



## Florida Department of Transportation Research Steel Framing Strategies for Highly Skewed Bridges to Reduce/Eliminate Distortion near Skewed Supports BDK80-977-21

In the past, bridges were aligned normal to crossing roads or obstacles in order to simplify bridge construction. However, the continuing expansion of the interstate system has challenged engineers to provide more horizontal clearance, reduce right-of-way impacts, and increase traffic flow, which have all lead to complex roadway alignments that require the use of skewed supports. Construction of highly skewed steel bridges often faces significant challenges due to the effects of the skewed supports on the framing of the bridge. Designing cross-frames is a challenging problem on its own, complicated by the ways a bridge changes at different construction stages, particularly as adding the deck changes the loading of the girders.

Cross-frame design can be approached in several ways, but the forces predicted by different methods may not agree, leading to different designs. Also, confusing terminology regarding the cross-frame geometry has led to miscommunications and expensive redesign or repair. Accuracy and consistency in the design process is important because of the substantial investment in materials, labor, and construction time in the cross-frame system. In some cases, poor bracing has compromised bridge stability, with severe results for workers and structures.

In this project, Florida International University researchers simplified design and construction of steel bridges with skewed supports by developing a complete and coherent design methodology. They structured their work in five tasks: introducing terms for detailing methods consistent with field practice; identifying structural responses affected by detailing methods; recommending methods of analysis to evaluate structural responses; developing methods to estimate fit-up forces and practices to reduce them; and developing design provisions for skewed bridges. Careful analysis revealed the critical elements for cross-frame design, summarized in



*The cross-frames visible between this bridge's steel girders add stability while the deck is added.*

a flow chart that can help designers choose the appropriate detailing method for cross-frame systems in straight skewed I-girder bridges.

The researchers introduced the terms erected fit and final fit to clarify which stage the cross-frames are being designed for. Erected fit corresponds to the girder webs being plumb without the concrete deck, and final fit corresponds to the girder webs being plumb in the completed structure. Cross-frames should be designed for the stage at which girder webs will be plumb.

The researchers examined the potential structural responses of straight skewed I-girder bridges that cross-frame designers must anticipate and the lack-of-fit effects that results. A 2D grid analysis, both traditional and an improved version, were applied to erected fit detailing. For final fit detailing, 3D finite element analysis was required. These analyses not only led to detailed designs but had important implications for order of installation of cross-frames.

In this project, careful and clear analysis led to a more straightforward design process for cross-frames. Projects like this are at the heart of engineering practice and its goal to produce designs that balance utility, economy, and safety.