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).

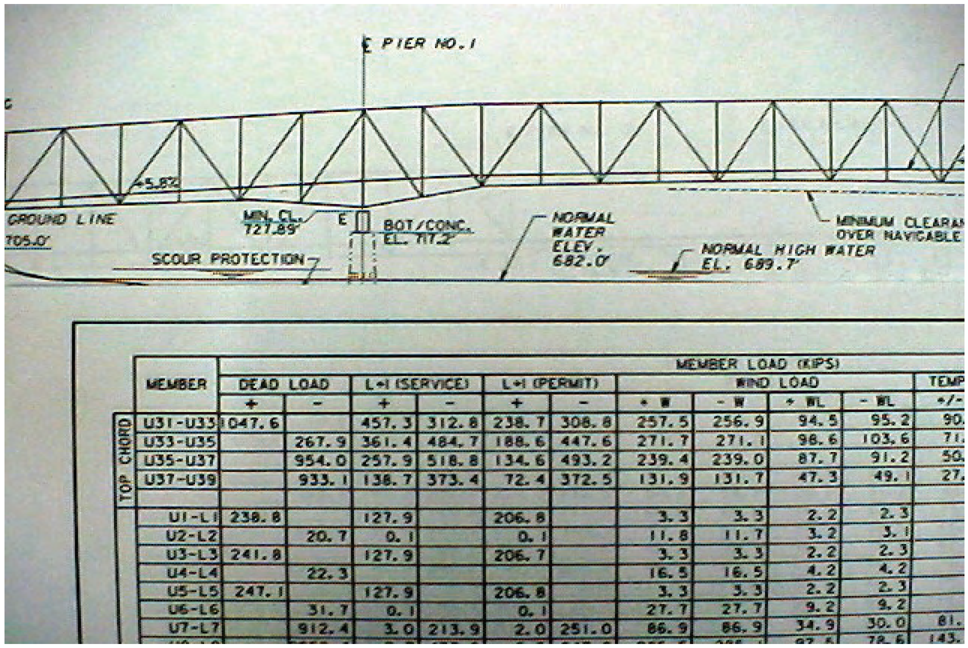

Figure 8.6.42 Truss Design Drawings: Member Load Table

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

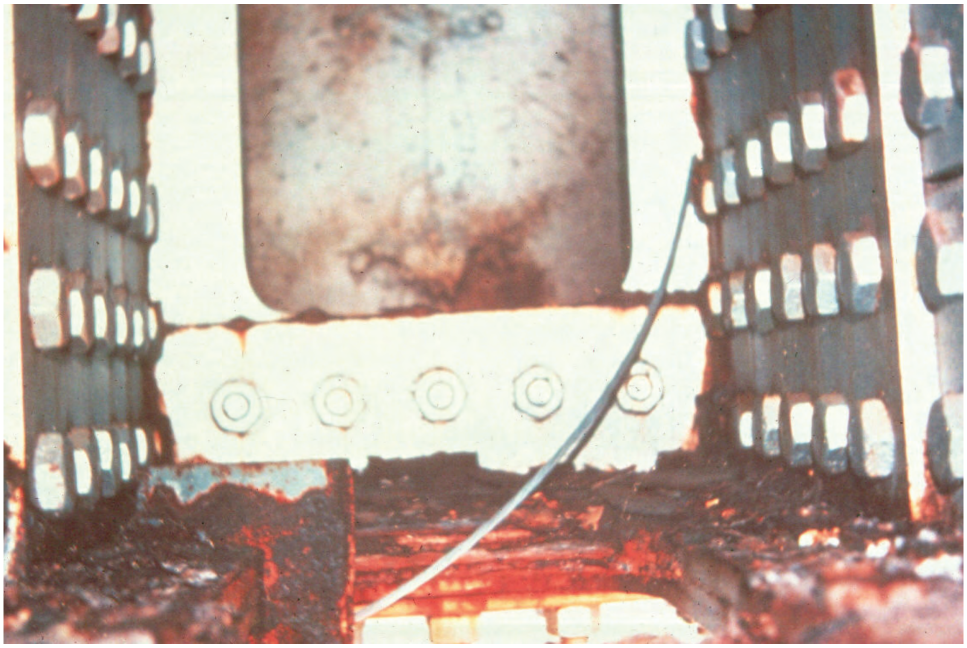

