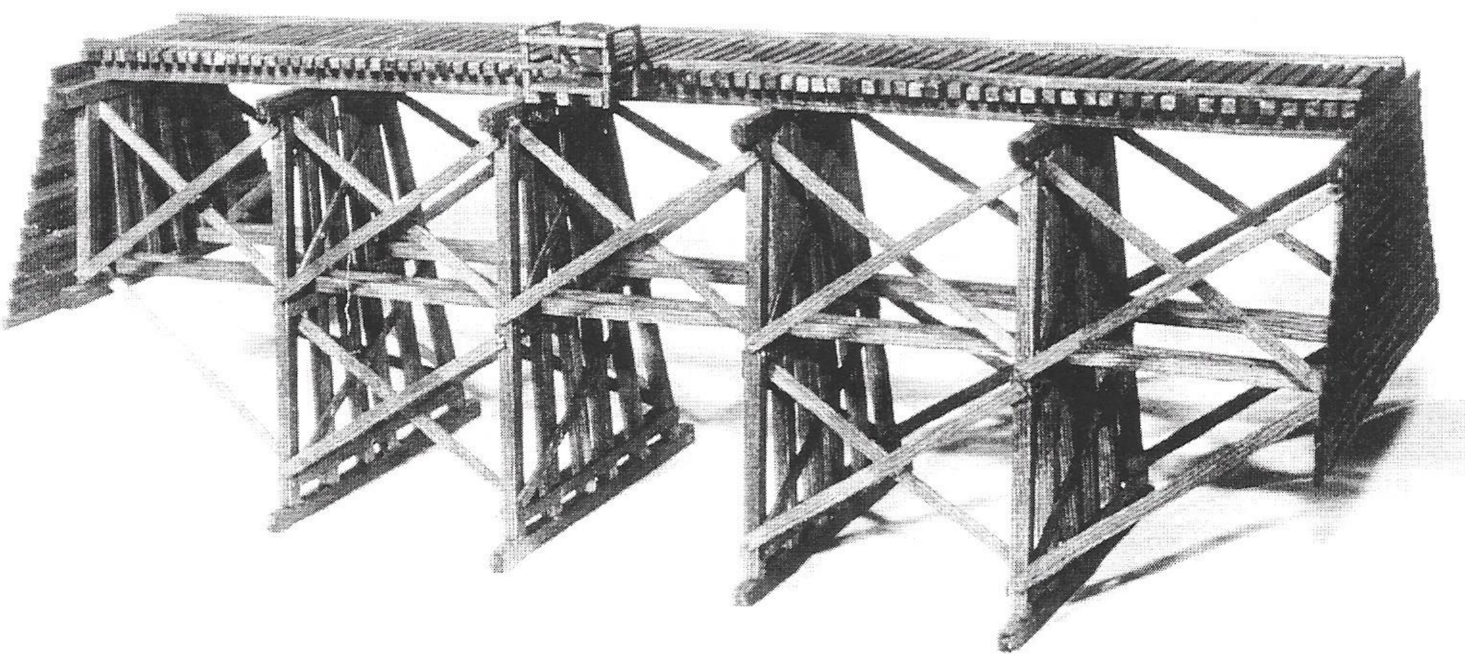
# BRIDGING THE GAP



*By Rick Hunter*
*Hunterline*

Reference Sources:
Bridges & Trestles: Model Railroader; by Kalmbach Books
Bridge and Trestle Handbook: by Paul Mallery; Carstens Publications

# Elementary Bridge Engineering

Should a modeler have plans for a prototype bridge fitting requirements for a bridge on the layout in question, those plans can be followed exactly. Certainly, for a contest model, it is best to follow a specific prototype. Unfortunately, it is most unlikely suitable plans can be found for each and every bridge required on a layout. Even with a book like this with a large number of examples, it probably will be necessary to modify published plans or to design free-lance models. Either to modify or to design requires an elementary knowledge of bridge engineering if the result is to be a believable bridge. Above all impossible structures must be avoided – impossible meaning that, if prototype, the bridge would not stand. Impossible bridges have been shown on covers of major model railroad magazines.

No modeler needs to know how to calculate stresses or how to design an economical strut. Modelers must understand, however, where bridge members are required and whether members are in tension, in compression, or being bent. Knowing the type of member to select, very acceptable models can be constructed by choosing details of similar members from bridges of approximately the same span, age, and loading. This chapter provides basic information to guide a modeler to reasonable choices when designing or modifying a bridge for a special need.

## 2.1 BASIC TERMS

Even in an elementary treatise such as this, it is necessary to use some technical words. Those employed here are far fewer in number than would be found in engineering works. In some cases usage has been simplified as many fine distinctions important in designing a real bridge have no significance to a modeler. Terms relating to a particular bridge type are defined in the chapter pertaining to that type. Some such words are used in this chapter. If their meaning is not clear, consult the Index for the pages on which the matters in question are defined. A few general terms are defined below:

Load: Forces exerted on a bridge to include:
- Dead Load: Weight of bridge and items fixed to it.
- Live Load: Weight of moving loads.
- Wind Load: Sidewise thrust of wind.

Compression: Pushing forces applied to ends of a member.

Tension: Pulling forces applied to ends of a member.

Bending: Force applied to bend a member out of its original shape.

Shear: Forces applied, as by a scissors, to slide one part against another, includes sliding within a member.

Crushing: Force applied to smash a member.

Stiffness: Ability to resist flexing or vibration.

Stress: Internal force within a member resisting applied load.

