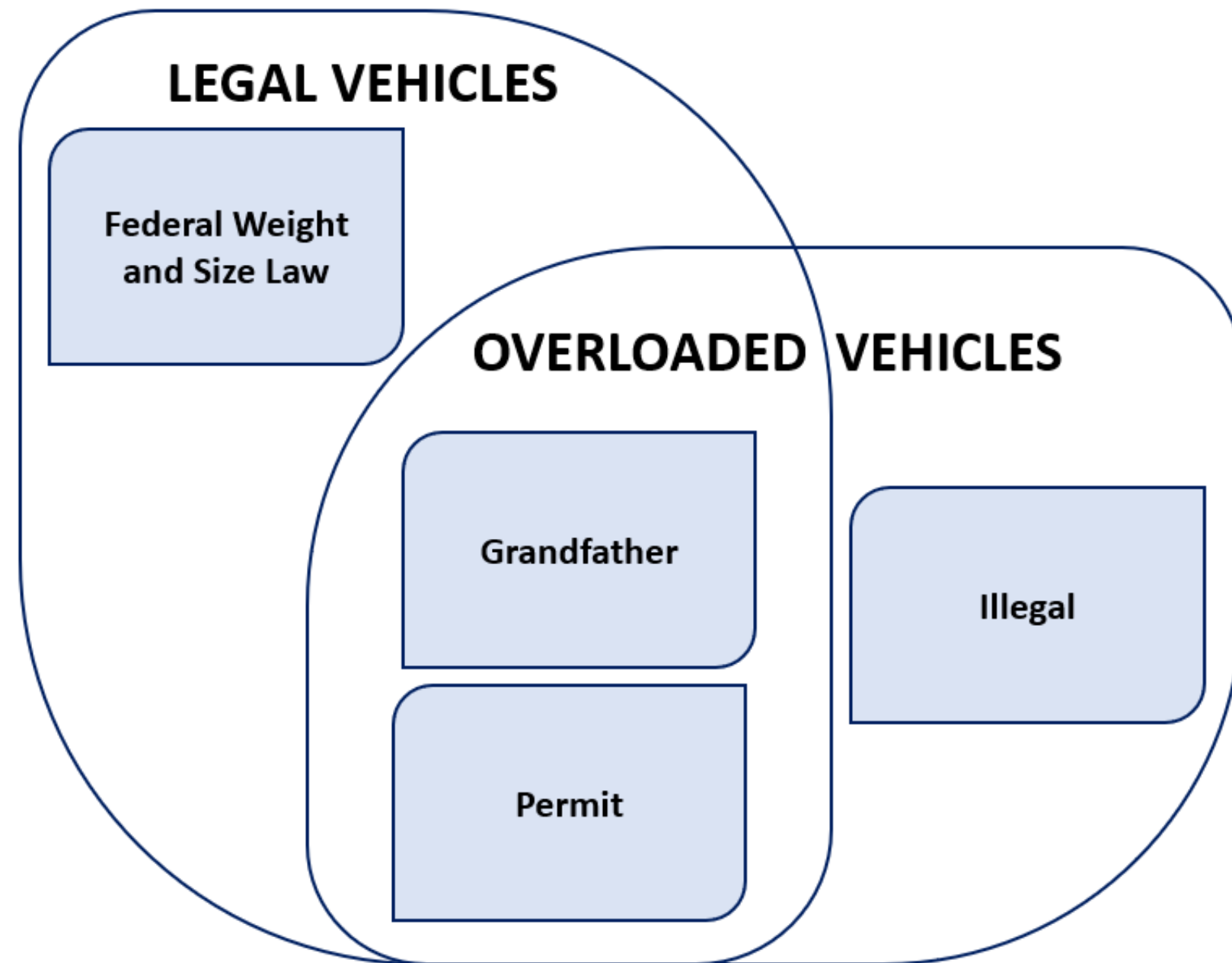AASHTOWare™
BRIDGE
DESIGN AND RATING

Live Load on Bridges

- Site-specific
- Seasonal
- Depends on Truck Size and Weight Laws
- Average Daily Truck Traffic
- Gross Vehicle Weight
- Vehicle Configurations

AASHTOWare™
BRIDGE
DESIGN AND RATING
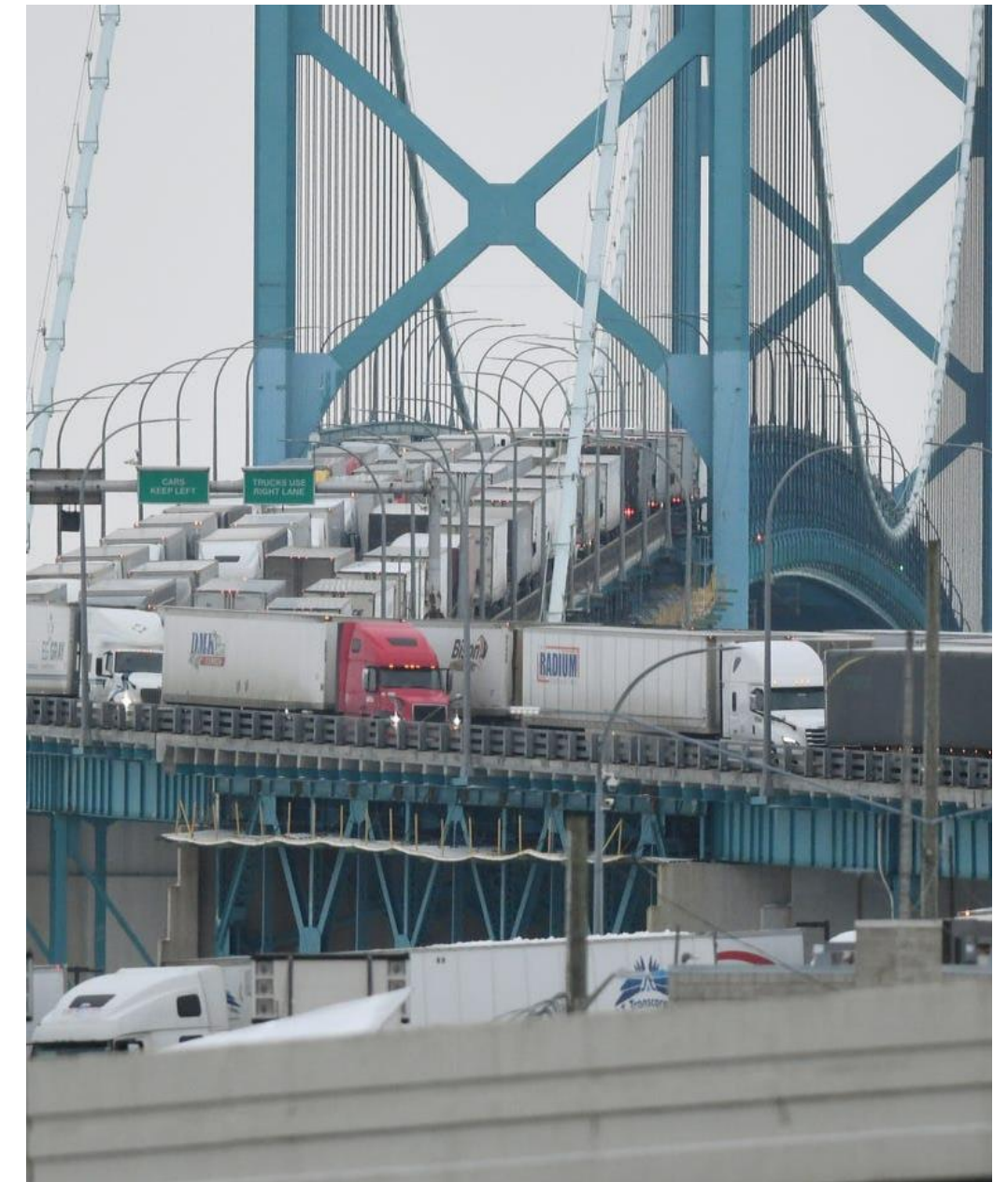
US Traffic Composition

- Federal Weight and Size Law:
  - Gross Vehicle Weight: 80,000 lbs
  - Single Axle Weight: 20,000 lbs
  - Tandem Axle Weight: 34,000 lbs
  - Federal Bridge Formula B
- Grandfather exceptions
- Permit traffic:
  - Single trip permits
  - Multi trip permits
  - Superloads

LEGAL VEHICLES

Federal Weight and Size Law

OVERLOADED VEHICLES

Grandfather

Permit

Illegal

AASHTOWare™
BRIDGE
DESIGN AND RATING

Grandfather Provisions

- The grandfather provisions are old rules that remain unchanged after a new rule was introduced
- Grandfather vehicles are exempted from federal truck size and weight law
- AASHTO MBE does not have provisions for legally overloaded vehicles under grandfather provisions

Vehicle Type/Commodity	Number of States with Exemptions
Aggregate Products (Rock, sand, gravel, road base, etc.)	15
Agricultural/Farm Products & Commodities	41
Construction Equipment/ Highway Machinery	28
Emission Reduction Equipment	40
Fire Trucks	29
Government-owned Vehicles	16
Implements of Husbandry	20
Snow Plows	10
Solid Waste/Rubbish/Trash	28
Timber Products & Commodities	22
Tow Trucks	22

Resource: https://ops.fhwa.dot.gov/Freight/policy/rpt_congress/truck_sw_laws/app_a.htm#ex7

AASHTOWare™
BRIDGE
DESIGN AND RATING

State Specific Legal Live Load Models

- Need for State-Specific Legal Live Load Models

- Certain state-permitted trucks may not adequately represented by AASHTO MBE

- State-specific models can be developed using:
    1) Deterministic Analysis
    2) Probabilistic Analysis – Calibration
    3) AASHTO MBE Site Specific Live Load Factor – C6A.4.4.2.3

AASHTOWare™
BRIDGE
DESIGN AND RATING

What do we need to develop State Specific Legal Live Load Model?

Understanding of State Truck Size and Weight Limits

Traffic Data

Live Load Envelope (Force Effects)

Live Load Model

Notional Rating Truck

Calibrated Live Load Factor

AASHTOWare™
BRIDGE
DESIGN AND RATING

Traffic Weight Data

- Gross Vehicle Weight
- Axle Weight
- Axle Spacing
- Traffic Composition, Volume
- Speed
- Lane Occupied

Traffic can be measured by:

- Portable Scales
- Weigh Station
- Weigh-in-Motion

AASHTOWare™
BRIDGE
DESIGN AND RATING

Weigh-in-Motion the US

- Officially over 2,000 WIM sites
- More than 500 million WIM records collected annually
- WIM data can be used to determine live load envelope on representative bridges

FHWA WIM Station Map updated 4/23/2025

AASHTOWare™
BRIDGE
DESIGN AND RATING
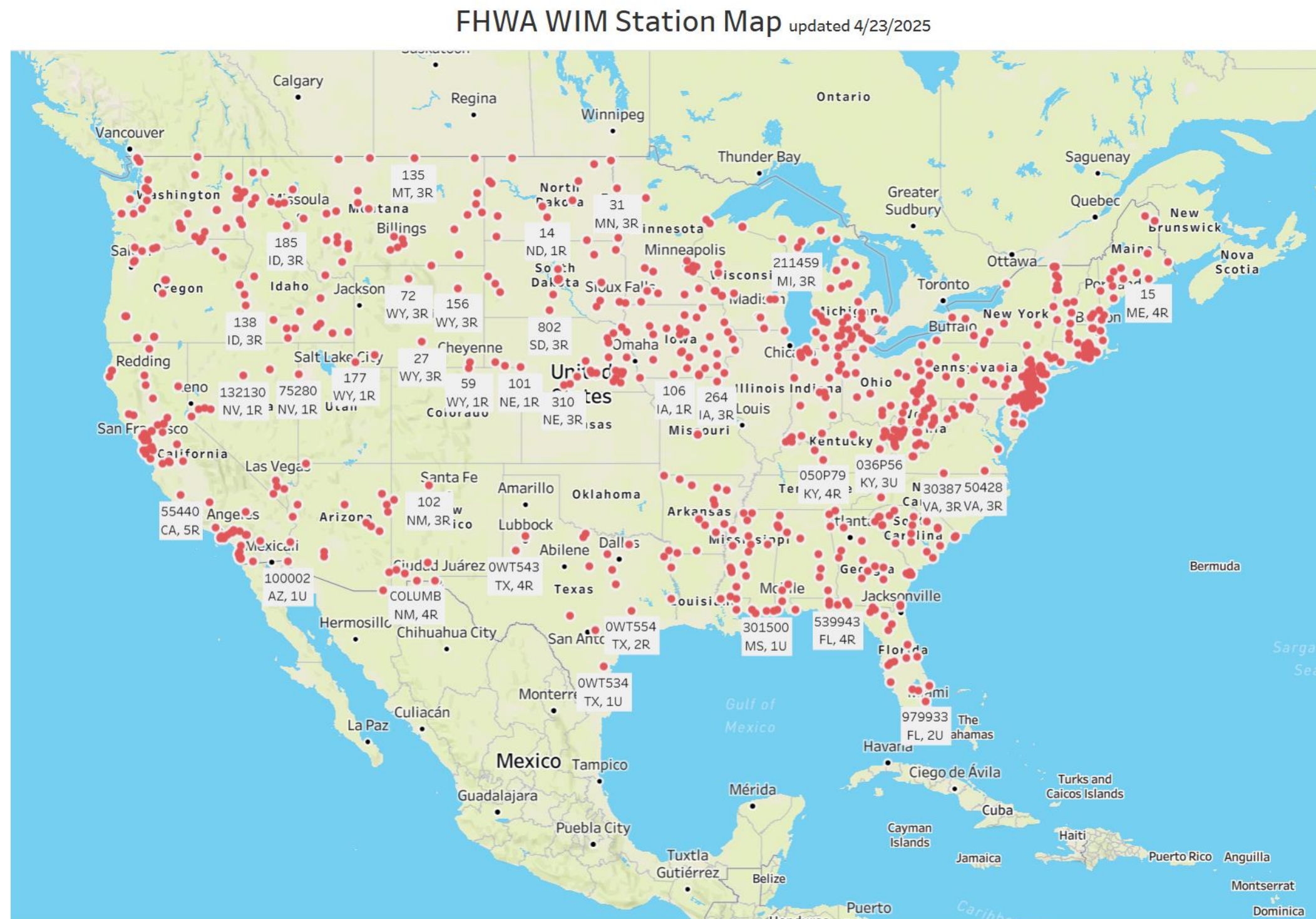
Notional Rating Truck

