Bridge Load Rating Questions and Answers

1. Are there additional resources available for LARS information?

   LARS users should frequently refer to Bentley's LARS Wiki website to check for any relevant updates and clarifications. The Wiki can be accessed at:

   http://communities.bentley.com/products/bridge_design___engineering/w/bridge_design_and_engineering__wiki/lars-bridge-and-lars.aspx

   Specifically, refer to the Bentley LARS Wiki above for guidance in modeling post-tensioned draped strands in a prestressed concrete beam using LARS.

2. When must a Consultant determine the number of unique members present for a given structure to be load rated?

   The number of unique members, along with the availability of other basic data pertaining to load rating, must be determined prior to the negotiation meeting. If a Consultant is unable to collect this data due to time constraints, then all load ratings hours in the project are to be negotiated separately as a modification to the agreement, once all pertinent data is known.

3. When is the user to provide more than a single BMD file for load rating a given structure?

   More than one BMD file is required if the total number of members rated for a structure is more than 50, as per LARS limitations. Additionally, for bridges where the As-Built and As-Inspected conditions are different, then each condition should be modeled in a separate LARS file. Typically an As-Inspected model is required when any member of the structure has more than 10% section loss at a critical location, or if there has been a change in dead loads acting on the bridge. For situations where an As-Built and As-Inspected model are both required, the As-Inspected model is to contain all members (not just those members exhibiting section loss).

4. What is the NJDOT policy when LARS does not support a particular bridge type that requires load rating?

   For bridge types that cannot be rated using the current version of LARS software, send an e-mail to Load.Rating@dot.state.nj.us and discuss the situation with the NJDOT Project Manager. The use of other load rating software, when required, needs the prior approval of the NJDOT Project Manager, who will discuss the matter with the NJDOT load rating team.

5. What is the NJDOT policy when plans are unavailable or lack all required information needed in order to perform load rating computations?

   If plans are unavailable or lack complete information to load rate a particular bridge, then do not include the bridge for load rating when developing the project cost proposal. If no rating currently exists, you must use engineering judgment for the load rating. If plans do not exist or are incomplete, but detailed calculations may still required (new or increased section losses, possible posting scenarios, etc.), then compose an e-mail to Load.Rating@dot.state.nj.us describing the situation, and determination for the proper course of action will be decided on a bridge-by-bridge basis.

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6. What specific LARS output reports are you seeking and for which specific (controlling, as-built, as-inspected) members?

The three LARS output reports of interest are:

Member Summary (TABULAR) – this report summarizes the ASR, LFR, and LRFR results for all members for all included live loads. This report is included in the main body of the bridge inspection report as well as the load rating appendix. Provide this report for the as-inspected condition.

Data Echo – this report provides a summary of all input used for load rating calculations. This report should be trimmed down so that only data pertaining to general input items and the controlling member(s) is included, then inserted into the load rating appendix. Provide this report for the as-inspected condition.

Flexural Tabular Report – this report provides in-depth calculations for member capacity for moment, service, and shear, and provides rating results by member. This report should be PDFed and included on the load rating deliverables CD. The Flexural Tabular Report does not need to be included in either the main body or the appendix of a bridge inspection report that includes load rating. Provide this report for the as-inspected condition.

The following LARS menu choices will be useful when generating these reports:

Report	Member(s) To Report	Design Method
Member Summary (TABULAR)	All	LRFD
Data Echo	(no effect on report)	(no effect on report)
Flexural Tabular Report	Controlling member(s) only	Method reported on SI&A

Refer to Sample 1 and Sample 2 under the Load Rating heading at:

