

Part 536 – Structural Engineering

536.0 General

NRCS provides structural engineering assistance in a variety of applications. Structural engineering requires the use of sound engineering principles.

536.1 – 536.9 Reserved

536.10 Method

A. The method selected for the analysis and design of structures must be based on a systematic and comprehensive evaluation of the structural functions expected during the design life. Consideration must be given to the structural resiliency, redundancy, robustness, durability, and sustainability.

B. The structural design method must include an evaluation of the following: function, operation, loading, stability analysis, structural analysis, and material criteria. In practice, the structural design will typically involve an iterative evaluation of each of these elements.

536.11 Function

All structure functions, whether intended or not, must be considered in the structural design evaluation. Functions typically include all the operational structure conditions for each external condition imposed on the structure. The designer must consider structure conditions imposed during construction, normal operations, extreme events, and maintenance activities.

536.12 Loads

A. Consider all anticipated loads and load combinations in the design of a structure. Loads typically include wind, snow, hydraulic, earth, occupancy, vehicular, equipment, and seismic. Designs must consider loads imposed during construction, normal operations, extreme events, and maintenance activities.

B. Use the applicable provisions of the current American Society of Civil Engineers (ASCE) Minimum Design Loads for Buildings and Other Structures (ASCE 7) to develop design loads and load combinations. In lieu of compliance with ASCE 7, use the applicable provisions of the current International Building Code (IBC) to develop design loads and load combinations.

C. In addition to the requirements in ASCE 7 or the IBC, where required by State regulation, local regulation, or other legal mandate, develop design loads and load combinations using local guidance and requirements.

536.13 – 536.19 Reserved

536.20 Design Criteria for Reinforced Concrete Structures

A. Design reinforced concrete structures, not classified as hydraulic or environmental in section 536.21 of this subpart, in accordance with the applicable provisions of the current American Concrete Institute (ACI) Building Code Requirements for Structural Concrete (ACI 318).

The specified yield strength of reinforcement (f_y), must not exceed 60,000 pounds per square inch (psi) unless approved in advance by the Director, Conservation Engineering Division (CED).

B. In lieu of the applicable provisions of ACI 318, designers may use the applicable provisions of the current ACI Code Requirements for Environmental Engineering Concrete Structures (ACI 350) to design reinforced concrete structures.

536.21 Design Criteria for Reinforced Concrete Hydraulic and Environmental Structures

A. A hydraulic structure is any structure subjected to hydrostatic or hydrodynamic pressures, either externally or internally. An environmental structure is any structure intended for conveying, storing, or treating water, wastewater, or other liquids and nonhazardous materials, such as solid waste, and for secondary containment of hazardous liquids or solid waste and designed to be liquid-tight, with minimal leakage under normal service conditions.

B. Design reinforced concrete hydraulic and environmental structures in accordance with the applicable portions of the current ACI 350.

- (1) The flexural tension reinforcement stress due to unfactored loads must not exceed 20,000 psi.
- (2) The specified yield strength of reinforcement (f_y) must not exceed 60,000 psi unless approved in advance by the Director, CED.
- (3) Construction joints, intended to be watertight, prepared in accordance with ACI Joints in Concrete Construction (ACI 224.3R-95), Section 3.2.1, need not include integral water stops stipulated in ACI 350-06, Section 6.4.7.

C. Designers may use Technical Release No. 30, “Structural Design of Standard Covered Risers” (TR 30), for the design and analysis of drop-inlet spillway riser structures.

D. Designers may use Technical Release No. 68, “Seismic Analysis of Risers,” including appendix D, as amended, 1992 (TR 68) for the seismic design and analysis of drop-inlet spillway riser structures.

- (1) For utilization with the computer program SARisers, combine the values for the zone “Z” and the site classification “S” to produce a base shear approximately equal to the base shear obtained using the methods described in ASCE 7. When interpolation of the combined zone and site class value is required, input the next higher value into the computer program.
- (2) For utilization with the computer program SARisers, determine the values for the zone using figure 4-1 in Technical Release No. 60, “Earth Dams and Reservoirs,” July 2005 (TR 60).
- (3) For drop-inlet spillway riser structures, designers may perform seismic analysis and design using rational methods not in compliance with TR 68, subject to approval of the Director, CED.

E. Reinforced concrete circular tanks designed in accordance with the Portland Cement Association’s Circular Concrete Tanks Without Prestressing (1993) need not comply with conflicting provisions of the current version of ACI 350.

536.22 Design Criteria for Concrete Slabs-on-Ground

A. Design concrete slabs-on-ground subject to distributed stationary loads, light vehicular traffic, or infrequent use by heavy truck or heavy agricultural equipment in accordance with applicable provisions of the current ACI Guide for the Design and Construction of Concrete Parking Lots (ACI 330R).

B. Design concrete slabs-on-ground subject to regular or frequent heavy truck or heavy agricultural equipment traffic in accordance with applicable provisions of the current ACI Design of Slabs-on-Ground (ACI 360R).