### Examples of Basic Terms

Fig. 2-1 A shows a simple beam with a bending force applied at its center. The beam bends until compressive stresses along its top and tension stresses along its bottom build up to the point where such stresses can

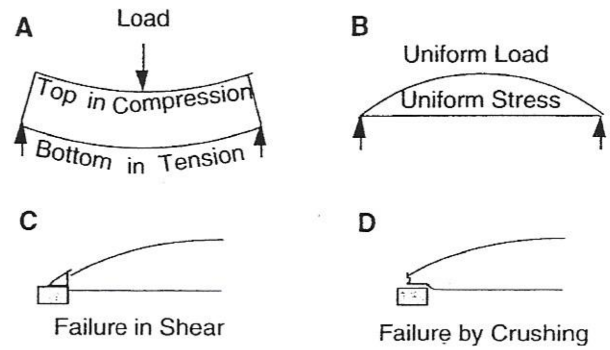



Fig. 2-1 Simple Beam Bridge

oppose the load. Since bending stresses are highest at the center of span and zero over supports, a uniform beam failing in bending either under a uniform load or centered load fails at its center.

Because bending stresses decrease from center to end, material can be saved without loss of strength by tapering beam (or truss) as shown in Fig. 2-1 B. Although bending stresses go to zero at the supports, the beam cannot have near-zero height at its supports or it will fail in shear as indicated at C or by crushing as at D.

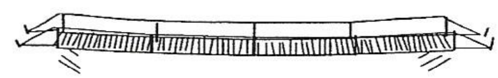


Fig. 2-2 Suspension Footbridge

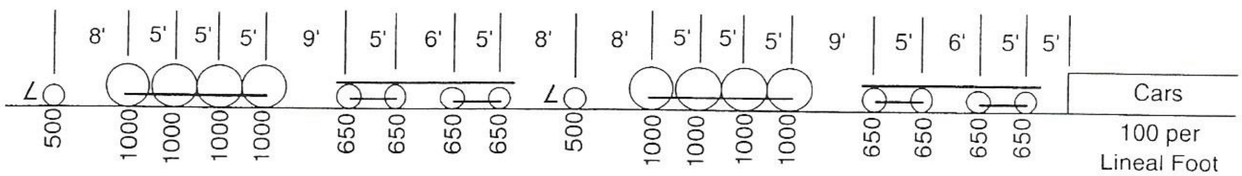
Strength to carry applied loads is not enough. Primitive suspension bridges as above are still used for pedestrian bridges. They can be made strong enough to carry automobiles, even trains. Indeed prior to 1800 this type of bridge carried vehicles. Today such an unstable bridge form is absolutely unsuitable for highways or railroads. No vehicle or train could stay on the bridge at any reasonable speed. A bridge for anything other than pedestrians must be stiff so the bridge floor will be held level and in line. One of the famous bridge disasters, that of the original Tacoma Narrows Bridge, was caused by insufficient stiffness. For the record, the engineer designed it properly but politicians modified his design.

# COOPER'S LOADING

## 2.4 COOPER'S LOADING

In this Handbook a bridge is described as "heavy modern", "light 1900", or similar descriptive terms as such factors are important in choosing a suitable prototype. Designers of real bridges, however, require a more precise way of specifying capacity of a bridge. One rating system for railroad bridges is so wide spread it warrants coverage here, Cooper's Loading. His system is based on double-header Consolidations pulling cars of uniform weight. Each particular loading is called a class and given an E number, e.g., E40. Pounds per axle for any given E loading can be determined by multiplying the E number by the multipliers given in Fig. 2-7 on next page. For example, Class E60 calls for 60,000 pounds per driving axle, 30,000 pounds on the engine-truck axle, 39,000 pounds per tender axle, and uniform loading by cars of 6,000 pounds per lineal foot. Although based on Consolidation steam locomotives, this system has proven practical for all types of locomotives and remains in use today. Other systems have been devised but they have never found favor. Since an available bridge plan may be known to be designed for a specific Cooper's Loading, it is important to recognize what type of traffic is appropriate for that bridge. The following table presents this information.

| Cooper's Loading Class | |
|---|---|
| E30 | Light service only |
| E40 | Lightest normally built in 1900 |
| E50 | Common loading of 1919 |
| E60 | Common main line of 1924 |
| E70 | Heavy main line of 1924 |
| E75 | Heaviest normally found |




Above Multipliers Times E-Class Number Gives Axle Load in Pounds

Fig. 2-7 Cooper's Loadings are Based on Double-Headed Consolidations

### A BRIEF HISTORY

Prior to the 1840s, the bridges found in the United States were either masonry edifices or flimsy wooden structures. Railroads greatly changed bridge-building practices. With their heavy equipment and constant need for easy grades and gentle curves, they forced engineers to devise better ways for overcoming natural obstacles.

Builders first relied on traditional materials, and some rather sophisticated bridges of masonry appeared on the Baltimore & Ohio and other early railroads. Many of these structures, like the Erie RR's famed Starrucca Viaduct shown above, were built so well that they can still carry heavily loaded freight cars.

Iron first appeared as a building material in the early 1840s. Up to the 1860s, steel was used mostly for tension members and wood for compression. By 1869, however, bridges made entirely of steel were being erected. As steel became more economical to use, solid steel continuous spans were built, along with arches and cantilevers. By the end of the 19th century, the first lift drawbridges were being constructed, and concrete was replacing stone for masonry arches, supporting piers, and abutments.

Bridge construction slowed during the depression era of the 1930s, just as railroads began to decline. All the same, notable changes did take place, such as the replacement of rivet assembly methods by bolted construction. By the 1950s, all-welded construction was commonplace.

