Quality Control and Quality Assurance Guide

Bridge Division, Design Section
January 2021

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Chapter 1
About this Guide

Purpose

The Texas Department of Transportation (TxDOT) Bridge Division, Design Section has developed and implemented this Quality Control and Quality Assurance (QC/QA) guide to provide the highest quality products to TxDOT divisions and districts, other state agencies, federal agencies, consultants, and contractors.

The QC/QA process applies to all types of Bridge Division, Design Section projects. In addition, the QC/QA process applies to the development of design guidelines, design examples, spreadsheets, manuals, and specifications. It may be necessary to modify the QC/QA process based on the complexity of the project. Additional QC/QA procedures may be required for large or complex structures, railroad bridges, historic structures, and other special structures.

Updates

The following summarizes the updates to this guide:

Revision History

Version	Publication Date	Summary of Changes
2012-1	August 2012	New guide published.
2013-1	October 2013	Design Sketch Checklists added.
2017-1	April 2017	Updated figures. Added Procedure for Archiving Bridge Design Notes.
2019-1	April 2019	Guide was reviewed, but no updates were needed.
2021-1	January 2021	Updated guidance for archiving bridge design notes.

Organization

The information in this guide is organized as follows:

- Chapter 1, “About this Guide,” contains introductory information on the purpose and organization of this guide.
- Chapter 2, “Goals and Objectives,” contains general information on the purpose and goals of Quality Control/Quality Assurance.

- Chapter 3, “Participants,” contains descriptions of the roles and responsibilities of those participating in QC/QA.
- Chapter 4, “Quality Control,” contains an overview of the quality control for calculations and details.
- Chapter 5, “Quality Assurance,” contains an overview of quality assurance for in-house prepared plans, consultant-prepared plans, and during construction.
- Chapter 6, “Records,” addresses document storage, control and retention.
- “Appendix,” contains the Quality Control Cover Sheet, Design Sketch Checklists, Flow Charts, and guidance on keeping records.

Feedback

You may direct any questions or comments on the content of this guide to the Design Section Director of the Bridge Division, Texas Department of Transportation.

Chapter 2
Goals and Objectives

The Quality Control/Quality Assurance (QC/QA) program establishes the following goals:

- Communicate openly to address concerns and solve problems immediately.
- Plan, coordinate, supervise, and provide technical direction.
- Employ skilled personnel who perform their work with care to produce a quality product.
- Produce quality work through review and checking by individuals not directly responsible for the initial work product.
- Take responsibility for the QA/QC of a project, regardless of role.

The objectives of the QA/QC program are to produce products that:

- Are designed free of errors and omissions.
- Contain designs for all elements and are thorough.
- Are appropriately designed.
- Conform to the policies and procedures defined in the relevant TxDOT manuals, and to the guidelines on the TxDOT website.
- Clearly define the sources of information for the calculations and the interface with related documents.
- Result in constructible plans.

Participants

- Supervisor/Group Leader – A licensed professional engineer who manages a group of Design Engineers and Technicians. The supervisor/group leader is responsible for assigning work to Design Engineers and Technicians based on their level of experience and the complexity of the project. In addition, a supervisor/group leader is responsible for internal Quality Assurance reviews.

- Design Engineer – A licensed professional engineer or engineering assistant working under the direct supervision of a licensed professional engineer. The Design Engineer is a person capable of performing analyses and calculations. The Design Engineer provides the data, such as design sketches, necessary for detail drawing development. In addition, the Design Engineer checks the details for errors, completeness, conformity, and consistency.

- Checker – A licensed professional engineer or engineering assistant working under the direct supervision of a licensed professional engineer. The Checker thoroughly checks the calculations and detail drawings for errors, omissions, completeness, applicability, and conformance.

- Technician – A drafter or engineer who generates and revises details, plan sheets, and drawings in electronic format.

- Engineer-of-Record – A licensed professional engineer who signs and seals the final plan set.

