6.1 Structural Steel Erection - General

Structural steel erection includes delivery of the steel to the site, handling, temporary storage, falsework, lifting assembly, completion of all connections, installation of bearing and expansion assemblies.

- The method and techniques used to erect structural steel depends on the type of structure, length of span, site conditions, and equipment available.

- The erection procedure should take into consideration the stability of the structure under **all** conditions of partial erection to withstand construction loading and wind loading encountered during erection.

- The girders must be erected in such a manner that they will perform as the design intended, and not be subjected to overstressing.

- Very large and/or unusual bridges require specialized erection techniques and scheduling.

- Continuous girder bridges generally require field splices. Longer spans require temporary intermediate supports or falsework to support the steel until adjacent members are connected.

6.2 Environmental Constraints

Be aware of the environmental constraints and note the following:

- Before final acceptance, the Contractor is required to remove all temporary works.

- All berm work, temporary pilings, and falsework are to be acceptably removed.

- The Contractor is required to leave the bridge site, roads, stream channel and adjacent property in a neat and satisfactory condition.

- If adjacent property outside the right-of-way has been affected, the Contractor must provide written evidence that his cleanup is satisfactory to the property owners.

- All disturbed riverbanks are to be acceptably restored, and borrow pits satisfactory reclaimed.

6.3 Safety

It is ESSENTIAL to have a pre-girder erection meeting with the Contractor to discuss all the safety issues. Refer to the following Parts in Alberta's Occupational Health and Safety Regulation, General Safety Requirements for specific safety requirements:

- Part 3 Health and Safety Plan
- Part 4 Hazard Assessment, Elimination and Control
- Part 5 Specifications and Certification
- Part 7 Cranes and Hoists
- Part 9 Entrances, Walkways, Stairways and Ladders
- Part 15 Personal Protective Equipment
- Issue "STOP WORK" order to the Contractor if necessary.

6.4 Bridge Inspector's Record

The following items must be included in the Bridge Inspector's record:

- Ensure agreements are in place between Contractor and private landowner(s) pertaining to borrow and disposal areas.
- Record traffic disruptions or minor traffic mishaps.
- Record all "as-built" survey information and camber corrections.
- Record all shim elevations.
- Record temperature and bearing settings.
- Record final girder elevations.

6.5 Preliminary Work

The erection proposal is to be submitted for review and approval by the Bridge Project Engineer. The Bridge Inspector must not allow any erection work to begin until approval of the erection scheme has been granted. This approval does not relieve the Contractor of

his responsibility for safety and for ensuring that the work is done in accordance with the plans and specifications.

The erection procedure should addresses the following:

- Traffic accommodation plan as necessary.
- Survey of substructure.
- Access to work, earth berms, work bridges, and ice bridges.
- Sequence of operations.
- Size and position of cranes.
- Lifting devices and lifting points.
- Falsework details (Professional Engineer's stamp required).
- Bolt torque sequence and method.
- Method for securing structure position prior to grouting.
- Grouting procedures.
- Falsework release.
- Temporary access removal.

The Bridge Inspector must ensure that the following steps are diligently carried out to ensure all erection requirements are satisfactory achieved.

- Review and understand the erection procedure.
- Review falsework and traffic accommodation plan.
- Survey the completed substructure prior to erection.
- The survey is to be done independently of the Contractor.
- Check that centerline of bearings for piers and abutments, and roadway centerline are in the correct location.
- Check the locations of anchor bolts or pockets, elevations of pier and abutment seats and elevations of bearing pads.

- Where girders are erected onto bearings, ensure that the Contractor is required to take special precautions with the bearing areas on the piers and the abutments.

- The concrete surface to receive the bearings is to be finished to a smooth, true, uniform surface to ensure full contact.

- Minor grinding, chipping or filling may be required to ensure proper contact of the bearings.

- Bearings to be grouted are generally set on stacks of thin galvanized steel shim plates.

- Check the elevations of the bearings and review the shims requirements to ensure that they will be stable under load, and are distributed such that the bearings will not damaged by high local stresses.

- Ensure that anchor bolts are fully grouted with an approved flowable grout.

- The grout must be kept sufficiently warm and wet to ensure proper curing.

6.5.1 Ice Bridge

It is advantages to schedule girder erection over a river during the cold weather months, to take full advantage of the river ice to support all the equipment necessary to complete the erection.

- The river ice thickness must be adequate to support the erection equipment and may require flooding.

- Normally, 1.5 m of SOUND ice is required to support the erection equipment and steel girders. However thicker ice may be required for extra heavy loads.

- In preparation for building ice, the snow should be piled around the perimeter to serve as a berm to contain the flooding water inside this area.

