



## 12-2 GUIDELINES FOR IDENTIFICATION OF STEEL BRIDGE MEMBERS

### General

Steel bridge members shall be identified as *Fracture Critical Member (FCM)*, *Main Member*, *Secondary Member* or *Primary Components of Main Member* in order to:

- Implement “AASHTO/AWS Fracture Control Plan (FCP) for Non redundant Members” and Nondestructive Testing (NDT) specified by the current AASHTO/AWS D1.5, Bridge Welding Code. This ensures that steel bridges with critical tension components will be useful and serviceable during the design life.
- Ensure that main tension members or components conform to the supplementary toughness requirement specified by ASTM A 709/A 709M-01 (AASHTO M 270M/M 270-02) S4 for “Non-Fracture-Critical, *T*, Material; Toughness Tests and Marking” and S5 for “Fracture-Critical, *F*, Material; Toughness Testing and Marking”.
- Comply with the federally mandated Fracture Critical Inspection Program requirements of the National Bridge Inspection Standards, Code of Federal Regulations, 23 Highways, Part 650, Subpart C.

### Responsibility

It is the bridge designer’s responsibility to identify *FCMs*, *Main Members*, *Secondary Members* and *Primary Components of Main Members* in designing a new steel bridge, or widening, strengthening, and seismically retrofitting an existing bridge with steel members/components and to designate or tabulate them on the contract documents (plans and/or Special Provisions). However, *FCMs* and a *FCP* must not be used indiscriminately by the designer; (1) as a means to require additional testing, (2) to meet more stringent material properties, or (3) to circumvent good engineering and fabrication practices. These designations trigger specific fabrication criteria.



## Definitions

*Bridge* – Any structure having an opening not less than 20.0 ft that forms part of a highway or that is located over or under a highway. For a bridge widening, strengthening or seismic retrofit, the newly designed structure and the existing structure should be considered as one bridge only if the newly designed structure, including deck and other components, and the existing structure are structurally connected. Otherwise, the newly designed structure should be considered as a separate bridge or structure. When the widened deck is separated by a longitudinal joint, the widened structure should be considered as a separate bridge.

*Fracture Critical Members (FCMs)* – Tension members or tension components of bending members (including those subject to reversal of stress) whose failure would be expected to result in collapse of the bridge.

*Main Members* – Any members on a critical load path that carry bridge dead and live loads. The loss of capacity of those members would have serious consequences on the structural integrity.

*Primary Components of Main Members* – The individual components that make up a main member (webs, flanges, stiffeners, etc.).

*Secondary Members* – Any members other than main members, not designed to carry primary load.

*Nondestructive Testing (NDT)* – Test methods used to evaluate an object, material, or system without impairing its usefulness. Visual inspection is considered a form of NDT. Regarding the AASHTO/AWS D1.5, Bridge Welding Code, NDT refers to ultrasonic (UT), radiographic (RT), magnetic particle (MT), and dye penetrant (PT) testing.

## Identification Guidelines

### Fracture Critical Members (FCMs)

The *FCM* designation must only be used for main members in tension or tension components of bending members (including those subject to reversal of stress) whose failure would cause the bridge or the bridge system defined above to collapse. Redundant tension members are not *FCMs*. Redundancy means that should a tension member or tension component fail, the load carried by the failed member could be redistributed to and carried by remaining members to avoid catastrophic collapse of the structure.



The members or components, including but not limited to the following, shall be explicitly identified on the plans or in the Special Provisions as *FCMs* only if their failure would cause a bridge to collapse:

- Tension ties in arch bridges,
- Tension members in truss bridges,
- Tension flanges and webs in two-girder bridges,
- Tension flanges and webs in single or double box girder bridges,
- Tension flanges and webs in floor beams/cross girders,
- Tension braces in the cross frame of horizontally curved girder bridges,
- Attachments welded to a *FCM* when their dimension exceeds 4 in. (100 mm) in the direction parallel to the calculated tensile stress in the *FCM*,
- Tension components of bent caps,
- Splice plates of a *FCM*, and
- All welds to *FCMs* in the tension zone.

