American Railway Engineering and Maintenance-of-Way Association
Letter Ballot 15-19-07

Assignment: At the February 2019 meeting in New Orleans, LA the Committee members present voted to submit the following for letter ballot:

Revise text to Article 1.3.13 and associated commentary 9.1.3.13

Rationale: This ballot replaces Letter Ballot 15-18-16 and addresses comments received. Changes have been recommended to Article 7.3.3.2 Fatigue that include addition of Impact Factors and alpha factors for application to the applied rating loads. In checking the proposed recommendation changes, it was realized that for truss hangers the proposed requirements for rating were more stringent than for design. The proposed modifications in this ballot adjust those deficiencies for truss hangers such that design is once again more stringent than rating. The changes also include modifications to language in and of the text of Article 1.3.13 and 9.1.3.13. Removed note from Table 15-1-7 and removed paragraph in Article 9.1.3.13d pertaining to Table 15-1-7 has been moved to Article 9.7.3.3.2 in a separate ballot.

Because of the extensive nature of the changes to the article, the full text of Article 1.3.13 is included for clarity. The commentary Article 9.1.3.13 is abbreviated due to length of the commentary article.

Submitted by: Christopher Johnson, Chair SC 1 Design Loading and Stresses

Due Date: August 23, 2019

Change existing Articles 1.3.13 and 9.1.3.13 as shown (additions shown as **underlined bold red** except Figures and Tables, deletions shown as ~~**bold red strikethrough,**~~ comments in brackets [ ] are not part of the final text):

1.3.13 FATIGUE (~~2017~~**2021**)[1]

a. Members and connections subjected to repeated fluctuations in stress shall meet the fatigue requirements of this article as well as the strength requirements of Section 1.4, Basic Allowable Stresses.

b. The major factors governing fatigue strength at a particular location of a member or connection are the number of stress cycles, the magnitude of the stress range, and the relevant Fatigue Detail Category. [insert paragraph break]

Both in-plane and out-of-plane stresses, even if secondary, shall be included in fatigue design of truss hangers (Reference 154a) and sub-verticals. For fatigue design of truss hangers and sub-verticals, impact is modified per Table 15-1-7 and axial and bending effects shall be included, in accordance with the provisions of Articles 1.3.14.2 and 1.3.15. For the effects of **other** secondary stresses see Article 1.3.15 and associated commentary.

[continued]

c. The number of stress cycles, N, to be considered shall be selected from Table 15-1-6, unless traffic surveys or other considerations indicate ~~otherwise,~~ **otherwise.** N depends upon the span length in the case of longitudinal members, and on the number of tracks in the case of floorbeams, hangers, and certain truss members.

d. ~~Mean Impact Load for fatigue design shall be taken as the Table 15-1-7 percentages of the impact load specified in Article 1.3.5.~~**The live load for fatigue design is specified in Article 1.3.3 and Article 1.3.6. The live load used for fatigue design shall be increased by impact. The fatigue design impact shall be the design impact calculated in Article 1.3.5 multiplied by the Fatigue Design Impact Factor in Table 15-1-7 for the type of member being designed.** [insert paragraph break]

~~Mean impact reductions shall not apply to~~ **Full design impact as calculated in Article 1.3.5 shall be applied under the following conditions:** [convert to bullet points]

- ~~m~~**M**embers whose load or impact is increased in Part 6, Movable Bridges, Articles 6.3.2 and 6.3.3~~, or any~~
- ~~structure~~ **Structures** ~~where~~ **with a discontinuity in** the rail ~~is not continuously fastened across the member; nor shall mean impact be applied to~~
- ~~m~~**M**achinery and similar parts of movable structures unless indicated in Part 6~~.~~
- Members supporting special trackwork (~~see~~ **Part 1, Design,** Article 1.2.14) ~~shall not have impacts reduced by the mean impact percentages tabulated in this article.~~

~~e. The live load for fatigue design is specified in Article 1.3.3.~~ [now included in paragraph d]

~~f.~~**e.** The live load stress range, S_R, is ~~defined as~~ the algebraic difference between the maximum and minimum calculated stress due to live load **with fatigue design impact**, ~~mean impact load,~~ and centrifugal load**, if applicable**. Fatigue need not be considered when the combination of live load and dead load results in net compressive stresses (except as noted in Article 9.1.3.13~~k~~**h**).

The stress range, S_R, shall be calculated on the basis of the effective net section or the effective gross section as shown in Table 15-1-8. **Examples of various construction details are illustrated and categorized in Table 15-1-8.** [last sentence moved from former paragraph g]

~~g. Examples of various construction details are illustrated and categorized in Table 15-1-8.~~

~~h.~~ The design stress range shall not exceed the allowable fatigue stress range~~.~~**,** S_{Rfat}, listed in Table 15-1-9. [eliminate paragraph letter, change period to comma]

~~i.~~**f.** Fracture is not necessarily the result of fatigue, yet fatigue of a member can lead to fracture. As such, low fatigue resistant details should be avoided on FCMs (fracture-critical members). Detail Category E and E' details shall not be used on FCMs, and Detail Category D details shall be discouraged and used only with caution.

