Shop Detail Drawing Review/Approval Guidelines for Fabricated Structural Steel

G1.1-2020

American Association of State Highway and Transportation Officials

National Steel Bridge Alliance

AASHTO/NSBA Steel Bridge Collaboration

PREFACE

This document is a standard developed by the AASHTO/NSBA Steel Bridge Collaboration. The primary goal of the Collaboration is to achieve steel bridge design and construction of the highest quality and value through standardization of the design, fabrication, and erection processes. Each standard represents the consensus of a diverse group of professionals.

It is intended that Owners adopt and implement Collaboration standards in their entirety to facilitate the achievement of standardization. It is understood, however, that local statutes or preferences may prevent full adoption of the document. In such cases, Owners should adopt these documents with the exceptions they feel are necessary.

DISCLAIMER

The information presented in this publication has been prepared in accordance with recognized engineering principles and is for general information only. While it is believed to be accurate, this information should not be used or relied upon for any specific application without competent professional examination and verification of its accuracy, suitability, and applicability by a licensed professional engineer, designer, or architect.

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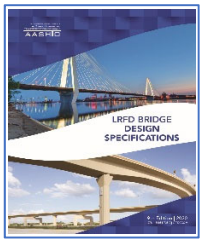
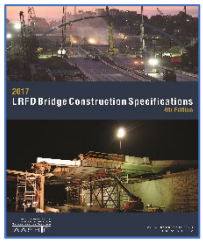


AASHTO LRFD Bridge Design Specifications

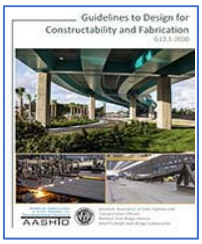


AASHTO LRFD Bridge Construction Specifications

G1.2—Design Drawings Presentation Guidelines

G1.3—Shop Detail Drawing Presentation Guidelines

G1.4—Guidelines for Design Details



G12.1—Guidelines to Design for Constructability and Fabrication

Contents

INTRODUCTION

This document presents guidelines on the preparation, review, and approval of bridge fabrication shop detail drawings and is intended to be used in conjunction with other applicable AASHTO/NSBA Steel Bridge Collaboration documents. This document attempts to standardize the review and approval processes so that consistency and economy is achieved. These guidelines represent a consensus on best practices that if employed will produce quality shop detail drawings in an efficient and economical manner. This is achieved through a collaborative effort between the Fabricator and Owner that includes an understanding of each party's interests and expertise. The intent of this document is to present perspectives of both Fabricator and Owner to better understand each other's needs, identify a common language to promote better communication, and to establish responsibilities of each party to facilitate smooth exchange of information.

The Fabricator has a working understanding of welding and shop processes, shop production, and thermal effects from welding including distortion and restraint. The Fabricator's interest is to maintain work flow, avoid shop delays, maintain employment, and produce economical work. The Owner has a working understanding of the design requirements, conditions to which the structure is subjected, and long-term performance needs. Where the Owner is a public entity, public investment and low life-cycle costs are of interest. The common interest of both Fabricator and Owner is quality products for safe use by the public at an economical cost.

This is achieved through collaborative effort. The Fabricator needs to communicate uncertainties in contract drawings, provide sufficient time in the schedule for Owner review, and recommend workable solutions where Owner-required details cannot be fabricated economically. The Owner needs to provide clear and complete contract documents with constructable details, provide timely reviews and comments, avoid restricting code-accepted practices where not necessary, and avoid late or unnecessary changes. Both Owner and Fabricator must maintain an open dialogue. In projects employing alternative delivery methods, e.g., Design–Build or Public–Private Partnerships, in which the Owner is not responsible for development of final contract drawings or shop drawing review, the goal is the same—collaboration and open dialogue between the Fabricator and project stakeholders

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Section 1: Definitions

Terms used in this document are in accordance with the AASHTO/NSBA Steel Bridge Collaboration standards. Terms that are specifically significant to this document are defined below.

1.1—Contract
The "Contract" includes the design plans, the Owner's standard specifications, supplemental specifications, and special provisions, as well as material specifications and associated industry standards referenced by the Contract, such as those published by the American Association of State Highway and Transportation Officials (AASHTO), American Welding Society (AWS), and ASTM International (ASTM). The Contract is a binding agreement between the Owner and the Contractor, and any changes must be acknowledged and accepted by both parties.

1.2—Shop Detail Drawings
"Shop Detail Drawings" are produced by the Fabricator (or the Fabricator's representative) and define how material is to be prepared, assembled, finished, repaired, or erected, as applicable. The intent of the Shop Detail Drawings is to provide instruction to the fabrication shop regarding how the components are to be fabricated. Shop drawings and erection drawings are types of Shop Detail Drawings. Shop Detail Drawings typically also include general notes and coating instructions.

1.3—Fabricator
The Fabricator is the entity performing such shop activities as cutting, welding, drilling, punching, cleaning, and coating of structural steel. "Fabricator" also includes any agents of the Fabricator, such as those who prepare Shop Detail Drawings. In some cases, the Fabricator may also be the Contractor, but usually the Contractor subcontracts to the Fabricator.

1.4—Detailer
The Detailer is the entity producing the Shop Detail Drawings or documents for the Owner's review and for the Fabricator's use.