Quality Control is the process of checking the accuracy of calculations and consistency of the drawings, detecting and correcting design omissions and errors prior to finalizing design plans and verifying the specifications for the load-carrying members are adequate for the service and strength loads. Use the Quality Control Cover Sheet (Appendix, Figure 2), to document the Quality Control process.

In addition, document the Quality Control process on the plan sheet by filling out the appropriate initials in the title block on the detail. See Figure 1 for more information.

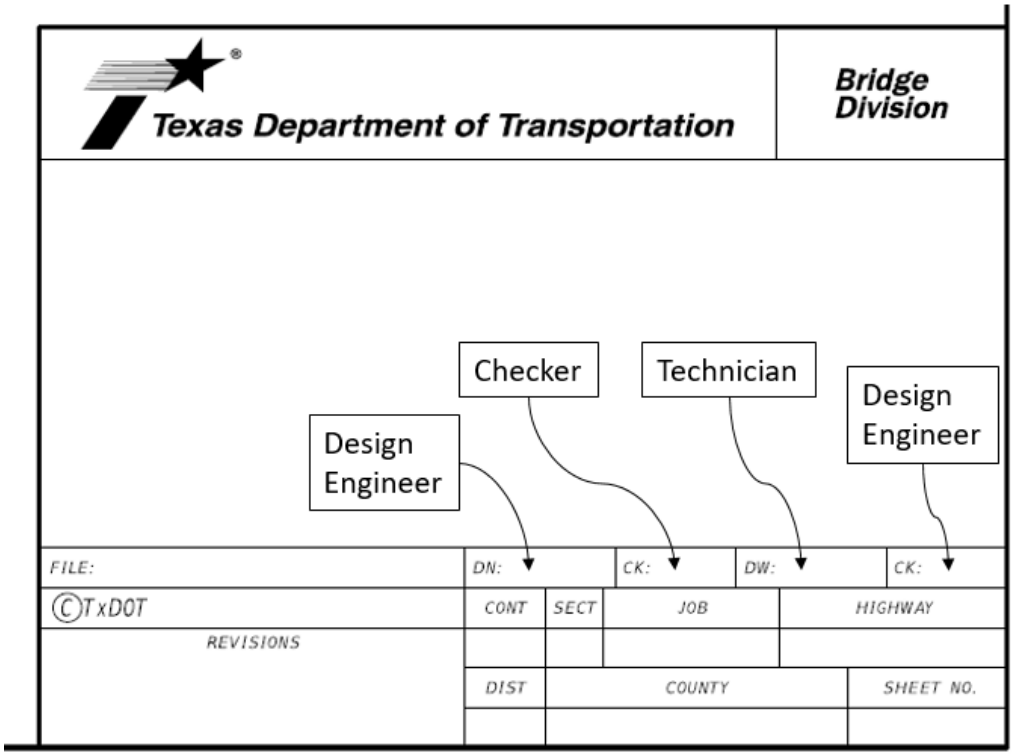

Figure 1: Detail Title Block

The Engineer-of-Record will sign and seal final details and modified standards. Do not sign and seal unaltered standards. The signature and seal on the details acts as the signature and seal for the calculations, as well as the details.

Quality Control of Calculations

This process applies to calculations, reports, studies, design spreadsheets and any other documents that are not details, plan sheets, or drawings.

Preparation (Design Engineer)

Prepare relevant, appropriate calculations and sketches containing all information (input, basis, comments, references and sketches) necessary to convey the purpose and nature of the calculations. Calculations are standalone, to the extent reasonably possible.

Present the calculations and sketches in a neat and logical manner that is conducive to checking.

Conform the calculations and design sketches to the policies and procedures defined in the relevant TxDOT Manuals. As directed or requested, follow the design guidelines on the TxDOT website. Use the Design Sketch Checklists provided in the Appendix, Figure 4 for direction on the information needed on the design sketches.

