

Legal Loads, Specialized Hauling Vehicles and Emergency Vehicles

A bridge that rates well for the HL-93 design load can still need posting for the trucks that actually use it. This course covers the three families of legal-load rating vehicles an engineer must consider under the AASHTO Manual for Bridge Evaluation (MBE) and FHWA policy: the routine commercial vehicles (Type 3, Type 3S2 and Type 3-3), the Specialized Hauling Vehicles (SU4 through SU7, screened by the Notional Rating Load), and the FAST Act Emergency Vehicles (EV2 and EV3). For each family it explains where the model came from, what FHWA memoranda require, how the live load factor and multiple presence are handled, and how results are turned into ratings and posting values. Every regulatory statement is drawn from the MBE, the FHWA memoranda of November 15, 2013 (SHVs) and November 3, 2016 (EVs), the FHWA Questions and Answers documents for each, and 23 CFR 650.313.

Learning objectives

- Identify AASHTO legal vehicles
- Explain why SHVs were added
- Describe FAST Act emergency vehicles
- Decide which vehicles to rate

Why legal loads are rated separately

The NBIS requires every highway bridge on a public road to be load rated in accordance with the AASHTO MBE, and to be posted or restricted when the rating shows it cannot safely carry the loads that are legally allowed to use it. Under the current regulation, 23 CFR 650.313(k) requires load rating in accordance with MBE Sections 6 and 8, and 650.313(l) requires a bridge to be posted as soon as possible, but within 30 days, after a load rating shows posting is needed. The FHWA SHV memorandum puts the intent plainly: all bridges must be evaluated to determine their safe live load carrying capacity considering *all unrestricted legal loads, including State routine permits*.

The design-load rating (HL-93 in LRFR, HS 20 in LFR) is a screening step. It tells the owner how the bridge compares with the design standard, but it does not tell the owner what tonnage to put on a sign. That requires rating for vehicles that represent real legal traffic. Since no engineer can rate for every truck that is legally allowed on the road, the MBE and FHWA use **load models**: a small set of notional vehicles that envelope the real fleet. The FHWA SHV Q&A (March 2014, Question 7) explains this directly: it is impossible to rate and post bridges for every physical vehicle the law allows, so load models are developed to represent them.

Three families of legal models matter today:

- **Routine commercial vehicles:** AASHTO Type 3, Type 3S2 and Type 3-3, representing three-axle single units, five-axle tractor semitrailers and six-axle tractor-trailer combinations.
- **Specialized Hauling Vehicles (SHVs):** SU4, SU5, SU6 and SU7, with the Notional Rating Load (NRL) as a screening model. These represent closely spaced multi-axle single unit trucks such as dump trucks and refuse haulers.
- **FAST Act Emergency Vehicles (EVs):** EV2 and EV3, representing heavy fire apparatus that Congress made legal on the Interstate and reasonable-access routes in 2015.

In addition, many States have their own State legal vehicles, and State routine permit vehicles that travel without restriction must also be considered. This course concentrates on the AASHTO and FHWA models; owner-specific vehicles follow the same logic.

The routine commercial vehicles: Types 3, 3S2 and 3-3

The traditional AASHTO family of legal loads has three vehicles with fixed axle spacings:

Vehicle	Represents	Axles	Gross weight
Type 3	Three-axle single unit truck	3	50 kips (25 tons)
Type 3S2	Five-axle tractor semitrailer (the "18-wheeler")	5	72 kips (36 tons)
Type 3-3	Six-axle tractor-trailer combination	6	80 kips (40 tons)

The NSBA Steel Bridge Design Handbook load rating chapter explains that these three vehicles model three portions of the Federal Bridge Formula, the parts that control short, medium and long span lengths. They give fairly uniform reliability across spans, they are used as truck symbols on posting signs, and they provide continuity with past practice. The axle-by-axle configurations are shown in MBE Figures D6A-1 through D6A-3; use the figures in the edition your owner has adopted rather than a copy from memory.

Lane loads with the legal trucks

For span lengths up to 200 ft, only the legal vehicle itself is placed in each lane. Two additional cases add a lane load:

- **Spans over 200 ft:** the critical effect comes from a Type 3-3 vehicle multiplied by 0.75, combined with a lane load of 0.2 kips per linear foot (MBE Figure D6A-4).
- **Negative moments and interior reactions, at any span length:** also consider two Type 3-3 vehicles multiplied by 0.75, spaced 30 ft from the rear axle of the lead truck to the front axle of the following truck, combined with the 0.2 klf lane load (MBE Figure D6A-5).

The FHWA EV Q&A (Question 23) confirms that the same 200 plf lane load rule continues to apply when the EVs are rated, because other than the two exceptions in the EV memorandum, the MBE governs.