[continued]

~~j.~~**g.** For span lengths exceeding 300 feet, a special analysis of the number of relevant cycles is required (see Part 9, Commentary).

~~k.~~**h.** Load paths that are sufficiently rigid to transmit all forces shall be provided by connecting all transverse members to appropriate components comprising the cross-section of the longitudinal member to deal with distortion-induced fatigue. To control web buckling and elastic flexing of the web, the provision of Article 1.7.3 must be satisfied.

Edit Note at bottom of Table 15-1-6 to read:

Note: This table is based on bridges designed for the live loading specified in Article ~~1.3.13e~~ **1.3.13d**. For bridges designed for other live loadings see Part 9, Commentary, Article 9.1.3.13.

Replace existing Table 15-1-7 as shown:

Table 15-1-7 Fatigue Design Impact Factors

Member	**Fatigue Design Impact Factor**
Hangers	0.65
Other Truss Members	0.65
Beams, Stringers, Girders and Floorbeams Loaded Length ≤ 10 feet	0.65
Beams, Stringers, Girders and Floorbeams Loaded Length > 10 feet	0.35

[Note at bottom of existing Table 15-1-7 is now covered in Table 15-7-1 providing Fatigue Rating Impact Factors per LB 15-19-14.]

[Articles 1.3.13.1, 1.3.13.2 and subsequent Tables unchanged]

9.1.3.13 FATIGUE (~~2016~~**2021**)

The following symbols…

a. Fatigue is now… [unchanged]

b. The major factors governing fatigue strength are the number of stress cycles (covered in section c), **and** the magnitude of the stress range ~~(section h),~~ and the type of constructional detail (section ~~g~~**e**).

[continued]

A review of the original data base for fatigue impact for the fatigue design of truss hangers and similar members indicated the need to include both in-plane and out-of-plane stresses even if they are secondary stresses (Reference 154a).

c. The derivation of… [unchanged, Table 15-9-4 also unchanged]

d. Impact values used in design are estimated to have a probability of occurrence of 1% or less. Considering that a railroad bridge is normally designed for an 80-year period, this level of impact is quite likely to occur at least once during the bridge life and probably more frequently. For fatigue design the ~~**mean value of impact**~~ **application of the Fatigue Design Impact Factor** is more appropriate. **The reference to "loaded length" in Table 15-1-7 refers to the load influence length of the member under consideration.**

For calculation of fatigue design impact, the Fatigue Design Impact Factor shall be applied to all portions of full design impact in Article 1.3.5, including the vertical effect and rocking effect.

~~**Nevertheless, the note to Table 15-1-7 covers cases of consistent and continuous poor maintenance practice with regard to wheel or track maintenance or places where there are joints in the rail due to switches or rail expansion or other joints where higher impact is a frequent occurrence. This is likely to include but is not restricted to locations where there is "FRA Excepted Track" or "FRA Class 1 Track."**~~

In locations where…

For members supporting…

Observations on 37 spans…

Tests on 15 bridges … structure. (References **154a,** 158, 159)

The ~~**mean impact**~~ **Fatigue Design Impact Factor** is a function of …

For Light Rail, the ~~**Mean Impact Load**~~ **fatigue design impact** shown in Article 1.3.13d should … and in Table ~~**15-1-6**~~ **15-1-7**.

~~**e.**~~ The fatigue criteria …

~~**f.**~~**e.** For the usual …

Residual and/or locked-in …

It has been shown …

A complete stress range …

[continued]

These provisions …

Fatigue design criteria …

Cross-frames and diaphragms …

~~g.~~ Components and details …

Table 15-1-8 illustrates …

Where fasteners and …

For information on …

Research on end-bolted …

~~h.~~ The requirement that …

For longer spans see Article 9.1.3.13c.

For cases where …

$(S_r) = (A/N)^{1/3}$

[Figure 15-9-3 unchanged]

Sr-N curves in …

[Table 15-9-5 unchanged]

Detail Category F …

~~i.~~**f.** Detail Category E and E' …

Eye bars and …

~~j.~~**g.** For span lengths …

~~k.~~**h.** When proper detailing …

[Articles 9.1.3.13.1 and 9.1.3.13.2 unchanged]

[Add citations to new reference added by LB 15-19-14]

154a. Sweeney, R.A.P. "Factors Derived from Tests for Fatigue Evaluation of Typical North American Steel Railway Bridges." *Journal of Bridge Engineering*. Paper 04018036, Vol. 23, Issue 7. Reston, VA: American Society of Civil Engineers, July 2018. Cited in Article**s 1.3.13b, 9.1.3.13b, 9.1.3.13d and** 9.7.3.3.2(c)2.