Perform all calculations on TxDOT calculation sheets, on spreadsheet equivalents (i.e. personal spreadsheets or design spreadsheets) or software. Provide a header on the calculation sheets or spreadsheets that provides the County, Hwy, CSJ, ID#, Design Engineer's Initials and Date and the Checker's Initials and Date.

Checking (Checker)

Check each component to ensure compliance with the policies and procedures defined in the relevant TxDOT Manuals and with the guidelines on the TxDOT website, as appropriate.

Check the calculations for internal consistency and traceability of sources.

Thoroughly check the calculations, including assumptions, given values, formulas, omissions, and accuracy of arithmetic.

Check methodology, reasonableness of results, and constructability.

If necessary, ask for clarification from the Design Engineer, request additional calculations, and if unsure of any particular element, seek technical advice.

Check the calculations by the method shown in the Quality Control of Calculations flowchart provided as Figure 5 in the Appendix. Alternatively, check the calculations by providing independent calculations. Keep the alternate, independent calculation with the original. Indicate on the original that an alternate calculation was used for checking.

When an error in computer input, assumptions, or load calculations is found, consider what that error will do to the outcome before asking the Design Engineer to redesign the member. If the error has a negligible impact to the final design, it may not be necessary to redo the calculation. For instance, it may be unnecessary to re- run a program for a 0.1 k difference in load or a 1-foot station difference in geometry.

When an error is found that will have significant impact on the remainder of the calculations, return the calculations to the Design Engineer for correction prior to completing checking of the calculations. Such an error is one leading to a design result that is more than 5 percent un-conservative or more than 15 percent conservative.

Correcting (Design Engineer)

Revise the calculations and sketches based on the mark-ups. If not in agreement with a mark-up, discuss it with the Checker. Come to an agreement on whether to incorporate the mark-up. If unable to come to a resolution, consult the supervisor/group leader.

Incorrect calculations should be removed from the complete calculation packet and replaced with corrected calculations.

Verifying (Checker)

Back check the revised calculations and sketches against the mark-ups to confirm all corrections have been incorporated or otherwise addressed.

Quality Control of Details

This process applies to details, plan sheets, and drawings. The Quality Control of Details flow chart included as Figure 6 in the Appendix provides the process for checking the details.

Preparation (Technician)

Develop all details in accordance with Bridge Detailing Guide and applicable Bridge Division policies and practices.

Checking (Design Engineer or Checker)

Check the details for completeness of the plan set for design intent.

Check the details for technical adequacy and conformity to applicable standards.

Check the details for consistency with the corresponding calculations.

Check individual drawings using appropriate checklists from the Bridge Detailing Guide for errors, completeness, conformance, and consistency.

Correcting (Technician)

Revise the details based on the mark-ups. If not in agreement with a mark-up, discuss it with the Checker. Come to an agreement on whether to incorporate the mark-up. If unable to come to a resolution, consult the supervisor/group leader. Mark any additional revisions on the originals.

Verifying (Design Engineer or Checker)

Back check the revised details against the marked ups to confirm all corrections have been incorporated or otherwise addressed.

Quality Control of Details Against Calculations

This process applies to details, plan sheets, and drawings. This process can be done concurrently with checking the calculations.

Preparation (Design Engineer)

Provide the calculations and the details prepared as outlined in the Quality Control of Calculations and the Quality Control of Details sections. The Quality Control of Details flow chart included as Figure 6 in the Appendix provides the process for checking the details.

Checking (Checker)

Check the details for consistency with the corresponding calculations.

Correcting (Design Engineer)

Revise the details based on the mark-ups. If not in agreement with a mark-up, discuss it with the Checker. Come to an agreement on whether to incorporate the mark-up. If unable to come to a resolution, consult the supervisor/group leader. Mark any additional revisions on the originals.

Verifying (Checker)

Check the revised details against the mark-ups to confirm all corrections have been incorporated or otherwise addressed.