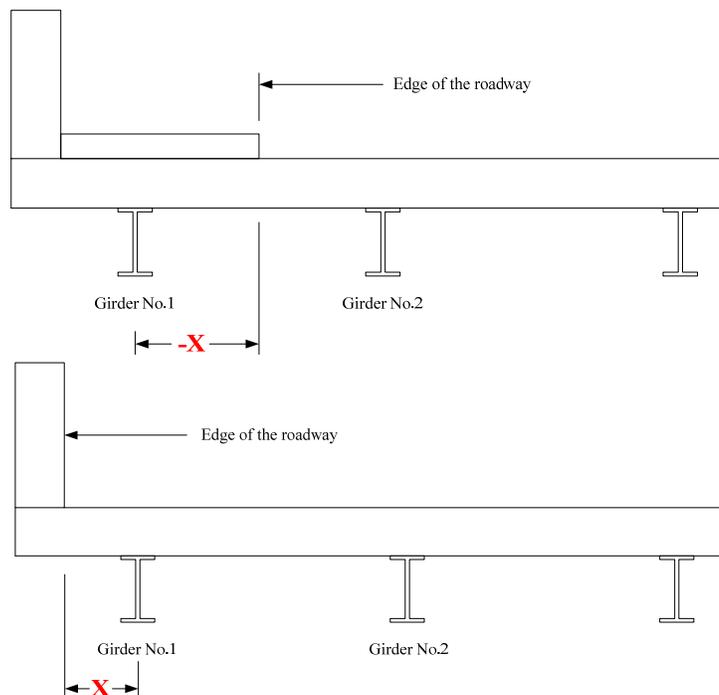http://www.state.nj.us/transportation/eng/structeval/downloads.shtm

7. For the load rating sample reports provided online on the NJDOT Structural Evaluation Website (9999999_2011… & 8888888…), why are the As-Built and As-Inspected Inventory LRFR ratings for standard vehicles Type 3, 3S2, 3-3 showing "---" instead of numerical values generated by the LARS Program (need values for SI&A Sheets)?

LRFR methodology does not differentiate between Inventory/Operating ratings for legal loads, but rather provides a single rating factor used to determine if posting is required for the given vehicle. If LRFR ratings are to be reported in the SI&A, then the Inventory values for the legal loads will be left blank (Items BS, BT, and BU). The LRFR Operating values for the legal vehicles (Type 3, 3S2, 3-3) and now also the specialized hauling vehicles to be reported on LRSS and SI&A should be taken from the right most column labeled "LGL" of the LARS Member Summary (Tabular) report (*not* the "OPR" column).

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8. For exterior members, what is the proper dimension to input for "Distance from edge of roadway to the face of beam (ft)" in *Description>General Member Information* screen, as shown below?

For simplicity, the LRE may input the distance from the edge of the roadway to the *centerline* of the beam. This distance can be positive or negative depending upon the presence and width of a sidewalk/parapet. For example, the top configuration below would yield a negative value while the bottom configuration would yield a positive value.

9. What is the proper method to calculate LFR moment Distribution Factors for longitudinal beam bridges?

For the LFR Moment Distribution Factor for exterior longitudinal beams, the LRE should use the lever rule as indicated in the updated Table B.1.1 in the Revised Pages for NJDOT Highway Bridge Load Rating Manual. Calculating the Moment Distribution Factor using the lever rule will yield equal values for both the Shear and Moment Distribution Factors for LFR.
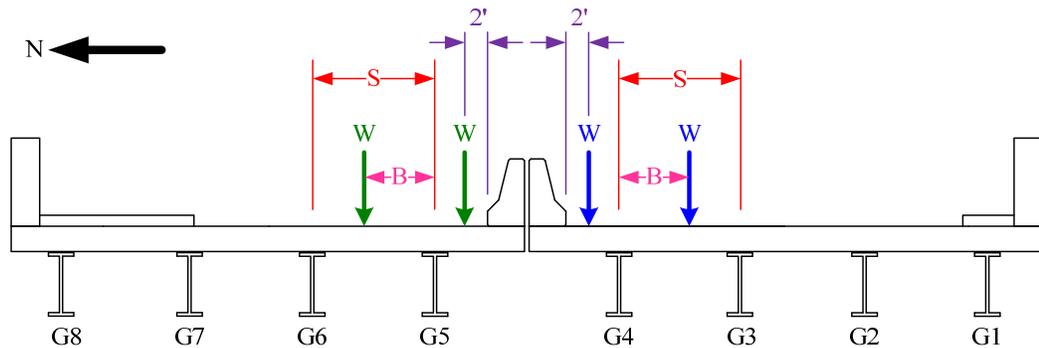
3

