PDHonline Course C484 (3 PDH)

FHWA Bridge Inspector's Manual Sections 8.6 - Steel Superstructures

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Inspection and Evaluation of Common Steel Superstructures

Topic 8.6 Steel Trusses

8.6.1 Introduction

Metal truss bridges have been built since the early 1800's. They can be thought of as a deep girder with the web cut out. They are also the only bridge structure made up of triangles. The original metal trusses were made of wrought iron, then cast iron, then steel. When trusses were first being built of metal, material costs were very high and labor costs were low. Because trusses were made up of many short pieces, it was cost effective to build the members in the shop and assemble them at the site. Today the higher costs of labor and the lower costs of material have limited the use of trusses to major river crossings.

8.6.2 Design Characteristics

The superstructure of a truss bridge usually consists of two parallel trusses (see Figure 8.6.2). The trusses are the main load-carrying members on the bridge. There are three types of trusses, grouped according to their position relative to the bridge deck (see Figure 8.6.2).

Figure 8.6.1 Single Span Truss

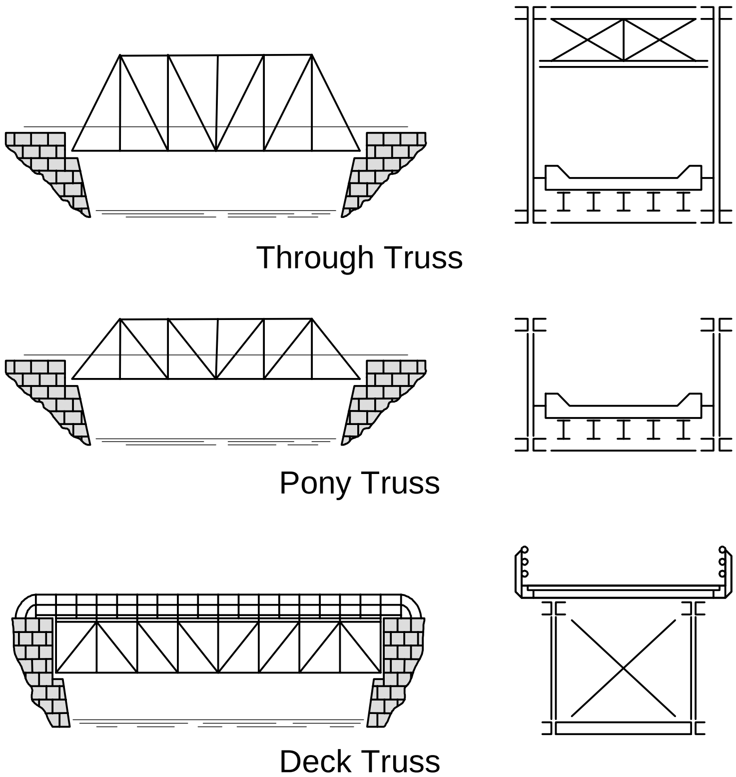

Figure 8.6.2 Through-Pony-Deck Truss Comparisons

Through Truss

On a through truss, the roadway is placed between the main members (see Figure 8.6.3). Through trusses are constructed when underclearance is limited.

Figure 8.6.3 Through Truss

Pony Truss

A pony or "half-through" truss (see Figure 8.6.4) has no overhead bracing members connecting the two trusses. The vertical height of the pony truss is much less than the height of a through truss. Today, pony trusses are seldom built, having been replaced by the multi-beam bridge.

Figure 8.6.4 Pony Truss

Deck Truss

On a deck truss (see Figure 8.6.5), the roadway is placed on top of the main members. Deck trusses have unlimited horizontal clearances and can readily be widened. For these reasons, they are preferred over through trusses when under-clearance is not a concern.

Figure 8.6.5 Deck Truss

Other Truss Applications

Trusses are generally considered to be main members. However, they are also used as floor systems in arches and as stiffening trusses in suspension bridges and arch bridges (see Figures 8.6.6 and 8.6.7). Trusses are also commonly used for movable bridge spans because they are lightweight and have higher overall stiffness (see Figure 8.6.8). Even towers are sometimes braced with web members, as a truss.

Figure 8.6.6 Suspension Bridge with Stiffening Truss

Figure 8.6.7 Arch Bridge with Stiffening Truss

Figure 8.6.8 Vertical Lift Bridge

Design Geometry

Bridge engineers have used a variety of arrangements in the design of trusses. Many of the designs were patented by and named after their inventor. One characteristic that all bridge trusses have in common is that the arrangement of the truss members forms triangles (see Figure 8.6.9).

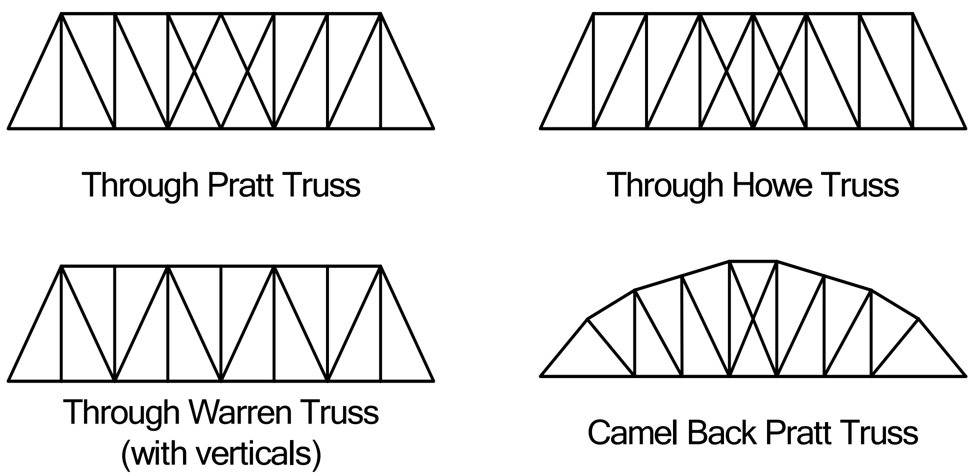

Figure 8.6.9 Various Truss Designs

Trusses have been constructed for short to very long spans, using simple, multiple and continuous designs (see Figure 8.6.10 to Figure 8.6.14). Cantilevered trusses often incorporate a "suspended" or "drop-in" span between two cantilever spans (see Figures 8.6.15, 8.6.16 and 8.6.17). The suspended span behaves as a simple span and is connected to cantilevered spans with pins or pin and hanger connections. The back span on a cantilever truss is called the anchor span.

Figure 8.6.10 Single Span Pony Truss

Figure 8.6.11 Single Span Through Truss

Figure 8.6.12 Multiple Span Pony Truss

Figure 8.6.13 Multiple Span Through Truss

Figure 8.6.14 Continuous Through Truss

Figure 8.6.15 Cantilever Through Truss

Figure 8.6.16 Cantilever Deck Truss

Figure 8.6.17 Cantilever Through Truss

As stated earlier, a truss can be thought of as a very deep girder with portions of the web cut out. Truss members are divided into three groups: (see Figure 8.6.18)

- Top or upper chord members
- Bottom or lower chord members
- Web members (diagonals and verticals)

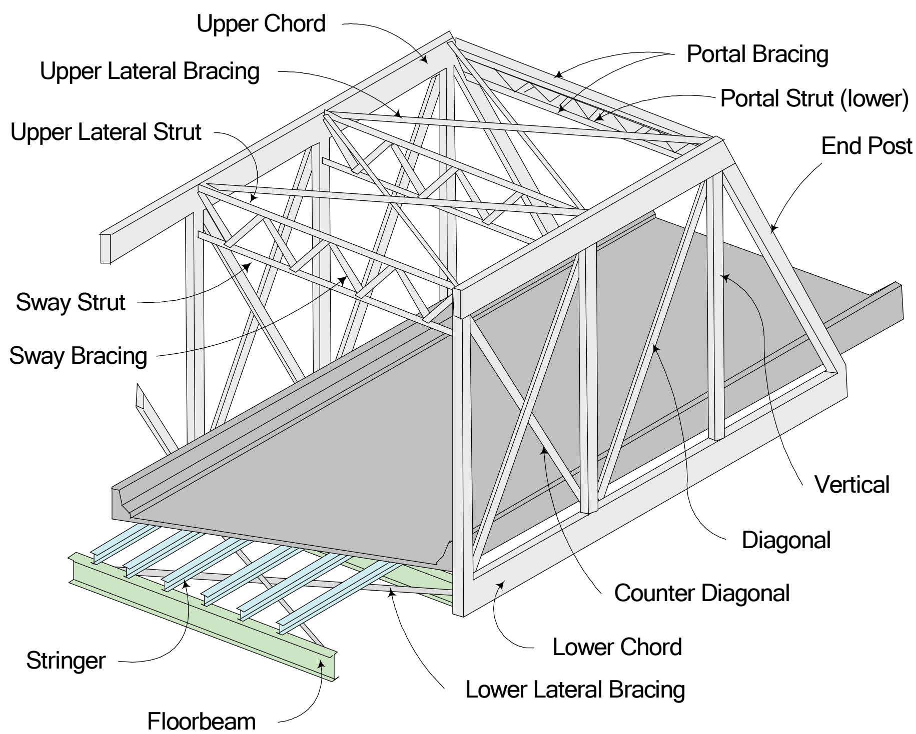

Figure 8.6.18 Truss Members and Elements

Truss members are fabricated from eyebars, rolled shapes, and built-up members (see Figure 8.6.19). Built-up sections are desirable for members that carry compression because they can be configured to resist buckling (see Figure 8.6.20). Structural tubing and fabricated box sections are popular for modern trusses because they provide a "clean" look and are easier to maintain.

