# SECTION VII: METAL GIRDER BRIDGES

## HISTORICAL DEVELOPMENT

Metal girder, or beam, bridges exemplify the modern application of traditional bridge technology. For many centuries, since ancient times, simply-supported beam bridges were constructed of wood, the most readily available material. Structurally, a beam carries its loads by bending, with upper fibers in compression and lower fibers in tension; determinants for span length include strength of materials and depth of cross section. The metal girder bridge is essentially a structure in which a floor system and roadway (made of timber or concrete) are supported by girders, generally consisting of rolled sections of metal (of various shapes, including "I" and "W") which are plain or encased in concrete. Girders are the members which span between the main supports of a structure. In bridge floor systems, the transverse members are floor beams and the smaller structural members parallel to the movement of traffic are called stringers (Merritt 1976:6-12, 6-13).

The use of metal for beam bridges followed its use for other metal structure types, such as the metal truss, metal arch, and suspension bridges. During the early nineteenth century, refinement processes such as the Bessemer process significantly reduced the carbon content of cast iron and wrought iron, thereby also reducing the tendency of the material to crack or become brittle (Chard 1986). By 1861, major bridge components were manufactured of rolled iron, and by 1870 techniques of mass production were applied to the making of a variety of iron structural shapes, including beams or girders (P.A.C. Spero & Company 1991:146-147). The general design and manufacture of such iron components between 1860 and 1890 led to the construction of many iron girder spans throughout the United States, particularly on railroads. By 1895, however, wrought iron structural shapes were rapidly becoming unavailable as steel took its dominant place in girder bridge construction (P.A.C. Spero & Company 1991:146-147).

Like their metal truss counterparts, the types of both iron and steel girder bridges developed in the nineteenth century may usefully be categorized by the relationship of the roadway, or deck, to the position of the girder or girders (Figure 14). There are deck girder, through girder, and half-through girder bridges. Plate girder spans are bridges in which the girders consist of built-up riveted sections with a deeper "web" between the top and bottom flanges of the girder. The plate girders may be placed beneath the bridge deck, in a deck girder configuration, or may rise above the level of the roadway, as in the half-through variant (P.A.C. Spero & Company 1991:146-147).