- Does not need to have configuration of real truck (i.e., HS-20 truck)
- Represents traffic-induced effects
- Provides consistent safety margin for broad range of bridges
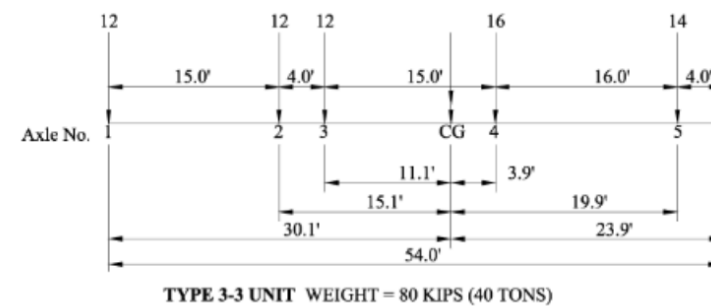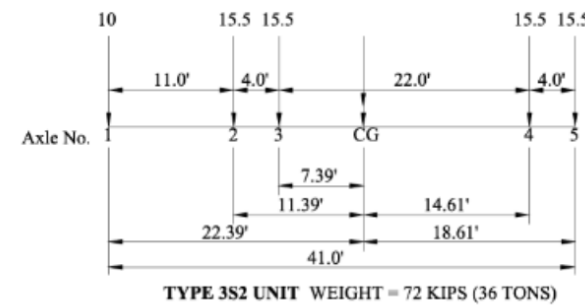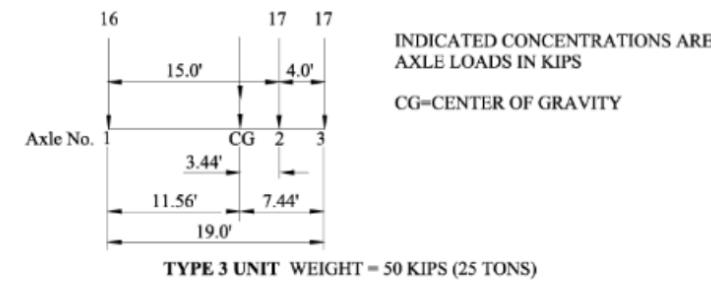
Figure 6B.7.2-1—Typical Legal Loads Used for Posting
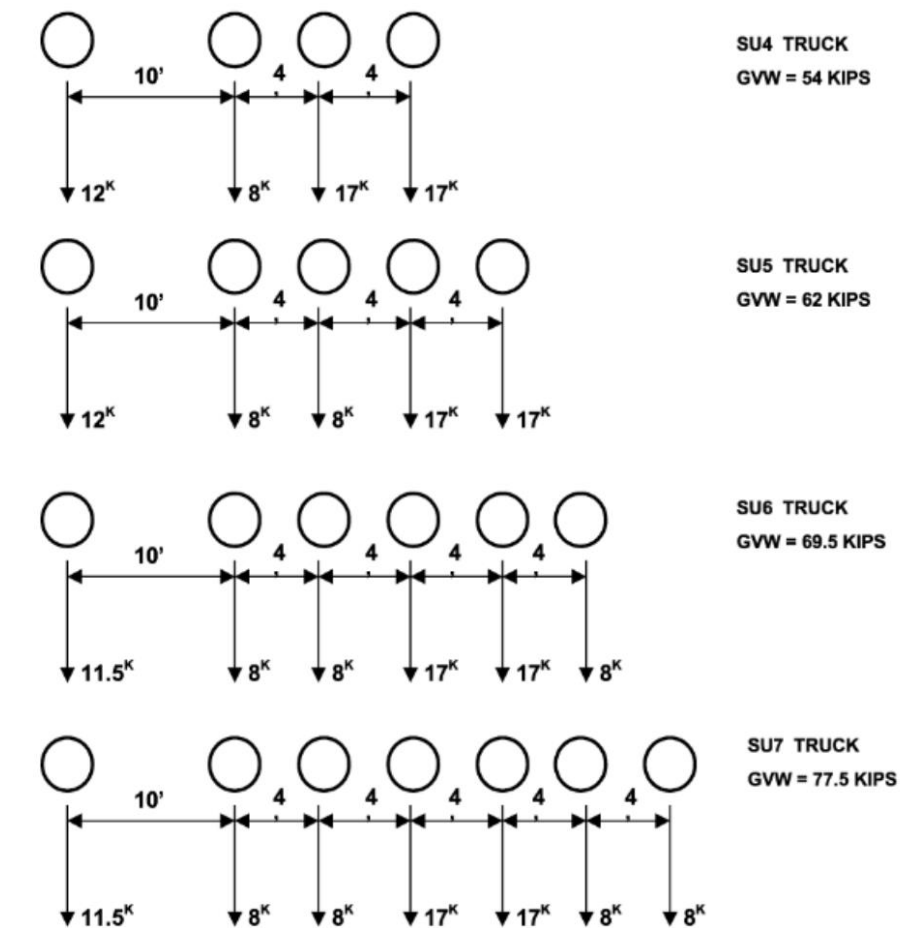
Figure 6B.7.2-2—Bridge Posting Loads for Single Unit Trucks that Meet Formula B

Live Load Model

Live Load Model requires:
- Traffic Data
- Force Effects Envelope
- Notional Truck
- Force Effects ratios between existing traffic and notional trucks

- Account for variability and uncertainty of live load

- Live Load Model provide input for calibration to determine live load factors

- Notional Truck & Live Load Factor should control probability of failure to meet the safety margin

AASHTOWare™
BRIDGE
DESIGN AND RATING

AASHTOWare™

BRIDGE

DESIGN AND RATING

Development of State-Specific Legal Load Rating Procedure

Probabilistic Analysis

1) Collect and Process Traffic Data

2) Develop Live Load Model for Notional Truck(s)

3) Calibrate Live Load Factor

4) Select Live Load Factor

5) Check safety margin (reliability Index) for selected Live Load Factor

AASHTOWare™
BRIDGE
DESIGN AND RATING

Deterministic Analysis

1) Develop representative truck configurations based on the state statute

2) Calculate critical force effects for representative trucks configurations

3) Compare force effects of representative trucks to rating trucks

4) Select suite of rating trucks

5) Use selected suite of rating trucks with live load factor of 1.30 to determine legal load rating

AASHTOWare™

BRIDGE
DESIGN AND RATING

Alaska Load Rating Study

AASHTOWare™
BRIDGE
DESIGN AND RATING

Alaska Rating Study Objectives

- Review Alaska statutes to identify weight limits on legal and routine permit traffic

- Develop an Alaska Legal Live Load model that encompasses all legal traffic

- Establish a consistent and practical bridge load rating and posting procedure

- Provide recommendations to guide implementation and policy updates

- Primary Probabilistic Analysis, but Deterministic check was also conducted

Alaska Traffic

- Low Traffic Volume
- No GVW Limit
- Significant traffic variability between locations
- Use of Long and Heavy Trucks
- 25% overload allowance on routine permit traffic
- Unique conditions require a state-specific approach to legal load rating and posting

AASHTOWare™
BRIDGE
DESIGN AND RATING

Alaska WIM Data

- Alaska has 8 active WIM sites

- Data for years 2015-2024 was received

- Over 16 million WIM records available, and 1.1 million records selected for analysis

- WIM Data was processed, and checked with Quality Control procedures

- Alaska WIM records were filtered to capture legal and routine permit traffic
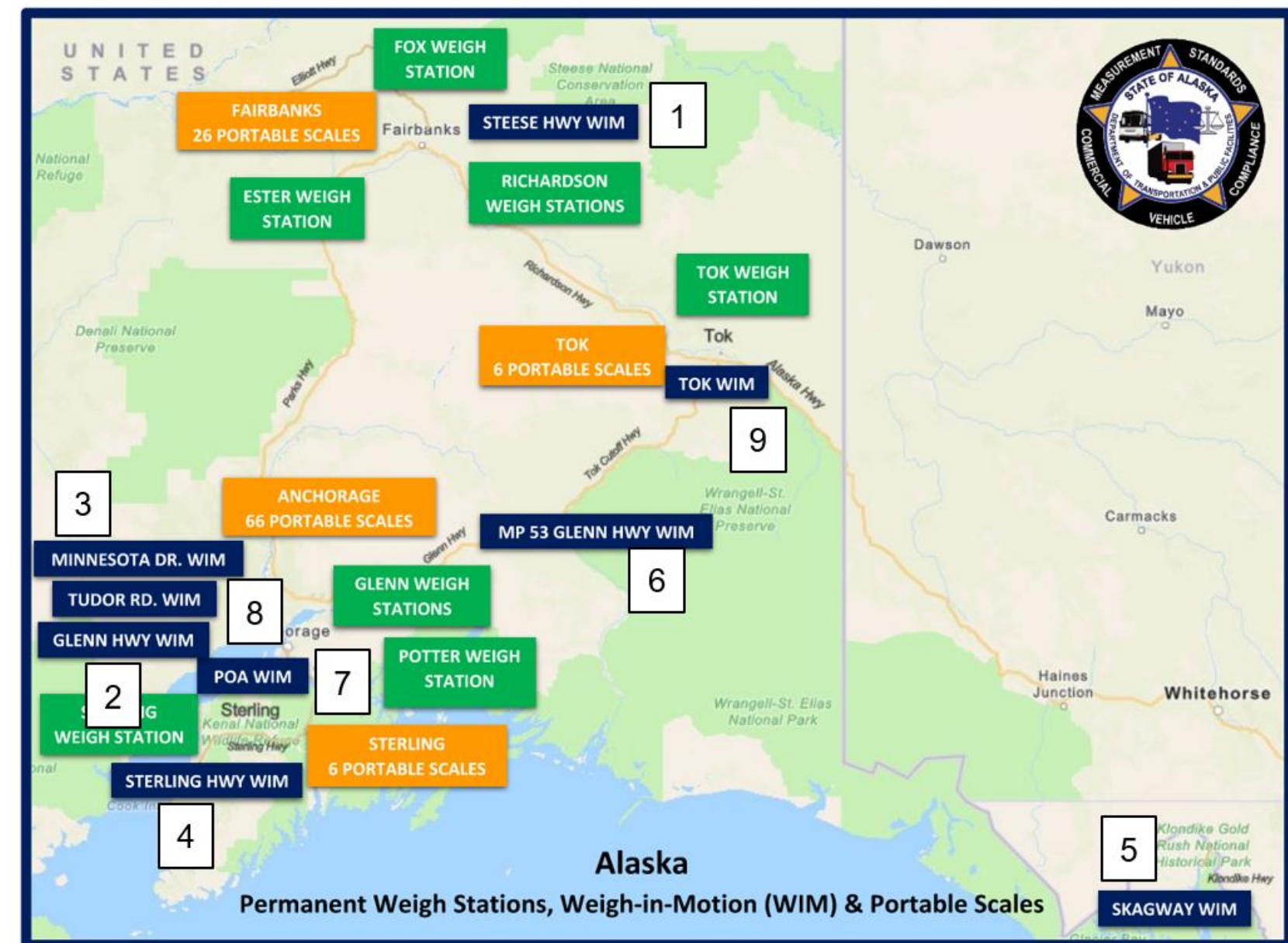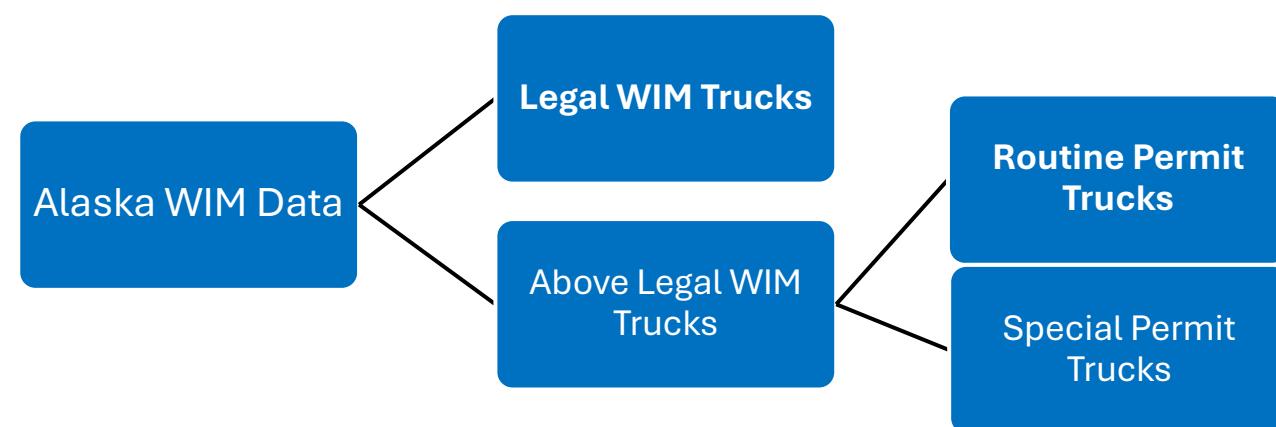
Alaska Traffic-Induced Load Effects