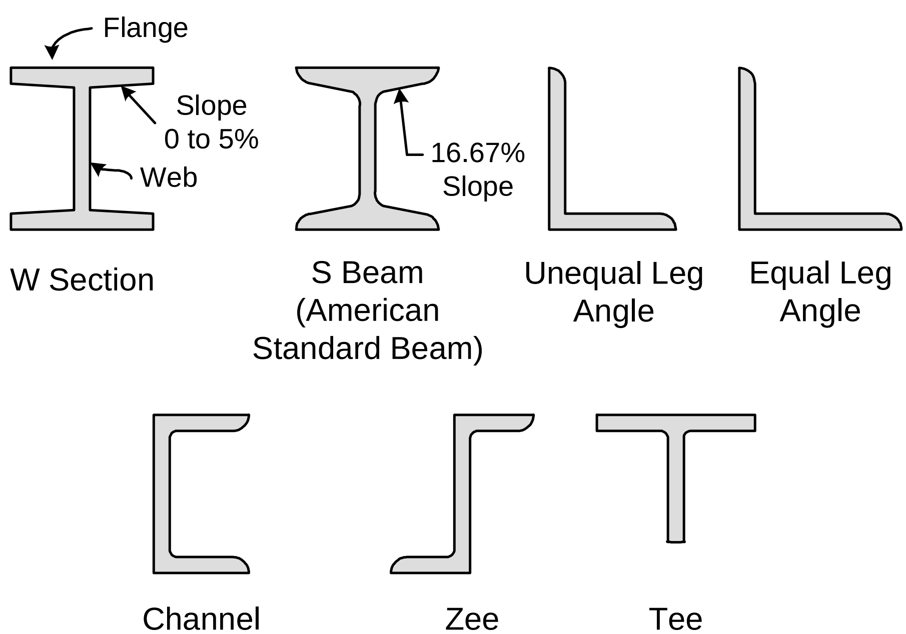

Figure 8.6.19 Rolled Steel Shapes

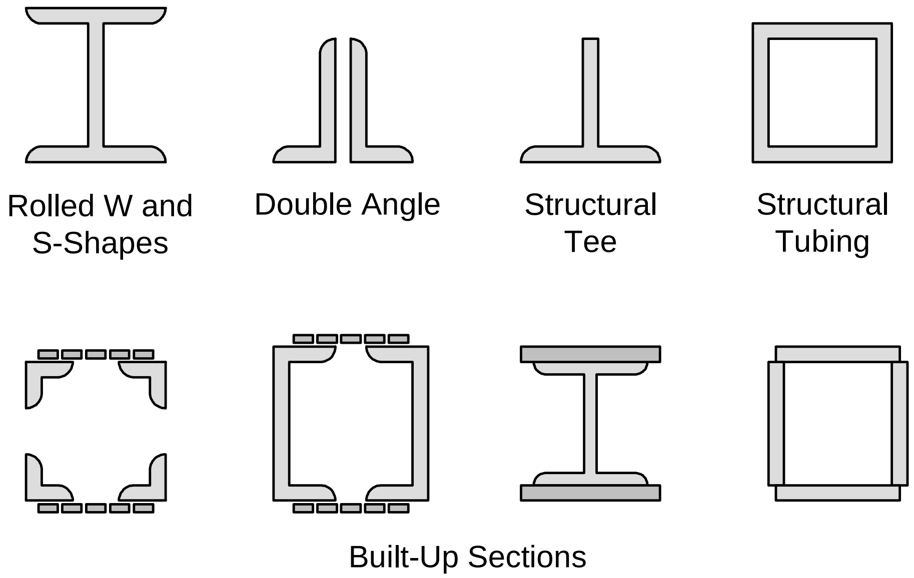

Figure 8.6.20 Typical Compression Members

Chord Members

Trusses, like beams and girders, support their loads by resisting bending. As the truss bends, the chord members behave like flanges of a beam and carry axial tension or compression forces (see Figure 8.6.21). On a simple span truss, the bottom chord is always in tension, while the top chord is always in compression. The diagonally sloped end post is a chord member. Top chords are also known as upper chords (U), and bottom chords are referred to as lower chords (L) (see Figure 8.6.22).

As truss bridge spans increase, cantilever and continuous designs are used, creating negative moment regions. Therefore, over an intermediate support, the top chord of a truss, like the top flange on a girder, is in tension (see Figure 8.6.21). The negative moment regions produce very large moments. It is common to find varying depth trusses on large complex structures, with the greatest depth at the supports where the moments are the largest (see Figure 8.6.23).

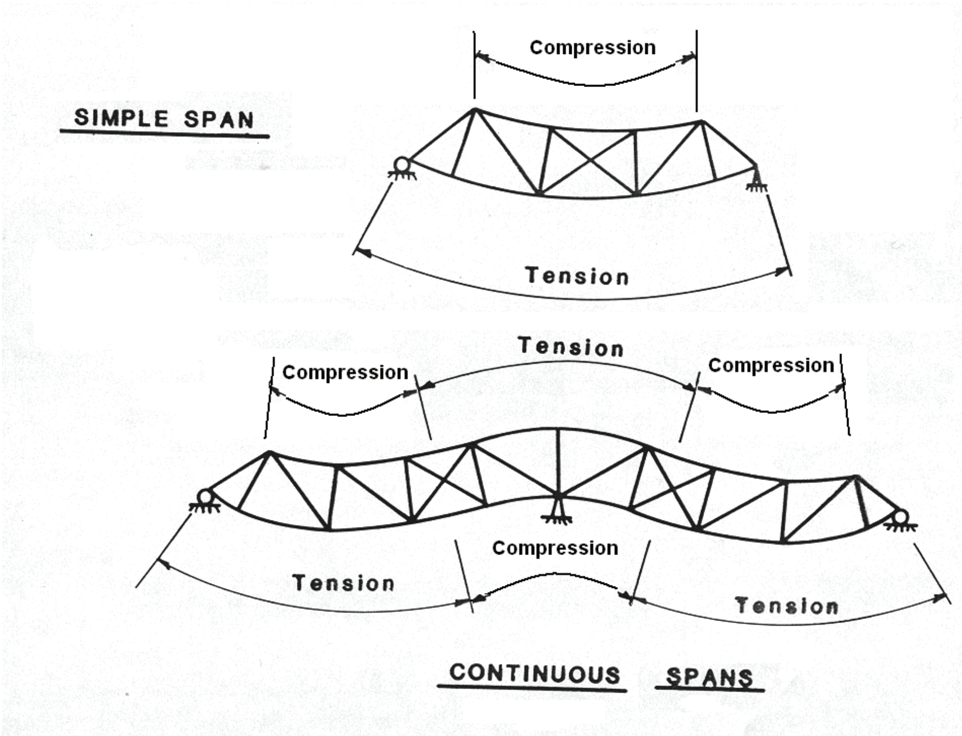

Figure 8.6.21 Axial Loads in Chord Members

Figure 8.6.22 Single Span Through Truss – General Elevation View

Figure 8.6.23 Continuous Through Truss

Web Members

The web members are typically connected to the top chord at one end and to the bottom chord at the other end. All trusses will have diagonal web members, and most trusses will also have vertical web members. Depending on the truss design, a web member may be in axial tension or compression, or may be subjected to force reversal and carry either type of stress for different loading conditions.

Diagonals

For simple spans, an easy method to determine when a truss diagonal is in tension or compression is to use the "imaginary cable - imaginary arch" rule (see Figure 8.6.24). Diagonals that are symmetrical about midspan and point upward toward midspan, like an arch, are in compression. Diagonals that are symmetrical about midspan and point downward toward midspan, like a cable, are in tension. This rule applies only to simple span trusses.

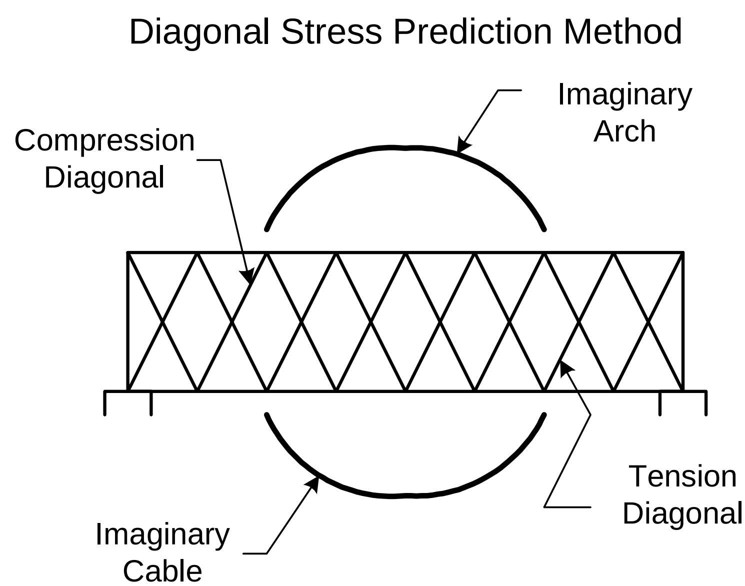

Figure 8.6.24 “Imaginary Cable – Imaginary Arch”

On older simple span trusses, the section of the member can be used to determine which members are in tension and which are in compression. The design of a 7.6 m (25-foot) tension member, subjected to a load, will require a much smaller member (cross section) than a 7.6 m (25-foot) compression member subjected to the same magnitude. On older pin-connected trusses, compression members are always the larger built-up members as compared to the tension members, which were often eyebar members. The Pratt truss, with all its diagonals in tension, quickly replaced the Howe truss, whose diagonals are in compression. The Pratt truss is lighter and therefore easier and less expensive to erect.

For trusses, counters are tension-resisting diagonals installed in the same panel in which the force reversal occurs. They are oriented opposite from each other, creating an "X" pattern. Counters are stressed only under live loads. On older bridges on which counters are bar shaped, they should be capable of being moved by hand during an inspection. Counters are found on many older trusses but rarely on newer trusses.

With more complex truss designs (continuous and cantilever), the diagonal web members must be capable of withstanding both tension and compression. This is known as force reversal, and it is one of the reasons that, on many modern truss bridges, the appearance of the tension and compression diagonals is almost identical.

As trusses become longer and, more importantly, as live loads become larger, the forces in some diagonals on a bridge continually change from tension to compression and back again. This situation occurs near the inflection points of continuous trusses. The inflection points in a continuous truss are similar to a continuous girder. The inflection points are located at the transition between positive and negative moments. Adjacent to the inflection joints, an unsymmetrical live load can cause large enough forces to overcome the symmetric dead load forces in the diagonals.

See Figure 8.6.18 of a sample truss schematic showing diagonals in a simply supported truss.

Verticals

There is also an easy method to determine when a vertical member is in tension or compression for a simply supported truss. Verticals that have one diagonal at each end are opposite to the force of the diagonals (see Figure 8.6.25). Verticals that have two diagonals at the same end are similar to the force in the diagonal closest to midspan (see Figure 8.6.26). Verticals that have counters on both ends are in compression (see Figure 8.6.27).

A vertical compression member is commonly called a post or column, while a vertical tension member is sometimes called a hanger.