10. How do you calculate exterior girder distribution factors in LRFR for longitudinal beam bridges?

As per the NJDOT Highway Bridge Load Rating Manual, use the lever rule and apply the appropriate Multiple Presence Factor (Table D.1.1) along with the Skew Correction Factor to calculate the LRFR distribution factors.

Additionally, the application of the Rigid Cross Section Requirement as described in Section D-4 of the NJDOT Manual should be disregarded at this time.
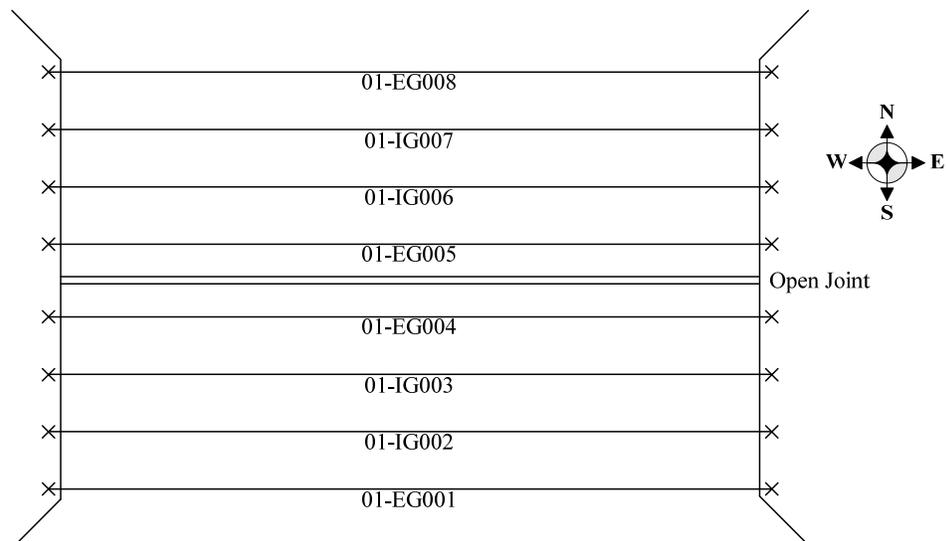
11. Are members adjacent to longitudinal open joint considered to be exterior members?

Yes. In reference to the sketch below, G1, G4, G5, and G8 are all exterior members.

12. In the situation shown in the above sketch, if G8 is assumed to handle zero live load (due to the presence of a wide sidewalk) and therefore does not require load rating, what is the proper way to create the Member Identification Sketch (MIS)?

Refer to the completed MIS below. In the situation above, members G1, G4, G5 and G8 are considered exterior girders. Shear D.F. and Moment D.F. for G4 and G5 = $1 + B/S$. If an exterior member is not being rated due to an assumed zero live load, it must still be shown on the MIS. For the purposes of creating the MIS and calculating live load Distribution Factors for shear and moment, the first interior member should still be treated as <u>interior</u> member (do not assume it to be an exterior member just because the rating for the actual exterior member is not being calculated).

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13. How are LFR Distribution Factors to be calculated for members of a bridge with varying beam spacing?

For bridges that have varying beam spacing, the LRE must calculate the LFR Distribution Factors on a member-by-member basis. The LRE has the option to use *either* the average beam spacing from the adjacent girders *or* the maximum beam spacing from the adjacent girders. The LRE *cannot* use the average or maximum girder spacing of the entire bridge. This is part of the reasoning behind modeling all members.