1.5—Owner
In this document, "Owner" refers to the entity paying the Contractor to fulfill the terms of the Contract, and could include representatives designated by the Owner. The Owner encompasses the following: those preparing the Contract documents, including the "Designer" responsible for the structure's adequate design; those with the authority to review and approve the Shop Detail Drawings, herein referred to as the "Approver;" and those representing the Owner during fabrication and construction, commonly called the "Engineer." The Designer, Approver, and Engineer may be employees of either the Owner or professional firms contracted for the work.

1.6—Contractor
The Contractor is responsible for proper completion of all tasks required by the Contract. Subcontractors, including Fabricators, erectors, and field painters, may be utilized by the Contractor, but the Contractor retains responsibility for all material, operations, and the final product. The Contractor may permit direct subcontractor interaction with the Owner to expedite the project, but subcontractors must inform the Contractor of any proposed modifications to Contract requirements accepted by the Owner. The Contractor may permit or reject the changes.

1.7—Acceptance

The Owner's acceptance of the Fabricator's Shop Detail Drawings is a verification that the drawings appear to be consistent with the Contract documents. Acceptance or approval does not relieve the Fabricator of the responsibility for the accuracy of dimensions on Shop Detail Drawings or for complete submittals satisfying applicable Contract requirements, nor does it permit deviations from the Contract without the Owner's documented consent.

1.8—Construction Change

Modifications to Contract requirements after award to the Contractor, including changes to design plans, specifications, and special provisions, shall be considered "Construction Changes." These may reflect alterations due to unanticipated site conditions, design plan errors, changes in project scope, Contractor-related problems or Owner-initiated changes. Corrections for Contractor-related problems must be proposed in writing by the Contractor with all necessary details, calculations, material alterations, and/or other pertinent information for the Owner's review and approval.

Section 2: Responsibilities

2.1—Fabricator

2.1.1

The Contractor and Fabricator are responsible for providing Shop Detail Drawings that accurately show the appropriate details, dimensions, material requirements, and other requirements necessary to fabricate and erect components of the structure in conformance with the Contract documents.

2.1.2

If errors or discrepancies are discovered in the Contract documents, they must be brought to the Owner's attention. They can be communicated through the Request for Information (RFI) process, or through a contract design deviation notification accompanying the submission of shop drawings.

2.1.3

The Fabricator must obtain the approval of the Contractor and the Owner before making any modifications to requirements in the Contract documents.

2.1.4

The Fabricator must ensure all material, geometry, and connections shown on the Shop Detail Drawings are in conformance with the Contract, subject to the accuracy of the essential dimensions shown on the Contract documents and any required field-verified information supplied by the Contractor.

2.2—Owner

2.2.1

It is the Owner's responsibility to review the Shop Detail Drawings to ensure that the Fabricator has correctly interpreted the intent of the Contract documents and that details properly reflect material and connection requirements.

2.2.2

Drawings will be returned with the Owner's stamp or signature indicating approval, some type of conditional approval, or rejection.

2.2.3

Rejection, requiring Shop Detail Drawings to be revised and resubmitted, should only be used when drawings either deviate significantly from Contract requirements without the Engineer's prior approval, or are unacceptable due to incompleteness, legibility, or number of errors (see Section 5.1). Uncertainty in attempting to replicate dimensions derived and detailed on the shop drawings should not be cause for rejection.

2.2.4

The time required to review Shop Detail Drawings must be kept to a minimum to enable the Fabricator to schedule fabrication and complete production in a timely manner. Subject to Contract requirements, and unless otherwise agreed between the Owner and Fabricator, drawings for most structures should be returned

within 3 to 4 weeks, though very complex structures can take longer. Partial submittals that include all interrelated drawings should be allowed if this is compatible with the situation and will expedite the project.

2.2.5

Construction Changes to the Contract are normally conveyed to the Contractor, but if changes will affect fabricated items, the Fabricator must also be notified as expeditiously as possible.

2.3—Team Effort

The Contractor, Fabricator, and Owner are responsible for approaching the Shop Detail Drawing submittal, review, approval, and distribution process as a team effort in order to ensure accurate and timely construction of the structure.

Commentary C2.3

Owners (or their agents) review Shop Detail Drawings to "ensure that the Fabricator has correctly interpreted the intent of the Contract documents and that details properly reflect material and connection requirements" (see Section 2.2.1). Regardless of the Owner's review and approval, the Contractor and the Fabricator are responsible for the accuracy of Shop Detail Drawings , the "Fabricator must ensure all material, geometry, and connections shown on the Shop Detail Drawings are in conformance with the Contract," (see Section 2.1.4), and the "Contractor is responsible for proper completion of all tasks required by the Contract" (see Section 1.6).

2.3.1

All parties must cooperate and maintain open lines of communication so problems can be quickly addressed and resolved.

2.3.2

Verbal discussions and agreements are encouraged and should be quickly followed by written confirmation.

2.3.3

Efforts should be made to expedite information and drawing transmission, including use of email, faxes, and electronic file transfer when applicable.

2.3.4

RFIs should indicate the urgency of a reply. The Owner should provide a timely response or acknowledgement (explanation, decision, request for additional information, or estimate of time needed to evaluate), usually within two business days.

2.3.5

The Owner should be receptive to considering alternate fabrication methods or configurations proposed by the Fabricator that will result in equaling or improving the expected performance, maintenance, and longevity of the structure. If necessary, the Owner or Approver should discuss proposals with the Designer and Fabricator to better understand the rationale and potential problems or benefits. The Contractor's acceptance of any modifications that alter the finished product must be verified before submission to the Owner.

