

Concrete Beam Bridges

Next to the slab bridge, the beam bridge is perhaps the simplest possible way to span an opening. Like the slab bridge, the beam bridge has the distinction of being a very ancient bridge design (Glidden 1935:11). Roman bridges are best known for their graceful masonry arches, but it appears that the beam bridges were built, especially for military uses. Julius Caesar described a temporary bridge constructed during his campaign in Gaul that is clearly a multiple-spanned beam bridge of wood; the sixteenth century architect, Andrea Palladio, presented his reconstruction of this bridge in his Third Book of Architecture (Palladio 1965:plate II; Whitney 1983:69).

The earliest concrete beam bridges in the nation were deck girder spans that featured concrete slabs supported by a series of longitudinal concrete beams. This method of construction was conceptually quite similar to the traditional timber beam bridge which had found such widespread use both in Europe and in America. Developed early in the twentieth century, deck girder spans continued to be widely used in 1920 when noted bridge engineer Milo Ketchum wrote *The Design of Highway Bridges of Steel, Timber and Concrete* (Ketchum 1920).

A variation of the girder design that was developed in the 1930s was the continuous girder bridge, in which a single set of girders extends over several spans. By 1939, structures with spans up to 348 feet had been constructed. The design offers several advantages: it requires a smaller amount of steel and concrete, fewer bearings, fewer expansion joints, and reduced deflection and vibration. Disadvantages include more complicated design and increased sensitivity to uneven settlement of foundations (Taylor et al. 1939:150).

Although visually similar to deck girder bridges, the T-beam span features a series of reinforced concrete beams that are integrated into the concrete slab, forming a monolithic mass appearing in cross section like a series of upper-case "T"s connected at the top. Milo Ketchum describes the type, as constructed in 1920, in this way:

In beam and slab construction, an effective bond should be provided at the junction of the beam and slab. When the principal slab reinforcement is parallel to the beam, transverse reinforcement should be used extending over the beam and well into the slab. The slab may be considered an integral part of the beam, when adequate bond and shearing resistance between slab and web of beam is provided but its effective width should be determined by the following rules: (a) it shall not exceed one-fourth of the span length of the beam; (b) its overhanging width on either side of the web

shall not exceed six times the thickness of the slab; (c) it must not exceed the distance between the beams [Ketchum 1920:290-291].

Thaddeus Hyatt is believed to have been the first to come upon the idea of the T-beam when he was studying reinforced concrete in the 1850s, but the first useful T-beam was developed by the Belgian Francois Hennebique at the turn of the present century (Lay 1992:293). The earliest references to T-beam bridges refer to the type as concrete slab and beam construction, a description that does not distinguish the T-beam design from the concrete deck girder. Henry G. Tyrrell was perhaps the first American bridge engineer to use the now standard term "T-beam" in his treatise *Concrete Bridges and Culverts*, published in 1909. Tyrrell commented that "it is permissible and good practice in designing small concrete beams which are united by slabs, to consider the effect of a portion of the floor slab and to proportion the beams as T-beams" (Tyrrell 1909:186).

By 1920, reinforced concrete, T-beam construction had found broad application in standardized bridge design across the United States (Plate 15). In his text, *The Design of Highway Bridges of Steel, Timber and Concrete*, Milo S. Ketchum included drawings of standard T-beam spans recommended by the U.S. Bureau of Public Roads as well as drawings of T-beam bridges built by state highway departments in Ohio, Michigan, Illinois, and Massachusetts (Ketchum 1920). By the 1930s the T-beam bridge was widely built in Maryland and Virginia.