14. Where can the LRE refer to when selecting a System Factor?

The LRE should refer to updated Table E.3.6.1 in the NJDOT Highway Bridge Load Rating Manual document for guidance when selecting the System Factor for LRFR. Note that this table has been revised from the 1st Edition of the NJDOT Highway Bridge Load Rating Manual, and will be updated in the 2nd Edition. The up-to-date version of the table is provided below, with revisions shown in red.

Superstructure Type	ϕ_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
All Other Girder Bridges and Slab Bridges	1.00
Floorbeams with Spacing >12ft. and Non-Continuous Stringers	0.85
Floorbeams without Stringers (Deck supported directly by Floorbeams)	0.85
Redundant Stringer Subsystems Between Floorbeams	1.00
Three Girder Bridges – Riveted	0.90
Three Girder Bridges – Welded	0.85
Four Girder Bridges	0.95

15. How does the LRE know what value to report on the LRSS for Resistance Factor?

LARS calculates the Resistance Factor but does not currently report the value the software uses. On the LRSS, the LRE may choose to manually calculate the Resistance Factor, or may simply indicate "LARS-Calculated"

16. How does the effective slab width differ from the member spacing?

The LRE must calculate the effective slab width for composite bridges. Typically, for interior members, the effective slab width is the center-to-center beam spacing. Typically, for exterior members, the effective slab width is the half of the center-to-center beam spacing plus the overhang distance.

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17. When is it acceptable for the LRE to modify the LARS Customization files from the standard values provided by NJDOT?

LARS ratings should typically be in accordance with the LARS Customization files contained on the Structural Evaluation website under the Load Rating heading. There will be instances, however, where the LRE must make certain changes to the Customization files in order to obtain accurate results. The LRE must clearly document any changes to the Customization files on the LRSS along with a clear justification for each change.

Note that the Customization file data is saved on your local computer, as opposed to within a particular LARS .bmd file. This means that if you change the Customization files while in one .bmd file, the changes will also affect all other .bmd files, until you undo the change. When you run a rating with modified Customization values, users running LARS on different computers (with the standard Customization values) may receive different results. That is why it is <u>critical</u> that the LRE note **all** <u>changes to the standard Customization files</u> on the LRSS. This is the only way for someone else to duplicate the rating results.

18. As per the MBE, posting analysis for LRFR *is not* required when the HL-93 rating factor is equal to or greater than 1.0. Does NJDOT allow for this?

NJDOT *always* requires posting analysis for LRFR. Posting analysis is required even for cases when the HL-93 rating factor exceeds 1, as well as for cases when the bridge is designed with LFD. Only by performing posting analysis can the Load Rating Engineer (LRE) provide the correct LRFR rating factors for the legal loads on the Load Rating Summary Sheet (LRSS). LARS rating files will be rejected if they do not contain LRFR posting rating analysis.

19. If a structure, originally designed according to either ASD or LFD, undergoes major rehabilitation designed in accordance with LRFD specification, what is the proper coding for SI&A Item 31 (Design Load)? Additionally, which analysis is going to govern for reporting load ratings in the SI&A?

In this instance, SI&A Item 31 should be coded as A (HL 93); for more information, please refer to the memorandum "Updates and Clarifications for Load and Resistance Factor Rating Implementation" dated May 10, 2012. Additionally, the controlling load rating methodology for SI&A reporting would be LRFR.

20. If a structure, originally designed according to either ASD or LFD, undergoes major rehabilitation designed in accordance with LFD specification, what is the proper coding for SI&A Item 31 (Design Load)?

In this instance, SI&A Item 31 should be coded in accordance with the rehabilitation plans.

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21. For State or County-owned minor bridges (≤20'), when is LRFR methodology to be used for load rating?