- Alaska WIM legal and routine permit traffic was run over influence line analysis

- Span lengths from 10-300 feet were selected

- 3 bridge span models were considered:
  - Simple Span
  - Two-equal Span Continuous
  - Three Span Continuous

- Together 22 span lengths, 9 load cases, and over 220 million runs to develop live load envelope
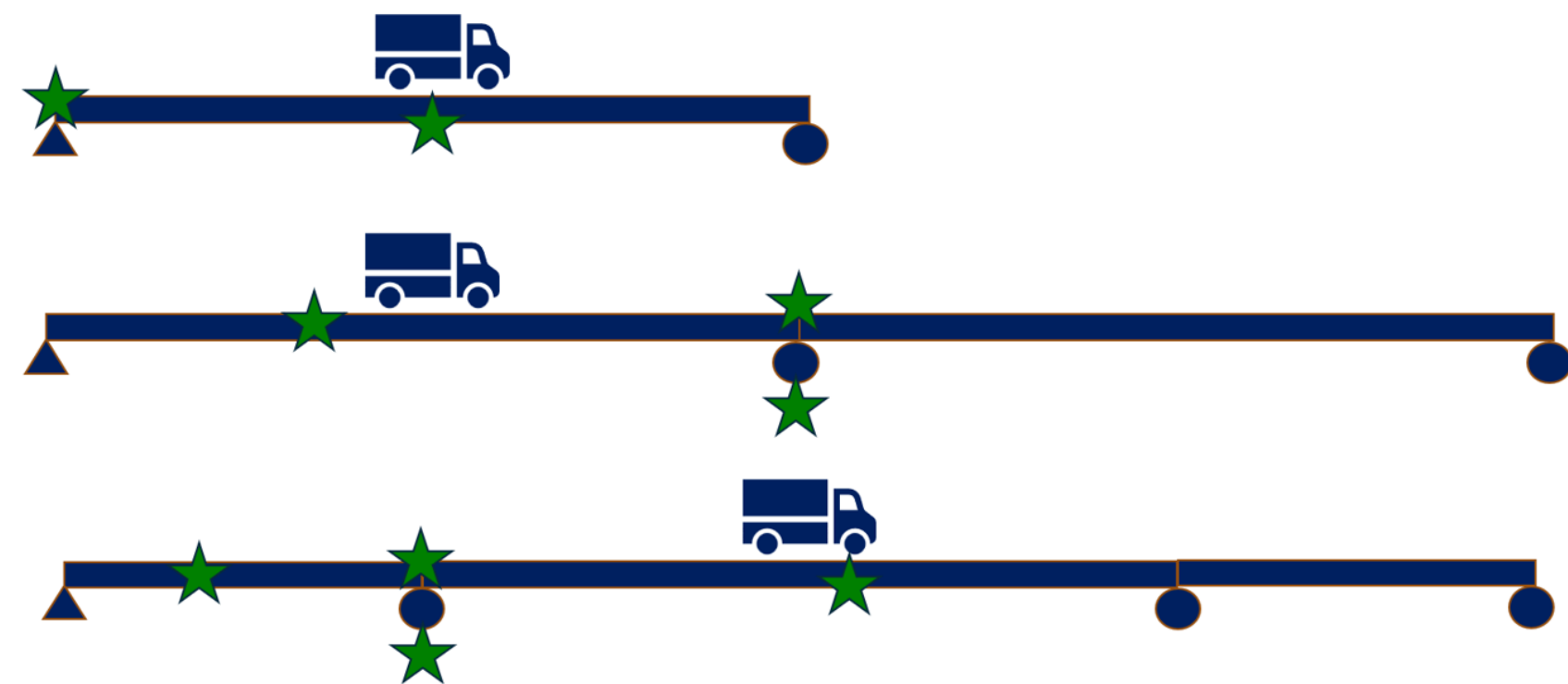
Alaska Legal Live Load Model

- Develop statistical model that captures the legal traffic-induced load effects, and determine maximum expected load on Alaska bridges

- Compute force effect ratios between Alaska WIM records and AASHTO MBE Type 3 trucks

- Statistical Parameters:
  - **Bias Factor**
    - Force Effect Ratio between Alaska WIM and AASHTO MBE legal rating trucks
  - **Coefficient of Variation**
   - Variation of Bias Factors between WIM sites

Simple Span Moment L=20 ft

LEGEND
fox
gln
min
ste
plm
poa
tds
tok
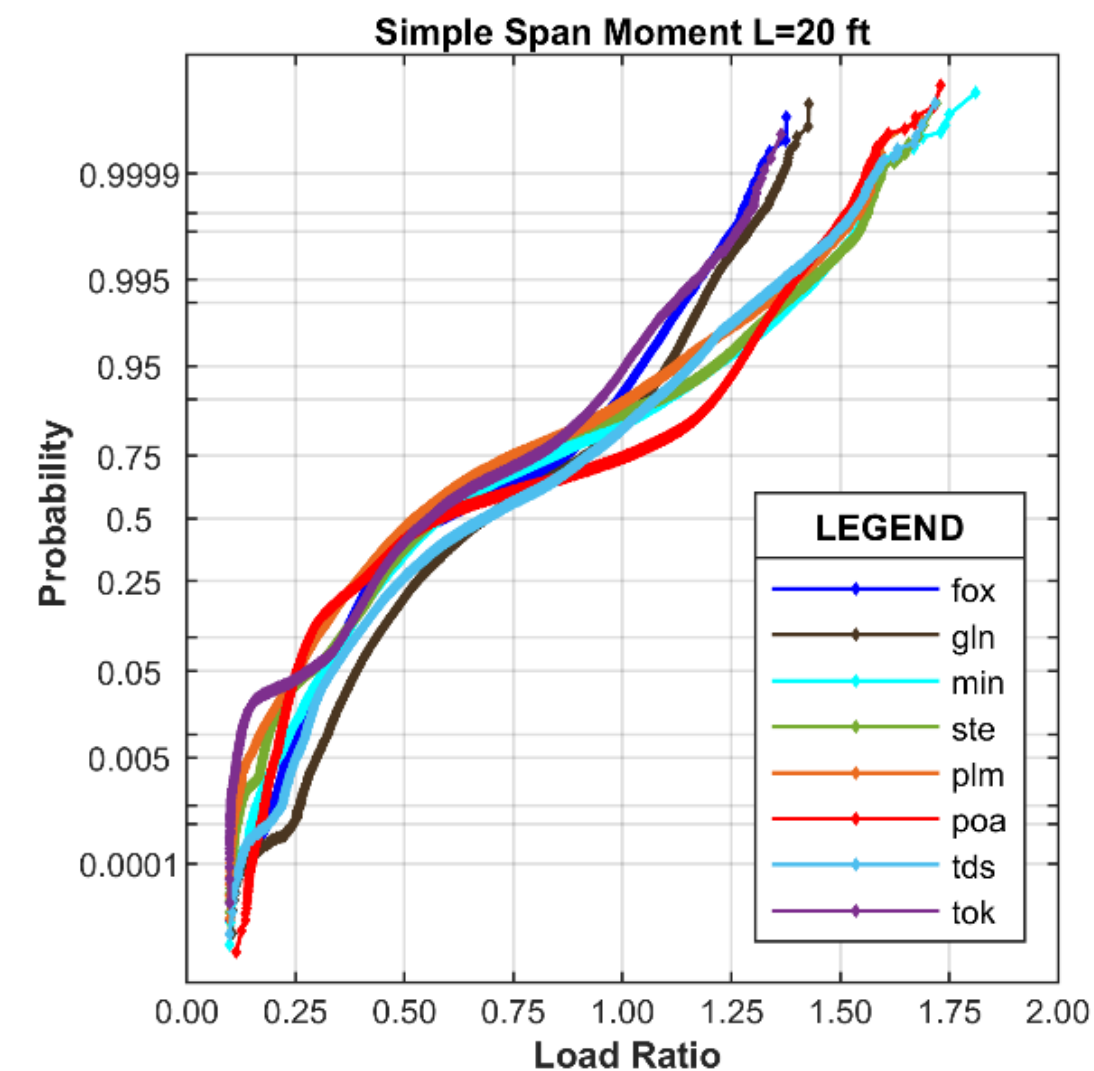
Alaska Legal Live Load Model

- AASHTO MBE Legal Rating Trucks (LRTs) include Type 3, Type 3S2, Type 3-3, and lane load and truck train models
- Controlling bias factors for moment, and shear are selected
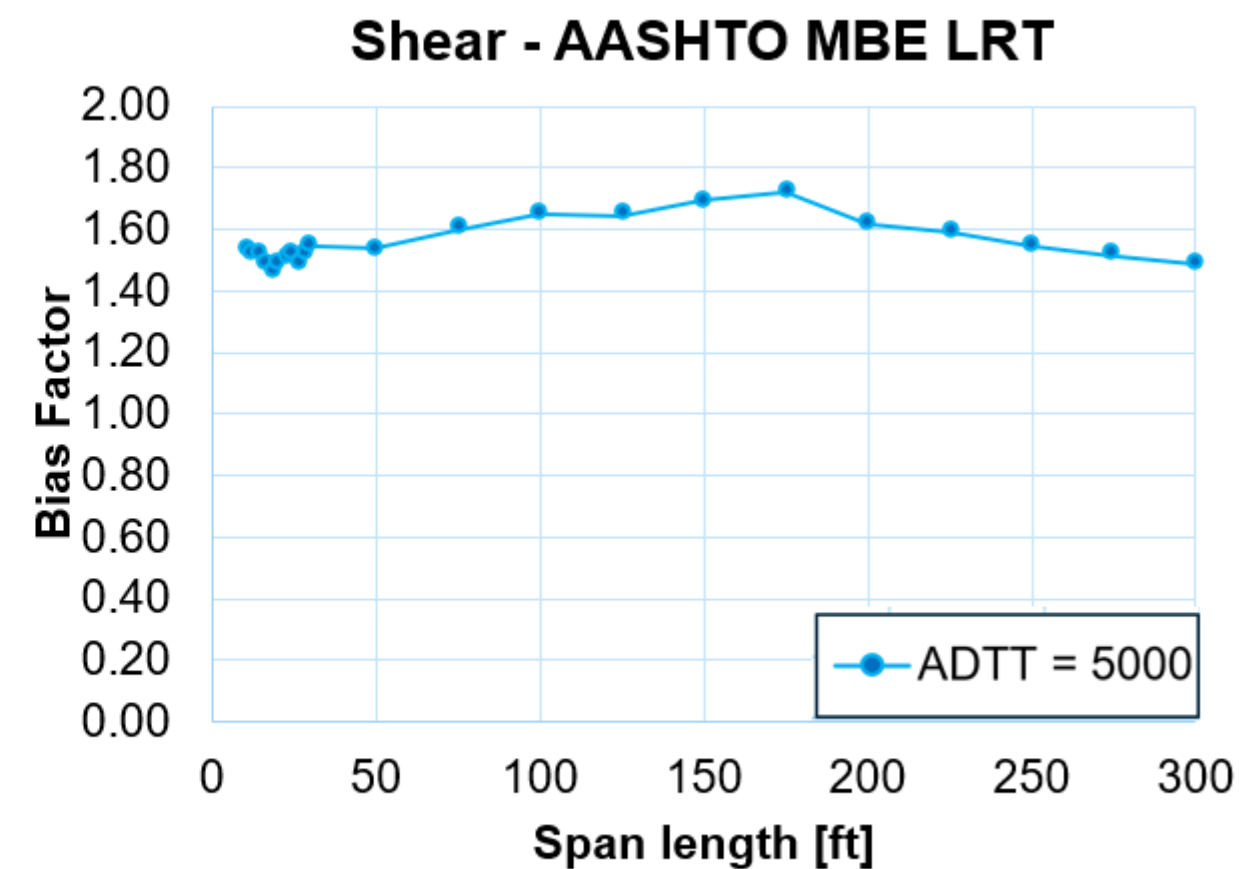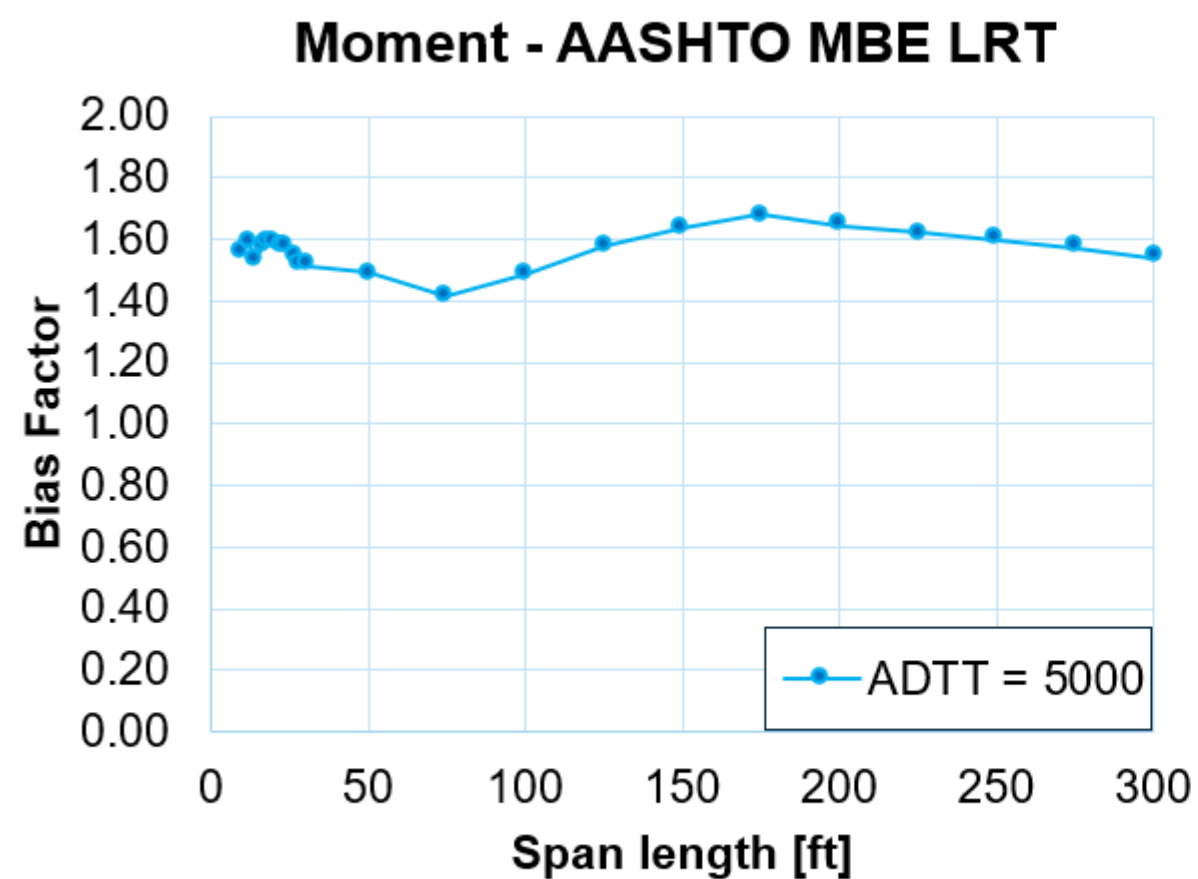
Alaska Calibration Approach