Figure 8.6.44   Inside of Box chord Member

Figure 8.6.45   Cracked Forge Zone on an Eyebar

Figure 8.6.46 Cracked Forge Zone on a Loop Rod

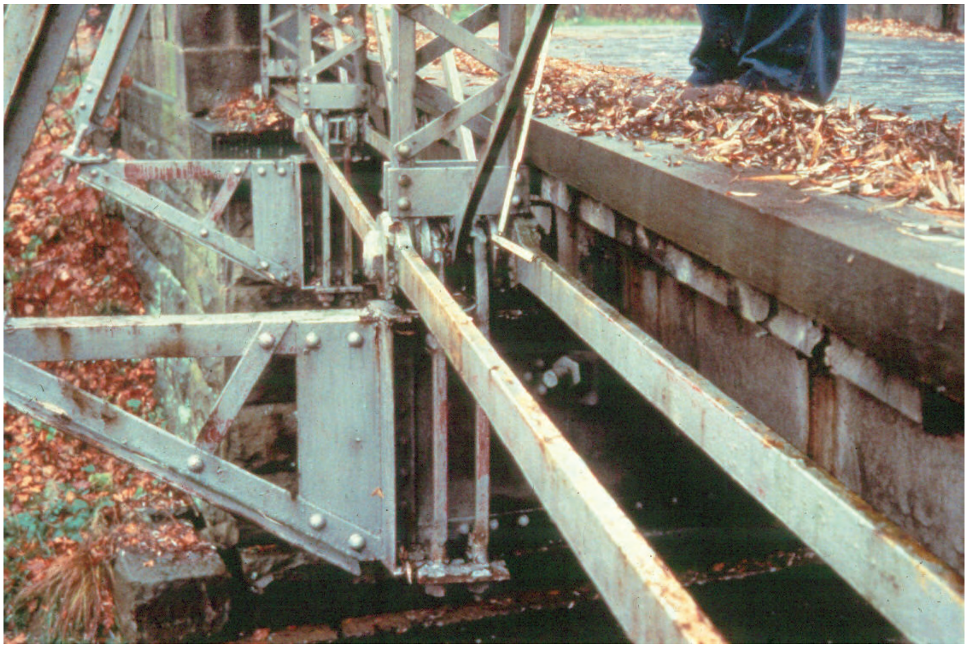

Figure 8.6.47 Bottom Chord

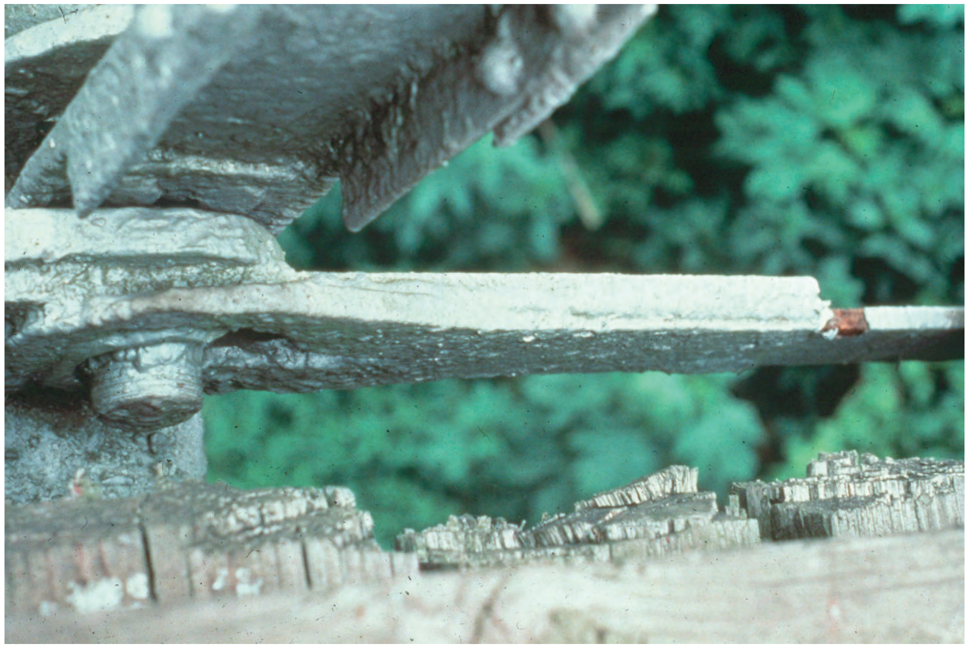