- On cold days, water can be pumped from holes drilled through the ice to flood the work area.

- It is sometimes advisable to do ice making during the night when air temperatures are more conducive.

- It is ESSENTIAL that the ice thickness be checked daily as the flowing water in the channel below the ice will have a continuous effect of eroding the ice thickness.

- When heavy loads are anticipated, it may be necessary to drive piles at crane outrigger locations for extra support.

- Falsework towers, if required to support the girders at the splice points, must be founded on piles not on ice.

- The ice bridge will tend to move, crack and heave. as the temperature conditions change, and it is therefore important that the supporting piles be free of the ice at all times, to prevent the piles from being “pushed-up”.

6.6 Erection and Assembly

Assembly of the structural steel members is to be done accurately as shown on the drawings, and in a manner that will prevent bending or other damage to the steel.

- The Bridge Inspector should check that the elevations of girders on are correct.

- Splices and field connections are to have 25% of the holes filled with bolts and 25% of the holes filled with erection pins before final bolting commences.

- Serious misfits are to be reported to the Bridge Project Engineer and an approved method of correction obtained.

- After the steel girders are erected and the splice points loosely pinned and bolted, all shims, wedges or jacks used to support the steel on the falsework are to be removed or lowered such that the steel girders are carrying their own dead load.

- When the entire superstructure is erected, take elevations at the piers, abutments, splice points and mid-spans to determine whether corrections are required.

- Ensure that expansion assemblies and bearings are offset with the corresponding temperatures as shown on the drawings.

- The Contractor shall not commence torquing until all the girders are erected and elevations approved.

- The structural steel in all areas is to be left clean and free from mud, dust, oil, etc.

- Ensure that falsework, temporary pilings, and berms in the stream channels are removed prior to spring breakup or other high water runoff periods.

6.7 High Strength Bolted Connections

High tensile strength bolts are used in bolted connections and tightened to a very high tension, which clamps the joined pieces between the head and the nut of the bolt. This clamping action enables the load to be transferred from one plate to the other by friction with no slip, thus producing a rigid joint.

- Under no circumstances shall ordinary bolts be substituted for high tensile strength bolts. The connections will not function as designed and could lead to failure.

- The clamping action created by the high tensile strength bolts enable the working loads to be transferred by friction and the bolts are not subjected to bearing or shear stresses. The frictional resistance is effective beyond the hole area, so the load is transferred over a relatively large area, reducing local stresses on the net section at the holes. In addition, the high initial tension prevents the nuts from loosening.

- Frictional resistance depends on the amount of initial tension in the bolt, therefore it is essential that proper tightening of the nut on the bolt develop adequate clamping forces. Special attention must be given to installing and tightening high strength bolts.

- The Bridge Inspector must check the torque of 100% of the bolts at splice locations and ensure the bolts are the same size, grade and condition as those used in the calibration device. The Contractor is required to provide safe and adequate access for inspection.

- The Contractor must tighten the bolts to produce the minimum tensions required. Tightening of the high strength bolts may be done either by using properly calibrated wrenches, or by the “turn-of- nut” method.

- The Contractor is required to provide at site, a calibrated device capable of indicating tension in bolts of the size being tightened. Beveled washers are required where the surface of the connected part slopes more than 1:20 (5%). High strength bolts must not be “re-used”.

- The contact surfaces must be cleaned and free of all dirt, oil, loose scale, burrs, pits, paint or lacquer, etc.

- At a splice location, bolts are to be tightened from the centre outward. Each bolt should be tightened to a tension of at least 5% but not more than 10% greater than the specified minimum tension.

- High strength bolts may be tightened by turning either the nut or the head of the bolt providing a washer is used at the tightening end.

6.7.1 Tightening by Calibrated Wrench

Tightening by calibrate wrench can be done using an impact wrench (powered by air pressure) which stalls or "cuts out" when the torque reaches a set value, or by using a manual torque wrench with an indicator that shows when a set torque value has been reached. The indicator on the manual torque wrench must be read while the nut is in motion rotating in the tightening direction.

- Where there are several bolts in a single joint, there may have minor separation between the joined parts when the first bolt was torqued.

- Separation will close up with torquing of subsequent bolts leaving the tension in the first bolts less than required.

- The Contractor is required to re-use the calibrated wrench to re-torque previously tightened bolts.

- The Contractor is required to calibrate the wrenches at least once a day on site, and the Bridge Inspector should witness this calibration.

- In calibrating the torque wrench, three bolts are to be tested and the average torque from the three tested bolts will be the "job inspecting torque" to be used.