Live load factors for legal loads

In the LRFR legal-load rating, the Strength I live load factor depends on truck traffic. The current MBE table gives 1.45 when ADTT is unknown or at least 5,000, and 1.30 when ADTT is 1,000 or less, with linear interpolation in between. The factors are calibrated to a target reliability index, β_T , of about 2.5, lower than the 3.5 used for design. In LFR the operating level live load factor is 1.3. Dynamic load allowance is normally 33 percent, but MBE Commentary C6A.4.4.3 allows it to be reduced for longitudinal members over 40 ft when a field evaluation shows the riding surface is smooth; the MBE Appendix A example uses 20 percent for a deck with only minor surface deviations.

Why SHVs were added

The FHWA SHV memorandum of November 15, 2013 describes SHVs as closely spaced multi-axle single unit trucks introduced by the trucking industry in the preceding decade, such as dump trucks, construction vehicles, solid waste trucks

and other hauling trucks. Many have lift (drop) axles, lowered when the truck is loaded. Because these trucks generally comply with Federal Bridge Formula B, they are considered legal in every State unless State law explicitly excludes them.

NCHRP Project 12-63 (Report 575, 2007) studied truck configurations and State legal loads. It found that the Types 3, 3S2 and 3-3 do not represent all legal loads, specifically SHVs. The SHV Q&A (Question 5) summarizes the finding: SHVs of up to 80,000 lb that meet Formula B can, because their axles are closely spaced, cause load effects up to 22 percent greater than HS 20 and more than 50 percent greater than the Type 3, 3S2 or 3-3 loads. SHVs heavier than the federal limits can cause even larger effects. The memorandum adds that the effect is greatest on bridges with short spans or short loading lengths, such as transverse floor beams.

AASHTO adopted SHV legal load models in 2005, and the memorandum states FHWA's position that SHVs must be included in rating and posting analyses per MBE Articles 6A.2.3 and 6B.9.2 (1st Edition; 6B.7.2 in the 2nd Edition), unless one of two conditions is met:

- **Condition A:** the State verifies that State law precludes SHV use; or
- **Condition B:** the State has its own legal load rating vehicles, verifies they envelope the applicable AASHTO SHV models, and has included those models in the rating and posting of all bridges.

SHV types that State law precludes (for example, six- or seven-axle single units) need not be considered. The SHV models apply to ASR, LFR and LRFR.

The SHV load models and the NRL

The MBE SHV family has four single unit models and one screening model:

Model	Axles	Gross weight
SU4	4	54 kips (27 tons)
SU5	5	62 kips (31 tons)
SU6	6	69.5 kips (34.75 tons)
SU7	7	77.5 kips (38.75 tons)
NRL	8	80 kips (40 tons)

Axle weights and spacings are in MBE Figure D6A-7 (SU4 to SU7) and Figure D6A-6 (NRL). The NRL is "notional" because it does not represent any actual truck. It was developed to envelope, on simple and continuous spans, the load effects of the most critical single unit SHV configurations up to 80 kips.

How screening works

The SHV memorandum and Q&A Question 13 set out the logic:

1. Rate the bridge for the NRL. If the RF is 1.0 or greater at the inventory level, or at the operating level (the legal load level in LRFR), the RFs for SU4 to SU7 will also be at least 1.0 at that level, and no SHV posting is needed.
2. If the NRL RF is below 1.0, rate the bridge for SU4, SU5, SU6 and SU7 individually. Some of them may still rate above 1.0; post only for those that do not.

Three points from the Q&A often come up in review:

- **The NRL may be skipped.** Rating directly for SU4 to SU7 is "totally appropriate and acceptable" (Question 14), and it is often simpler in software.
- **SU7 as a screen.** For simple spans, SU7 produces higher demands than SU4 to SU6 and can serve as the screening load. For other structure types or span arrangements, FHWA considers the NRL the more prudent screen (Question 15).
- **Never post from the NRL.** The NRL is a screening load only. Its rating tonnage is typically higher than the rating tonnage for SU4 to SU7, so posting from the NRL tonnage would not be conservative (Question 23).

One technical footnote (Question 9): the AASHTO SHV models meet the 23 CFR 658.17 limits except at a three-axle group with exterior axles exactly 8 ft apart. Formula B gives 42,000 lb for that group, and the models represent the real trucks whose spacing is a fraction of an inch more than 8 ft. For practical purposes, they are models of Formula B-compliant SHVs.

SHVs and State law: the decision tree

Most of the questions States sent FHWA after the 2013 memorandum were about how State law interacts with the requirement. The March 2014 SHV Q&A answers them in a way that can be arranged as a decision tree.

Step 1: What are the federal limits?

Under 23 CFR 658.17, trucks on the Interstate System must meet four limits: a single axle of no more than 20,000 lb, a tandem axle of no more than 34,000 lb, a gross vehicle weight of no more than 80,000 lb, and Federal Bridge Formula B. Part 658 also recognizes grandfathered exemptions above those limits in some States (Q&A Question 4).