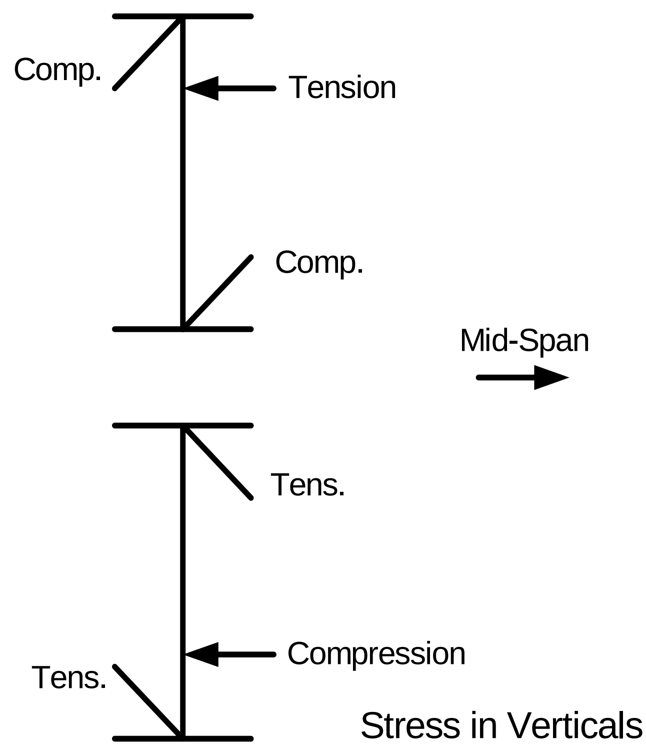

Figure 8.6.25 Vertical Member Stress Prediction Method

See Figure 8.6.18 of a sample truss schematic showing verticals in a simply supported truss.

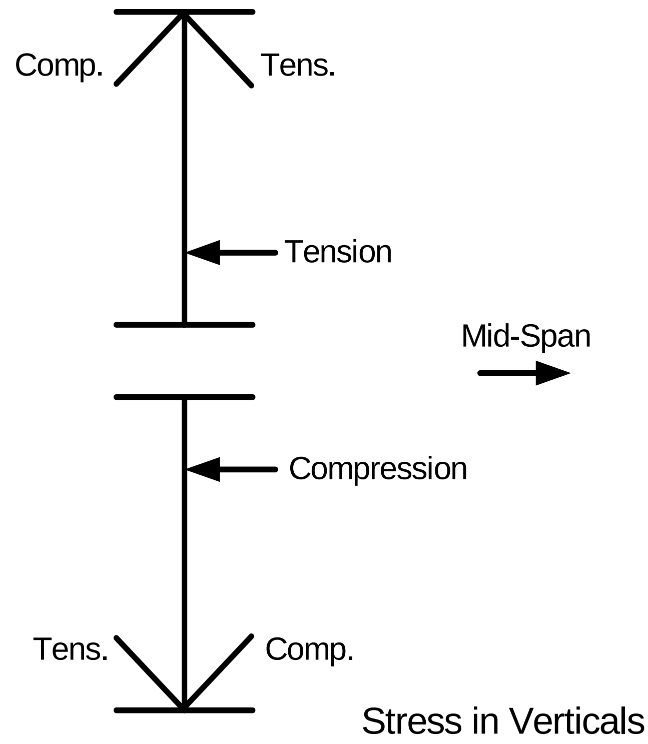

Figure 8.6.26 Vertical Member Stress Prediction Method

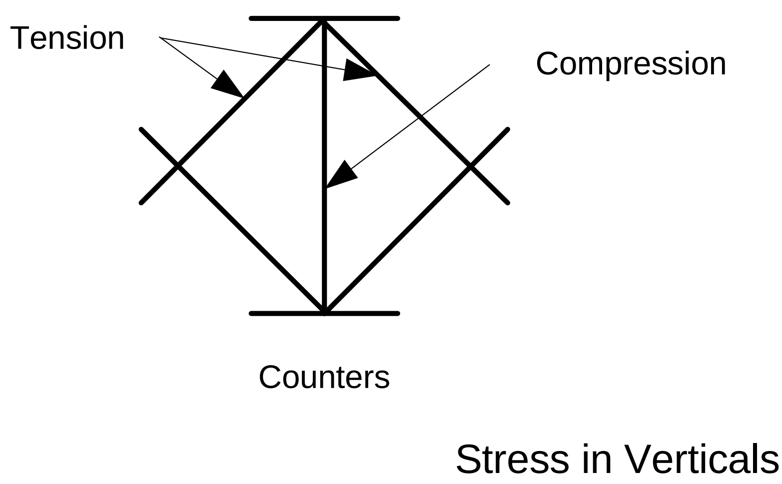

Figure 8.6.27 Vertical Member Stress Prediction Method

Panel Points and Panels

A panel point is the location where the truss members are connected together. Modern truss bridges are generally designed so that all members have approximately the same depth, thereby minimizing the need for shims and filler plates at the connections. This is often accomplished by varying the plate thicknesses of built-up members or using several grades of steel to meet varying stress conditions.

The connections are typically made using gusset plates and are made by riveting, bolting, welding or a combination of these methods. Connections using both rivets and bolts were popular on bridges constructed in the late 1950's and early 1960's, as high strength bolts began to replace rivets. Rivets were used during shop fabrication while bolts were used to complete the connection in the field (see Figure 8.6.28). Old trusses used pins at panel point connections (see Figure 8.6.29). Truss members may also be spliced, sometimes at locations other than the panel points.

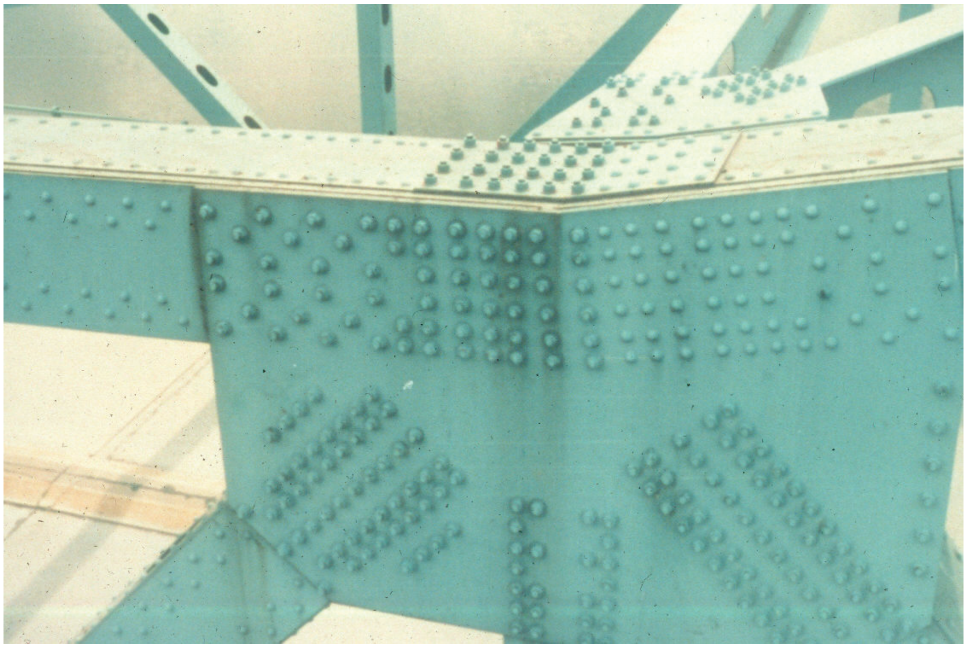

Figure 8.6.28 Truss Panel Point using Shop Rivets and Field Bolts

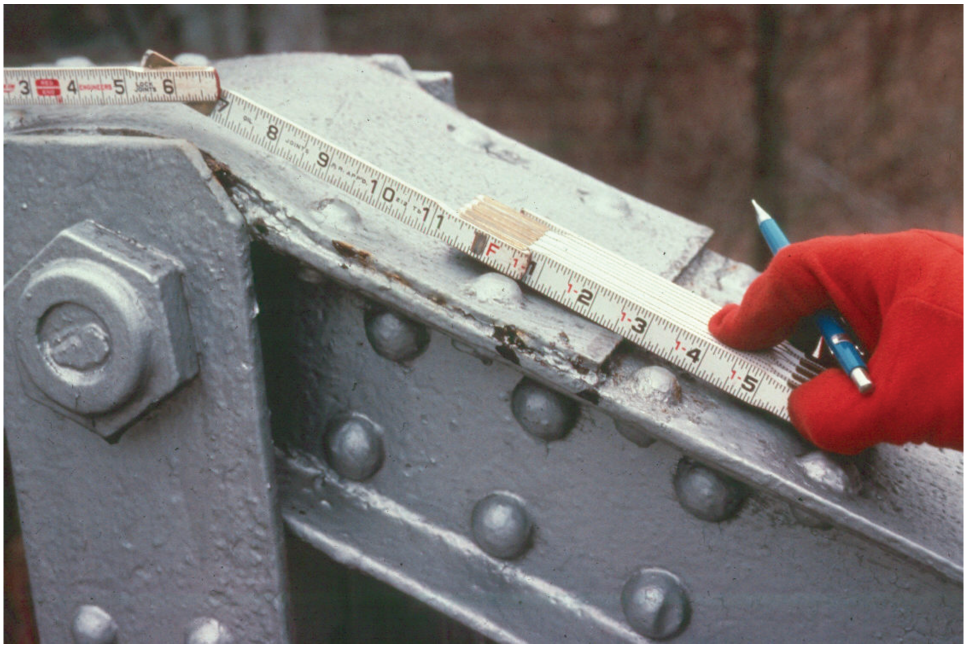

Figure 8.6.29 Pin Connected Truss

Either the letter U, for upper chord, or the letter L, for lower chord, or the letter M, for middle chord designates a panel point. Additionally, the panel points are numbered from bearing to bearing, beginning with 0 (zero). Most trusses begin with panel point L_0. Some deck trusses may begin with U_0. Upper and lower panel points of the same number are always in a vertical line with each other (e.g., U_7 is directly above L_7) (see Figures 8.6.30 and 8.6.31).