- Use of AASHTO MBE rating trucks to represent of Alaska legal traffic

- No new rating trucks

- Determine Live Load Factor based on the Alaska traffic composition, volume, and frequency

- Use consistent approach with original AASHTO calibration

- Change of Live Load Factor allow for simple Rating Factor scaling to re-rate bridge inventory
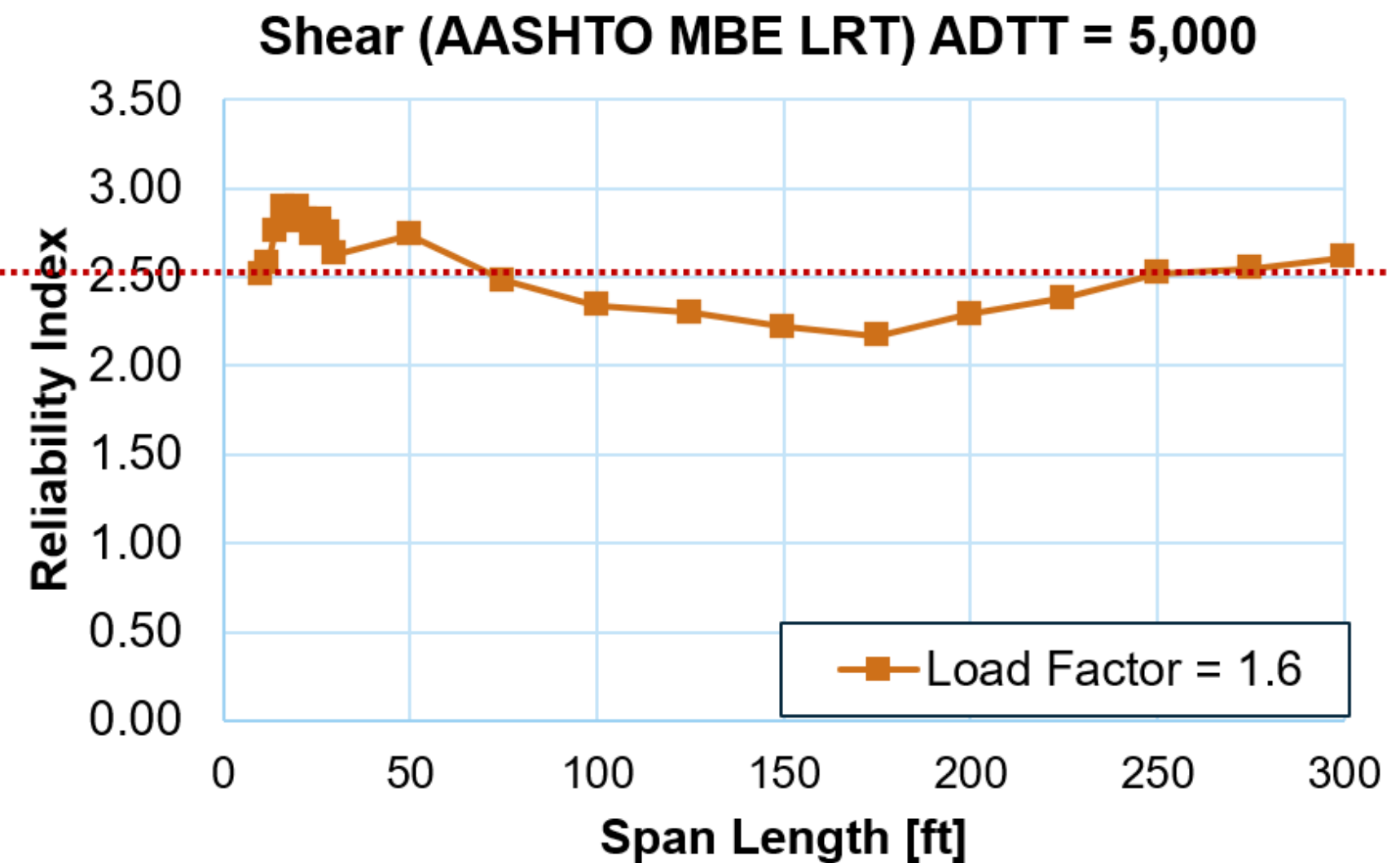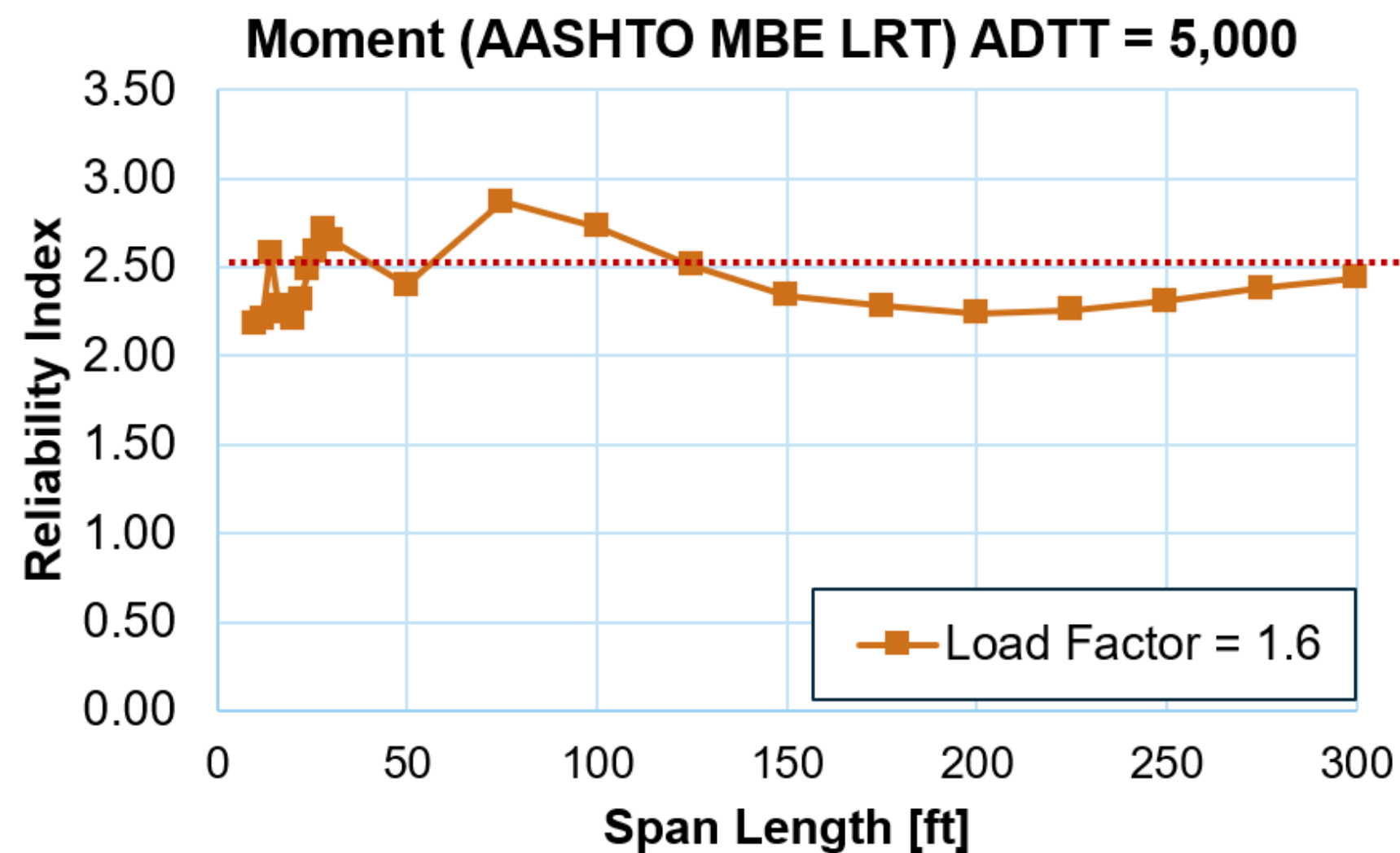

2025 Rating and Design User Group Meeting

AASHTOWare™
BRIDGE
DESIGN AND RATING
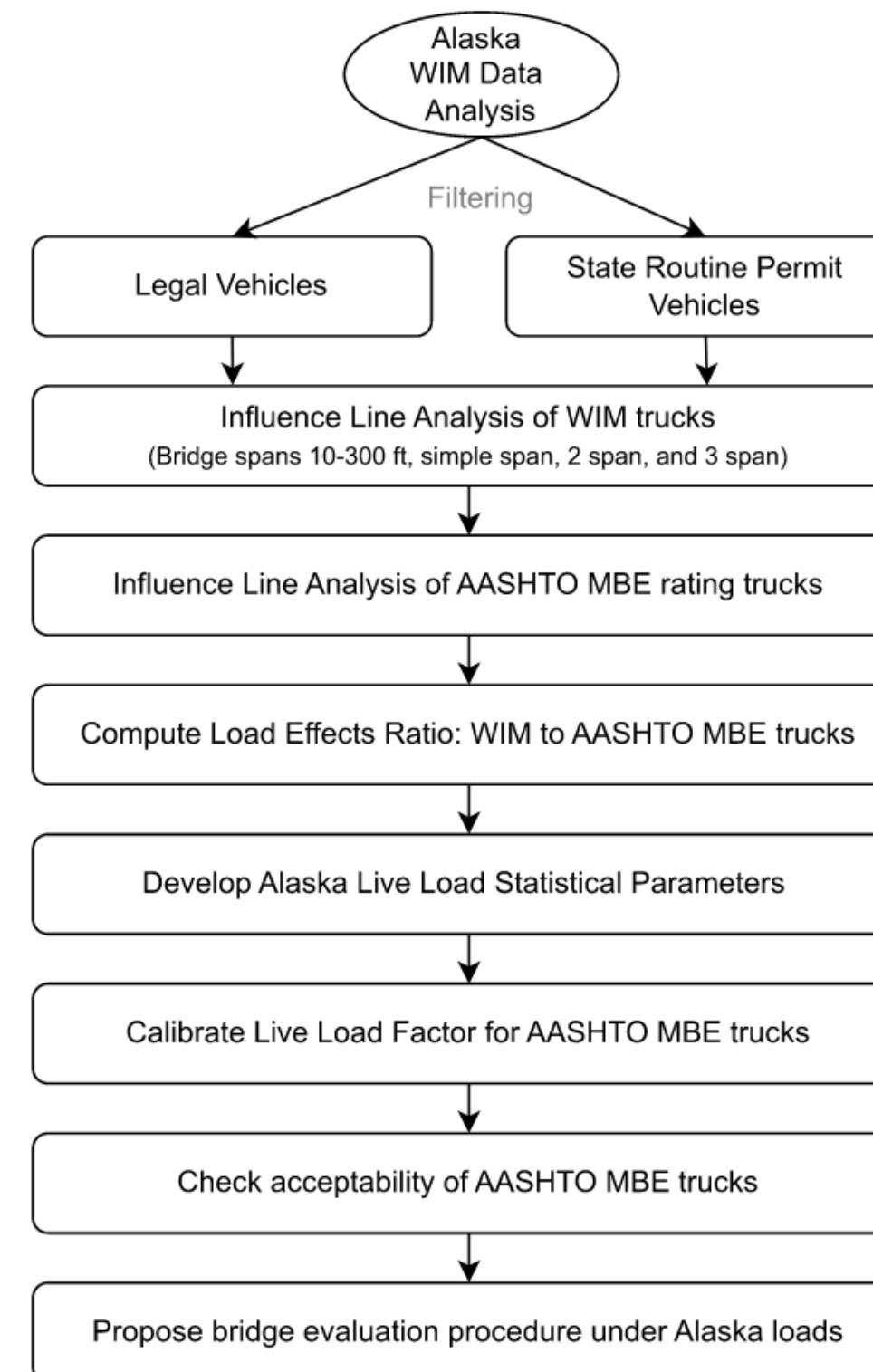
Calibrated Live Load Factors