Step 2: Are SHVs on the Interstate?

States have no authority to keep vehicles that meet the four federal limits, including SHVs, off the Interstate. Condition A of the memorandum (State law precludes SHVs) therefore **never applies to Interstate bridges**. The AASHTO SHV models must be included in rating and posting every Interstate bridge (Questions 16 and 17).

Step 3: What does State law say for other routes?

- **State law bans SHVs outright:** rating and posting for SHVs is not required where they cannot legally operate, except on the Interstate (Question 16).
- **State law bans certain types,** such as single units with five or more axles: those types (SU5, SU6, SU7 in that example) need not be rated on routes where State law applies. SU4 is still required, and all four are required on the Interstate (Question 17).
- **State law caps vehicles at federal limits but is silent on SHVs:** Formula B-compliant SHVs are legal, so the AASHTO models must be included (Question 18).
- **State law allows SHVs heavier than the federal limits** without permits: the State must determine whether those trucks produce higher effects than SU4 to SU7. If so, State-specific models or actual vehicle configurations must be used in rating and posting (Questions 10, 11 and 19).

Step 4: Do State models envelope the AASHTO SHVs (Condition B)?

Question 20 adds a subtlety many engineers miss. If a State-specific SHV model envelopes SU4 to SU7 and has been included in the rating, then a bridge that does *not* need posting for the State model does not need separate SU4 to SU7 ratings. But a bridge that *does* need posting for the State model must still be rated for SU4 to SU7, because the safe posting tonnage for each configuration has to be determined.

Economic arguments do not count

Question 22 asks about a State where five- to seven-axle SHVs do not operate for economic reasons, supported by weigh-in-motion data, but are not prohibited by statute. The answer turns on legal status, not observed frequency: if the law does not exclude a vehicle, it is a legal load and must be considered.

Comparing vehicles correctly

A common shortcut is to argue that one vehicle "envelopes" another because it is heavier or produces larger moments. SHV Q&A Question 21 explains why this is often not enough.

- Comparing axle weights, spacings and gross weights alone is typically insufficient.
- Comparing load effects (moments and shears) is sometimes enough. If vehicle A produces larger effects than vehicle B, and the bridge has enough capacity for A, then it has enough for B.
- But if the bridge does *not* have enough capacity for A, nothing can be concluded about B. A posting based on A's rating tonnage may be unconservative or overly restrictive for B.

To compare vehicles, compare **load ratings**. Question 27 shows the practical consequence. A State that wanted to post a single single-unit tonnage based on its triple-axle dump truck was told that if the dump truck is heavier than some AASHTO SHVs, its rating tonnage may be higher than theirs at the same rating level, and a posting based on it would be unconservative for those configurations.

The reason is that the rating tonnage is $RF \times W$. A heavy truck with well-distributed axles can have a large tonnage capacity, while a lighter truck with tightly grouped axles has a smaller one. A sign showing the larger number lets the lighter, more concentrated truck cross at a weight the bridge cannot carry.

Parametric studies

Question 21 accepts parametric studies as a way to narrow down which bridges need SHV rating, with a limit: the conclusions apply only to the structure type studied. A study of simple spans with uniform girders can screen a large share of an inventory, but it cannot be extended to continuous units, trusses or floor systems. Floor beams and other short loading lengths deserve particular attention, since the SHV memorandum names them as the members most affected.

Posting signs for SHVs

MBE posting provisions defer to the MUTCD for sign design. The SHV Q&A (Question 26) describes FHWA's 2013 consultation with the MUTCD Team in the Office of Operations. Its conclusion was that States may modify the written posting signs R12-1 through R12-4, which carry no silhouettes, to suit vehicle configurations. Silhouettes that are not pre-approved or included in the MUTCD require a human factors study to be MUTCD-compliant.

FHWA pointed to an Illinois sign (R12-I100) as a model, suggesting a single-vehicle block such as:

SINGLE VEHICLES	
3 OR LESS AXLES	xx T (Type 3 or similar)
4 TO 7 AXLES	xx T (SHVs)

The axle cut-offs should match each State's vehicle law. The guiding principle is that a sign should restrict only the vehicles that need restricting. A well-worded sign separates single units (Type 3, SHVs) from combinations (3S2, 3-3) without penalizing vehicle types that do not need it.

Assigned and method choices

The selection of load rating method for SHVs should follow FHWA's October 30, 2006 policy memorandum on load ratings for the NBI. The SHV memorandum confirms that the SHV models apply to ASR, LFR and LRFR. A State could use an alternative approach in place of the memorandum's timelines only if FHWA reviewed and formally accepted it.

Historical timelines

The memorandum grouped bridges for re-rating where neither Condition A nor Condition B applied.