Addendum and Change Orders

It is sometimes necessary to submit revised plan sheets to address a change order or an addendum. For change orders and addendum, follow the procedures presented within this Chapter. Remember to update all relevant calculations and details. Notify the shop plan reviewers in the Design Section of the Bridge Division of any changes to plan details.

Chapter 5
Quality Assurance

Quality Assurance is the process of reviewing the quality control process for use and effectiveness at preventing mistakes and ensuring compliance. The Quality Assurance process varies depending on the stage of plan development and who develops the plans.

Reviews occur for all plans regardless of who prepared them. These include a District review prior to finalizing the plans and, optionally, a Division review prior to letting. The District review occurs in the district where the project is to be constructed and focuses on constructability, applicability, and conformity. If requested, the Division review focuses on the same items as the District review and is comparable to a peer review.

In-House Prepared Plans

For in-house prepared plans, the supervisor/group leader is responsible for Quality Assurance. The supervisor/group leader determines the level and complexity of the Quality Control process, assigns the Design Engineer, Checker, and Technician. The supervisor/group leader confirms the Quality Control process by reviewing the Quality Control cover sheet and the detail title block. In addition, the supervisor/group leader completes a review of the details for constructability, applicability, completeness, and conformity.

Consultant Prepared Plans

For consultant-prepared plans, the consultants are required to submit their Quality Control Plan in writing prior to starting work or as otherwise directed in the contract. TxDOT reserves the right to review the consultants' quality control process.

During the development of the plans, TxDOT reviews the plans at 30%, 60%, and 90% completion (or equivalent). TxDOT reviews the plans for constructability, applicability, completeness, and conformity. The TxDOT manager of the work authorization or contract typically handles this review. However, they may assign a representative to complete the task. Frequently, the District will be involved in these reviews.

During Construction

During construction District engineers assume the role of Engineer-of-Record and complete field-engineering reviews. If a complex problem occurs, the District contacts the original Engineer-of-Record, who will determine a solution and if necessary, provide calculations and revised details.

Notebook/File

The Design Engineer keeps a binder or folder clearly labeled with the Structure Name, County, and Control-Section-Job (CSJ) number that contain the following:

- Design Request Submittal – This submittal is comprised of the design information provided by the district. At a minimum, the Information Sheet for Structural Design and Bridge Layout will be part of this package. The submittal may also include Plan Profiles, Typical Sections and/or Construction Sequences.

- Correspondence – Correspondence includes emails, memos, or other documents that affect the design of the structure or clarify design requirements.

- Calculations – Calculations generated and reviewed in accordance with the Quality Control Program. Calculations include hand-written documents, spreadsheets, and output from software. Convert the calculations to PDF for inclusion in the design file and eventually in the Bridge Database. Appendix: Guidance for Calculation Retention contains guidance for including documents as part of the PDF and Appendix, Procedure for Archiving Bridge Design Notes.

- Details –Final Plan Sets generated and reviewed in accordance with the Quality Control Program. During plan set development, check prints may also be kept in the file.

- Any other documents required for design, such as existing plan sheets and review comments.

After releasing the project as a 100% Plan Set, the Design Engineer converts the notebook to a PDF format by scanning or other means and saves the resultant electronic Notebook/File.

After releasing the project as a 100% Plan set, the Design Engineer may dispose of the Check Prints and only keep an electronic (PDF) copy of the 100% Plan Set. This is not the official copy of the plan set.

The Design Engineer documents any changes that occur after the Plan Review, such as Addendum, and post-letting, such as Change Orders and RFIs by including correspondence, calculations, and details that relate to the change or request in the electronic Notebook/File for the project.