Moment (AASHTO MBE LRT) ADTT = 5,000
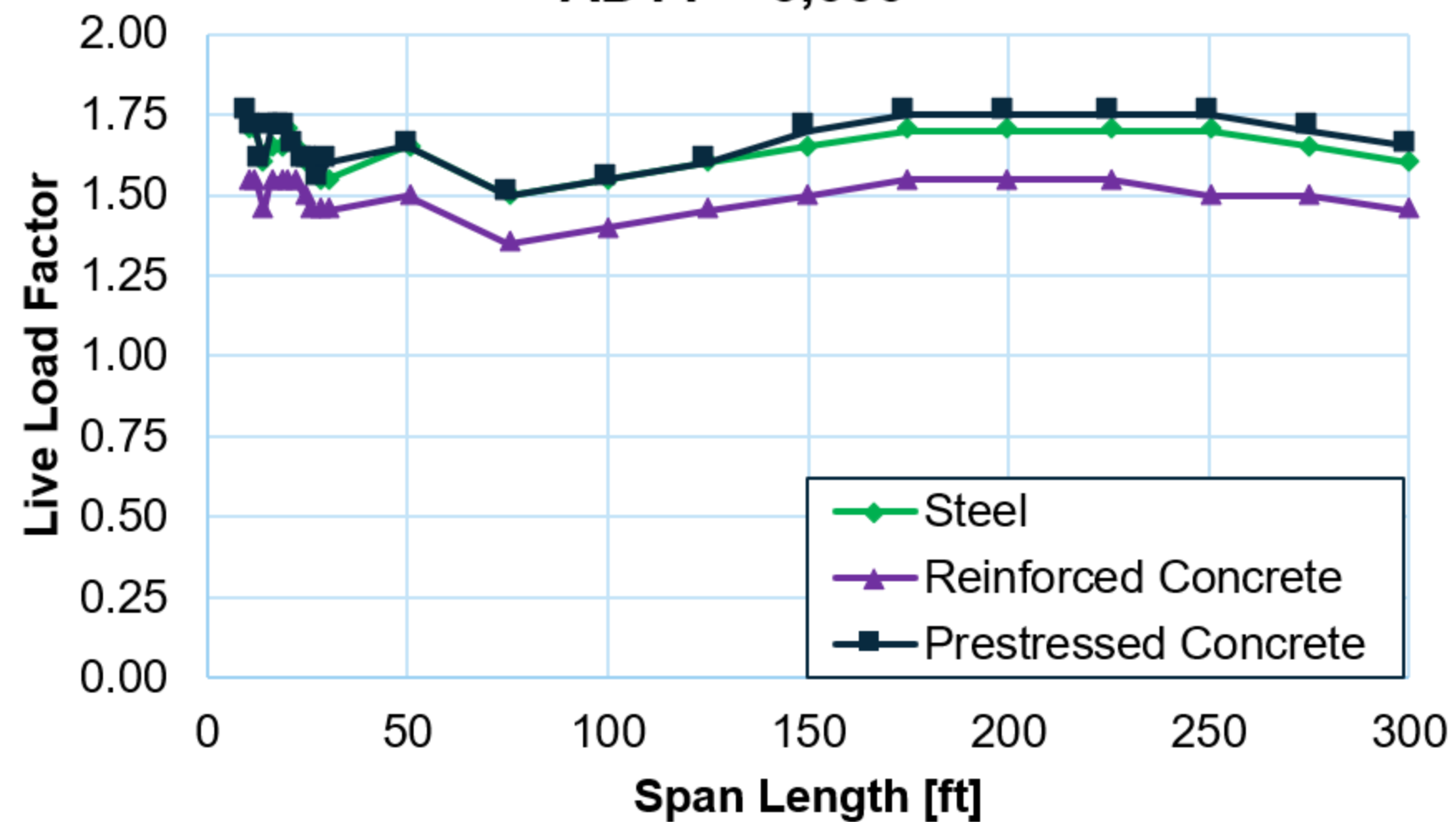
Shear (AASHTO MBE LRT) ADTT = 5,000

Safety Margin – Reliability Index

Moment (AASHTO MBE LRT) ADTT = 5,000

Shear (AASHTO MBE LRT) ADTT = 5,000
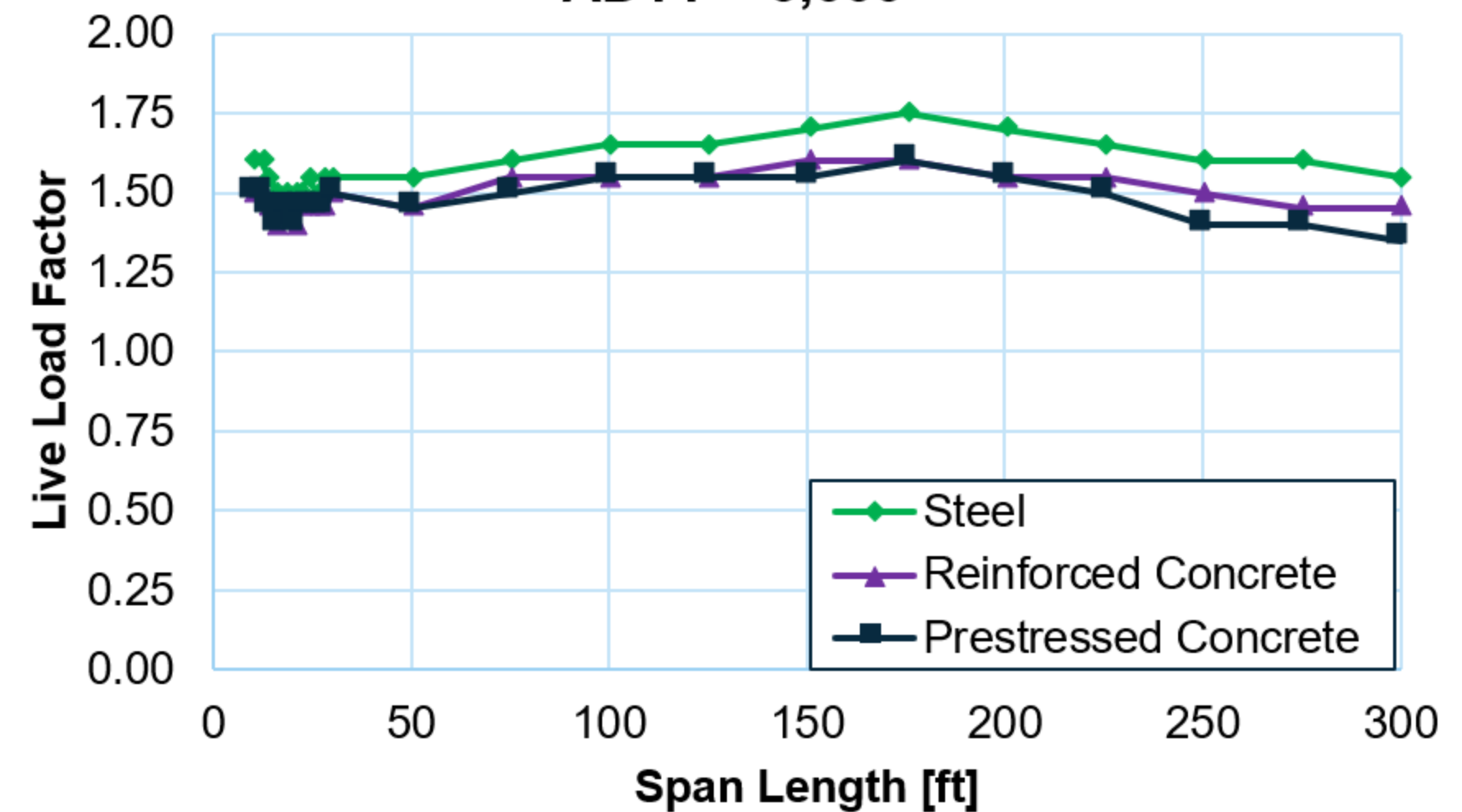
Alaska Ore Traffic

- Alaskan ore trucks are double tractor-trailered vehicles designed for heavy-duty hauling

- 16 axles, 95 feet, and 165,000 lbs

- At peak operation, up to 120 ore trucks expected to travel daily along the Alaska/Richardson Highway corridor between Tok and Fox for an estimated 5 years

- Ore traffic impacts traffic by increasing overall truck volume by 40%
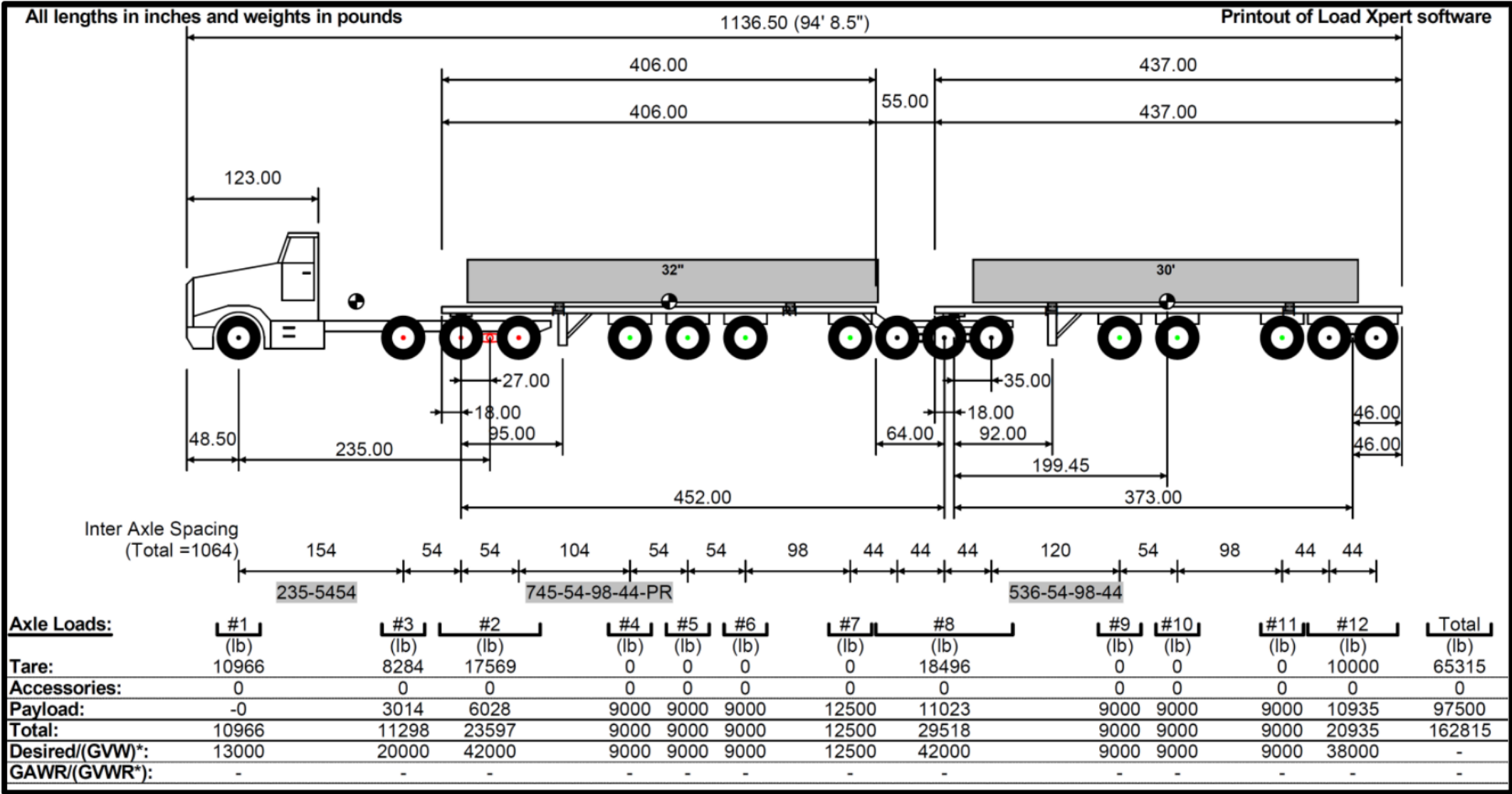
Ore Traffic Simulation

- WIM system records up to 14 axles

- Ore trucks were not fully recorded by WIM data

- WIM data shows a low number of long trucks

- Ore truck simulation used fixed truck configuration, and variable weights based on static ore truck Weigh Station Measurements