As per AASHTO LRFD Bridge Design Specifications Section 4.6.2.2, the length of the structure is included in the distribution factor formula for several bridge types. The specifications state that the equations are only applicable when the structure length is greater than 20 feet. Therefore, for minor bridge types where structure length is a factor in distribution factor calculations, LRFR ratings may be ignored, and ratings can simply be performed in accordance with ASD or LFD. For example, girder-type minor bridges will be rated using only LFR, but slab-type minor bridges will be rated using both LFR and LRFR.

22. What is NJDOT's load rating policy regarding bridges with fill?

Structures with 2 feet of fill or less (that are ratable with LARS) may be rated using LARS with the presence of fill ignored for live load distribution. The dead load of the fill must be included in the hand calculations. Additionally, the impact factor shall be reduced based on the depth of fill in accordance with AASHTO Standard Specifications Section 3.8.2.3 and AASHTO LRFD Bridge Design Specifications Section 3.6.2.2. Note that at this time, LARS is not properly handling ASD/LFD Impact Factor ranges on the "General Information Screen". If the user calculates a reduced Impact Factor of 15% due to the presence of fill, then the user must set both the Max and Min Impact Factors to 15, thus forcing the software to use that specific value in calculations.

Structures with fill greater than 2 feet and up to 8 feet in depth (that are ratable with LARS and has to be a slab type of structure) may be rated using LARS with the live load distribution calculated accordingly depending on the depth of fill. The dead load of the fill must be included in the hand calculations.

Structures exceeding 8 feet of fill are to be rated using engineering judgment.

For additional information on structures under fill, refer to AASHTO Standard Specifications Section 6.4 and the ASHTO LRFD Bridge Design Specifications Sections 3.6.1.2.6 and 4.6.2.10.

23. In LARS Bridge Modeler concerning steel members, there are no inputs for section modulus or moment of inertia in the interface. How do you recommend rating built-up / defective members accurately without these parameters (currently the built-up option only involves cover plates and defect / hole option is problematic)?

The current version of LARS allows the independent input of web, top flange, and bottom flange elements.

When a defect is modeled in LARS, make sure to indicate the positioning in the Rating Position Location, so LARS will run calculations for the section properties at the exact location of the defect.

24. How do you recommend rating older rolled steel members in LARS with the variable flange thicknesses at web and edges?

At this time, LARS does not allow users to input flanges of varying thickness from web to edge. LARS does, however contain many of the older rolled steel members with variable flange thicknesses at the web and edges in the standard shape library. If the shape is not contained within the library, it is the Load Rating Engineer's task to assume a comparable section. Sloped flanges of older rolled steel sections not included in the LARS shape library can be modeled using the average thickness, which can be taken as the simple average of the "m" and "n" dimensions listed in "AISC Iron and Steel Beams 1873 to 1952".

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25. How can varying stiffener spacing be modeled in LARS if the changes in spacing do not correlate with the diaphragm spacing?

Within each bracing range, you may assume the minimum stiffener spacing.

26. In the LARS *Description* > *Analysis Codes* window, what is the difference in calculations if "Transversely Stiffened" is selected versus "Transversely and Longitudinally Stiffened" for a composite steel bridge member?

When a member is transversely stiffened only, the program is calculating the moment capacity based on the AASHTO Standard Specifications Section 10.50.1.1. For these cases, the moment capacity is equal to or near the *plastic* moment. When the member is both transversely and longitudinally stiffened, the program is calculating the moment capacity based on the AASHTO Standard Specifications Sections 10.48.6.1 and 10.48.6.2. In these cases, the moment capacity is near the *yield* moment. The LRE must use caution while inputting the analysis codes to ensure that the proper specification is selected by the software.

27. Are concrete-encased steel girders to be treated as composite or non-composite for LARS ratings?

Concrete-encased girders may be modeled as either "SS" (non-composite) or "CSC" (composite) members, depending on the depth of the embedment of the top flange of the girder into the deck. Typically, if the top flange is embedded above the primary reinforcement of the deck, the member is to be considered composite. The LRE is to calculate the depth of the neutral axis for a cracked section, and apply this calculated depth as the Effective Slab Thickness of the deck within the LARS model.