Commentary C2.3.5

Some examples of alternative methods or configurations that may be proposed include:

- use of weld joint configurations providing equivalent strength and fatigue resistance (see Section C4.1)
- increase of the thickness of connection plates or intermediate and longitudinal stiffeners to avoid welding problems
- relocation of flange and web butt welds or field splices slightly to miss adjacent details or facilitate use of plate lengths available from mills
- avoiding beveled plates by angling other connections
- reducing residual stresses and possible plate damage by avoiding highly restrained welds
- alteration of a weldment's configuration to permit access for fabrication
- use of two thinner fills instead on one heavier fill
- substituting either equivalent types of material or thicker material due to availability

2.4—Professional Seal

Generally, Shop Detail Drawings do not require the stamp and signature of a registered Professional Engineer (PE). However, there are some circumstances where a PE stamp or seal is warranted. Contract requirements may also mandate this evidence of a PE's review.

2.4.1

All changes to the design of the structure proposed by the Fabricator require the Owner's and Contractor's approval, but not all changes need to be sealed by a PE. Standard practice is for the Owner to approve or reject changes proposed by the Fabricator, based on the anticipated effects on the structure and the Fabricator's justification for the alteration (constructability, reducing distortion or residual stresses, etc.). Fabricator-proposed changes may require a PE seal when they significantly affect structural behavior, construction, or performance.

2.4.2

Value-engineering proposals may require a PE's seal and signature, and a formal submittal from the Contractor to the Owner with all calculations and justifications for the change.

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Section 3: General Review Guidelines

3.1—Materials
The Owner will verify that structural materials conform to the contract documents, unless specific substitutions are approved.

3.1.1
Exceptions are permitted when the Fabricator has received prior documented approval from the Owner for substitutions of equivalent material type, plate thickness, or member size to facilitate purchasing or fabrication. Such substitution should be allowed providing there is no additional cost to the Owner and changes meet the design performance objectives (see Section 2.3.5).

3.1.2

The Owner should permit material substitutions that meet or exceed the design requirements when the specified material grade or size is not readily available. For example, the Owner should consider and permit requests to increase plate thickness when originally specified in increments of 1/16" or requests to substitute an equivalent or larger rolled shaped for one that is infrequently produced. Alternate structural quality materials such as ASTM A606 or A570, with corrosion resistance equal to adjacent material, should be permitted for shims and fills. Substituted material must satisfy specific required properties (e.g., yield, elongation, Charpy V-Notch (CVN) toughness).

3.1.3

Fills and shims do not usually require CVN testing.

3.2—Weld Symbols

3.2.1

Weld symbols on Shop Detail Drawings should be compatible with joints shown on the plans, but for groove welds the Fabricator may prefer joint preparations different than those indicated on the plans. Alternate weld details should be allowed as long as the weld satisfies the intent of the plans and does not violate fatigue constraints.

3.2.2

Fabricators sometimes place Welding Procedure Specification (WPS) identification numbers in the weld symbol tail, indicating the procedure to be used. This may be done for the Fabricator's internal processes or may be a requirement of the Owner. The WPSs must be submitted for the Owner's approval, but for efficiency, this is usually done separately from the Shop Detail Drawing review and approval process. Therefore, unless the Owner requires the WPS identification number on the shop drawings, the Approver does not usually review the weld identification numbers shown. During fabrication, inspectors will ensure that appropriate WPSs, approved by the Owner, are used.

3.3—Format
Fabricators have different systems for detail drawing presentation, such as drawing order and designations, piece marking, location of dimensions, and wording of notes governing shop procedures. The Owner should not review or mandate the format.

3.4—Submittal Procedures

Shop Detail Drawings should be submitted and returned by the most expeditious routing consistent with the Contract documents. The Owner should work with the Fabricator, the Contractor, and other related parties to establish the most effective procedures. Subject to concurrence by the Contractor and Owner, submission of review copies from the Fabricator directly to the Approver, via electronic delivery, is optimal. Shop drawings should be submitted and returned electronically as much as possible, allowing for concurrent transmission to various stakeholders.

3.5—Number of Drawing Copies

If hard copies of the shop drawings are required, the Contract documents should indicate the number of drawing copies needed for each step in the review, approval, and distribution process, and whether any reproducibles must be supplied to the Owner or other parties.

3.6—Reduced-Size Copies

If hard copies of the shop drawings are required, the use of reduced-size (11 in. × 17 in.) copies, rather than full-size drawings (22 in. × 34 in. or 22 in. × 36 in.), may be permitted by the Owner for review and distribution. Clarity and legibility of details, notes, and material lists must be maintained with any format used to avoid errors and provide a permanent record for future maintenance and structural evaluation. Adequate space must be provided for approval stamps on each drawing.

3.7—Accuracy

Steel fabrication details are normally shown to the nearest 1 mm ($^{1}/_{16}$ in.), but if details vary from plan dimensions by small amounts, the details should be approved unless a significant cumulative error results. Machined surfaces are an exception to this tolerance.

3.8—Drawings Not Required

Depending upon the Owner, some minor fabricated items—such as drains, pedestrian fencing, and armor bars for compressible seal joints—may not require submittal of Shop Detail Drawings for review. The Fabricator should research the Contract documents or contact the Owner to determine any such policy and save preparation and review time.

