



Illinois Department of Transportation

Memorandum

To: ALL BRIDGE DESIGNERS 23.1

From: Jayme F. Schiff 

Subject: Nonredundant Steel Tension Members in Design

Date: August 25, 2023

Bridges with Nonredundant Steel Tension Members (NSTMs) require hands-on inspection by qualified inspectors at an interval defined in the Illinois Department of Transportation (IDOT) *Structural Services Manual* Section 3.4.5 – Fracture Critical Member Inspection Interval. This hands-on inspection often requires additional equipment, such as manlifts and snooters, and the accompanying lane closures to accommodate said equipment. This results in considerable traffic delays and monetary costs to the motoring public and bridge owners.

To avoid these costs, some members that do not have load path redundancy may be shown to be system redundant or internally redundant, therein removing the NSTM classification and the hands-on inspection requirements. In order to classify a member as redundant, Federal Highway Administration (FHWA) requirements must be met. These requirements are provided in the May 9, 2022, FHWA memorandum titled [“Inspection of Nonredundant Steel Tension Members”](#).

The May 9, 2022, FHWA memorandum was written in response to new updates to the [National Bridge Inspection Standards \(NBIS\) in 23 CFR part 650, subpart C \(23 CFR 650.C\)](#) that became effective June 6, 2022.

To reduce costs associated with NSTM inspections, primary steel tension members without load path redundancy should be designed as system or internally redundant whenever possible. The purpose of this memorandum is to clarify guidelines for the classification of primary steel tension members in accordance with FHWA and NBIS policies.

This memorandum provides guidance on the following:

- Definitions of types of redundancy for steel members
- Classification of member redundancy
- Required submittals and plan details for system redundant, internally redundant, and nonredundant members

The policies in this memorandum apply to newly designed yet to be constructed bridges only.

Definitions of Types of Redundancy for Steel Members

The first update resulting from the latest NBIS is the introduction of the term Nonredundant Steel Tension Member, defined as a primary steel member fully or partially in tension, and without load path redundancy, system redundancy or internal redundancy, whose failure may cause a portion of or the entire bridge to collapse. The

term NSTM replaces the term Fracture Critical Member (FCM). The design, fabrication, in-service inspection, and load rating requirements currently in place for FCMs shall apply to NSTMs.

The second update resulting from the latest issuance of the NBIS is the formal recognition of the following sources of redundancy:

Load path redundancy: A redundancy that exists based on the number of primary load-carrying members between points of support, such that fracture of the cross section at one location of a member will not cause a portion of or the entire bridge to collapse.

FHWA considers the primary longitudinal load-carrying members in bridges with three or more primary load-carrying members to be load path redundant members, (e.g., girders in a three-girder system). A redundancy evaluation is not necessary for the determination of load path redundancy, as it is for system redundancy or internal redundancy.

Primary steel tension members that do NOT have load path redundancy are by default considered NSTMs, unless system redundancy or internal redundancy is shown. The list of members that IDOT considers to NOT have load path redundancy can be found in the [IDOT Structural Services Manual Section 3.3.5.1](#) as well as in the coding instructions of [Item No. 92A1 in the Illinois Highway Information System Structure Information and Procedure Manual](#). Note that the documents referenced are current as of June 2023 and that IDOT is currently working on updates to both of these documents.

System redundancy: A redundancy that exists in a bridge system without load path redundancy, such that fracture of the cross section at one location of a primary member will not cause a portion of or the entire bridge to collapse.

To demonstrate system redundancy it is necessary to evaluate the structure following a hypothetical failure of a primary load carrying member, as the number of primary load carrying members is not sufficient to demonstrate load path redundancy. Therefore, refined structural analysis is typically required to demonstrate system redundancy.

Internal redundancy: A redundancy that exists within a primary member cross-section without load path redundancy, such that fracture of one component will not propagate through the entire member, is discoverable by the applicable inspection procedures, and will not cause a portion of or the entire bridge to collapse.

Internally redundant members are typically built-up sections, where failure of one component in a section will not result in failure of the entire section.

NSTMs are typically classified as such due to the lack of load path redundancy. If a recognized source of redundancy is demonstrated, NSTM classification may be modified and, therefore, NSTM inspection requirements would no longer apply.

IDOT expects that new bridges will be designed with no NSTMs; however, it is understood that in some instances, it is not possible or practical for all primary steel tension members to be load path redundant. For such instances, IDOT considers system redundancy as the preferred source of redundancy to avoid primary steel members to be classified as NSTMs. Internal redundancy is considered as an alternate source to be considered when system redundancy cannot be demonstrated.

Classification of Member Redundancy

According to NBIS Section 650.313(f)(1)(i), a State transportation department may choose to demonstrate a member has system or internal redundancy such that it is not considered a NSTM. Current classification of a NSTM may be modified if a recognized source of redundancy is demonstrated. System redundancy and internal redundancy require analysis supplemental to conventional design. Supplemental analysis shall be based on a nationally recognized method.

The following guide specifications are considered nationally recognized methods for System Redundant Member (SRM) and Internally Redundant Member (IRM) analysis.