**Fig. 2** BRIDGE CONSTRUCTION

| TYPE | BRIDGE MATERIAL | SPAN IN FEET 19th Century | 20th Century | Modern |
|---|---|---|---|---|
| Beam | Wood | to 20 | to 15 | to 10 |
| | Steel | – | to 20 | to 40 |
| | Concrete | – | to 10 | to 20 |
| Plate Girder | Steel | to 100 | 10-150 | 20-200 |
| Simple Truss | Wood | 15-150 | 15-150 | – |
| | Steel | 50-300 | 50-500 | 100-700 |
| Arch | Wood | 50-200 | 50-200 | – |
| | Steel | 100-700 | 100-1000 | 100 + |
| | Concrete | to 100 | to 200 | to 300 |
| Cantilever | Steel | 200-1000 | 300-1500 | 300 + |
| Continuous | Steel | – | 300-800 | 300-800 |

**Fig. 3** TRESTLE BENTS

NUMBER OF COLUMNS PER BENT

| | Loading | OPEN DECKS E45 | E60 | E72 | BALLASTED DECKS E45 | E60 | E72 Piles | E72 Posts |
|---|---|---|---|---|---|---|---|---|
| Length of panel | 12' | 4 | 5 | 5 | 5 | 6 | 6 | 6 |
| | 13' | 4 | 5 | 6 | 5 | 6 | 7 | 6 |
| | 14' | 4 | 5 | 6 | 5 | 6 | 7 | 6 |
| | 15' | 5 | 5 | - | 5 | 6 | 7 | 6 |
| | 16' | 5 | 6 | - | - | - | - | - |

Courtesy National Model Railroad Association

# Chapter 3
# Types of Bridges

Over the years a great many types of bridges have been built. Some are unique examples, others are wide spread. To keep this book within reasonable bounds, only forms of bridges which are (or were) in common use are described in detail. Nevertheless, all bridges are interesting. Consequently unusual types are included although not covered in depth. This Chapter deals only with basic classifications of bridges. For details and subdivisions within each classification, see the appropriate chapters.

Since this is a handbook primarily for use by modelers of North American practice, most examples included are from that region. Reference is made to other areas for historical background, record spans, or only examples.

Bridges may be classified in many ways. Important distinctions include: deck or through; movable or fixed; timber, steel, or masonry; beam, truss, or plate girder; and simple, continuous, cantilever, arch, or suspension. Through these and other recognized classifications, a bridge can be described concisely and accurately.

## 3.1 BRIDGE, TRESTLE, VIADUCT, CULVERT

*Bridge* is the general term for a structure carrying track, road, or waterway over an opening. If there are a number of bridges in succession, particularly if spans (distance between supports) are short in relation to height above the surface, the structure is usually called a *trestle*. When spans are long, such as the succession of 180' (53m) reinforced concrete arches built by the Lackawanna at Nicholson, PA, *viaduct* is often applied. Highway trestles are customarily called viaducts regardless of span, sometimes *causeways* if exceptionally long. Viaducts or trestles carrying water channels generally are referred to as *aqueducts*. A bridge is frequently referred to as a *span*. Whether a series of bridges is a multi-span bridge, a trestle, etc., is blurred. Fortunately, in practice, this presents no problem.

An opening through the roadbed, particularly if it has a man-made bottom, e.g., a pipe, is usually called a *culvert*. Since culverts can be large, over 20' spans, the border line between bridge and culvert is also blurred.

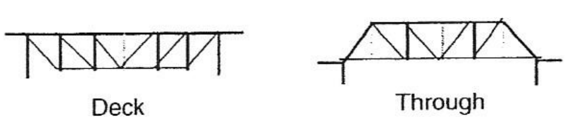



Fig. 3-1 Deck and Through Bridges

## 3.2 DECK OR THROUGH

A distinction among bridges is whether trains or other vehicles run on top of the trusses, arches, or girders (*deck bridge*) or whether they run between them (*through bridge*) as diagramed above. A through bridge provides greater clearance under the bridge than does a deck bridge but is more expensive for the same span and loading, also more difficult to stiffen. Therefore, unless clearance is important, a deck bridge is the preferred type. A common error on model railroads is installing a through bridge when a deck bridge would serve.

There are truss bridges on which the floor is well up on the trusses but not at their tops. Such bridges are sometimes referred to as *semi-through*.


Fig. 3-2 Bridges Use Materials to Advantage

## 3.3 STEEL, TIMBER, MASONRY

The material used to construct a prototype bridge has great impact on the type of bridge and its details. Although a modeler is not concerned with materials as such (a steel prototype may be modeled in wood), differences in appearance caused by prototype material is very important. Masonry and wood are stronger in compression than in tension. Steel is stronger in tension. Bridge engineers use materials to best advantage. A timber truss bridge would have as many members in compression as possible while a steel bridge would make extensive use of tension members. This is illustrated in Fig. 3-2 where main-truss diagonals for the timber Howe truss are in compression as indicated by heavy lines and slant in the opposite direction from the diagonals in the steel Pratt truss which are in tension as indicated by thin lines.

## 3.4 MOVABLE OR FIXED

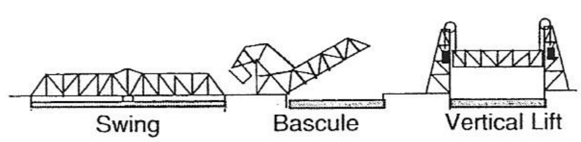



Fig. 3-3 Common Types of Movable Bridges to Open a Water Passage

The great majority of bridges are *fixed*, that is they remain continuously in one position. But there are many bridges which move. *Turntables* and *transfer tables* are used to handle locomotives and cars at roundhouses and shops. *Transfer bridges*, also called *aprons*, adjust to connect track or road on land to a car float or ferry. *Draw bridges* open passages permitting water traffic to pass. The three common forms of draw bridges are shown above. *Swing bridges* rotate horizontally around a pivot, *bascules* rotate upward, and *vertical lift bridges* rise in the manner of elevators.

## 3.5 RIVETED, WELDED, OR PIN CONNECTED

Connections between members of a steel truss are, in general, made either by fastening members to a *gusset plate* or by a heavy steel pin as shown in Fig. 3-4 on next page. Gusset plates have always been used. Originally they were connected to truss members with rivets. By 1960 bolts frequently replaced rivets for field connections. Welding started with highway bridges but, by 1975, had become routine even on railroad bridges.