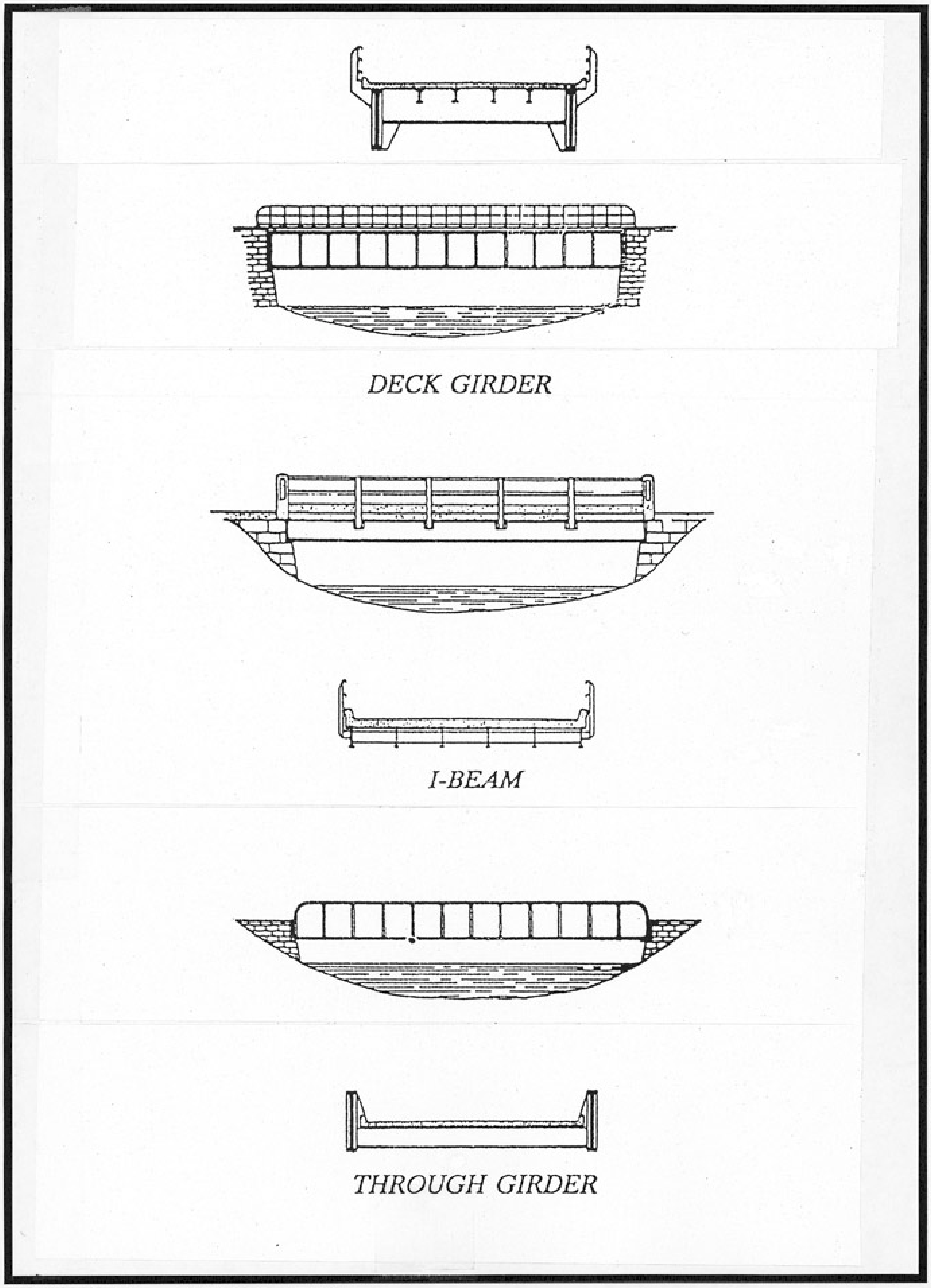


**FIGURE 14: Types of Metal Girder Bridges** SOURCE: P.A.C. Spero & Company 1991

Metal girder bridges constructed of iron began to be constructed during the middle of the nineteenth century in response to industrial and manufacturing advances. Bridge engineering historian Henry Grattan Tyrrell in 1911 stated that the earliest wrought iron girder bridge in the world, a 31.5-foot-long structure with six parallel lines of supporting beams, was built by A. Thompson in 1841 to carry a highway over the Pollack and Govan Railroad near Glasgow, Scotland. Tyrrell also noted that in 1846, both William Fairbairn in England and James Milholland in the United States had constructed the earliest plate girder bridges. Milholland's span, a 50-foot iron plate girder with top flange reinforced by wood, was constructed for the Baltimore and Susquehanna Railroad (precursor of the Northern Central) near Bolton station or depot in the City of Baltimore, Maryland (Tyrrell 1911:195). Historian and prominent engineer J.A.L. Waddell in 1916 seconded Tyrrell's findings, adding that important plate girders were built for the Pennsylvania Railroad in 1853 and the Boston and Albany Railroad in 1860 (Waddell 1916:22-23).

Under the impetus of the railroads, metal girder bridge design and construction reached full development during the last quarter of the nineteenth century. Prominent bridge engineer Theodore Cooper, a key proponent of empirical bridge design and standardization, observed in 1889 that plate girders were "generally used for spans up to 65 feet and give excellent satisfaction" when riveted at the bridge fabrication shop (P.A.C. Spero & Company 1991:147-148). Crediting the "great advance in the science of detailing and proportioning" for the increasingly scientific approach to design of rolled I-beam spans and plate girders, Waddell dated popular recognition of the "great value of plate-girders for short spans" to the 1880s. By 1905, standard design plans and specifications for all types of girder bridges were available through such organizations as the American Railway Engineering Association, and the American Society of Civil Engineers, and such prominent private bridge building firms as the American Bridge Company.

With the automotive revolution bringing heavy traffic loads to ordinary highway bridges, the early twentieth century witnessed further standardization of design for girders erected on roads as well as railroads. Highway engineer Milo S. Ketchum in a 1908 handbook noted that "for spans of, say, 30 feet and under rolled beams are often used to carry the roadway, while for spans from about 30 to 100 feet plate girders are used" (Ketchum 1908:11). Waddell in 1916 observed that "the ordinary limit of plate girder spans is about one hundred (100) feet, but that limit has often been surpassed by twenty-five (25) or thirty (30) per cent for simple spans and by much more for swing spans" (Waddell 1916:409).