Section 4: Approval Items to be Checked

The following is a list of common items that should typically be checked on Shop Detail Drawings. This list is also provided in checklist form in Appendix A. Unusual designs may contain unique details that are beyond the scope of this guide and not fully covered here. The Approver's judgment must prevail in determining the extent and depth of review on each project.

4.1—General Notes and Detail Sheets for Cleaning and Coating

- Governing standard and project-specific specifications
- Standard details (weld terminations, plate clips, match marking, etc.)
- Corner preparation (if required for cut edges)
- Cleaning, required surface preparation (SP6, SP10, etc.), and profile depth (if specified)
- Shop Primer: type, manufacturer, wet or dry film thickness range, verification of cure before shop application of subsequent coats, applicable restrictions on field contact (faying) surfaces, any requirements for pre-priming shop contact surfaces before assembly (e.g., inside boxes, shop-bolted assemblies), and designation of any field weld areas to be left unprimed
- Intermediate and Top Paint Coats: type, manufacturer, wet or dry film thickness range, intermediate coat cure times or recoating time if specified by the Contract documents or paint manufacturer's data sheet, any blockout areas where shop topcoats are not permitted (e.g., field splices, diaphragm/cross frame connections, bearings)
- Other Coating Systems, such as hot dip galvanizing, metalizing, metalizing seal coat

Commentary C4.1

Unless superseded by Contract document requirements, surface preparation and coating application should be governed by the manufacturer's product data sheet instructions. All coats in a system (primer, intermediate, and top) should come from the same manufacturer to insure compatibility and accountability. The shop coat manufacturer should be shown on the Shop Detail Drawings to ensure the field coat(s) comply.

4.2—Erection Framing Plan Details

- Centerline of bearing to centerline of bearing lengths and, where appropriate, transverse girder spacing
- Pier and abutment identifications
- Identification/presence of field splices
- Orientation of structure (north arrow), skew, spot checks of curve or flare geometry if shown
- Adjustments for special bearings, expansion joints, or other items not adequately covered by the contract plans to compensate for temperature or other variables where applicable
- Piecemarks indicated for every element, and their relative location (end, side) is shown to clarify member orientation
- Erection notes in accordance with contract documents

4.3— Material and Material Testing

- Designation of material, tension zones, and welds for Fracture Critical Members (FCMs), including applicable nondestructive testing
- Material specified in accordance with the Contract documents

- Substitutions for material less than 10 mm ($^3/_8$ in.) thick, especially fills and shims (see Section 3.1)
- Substitutions for material over 10 mm ($^3/_8$ in.) (see Section 3.1)

4.4—Principal Controlling Dimensions, Material Properties, and Connection Properties

The following principal controlling dimensions, material properties, and connection properties should be considered essential items for reviewing all Shop Detail Drawings:

- Total structure length and length of spans, e.g., the horizontal distance between bearings, pin centerlines or other points of support, and horizontal curvature
- Thickness and width of plates in primary members and splices
- Designation of rolled shapes
- Diameter, specification, and grade of mechanical fasteners (e.g., bolts, nuts, studs, couplers), and coating if required (e.g., mechanically galvanized or hot-dip galvanizing)
- All dimensions of machined pins, hangers, and complex bearings
- Specification, grade, and, when required by the Owner, toughness testing requirements for steel components
- Bottom of steel elevations or elevation of seats or other bearing supports for steel members when bearings or supports are provided by the Fabricator
- Weld details and symbols, including size of fillet welds and partial joint penetration welds, and appropriate partial and complete joint penetration weld configurations
- Members or areas of members to be painted or coated

Commentary C4.4

The Owner should adequately check geometry to verify that the shop details generally conform to the intent of the design and permit proper assembly. Shop girder laydown diagrams should be selectively checked to ensure the girder profiles are consistent with the plan configuration, including support locations. Spot checks among similar members may suffice, but if errors are found, more in-depth reviews are needed.

Longitudinal and lateral dimensions in the Contract plans are usually in the horizontal plane, but Shop Detail Drawings reflect true dimensions along the individual member and account for changes in slope, grade, and camber corrections, so the Approver must consider this in the review. Small inconsistencies between the Approver's calculations and detail dimensions for items such as camber or sweep ordinates should not be noted for correction as fabrication tolerances in the Contract documents permit such deviations and they will not impede construction or affect performance.

Fillet welds are usually based on the minimum sizes permitted by the current AASHTO/AWS D1.5/D1.5M *Bridge Welding Code* (BWC). The minimum required fillets are 6 mm (¼ in.) for material up to 20 mm ($^3/_4$ in.) thick and 8 mm ($^5/_{16}$ in.) for heavier plates, minimizing residual stress and distortion, especially on thin material. In areas of high shear or when two plates must act together, larger fillet welds may be needed, and these should be specified on the plans. In production, flange-to-web welds are terminated on weld tabs beyond the limits of the completed member, so they are continuous, but stiffeners and connection plates have fillet welds terminating on webs and flanges. These welds should end about 6-mm (¼-.) away from an edge (snipe, clip, etc.) to help ensure a quality weld termination (see NSBA Guideline document G1.4, *Guidelines for Design Details*, for specific weld termination guidance). There are various configurations of complete joint penetration (CJP) and partial joint penetration (PJP) welds, and the Fabricator should be allowed reasonable latitude in selecting a joint that meets the design requirements. Preferred joint configurations are shown in the BWC. If the plans necessitate a joint not shown in the BWC (e.g., a fillet or CJP weld between two converging plates with a 25-degree included angle), the Fabricator can pursue alternate joint qualification in accordance with the BWC, and this should be considered by the Owner (see Section C2.3.5).

