0-6937: Fracture Critical Steel Twin Tub Girder Bridges

Background

Steel twin tub girder (STTG) bridges (Figure 1) are a popular choice for dealing with long-spanned bridges in Texas, especially when tight-radii curves are necessary. Such solutions are aesthetically pleasing. However, these bridges are deemed fracture critical; with this comes a high price of biennial inspection. Since the structural members are prone to fatigue and fracture failures, the nonredundant structural elements of fracture critical bridges make these susceptible to sudden total or partial collapse that is initiated by the failure of a single member. The massive damage to life and property that is incurred due to such failures dictate the Texas Department of Transportation (TxDOT) allocate huge funds for fabrication, maintenance, and close hands-on inspections. The primary motivation behind this research is to investigate whether the fracture critical designation may be removed for certain bridges in this twin tub class. The consideration of load path redundancy alone may be misleading in classifying non-fracture critical members as fracture critical members (FCMs), causing unnecessary expenditure.

What the Researchers Did

To identify the merit of the designation of STTG bridges as FCMs, the following tasks were conducted:

1. Due to the huge risk of impending failure and consequential damages, three independent analysis methods were investigated to identify the reserve capacity of 15 preselected bridges. The key research question was: If the outside steel tub girder completely fractured, what is the ultimate load that may be sustained?
2. A rapid approach that uses plastic analysis methods was investigated. Upper and lower bound yield line analyses were used to obtain a sense of the collapse (limit) loads.

Figure 1. Typical STTG Bridge.

3. An efficient nonlinear computational push down grillage analysis was conducted. This method also provides information on deflection limits.
4. An exacting analysis was also used to verify the simplified analyses. Thus analyses using the nonlinear finite element method (FEM) with a refined mesh were conducted (Figure 2).
5. The results from the three methods were first validated against previous test results (Figures 3 and 4) and then used for assessing the load capacity of the suite of 15 bridges.

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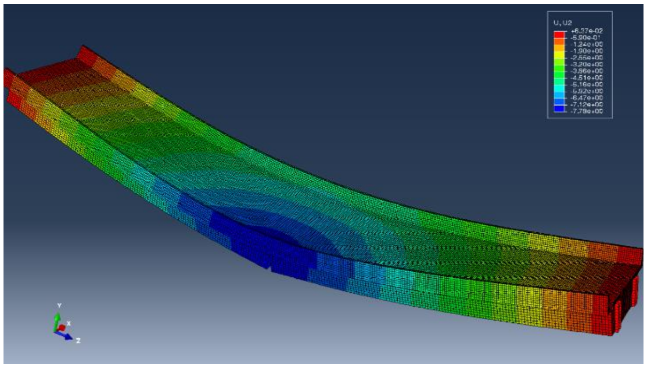

Figure 2. FEM Model.

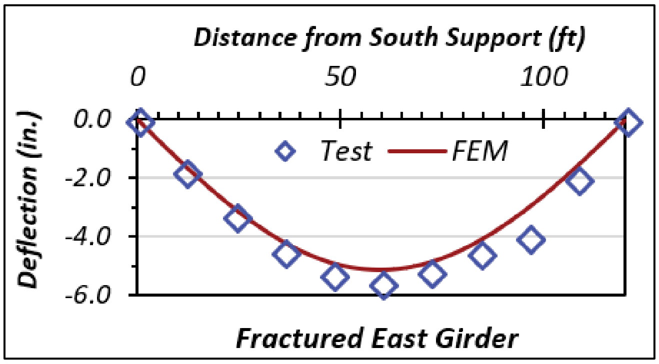

Figure 3. Validation Using Experimental Results.

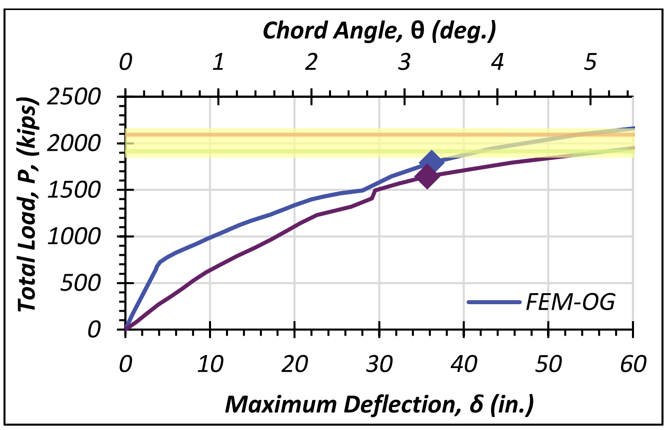

Figure 4. Results from Three Methods.

What They Found

The behavior of STTG bridges with one (outer) girder fracture and built-in redundancy has sufficient overstrength to sustain the design factored (ultimate) loads without overall collapse. Built-in redundancy includes bridges with two or more spans where those spans are continuous over the pier supports.

Therefore, the researchers recommend, with some caveats, that continuous STTG bridges may be declassified from being fracture critical and reclassified as being non-fracture critical. The caveats are:

- Single-span bridges may be declassified providing the span length is less than 120 ft.
- All end spans whose length is greater than 200 ft shall remain classified as fracture critical.
- All interior spans greater than 350 ft in length shall remain classified as fracture critical.
- All bridges that are restricted to remain fracture critical (due to their span length or lack of redundancy) may be reclassified if two of the three independent methods of analysis show that sufficient overstrength exists if one of the steel tub girders are fractured.

What This Means

In general, most STTG bridges in Texas may be declassified from being fracture critical, provided they have multiple continuous spans and their span lengths are not uncommonly long. For bridges that cannot be deemed non-fracture critical, it may be possible, on a case-by-case basis, to have those bridges reclassified if rigorous analysis shows that sufficient reserve capacity exists.

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