- Over 500,000 ore truck configurations were simulated

- Simulated traffic was used to develop Ore Live Load Model

- Calibration for expected 120 ore trucks daily for next 5 years

AASHTOWare™
BRIDGE
DESIGN AND RATING

Ore Traffic Calibration
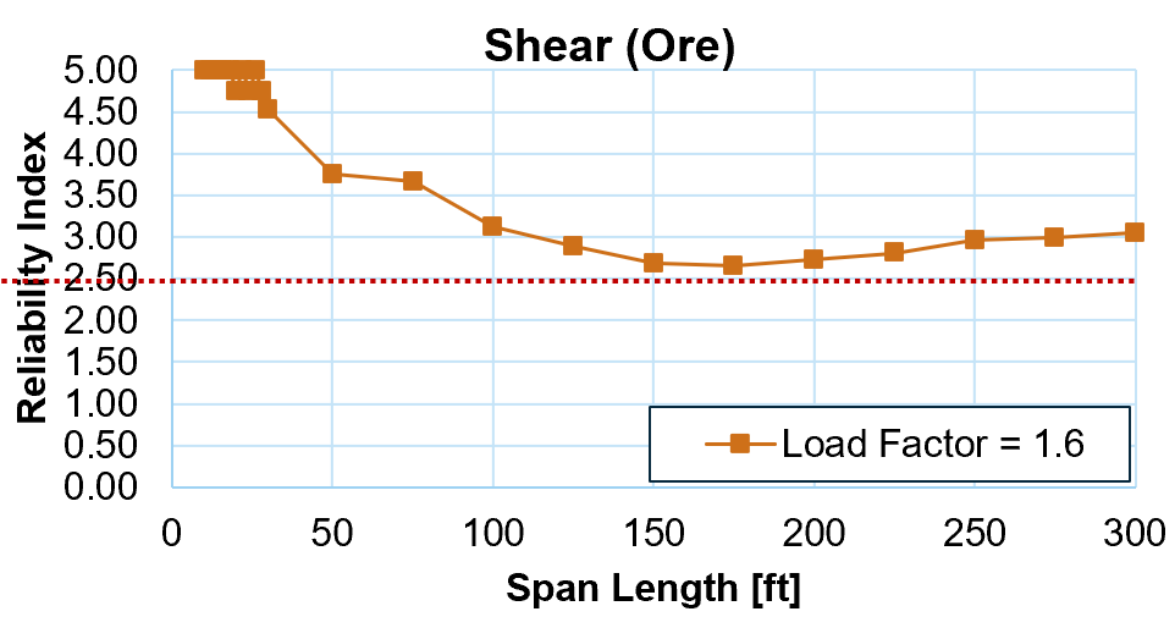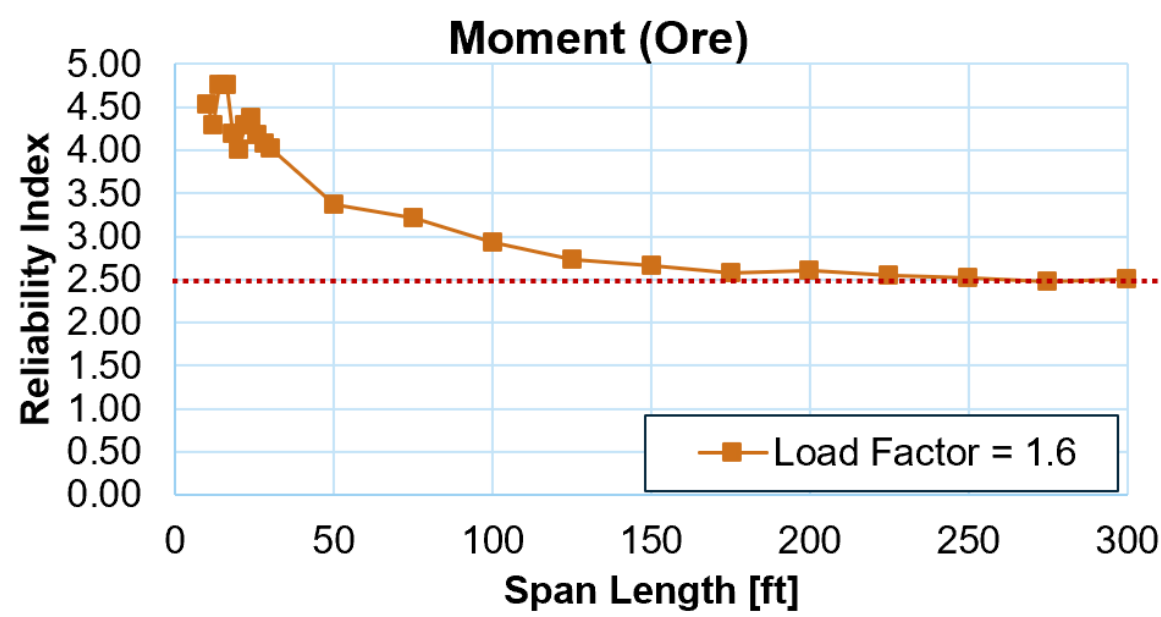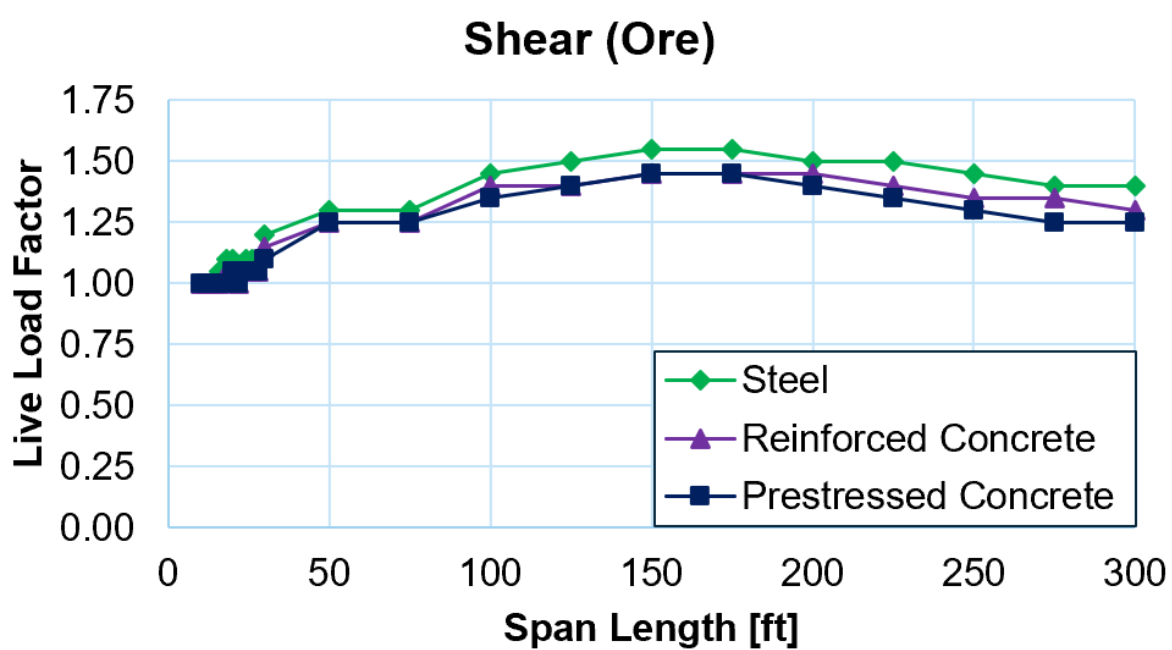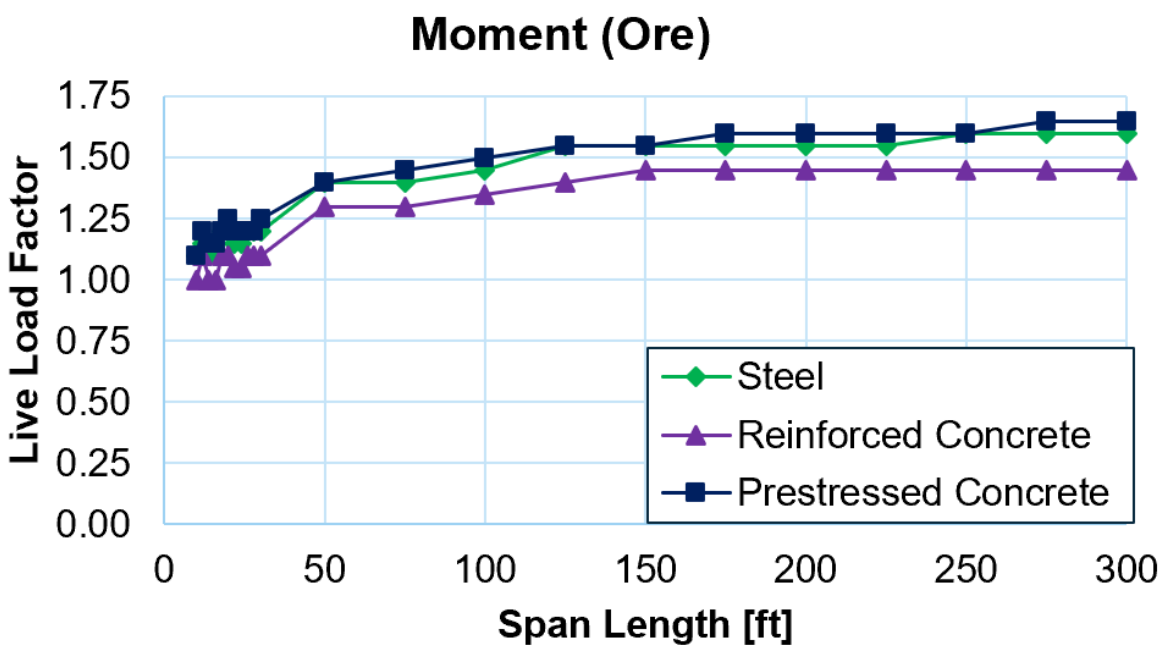
Low variation and traffic volume

Alaska Long Combination Vehicles

- Alaska LCVs have wheelbases over 75 feet, with typical lengths ranging from 90–95 feet for doubles and up to 120 feet for triples

- These vehicles are legally allowed to operate with gross vehicle weights exceeding 80,000 lbs

- To account for LCV traffic, a separate calibration was performed using WIM data for trucks exceeding 75 feet in length. Based on this analysis, a dedicated LCV live load model was developed

- To meet the target reliability index, live load factors should be increased to **1.75** for ADTT 5,000, particularly for bridges with maximum span lengths greater than 150 feet

Moment (LCV), LLF = 1.75

Shear (LCV), LLF = 1.75
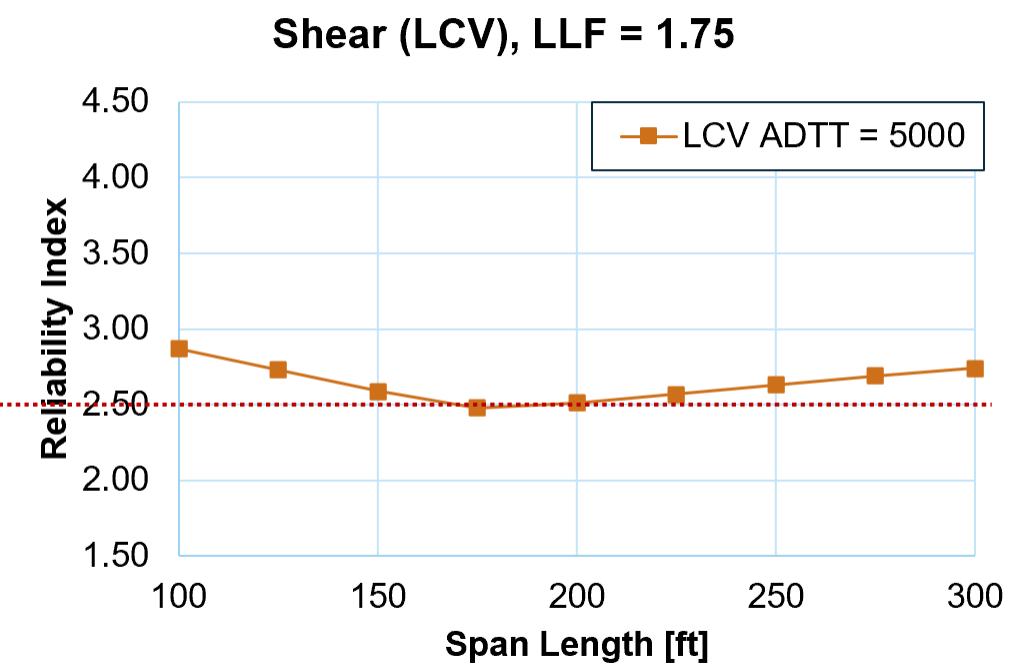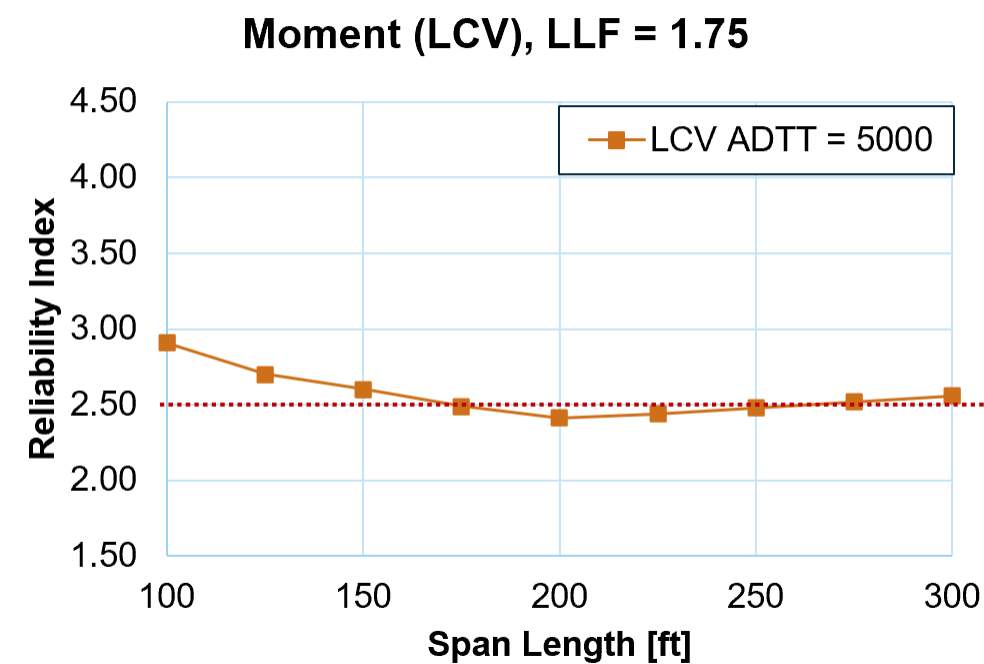
Study Recommendations

