

**ATTACHMENT 42 – Mn/DOT LOAD AND RESISTANCE FACTOR DESIGN
(LRFD) BRIDGE DESIGN MANUAL**
(6 pages)

**1.2.4 Limit States
to Consider in
Design**

Bridge designs shall typically consider Strength, Service, Extreme Event, and Fatigue limit states. The limit state checks will vary with the component under consideration. Not all elements will require consideration of all limit states. For example, the fatigue limit state need not be considered for fully prestressed pretensioned elements.

1.3 Procedures

This section covers the Bridge Office procedures for checking of bridge plans, scheduling of projects, and revising or creating standards.

**1.3.1 Checking of
Mn/DOT Prepared
Bridge Plans**

The general practice of most engineering offices is to require that designs they produce be checked before they are reviewed and certified by the "Engineer in Responsible Charge". Although this practice has always been required for structures designed for Mn/DOT, it is recognized that the quality of the checking process often varies according to time restraints, confidence in the designer, and the instructions given to the checker. Therefore, in order to maintain a consistent design checking process the following guidance is given for routine bridge designs.

For more complex or unusual designs, the checker is advised to discuss additional requirements with the design unit leader. Also, the checking process described is not meant to apply to the check or review functions required for Mn/DOT review of consultant plans (see Section 1.3.2.) or for construction false work reviews. (See the Bridge Construction Manual.)

Three types of design checking will apply:

- 1) An independent analysis of the completed design.
- 2) A check of original design computations for mathematical accuracy, application of code, and accepted engineering practice.
- 3) A review of drafted details for constructibility and accepted engineering practice.

Generally, an independent analysis to confirm the adequacy of the complete design is preferred. Significant differences should be discussed and resolved before the plan is certified. The separate set of calculations should be included with the design file as a record of the completed design check.

When circumstances prevent a complete independent analysis, as a minimum, an independent analysis shall be completed for the following:

- 1) Live and dead loads
- 2) Critical beam lines
- 3) A pier cap

- 4) A pier footing
- 5) Main reinforcement for high abutments
- 6) An abutment footing

However, for the elements not independently analyzed, the original computations should be checked for mathematical accuracy of original design computations, applications of code, and accepted engineering practice. Checked computations should be initialed by the checker, and the independent analysis should be included in the design file.

When doing a separate analysis, the checker may make simplifying assumptions to streamline the checking process. However, when major differences are found, results must be discussed and resolved with the designer. For instance, for normal piers, piling might be analyzed for dead and live loads only if lateral loads appear to have been reasonably applied in the original computations or the "AISC Beam Diagram and Formula Tables" may be used to approximate pier cap moment and shear.

Whether the check is a completely independent analysis or a minimal analysis combined with a computations check, some details, such as the reinforcing details in a wall corner, also require review by the checker. Often referencing old bridge plans with similar details allows the checker to compare the current design to details that have performed well in the past.

1.3.2 Checking of Consultant Prepared Bridge Plans

Consultant prepared bridge plans are created by private engineering firms through contracts with the Department. The finished plans are complete to the extent that they can be used for construction.

Since these plans receive final approval of the State Bridge Engineer, there must be assurance that the plans are geometrically accurate and buildable; structural design is adequate and design codes have been correctly applied; proper direction is given to the construction contractor; and all construction costs are accounted for. Plan errors may cause costly construction delays or safety may be compromised by an inadequate design.

To keep consultant plan reviews consistent and timely, a procedure was developed as a guide that assigns priority to specific items in the plans. The overall review includes "a Thorough Check" and "Cursory Review" of various items. The distinction between "Thorough Check" and "Cursory Review" is as follows:

Thorough Check refers to performing complete mathematical computations in order to identify discrepancies in the plans, or conducting careful comparisons of known data and standards of the Project with values given in the plan.

Cursory Review refers to a comparative analysis for agreement with standard practice and consistency with similar structures, all with application of engineering judgment. Mathematical analysis is not required, but may be deemed necessary to identify the extent of a discrepancy.

The review procedure is listed on the CONSULTANT BRIDGE PLAN REVIEW form following this section. Headings on this list are defined as follows:

PARTIAL PLAN: In order to assure that the consultant is proceeding in the right direction, an early submittal of the plan is required. This submittal usually consists of the General Plan and Elevation sheet showing the overall geometry of the structure and the proposed beam type and spacing; the Bridge Layout Sheet; the Framing Plan sheet; and the Bridge Survey sheets. Errors and inconsistencies found in this phase can be corrected before the entire plan is completed. For example, a framing plan, including the proposed beams, must be assured as workable on the partial plan before the consultant gets deep into the design of the remainder of the bridge.