- **Group 1** covered bridges whose shortest span was 200 ft or less and that met one of these:
 - Last rated by ASR or LFR, with an operating rating for Type 3, 3S2 or 3-3 below 33, 47 or 52 tons respectively.
 - Last rated by LRFR, with a legal load RF below 1.3 for any of those vehicles.

Group 1 bridges were to be re-rated after their next NBIS inspection, and no later than December 31, 2017.

- **Group 2**, all other bridges, were due by December 31, 2022.

Both deadlines have passed, so today SHVs are simply part of every legal load rating. Whenever a re-rating is warranted by a change in condition, loading or configuration, it must include them.

FAST Act Emergency Vehicles: the legal basis

Section 1410 of the Fixing America's Surface Transportation (FAST) Act of 2015 amended 23 U.S.C. 127 to set weight limits for emergency vehicles on the Interstate System. The FHWA memorandum of November 3, 2016 on load rating for FAST Act EVs lists the statutory maximums:

Element	FAST Act EV maximum	Normal federal limit (23 CFR 658.17)
Steering axle	24,000 lb	(no separate federal steering limit)
Single drive axle	33,500 lb	20,000 lb
Tandem axle	62,000 lb	34,000 lb
Tandem rear drive steer axle	52,000 lb	—
Gross vehicle weight	86,000 lb	80,000 lb

Section 1410 sets only these axle and gross weights. As EV Q&A Question 16 notes, it does not prescribe axle spacing or configuration. EVs that meet the limits do not have to satisfy Federal Bridge Formula B, and that is the core of the problem. Formula B limits the weight on any group of two or more consecutive axles according to the distance between the outer axles and the number of axles (23 U.S.C. 127(a)(2)). Question 12 explains that non-Formula B vehicles generally produce worse effects than Formula B vehicles of the same gross weight, and that posting for both gross and axle weight may be necessary because weight can shift significantly between axles.

How much heavier?

Question 14 quantifies it for simple span girders of 15 to 200 ft. Compared with an AASHTO Type 3 (25 tons):

- A two-axle EV with a gross weight of 57,500 lb can produce girder moments and shears up to **35 percent** greater.
- An EV with a single front axle and tandem rear axle at 86,000 lb can produce effects up to **82 percent** greater.

Many bridges were never designed for loads like these.

Where EVs are legal

The FAST Act makes compliant EVs legal on the Interstate and on routes within reasonable access to it. Question 7 explains that if a State has no FHWA-approved reasonable access policy, reasonable access must be taken as within one road-mile of the Interstate for EV posting or restriction. Question 45 adds that a State cannot exclude remote exits that lack services.

States that adopt the EV provision into their own law, or exempt EVs from load limits, make them legal on other routes as well. Those bridges must also be rated and posted or restricted (Question 41).

The EV2 and EV3 rating models

The memorandum defines two rating vehicles:

Model	Front axle	Rear axle(s)	Wheelbase	Gross
Type EV2	24 kips	33.5 kip single	15 ft	57.5 kips (28.75 tons)
Type EV3	24 kips	62 kip tandem (two 31 kip axles at 4 ft)	17 ft (to tandem centerline)	86 kips (43 tons)

Question 17 explains what they represent:

- **EV2:** EVs with two single axles, such as commercial and custom chassis pumpers, industrial foam pumpers and certain aerial ladders.
- **EV3:** EVs with a single front axle and tandem rear axle, such as tankers, tandem-axle foam pumpers, certain aerial ladders and aerial platforms.

Where the wheelbases came from

The statute is silent on spacing, so FHWA's Office of Bridges and Structures ran a comparative study (Question 19). It drew on the typical apparatus configurations in the International Association of Fire Chiefs (IAFC) and Fire Apparatus Manufacturers' Association (FAMA) guideline, along with manufacturer data. The shortest practical wheelbase is about 14 ft, and commercial chassis tend to be shorter than custom chassis.

The study analyzed simple span moments and shears for eight configurations, each over nine wheelbases:

- Four single rear axle cases (A21EV to A24EV), with gross weights of 49 to 57.5 kips.
- Four tandem rear axle cases (A31EV to A34EV), with gross weights of 74 to 86 kips.

A 15 ft single rear axle model and a 17 ft tandem model enveloped all typical apparatus in their class. The EV models are not "real trucks," but Question 44 confirms that they are representative enveloping loads that meet the 23 U.S.C. 127(r)(2) definition. Unless better information is available, the AASHTO LRFD Article 3.6.1.2.5 tire contact area may be used.

Tiller trucks and other configurations

Question 18 notes that tiller-axle trucks need not meet Formula B either. However, their much longer wheelbase means they normally do not control, and EV2 and EV3 envelope typical apparatus that stay within the FAST Act limits.

Do older design loads cover the EVs?