# Types of Bridges

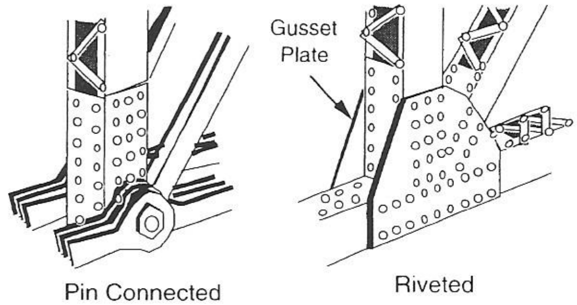



Fig. 3-4 Connections Between Truss Members

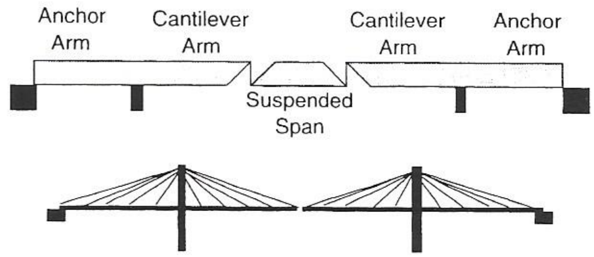



Fig. 3-6 Cantilever Bridge

The first major pin-connected bridge was erected in the U.S. in 1851. Prior to World War I pin connection was the preferred form for spans of 150' or greater.

In Fig. 3-4 the pin connects a post fabricated of two channels with a bottom chord and a main tie of eyebars. Eyebar tension members are frequently found on pin-connected bridges but the pin connection is also used between stiff members as shown on the Northern Pacific bridge of Fig. 10-32, page 59. Eyebars are neither as stiff as fabricated members nor can they resist compression. The need for rigidity in modern bridges is the main reason for the abandonment of the pin connection (except to shoes).

## 3.6 SIMPLE, CANTILEVER, CONTINUOUS, ARCH, SUSPENSION

From a prototype design point of view, the most-important classification is how a bridge carries its load. Almost anything will carry the load on a model but, as this classification greatly affects both general appearance and details, it is also the most-important classification for a model bridge.

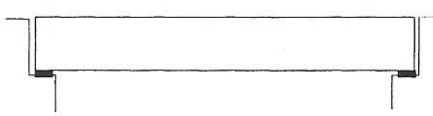


Fig. 3-5 Simple Bridge

### Simple

A *simple bridge* is a beam, girder, or truss of any description supported only by vertical forces at each end. It is by far the most-common type of bridge. Fig. 3-5 illustrates the essence of a simple bridge. Its stresses are shown in Fig. 2-1, page 7.

### Cantilever

A *cantilever bridge* has at least one section not supported at one end. At the top of Fig. 3-6 is illustrated a typical form. It has two unsupported arms, called *cantilever arms*, two *anchor arms*, also called *shore arms*, and a *suspended span*. Suspended spans are simple bridges hung from the cantilever arms. Loads applied to supports for cantilevers are vertical only. Cantilever bridges are suitable for the longest spans of interest to model railroaders. The Quebec Bridge, completed in 1917, then carrying two RR tracks and a road, has a main span of 1,800' (549m). One track was eliminated to make room for a wider road.

Cantilever bridges take many other forms. Several are shown in Chapter 14. For instance there may be no suspended span but the two cantilever arms must not be connected so stresses can be transferred between the arms. Queensborough Bridge, New York City, 1181' (358m) main spans, is a famous example of a cantilever without suspended spans. Cantilever bridges exist having at least one suspended span hung from a cantilever arm only on one end, the other end resting on a pier or abutment. Reinforced-concrete cantilevers often have cantilever arms projecting toward the shore. At the bottom of Fig. 3-6 is a type of cantilever called *cable-stayed* among other names. It gained popularity for highway bridges starting about 1960.

The stress break at the free end of a cantilever arm makes the bridge tolerant of minor shifts of piers or abutments. This combined with vertical forces only on supports makes cantilevers suitable for locations where foundations cannot be placed on rock. Every bridge across the Mississippi south of St. Louis is a cantilever.

Stresses in cantilever and anchor arms are the reverse of those in a simple bridge. Such stresses are detailed in Fig. 2-6, page 9. Anchor arms often pull up on their piers or abutments rather than pressing down.

An understanding of cantilevers is important when free-lancing a swing or bascule bridge. Such bridges carry loads when closed either as simple or as continuous bridges but act as cantilevers when open. Thus trusses of such bridges must resist both tension and compression in chords and diagonals.

Fig. 3-7 Continuous Bridge

### Continuous

A *continuous bridge* is one built without a stress break over at least three supports as indicated above. Continuous bridges act as both cantilevers and as simple bridges. The compressive force applied to the top chord of a simple bridge tends to cancel the tension force applied to the same chord of a cantilever arm. The same is true of the bottom chord and diagonals. This saves steel or concrete. Stresses in continuous bridges are difficult to calculate. On railroads they have been used essentially only for long-span bridges. A classic example is the C&O

bridge over the Ohio at Sciotoville. It has two 775' (236m) spans. Continuous bridges have always been more-frequently built for highways than for rail. By 1980 they had become common, particularly in the form of beam or plate-girder bridges.

### Arch

An *arch bridge* depends solely on compressive strength for its load-carrying ability. As masonry and timber are both strong in compression, arches came into use early in history. Romans built stone arch bridges up to 142' (43m) span and timber arch bridges up to 170' (52m) span. Cast iron also was used. In 1992 the arch remained the only suitable type for long-span bridges of masonry. The Gladesville Bridge built in 1964 in Australia has a 1000' (305m) span. Steel is eminently suitable for medium- and long-span arch bridge. Steel arch bridges with spans greater than 1,600' (487m) exist.

