American Railway Engineering and Maintenance-of-Way Association
Letter Ballot 15-21-24

Assignment: At the September 2021 meeting, the Committee members present voted to submit the following for letter ballot:

Revisions to Articles 1.3.14.3c (including Table 15-1-10), 1.4.1 (Table 15-1-11), and Commentary Article 9.1.4.1.

Rationale: Currently, a higher factor of safety is used for certain allowable tension stresses of floorbeam hangers where ASTM A307 bolts or non-pretensioned high-strength bolts are used in end connections. The approach of using a higher safety margin was introduced in 1961 to address the many fatigue failures experienced in these situations, as they were observed on riveted connections where there is low pretension in the fastener. It is noted that at that time there were no explicit fatigue provisions in the Manual. Since our current provisions for fatigue directly address fatigue strength, it is no longer necessary to use different safety margins on allowable stress in addition to applying the provisions for fatigue found in the design provisions that have been in place for nearly 40 years.

For further background regarding the rationale behind these proposed revisions, please refer to the attachment (beginning on page 4). Also note that a companion ballot, 15-21-18, is being submitted by SC 5.

Submitted by: Chris Johnson, Chair SC 1 (Design Loadings and Stresses)
Due Date: January 21, 2022

Make the following changes as shown (additions shown as **underlined bold red**, deletions shown as ~~**bold red strikethrough**~~, comments in brackets [ ] not part of final text):

1.3.13 FATIGUE (~~**2021**~~**2023**)[1]

a. Members and connections …

b. The major factors …

Fatigue strength in floorbeam hangers shall include the effects of bending at the connection between the floorbeam and the hanger due to end rotation of the floorbeam. These effects must also be included in strength design of the floorbeam hanger according to Article 1.3.14.2.

Both in-plane …

[remainder of Article 1.3.13 unchanged]

1.3.14 COMBINED STRESSES (~~**2018**~~**2023**)[1]

1.3.14.1 Axial Compression and Bending [unchanged]

1.3.14.2 Axial Tension and Bending [unchanged]

1.3.14.3 Allowable Stresses for Combinations of Loads or Wind Forces Only

a. Members subject to …

b. The basic allowable …

c. ~~**Except for floorbeam hangers, the**~~ **The** basic allowable stresses of Section 1.4 may be increased by 25% for members which are subject to the loadings in paragraph a plus additional longitudinal forces and/or lateral forces. However, the section of the member shall not be less than that required to meet the provisions of paragraph a or paragraph b alone.

d. Table 15-1-10 is a summary …

[remainder of Article 1.3.14 unchanged]

[Revise Table 15-1-10 by deleting the following as noted below:]

Table 15-1-10. Summary of Percentage of Allowable Stresses for Combinations of Loads or Forces
(References 157,173)

Member	Allowable Stress Factor	Load Combination	Reference Article
All members	100%	DL + LL + I + CF	1.3.14.3a
Truss web member		See Article 1.3.16	
All members ~~**except Floorbeam hangers**~~	125%	DL + LL + I + CF + W_L + LF + N + CWR + OF	1.3.14.3c
~~**Floorbeam hangers**~~	~~**100%**~~	~~**DL + LL + I + CF + W_L + LF + N + CWR + OF**~~	~~**1.3.14.3c**~~

[Remainder of table unchanged.]

[Revise Table 15-1-11 by deleting the following as noted below:]

Table 15-1-11. Structural Steel, Fasteners and Pins

Stress Area	Pounds per square inch
Axial tension, structural steel, gross section	$0.55F_y$
Axial tension, structural steel, effective net area (See Articles 1.5.8 and 1.6.5)	$0.47F_u$
Axial tension, structural steel, effective net area at cross-section of pin hole of pin-connected members	$0.45F_y$
Tension in floorbeam hangers, including bending **due to floorbeam end rotation**, gross section~~**:**~~ **using high strength bolts in end connections** ~~**Using ASTM A307 bolts or non-pretensioned high-strength bolts in end connections**~~ ~~**Using high-strength bolts in end connections**~~ ~~**Tension in floorbeam hangers, including bending, effective net area at cross-section of pin hole of pin-connected members:**~~ Tension in floorbeam hangers, including bending **due to floorbeam end rotation**, on effective net ~~**section**~~ **area**~~**:**~~ **Tension in floorbeam hangers, including bending due to floorbeam end rotation, effective net area at cross-section of pin hole of pin-connected members**	**$0.55F_y$** ~~**$0.40F_y$**~~ ~~**$0.55F_y$**~~ ~~**$0.45F_y$**~~ ~~**0.50**~~**0.47**F_u **$0.45F_y$**

[Remainder of table unchanged.]

[continued]

9.1.4.1 STRUCTURAL STEEL, FASTENERS AND PINS (~~2018~~2023)

In determining the allowable stresses, the value of 1.82, which is equal to 1/0.55, has been adopted as the usual factor of safety in tension, based on the minimum yield point of the material. The same value has been used for such compression applications as are not affected by axial combined with bending effects.

Yielding of the gross area and fracture of the effective net area are considered the failure limit states. Yielding of the gross area can lead to excessive elongation of the member. This uncontrolled elongation can precipitate failure of the overall structural system. Fracture of the effective net area was proposed by Munse and Chesson (Reference 45, and 117) and has been long since adopted as a limit state by both the AISC (References 18, 19, and 20) and AASHTO (Reference 10). The allowable stress of 0.47 F_u has been adopted by AREMA to align with AASHTO and to provide an additional factor of safety due to the sudden nature of this failure state.

The more conservative design approach for pin-connected members is based on the results of experimental research (Reference 99).

~~**Since there have been more failures in floorbeam hangers with connections that do not have pretensioned high-strength fasteners than in other members, a greater apparent factor of safety has been adopted for such members (Reference 37).**~~

Historically, fatigue cracking in floorbeam hangers with riveted connections has been the dominant form of cracking in riveted truss bridges. Failures occurred because in design there was a lack of the now current understanding of fatigue, and that the nature of the loading is a combination of axial and flexural stresses due to rotation of the floorbeam. Earlier versions of the Manual included provisions that placed additional restrictions and limitations on the design of hangers to reduce the likelihood of cracking in such members. The limitations were based on observations where cracking did and did not occur, rather than engineering-based approaches. However, today (2021) using current fatigue design procedures included in the Manual and analytical tools that accurately estimate both the in-plane and out-of-plane stress ranges in hangers, these restrictions are no longer necessary and have been removed from the Manual. The current Manual recommendations require design for both strength and fatigue.

[Remainder of Article unchanged]