C. For liquid-tight slabs-on-ground, with minimal leakage under normal service conditions, design in accordance with the applicable provisions the current ACI Code Requirements for Environmental Engineering Concrete Structures, Appendix H, Slabs-on-Soil (ACI 350 App. H).

536.23 Existing Designs for Reinforced Concrete Structures

States may utilize existing designs, including State and national standard designs, previously developed in accordance with Technical Release No. 67, “Reinforced Concrete Strength Design” (TR 67), or Title 210, National Engineering Handbook (NEH), Section 6, “Structural Design,” provided that no substantial changes are necessary to implement the use of the design.

- (1) For minor changes to an existing design for a reinforced concrete structure, design the changes in accordance with TR 67, 210-NEH, Section 6, or both.
- (2) For substantial changes to an existing design for a reinforced concrete structure, reanalyze and redesign the structure to comply with section 536.30 or section 536.31 as applicable.

536.24 – 536.29 Reserved

536.30 Design Criteria for Steel Structures

- A. Design steel structures in accordance with the applicable provisions of the current American Institute of Steel Construction (AISC) Steel Construction Manual.
- B. Use seismic analysis and design in accordance with applicable provisions of the AISC Seismic Design Manual.

536.31 – 536.39 Reserved

536.40 Design Criteria for Wood Structures

Design wood structures in accordance with the applicable provisions of the current American Wood Council National Design Specification for Wood Construction.

536.41 – 536.49 Reserved

536.50 Design Criteria for Masonry Structures

Design masonry structures in accordance with the applicable provisions of the current ACI Building Code Requirements for Masonry Structures (ACI 530).

536.51 – 536.59 Reserved

536.60 Design Criteria for Bridges

- A. Design vehicle, livestock, and pedestrian bridges in accordance with American Association of State Highway and Transportation Officials Load Resistance Factor Design (LRFD) Bridge Design Specifications, with interim revisions.
- B. Designate the vehicle or live load used for design on the construction drawings and in the specifications.
- C. Design all bridges with railings, guardrails, or barriers to protect the users of the bridge. Railings, guardrails, or barriers, their connections to the bridge superstructure, and the supporting bridge

superstructure must comply with applicable requirements stipulated in the LRFD Bridge Design Specifications, with interim revisions.

Exceptions to the railings, guardrails, or barriers requirement on bridges require authorization from the State conservation engineer (SCE) and must meet both of the following criteria:

- (i) The intended use of the bridge is for vehicles, machinery, or equipment having dimensions or proportions such that they cannot access the bridge with approved railings, guardrails, or barriers installed.
- (ii) Bridges constructed without railings, guardrails, or barriers, or with railings, guardrails, or barriers that do not comply with applicable requirements stipulated in the LRFD Bridge Design Specifications, with interim revisions, must have signs installed at or near each end of the bridge to warn users of the lack of railings. Signage must comply with applicable requirements stipulated in the U.S. Department of Transportation's Federal Highways Administration Manual on Uniform Traffic Control Devices.

536.61 – 536.69 Reserved

536.70 Standard Designs

- A. Developing standard designs for frequently used structures or structural features can be an efficient method of providing technical assistance.
- B. Developing standard designs based upon conservative assumptions may permit the ready adaptation of those designs to a wide variety of locations and applications.

536.71 Use of Standard Designs

- A. Use standard designs when appropriate for the development of construction drawings.
- B. The design engineer must determine the site conditions, structure function, and hydraulic and structural requirements. The design engineer must examine the applicability of a standard design and include in the design notes the verification for the selection of a standard design. If differing site conditions preclude the use of a standard design, the design engineer must include this determination in the design notes.
- C. The approving engineer must determine the appropriate use of standard designs by considering the acceptability of performance, the overall efficiency of adapting the standard design to a specific project, and the risk of incorporating errors if modifications are required.
- D. A State office may not develop standard designs if standard designs are available from CED for the same size and kind of structure, component, or appurtenance.
- E. Keep documentation containing the design notes and computations developed for standard designs for reference as long as the designs are available for use.

536.72 Standard Design Drawings

- A. Develop standard design drawings as detailed construction drawings based upon standardized design assumptions. Select the design assumptions such that the design drawings will provide for the requirements of many sites.
- B. Design structures for standard design drawings to perform satisfactorily within the range of conditions assumed in their development. Indicate the assumed range of conditions in reference drawings, technical releases, or design notes. Include design assumptions and notes on material

quality on the drawings.

C. Prepare essentially complete standard design drawings for use directly in preparing construction drawings for incorporation in contract documents. They are to be complete in construction or fabrication detail.

D. Portions of the drawings may provide for changes in size or length and thus require some additions for completion. Consider these changes during the development of the design and ensure that the changes do not affect the performance or capability of the structure. Incorporate the provisions for these adaptations into the drawings in a manner to facilitate their use.

E. Support each standard design drawing using design notes, computations, drawings, sketches, and other pertinent data. Record and organize documentation in a manner that allows for reproduction, and comply with applicable provisions of section 511 of this manual.