Figure 8.6.48 Welded Repair to Loop Rod

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

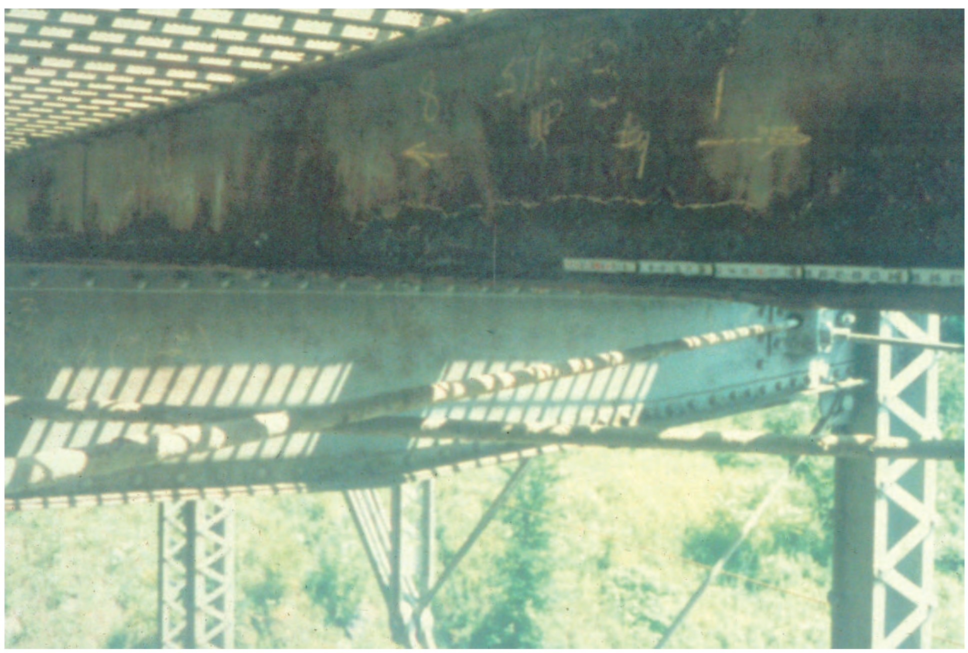

Figure 8.6.54 Corroded Stringer

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.