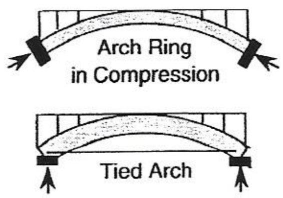



Fig. 3-8 Arch Bridge

The basic compressive member of an arch bridge, the *arch ring*, is shown in Fig. 3-8. In its traditional form (top of figure), the arch ring exerts spreading forces on its supports. This limits its application to locations where suitable foundations can be built. However, as shown at the bottom of the figure, a tension member can connect the ends of the arch to accept the outward thrust. Such a bridge is called a *tied arch* and, by 1992, was enjoying increasing popularity for rail and, especially, for road bridges, including for suspended spans in cantilevers. A tied arch fits the definition of a simple bridge but is always called a tied arch.

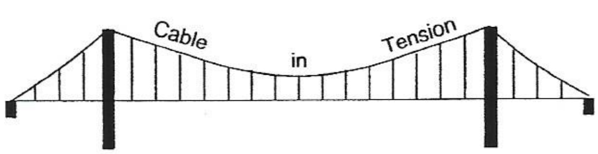



Fig. 3-9 Suspension Bridge

### Suspension

A *suspension bridge* is the exact opposite of an arch. Its load-carrying members are completely in tension. This type of bridge takes full advantage of steel and is capable of spanning thousands of feet, an ability not particularly valuable to a model railroader. Fig. 3-9 illustrates the basic tension member (called cable in the figure) of a modern suspension bridge. This tension member is usually one or more steel cables on each side of the bridge but, on old bridge, might be a chain of eyebars, even conventional chains. In most cases the roadway hangs from the cables by tension members called *hangers* or *suspenders*, usually small cables. The first suspension bridge of the modern type, one with nearly horizontal floor hung from cables, was erected by James Finley in 1801 at Greensburg, PA. Earlier suspension bridges had a floor laid directly on cables as illustrated by the foot bridge of Fig. 2-2, page 7.

A cable is not rigid. It can – and will – sway in winds and under loads. Even for a highway bridge the floor must be rigid. Necessary rigidity is provided by stiffening trusses or girders at the level of the roadway although some older suspension bridges designers attempted to stiffen the floor by trussing the cables. A few suspension bridges, notably of the eyebar type, used the cables as top chords of stiffening trusses. Several bridges of this type are over the Ohio. The Silver Bridge near Gallipolis, made famous by its collapse in 1967 with a loss of 46 lives, was one.

So much steel is required for stiffening that suspension bridges are not economical for short or medium spans except as foot or pipe-line bridges. The 400' (122m) highway span at Massena, NY is one of the shortest modern examples of suspension bridges. Railroads require even greater rigidity than do highways. Thus, the suspension bridge is not used for railroads although often for street car and rapid transit. The Brooklyn Bridge, first of the great suspension bridges, originally carried both street cars and an elevated railway. The San Francisco-Oakland bridge once carried interurban trains. In 1992 the Benjamin Franklin Bridge, Philadelphia, and the Williamsburgh Bridge, New York, carried two tracks of rapid transit. The Manhattan Bridge, New York, carried four subway tracks.

The only major suspension bridge for railroad use in North America was built by John Roebling across the Niagara River (1851-1855) with a span of 812' (247m). Some references cite 820' span. Some traffic was diverted from this bridge when the Michigan Central cantilever was built near the same point in 1883 but the Grand Trunk suspension remained in service for 42 years until replaced by a steel arch. In Brazil and Japan suspension bridges carrying both highway and railroad were constructed. Suspension bridges were designed for railroad service at Poughkeepsie, NY and Quebec but bridges there were actually built as cantilevers.

Since a suspension bridge is inappropriate as a prototype for railroad, and even an extremely short highway bridge would be about 5' (1.5m) in overall length for an N-scale model or 9' (2.7m) for an HO model, this type of bridge has no place on a model railroad. Therefore suspension bridges are not covered in detail.

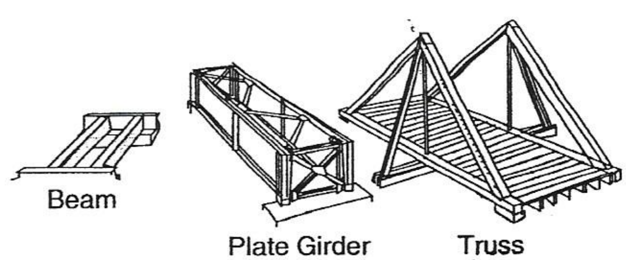



Fig. 3-10 Types of Simple Bridges

### 3.7 BEAM, PLATE GIRDER, TRUSS

When load-carrying members of a simple bridge are timbers, rolled steel shapes (such as I or H beams), concrete beams (reinforced or prestressed), or reinforced concrete slabs, the bridge is called a *beam bridge*. Such bridges are usually short although prestressed concrete beam bridges reach spans of more than 100' (30m). A beam bridge of two timbers is on the left in Fig. 3-10 preceding page. Beam bridges often support floors on other types of bridges.

Plate girders are the work horses of the bridge family. As the name implies, a *plate girder* has as its main member a steel plate set on edge and reinforced by steel angles (and often by other plates). A simple bridge in which the main load-carrying members are plate girders is called a plate-girder bridge. One is shown at the center of Fig. 3-10 on preceding page. By 1992 plate-girder simple bridges were being built in North America for spans exceeding 200' (61m) and in Europe for spans exceeding 800' (244m). Plate girders are also used as main members for cantilevers, arches, and continuous bridges. They are widely applied as floorbeams, stringers, headers on piers, and, sometimes, even as portals.

Girders and beams bear loads by bending. As described in Section 2.2, page 7, trusses use members in tension or compression rather than in bending and thus are far stronger than girders or beams for the same weight of material. A king-post truss is shown on the right in Fig. 3-10. *Truss bridge* usually implies a simple bridge but trusses are used in all other types including as lateral bracing on beam and plate-girder bridges.