Plate girder bridges were typically riveted in the shop and shipped by rail to the intended sites (Figure 15; Plates 10 and 11). As in the case of metal trusses, the introduction of the portable pneumatic riveter allowed some early twentieth century plate girders to be riveted in the field, but as Waddell observed in 1916, there were many important shipment and construction considerations:

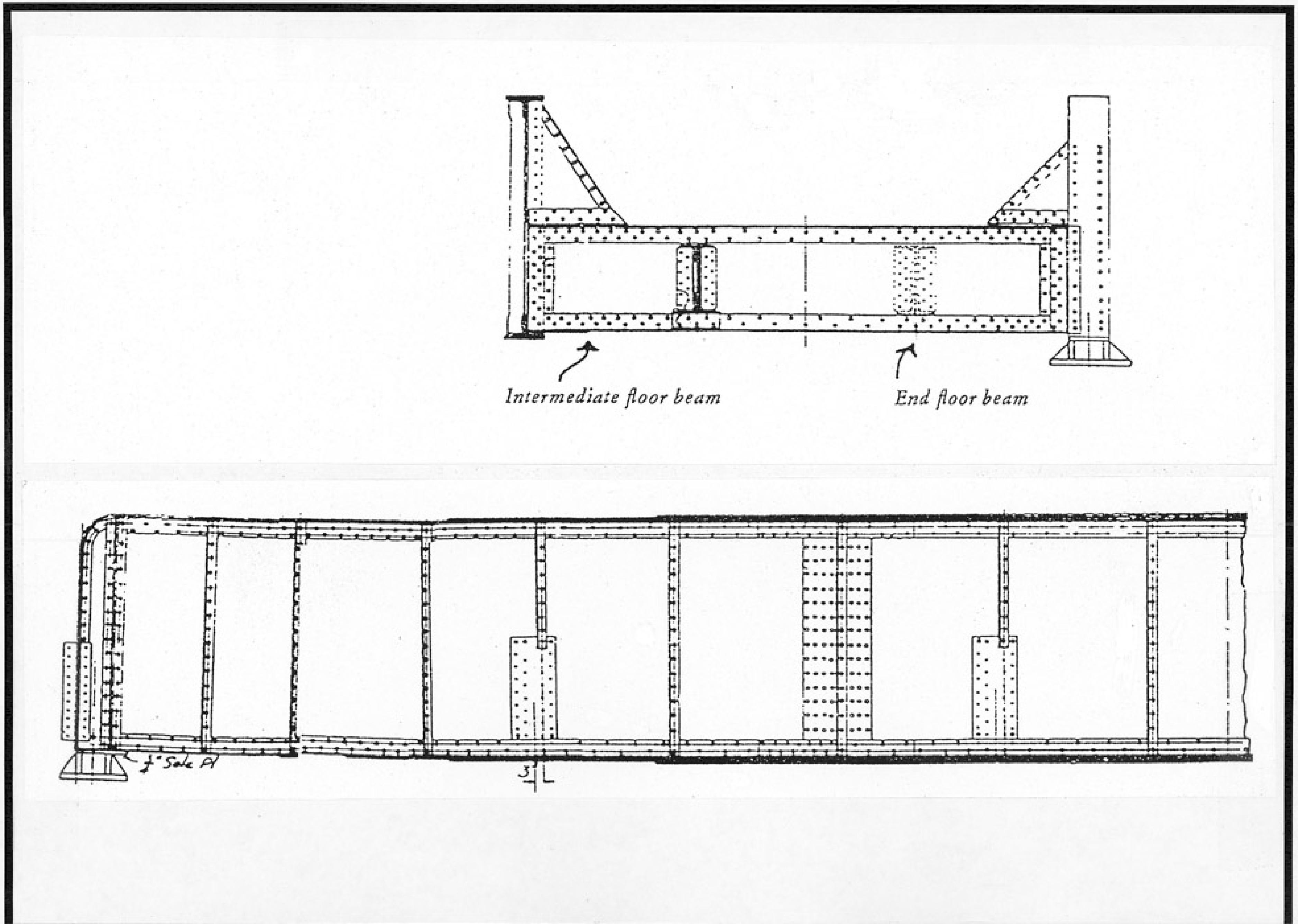


**FIGURE 15: Detail, Typical Metal Plate Girder Bridge**

SOURCE: Weitzman 1980