Question 26 explains that HS 20 moments and shears, factored by the design load factor of 2.17, envelope EV2 and EV3 factored by the operating factor of 1.3. H 15 does not envelope them. H 20 may envelope them for short spans but not long ones.

Question 27 adds that HL-93 envelopes the FAST Act EVs. A bridge with full HL-93 design capacity can carry them, so the memorandum does not affect new design. Question 29 accepts Assigned Load Ratings for EVs if the September 29, 2011 assigned-rating memorandum's conditions are met.

Rating rules for EVs: the two exceptions

The memorandum requires EVs to be rated at the operating level (legal load level in LRFR), following the MBE, with two exceptions.

Exception 1: multiple presence

If necessary, the EV only needs to be placed in a single lane of one direction, combined with other unrestricted legal loads in the other lanes. Question 21 gives the reasoning: two heavy EVs side by side are improbable. The exception lowers the computed effects and raises the rating.

- With the simplified LRFD distribution equations, pick the equation that matches the number of design lanes.
- For narrow bridges with roadways under 18 ft, where the one-lane distribution factor is used, the built-in 1.2 multiple presence factor may be divided out.
- In refined analysis, place only one EV, together with the other legal loads.

Question 22 clarifies that in ordinary legal load rating every lane carries the same legal truck with a multiple presence factor. The EV exception lets one lane carry the EV while the others carry the usual, lighter legal loads.

Exception 2: live load factor of 1.3

A single live load factor of 1.3 may be used (Question 24). It matches the LFR operating factor and falls within the LRFR legal-load range of 1.30 to 1.45. Question 47 is candid: the factor was not calibrated, for lack of EV data. It was chosen on the assumption that EVs have weight spectra similar to other legal loads, so it maintains a similar safety margin.

The exception does **not** extend to buried structures. For culverts, use 2.0 per MBE Article 6A.5.12.10.3 (Question 24).

Everything else follows the MBE

- **Dynamic load allowance:** use the MBE allowance for normal legal loads. There are not enough data to justify a reduced value, and posting a lower speed to reduce impact is not considered a valid option because EV drivers cannot be expected to self-enforce it, especially on the Interstate (Question 46).
- **Lane loads:** the 200 plf lane load for spans over 200 ft and for continuous spans still applies. Striped shoulders should not be loaded as lanes, even though EVs drive on shoulders to get around traffic (Question 23).

- **Limit states:** per the NSBA handbook, Strength I and Service II are mandatory for EV ratings of steel bridges, as at the legal level.
- **Method:** LFR or LRFR, following the 2006 FHWA policy memorandum (Question 28).

Prioritization and timelines

The memorandum put bridges into Group 1 if they met any one of:

- A Type 3 rating factor of at least 1.85.
- An LFR HS 20 inventory RF of at least 1.0.
- An LRFR HL-93 inventory RF of at least 0.9.

Group 1 bridges did not need an immediate EV rating. Group 2 bridges were to be rated after their next inspection, and no later than December 31, 2019. Tunnels were also due by December 31, 2019 (Question 42).

Under Revision R01 of the Q&A, States that made EVs legal off the Interstate were to complete those ratings by December 31, 2022. Bridges in either group must include the EVs whenever a re-rating is warranted (Question 41).

Posting for EVs: axle and gross limits

EVs carry heavy loads on few axles, so a gross weight limit alone does not protect a bridge. EV Q&A Question 32 gives two cases. Both start from an EV3 rating factor of 0.8, which gives a safe tandem limit of $0.8 \times 31 = 24.8$ tons (say 24 T) and a gross limit of $0.8 \times 43 = 34.4$ tons (say 34 T).

- **Post axle weight only:** a truck with a 12 ton steer axle, a 24 ton tandem and a 7 ton tiller axle stays within the FAST Act limits and the tandem posting. But it weighs 43 tons, 26 percent over the safe gross limit. That is unacceptable on longer spans.
- **Post gross weight only:** a truck with a 5 ton steer axle and a 29 ton tandem weighs 34 tons and passes the gross posting. But its tandem is 21 percent over the safe tandem limit. That is unsafe on short spans.

The comparative study found that axle-only posting is suitable only for very short spans, or where the RF is close to 1.0. Gross-only posting is suitable only for longer spans. To cover every span length, configuration and condition, both should be posted.

The FHWA posting flowchart (Question 31, Figure 5)

1. Compute RF2 for EV2 and RF3 for EV3, at the legal level, using the two exceptions.
2. If $RF3 \geq 1.0$, no EV posting is required.
3. If $RF3 < 1.0$ and $RF2 \geq 1.0$:
 - Single axle limit = $33.5/2$ tons (the full statutory single axle).
 - Tandem limit = $RF3 \times 31$ tons.
 - Gross limit = $RF3 \times 43$ tons.
4. If both are below 1.0:
 - Single axle limit = $RF2 \times 33.5/2$ tons.
 - Tandem limit = $RF3 \times 31$ tons.
 - Gross limit = the smaller of $RF3 \times 43$ tons and $RF2 \times 57.5/2$ tons.

