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MEMORANDUM

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Subject: Interim Guidance for Load Rating of Timber Bridges

This document is intended to supersede Section 8.2.6.3 in the current *MDT Bridge Inspection and Rating Manual.* This interim guidance will stay in effect until a new edition of the manual is published, or until otherwise superseded.

Superseded Version(s)/Date(s)	Description of Change
Version 1.0 – July 1, 2019	Update to section 8.2.6.3.2.1, change in guidance for C_H and modification of F_v on bridges constructed in accordance with MDT standard timber detail drawings

8.2.6.3 Timber Bridges

8.2.6.3.1 General Assumptions for all Timber Bridges

Timber is a very subjective material to analyze. This section is meant to provide guidance on assessing timber to ensure a level of consistency between load ratings done by different Load Rating Engineers and over time. The assumptions in this section are applicable to all timber bridges in Montana. Guidance that is specific to ownership (State-owned vs non-State-owned) is provided later in this section.

Use the actual dimensions for section property calculations and the nominal measurements for adjustment factors when they're available. Estimate the typical net section or use the dressed sized in the most recent edition of the *AASHTO Standard Specifications for Highway Bridges, 17th edition,* when measurements of the actual dimensions are not available. Refer to the *National Design Specification for Wood Construction (NDS), 2015 edition,* Section 4.1.5 for more information.

8.2.6.3.1.1 Timber Decks

In almost all cases of nail-laminated or plank timber deck construction, the deck is continuous transversely across multiple girders. In the AASHTOWARE BrR software, check the box for the deck being continuous over more than 2 spans when this condition exists.

Most timber decks have gravel, asphalt, or other material on them that holds moisture against the wood for at least a few months of the year. Use wet condition factors for rating timber decks regardless of the moisture condition at the time of the inspection/measurement when a cover or overlay is present on the deck. In cases where a timber deck is bare and is in a fairly dry environment, use the dry condition factors.

8.2.6.3.1.2 Timber Girders

Use the dry condition factors when rating girders, unless a girder is in a wet environment or shows signs of moisture (i.e. algae or mushroom growth, water staining); then use the wet condition factors.

When rating a bridge with broken girders, remove the broken girder from the model, and rate the bridge (girders and deck) as if that girder doesn't exist.

When rating a bridge with damaged girders, reduce the strength of the girder in the rating model in accordance with the guidelines specific to ownership below. If the damaged girder then controls the rating, perform an alternate rating assuming that girder has failed (i.e., remove the girder from the model). Use whichever model (damaged girder model or the removed "failed" girder model) yields the ***highest*** rating factor for the girder rating. Use of the "failed" girder model will affect the deck rating since the deck span in the "failed" girder model will be double the deck span in the "damaged" girder model. If using the "failed" girder model, ensure that the final deck rating used reflects the double deck span in the "failed" girder model.

Broken or severely compromised timber girders are sometimes addressed by in-house MDT or County Maintenance personnel using a "sister" or "buddy" girder placed immediately adjacent (usually in contact) to the compromised beam. These sister or buddy girders may consist of timber or steel. When rating these components, always remove the compromised girder from the rating model and include the sister or buddy girder in the model using the actual dimensions and material of the new girder at the new location and girder spacing.

8.2.6.3.2 Owner-Specific Guidance for Timber Structures

The guidance in this section is based on ownership, either State-owned or non-State-owned. Assumptions that vary from the following guidelines for State-owned bridges (F_b reductions) and non-State-owned bridges (species, grade of timber, and F_b reductions) are allowed, however, all deviations must be based on sound engineering judgement with all assumptions documented and justified.

8.2.6.3.2.1 State-Owned Bridges

All or almost all State-owned timber structures were constructed in accordance with standard timber details or bridge specific plan sheets using high quality, old growth, Coastal Douglas Fir. The majority of these were constructed between the early 1930's and the mid 1950's. These bridges are typically found on all primary routes and many secondary routes and were constructed in accordance with one of the standard timber details sheets with an MDT drawing number.

State-Owned Timber Decks

The typical nail-laminated timber decks on most State-owned bridges in good condition should be rated with a bending capacity of 1.15 ksi (No. 1 & Better Douglas Fir – Larch) before factoring (F_b). This value may be adjusted depending on the quality and condition of the deck timber.