F. Standard design drawings may be prepared as a series to provide for a range of sizes frequently needed.

G. Drafting must comply with applicable requirements of section 541 of this manual.

H. Design Note No. 18, “Unattached Engineering Standard Drawings” (DN 18), includes an index of available standard drawings for hydraulic structures.

536.73 Adaptation of Standard Design Drawings

A. Make additions or minor changes to standard detail drawings by including reference drawing numbers, notes, or details. These additions or changes should not affect the performance of the structure as originally designed.

B. If an adaptation of the standard design drawing affects the performance of the original design, amend and incorporate the original design notes and computations for the design into the design documentation for the project utilizing the adapted standard design. This documentation must include new or differing design assumptions, the effect of the modification on the original design, and the revised analysis and design of the structure.

536.74 Revision of Standard Design Drawings

Periodically review and revise standard design drawings as necessary to comply with current design and construction practice criteria. Furnish revisions to the office responsible for the standard drawing.

536.75 Availability of Standard Design Drawings to the Public

A. Provide copies of drawings when requested, in accordance with the procedures in Title 120, General Manual (GM), Part 408, Subpart C, “Freedom of Information Act and Privacy Act.”

B. Each drawing provided must include—

- (1) A precautionary statement stipulating that the design presented is a standard design that may require adaptation for a specific use or site. The statement must also stipulate that a qualified registered professional engineer perform or review the adaptation.
- (2) Material design strength and quality assumptions.
- (3) Site conditions assumed in the design.
- (4) Name and address of the office retaining the design notes and computations.

536.76 National Standard Detail Drawings

- A. Standard detail drawings are prepared for structures, spillways, and appurtenances. These drawings are prepared according to hydraulic and structural design criteria in 210-NEH, technical releases, or design notes. The drawings are prepared to permit direct use without any significant change.
- B. The drawings may be prepared as a series to provide the range of sizes frequently used. The Director, CED, determines the kind of structures and range of sizes.
- C. The CED keeps original drawings on file. SCEs may request drawings from CED for use in preparing plans for specific structures. Indexes of available standard detail drawings are in DN 18.

536.77 State Standard Detail Drawings

- A. Only prepare standard detail drawings for structures and structural appurtenances that are likely to be constructed on a regular basis. Prepare the design supporting the drawings in accordance with all NRCS design procedures, criteria, and materials specifications. Prepare drawings in accordance with section 541.
- B. Keep the folder containing the design notes and computations made during the preparation of these drawings on file for reference as long as the drawings are available.
- C. States must maintain a current index of standard detail drawings prepared by that State containing:
 - (1) Name or type of structure, structure element, or appurtenance
 - (2) State responsible for the design
 - (3) Date of design
 - (4) Criteria used for design
 - (5) Location of folder containing design notes and computations
 - (6) Types of materials used in the structure or element, size ranges, general application, and significant limiting assumptions
- D. The SCE should review all standard detail drawings as part of the design review before approval is given. This may require the SCE to request the design folder with the design notes and computations that support the standard drawing from the State that developed the standard drawing.
- E. States may use State standard detail drawings in class-VI or class-VII jobs as long as the States follow the proper design review process outlined in section 501.5 of this manual.

536.78 Standard Detail Drawings Prepared by Non-NRCS Engineers

- A. Non-NRCS engineers, other engineering organizations, vendors, and fabricators prepare standard detail drawings for NRCS conservation practices and systems. The design documentation supporting the drawings and the materials used in the structures or appurtenances must meet minimum NRCS criteria and should be of professional quality. Maintain the documentation on file for reference as long as the drawing is available for use.
- B. The SCE must review and concur in any use of standard detail drawings prepared by non-NRCS engineers. In conducting the review, the SCE may request assistance from the National Design Construction and Soil Mechanics Center. Accompany requests by documentation indicating the frequency of use and an estimate of the regional application of the drawing. Accompany all drawings with documentation containing design notes and computations.
- C. Use of standard detail drawings prepared by non-NRCS engineers in class-VI or class-VII jobs is

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allowed as long as the proper design review process is followed as outlined in section 501.4 of this manual.

D. The SCE must maintain an index of standard detail drawings used in the State and prepared by non-NRCS engineers. The index must contain the following information:

- (1) Name and type of structure, structural element, or appurtenance
- (2) Name and address of designer
- (3) Name and address of the vendor, distributor, or fabricator
- (4) Identifying name and number of the drawing
- (5) Date of original design and all revisions
- (6) Criteria used for design
- (7) Location of the folder containing design notes and computations
- (8) Type of materials used in the structure or element, size ranges, general application, and significant limiting assumptions

E. The SCE should review the consolidated index and, as appropriate, request from the State, vendor, or fabricator a copy of the desired standard detail drawing. When using a standard detail drawing so obtained, the SCE must obtain a copy of the folder containing the design notes and computations, including design assumptions that identify the limitations for use of the structure or elements.