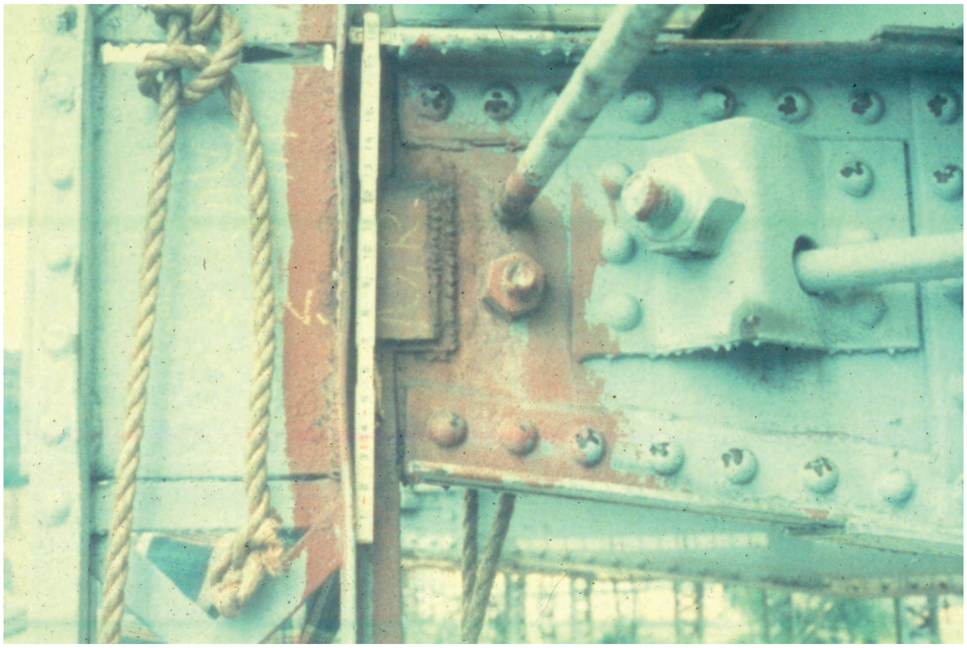

Figure 8.6.57   Welded Repair Plate

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

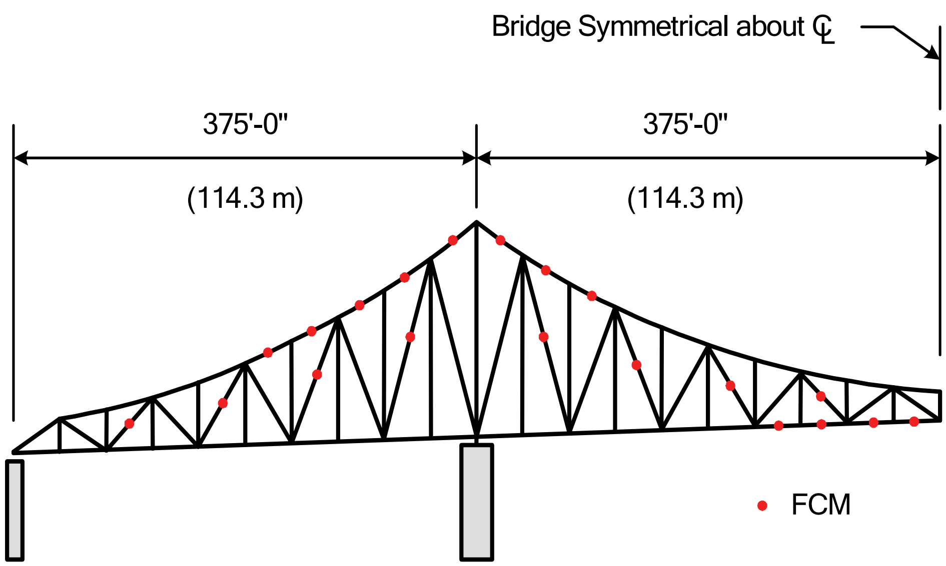

Figure 8.6.62 Sewickley Bridge with Fracture Critical Members Identified

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).