6.7.2 Tightening by the "Turn-of-Nut"

The turn-of-nut" method of tightening assures proper tension by imposing a set amount of strain (lengthening) in the bolt. The bolts are tightening snugly to ensure full contact of jointed parts, and the nut (or bolt head) is then turned a further specified amount. The nut moving along the pitch of the thread forces the bolt to stretch, thus developing the required tension in the bolt. The amount of rotation required depends on the length of the bolt and the "flatness" of the surface beneath the nut and head of the bolt, and is tabulated in the specifications.

- Snug tight is defined as the tightness reached with a few impacts of an impact wrench, or when tightened with the full effort of a man using an ordinary spud wrench.

- In using the "Turn-of-Nut" method, the Contractor must snugly tighten enough bolts to ensure that the parts of the joint are brought into full contact.

- Bolts are to be placed in all remaining holes in the connection and brought to snug tightness.

- All bolts are to be tightened to the minimum bolt tension by rotating the turned part through the required portion of a turn, working systematically from the most rigid part of the joint to its free edges.

- During tightening, there must be no rotation ("wheeling") of the head or nut not turned by the wrench.

- The Bridge Inspector must observe procedures to be assured that the joints are being properly snugged, and that the required rotations are being achieved.

- The Bridge Inspector should mark the bolts after they are snugged to indicate that the required rotations have been obtained.

- If any nut or bolt head is turned by the "job inspecting torque", the Contractor is required to test the torque of 100% of the bolts in the connection, and properly tighten all bolts.

6.8 Checklist

6.8.1 Bridge Inspector's Responsibilities

- Review the applicable specification and study the Drawings.

- Survey the substructure independently of the Contractor prior to erection, checking centrelines, bearing and anchor locations and elevations. Compare with Contractor's layout. Notify the Bridge Project Engineer of discrepancies.

- Check that the erection scheme and the falsework details submitted have approved by the Bridge Project Engineer.

- Report any departures from the erection proposal to the Bridge Project Engineer.

- Check that the falsework is constructed in accordance with the approved details and that it is monitored daily by the Contractor for tightness of bolts, wedges and cables.

- Check the access roads and the berms for stability, scour and drainage. Ensure conformity with the Environmental Code of Practice.

- Check bearings that:
  - Bearing elevation is correct.
  - Shims are stable and adequately distributed.
  - Anchors are set accurately as detailed.
  - Expansion bearings are offset for ambient air temperature.

- Check that the crane wheel or the outrigger loads will not induce excessive pressure to substructure, e.g. wingwall, backwall.

- Check that the structural steel stored at site is:
  - Off ground on blocking.
  - Tilted for drainage.
  - Has beams, girders braced upright.
  - Has slender members supported frequently.

- Check the elevation of the temporary supports and the falsework relative to the required cambers.

- During erection check that:
  - Splices and field connections have half the holes filled with bolts and erection pins.
  - Problems with misfit are reported to the Bridge Project Engineer.
  - Method of correction of misfit approved by the Bridge Project Engineer.
  - Approved correction of misfit observed by Bridge Inspector.
  - All bracing and diaphragms fully connected and properly fitted.
  - Contractor gives full regard for security and stability of all erected pieces.

- Survey the continuous girders when the falsework is removed but prior to torquing of the bolts.
  - Report discrepancies to the Bridge Project Engineer BEFORE any torquing is allowed.

- For High Strength Bolted Connections check that:
  - All fraying surfaces seat solidly and are free from dirt, oil, paint, loose scale, burrs, and pits.
  - Beveled washers are used where required.
  - Contractor's wrenches are calibrated daily in the presence of the Bridge Inspector.
  - In connections with several bolts, that the first bolts torqued are re-torqued after all bolts are tightened.
  - All bolts are "snug tight" before using "turn-of-nut" method
  - The "inspection wrench" is kept properly calibrated.
  - 100% of bolts checked for proper tightness.
  - Check bolt tightness as soon as possible when Contractor is readied.

- For grouting check that:
  - Flowable grout has approved by Bridge Project Engineer.
  - Flowable grout is mixed in required proportions.
  - Flowable grout is being placed fully under masonry plates and in anchor bolt holes.

- After the completion of erection check that:
  - Temporary piles, berms and falsework are removed.

  - The site, including stream channels and banks, is left in a neat and satisfactory condition.
  - The owner is satisfied with the cleanup if private property has been affected.
  - The steel is left clean, free from mud, dust, and oil.

- Do the post-erection survey on the girders recording elevations of the top flanges at 1/10 points for each span.

- Initiate payment upon the acceptable completion.

6.8.2 Bridge Project Engineer's Responsibilities

Discuss the following items with the Contractor and the Bridge Inspector:

- "As-built" survey information and decide on corrections and elevations.

- Erection procedure.

- Access road and berm locations.

- Bent locations if required.

- Final girder alignment.

- Proposed methods employed for securing the structure.