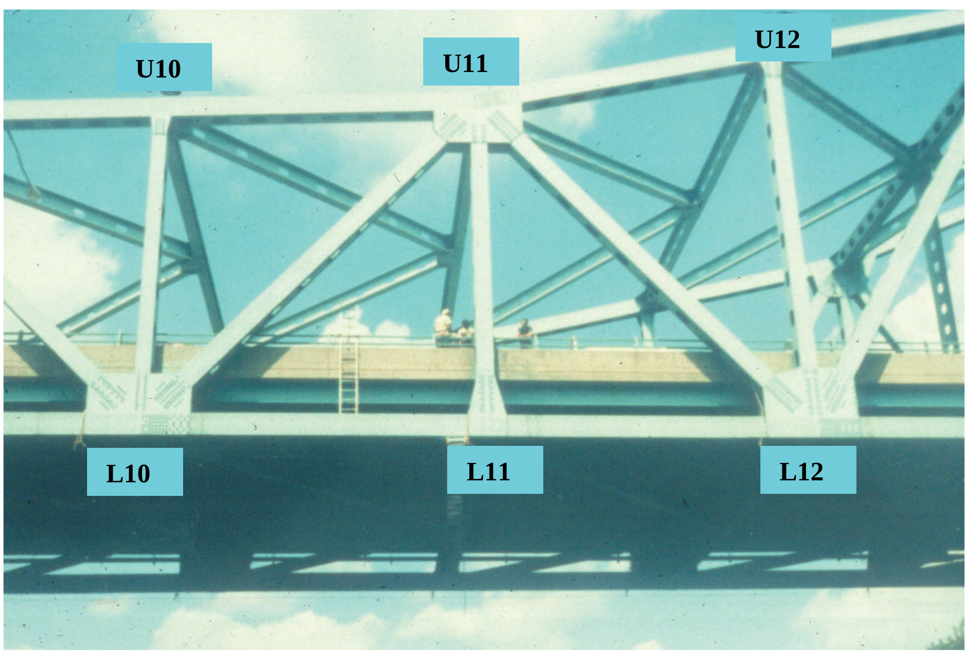

Figure 8.6.30 Truss Panel Point Numbering System

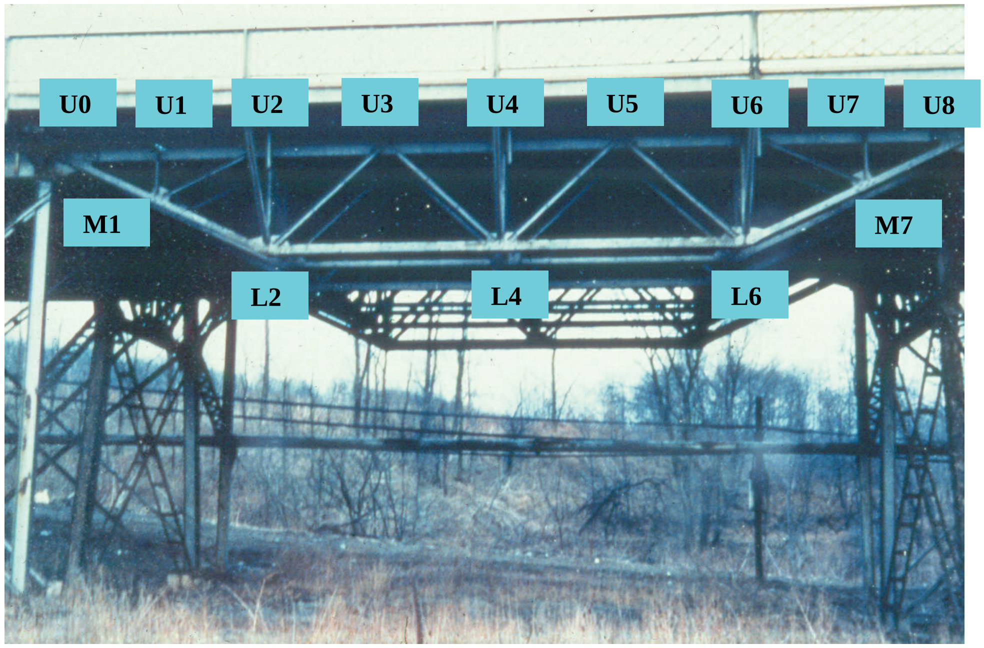

Figure 8.6.31 Deck Truss

A panel is the space, or distance, between panel points. Truss panels are typically 6 to 7.5m (20 to 25 feet) long and range 5 to 10 m (16 to 32 feet) deep. The panel length is a design compromise between cost and weight, with the longer panels requiring heavier floor systems.

As truss spans became longer, they also had to become deeper, increasing the distance between the upper and lower chords. They also required longer panels. As the panels became longer, the diagonals became even longer and the slope became flatter. The optimum angle between the diagonal and the horizontal is 45° to 55°.

To obtain a lighter floor system, designers subdivided the panel. The midpoint of each diagonal was braced with a downwardly inclined sub-diagonal in the opposite direction and with a sub-vertical down to the lower chord. Subpanel points are designated with the letter M. Sometimes, the "half" number of the adjoining panels is used for these diagonal midpoints (e.g., $M_{7\ 1/2}$). The method of subdividing the truss created a secondary truss system within the main truss to support additional floorbeams. Baltimore and Pennsylvania trusses, patented in the 1870's, use this method. The K truss, a more recent design, accomplishes the same purpose (see Figure 8.6.32).

Figure 8.6.32 A Pennsylvania Truss, a Subdivided Pratt Truss with a Camel Back Top Chord

Floor System Arrangement

Most trusses have a floor system arrangement consisting of stringers and floorbeams similar to the two girder systems (see Figure 8.6.33). Floor systems support the deck and are supported by the trusses. Floor systems (floorbeams and stringers) are subjected to bending, shear and out-of-plane bending stresses. Trusses have floorbeams at each panel and sub panel point along the truss. Floorbeams should be designated by their panel point number. Some floor systems only contain floorbeams and no stringers (see Figure 8.6.34).

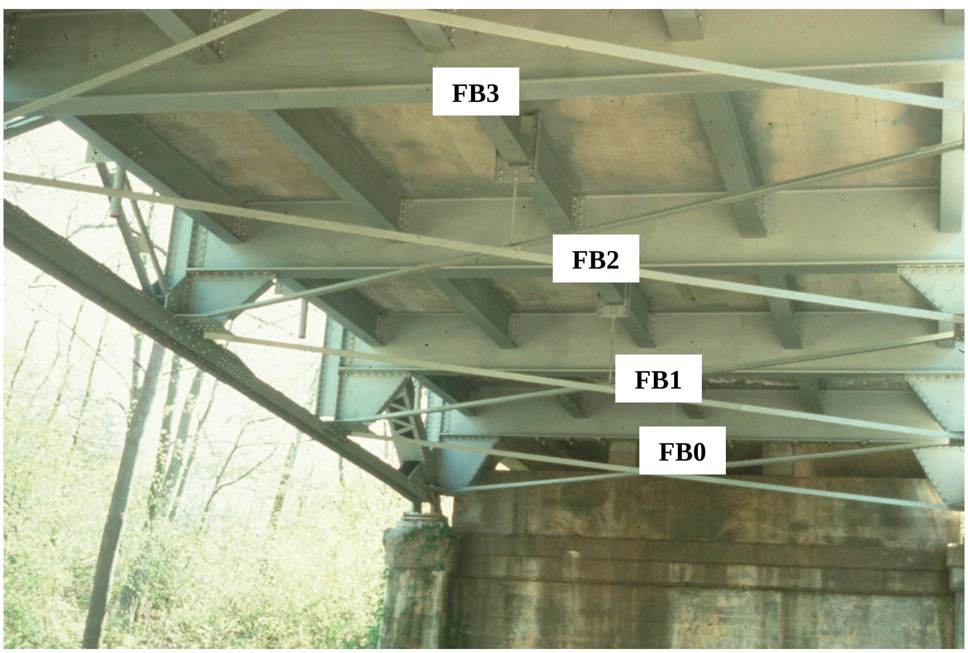

Figure 8.6.33 Floorbeam Stringer Floor System

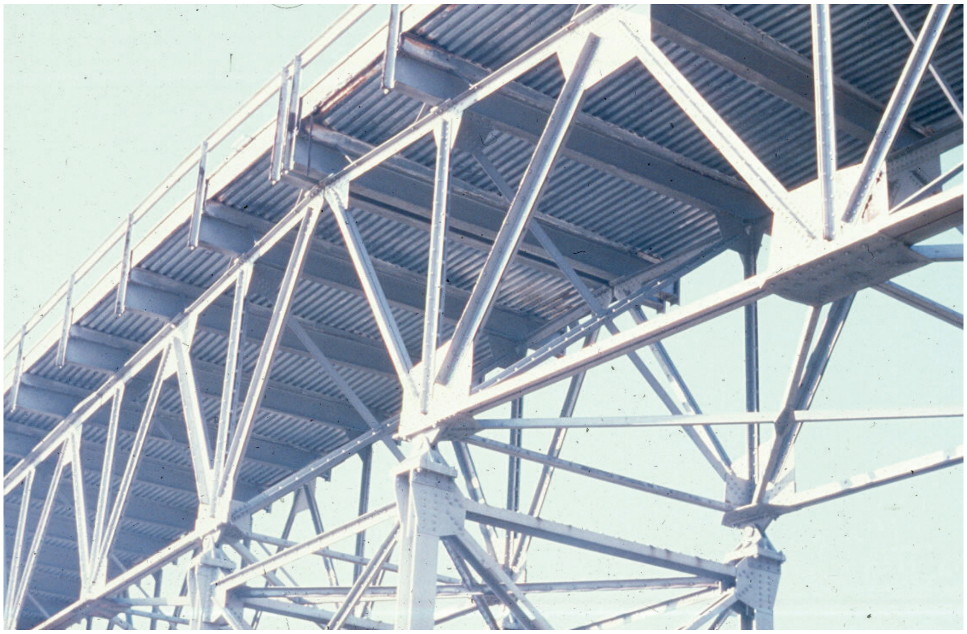

Figure 8.6.34 Floorbeam Floor System

See Figure 8.6.18 of a sample truss schematic showing a truss floor system consisting of floorbeams and stringers.

Lateral Bracing

Upper/lower lateral bracing is in a horizontal plane and functions to keep the two trusses longitudinally in line with each other. Most trusses have upper and lower chord lateral bracing, with the exception of pony trusses, which do not have upper lateral bracing. The bracing is typically constructed from built-up and rolled shapes and is connected diagonally to the chords and floorbeams at each panel point using gusset plates (see Figure 8.6.18, Figure 8.6.35, Figure 8.6.36 and Figure 8.6.37). Lateral bracing is subjected to tensile stresses caused by longitudinal or transverse horizontal loadings.