Appendix

A.1 Quality Control Cover Sheet

TXDOT BRIDGE DIVISION		
	County:	
	C-S-J:	
	Highway:	
	Project:	

Group Leader (Approval for Release): _____

Date: _____

Calculations

Structure	Component	Design Engineer Assigned	Software Used	Software Version	Checker Assigned	Design Engineer Prepared Initial	Design Engineer Prepared Date	Checker Checked Initial	Checker Checked Date	Design Engineer Corrected Initial	Design Engineer Corrected Date	Checker Verified Corrections Initial	Checker Verified Corrections Date

Checker's Comments

☐ No Changes
☐ Revise Design as shown
☐ Other Comments/Conclusions _____

☐ Minor corrections: original design satisfactory

Details

Structure	Component	Bridge ID#	Technician Assigned	Technician Prepared Initial	Technician Prepared Date	Design Engineer Checked Initial	Design Engineer Checked Date	Technician Corrected Initial	Technician Corrected Date	Design Engineer Verified Corrections Initial	Design Engineer Verified Corrections Date

DO NOT DISCLOSE. THIS INFORMATION IS CONFIDENTIAL UNDER THE TEXAS HOMELAND SECURITY ACT & 23 U.S.C SECTION 409, SAFETY SENSITIVE INFORMATION .

Figure 2: Quality Control Cover Sheet

Some calculations are stand-alone and require an engineer's seal and signature. For stand-alone calculations replace the details section on the Quality Control Cover Sheet with the information shown in Figure 3.

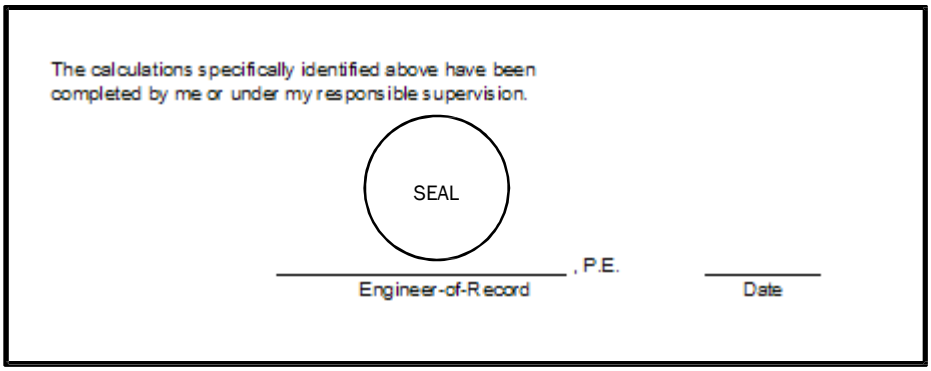

Figure 3: Engineer-of-Record Block

A.2 Design Sketch Checklists

Estimated Quantities
1. Tabular list of bid items
Abutment
1. Width 2. Location of the horizontal control line 3. Wing wall length; Founded (yes/no) 4. Foundation size, location and load 5. Cap size and steel arrangement (if non-standard) 6. Dowels D (yes/no) 7. Girder type and spacing 8. Approach slab (yes/no) 9. Skew angle and direction 10. Phased (yes/no). If yes, label phases, show phase lengths and reinforcing steel laps or connection 11. Project specific notes 12. Identification of Abutment and Bridge Name, for Title Block 13. CSJ 14. District 15. County 16. Highway 17. Project ID 18. Provide initials of design checker, if checked.
Bent
1. Width 2. Location of horizontal control line 3. Cap size and reinforcing steel arrangement (continuous/cut and stirrups) 4. Footings(yes/no) If yes include size and foundation type 5. Column size, location and load. Provide reinforcing steel arrangement if non-standard. 6. Dowels D (yes/no). If yes, at what bents? 7. Bearing seat size and Girder type (forward and back if different) 8. Girder spacing (forward and back if different) 9. Skew angle and direction 10. Phased (yes/no). If yes, label phases, show lengths and reinforcing steel laps or connection 11. H-Heights 12. Project specific notes 13. Identification of Bent and Bridge Name, for Title Block 14. CSJ 15. District 16. County 17. Highway 18. Project ID 19. Provide initials of design checker, if checked.