4.5—Welded Girders and Hot-Rolled Beams

- Shop butt weld splice locations
- Flange and web tapers and haunches (controlling dimensions only)
- Cover plate dimensions and termination details.
- Location of tension and compression zones in welded members
- Length of field sections
- Drip bar details and other attachments on member
- Field section piecemarks match proper location on erection plan
- Size and grade of material in bill of materials
- Shear connector size and spacing, if shop installed
- Bolt hole spacings, edge distances, and compatibility of bolt pattern with connection details
- Faying surface treatment

Commentary C4.5

Some Owners may also require tension zones to be identified on flanges to clarify welding and nondestructive evaluation (NDE) requirements; verification of minimum and maximum lengths between welded splices; or approval for butt welds not shown on the design plans. Some Owners have stipulations regarding the relative proximity of plate girder flange and web butt welds, as well as nearby stiffener or connection plate attachment welds.

4.6—Stiffener and Connection Plates

- Width, thickness, material grade, and toughness testing, if required (e.g., curved bridge, floor beam connection)
- Weld size and termination details and bolting to web and flange details
- Appropriate spacing of intermediate stiffeners
- Avoiding interference with shop web and flange splice locations and anchor bolts
- Fit, location, and orientation (vertical or normal to grade) of stiffeners and connection plates
- Bolt hole edge distances and compatibility with diaphragm/cross frame connections.
- Plate clip details
- Verification that plate piecemarks are incorporated into proper assembly (e.g. in proper girder or stringer)

Commentary C4.6

Bearing stiffeners typically stipulate “mill to bear” at the flange attached to the bearing to insure direct, steel-to-steel load transfer. This may also be achieved by a “grind to bear” or “finish to bear,” especially where stiffeners are not perpendicular to flanges. The opposite end of the bearing stiffener is normally “tight fit,” thereby forcing the bearing end into intimate contact. The *Bridge Welding Code* establishes requirements for the fit of bearing ends of bearing stiffeners and the end of intermediate stiffeners specified to be “tight fit,” so they need not be further defined on the drawings. Intermediate stiffeners, connection plates, and girder webs (even over bearings) do not require “mill to bear” or “tight fit.” The *AASHTO LRFD Bridge Design Specifications* (9^{th} Edition) require bearing stiffeners supporting diaphragms or cross frames to be attached to the flanges, but this does not eliminate the requirement for a bearing fit at the supporting flange.

4.7—Bolted Splices

- Length and width of flange splices, width and depth of web splices
- Number, size, and spacing of bolts and holes in splice material
- Fill plates if necessary
- Proper bolt hole edge distances

Commentary C4.7

Computer numerically controlled (CNC) equipment may typically be used in lieu of manual drilling or subpunching and reaming, and should be considered. The Approver should contact the Owner if the Fabricator proposes a method not specifically allowed by the Contract documents. When the Contract plans specify edge distances, the Fabricator may increase them (including at the girder ends) slightly, as long as splice plates neither encroach fillet welds nor interfere with adjacent material. This may avoid problems if a drill or plate is not exactly positioned. Bolt lists should reflect adequate additional bolts for testing, loss, etc. For slip-critical connections, bolt holes may be drilled or reamed in assembly to ensure accuracy, but this may not always be possible or practical. CNC equipment, templates with hardened steel bushings, field drilling or reaming, and other methods may be used in lieu of assembly if permitted by the Contract documents and accuracy and quality (e.g., holes not elongated) can be assured. This may include a limited number of check assemblies or comparative templates.

4.8—Cross Frames and Diaphragms

- Global geometry (e.g., center-to-center of girder webs, girder depth)
- Distances between work points
- Cross frame member sizes and material grade
- Weld details, sizes, lengths, and terminations
- Gusset plate thickness, general shape, and material grade
- Number, size, and spacing of connection plate bolts, edge distances, and type of holes, especially for slip critical connections or details required for differential deflections. Compatibility of bolt pattern with connection details
- Faying surface treatment
- Shear connector size and spacing on cross frames or diaphragms, if shop installed
- Verification that component piecemarks are incorporated into proper assembly (e.g., in proper cross frame or diaphragm)
- Piecemarks match proper location on erection plan
- Verification that members are detailed for the fit condition specified on the Contract Plans, if applicable

Commentary C4.8

Depending on the structure's cross section and the plan details, the Fabricator may have considerable latitude in detailing cross frames. The Approver should only verify that the proposed geometry and joining methods will satisfy the intent of the design. Unless critical to the assembly's structural performance, such items as the exact length and orientation of cross frame components, shapes of gusset plates, and whether rows of bolts are parallel to the girder web or the edge of the gusset may be left to the Fabricator's preference. If the plans stipulate slotted holes or other provisions to accommodate differential movement or to limit rotation of adjacent girders, the bracing must incorporate these considerations. Provisions to control differential deflection or lateral movement (twist) during construction should be addressed on the Contract plans or agreed to between the Owner and Contractor.