### 3.8 TYPES OF TRUSSES

Simple truss bridges are classified by their main-truss type (*main truss* is the truss which carries the load as distinguished from lateral stiffening trusses and the like). Truss classifications may be carried over to other than main trusses when appropriate. For example, on Town covered bridges, the top lateral bracing was usually, perhaps always, a Howe truss.

Some truss types are named after their inventors, e.g., Whipple and Warren, after railroads, e.g., Pennsylvania and Baltimore, or by appearance, e.g., K and Lenticular. Fig. 3-11 diagrams common named trusses. Other rare named types exist, particularly for early timber bridges. As is standard throughout this Handbook for truss diagrams, main-truss members are shown in black, other members in grey, compression members by heavy lines, and tension members by light lines.

Note in Fig. 3-11 sometimes the same truss type bears a different name if the top chord is curved, for example a curved-chord Pratt for reasons not clear has been called a Parker. It is probably more commonly identified as a curved-chord Pratt. Also note Pennsylvania and Baltimore trusses are both subdivided-panel Pratt trusses.

Truss names get confused when applied to deck bridges, particularly when the bottom chord is curved or when panels are subdivided. A case in point is a deck subdivided Pratt with a straight bottom chord. This truss resembles a Baltimore yet the subdiagonals are in tension as in a through Petit. Fortunately, from the standpoint of a modeler, what name to apply in such cases is a matter of no significance.

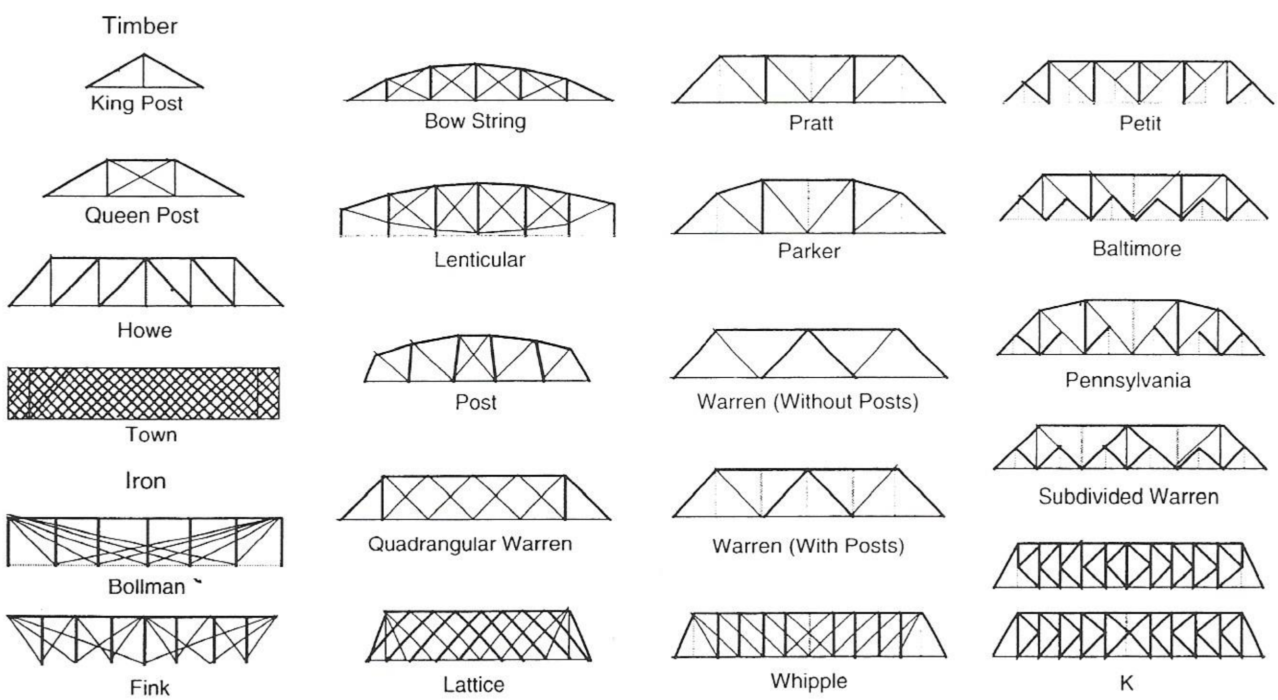



Fig. 3-11 Types of Trusses

# SUSPENSION BRIDGES

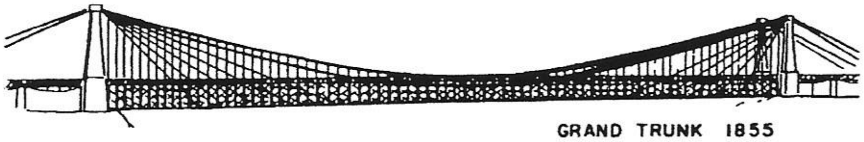



Fig. 14-17 Grand Trunk Niagara Bridge, Rail and Highway

Figs. 14-16 and 17 show the only suspension bridge ever built in North America for railroad traffic, the Grand Trunk Bridge built at Niagara Falls in 1855 by Roebling. It replaced an earlier highway suspension bridge by Charles Ellet. During the 42 years carrying traffic it was extensively modified. In 1880 timber stiffening trusses were replaced with steel. In 1866 the stone towers were replaced by steel towers. It was replaced in 1897 by the double-deck spandrel braced steel arch of Fig. 12-28, page 88.

Although no other suspension bridge in North America served a standard rail line, several carried rapid transit and street car lines, the Brooklyn Bridge even a cable-car line later changed to an electrified elevated line. To the right are details of rail lines, roadways, and sidewalks as originally designed for three major suspension bridges in New York City. Extensive changes have been made on all. In 1992 the Williamsburg Bridge still carried two subway tracks and the Manhattan Bridge four subway tracks. All rails had long been removed from the Brooklyn Bridge.