To calculate the depth of the neutral axis for a cracked section (y_{tc}) and the distance from the top of the steel beam to the centroid of the effective slab (d_c), use the formulas below:

$$\frac{w y_{tc}^2}{2} + A_b y_{tc} - A_b \left(t_s + d' - \frac{d}{2} \right) = 0, \quad \text{where:}$$

$$d_c = t_s - (d - d') - \left(\frac{y_{tc}}{2} \right)$$
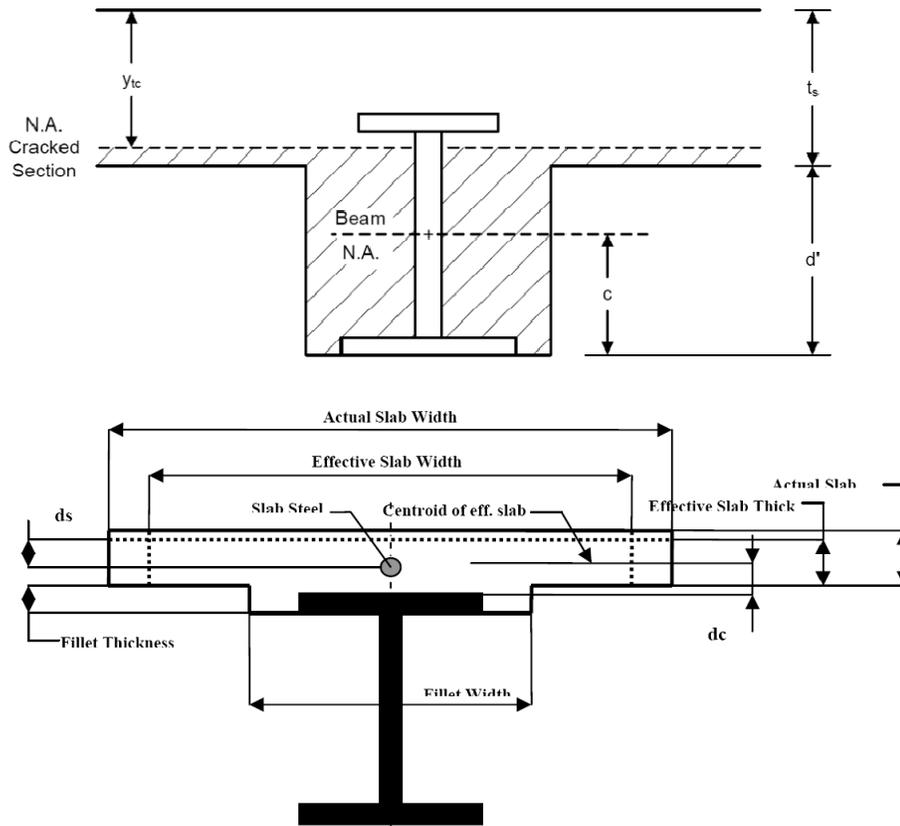
$$w = effective\ slab\ width$$
$$A_b = area\ of\ steel\ beam$$
$$t_s = thickness\ of\ slab$$
$$d' = distance\ from\ bottom\ of\ slab\ to\ bottom\ of\ beam\ (ignoring\ bottom\ encasement)$$
$$d = total\ depth\ of\ steel\ beam$$

The equation for y_{tc} is quadratic and can be solved by trial and repeat or by using the quadratic formula with $a = \frac{w}{2}$, $b = A_b$ and $c = -A_b \left(t_s + d' - \frac{d}{2} \right)$. Also, the computed effective slab thickness y_{tc} is subject to ½" wearing surface reduction for slabs at grade. In cases where neutral axis is below bottom of slab ($y_{tc} > t_s$), for simplicity y_{tc} can be assumed equal to t_s.

Refer to the sketches below:

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28. What is the best procedure using LARS to model a prestressed concrete box beam which does not contain any voids?