4.9—Camber and Sweep

- Length of field section (e.g., sloped and horizontal distances along reference line)
- Length of span (e.g., sloped and horizontal distances along reference line)

- Elevation of supports, if applicable
- Offsets to bottom of steel from reference line; camber ordinates (spot check)
- Sweep ordinates, radius, point of curvature (POC), or point of tangency (POT) of girders (spot check)
- Piecemarks match shop details

4.10—Shop Assembly Diagrams

- Elevation at center of span or segment, elevation at field splice, elevation at abutment, and elevation at pier ordinates

4.11—Incorporation of all necessary revisions into the Shop Detail Drawings

- Errors or discrepancies in the Contract plans discovered during Shop Detail Drawing preparation or review
    - Such errors must be conveyed to the Owner and the Contractor to determine and implement appropriate corrective actions. Depending on the extent, importance, and urgency, Contract plan corrections or project modifications may be distributed by the Owner as Construction Changes or notification may be verbal, followed by written documentation to all parties.
- All Construction Changes that affect the Shop Detail Drawings
    - Recent Construction Changes not incorporated into the Shop Detail Drawings do not usually justify rejection. Unless changes will drastically alter fabrication details, a copy of the Construction Change may be returned with "approved as corrected" or "approved as noted" Shop Detail Drawings in such circumstances. Note: Corrections noted on Shop Detail Drawings do not constitute "Construction Changes" and should not be used to informally effect Construction Changes.
- Fabricator-proposed modifications approved by the Owner and Contractor
    - These include deviations from the Contract requirements, substitutions of material, or modifications to the Contract plan details, based upon the Fabricator's request (at no cost to the Owner), that have received prior approval from the Owner and Contractor.

4.12—Fabricator Questions on Shop Drawings

- Answer or acknowledge all appropriate questions noted on Shop Detail Drawings as "Engineer verify" (does not include "Contractor verify" or "Field verify" queries that must be resolved by others before final Shop Detail Drawing approval)

4.13—Compliance with Owner-Specific or Project-Specific Requirements that May Supersede the Requirements of This Checklist

- Inclusion of Owner requirements for sheet title box information (e.g., contract number, bridge identification number, pay item)
- Verification that standard title box notes (e.g., hole diameter, welding, coating) do not conflict with Contract requirements
- Proper notation of revision date and number on revisions after the first submission
- Miscellaneous project-specific items such as utility attachments, special connections or connection materials (e.g., pins, links, cables), and stage removal and construction
- Professional Engineer Seal, if required
- Design calculations associated with Fabricator-proposed changes, if applicable and required

4.14—Special Needs for Special Structures, Including Truss, Cable-Stayed, Suspension, Tied Arch, and Movable (e.g., Lift, Swing, Bascule) Bridges:

- Number and spacing of bolts in floor beam and cross girder connections as well as special attachments (e.g., brackets, pot bearings)
- Handling instructions or temporary fixtures for lifting, positioning, and transportation
- Protection of critical components and connections
- Dimensional controls required for shop and field assembly

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Section 5: Return and Distribution of Drawings

5.1—Acceptance Levels

5.1.1

Acceptable Shop Detail Drawings should be "Approved" and expeditiously returned to the Fabricator.

5.1.2

The Shop Detail Drawings should be conditionally accepted ("Approved as Noted," "Approved as Corrected," "Accepted Subject to Comments," etc.) if required corrections are limited and the Owner is satisfied that the drawings fundamentally satisfy the Contract. Examples of limited corrections include sporadic, minor dimensional errors and shop notes not fully consistent with specifications or special provisions. Conditional approval permits the Fabricator to proceed with fabrication (subject to the comments marked on the shop drawings or other Owner restrictions). The Owner may require resubmittal of the corrected Shop Detail Drawings for final approval.

To help eliminate schedule delays associated with resubmittal cycles of "Rejected" or "Revise and Resubmit" shop drawings, every effort should be made by Approvers to return shop drawings stamped "Approved as Noted" if the drawing cannot be returned "Approved." In many cases, direct communication between the Approver and Detailer can resolve discrepancies or eliminate questions, thus enabling the Approver to return the shop drawings stamped "Approved as Noted."

5.1.3

Drawings should not be returned stamped "Rejected" or "Revise and Resubmit" unless the drawings cannot be "Approved," "Approved as Corrected," or "Approved as Noted" due to nonconformance, poor quality (e.g., legibility; lack of adequate dimensions, details, or notes; contradictory information), or other problems that may lead to significant shop errors. Only individual sheets with such errors or required modifications should be rejected. Other sheets may still be fully or conditionally accepted unless their required interaction with the rejected drawings precludes this possibility.

Commentary C5.1

In assessing whether a shop drawing should be stamped as "Approved as Noted" or "Revise and Resubmit," "Approved as Noted" should be used for those cases where the shop drawing could be "Approved" if the change were made exactly as marked. In these cases, it is clear that the inclusion of the marked correction is the single condition which is correct. If there is uncertainty on the Approver's part, it is recommended that the Approver contact the Detailer to discuss the issue and reach agreement on the resolution such that the shop drawing can be marked accordingly and returned "Approved as Noted."

Stamping a shop drawing "Revise and Resubmit" is reserved for only those cases where a single resolution is not possible, and the detailer must either rework the details or investigate errors, omissions, or nonconforming work.