The San Francisco-Oakland Bridge originally had two interurban tracks on its lower level and highway on both levels. In a classic blunder, politicians forced the rail line off the bridge so they could add more lanes to reduce highway congestion. It turned out that extra cars driven by those previously using the Key System more than filled the added lanes. Traffic congestion was worse than before. This led to constructing a tunnel for a subway line (BART).

Since a suspension bridge carrying a railroad line on a layout would be a gross error, no information is provided on modeling suspension bridges.

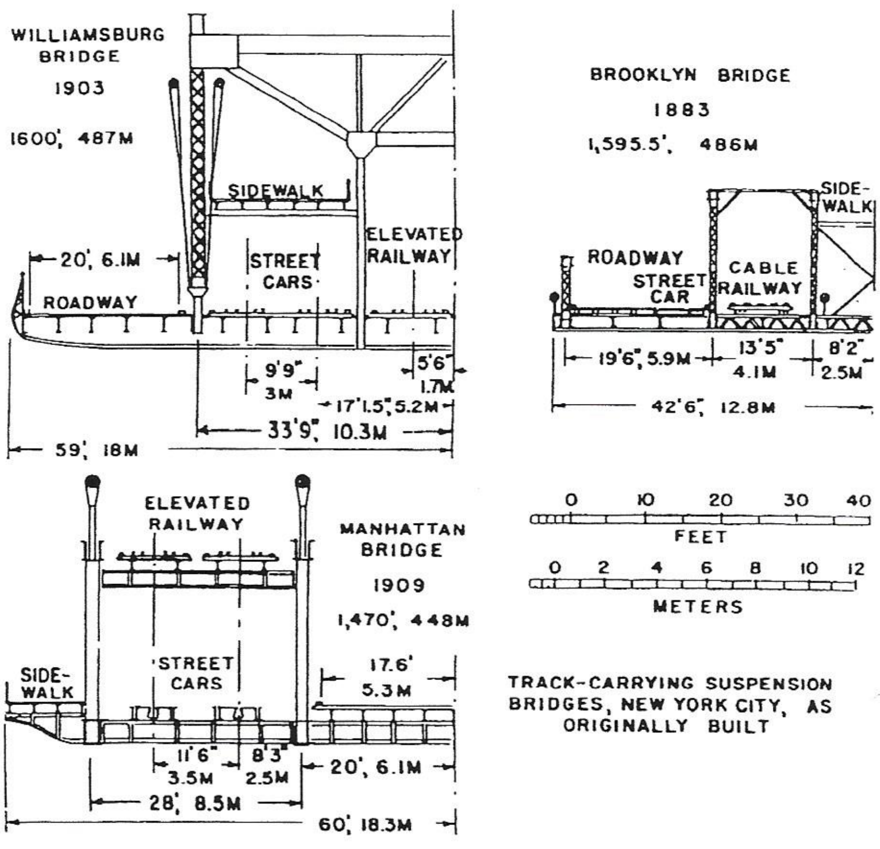



Fig. 14-18 New York City Track-Carrying Suspension Bridges

# A Comedy of Errors

See paragraphs headed by same letter on pages 147 and 149 for detailed explanations.