Where state owned timber bridges have been widened as described below, the deck is not continuous between the two side-by-side girders (see example in *Figure 8.2A*).

State-Owned Sawn Timber Girders

The girders of all timber bridges constructed by MDT using one of the standard timber detail sheets or bridge specific plans were designed with a unit stress in bending (F_b) of 1.55 ksi. This value should be used for all of these timber girders that are free of deterioration, repairs, or other defects (see *Figure 8.2B*).

The girders of all timber bridges constructed by MDT using one of the standard timber detail sheets were designed with a unit stress in shear parallel to grain (F_v) of 0.120 ksi. These designs were done during a time when most timber beams were cut from old growth timber, which is much more dimensionally stable than second growth timber. The Shear Stress Factor (C_H) – which accounts for the reduced dimensional stability and higher variability of conditions found in second growth timber – was developed after most of these MDT timber bridges were designed and constructed. The tabulated design value for shear stress parallel to grain (F_v) specified in Table 13.5.1A of the *AASHTO Standard Specifications for Highway Bridges, 17th edition* is based on the worst-case assumption that a check or flaw is the full length of the member (*Timber Bridges – Design, Construction, Maintenance and Inspection, USDA, August 1992, Chapter 5, page 38*). In light of the unique timber material (old growth Doug-Fir) and design history of MDT timber bridges, supported by the fact that very few, if any, shear failures have been documented in these structures, MDT has developed the following guidance regarding the modification of F_v for bridges constructed in accordance with MDT standard timber detail drawings:

- Use F_v = 0.085 ksi (tabulated design value for Douglas Fir-Larch Beams and Stringers, from Table 13.5.1A of the *AASHTO Standard Specifications for Highway Bridges, 17th*)
- Determine a shear stress factor, C_H, as follows:
  - If there are no documented defects that would correlate to a shear stress factor value lower than 1.50, use C_H = 1.41. This results in a modified F_v that matches the original design shear stress.

$$(F_v = 0.085) \times (C_H = 1.41) = 0.120 \text{ ksi}$$

- If there are documented defects (photos or descriptions) that correlate to a shear stress factor value lower than 1.33, assign C_H in accordance with Table 13.5.1A, Footnote 6 of the *AASHTO Standard Specifications for Highway Bridges, 17th edition.*

Many of the State-Owned timber bridges have been widened from their original construction. Generally, these widenings were done by extending the timber caps with steel channel extensions, rather than adding new piles. If measurements are unavailable, girder spacing can typically be determined by comparing the out-to-out deck width on the as-built standard timber detail sheets with the measured out-to-out deck width in SMS. Generally, widening practices consisted of two or three additional girders on each side- one or two next to the original exterior girder, with another one or two spaced out to get the desired additional width (see *Figure 8.2A*). Inspection photographs can be examined to determine the number and configuration of girders used in the widening. Spacing of the girders in the widened section can then be calculated using the configuration in the photos and the new out-to-out deck width listed in the inspection. The rating model should reflect the actual spacing of all girders. Include both girders that are adjacent to each other at the widening phase line in the load rating model; do not treat these as "sister" or "buddy" girders as described in *Section 8.2.6.3.1 General Assumptions for all Timber Bridges*.

Check dead loads carefully. The Madero engine that is used to rate timber structures in BrR uses the spacing of the first girder bay and assumes that spacing for all girders across the deck when calculating dead loads. If the spacing of the first bay is larger or smaller than the rest of the spacings across the bridge, it could result in too much or not enough dead load applied to each girder. If this is the case, it might be best to remove the wearing surface and apply uniform loads to each girder individually in order to properly distribute the wearing surface load.