If the Shop Detail Drawings appear to have misinterpreted the Contract plan requirements or if the Approver is uncertain regarding detailing methods (e.g., camber presentation or cutting diagrams), the Approver should contact the detailer directly to avoid unnecessary markups or resubmittals. When errors are extensive, the review should be terminated, and the drawings returned. The Approver may include recommendations to facilitate corrections of minor or occasional errors, but extensive corrections should not be provided. The Contractor and Fabricator remain responsible for drawing accuracy, even if suggested corrections are provided.

5.2—Approval Stamp

5.2.1

The Owner will stamp the shop drawings to indicate acceptance. The stamp indicates the Owner is satisfied that the Shop Detail Drawings generally conform to the intent and requirements of the contract documents, but the Fabricator and Contractor remain responsible for satisfying all Contract requirements.

5.2.2

If the Approver is a contractual agent of the Owner rather than an employee of the Owner, the stamped plans may be sent to the Owner if required for further acceptance and processing. If the structure will carry a railroad, rapid transit, or other loads besides the Owner's, then "Approved" copies may be routed to such organizations for their concurrence or approval.

Appendix A—Checklist for Shop Drawing Approval Items

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A. General
- ☐ Copy of Design Plans Available
- ☐ Copy of Standard Specifications Available
- ☐ Copy of Any Special Provisions Available
- ☐ Copy of Any Pertinent RFIs Available
- ☐ Copy of Any Related Shop Drawings Available
- ☐ Project-Specific Shop Drawing Approval Stamp Available

B. General Notes and Detail Sheets for Cleaning and Coating (Ref. G1.1, Section 4.1)
- ☐ Governing standard and project-specific specifications
- ☐ Standard details (e.g., weld terminations, plate clips, match marking)
- ☐ Corner preparation (if required for cut edges)
- ☐ Cleaning, required surface preparation (SP6, SP10, etc.), and profile depth (if specified)
- ☐ Shop Primer: type, manufacturer, wet or dry film thickness range, verification of cure before shop application of subsequent coats, applicable restrictions on field contact (faying) surfaces, any requirements for pre-priming shop contact surfaces before assembly (e.g., inside boxes, shop bolted assemblies), and designation of any field weld areas to be left unprimed
- ☐ Intermediate and Top Paint Coats: type, manufacturer, wet or dry film thickness range, intermediate coat cure times or recoating time if specified by the Contract documents or paint manufacturer's data sheet, any blockout areas where shop topcoats are not permitted (e.g., field splices, diaphragm/cross frame connections, bearings)
- ☐ Other Coating Systems, such as hot-dip galvanizing, metalizing, metalizing seal coat

C. Erection Framing Plan Details (Ref. G1.1, Section 4.2)
- ☐ Centerline of bearing to centerline of bearing lengths and, where appropriate, transverse girder spacing
- ☐ Pier and abutment identifications
- ☐ Identification/presence of field splices
- ☐ Orientation of structure (north arrow), skew, spot checks of curve or flare geometry if shown
- ☐ Adjustments for special bearings, expansion joints, or other items not adequately covered by the contract plans to compensate for temperature or other variables where applicable
- ☐ Piecemarks indicated for every element, and their relative location (end, side) is shown to clarify member orientation
- ☐ Erection notes in accordance with contract documents

D. Material and Material Testing (Ref. G1.1, Section 4.3)
- ☐ Designation of material, tension zones, and welds for Fracture Critical Members (FCMs), including applicable nondestructive testing
- ☐ Material specified in accordance with the Contract documents
- ☐ Substitutions for material less than 10 mm ($^3/_8$ in.) thick, especially fills and shims
- ☐ Substitutions for material over 10 mm ($^3/_8$ in.)

E. Principal Controlling Dimensions, Material, and Connection Properties (Ref. G1.1, Section 4.4)
- ☐ Total structure length and length of spans, e.g., the horizontal distance between bearings, pin centerlines or other points of support, and horizontal curvature
- ☐ Thickness and width of plates in primary members and splices
- ☐ Designation of rolled shapes
- ☐ Diameter, specification, and grade of mechanical fasteners (bolts, nuts, studs, couplers, etc.), and coating if required (e.g., mechanically galvanized or hot-dip galvanizing)
- ☐ All dimensions of machined pins, hangers, and complex bearings
- ☐ Specification, grade, and, when required by the Owner, toughness testing requirements for steel components
- ☐ Bottom of steel elevations or elevation of seats or other bearing supports for steel members when bearings or supports are provided by the Fabricator
- ☐ Weld details and symbols, including size of fillet welds and partial joint penetration welds, and appropriate partial and complete joint penetration weld configurations
- ☐ Members or areas of members to be painted or coated

F. Welded Girders and Hot-Rolled Beams (Ref. G1.1, Section 4.5)
- ☐ Shop butt weld splice locations
- ☐ Flange and web tapers and haunches (controlling dimensions only)
- ☐ Cover plate dimensions and termination details.
- ☐ Location of tension and compression zones in welded members
- ☐ Length of field sections
- ☐ Drip bar details and other attachments on member
- ☐ Field section piecemarks match proper location on erection plan
- ☐ Size and grade of material in bill of materials
- ☐ Shear connector size and spacing, if shop installed
- ☐ Bolt hole spacings, edge distances, and compatibility of bolt pattern with connection details
- ☐ Faying surface treatment