Herein referred to as the “SRM Guide Specifications”:

AASHTO Guide Specification for Analysis and Identification of Fracture Critical Members and System Redundant Members, First Edition, 2018

Herein referred to as the “IRM Guide Specifications”:

AASHTO Guide Specifications for Internal Redundancy of Mechanically-Fastened Built-Up Steel Members, First Edition, 2018 with 2022 Interims

These Guide Specifications establish analytical processes and requirements, loading, and performance criteria that a member classified as a NSTM needs to meet to be re-classified as an SRM or an IRM. For a particular bridge redundancy evaluation, modifications to the approaches outlined in the *IRM Guide Specifications* or *SRM Guide Specifications*, or other alternative nationally recognized methods may be accepted by IDOT at its discretion.

Primary steel members that do not have load path redundancy, in which both system and internal redundancy are demonstrated are considered as SRMs for inspection purposes, (i.e., they are not subject to the inspection requirements of IRMs). It should be noted that designers are not required nor expected to demonstrate both system redundancy and internal redundancy.

There may be cases where members may not be able to be classified as system or internally redundant. In these cases, the members will be required to be classified as NSTMs.

Submittals

The intent to classify members as SRMs, IRMs, or NSTMs should be communicated as early as possible in the planning and design phase and shall be included in the Plan Development Outline (PDO). The PDO shall include identification of the members to be classified as SRMs, IRMs or NSTMs.

Designers shall submit a signed and sealed stand-alone written summary of the redundancy analyses along with the Final Structure Plans for acceptance and records. The summary shall include:

- 1) Identification of the members subjected to a redundancy analysis.
- 2) Member designations (i.e., SRM, IRM, NSTM) based on redundancy analysis results.
- 3) Nationally recognized methods used to evaluate redundancy. Any modifications to the nationally recognized methods shall be described.

- 4) In-service inspection requirements for those members designated as IRMs or NSTMs, as applicable. Inspection requirements for load path redundant members and system redundant members are only subject to routine inspection requirements. This does not need to be added to the submittal.

The Final Structure Plans shall reflect all details and notes associated with the redundancy analysis in accordance with this memo.

Plan Details

SRMs: Members in new designs that have demonstrated system redundancy through analysis in accordance with the *SRM Guide Specifications* shall be labeled as SRM in applicable design and in-service inspection documents. SRMs are required to be fabricated in accordance with NSTM fabrication requirements. The following notes shall be included in the design plans for newly designed yet to be constructed bridges containing SRMs:

Note	Application
Members designated as “SRM” are System Redundant Members	All SRMs
Members designated as “SRM” shall be fabricated to satisfy the provisions of Clause 12 of the AASHTO/AWS D1.5M/D1.5 Bridge Welding Code.	All SRMs with welds.
Fabricated plate components of members noted as “SRM” shall satisfy the Fracture-Critical Tension Component Impact Test Requirements, zone 2 specified in AASHTO M 270M/M270 (ASTM A709/A709M).	All load-carrying <u>fabricated plate</u> components of SRMs.
Rolled section components of members noted as “SRM” shall satisfy the Non-Fracture-Critical Tension Component Impact Test Requirements, zone 2 specified in AASHTO M 270M/M270 (ASTM A709/A709M).	All load-carrying <u>rolled section</u> components of SRMs.

IRMs: Members in new designs that have demonstrated internal redundancy through analysis in accordance with the *IRM Guide Specifications* shall be labeled as IRMs in applicable design and in-service inspection documents. IRMs are required to be fabricated in accordance with NSTM fabrication requirements. The following notes shall be included in the design plans for newly designed yet to be constructed bridges containing IRMs:

Note	Application
Members designated as “IRM” are Internally Redundant Members	All IRMs
Fabricated plate components of members noted as “IRM” shall satisfy the Fracture-Critical Tension Component Impact Test Requirements, zone 2 specified in AASHTO M 270M/M270 (ASTM A709/A709M).	All load-carrying <u>fabricated plate</u> components of IRMs.
Rolled section components of members noted as “IRM” shall satisfy the Non-Fracture-Critical Tension Component Impact Test Requirements, zone 2 specified in AASHTO M 270M/M270 (ASTM A709/A709M).	All load-carrying <u>rolled section</u> components of IRMs.

NSTMs: Members in new designs that have not been established as system or internally redundant through analysis shall be labeled as NSTMs in applicable design and in-service inspection documents. The following notes shall be included in the design plans for newly designed yet to be constructed bridges containing NSTMs:

Note	Application
Members designated as “NSTM” are Nonredundant Steel Tension Members	All NSTMs
Members noted as “NSTM” shall be fabricated to satisfy the provisions of Clause 12 of the AASHTO/AWS D1.5M/D1.5 Bridge Welding Code	All NSTMs with welds
Fabricated plate and rolled section components of members noted as “NSTM” shall satisfy the Fracture-Critical Tension Component Impact Test Requirements, zone 2 specified in AASHTO M 270M/M270 (ASTM A709/A709M)	All NSTMs

Implementation

The policies in this memorandum shall be implemented on applicable projects with TS&Ls approved after September 1, 2023, and as soon as practical on newly designed yet to be constructed bridges. Please direct questions to Mark Shaffer, Bridge Design Engineer, by telephone at (217) 785-2914 or email at mark.shaffer@illinois.gov.

This policy will continue to be reviewed and updated as IDOT identifies NSTMs based on lack of load path redundancy. A policy to declassify NSTM members in existing structures will also be developed for future updates.