FINAL PLAN: A final plan should be complete in all areas to the extent that it can be certified by the designer, although a certification signature is not required for this phase.

THOROUGH CHECK: Items indicated for checking on the consultant's partial plan must be correct. Given geometry must fit the roadway layout. Most of this information can be checked using data from the approved preliminary plan. Approval of the partial plan will indicate that Mn/DOT is satisfied with the geometry and proposed structure, and the consultant may proceed with further development of the plan. For the final plan, obvious drafting and numerical errors should be marked to point out the errors to the consultant, however, the reviewer should not provide corrections to errors in the consultant's numerical computations.

Checking on the final plan should be thorough to eliminate possible errors that may occur, such as the pay items in the Schedule of Quantities. Plan notes and pay items can be difficult for a consultant to anticipate because of frequent changes by Mn/DOT. Pay items must be correct

because these are carried throughout the entire accounting system for the Project. Plan (P) quantities must also be correctly indicated.

CURSORY REVIEW: Normally, a cursory review would not require numerical calculations. This type of review can be conducted by reading and observing the contents of the plan in order to assure the completeness of the work. The reviewer should be observant to recognize what looks right and what doesn't look right. Obvious errors or inconsistencies on any parts of the plan should be marked for correction.

Although structural design is usually the major focus of any plan, most consultants are well versed in design procedures and should need only minimal assistance from our office. A comparison of the consultant's calculations with the plan details should be performed to assure that the plans reflect their design and that the applicable codes are followed. An independent design by our office is time consuming and is not recommended unless there is a reasonable doubt as to the adequacy of the consultant's design.

NO REVIEW: A thorough review of these items would be time-consuming and may not produce corrections that are vital to construction; therefore, it is recommended that little or no time be spent on the listed items. Numerous errors can occur in the Bills of Reinforcement and quantity values. However, checking this information is also time-consuming, hence the burden of providing correct data should be placed on the consultant.

CONSULTANT BRIDGE PLAN REVIEW

Br. No. _____ RTE _____ DATE: PARTIAL PLAN REC'D. _____ DATE FINAL PLAN REC'D. _____

DESIGN GROUP _____ CONSULTANT _____

No. OF SHEETS IN PLAN _____ DESCRIBE COMPLEXITY _____

EST. REVIEW TIME BY DESIGN GROUP _____ (hrs.) ACTUAL REVIEW TIME _____ (hrs)

PARTIAL PLAN		FINAL PLAN	
THOROUGH CHECK		THOROUGH CHECK	
	Horizontal and vertical clearances		Pay items and plan quantities
	Stations and elevations on survey line		Project numbers
	Deck and seat elevations at working points		Design data block & Rating on GP&E sheet
	Deck cross-section dimensions		Job number
	Working line location and data		Certification block
	Coordinates at working points and key stations		Standard plan notes
	Substructure locations by station		Concrete mix numbers
	Framing Plan		Construction joint locations
	Conformance to preliminary plan		Prestressed beam design if inadequate design is suspected
	Design loads		Bridge seat elevations at working points
			Utilities on bridge
			Existing major utilities near bridge
		CURSORY REVIEW	
			Steel beam splice locations and diaphragm spacing; flange plate thickness increments (enough to save 800+ # of steel)
			Abutment and Pier design to be checked against consultant's calculations
			Conformance to foundation recommendations.
			Pile loads and earth pressures. Check against consultant's calculations.
CURSORY REVIEW			Rebar series increments (min. 3")
	Proposed precast beams [per 5-393.509(2)]		Interior beam seat elevations
	Precast conformance to industry standards		Bottom-of-footing elevations (for adequate cover)
	Proposed steel beam sections		Railing lengths and metal post spacing (check for fit)
			Use of B-details and standard plan sheets
			Conformance to aesthetic requirements
			Notes - General, construction, reference, etc.
			Quantity items on tabulations
			Precast beam design (Check against consultant's calculations)
		NO CHECK OR REVIEW REQUIRED	
			Diagonals on Layout sheet
			Figures in Bills of Reinforcement
			Bar shapes and dimensions
			Rebar placement dimensions
			Bar marks on details against listed bars
			Quantity values (including total of tabulations)