The following members or components should not be identified as *FCMs*:

- Members or components that are not subjected to tensile stresses under any conditions of live load,
- Compression members and components,
- Attachments welded to the compression areas of bending members, and
- Tension flanges and webs in multi-girder (3 girders and more) bridges.

For those main tension members within a seismic load path in an Important Bridge as defined in MTD 20-1, if there is a need to increase material and inspection requirements for those members similar to *FCMs*, those members shall be clearly identified and their material and inspection requirements shall be explicitly specified on the contract documents (plans and/or Special Provisions).

It is considered undesirable from an operation and maintenance standpoint to have a bridge member reach its nominal resistance as determined by the current AASHTO-LRFD Bridge Design Specifications and the California Amendments. In general, the *FCMs* can be identified by removing the tension member or component and checking the remaining members to see if any members have reached their nominal resistance under combined unfactored dead and unfactored vehicular live loads HL-93 with dynamic load allowance  $IM = 33\%$ .

For a statically determinate drive-through-truss bridge, all tension members are *FCMs*. The flowchart shown in Figure 1 may be used to locate *FCMs* for a complex bridge system.

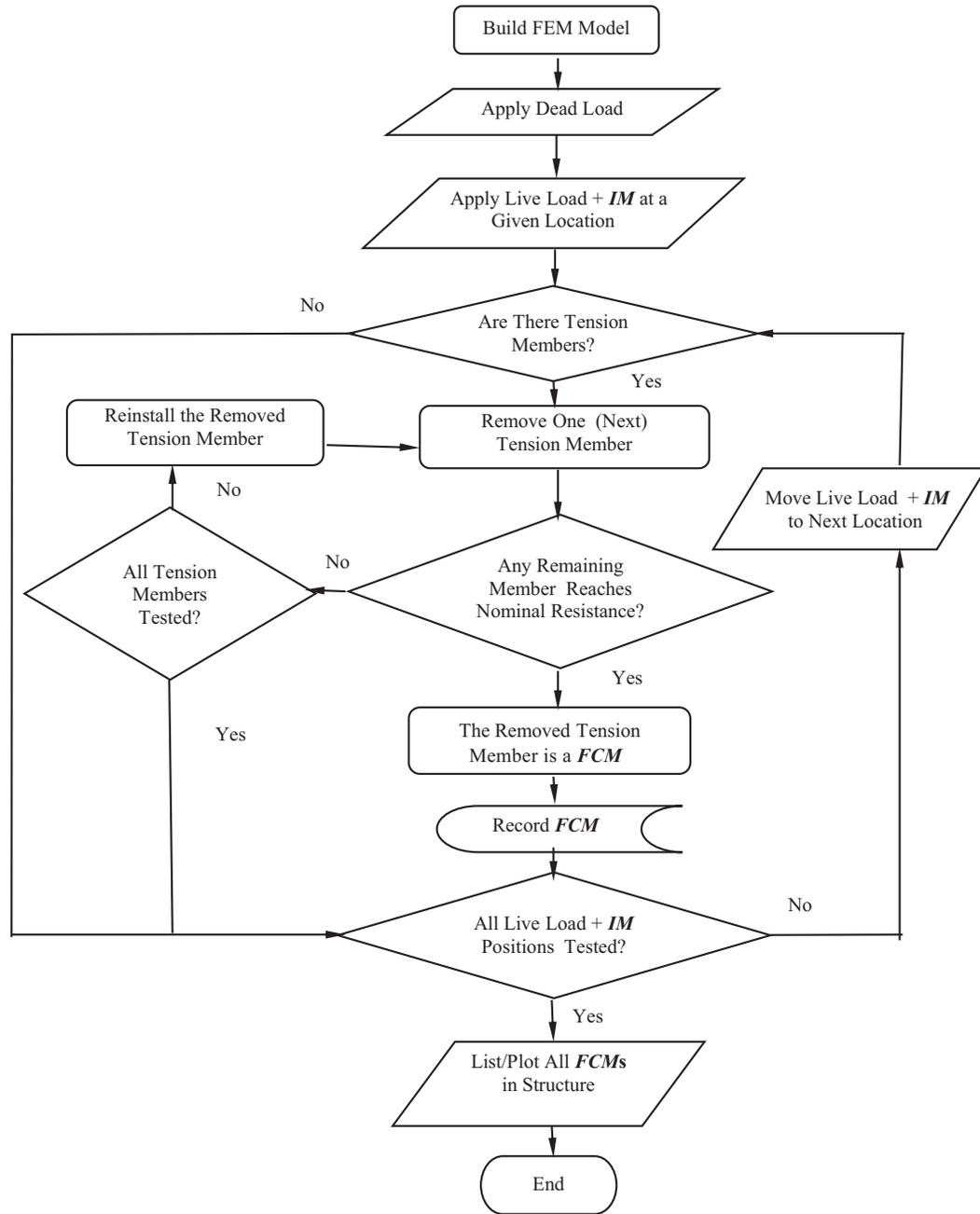


Figure 1 Flowchart for identifying FCMs of complex steel bridges.