- To address Alaska-specific traffic demands, Live Load Factors (LLFs) for AASHTO MBE LRTs should be increased:
  - 1.60 for Typical Trucks
  - 1.75 for LCVs and bridges with spans > 150 ft
- **Option 1: Apply Scale Factor**
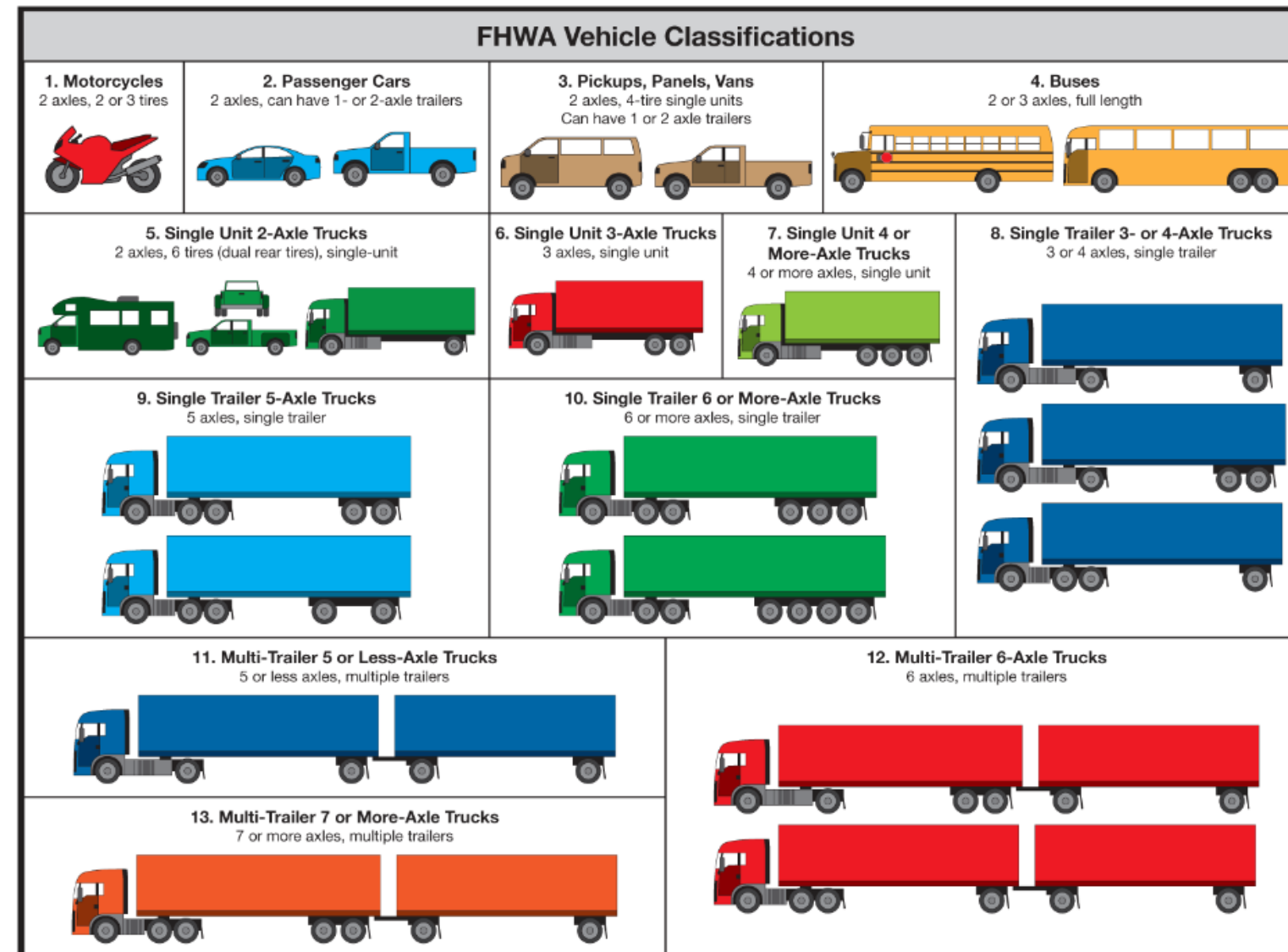 - Adjust existing AASHTO Rating Factors using a scale factor:

$$Scale\ Factor = \frac{Calibarted\ LLF}{AASHTO\ MBE\ LRT\ LLF}$$

$$Adjusted\ RF = \frac{Current\ RF}{Scale\ Factor}$$

- **Option 2: Recalculate Rating Factor**
  - Recalculate bridge ratings directly using the calibrated LLF (1.60 or 1.75)

Deterministic Analysis: Development of a Suite of Representative Alaska Legal Trucks

- Typical Vehicles
  - Based on FHWA Classification
  - 2-7 axles trucks
  - Single Unit, Single Trailer, and Multi Trailer
- Combination Vehicles
  - Alaska trucks with 8-11 axles
  - Length limit < 75 feet
- Long Combination Vehicles
  - Alaska trucks with 8-16 axles
 - Total length > 75 feet & < 120 feet

FHWA Vehicle Classifications

1. Motorcycles
2 axles, 2 or 3 tires

2. Passenger Cars
2 axles, can have 1- or 2-axle trailers

3. Pickups, Panels, Vans
2 axles, 4-tire single units
Can have 1 or 2 axle trailers

4. Buses
2 or 3 axles, full length

5. Single Unit 2-Axle Trucks
2 axles, 6 tires (dual rear tires), single-unit

6. Single Unit 3-Axle Trucks
3 axles, single unit

7. Single Unit 4 or More-Axle Trucks
4 or more axles, single unit

8. Single Trailer 3- or 4-Axle Trucks
3 or 4 axles, single trailer

9. Single Trailer 5-Axle Trucks
5 axles, single trailer

10. Single Trailer 6 or More-Axle Trucks
6 or more axles, single trailer

11. Multi-Trailer 5 or Less-Axle Trucks
5 or less axles, multiple trailers

12. Multi-Trailer 6-Axle Trucks
6 axles, multiple trailers

13. Multi-Trailer 7 or More-Axle Trucks
7 or more axles, multiple trailers

AASHTOWare™
BRIDGE
DESIGN AND RATING

Alaska Typical Trucks

- Alaska typical truck traffic does not differ from other parts of the US
- Dominated by 3-axle and 5-axle trucks
- Previous studies, typical legal rating trucks used in other states, and WIM data served as a basis to develop representative typical truck configurations
- A total of 24 truck configurations were developed to represent Alaska's typical truck traffic
- Also, AASHTO MBE Type 3 trucks and SU-trucks were used to adjust the weights to meet Alaska statute (7 truck configurations)
- Trucks with #2-7 axles, and GVW from 40,000 to 105,000 lbs

Alaska Typical Legal Trucks
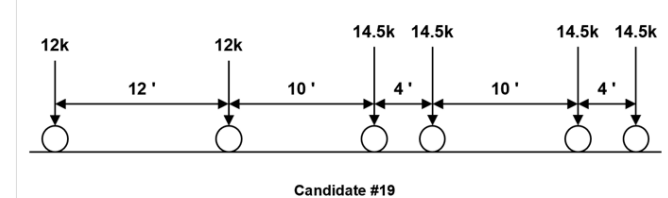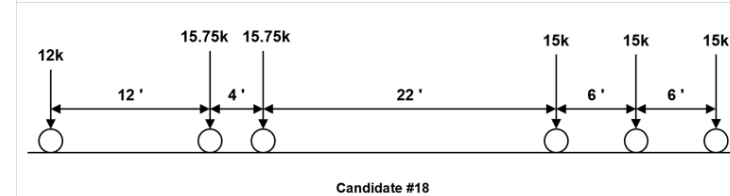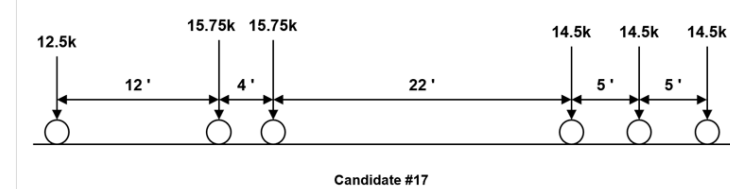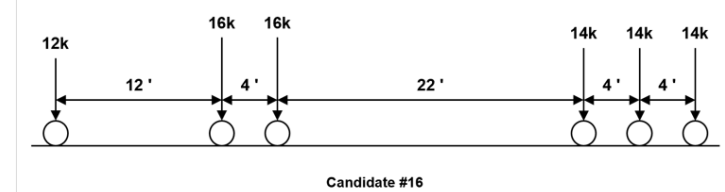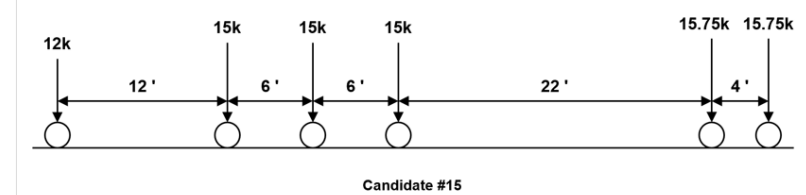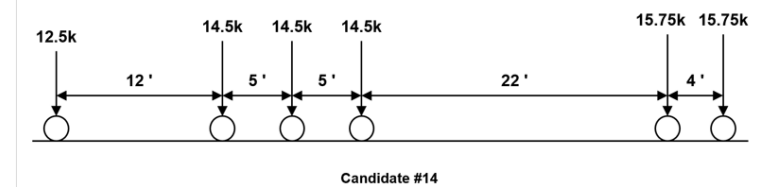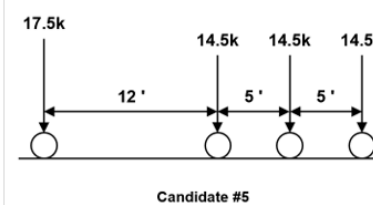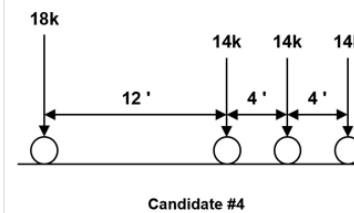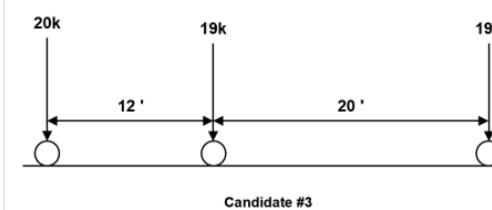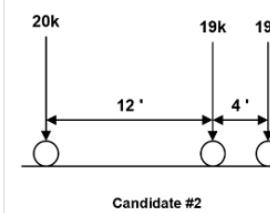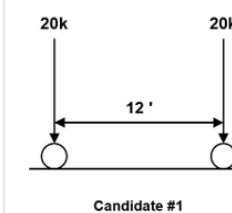
Alaska Combination and Long Combination Vehicles