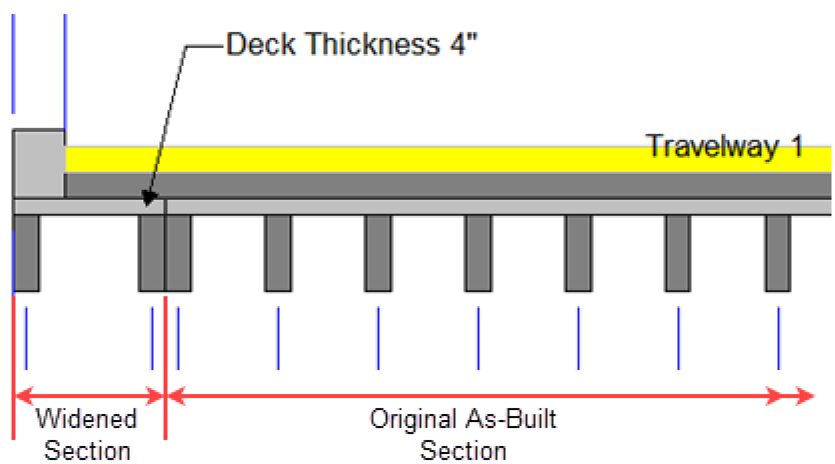

Figure 8.2A - Girder Layout for Widened Bridges

8.2.6.3.2.2 Non-State-Owned Bridges

The majority of non-State-owned bridges were not constructed using the same standard detail sheet and timber materials as State-owned structures. They consist of a very large variation of span lengths, materials, quality (grade), element sizes, treatments, and age. Some non-State-owned bridges may have engineered plans and specifications; however, this will be the exception.

There are also some County-owned timber structures on Secondary ("S") routes that were constructed in accordance with one of the standard timber detail sheets used for State-owned bridge construction. These non-State-owned bridges that have MDT plans available should be rated following the guidelines in the section for *State-Owned Bridges (8.2.6.3.2.1)*.

The majority of timber bridges owned by local agencies typically will only have measurement sheets available (no original plans or design information). MDT generally did not have oversight during design and construction of these bridges, so there's a high degree of uncertainty about materials and specifications used. It's likely that there will be a considerable number of required assumptions, and the overall expectation is that engineering judgement be used and documented accordingly. Because the nature of timber is so variable with infinite assumptions and material conditions possible, the intent of this guidance is to facilitate consistency for rating of local agency-owned timber bridges.

When timber properties are not provided on the original plans and cannot be determined from any other source (i.e. field sketches, measurements, initial inventory inspection reports), beam stresses should be based on values listed in the *National Design Specification for Wood Construction (NDS)* referenced in the *AASHTO Standard Specifications for Highway Bridges, 17th edition,* for the species of wood.

Use photos to assess the most appropriate grades for the girders and deck, and document assumptions accordingly. If the species and grade is not indicated and not obviously something other than Douglas Fir-Larch, assume the species is of the Douglas Fir-Larch category. Use grade "Dense No. 1", "No. 1" or "No. 2" for girders and "No.1 & Btr", "No.1", or "No. 2" for decks, unless a higher grade can be verified. Reductions to these determined bending stresses due to defects or deterioration should be done in accordance with *Figure 8.2C*.

The default C_H value of 1.0 can be very conservative for timber girders that were not designed and constructed by MDT or using one of the standard timber detail sheets. When C_H = 1.0 is used, the numbers may show that shear controls, however, it is not likely that a shear-controlled timber load rating is valid. For these non-State-Owned bridges, the girder conditions (checks, shakes, and splits) should be evaluated and C_H adjusted up in accordance with table 13.5.1A, Footnote 6 of the *AASHTO Standard Specifications for Highway Bridges, 17th edition*.

Increasing the Shear Stress Factor (C_H) for non-State-Owned timber decks should always be considered on members where the load is applied perpendicular to the wide face of the member (i.e. plank decks), since any splits or checks will typically be oriented parallel to the load direction and not affect the shear strength of the member parallel to the grain.

8.2.6.3.3 Rating Timber Components with Defects or Deterioration

The condition, extent of deterioration, and defects of structural components (rot, cracks, maintenance repairs, etc.) should be considered in rating computations. Use engineering judgement to determine how to most appropriately account for defects and deterioration, and clearly document logic in the assumptions and comments section of the load rating report. MDT's common practice has been to account for defects and deterioration in each member's bending stress, as opposed to reducing the member section. The only time a section size reduction should be used is in the case of charring from a fire. In this case, the remaining section (dimensions) of sound timber should be used after the charring has been omitted.