- Final site cleanup, including restoration of riverbanks, access road, borrow pits and disposal areas.

SECTION 6

STRUCTURAL STEEL ERECTION

6-1 Trapezoidal box girder delivered with pot bearing assemblies attached

6-4 Winter frozen condition between piers permits one crane for erection of girder

6-2 Spreader used to pick up box girder

6-5 Splice connection between girder segments

6-3 Erecting box girder between abutment and spanning over pier

6-6 Girder erection in winter months utilizing single crane

SECTION 6

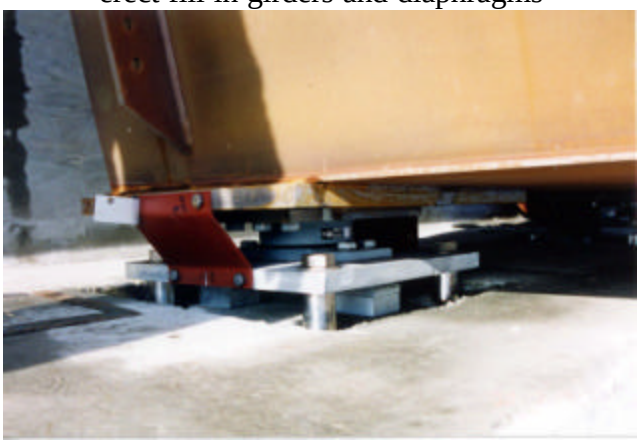
STRUCTURAL STEEL ERECTION

6-7 Summer open water condition requires two cranes and elaborate maneuverings to erect girders

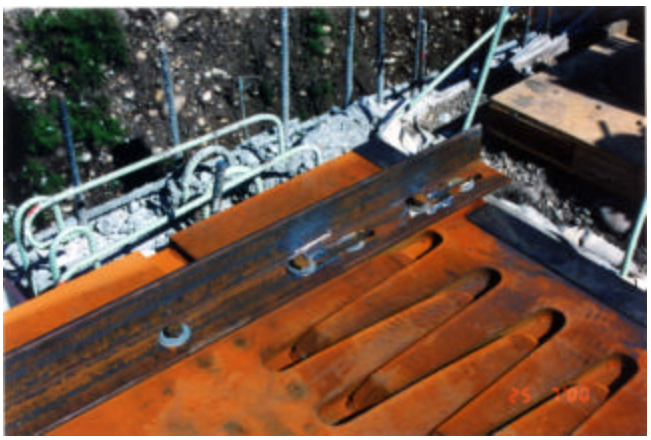
6-10 Finger plate deck joint assembly, delivery and temporary storage

6-8 Summer open water condition requires two cranes and elaborate maneuverings to erect fill in girders and diaphragms

6-11 Deck joint installatio n



6-9 Bearing assembly supported on shim stacks



6-12 Deck joint gap set in accordance with the “Expansion Gap Setting Table”

SECTION 6

STRUCTURAL STEEL ERECTION

6-13 Casting in abutment side of finger plate deck joint

6-16 Delivery, handling and temporary storage

6-14 Pressure grouting voids under the finger plates

6-17 Girder delivered to site by truck

6-15 Steel plate girders off-loaded from railcar with braces installed to stabilize girders

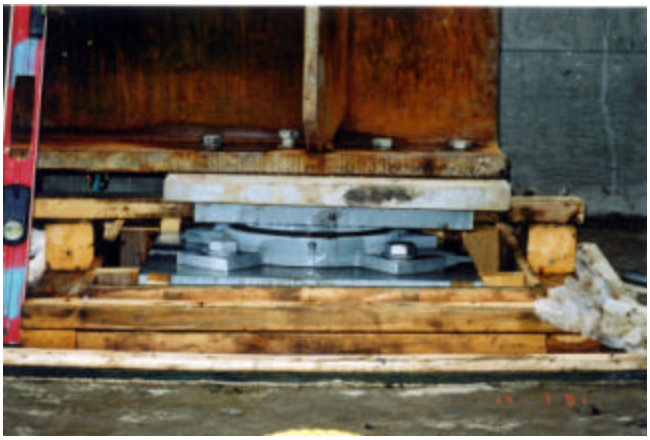
6-18 Erecting girder between abutment and temporary support tower at splice location

SECTION 6

STRUCTURAL STEEL ERECTION

6-19 Steel plate girders are erected in pairs and are stabilized with steel diaphragms

6-22 Splice connection on top of support tower with 50% bolts and 50 % pins



6-20 Setting abutment expansion bearing in accordance with the "Expansion Bearing Setting Table"

6-23 Girder erection between piers

6-21 Setting pier fixed bearing

6-24 Splice connection in the air