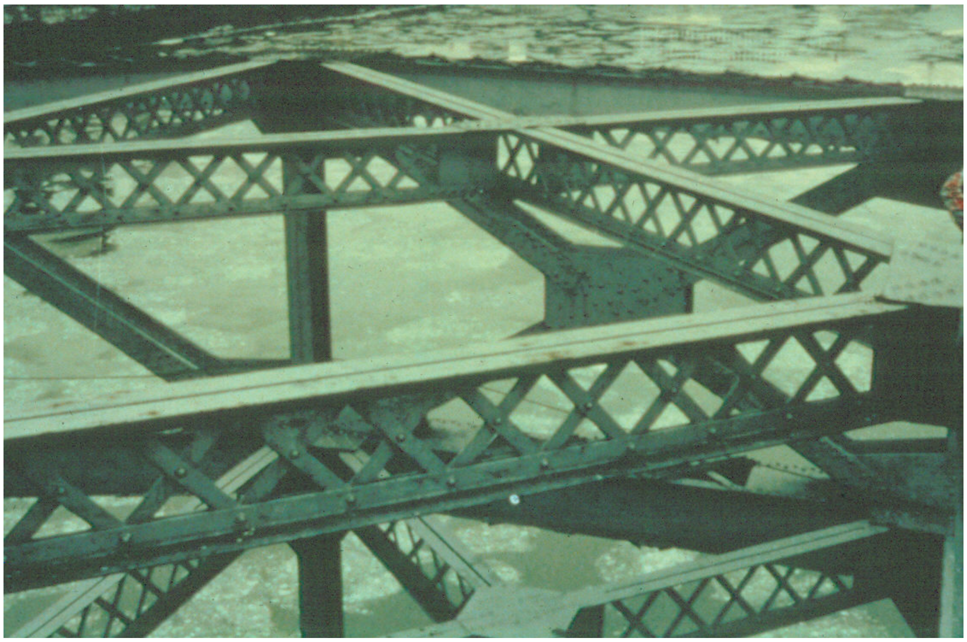

Figure 8.6.35 Upper Lateral Bracing

Figure 8.6.36 Lower Lateral Bracing

Figure 8.6.37 Lateral Bracing Gusset Plate and Lateral Bracing

Sway/Portal Bracing

Sway bracing is in a vertical plane and functions to keep the two trusses parallel. The bracing is typically constructed from built-up or rolled shapes. The sway bracing at the end diagonal is called portal bracing and is much heavier than the other sway bracing. Sway bracing on old through trusses often limits the vertical clearance, and it therefore often suffers collision damage. Large pony trusses also have sway bracing in the form of a transverse diagonal brace from top chord to bottom chord (see Figures 8.6.18, 8.6.38, 8.6.39, 8.6.40 and 8.6.41). Sway and portal bracing are subjected to compressive stress caused by transverse, horizontal loads. They also help resist buckling of compression chords.

Figure 8.6.38 Sway Bracing

Figure 8.6.39 Sway Bracing

Figure 8.6.40 Portal Bracing

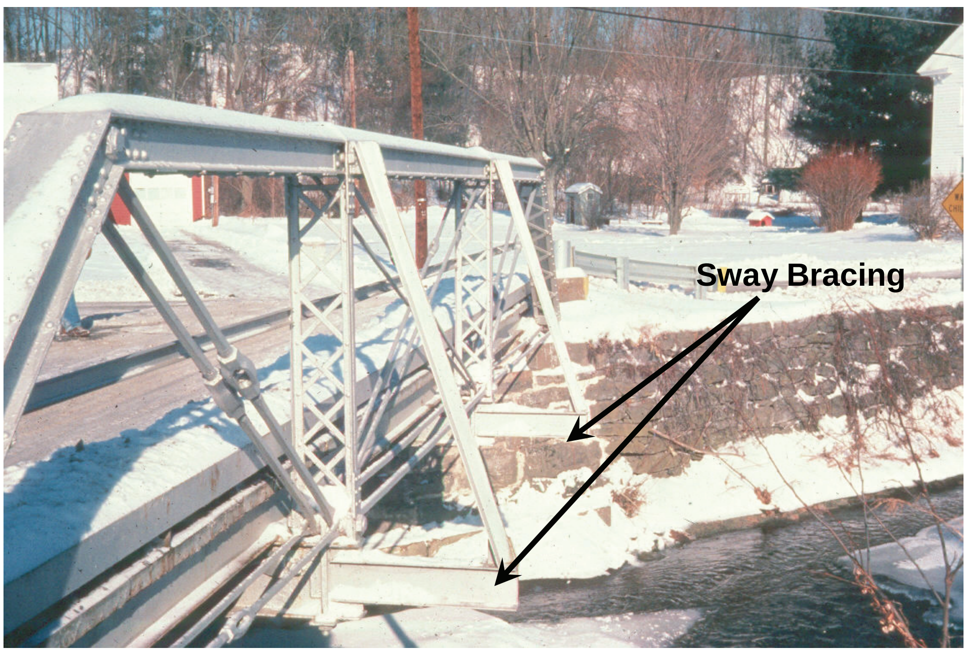

Figure 8.6.41 Pony Truss "Sway Bracing"

Primary Members and Secondary Members

Primary members carry dead load and primary live load and consist of:

- Trusses (chords and web members)
- Floorbeams
- Stringers

Secondary members resist horizontal and longitudinal loads and consist of:

- Portal bracing

- Lateral bracing
- Sway bracing

Secondary members do not contribute to the primary live load-carrying capacity of the bridge. Rather, they function only to keep the primary members properly aligned and resist secondary live loads.

Primary and secondary members are shown on Figure 8.6.18.

8.6.3 Overview of Common Defects

Common defects that occur on steel truss bridges are:

- Paint failures
- Corrosion
- Fatigue cracking
- Collision damage
- Overloads
- Heat damage

See to Topic 2.3 for a detailed presentation of the properties of steel, types and causes of steel deterioration, and the examination of steel. Refer to Topic 8.1 for Fatigue and Fracture in Steel Bridges.

8.6.4 Inspection Procedures and Locations

Inspection procedures to determine other causes of steel deterioration are discussed in detail in Topic 2.3.8.

Procedures

Visual

The inspection of steel bridge members for defects is primarily a visual activity.

Most defects in steel bridges are first detected by visual inspection. In order for this to occur, a hands-on inspection, or inspection where the inspector is close enough to touch the area being inspected, is required. More exact visual observations can also be employed using a magnifying unit after cleaning the paint from the suspect area.

Physical

Removal of paint can be done using a wire brush, grinding, or sand blasting, depending on the size and location of the suspected defect. The use of degreasing spray before and after removal of the paint may help in revealing the defect.

When section loss occurs, use a wire brush, grinder or hammer to remove loose or flaked steel. After the flaked steel is removed, measure the remaining section and compare it to a similar section with no section loss.

The usual and most reliable sign of fatigue cracks is the oxide or rust stains that develop after the paint film has cracked. Experience has shown that cracks have generally propagated to a depth between one-fourth and one-half the plate thickness before the paint film is broken, permitting the oxide to form. This occurs because the paint is more flexible than the underlying steel.

Smaller cracks are not likely to be detected visually unless the paint, mill scale, and dirt are removed by carefully cleaning the suspect area. If the confirmation of a possible crack is to be conducted by another person, it is advisable not to disturb the suspected crack area so that re-examination of the actual conditions can be made.

Once the presence of a crack has been verified, the inspector should examine all other similar locations and details.

Advanced Inspection Techniques

Several advanced techniques are available for steel inspection. Nondestructive methods, described in Topic 13.3.2, include:

- Acoustic emissions testing
- Computer programs
- Computer tomography
- Corrosion sensors
- Smart paint 1
- Smart paint 2
- Dye penetrant
- Magnetic particle
- Radiographic testing
- Robotic inspection
- Ultrasonic testing
- Eddy current

Other methods, described in Topic 13.3.3, include:

- Brinell hardness test
- Charpy impact test
- Chemical analysis
- Tensile strength test

Locations

A truss consists of members, which are primarily under axial loading only. Furthermore, many truss members are designed for force reversal. If a review of the bridge's design drawings indicates that a member is subjected to tension and compression, it should be inspected as a tension member subjected to cracking/elongation or as a compression member subjected to buckling (see Figure 8.6.42).

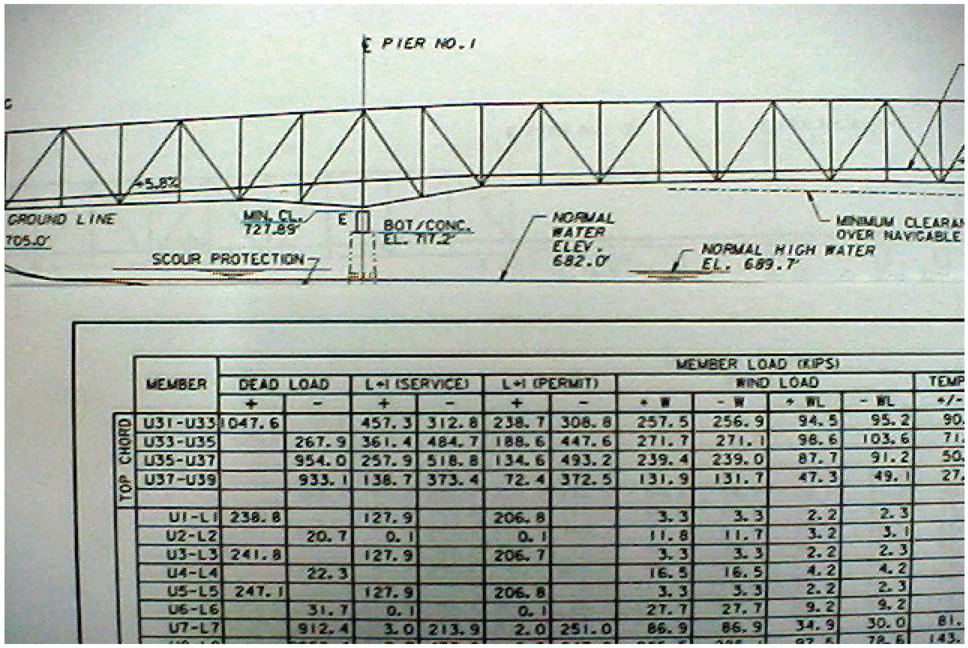

Figure 8.6.42 Truss Design Drawings: Member Load Table

Bearing Areas

Examine the web areas of the stringers, floorbeams and truss members over their supports for cracks, section loss and buckling. If bearing stiffeners, jacking stiffeners and diaphragms are present at the supports inspect them for cracks, section loss and buckling also.