The flowchart only branches on RF3, because in the FHWA study EV3 controls. Note too that the tandem is posted as the full tandem weight (31 tons for EV3), even though each axle in it carries 15.5 tons.

FHWA's worked examples

Example	RF2	RF3	Single axle	Tandem	Gross
1	1.55	1.05	No EV posting ($RF3 \geq 1.0$)		
2	1.10	0.73	$1.1 \times 16.75 = 18.4$, capped at 33.5/2: 17 T	$0.73 \times 31 = 22.6$: 22 T	$0.73 \times 43 = 31.4$: 31 T
3	0.80	0.55	$0.8 \times 16.75 = 13$ T	$0.55 \times 31 = 17$ T	$\min(23.7, 23.0)$: 23 T

In FHWA's examples the computed limits are rounded down to whole tons.

Signs, State law, and restriction alternatives

Signs

The FHWA MUTCD Team created two signs for EVs (Question 49):

- **R12-7:** a stand-alone EMERGENCY VEHICLE WEIGHT LIMITS sign listing SINGLE AXLE, TANDEM and GROSS limits.
- **R12-7aP:** a plaque used only below a primary regulatory Weight Limit sign (see MUTCD Section 2B.59).

The words "Emergency Vehicle" should not be removed from the sign, because they identify the vehicles it targets (Question 33). For FHWA example 3, the sign reads EMERGENCY VEHICLE WEIGHT LIMITS, SINGLE AXLE 13T, TANDEM 17T, GROSS 23T.

State law conflicts

Some States had laws exempting fire apparatus from posted limits. FHWA's answer (Questions 34 and 39) is that when FAST Act EVs can legally cross a bridge that does not rate for them, the bridge must be posted or restricted under the NBIS. The State must either change its law to allow EV weight posting, or restrict EVs in another way, such as requiring special permits.

Permits are not an option on the Interstate or within reasonable access, because the FAST Act makes these vehicles legal there (Questions 34 and 35). Off those routes, States choose how to handle it. Question 48 adds that EVs meeting the FAST Act limits are legal loads, and EVs exceeding them may still be treated as non-divisible loads for overweight permits.

Notification as a restriction

Can a State simply tell fire departments which bridges they cannot cross? Question 40 says notification may count as an acceptable restriction if the agency can show it is enforceable and actually keeps EVs off bridges that cannot carry them. FHWA's guidance is:

- Use load posting for bridges on the Interstate and within reasonable access. Apparatus from other jurisdictions and drive-away deliveries will not have received the notice.
- Off those routes, consider either posting or effective restrictions such as permits.

Outreach

FHWA expects States to educate fire departments, operators of large equipment and law enforcement (Question 36). Question 37 suggests several measures:

- Publish maps of EV-restricted bridges.
- Coordinate with fire departments and apparatus manufacturers.
- Have departments consider bridge capacities when buying apparatus, and arrange mutual aid where a neighboring station can respond faster without crossing a posted bridge.

FHWA's view is that the memorandum does not impede emergency response, since overweight EVs were never permitted on bridges with insufficient capacity even before the FAST Act. Question 38 notes there is no national database of bridge failures caused by fire trucks, and no national standard ensuring that fire crews understand bridge capacity, which is why outreach matters.

Interaction with existing postings

The Revision R01 questions (51 to 58) cover existing postings and NBI coding. Engineers should read them in full before deciding whether a bridge already posted for ordinary legal loads also needs an EV rating and sign. The answers depend on the existing posting level and the State's sign practice, so they are not reproduced here.

Worked example 1: routine vehicles and SHVs on a 65 ft span

This example uses the live load effects from the MBE Appendix A steel girder example (65 ft simple span, interior girder):

- Moment distribution factor $g = 0.626$.
- Dynamic load allowance reduced to 20 percent, per Table C6A.4.4.3-1, after a field evaluation found only minor surface deviations.

The MBE example lists $g \cdot M_{LL+IM}$ per girder as:

Vehicle	Type 3	Type 3S2	Type 3-3	SU4	SU5	SU6	SU7	NRL
gM_{LL+IM} (kip-ft)	496.3	531.2	484.3	559.4	616.9	686.2	746.8	779.0

The SHVs dominate. SU7 is about 50 percent above Type 3, which matches the NCHRP 12-63 finding quoted by FHWA.

The capacity figures below are illustrative numbers chosen for teaching. They are not from the MBE example. Suppose the factored flexural capacity left after dead load, $\phi_c \phi_s \phi_R n - \gamma_{DC} \cdot DC - \gamma_{DW} \cdot DW$, is **1,200 kip-ft**. ADTT is unknown, so $\gamma_{LL} = 1.45$.