G. Stiffener and Connection Plates (Ref. G1.1, Section 4.6)
- ☐ Width, thickness, material grade, and toughness testing, if required (e.g., curved bridge, floor beam connection)
- ☐ Weld size and termination details and bolting to web and flange details
- ☐ Appropriate spacing of intermediate stiffeners
- ☐ Avoiding interference with shop web and flange splice locations and anchor bolts
- ☐ Fit, location, and orientation (vertical or normal to grade) of stiffeners and connection plates
- ☐ Bolt hole edge distances and compatibility with diaphragm/cross frame connections.
- ☐ Plate clip details
- ☐ Verification that plate piecemarks are incorporated into proper assembly (e.g. in proper girder or stringer)

H. Bolted Splices (Ref. G1.1, Section 4.7)
- ☐ Length and width of flange splices, width and depth of web splices
- ☐ Number, size, and spacing of bolts and holes in splice material
- ☐ Fill plates if necessary
- ☐ Proper bolt hole edge distances

I. Cross Frames and Diaphragms (Ref. G1.1, Section 4.8)
- ☐ Global geometry (e.g., center-to-center of girder webs, girder depth)
- ☐ Distances between work points
- ☐ Cross frame member sizes and material grade
- ☐ Weld details, sizes, lengths, and terminations
- ☐ Gusset plate thickness, general shape, and material grade
- ☐ Number, size, and spacing of connection plate bolts, edge distances, and type of holes, especially for slip critical connections or details required for differential deflections. Compatibility of bolt pattern with connection details
- ☐ Faying surface treatment
- ☐ Shear connector size and spacing on cross frames or diaphragms, if shop installed
- ☐ Verification that component piecemarks are incorporated into proper assembly (e.g., in proper cross frame or diaphragm)
- ☐ Piecemarks match proper location on erection plan
- ☐ Verification that members are detailed for the fit condition specified on the Contract Plans, if applicable

J. Camber and Sweep (Ref. G1.1, Section 4.9)

- ☐ Length of field section (i.e., sloped and horizontal distances along reference line)
- ☐ Length of span (i.e., sloped and horizontal distances along reference line)
- ☐ Elevation of supports, if applicable
- ☐ Offsets to bottom of steel from reference line; camber ordinates (spot check)
- ☐ Sweep ordinates, radius, point of curvature (POC), or point of tangency (POT) of girders (spot check)
- ☐ Piecemarks match shop details

K. Shop Assembly Diagrams (Ref. G1.1, Section 4.10)

- ☐ Elevation at center of span or segment, elevation at field splice, elevation at abutment, and elevation at pier ordinates

L. Incorporation of All Necessary Revisions into the Shop Detail Drawings (Ref. G1.1, Section 4.11)

- ☐ Errors or discrepancies in the Contract plans discovered during Shop Detail Drawing preparation or review

Such errors must be conveyed to the Owner and the Contractor to determine and implement appropriate corrective actions. Depending on the extent, importance, and urgency, Contract plan corrections or project modifications may be distributed by the Owner as Construction Changes or notification may be verbal, followed by written documentation to all parties.

- ☐ All Construction Changes that affect the Shop Detail Drawings

Recent Construction Changes not incorporated into the Shop Detail Drawings do not usually justify rejection. Unless changes will drastically alter fabrication details, a copy of the Construction Change may be returned with "approved as corrected" or "approved as noted" Shop Detail Drawings in such circumstances. Note: Corrections noted on Shop Detail Drawings do not constitute "Construction Changes" and should not be used to informally effect Construction Changes.

- ☐ Fabricator-proposed modifications approved by the Owner and Contractor

These include deviations from the Contract requirements, substitutions of material, or modifications to the Contract plan details, based upon the Fabricator's request (at no cost to the Owner), that have received prior approval from the Owner and Contractor.

M. Fabricator Questions on Shop Drawings (Ref. G1.1, Section 4.12)

- ☐ Answer or acknowledge all appropriate questions noted on Shop Detail Drawings as "Engineer verify" (does not include "Contractor verify" or "Field verify" queries that must be resolved by others before final Shop Detail Drawing approval)

N. Compliance with Owner-Specific or Project-Specific Requirements that may Supersede the Requirements of this Checklist (Ref. G1.1, Section 4.13)

- ☐ Inclusion of Owner requirements for sheet title box information (e.g., contract number, bridge identification number, pay item)
- ☐ Verification that standard title box notes (e.g., hole diameter, welding, coating) do not conflict with Contract requirements
- ☐ Proper notation of revision date and number on revisions after the first submission
- ☐ Miscellaneous project-specific items such as utility attachments, special connections or connection materials (e.g., pins, links, cables), and stage removal and construction
- ☐ Professional Engineer Seal, if required
- ☐ Design calculations associated with Fabricator-proposed changes, if applicable and required

O. Special Needs for Special Structures, Including Truss, Cable-Stayed, Suspension, Tied Arch, and Movable (e.g., Lift, Swing, Bascule) Bridges (Ref. G1.1, Section 4.14)

- ☐ Number and spacing of bolts in floor beam and cross girder connections as well as special attachments (brackets, pot bearings, etc.)
- ☐ Handling instructions or temporary fixtures for lifting, positioning, and transportation
- ☐ Protection of critical components and connections
- ☐ Dimensional controls required for shop and field assembly

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