Examine the bearings at each support for corrosion. Check the alignment of each bearing and note any movement. Report any build up of debris surrounding the bearings that may limit the bearing from functioning properly. Check for any bearings that are frozen due to heavy corrosion. See Topic 9.1 for a detailed presentation on the inspection of bearings.

Tension Members

For truss members subjected to tensile loads, special attention should be given to the following locations:

- Check for section loss (corrosion) and cracks (see Figure 8.6.43).
- For box-shaped chord members, check inside for debris and corrosion, cracks or section loss (see Figure 8.6.44).
- Examine eyebar heads for cracks in the eyes and in the forge zone (see Figure 8.6.45).
- Check loop rods for cracking where the loop is formed (see Figure 8.6.46).
- Where multiple eyebars make one member, check to see if the tension is evenly distributed - each eyebar element should be perfectly parallel and evenly spaced to adjacent elements (see Figure 8.6.47).
- Check eyebars or loop rods where attachments are welded to them,

especially if such attachments connect the eyebars together (see Figure 8.6.48).

- Determine whether the spacers on the pins are holding the eyebars and loop rods in their proper positions.
- Look for repairs, especially welded repairs, if they have been applied to steel tension members. Base metal cracks can easily develop at these locations (see Figure 8.6.48).
- Check the alignment of the members, make sure they are straight and not bowed - this could be a sign of pier movement, collision damage or unintentional force reversal (see Figure 8.6.49).
- A member may not be acting as designed such as a buckled bottom chord member in s simply supported truss (see Figure 8.6.5). Try to determine the cause of different loading and look at adjacent members. They may be overstressed.
- Observe the counters under live load for excessive wear and abnormal rubbing where the counters cross.

Check the condition of threaded members such as counters at turnbuckles. They should not be over-tightened or under-tightened. Pulling transversely by hand can check the relative tension. The counter should move slightly. If a problem is found, the inspector should not adjust the turnbuckle, but notify the bridge engineer.

Figure 8.6.43 Bottom Chord

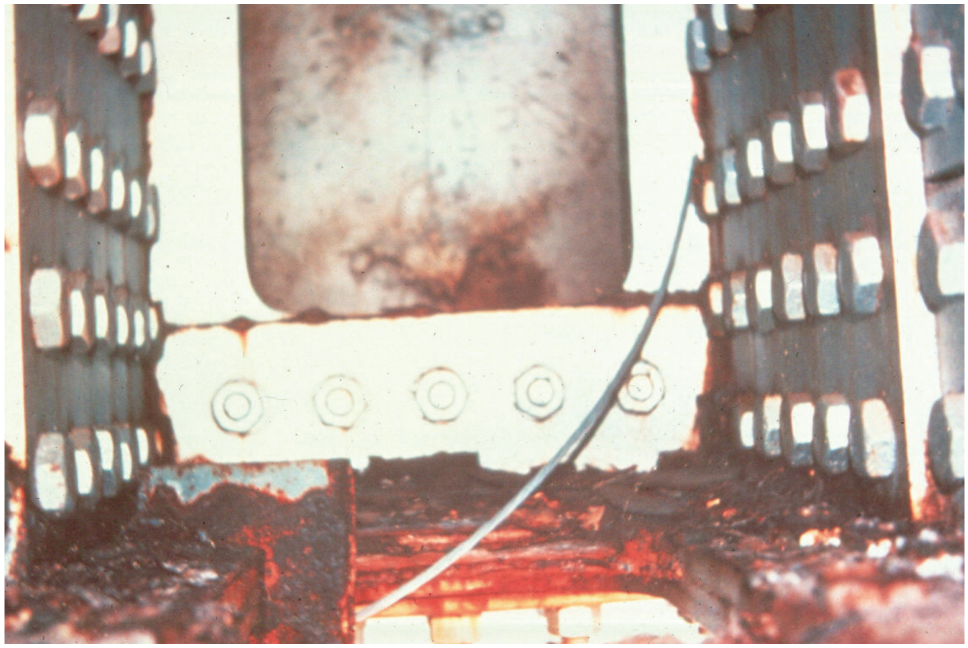

Figure 8.6.44 Inside of Box chord Member

Figure 8.6.45 Cracked Forge Zone on an Eyebar

Figure 8.6.46 Cracked Forge Zone on a Loop Rod

Figure 8.6.47 Bottom Chord

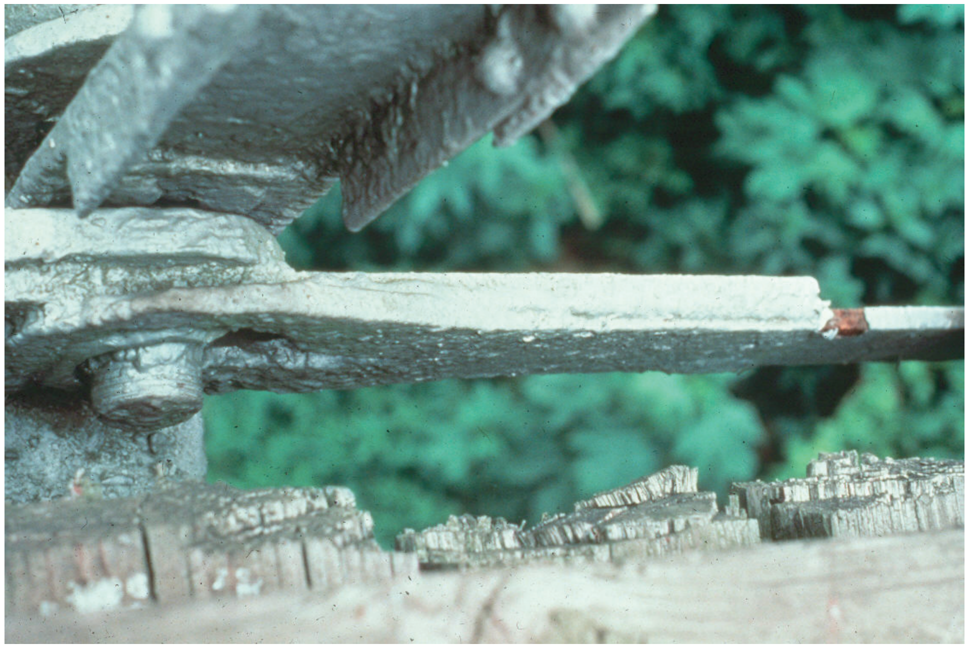

Figure 8.6.48 Welded Repair to Loop Rod

Figure 8.6.49 Bowed Bottom Chord Eyebar Member

Figure 8.6.50 Buckled Lowered Chord Member L0L1, due to Abutment Movement

On trusses with cantilevered and suspended spans, the pin-connected joints that permit expansion are susceptible to freezing or fixity of the pinned joints. This can result in undesirable stresses in the structure - changing axial loaded members to bending members. Carefully inspect the pins at such connections for corrosion and fixity.

Compression Members

For truss members subjected to compressive loads, special attention should be given to the following locations:

- End posts and web members, which are vulnerable to collision damage from passing vehicles. Buckled, torn, or misaligned members may severely reduce the load carrying capacity of the member (see Figure 8.6.51).
- Check for local buckling, an indication of overstress (see Figure 8.6.52).
- Wrinkles or waves in the flanges, webs or cover plate are common forms of buckling.

Figure 8.6.51 Collision Damage to Vertical Member

Figure 8.6.52 Buckled End Post and Temporary Supports

Floor System

The floor system on a truss contains floorbeams and, possibly, stringers. These members function as beams and are subjected to bending, shear and out-of-plane bending stresses. Distortion induced fatigue cracks have also developed in the webs of many floorbeams at connections to truss bridge lower chord panel points when the stringers are placed above the floorbeams. The webs of these floorbeams at the connections and adjacent to flanges and stiffeners need to be inspected routinely.

For steel truss floor systems, special attention should be given to the following locations:

- Check the end connections of floorbeams for corrosion as they are exposed to moisture and de-icing chemicals from the roadway (see Figure 8.6.53).
- Check the floorbeams and stringers for corrosion, particularly under open grid decks (see Figure 8.6.54).
- Check floor system member flanges and webs for corrosion and cracks Figure 8.6.55).
- During the passage of traffic, listen for abnormal noises caused by moving members and loose connections with the passage of traffic (see Figure 8.6.56).

Figure 8.6.53 Corroded Floorbeam End and Connection

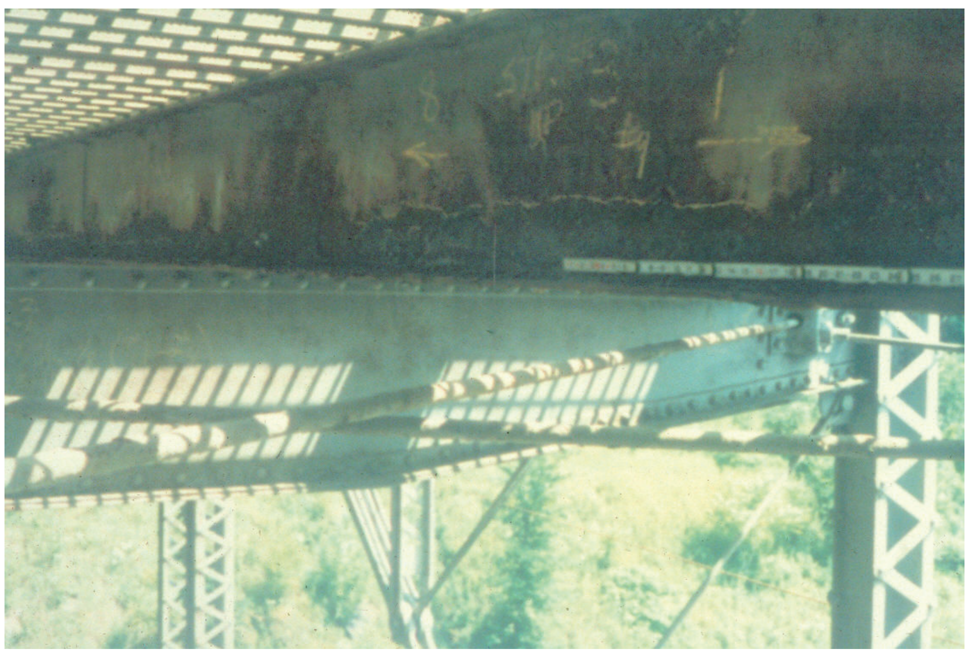

Figure 8.6.54 Corroded Stringer

Figure 8.6.55 Corroded Stringer Connection

Figure 8.6.56 Corroded Floorbeams and Stringers

Fatigue Prone Details

For fatigue prone details, special attention should be given to the following locations:

- Check ends of welded cover plates on tension flanges.
- Check the welded attachment of signs, railings, and utilities in tension zone.
- Check the welds on any repair or reinforcement plate attached to the truss

member (see Figure 8.6.57).