Simply model as Element Type "Rectangular" for the member shape description, and do not add any voids.

29. What is the best procedure using LARS to model a prestressed concrete box beam which has voids and internal diaphragms?

If the box beam is a "standard section" available in LARS shapes library, use this option. If the member is not available in the shapes library, model the beam as Element Type "Rectangular" and then define the void(s).

LARS will calculate the self-weight of the box beam, but this will not include the self-weight of the internal diaphragms. Users should not attempt to model internal diaphragms while modeling the prestressed beam section, as LARS is not accurately calculating the resulting dead load effects. The weight of the diaphragms must be included in the manual calculations of Dead Load 1 on the box beam and be distributed uniformly.

30. How are beams with both pre-tensioning and post-tensioning strands modeled in LARS?

First, model the beam with only the pre-tensioning effects and determine the prestress loss. After finding the prestress loss, calculate the equivalent pre-tensioning initial force for the given final force due to post-tensioning, and the equivalent total strand area for the total initial force. Model the calculated total strand area in LARS to get the combined pre-tensioning and post-tensioning effect.

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31. Can live load continuous prestressed concrete structures be conservatively modeled as simply-supported structures?

No, live load continuous prestressed concrete beams are to be modeled as continuous members.

32. How can a reinforced concrete or prestressed concrete channel beam be modeled using LARS?

At this time, since LARS does not model channel sections, the user can model channel beams as an equivalent T-beams.

33. How are reinforced concrete slabs to be modeled using LARS?

Reinforced concrete slabs are to be divided into 12 inch wide rectangular reinforced concrete beams. If shear is controlling the LFR ratings, then the user may change the LFR shear live load distribution from 1 wheel to equal to LFR moment live load distribution factor. Note that this assumption is only valid for structures where there is no evidence of shear problems (e.g. diagonal tension cracks near the supports of the slab).

34. When rating a non-segmental prestressed concrete bridge, what is the allowable tensile stress limit? How are these limits to be input in LARS?

For members with bonded prestressing tendons, the limit is $3 \times \sqrt{(f'c)}$ psi. For members with unbonded prestressing tendons, the limit is 0.

For LFR ratings, the user can input the stress limit value through *Analysis > Customization* and adjusting the "Factor for elastic theory moment capacity" value in the PSC tab. For LRFR ratings, the user can adjust the stress limit value by through the "Corrosion Condition" input as described in the next question.

35. What is the proper input for the "Corrosion Condition" field in the LARS *Description > Material of Construction* window?

In order to achieve a stress limit state of $3 \times \sqrt{(f'c)}$ psi. (as required by NJDOT), select the "Severe" corrosion condition. If the appropriate stress limit state is $6 \times \sqrt{(f'c)}$ ps (possible for bridge owners other than NJDOT), select the "Moderate" corrosion condition. Currently, LARS (version 5.00.06.09) will not allow the user to input a tensile stress limit value of zero. If the user must use a tensile stress limit value of zero in the model and Service III limit state is governing the LRFR ratings, then the user must perform hand calculations if the bridge is designed with LRFD. If the bridge is not designed with LRFD, then no hand calculations are required.

36. For LRFR posting analysis, what live load gamma value is LARS using for the Service III limit state?

At this time, LARS (version 5.00.06.09) is incorrectly using a value of 0.8 instead of 1.0 as described in the MBE. If the Service III limit state is governing the LRFR ratings, then the user must perform hand calculations if the bridge is designed with LRFD. If the bridge is not designed with LRFD, then no hand calculations are required.

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37. How is DL2 to be distributed for prestressed concrete adjacent voided slab bridges and adjacent box beam bridges?

As long as there are no defects observed with lateral post-tensioning, DL2 should be distributed equally for adjacent voided slabs and adjacent box beams.