Figure 4: Design Sketch Checklists

Span
1. Unit length, width, number of spans and span lengths 2. Number of girders, girder spacing and type(s) 3. Location of horizontal control line 4. Skew angle and direction 5. Breakback 6. Slab thickness 7. Reinforcing steel size, spacing and cover, if non-standard 8. Overhang thickness 9. Sidewalk dimensions (and reinforcement if not standard). 10. Panels (yes/no). List any specific prohibition of use. 11. Cross slope and location 12. If phased, label phases, show phase lengths and reinforcing steel laps or connection 13. Joint type 14. Location of PGL in Typical Section 15. Dead load deflections 16. Project specific notes 17. Identification of Span or Unit and Bridge Name, for Title Block 18. CSJ 19. District 20. County 21. FMS project ID 22. Provide initials of design checker, if checked 23. Provide Detailer access to a. Layout b. Haunch Calculations (X, Y, and Z values) c. BGS LS2 file (bridge geometry) d. BGS LS4 file (beam report and bent report) e. .dgn file created from BGS Additional info req'd for Steel Girder Spans/Units 1. Top of slab to top of web dimension (plate girders) 2. top of slab to top of beam dimension (rolled beams) 3. Girder or beam elevations 4. Bolted field splice details 5. Web Camber table plus Dead Load Deflection Table, at 0.10 pts and all field splice points **6.** Beam blocking diagram (only if beams are not cambered per standard practice)

Figure 4: Design Sketch Checklists (cont.)