- Type 3: $RF = 1,200 / (1.45 \times 496.3) = 1,200 / 719.6 = \mathbf{1.67}$
- Type 3S2: $RF = 1,200 / 770.2 = \mathbf{1.56}$
- Type 3-3: $RF = 1,200 / 702.2 = \mathbf{1.71}$
- NRL: $RF = 1,200 / (1.45 \times 779.0) = 1,200 / 1,129.6 = \mathbf{1.06}$

The NRL rates above 1.0, so the screen is passed. No SU4 to SU7 ratings are required, and no legal-load posting is needed for flexure. Shear and the service limit states still have to be checked.

Same girder after deterioration

Now suppose section loss reduces the available capacity to **900 kip-ft**.

- Type 3: $900 / 719.6 = 1.25$. Type 3S2: $900 / 770.2 = 1.17$. Type 3-3: $900 / 702.2 = 1.28$. All above 1.0.
- NRL: $900 / 1,129.6 = 0.80$. Below 1.0, so rate the individual SHVs.
- SU4: $900 / (1.45 \times 559.4) = 900 / 811.1 = \mathbf{1.11}$
- SU5: $900 / 894.5 = \mathbf{1.01}$
- SU6: $900 / 995.0 = \mathbf{0.90}$
- SU7: $900 / 1,082.9 = \mathbf{0.83}$

Only SU6 and SU7 need posting. Their safe load capacities are $RF \times W$:

- SU6: $0.90 \times 34.75 = 31.3$ tons
- SU7: $0.83 \times 38.75 = 32.2$ tons

The NRL's own tonnage would be $0.80 \times 40 = 32.0$ tons. That is higher than SU6's 31.3 tons, which shows numerically why FHWA forbids posting from the NRL. The posting value itself comes from the MBE posting procedure (Article 6A.8), covered in the next course, BR-L03.

Worked example 2: an EV posting

A two-lane bridge on a route within one road-mile of an Interstate interchange is rated for the EVs at the legal level. Following the memorandum:

- The EV is placed in one lane only, with an AASHTO legal truck in the other lane.
- $\gamma_{LL} = 1.3$.
- The dynamic load allowance is the normal MBE value.

Suppose the controlling results are **RF2 = 0.92** and **RF3 = 0.68**. These are illustrative values. Both are below 1.0, so the second branch of the FHWA flowchart applies:

- Single axle: $0.92 \times 33.5/2 = 0.92 \times 16.75 = 15.4$, so **15 T**.
- Tandem: $0.68 \times 31 = 21.1$, so **21 T**.
- Gross: $\min(0.68 \times 43, 0.92 \times 57.5/2) = \min(29.2, 26.5) = 26.5$, so **26 T**.

Here the gross limit comes from EV2 rather than EV3. That can happen when EV2 also rates below 1.0, and it is why the flowchart takes the minimum (see also Question 50). The sign is an R12-7, or an R12-7aP plaque under the regular weight limit sign: EMERGENCY VEHICLE WEIGHT LIMITS, SINGLE AXLE 15T, TANDEM 21T, GROSS 26T.

Because the bridge is within reasonable access of the Interstate, FHWA expects a posting rather than notification alone. Under 23 CFR 650.313(l), the sign must go up as soon as possible, and within 30 days.

Check against the screening criteria

Suppose this bridge had an LRFR HL-93 inventory RF of 0.92. It would have met the memorandum's Group 1 criterion (≥ 0.9), so it was not on the 2019 list. But a re-rating triggered by deterioration must include the EVs, and that re-rating is what produced these results. Screening criteria set priorities. They do not establish adequacy.

Worked example 3: a long continuous unit

A three-span continuous girder unit has spans of 180, 240 and 180 ft. For legal-load rating of the routine commercial vehicles, three things apply:

1. **Positive moment in the 240 ft span.** The span exceeds 200 ft, so rate for $0.75 \times$ Type 3-3 plus 0.2 klf of lane load, as well as the individual legal vehicles.
2. **Negative moment and interior pier reactions.** Regardless of span length, also check two Type 3-3 trucks, each multiplied by 0.75, spaced 30 ft (rear axle of the first to front axle of the second), with the 0.2 klf lane load. Place them in adjacent spans to maximize the effect.
3. **The 180 ft spans.** For positive moment, the individual legal vehicles govern. The negative moment check over the piers still includes the two-truck-plus-lane case.

For a rough sense of scale, a 0.2 klf lane load alone on a 240 ft simple span produces $wL^2/8 = 0.2 \times 240^2 / 8 = 1,440$ kip-ft of moment for the lane. This lane-load effect alone exceeds the truck effect for many shorter spans, so leaving it out of a long-span legal rating is a significant unconservative error. Continuity changes the actual numbers, and the rating must use the continuous-beam influence lines.