- Determine Alaska-specific trucks with #Axles > 7, beyond FHWA Classification
- Review WIM data and develop weights and spacing distributions
  - Axle Weight
  - Axle Spacing
  - Number of Axles
  - GVW
- A total of 33 truck configurations were developed to represent Alaska Combination and Long Combination Vehicles
- Trucks with #8-19 axles, and GVW from 107,000 to 200,000 lbs
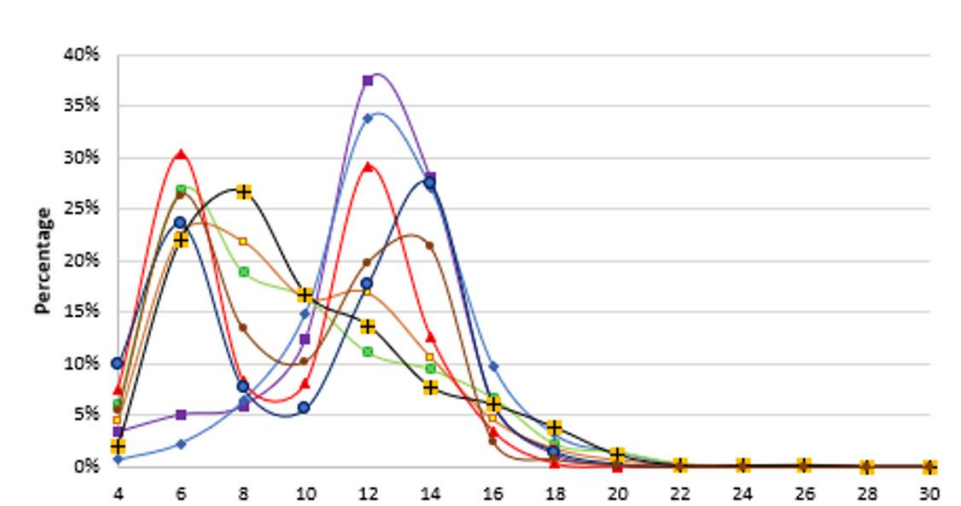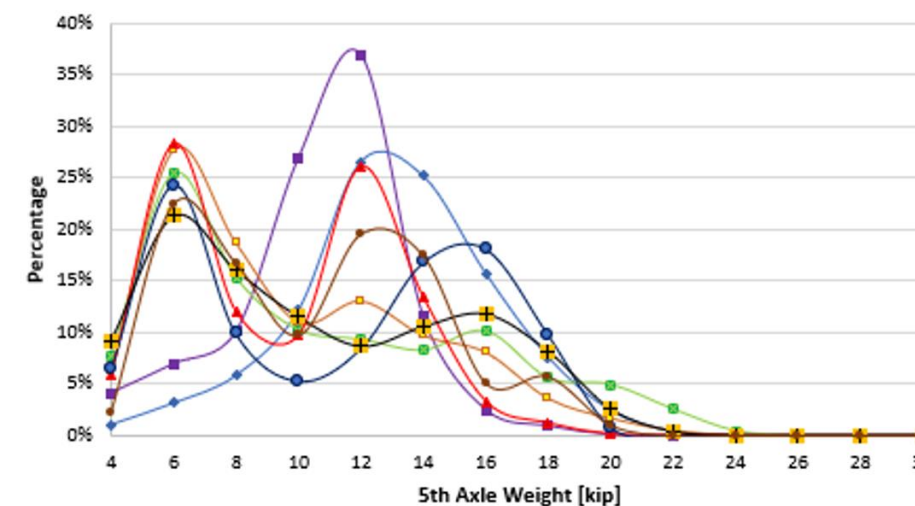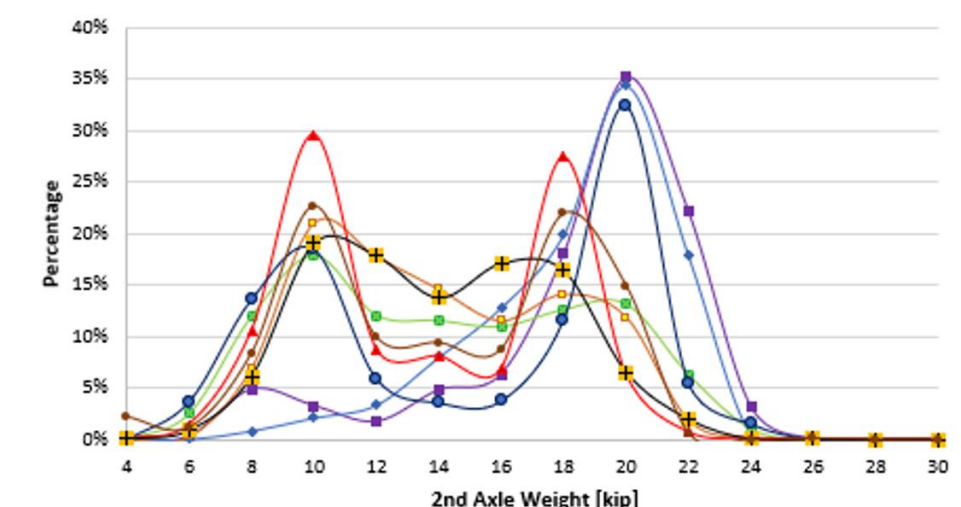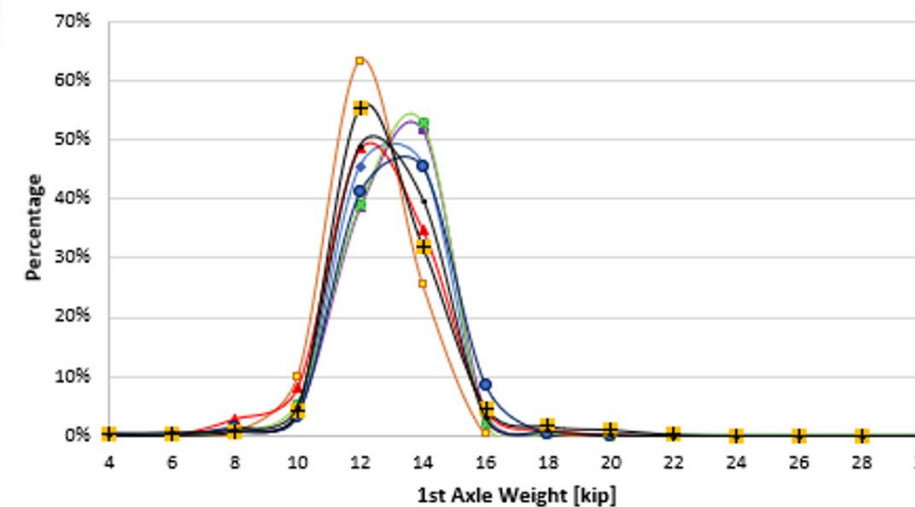
Alaska Representative Trucks

- 64 distinct truck configurations were developed

- Representative truck configurations were maximized to meet Alaska weight limits for:
  - Legal traffic
  - Routine permit traffic

- GVW ranges from 40,000 to 200,000 lbs with #Axles 2-19

AASHTOWare™
BRIDGE
DESIGN AND RATING
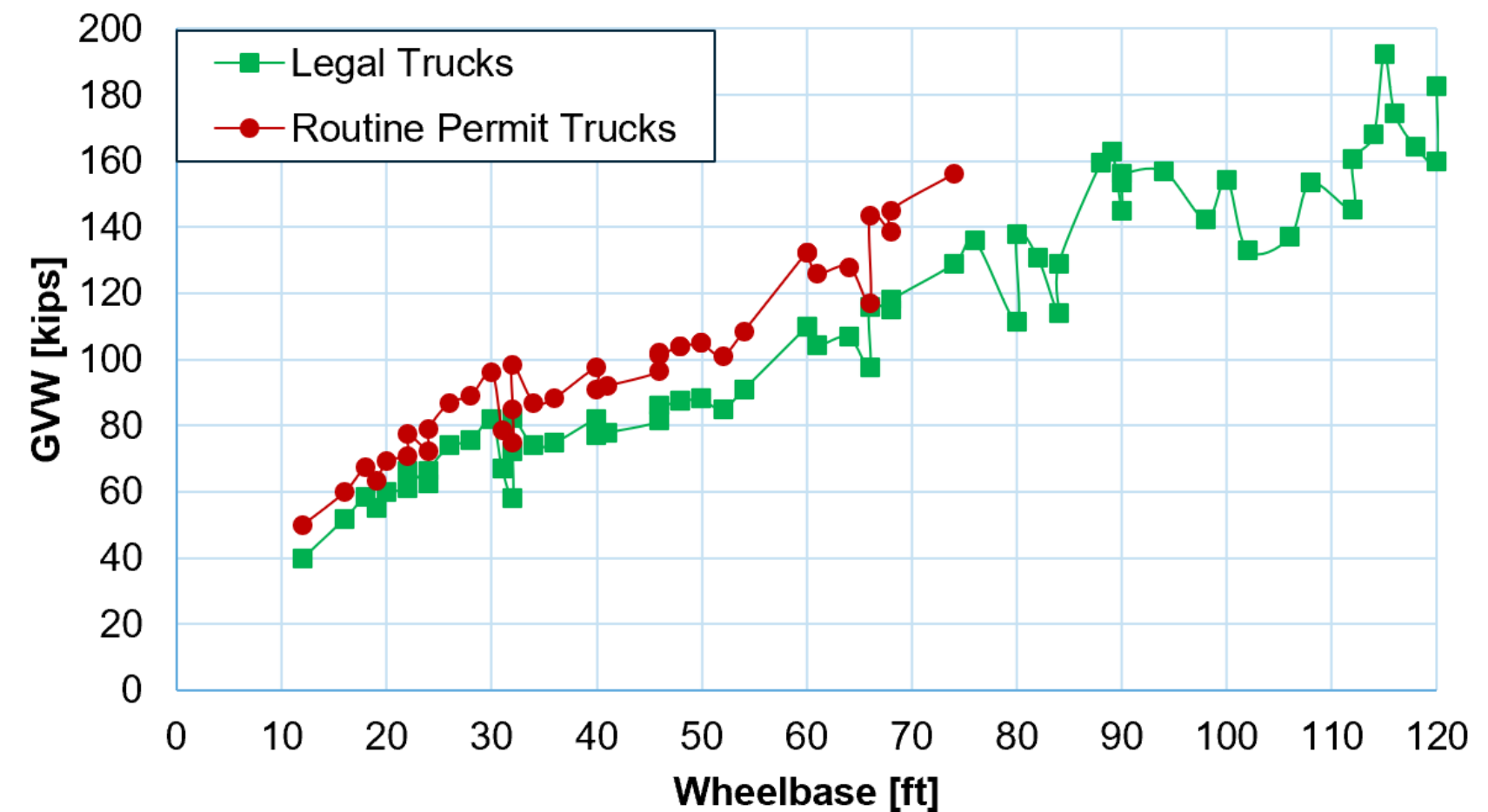
Deterministic vs. Probabilistic Analysis

Deterministic Analysis

- Develop maximized representative truck configurations – 64 Alaska trucks

- Use suite of trucks with Live Load Factor of 1.30 to determine legal load rating
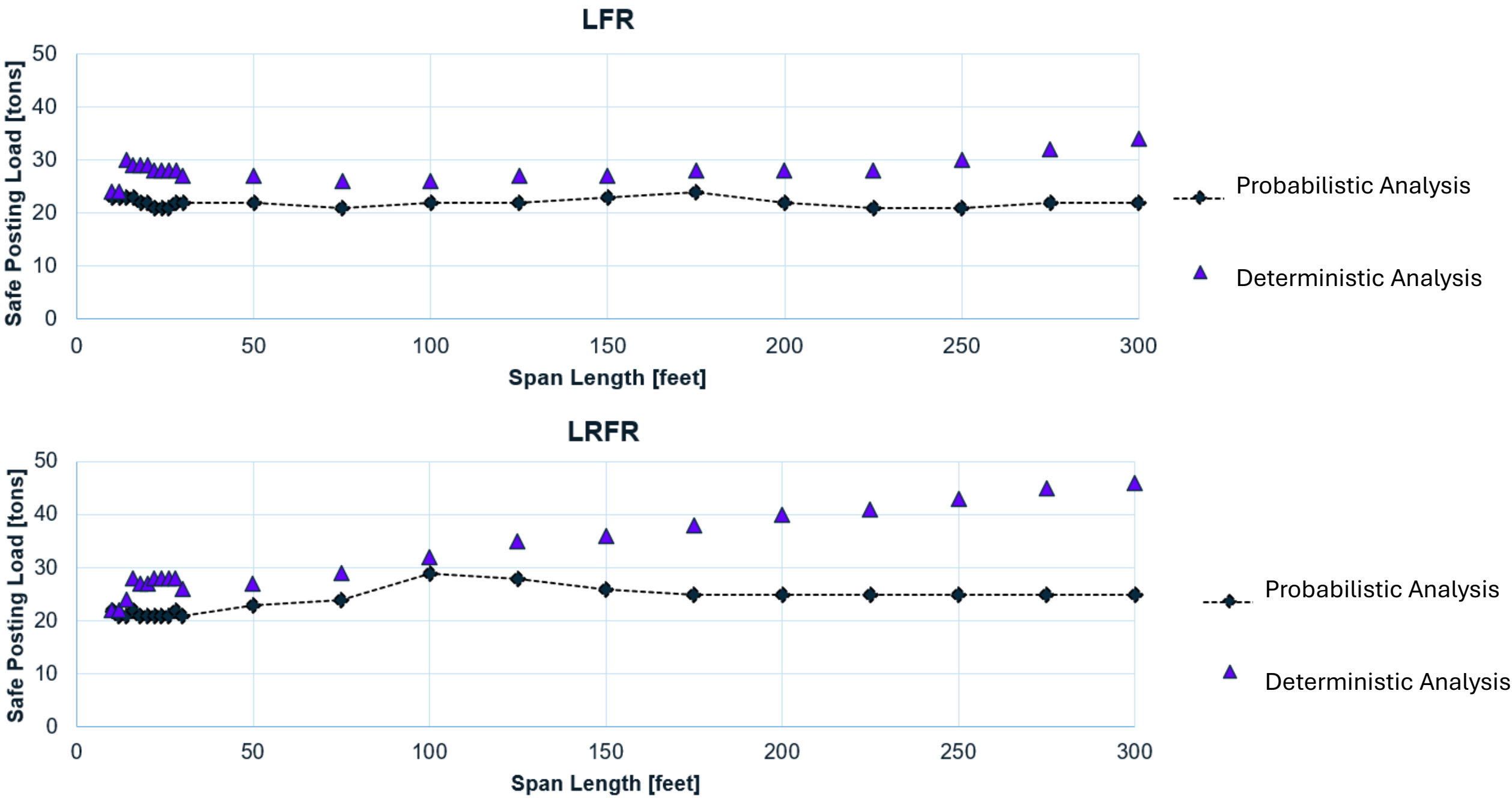
Probabilistic Analysis

- Develop Live Load Model and select Notional Truck(s)

- Calibrate Live Load Factor

- Use AASHTO MBE LRTs (Type 3 trucks) with increased Live Load Factors:
  - 1.60 for Typical Trucks
  - 1.75 for LCVs and bridges with spans > 150 ft

*Compare Safe Posting Load from these two methods

$$Safe\ Posting\ Load\ =\ (Rating\ Facor)(Truck\ Weight)$$

Posting Evaluation Comparison

LFR

Probabilistic Analysis, SPL ~22 tons and deterministic ~28 tons

- ◆ Probabilistic Analysis
- ▲ Deterministic Analysis

LRFR

- ◆ Probabilistic Analysis
- ▲ Deterministic Analysis

AASHTOWare™
BRIDGE
DESIGN AND RATING

AASHTOWare™ BRIDGE DESIGN AND RATING

Summary

Deterministic Analysis

- Develops suite of state-specific notional trucks based on statute
- Uses maximized legal weight limits to define representative trucks
- Does not require traffic data
- Tailored to reflect state-specific legal loads
- Applies the maximum truck GVW for the posting decisions

- Does not provide Live Load Factor
- Does not account for live load variability and uncertainty
- Does not check the safety margin in terms of reliability index
- Implementation requires re-rating for every truck configuration

AASHTOWare™
BRIDGE
DESIGN AND RATING

Probabilistic Analysis

- Provides Notional Truck(s) and calibrated Live Load Factor(s)
- Analyzes actual traffic volumes, weights, and configurations
- Consistent with AASHTO original calibration
- Evaluates safety margins in terms of reliability index
- Reduces re-rating effort by scaling existing rating factors

- Requires traffic data and processing tools
- Demands staff with calibration expertise

AASHTOWare™
BRIDGE
DESIGN AND RATING

Questions?

Sylwia Stawska, PhD, PE: SVStawska@modjeski.com

Rachel Mertz, PE, SE: RLMertz@modjeski.com

Thomas Murphy, PhD, PE, SE: TPMurphy@modjeski.com