## Main Members

The members or components, including but not limited to the following, shall be explicitly identified on the plans or in the Special Provisions as *Main Members*:

- Beam/girders, bent caps,
- End Cross frames/diaphragms,
- Cross frames/diaphragms in horizontally curved girder bridges,
- Columns, arch ribs and tower members,
- Suspenders/tension ties and anchorage,
- Truss diagonal and chord members, and
- Suspension cables and anchorages.

## Primary Components of Main Members

The following components, including but not limited to the following, shall be explicitly identified on the plans or in the Special Provisions as *Primary Components of Main Members*:

- Flanges, webs, splice plates and cover plates,
- Transverse and longitudinal stiffeners and bearing stiffeners,
- Gusset plates, diaphragm sealing plates, stay plates and lacing, and
- Eye bars and hanger plates.

The labeling of main members and primary components of main members as tension (T) or compression (C) invokes fabrication practices as specified in AASHTO/AWS D1.5, Bridge Welding Code. In particular the designation *Main member* directs the Contractor to follow the NDT as prescribed in the Code for non-FCMs.

## Secondary Members

Secondary members need not be identified in the project documents. The following components, including but not limited to the following, shall be considered as *Secondary Members*. Members not delineated as *Main Members* or *Primary Components of Main Members* are treated as *Secondary Members* for the purposes of fabrication:

- Column casing, and
- Cross frames or diaphragms between straight girders.