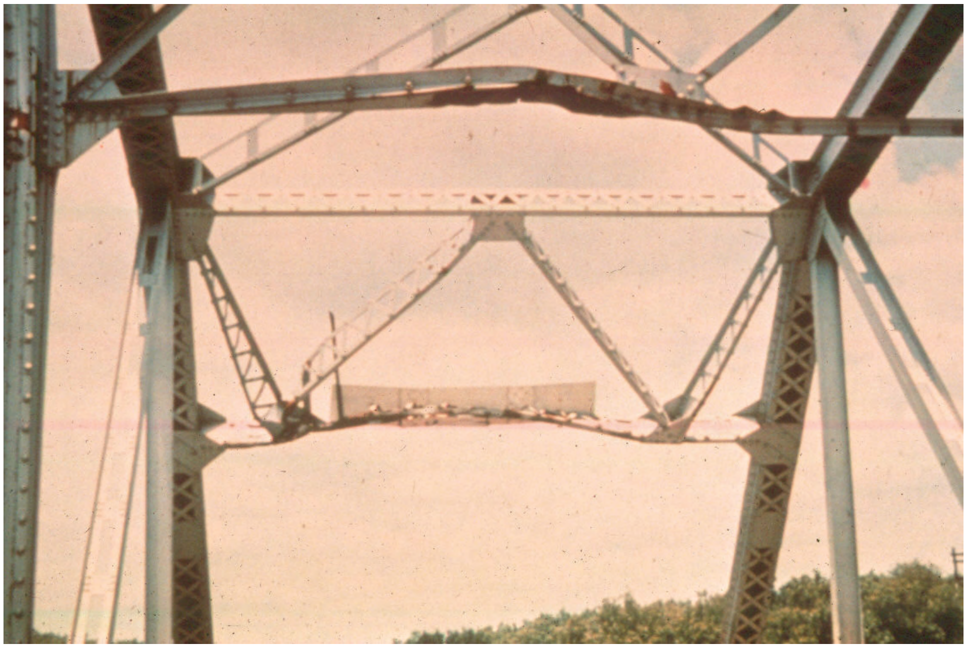

Figure 8.6.64 Collision Damage to Portal

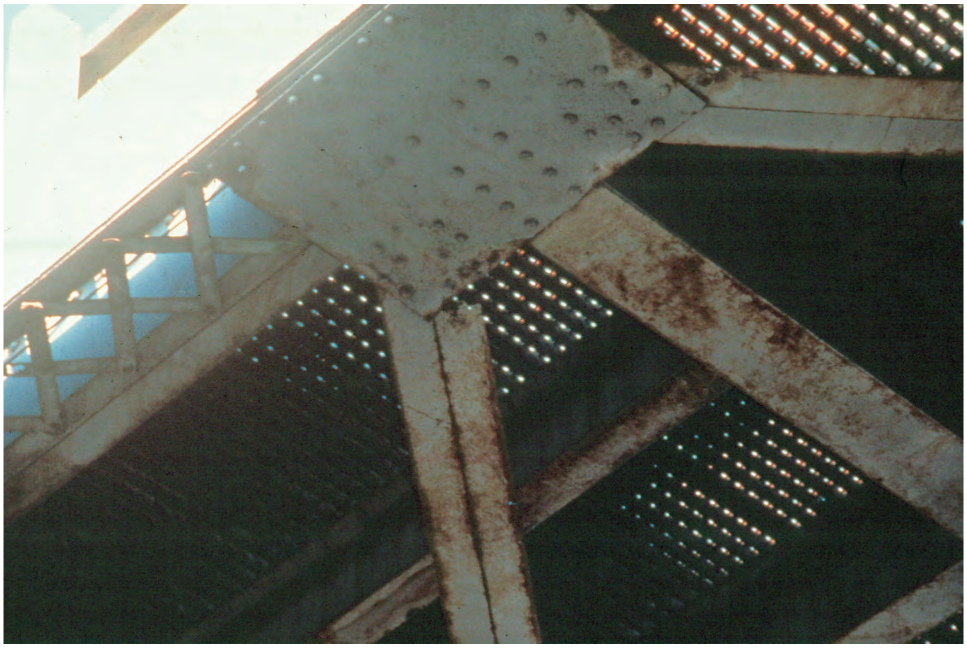

Figure 8.6.65 Lateral Bracing

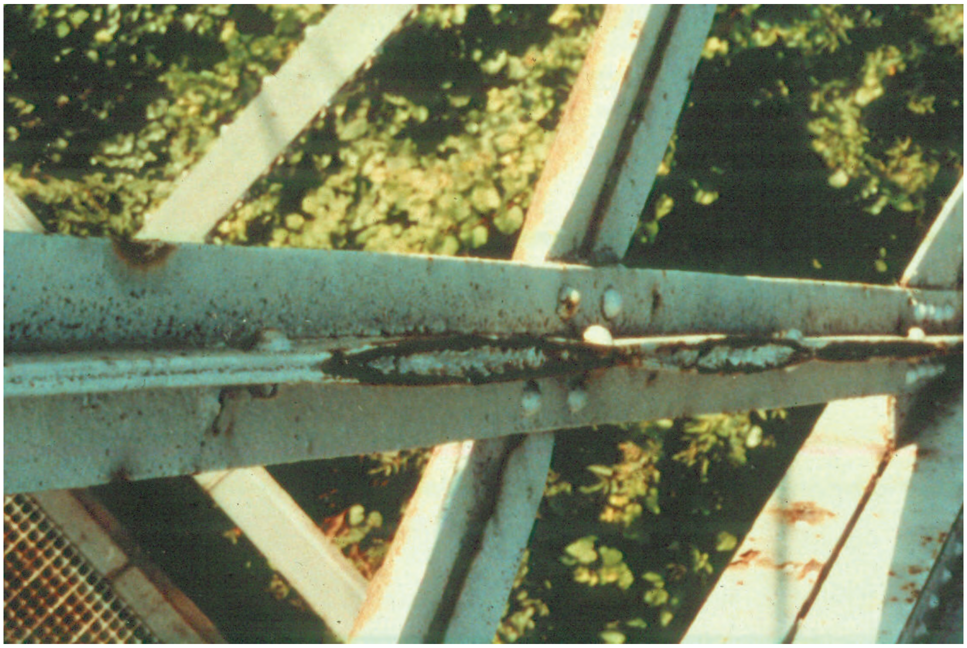