- Check for cracks at the copes and blocked flanges at ends of floorbeams and stringers (see Figure 8.6.58).
- Check the floorbeam and stringer connection angles for cracks (see Figure 8.6.59). The floorbeam to truss is a very critical load path; these connections deserve very close scrutiny.
- Check the horizontal gusset plate connections of the lateral bracing to the floorbeam flanges or webs.
- Check the ends of the vertical truss members and the end gusset plates for cracks.
- Check the ends of the vertical and diagonal eyebar members for cracks.
- Check pins on suspended spans (see Figure 8.6.60).
- Check all tack welds, for example, between gusset plates and main members and between floorbeam and stringer connections. The existence of tack welds should be immediately brought to the attention of the bridge engineer.

If the truss is riveted or bolted, check all rivets and bolts to determine that they are tight and in good condition. Check for cracked or missing bolts, rivets and rivet heads. Also, check the base metal around the bolts and rivets for cracking or section loss.

Inspect the member for misplaced holes or repaired holes that have been filled with weld material. Check for plug welds. These are possible sources of fatigue cracking.

Refer to Topic 8.1 for inspection procedures for fatigue prone details.

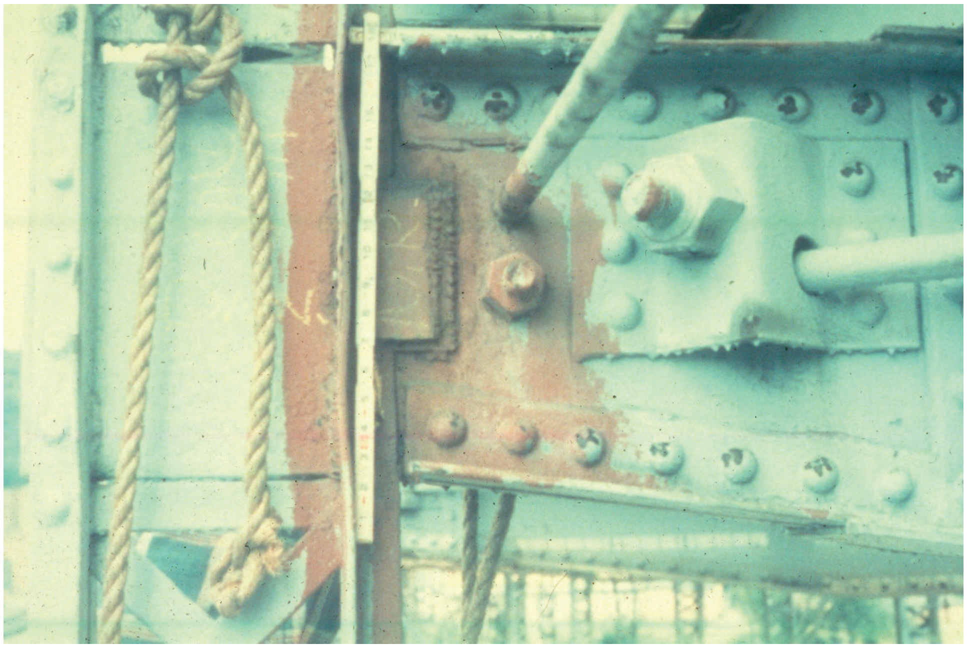

Figure 8.6.57 Welded Repair Plate

Figure 8.6.58 Coped Stringer

Figure 8.6.59 Clip Angles at Floorbeam and Stringer Connections

Figure 8.6.60 Suspended Span Pin

With two primary members in a truss, there is no load path redundancy. Therefore, trusses are non-redundant structures. Trusses are not, however, a single member. They are formed by the connection of many small members. Whether the failure of any given tension member would cause the truss or a portion of the truss to collapse is best determined by a detailed engineering analysis. The bridge inspector should assume that all tension members are fracture critical members until an analysis is performed and the FCM's have been identified.

Trusses by nature, can have some internal redundancy, depending upon its configuration. For example, the structure in Figure 8.6.61 has 119 members. The structural analysis indicated that there are 66 tension members, 30 of which are fracture critical (see Figure 8.6.62). The National Bridge Inspection Standards [650.313(e)(1)] require that fracture critical members be identified for individual bridges and the procedures for inspection listed.

Inspect pins for scoring and other signs of wear (see Figure 8.6.63). Be sure that spacers, nuts, retaining caps, and keys are in place.

Figure 8.6.61 Sewickley Bridge

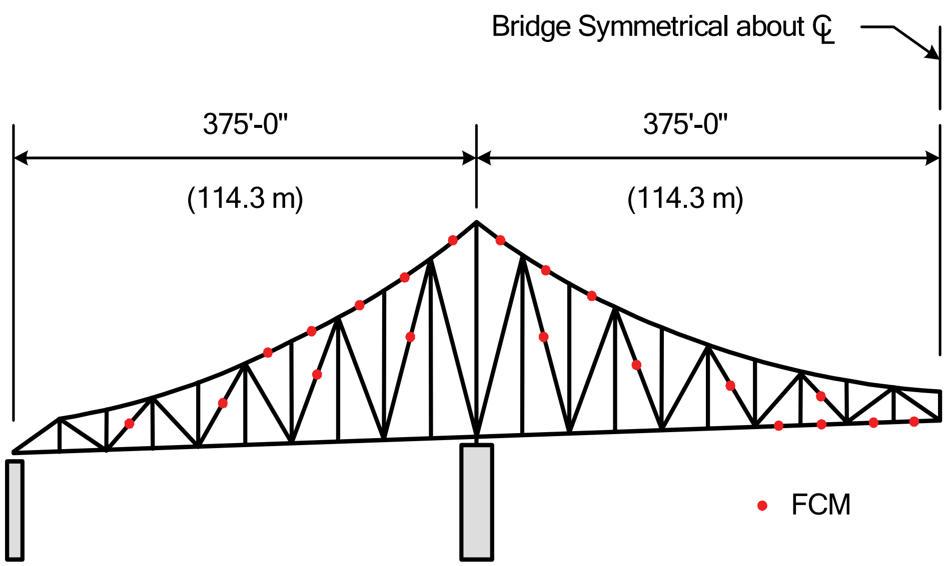

Figure 8.6.62 Sewickley Bridge with Fracture Critical Members Identified

Figure 8.6.63 Worn and Corroded Pin

Pin and hanger connections, when used in suspended span configurations in non-redundant truss systems, are fracture critical. Corrosion between the hanger and pin can cause fixity in the connections. This fixity changes the structural behavior of the connection and can be a source of cracking.

It is difficult to find a fixed pin and hanger reference point because the gusset plate dimensions are not usually given on design plans. However, two recommended options are the intersection of the upper or lower chord and nearest diagonal or the edge of the gusset plate along the axis of the hanger. Both of these points will provide readily identifiable reference points that can be re-created easily by the next inspection team. For this reason, measurements should be carefully documented along with the temperature and weather conditions. When inspecting a truss pin and hanger, locate the center of the pin, measure to a reference point to determine section loss, and compare the measurements to plans or previous inspection notes. Refer to Topic 8.4.4 for further details about the inspection of pin and hanger connections.

Secondary Members

Investigate the diaphragms, if present, and the connection areas of the lateral bracing for cracked welds, fatigue cracks, and loose fasteners. Check the lateral bracing gusset plates for corrosion. These horizontal plates typically deteriorate more rapidly than other elements on a truss because they are exposed to, and retain, moisture and deicing salts (see Figure 8.6.37). Inspect the bracing members for any distortion, or corrosion and rust packing (see Figure 8.6.65 and Figure 8.6.66). Distorted or cracked secondary members may be an indication the primary members may be overstressed or the substructure may be experiencing differential settlement.

For steel truss secondary members, check for collision damage at the portals and at knee braces (see Figure 8.6.64).