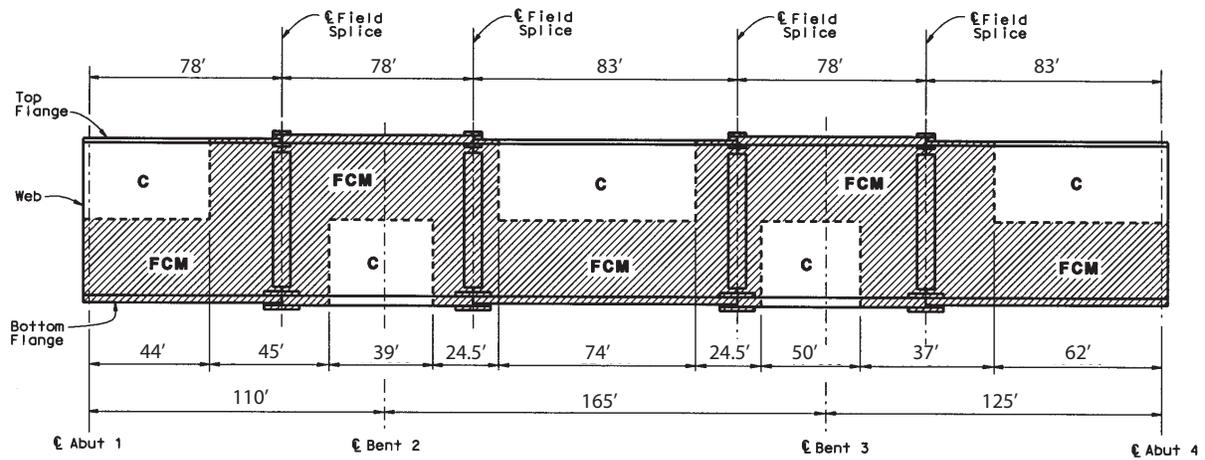


## Design Implementation and Examples

- All *Fracture Critical Members* shall be designated as *FCMs* explicitly on the contract documents (plans and/or Special Provisions).
- All *Main Members (Non-Fracture-Critical)* subjected to tensile stresses and tension components of bending members (including those subject to reversal of stress) shall be designated as “*T*” explicitly on the contract documents (plans and/or Special Provisions). The Charpy V-notch (CVN) impact values listed in Section 55.1.02A(2) of the Standard Specifications are for Zone 2 for non-fracture-critical members. For service temperature from  $-35^{\circ}\text{C}$  ( $-31^{\circ}\text{F}$ ) to  $-51^{\circ}\text{C}$  ( $-60^{\circ}\text{F}$ ), Zone 3 CVN values shall be inserted into the Special Provisions.
- All *Main Members* subjected to only compressive stresses and compression components of bending members shall be designated as “*C*” explicitly on the contract documents (plans and/or Special Provisions).
- All *Main Members* subjected only to shear stresses need not be designated on the contract documents (plans and/or Special Provisions), unless identified by *FCM*, *T* or *C*.
- *Primary Components of Main Members* need to be identified. A note describing the primary components of main members could be added on the contract documents (plans and/or Special Provisions). For example, for a straight girder bridge, a note such as *Primary Components of Main Members* are flanges, webs, splice plates and cover plates, transverse and longitudinal stiffeners and bearing stiffeners should be added.
- *Secondary Members* need not be designated explicitly. Instead, a note such as All members not designated as either *FCMs*, or *Main Members* are *Secondary Members* should be added on the contract documents (plans and/or Special Provisions).
- The temperature zone in which the structure will be constructed shall be noted on the contract documents (plans and/or Special Provisions).
- For a girder, *FCM*, *T* and *C* zones shown extended to the middle depth of the web shall be added on the contract documents (plans and/or Special Provisions).

### Example 1 - FCM Designations

The following figure shows FCM designations for a two-girder bridge.



**Notes:**

FCM – Denotes Fracture Critical Member

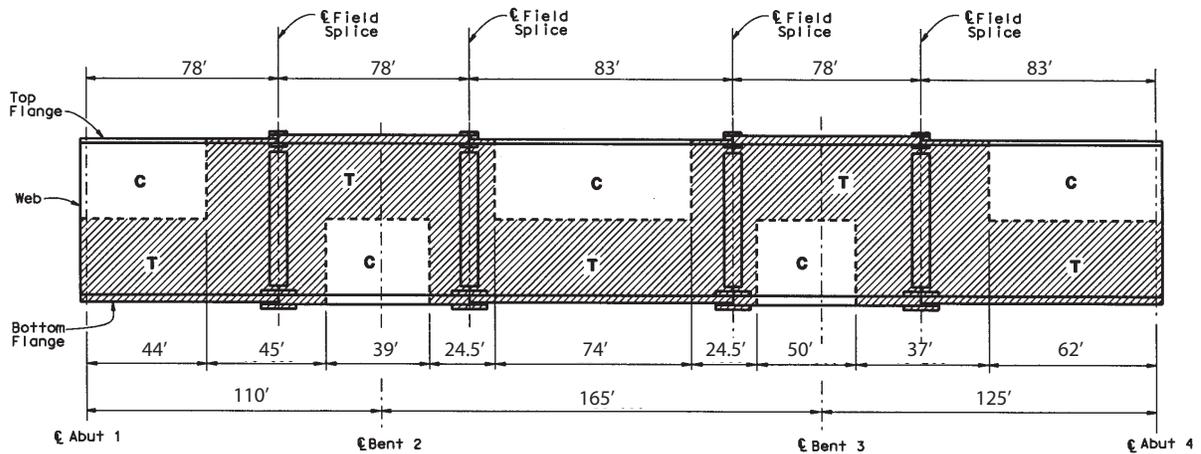
C – Denotes Main Compression Member

FCM and C zones shown extend to the middle depth of the web

**Figure 2 FCM Designations.**

### Example 2 – Main Member Designations

The following figure shows *Main Member* designations for a four-girder bridge.



**Notes:**

- T – Denotes Main Tension Member (Non-Fracture Critical Member)
- C – Denotes Main Compression Member
- T and C zones shown extend to the middle depth of the web

**Figure 3 Main Member Designations.**

*Original signed by Barton J. Newton*

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