Assessing defects can be very subjective. The charts below are intended to develop consistent stress reduction values within each category across the defect severity spectrum. Select the appropriate chart based on whether the bridge is a State-Owned structure (*Figure 8.2B*) designed to one of the standard timber details, or whether it is a non-State-owned structure *(Figure 8.2C)* with unspecified/unknown species and grades. On the appropriate chart, select the category that best indicates a member's available capacity based on observed condition documented in the inspection report. Assumptions of available capacity should be based on sound engineering judgement and *MDT Timber Bridge Inspection Guide* (uploaded to SMS). Checks or shakes on a member should not be considered as a defect or reason for a F_b percent reduction but should be considered when assigning the C_H value for calculating shear capacity.

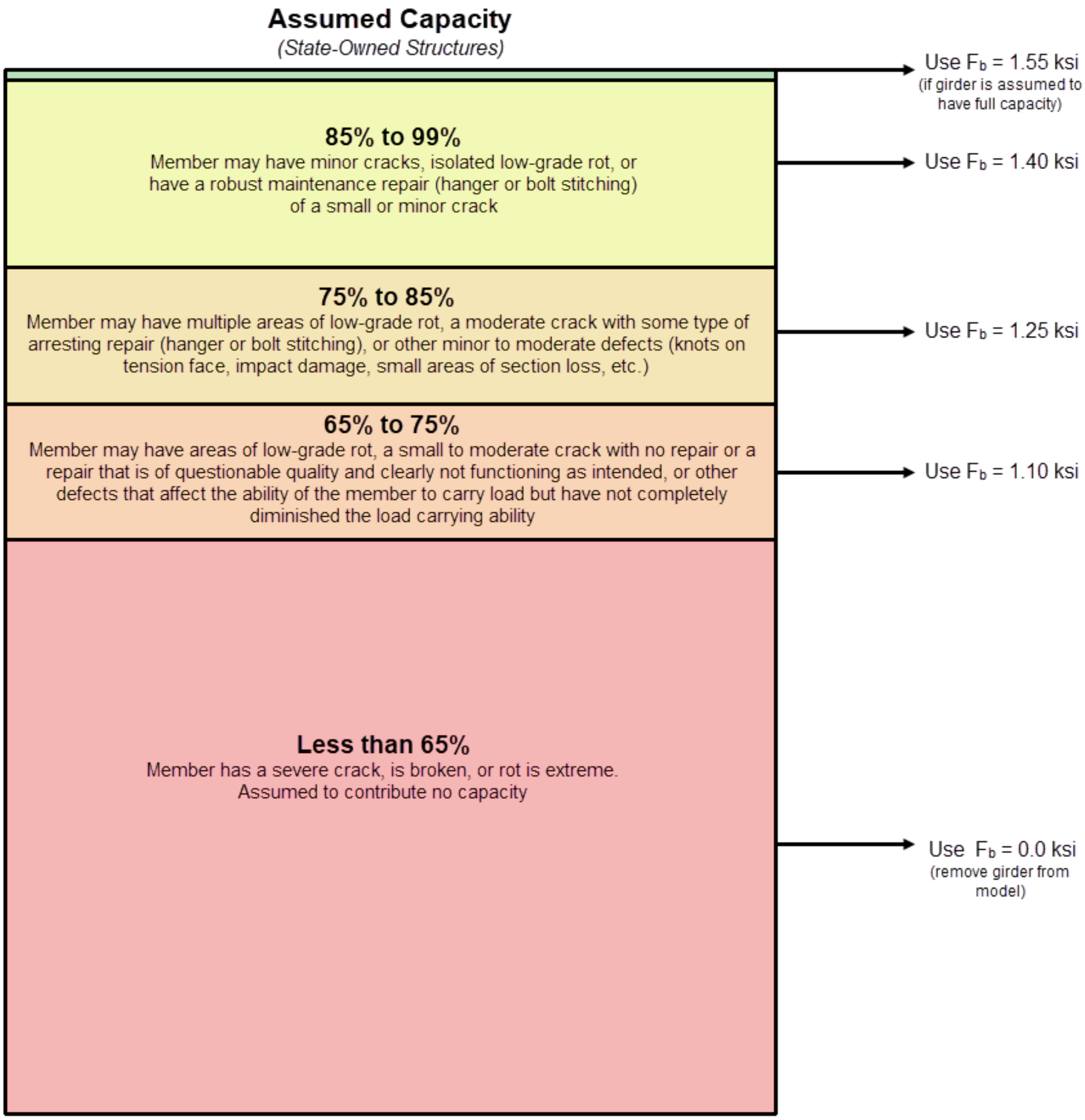

Figure 8.2B - State-Owned Assumed Capacity Chart

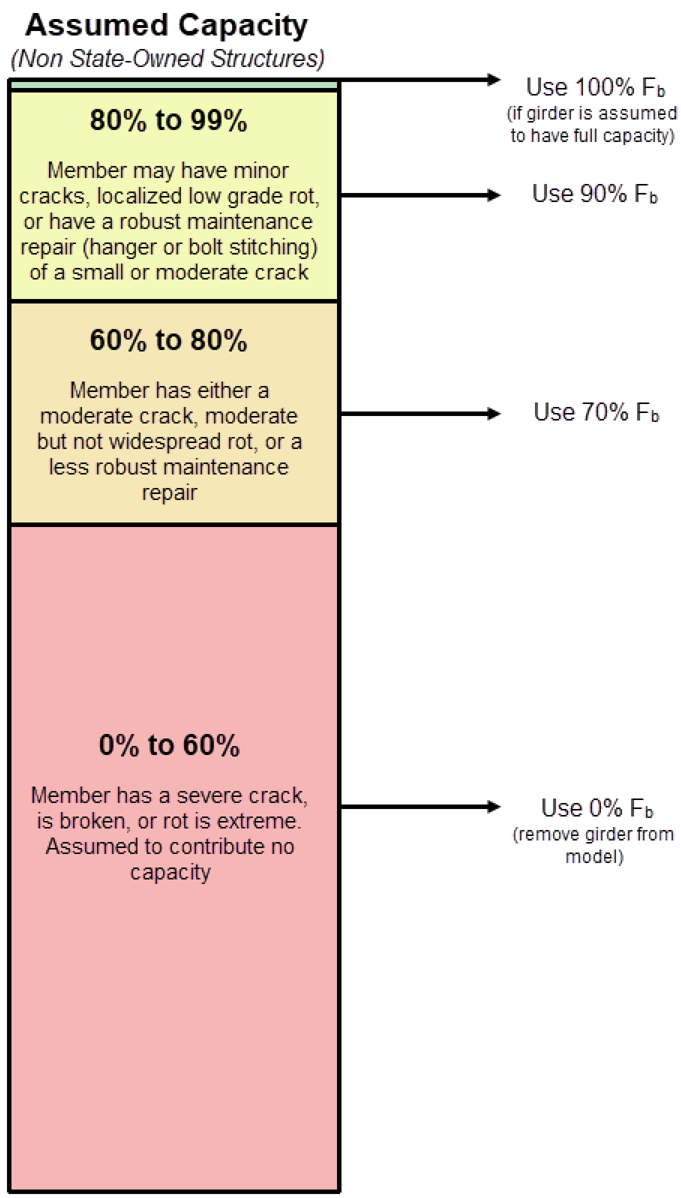

Figure 8.2C - Non-State-Owned Capacity Assumption Chart

8.2.6.3.4 BrR Guidance and Naming Convention for Timber

Altered material properties (i.e. stress reductions) should only be applied to specific member(s) with defects. Do not apply to all members in a span. Use the following BrR naming conventions to indicate where reduction of bending stress has been used on girders or decks and for naming of materials, superstructure definitions, and member alternatives.