38. Are standard New Jersey concrete shapes available in LARS?

Bentley has provided a standard prestressed concrete shape library. This library contains predefined dimensions for girders, box beams, voided slabs, and bulb tee beams that are defined in the New Jersey Design Manual. In order to access the New Jersey standard sections in LARS, every user must copy the provided **section_psc.csv** file into the folder *C:\BKey\Analysis*. If you did not receive this file via e-mail from NJDOT on 9/10/12, you may request the file through e-mail to Load.Rating@dot.state.nj.us. Note that LARS does not display the voids for the standard sections when viewing the member cross section image, but the voids are accounted for in the beam model. The voids are the full span length, meaning that dead load of the internal diaphragms must be accounted for by the LRE.

Note that an Excel spreadsheet that contains the dimensions of the NJ standard shapes and the corresponding LARS Designation is posted on the Structural Evaluation webpage under the Load Rating section.

39. Is the Load Rating Engineer required to manually verify the LRFD live load Distribution Factors that are calculated by the LARS software?

If the LRFR rating factors are being reported in the SI&A, then the Load Rating Engineer is required to verify the LRFD live load Distribution Factors for the controlling member with hand calculations. If LRFR rating factors are not being reported in the SI&A, then the LRFD live load Distribution Factors calculated by LARS do not need to be verified. The LRSS Rating Comments section should include a statement in cases where the LRFR distribution factors have not been verified by manual calculations, so this will be clear in the future.

40. How is LARS applying an impact factor to floorbeams?

There is currently an error in LARS where the software is always applying a 10% impact factor to floorbeams, instead of appropriately applying the range (Max and Min) of impact factors. As a temporary work-around to this issue, users should calculate the appropriate impact factor by hand, in input the result as both the Max and Min impact factor (forcing the software to use the appropriate value). The impact factor can be calculated using the equation below (where L is equal to span length):

$$IM = \frac{50}{L + 125}$$

Note that the maximum value for *IM* is 30% and that all structures with span lengths less than 42 feet will have *IM* = 30%.

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41. In the LARS "General Bridge Information" window, how is the "Road Width" and "Edge Dist. A" determined?

The "Road Width" and "Edge Dist. A" fields are important parameters when rating transverse members (floorbeams). The "Road Width" is always equal to the curb-to-curb distance (SI&A Item 51). The "Edge Dist. A" should equal 24 inches when the "Road Width" is greater than or equal to 20 feet (in this case, LARS will assume a lane width of 10 feet). The "Edge Dist. A" should equal 18 inches when the "Road Width" is less than 20 feet (in this case, LARS will assume a lane width of 9 feet). For lane widths of 12 feet, use an "Edge Dist. A" of 24 inches and apply a factor (based on judgment) in the field "Multi-Floor Beam Only" to compensate the number of lanes LARS is going use with an "Edge Dist. A" of 24 inches.

42. Is the skew correction factor to be applied for both moment and shear distribution factors in LRFR analysis?

According to the NJDOT Highway Bridge Load Rating Manual (Appendix B), the skew correction factor is to be applied for both moment and shear distribution factors in LRFR analysis.

43. LARS Version 5.00.06.09 introduced several additional 'Customization' options. What is the NJDOT policy for these new options?

RC Tab: Ignore additional ASD/LFD checkpoints from face of support - YES
PSC Tab: Use AASHTO 1979 shear specifications - NO
PSC Tab: Use same ASD/LFD shear capacity for positive and negative shear - NO
PSC Tab: Ignore additional ASD/LFD checkpoints from face of support - YES

44. LARS is reporting an LRFR rating factor of -999 for a single span non-composite steel girder bridge, where the compression flange is continuously braced. In this situation, what ratings is the user to report in the LRSS?

For the above structure type, LARS is reporting different values for the compression flange capacity and tension flange capacity. Since there is a LARS error in reporting the compression flange capacity, the user, as a temporary solution, is to report tension flange capacity until the issue is resolved for the compression flange. Note that the rating factor for the tension flange capacity can be found in the Flexural Tabular Report (with LRFD selected in report options).

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