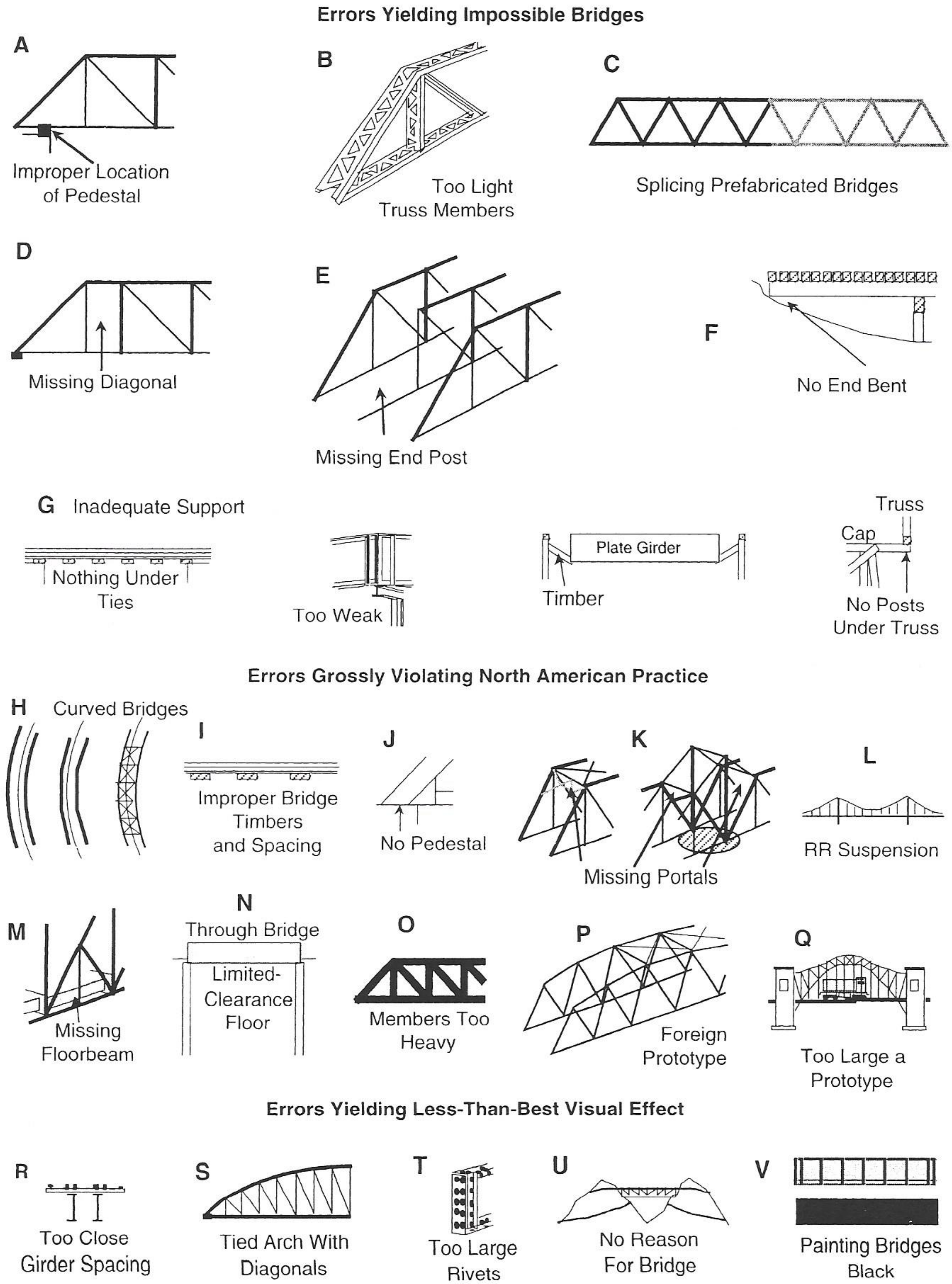



Fig. 16-23 A Comedy of Errors

### H: Curved bridges

This error refers to bridges which curve between abutments or piers, not to a series of straight bridges generally conforming to a curving track. By 1992 curved deck bridges, both steel and concrete, were widely used for modern highways, even in a few cases for recently-built rapid-transit lines. But curved bridges have no place for through bridges or railroad bridges on any layout regardless of conceptual era.

Curving a through plate-girder bridge is probably the most-common gross error for model bridges. Even worse is a curved through bridge made up of a series of straight girders yet one appeared in a cover picture. At least one curved through truss bridge was installed by a club.

### I: Incorrect bridge timbers

A very common error is using standard track ties on an open floor. Particularly bad are ties of prefabricated track or low-profile ties. Bridge timbers are longer, thicker, and more-closely spaced that ties of track laid in ballast (Fig. 7-1, page 29).

### J: Missing pedestals and shoes

Except for beam bridge and masonry arches, also some trestles, bridges do not rest directly on abutments and piers. Rather a shoe is attached to the bridge, that shoe resting on a pedestal on pier or abutment (Section 6.3, page 28).

### K: Missing portals

Almost every through truss bridge with sufficient vertical clearance, particularly railroad bridges, has heavy bracing (portals) between end posts (Fig. 10-8, page 49). Swing bridges have portals also between diagonals leading up from the bearings. European practice omits portals for the most part, one reason why unmodified European commercial model bridges should not be installed on a North American layout. An otherwise fine bridge shown in a cover photograph was marred by a lack of portal, especially since this bridge was high at the hip. A swing bridge at a major club had no portals at the center.

### L: Suspension bridge in RR service

Suspension bridges are suitable only for very long spans and only one was ever in RR service in North America (Section 14.3, page 128). A commercial kit was put out for a while for an extremely short-span HO suspension. As a result layout photos with this bridge showed up in the model press.

### M: Missing intermediate floorbeam

The only reason for subdividing panels on through trusses is to shorten stringer spans by floorbeams at midpanel (Fig. 10-4, page 48). Nevertheless a cover picture clearly showed a subdivided-panel through truss bridge with floorbeams only at main panel points.

### N: Bridge in wrong place

An otherwise excellent bridge put in the wrong place raises questions. Shown is a combination of two common errors: a through bridge when there is more than ample clearance for a deck bridge and a limited-clearance floor with no reason for such expensive, high-maintenance construction. Other examples are expensive, ballasted-floor bridges on spurs (unless scenery clearly indicates this was once a main track) and light, old bridges on a high-speed, heavy duty line.

### O: Too heavy truss members

Not as common as too light truss members but nevertheless a frequent error are members too large. Sometimes chords and end posts are proper but the same size used for posts and diagonals.

### P: Foreign prototype

Perhaps unfortunately, several well-detailed, well-made commercial bridges of foreign prototypes have been available. If installed on a North America set layout, they create the same effect as interspersing British 4-wheel 10-ton freight wagons among double stacks. A very few of these foreign bridges can be modified to resemble North American prototypes but most, like the one illustrated, cannot.

### Q: Too large a prototype

A suitable prototype exists for every bridge needed on any layout. Choosing a bridge type used only for spans greatly in excess of that needed on the model yields a fairyland effect, particularly if the prototype is recognizable. Lionel put out fantasy of Hell Gate. That is no reason for a modeler to do the same.

### Errors yielding less-than-best results

These errors do not lead to impossible bridges. Some even may be justified by "there is a prototype for everything". Nevertheless such errors take away from realism and so are to be avoided.

### R: Insufficient girder or truss spacing

Girders or trusses must be spaced for lateral stiffness. An otherwise excellent model of a long-span deck plate girder bridge at a club was spoiled by close spacing of the girders. For plate girders see Section 9.2, page 38, for trusses see page 50.

### S: Diagonals in tied arch

A tied arch is a questionable prototype for a RR bridge (page 88). But, if used, except for an old timber prototype, diagonals should not be installed. They have no function on a tied arch. An otherwise-excellent tied arch at a club was degraded by having diagonals.

### T: Oversize details

Details so large they can be distinguished from distances when scale details would not be noticed hurt, not help. The oversize rivets shown are best left off.

### U: Unbelievable setting

To make possible significant bridges, many model railroads have tracks at distinctly different levels. If tracks must climb to provide a setting for a high-level bridge, this climb (on one side at least) must not be obvious when viewing the bridge. It makes no sense to spiral up one peak then down another yet this was essentially the case at a large club.

### V: Painting bridges black

Painting model bridges black is probably the most-prevalent realism-destroying error made with respect to bridges. The effect of the scale hundreds of feet of air between the viewer and the model must be painted in (Section 16.10, page 146). Unfortunately the drawing hardly shows the difference between a blue-gray bridge and a black bridge. Compare a color photograph of a "black" steam locomotive with a color photograph of a model painted black.