Figure 8.6.66 Sway Bracing with Rust Packing

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).

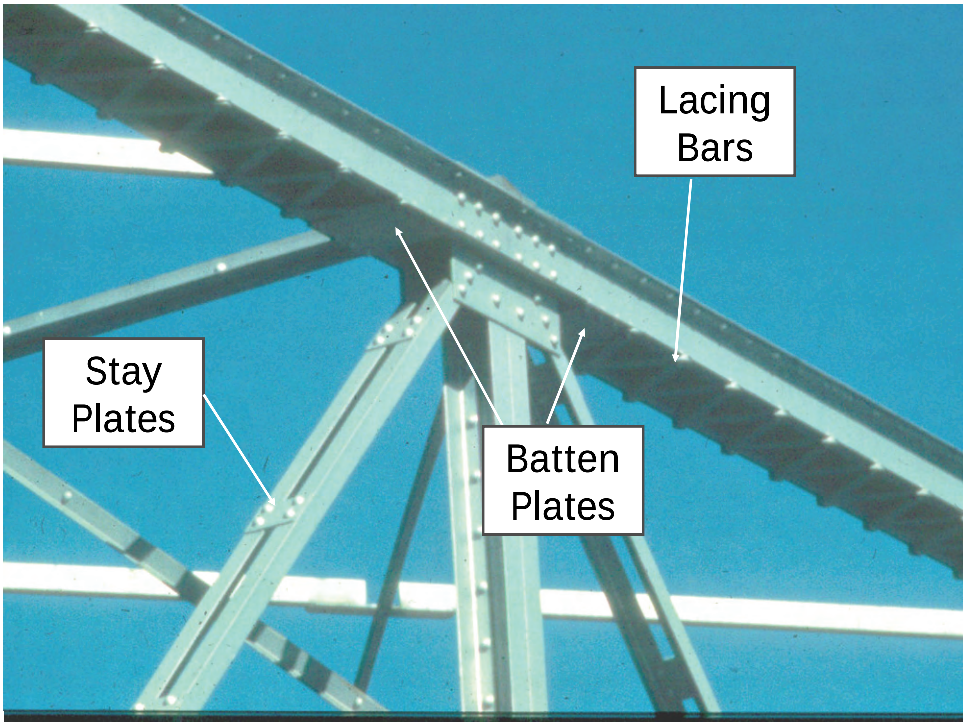

Figure 8.6.67 Non-critical Elements

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.