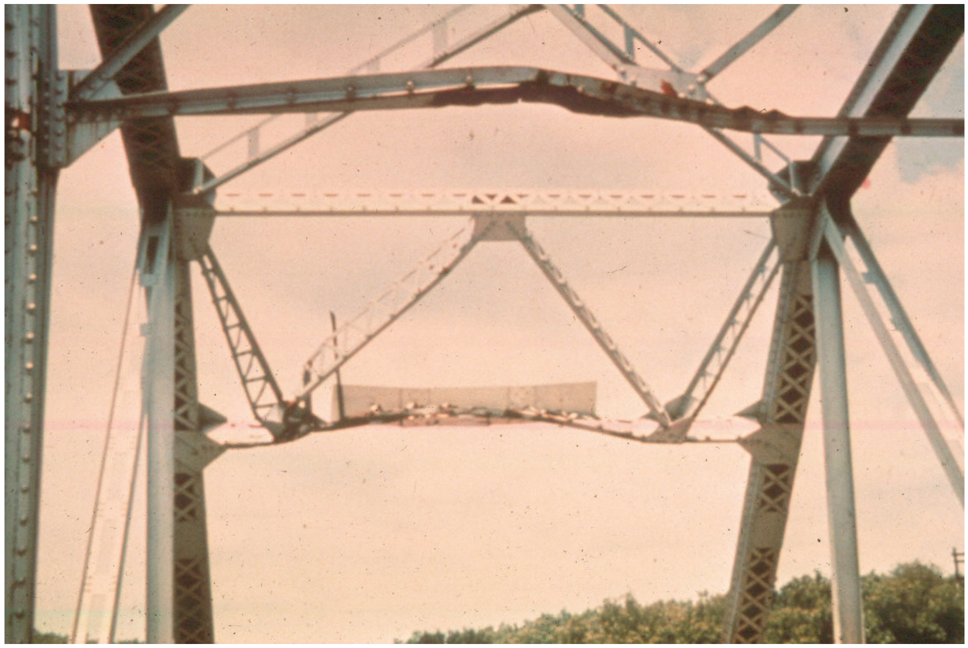

Figure 8.6.64 Collision Damage to Portal

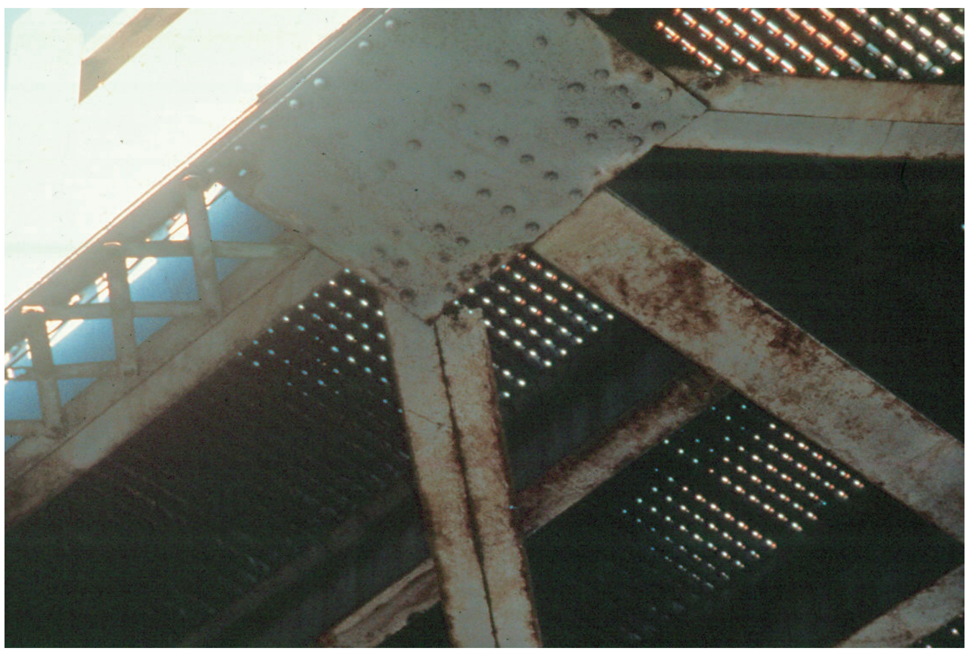

Figure 8.6.65 Lateral Bracing

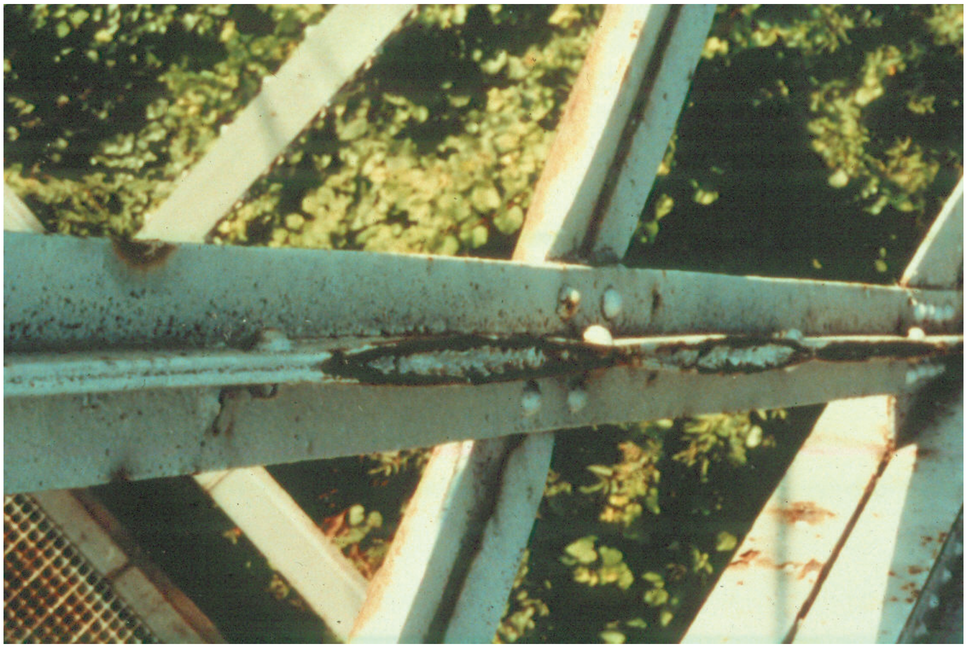

Figure 8.6.66 Sway Bracing with Rust Packing

Areas that Trap Water and Debris

Check horizontal surfaces that can trap debris and moisture and are susceptible to a high degree of corrosion and deterioration. Areas that trap water and debris can result in active corrosion cells and excessive loss in section. This can result in notches susceptible to fatigue or perforation and loss of section.

On steel truss bridges check:

- lateral bracing gusset plates
- inside built-up chord members (horizontal surfaces)
- areas exposed to drainage runoff
- pockets created by floor system connections
- tightly packed panel points
- pin and hanger assemblies
- bottom flanges of chord members and floor system

Non-critical Elements

Inspect chord members for corrosion, examining horizontal surfaces where moisture can collect. Check for corrosion and general deterioration of the lacing bars, stay plates, and batten plates (see Figure 8.6.67).

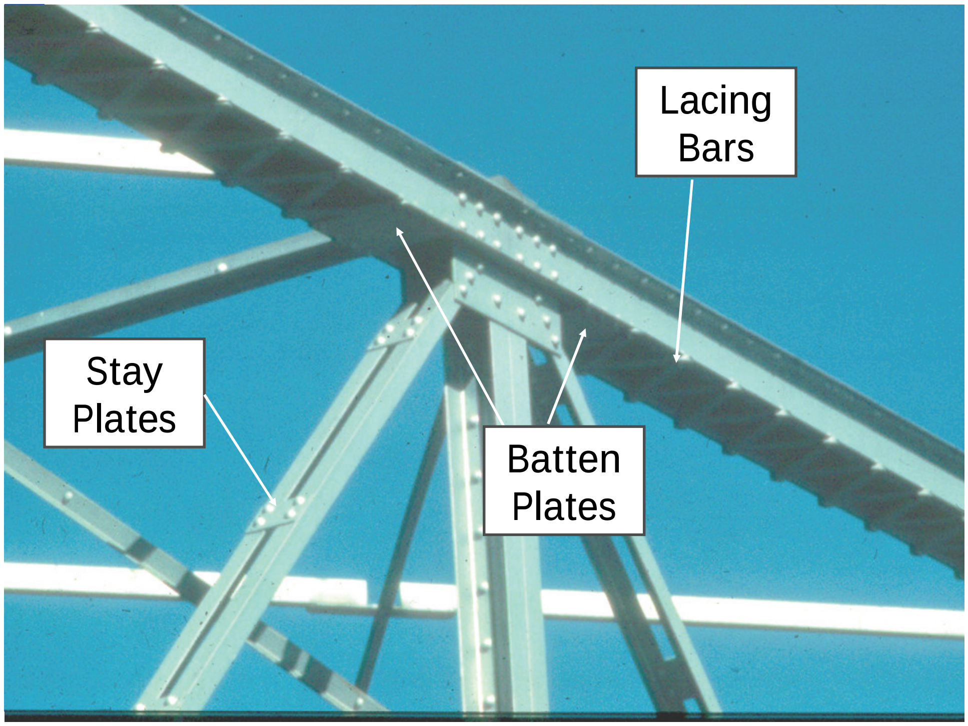

Figure 8.6.67 Non-critical Elements

8.6.5 Evaluation

State and federal rating guideline systems have been developed to aid in the inspection of steel superstructures. The two major rating guideline systems currently in use are the FHWA's *Recording and Coding Guide for the Structural Inventory and Appraisal of the Nation's Bridges* used for the National Bridge Inventory (NBI) component rating method and the AASHTO element level condition state assessment method.

NBI Rating Guidelines

Using NBI rating guidelines, a 1-digit code on the Federal Structure Inventory and Appraisal (SI&A) sheet indicates the condition of the superstructure. Rating codes range from 9 to 0 where 9 is the best rating possible. See Topic 4.2 (Item 59) for additional details about NBI Rating Guidelines.

The superstructure rating is only influenced by the condition of the main load carrying primary members.

Only corrosion, section loss, and fatigue cracks impact the superstructure rating. The location, dimensions and extent of the above mentioned discrepancies should be noted on inspection forms.

The previous inspection data should be considered along with current inspection findings to determine the correct rating.

Element Level Condition State Assessment

In an element level condition state assessment of steel trusses, the AASHTO CoRe element is:

Element No.	Description
	Floor System
106	Open Girder/Beam – Unpainted Steel
107	Open Girder/Beam – Painted Steel
112	Stringer – Unpainted Steel
113	Stringer – Painted Steel
151	Floorbeam – Unpainted Steel
152	Floorbeam – Painted Steel
	Truss
120	Thru Truss (Bottom Chord) – Unpainted Steel
121	Thru Truss (Bottom Chord) – Painted Steel
125	Thru Truss (Excluding Bottom Chord) – Unpainted Steel
126	Thru Truss (Excluding Bottom Chord) – Painted Steel
130	Deck Truss – Unpainted Steel
131	Deck Truss – Painted Steel

The unit quantity for the floor system and truss is meters or feet, and the total length must be distributed among the four available condition states for unpainted and five available condition states for painted structures depending on the extent and severity of deterioration. In both cases, Condition state 1 is the best possible rating. See the *AASHTO Guide for Commonly Recognized (CoRe) Structural Elements* for condition state descriptions.

A Smart Flag is used when a specific condition exists, which is not described in the CoRe element condition state. The severity of the damage is captured by coding the appropriate Smart Flag condition state. The Smart Flag quantities are measured as each, with only one each of any given Smart Flag per bridge.

For damage from steel fatigue, the "Steel Fatigue" Smart Flag, Element No. 356, can be used and one of the three condition states assigned. For signs of rust packing between steel plates, the "Pack Rust" Smart Flag, Element No. 357 can be used and one of the four condition states assigned. For damage from traffic impact, the "Traffic Impact" Smart Flag, Element No. 362, can be used and one of the three condition states assigned. For damage from section loss, the "Section Loss" Smart Flag, Element No. 363, can be used and one of the four condition states assigned.

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