If EVs are legal on the route, the same lane load is applied with the EV per Question 23. The EV goes in one lane with legal trucks in the others, and the shoulders are not loaded.

Common errors and a reviewer checklist

Errors seen in legal-load ratings

- **Rating only HL-93** and treating an inventory RF above 1.0 as proof that no posting is needed for every vehicle. The memorandum's screening criteria applied only to the timing of the 2016 EV program. They are not a permanent exemption.
- **Posting from the NRL tonnage.** Rate SU4 to SU7 and post from them.
- **Claiming Condition A on Interstate bridges.** States cannot exclude Formula B-compliant SHVs from the Interstate.
- **Claiming Condition B by comparing gross weights or moments only.** Compare ratings, and remember that bridges posted for the State model still need SU4 to SU7 ratings.
- **Leaving out the lane load** for spans over 200 ft, or the two-truck case for negative moment.
- **Applying the EV factor of 1.3 to culverts.** Use 2.0 for buried structures.
- **Loading EVs in every lane** with a multiple presence factor, which is overly conservative. Or the reverse: dividing out the 1.2 factor on bridges 18 ft wide or more, where the one-lane distribution exception does not apply.
- **Reducing impact for EVs** or relying on a speed posting. FHWA does not accept either.
- **Posting only gross weight for EVs**, which is unsafe for short spans and floor systems.
- **Dropping "Emergency Vehicle" from the sign.**

Reviewer checklist

1. Which legal vehicles are legal on this route, under State law and federal law for the Interstate and reasonable access?
Are State routine permits included?
2. Were Types 3, 3S2 and 3-3 rated, with lane loads where required?
3. Was the NRL screen passed? If not, were SU4 to SU7 rated individually?
4. Were EV2 and EV3 rated where EVs are legal, with the single-lane and 1.3 exceptions applied correctly?

5. Are the live load factor (ADTT basis), impact and distribution documented?
6. Were all applicable limit states and force effects checked, including floor beams and short loading lengths?
7. Do the posting values follow the MBE (ordinary legal loads) and the FHWA flowchart (EVs), on MUTCD-compliant signs?
8. Were the results coded into the SNBI load rating items, and is a posting or restriction scheduled within the 30-day window?

Summary

Legal-load rating answers the question an owner actually has to act on: can every vehicle that may legally cross this bridge do so safely, and if not, what should the sign say?

- **Routine commercial vehicles:** rate Types 3, 3S2 and 3-3, with the $0.75 \times$ Type 3-3 plus 0.2 klf lane load cases for long spans and negative moment.
- **SHVs:** they are legal nationwide unless State law excludes them, and never excludable on the Interstate. Screen with the NRL or SU7 (simple spans), rate SU4 to SU7 when the screen fails, and post from the individual models.
- **FAST Act EVs:** on the Interstate and reasonable-access routes, and anywhere State law allows them, rate EV2 and EV3 at the legal level. Use $\gamma_{LL} = 1.3$ (2.0 for culverts), the EV in one lane, and normal impact. Where RF falls below 1.0, post single axle, tandem and gross limits per the FHWA flowchart on R12-7 or R12-7aP signs.
- **Comparing vehicles:** compare ratings, not weights or moments, when claiming that one vehicle envelopes another.
- **Timing:** post or restrict within 30 days of a rating that shows the need (23 CFR 650.313(l)).

The next course, BR-L03, takes the legal-load rating factors from this course and turns them into posting values, signs and closure decisions.

Key takeaways

- Design-load ratings screen; legal-load ratings decide posting. Rate for every unrestricted legal load and routine permit.
- Types 3, 3S2 and 3-3 weigh 25, 36 and 40 tons. Over 200 ft, and for negative moment at any span, add $0.75 \times$ Type 3-3 with a 0.2 klf lane load.
- SHVs (SU4–SU7: 27, 31, 34.75, 38.75 tons) must be rated unless State law precludes them or State models envelope them; Condition A never applies on the Interstate.
- The NRL (80 kips, 8 axles) is a screen only: if $RF \geq 1.0$, stop; otherwise rate SU4–SU7 and post from them, never from the NRL.
- EV2 is 24 + 33.5 kips at 15 ft; EV3 is 24 kips + a 62 kip tandem at 17 ft. Rate at the legal level with $\gamma_{LL} = 1.3$ and the EV in one lane only; use normal MBE impact.
- When $EV\ RF < 1.0$, post single axle, tandem and gross limits using the FHWA flowchart and EMERGENCY VEHICLE signs (R12-7 or R12-7aP).

References

1. AASHTO, The Manual for Bridge Evaluation, 3rd Edition, 2018 (with interim revisions)
2. FHWA Memorandum, Load Rating for Specialized Hauling Vehicles, November 15, 2013
3. FHWA Memorandum, Load Rating for the FAST Act's Emergency Vehicles, November 3, 2016