A.3 Quality Control Flowcharts

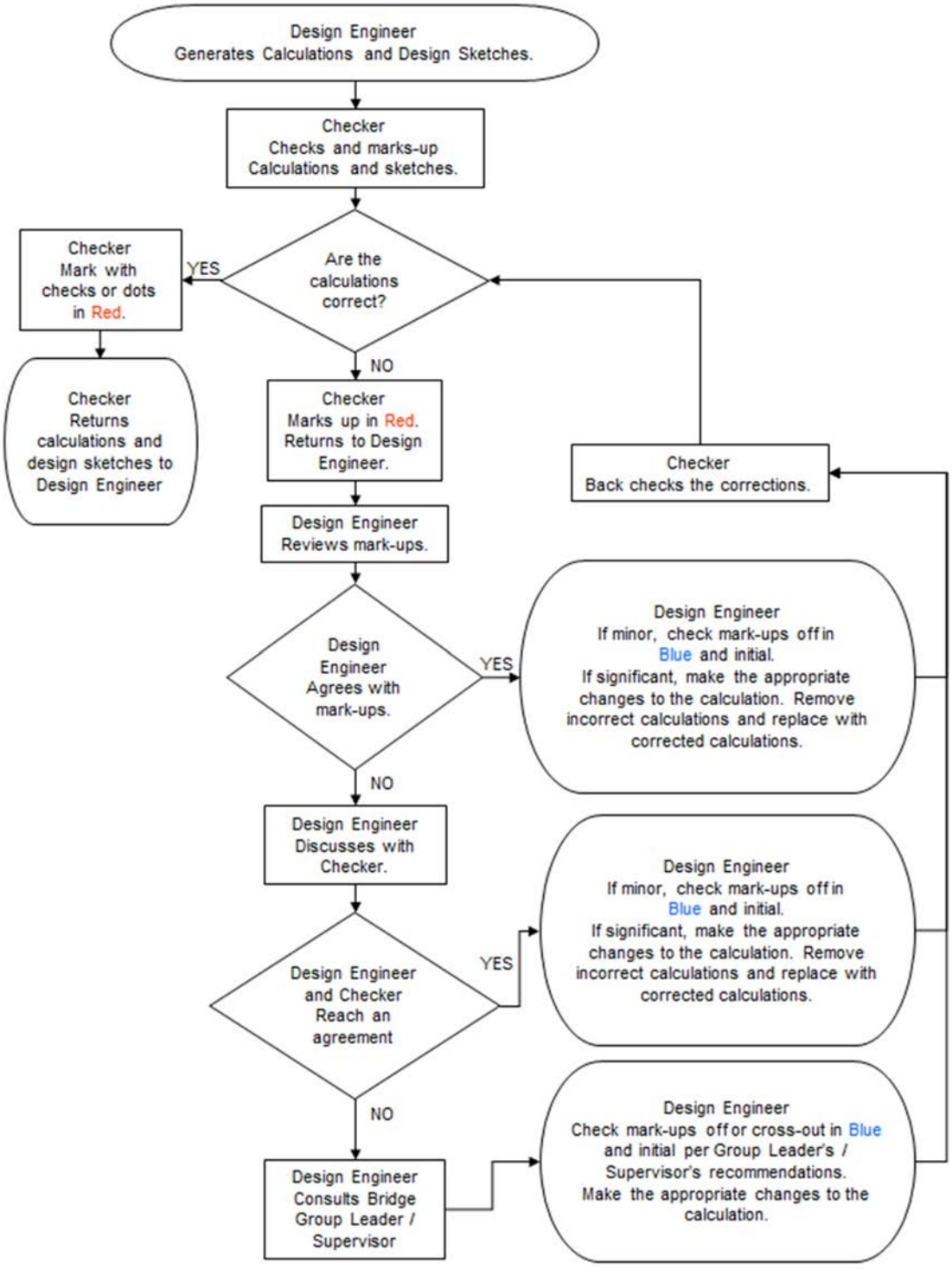

Figure 5: Quality Control of Calculations

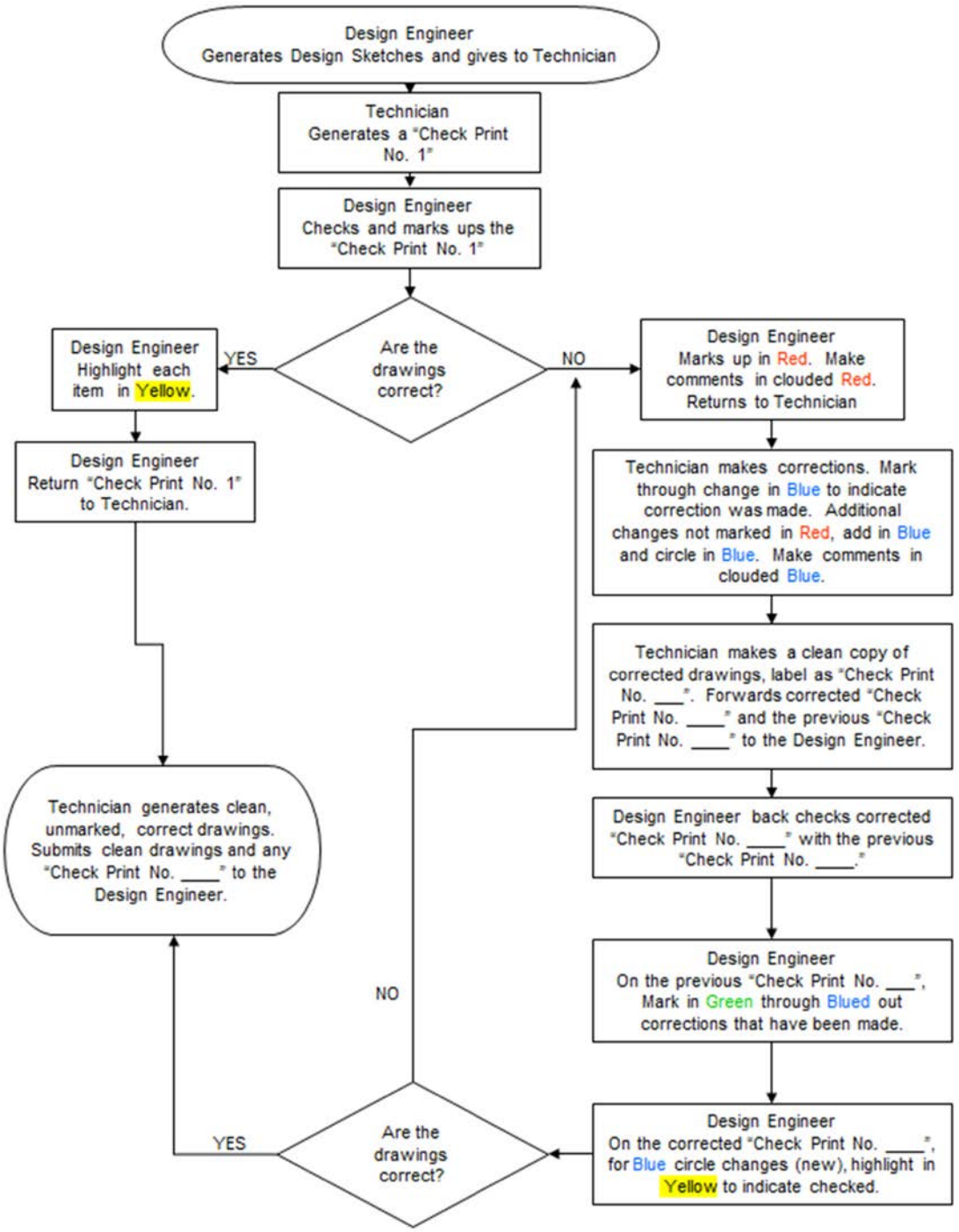

Figure 6: Quality Control of Details

A.4 Guidance for Calculation Retention

Scan or convert to PDF format design notes and computer output, with superstructure design notes first, followed by substructure design notes.

A hard copy of computer software input files is not required. Hard copies of computer software output should be included with the following:

- Input echo
- Key pages of output, annotated by hand if necessary, such that the design's outcome—including controlling load case and limit state—can be understood by review of the output and annotation.
- Key pages of output, annotated by hand if necessary, demonstrating that other load cases and limit states do not control the outcome of the design.

Design Notes Required	Design Notes NOT Required
• Calculations and other documentation establishing the bridge's superstructure design satisfies controlling load cases and limit states, for the following elements: o Girders or beams o Stringers o Floor beams o Trusses, including secondary elements such as bracing and gusset plates o Arches and hangers, including secondary elements such as bracing and gusset plates o Cable stays o Other elements not specifically excluded • Calculations and other documentation establishing the bridge's substructure design satisfies controlling load cases and limit states, for the following elements: o Cap beams o Columns, Towers, and Pylons o Other elements not specifically excluded • Calculations and other documentation establishing the bridge's foundation design satisfies design requirements, for the following elements: o Piling o Drilled shafts o Spread footings o Other elements not specifically excluded	• Decks, if per current TxDOT Manuals and standard drawings • Bearings, if per current TxDOT Manuals and standard drawings • Railings, if per current TxDOT Manuals and standard drawings • Expansion joints, if per current TxDOT standard drawings • Standard round columns if column height and diameter is within prescribed limits of acceptability in TxDOT Manuals • Abutment design, if details follow current TxDOT Manuals and standard drawings • Pile and/or Footing design, if details follow current TxDOT standard drawings • Other structural items from current TxDOT standard drawings such as diaphragms/cross-frames for steel girders and beams, etc.

Table 1: Guidance for Calculation Retention

A.5 Procedure for Archiving Bridge Design Notes

In order to comply with FHWA requirements for maintaining records, the Bridge Division implemented a procedure for archiving bridge design notes in TxDOT's bridge inspection database management system. See the *TxDOT Bridge Design Manual – LRFD* for more information.