SECTION 500 - STRUCTURES

504.00 Structural Metals.

General. The term structural metals generally applies to steel used for steel bridges. However, the provisions of this subsection could apply to other structural steel application such as those used in sign structures, piling or other features. Therefore, the following guidance could be applicable for them as well. The inspector on the project should become familiar with the outside appearance of acceptable fabrication, even though shop inspection is made by a qualified testing laboratory. The size and tolerances of rolled shapes should be spot checked against the American Institute for Steel Construction (AISC) *Manual for Steel Construction* to assure that a lighter weight shape of the same series has not inadvertently been delivered. Each District should have a copy of the latest edition of this manual. A copy of this manual is usually available in the Central Materials Lab and the Bridge Section libraries.

Fabricated shapes must be inspected for cracked welds, bent stiffeners and clip angles, bent flanges, torn or buckled plates, and other damage which might occur in shipping. A list of defects, which may be cause for rejection, should be furnished by the consultant shop fabrication inspector. These items should be documented in writing along with the corrective action taken.

Ensure the steel is unloaded in a manner that will not damage the members. Proper equipment and manpower should be checked before unloading begins.

Beams and girders should be kept in an upright position and set on wooden blocks that keep them off the ground. Long member should have adequate support to protect against damage from deflection. Bracing may be needed to prevent overturning.

Material stored on the project should be protected from damage. Steel should be stored in a well-drained area.

Assembly and Erection. Before erection, each member should be identified for proper location in the structure. Members are seldom interchangeable, because of location of bolt holes, special bevels, cuts or hangers. A plan must be developed for proper erection sequence, including details of field connections which are usually omitted from the contract plans. Sufficient equipment with adequate capacity and reach is needed to erect the steel without accident to men or material. Long girders may require more attention than weight alone would indicate because of lack of stiffness. Severe damage and over stressing may result from careless handling and erection.

Bearing surfaces of the structural members and of the substructure must be inspected for cleanness and freedom from defect. Contact of bearing surfaces, alignment, clearances, and in place camber, are items that require checking as erection proceeds and field connections are made. Before the erection of the structural steel the centerline of bearings must be laid out on all substructure units by precise methods and clearly marked on the concrete. Bearing areas need to be checked to ensure a

flat surface is provided at the correct elevation. Any modifications required to make this happen (grinding, shims etc.) needs to be approved.

Generally, anchor bolts are used to tie the substructure to the superstructure. Anchor bolts are usually plain round bolts with the head and washer plate on the lower end and the thread and nut at the top end. These bolts are set in pipe sleeves to allow room for adjustment of the span. The location of the anchor bolt sleeve is very critical and must be verified by the Inspector. Also, the exposed length of anchor bolts should be checked to ensure enough thread is exposed out of the pier cap to tie down the lower bearing assembly. Anchor bolt holes and the void underneath masonry plates shall be grouted after all the structural steel is erected and adjusted for length and camber and at least seven days before the deck concrete is placed.

Field connections are normally restricted to bolts because of the difficulty and expense of properly inspecting welds in the field. Where field welded connections are permitted or specified, it may generally be said that a weld with a uniform appearance after slag has been removed is a satisfactory weld. Rough or slipshod appearance and defective welds often go together.

If there are suspected or apparent deficiencies such as laminations or inclusions in a weld and a check is desired the Inspector should notify the Resident Engineer and he should contact the Central Materials Lab for a listing of qualified consultant who are trained specialists in the operation of ultrasonic flaw detectors.

Steel members should fit together with very little strain or distortion. Bolt holes that are slightly out of alignment are generally brought into alignment with the use of drift pins. Excessive use of force that distort or enlarge the hole or making cuts or adjustments with a welding torch are not allowed. Excessive force can introduce stresses into the component for which it was not designed. When this is not feasible to adjust the holes alignment with the application of a modest amount of force the Resident Engineer and designer should be consulted. The material may be rejected or the Contractor directed to submit a plan for correction that must be approved. Straightening a member should always be done only after approval by the Engineer. It is desirable that an entire unit or continuous span of the structure be temporarily fitted, assembled, connected, adjusted and checked before the permanent connections are made.

Field connections are often permanently bolted. Bolted joints gain much of their strength from friction between the surfaces held together. Friction rather than shear or bearing allows the stresses to be transferred. This friction depends on bolt tension, which is a primary importance.

Special high strength bolts are used so that proper tension may be applied without stretching or breaking the bolt. A copy of Section 2.10.20 of *the Standard Specifications for Highway Bridges* adopted by AASHTO covering connections using high strength bolts should be obtained and enforced. Bolts should be checked carefully for compliance with material specifications.

High tensile strength bolts vary only slightly in shape, dimension and appearance form ordinary machine bolts. Both have hexagonal heads and nuts that differ only in that the heads and nuts are finished more accurately on the high strength bolts (to allow for more uniform bearing) and in the markings. Inspectors should be careful to ensure they are not interchanged. High strength bolts are

designated Type 1, 2, and 3 and will be marked A325M or M164M along with a symbol identifying the manufacturer. AASHTO M-164 requires that Type 1 bolts be marked with an 8S, Type 2 bolts with and 8S underlined and Type 3 bolts shall be marked 8S3. Marks may be raised or recessed but must be located on the top of the bolt head.

The dimensions and specifications of bolts and washers should be spot checked to ensure they are in conformance with the contract requirements. The Resident and his staff are referred to current publications that provide this information including the AISC *Manual for Steel Construction.* The following ASTM standard specifications are also useful references:

- ASTM A 325 High Strength Bolts for Structural Steel
- ASTM F 436 Hardened Steel Washers
- ASTM A 490 Heat Treated Steel Structural Bolts
- ASTM A 563 Carbon and Alloy Steel Nuts

Proper bolt tension may be obtained with the use of Direct Tension Indicators (DTI) or by the "turn-of-the-nut method" described in Subsection 504.03.L of the Standard Specifications.

A DTI is a hardened round, steel shaped device similar to a washer with protrusions or bumps on one side or face. When the bumps are placed against the underside of a bolt head or against a hardened flat washer there is a noticeable gap. As the bolt and nut are tightened the clamping force flattens the bumps and reduces the gap. The more you tighten the more the bumps are flattened. When the gap is reduced to the required dimension you know the bolt has been properly tensioned. If used correctly, they will give satisfactory results. The Engineer must check the specifications to be sure this type of device is approved for the project, and install them in accordance with the manufacturer's recommendations. ASTM F 959 gives additional details on DTIs and their installation.

The field procedure for installing high tensile bolts is as follows:

- Flair-up holes with enough pins to maintain dimensions and plumbness of the structure. Pins are not to be removed until bolts in all other holes have been tightened.
- Install bolts in remaining holes.
- Tighten a pattern of bolts from the center of the pattern working outward, being sure that the connected parts are properly fitted.
- Using a spud wrench, tighten the nut of each bolt not used for fit up to a snug position, then continue to tighten it by turn-of-nut as specified, depending on grip length. Snug is defined as the tightness that exists when all plies are in firm contact. This may be obtained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.
- Replace pins with bolts and tighten as above.
- Back off the nut on each fit-up bolt (these bolts have previously been marked) then tension as per AASHTO turn-of-nut method.
- The bolt up crew should mark completed work with an identifying symbol.

Safety and safe practices are of paramount importance in all phases of structural steel work. The inspector should become familiar with the OSHA steel erection safety requirements, and be constantly alert to hazards.

Torque wrench and calibrated impact wrench methods shall not be used for tightening of bolted connections.

Documentation for Pay Quantities. See Subsection 504.04 and 504.05 of the Standard Specifications.

Reports. None.