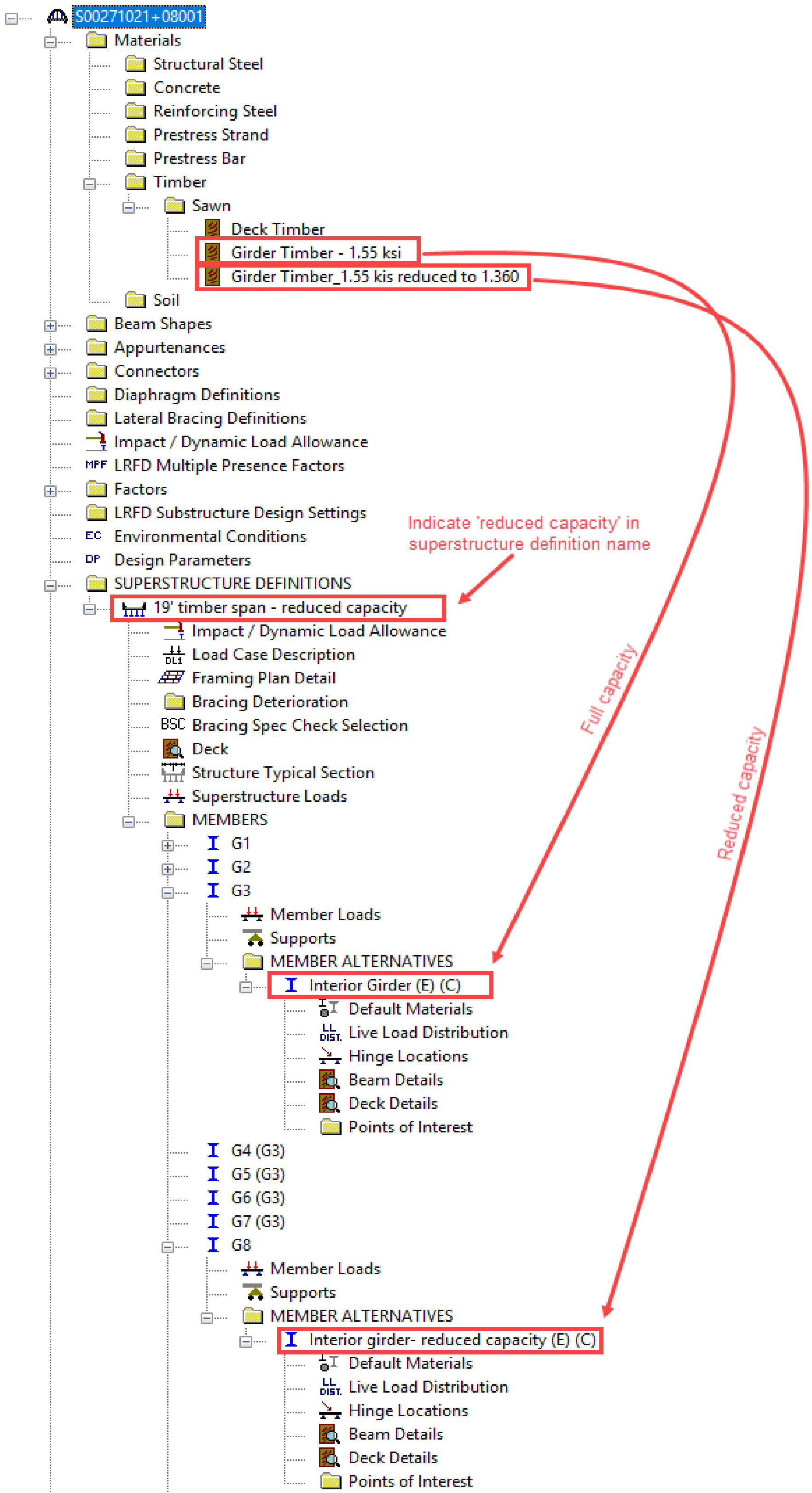

Figure 8.2D – BrR naming conventions

8.2.6.3.5 Glue-Laminated Timber Girders

BrR is not capable of rating glue-laminated timber bridges. Use alternate software with approval by MDT or include calculation in Mathcad or Excel sheets with each load rating. Mathcad and Excel sheets need to be well organized and easily understood for verification and future rerating by internal MDT staff or MDT's consultants.

8.2.6.3.6 Timber Piles

As stated in *MDT's Bridge Inspection and Rating Manual Section 8.2.5*, substructures will very seldom govern the load capacity of a bridge. There are exceptions however, and generally those exceptions occur in bridges with timber substructures. When it can be determined from a bridge inspection that a timber pile has been compromised to the extent that it can no longer adequately support the loads it was intended to carry, it will need to be removed from the bridge model. At that point, the capacity of the pile cap between the adjacent "good" piles may govern the load rating for the bridge. Such an analysis must be included in the load rating when the capacity of a substructure unit is in question.