PART 511 - DESIGN

SUBPART A - PROCEDURES

511.00 General.

(a) Engineering design is an organized and rational process that applies the natural laws of science for the enhancement of human welfare. Engineering design should be sensitive to the needs of people, their activities, and the landscape.

(b) Engineering design is done at many organizational and geographic locations. The designs made are of varying complexity and are often performed at locations some distance from the construction site. The design is performed by personnel having various levels of knowledge and skill. The designs often require review and approval by someone at a location other than the construction site or design office. Designs need to be reviewed to insure adequate performance and safety. Because of the diverse nature of the design activities in SCS, some standardization of basic nomenclature and procedures is needed.

(c) The principles defined in this part apply to all sizes and complexities of designs. The detail to which the procedures are to be followed varies according to the need. The simplest conservation practice may require only a few notes, computations, and drawings. Larger and more complex works may require numerous notes, computations, and drawings to complete all stages of the design. Likewise, the complexity of site conditions and engineering along with the number of alternatives and organizational units affects the intensity and duration of work at each design stage.

511.01 Design objectives.

Engineering design is to provide structural improvements having the quality and durability required for the economic life of the structure at the least total cost consistent with functional requirements. Engineering designs are to be determined by comparative design studies and cost estimates prepared with full consideration of the landscape, topography, foundation, and other site conditions including environmental quality, and the economy and feasibility of construction, operation, and maintenance. Economic comparisons of alternative designs are to be determined by the amortized average annual cost of installation (including costs of landrights), operation, and maintenance. Environmental comparisons are to consider ecological, cultural, and aesthetic values.

511.02 Design stages.

(a) To provide standard terminology for orderly scheduling of work and coordination with work, three stages of design activity are defined. This terminology is to be used in all SCS correspondence, publications, and documents relating to design. The design activities included in these stages may be further subdivided into phases or subphases as necessary to control SCS work or to administer engineering services contracts and agreements.

(b) On small and simple structural measures, all three stages of design can be done in one brief period of time and in a manner such that they are nearly inseparable. On larger works, such as projects, much of the work in stages one and two may be done during planning (510.01). Items for which the final design data are known during planning, such as topographic, hydrologic, and hydraulic features, should be completed for final design purpose at that time. The planning data need then only be reviewed before design commences in order to verify accuracy and adequacy. In this manner, data gathered during planning can be used to avoid duplication of effort and ensure that there is little or no modification needed in the general layout during final design. Similarly, data should be gathered on the geology and foundation if assurance against significant cost changes is desired.

(c) Stage one includes data collection and evaluation for all information on:

(1) Physical data. Topographic, hydrologic, visual, biologic, geologic, and archeologic data.

(2) System and structure functional requirements and purpose. The capacity, controlled water level, and location.

(3) Site constraints. Information on ownership boundaries and water rights.

(d) Stage two is the preliminary design, which consists of developing the general features of the works of improvement. It includes selecting the most suitable types of structures, the optimum layout and arrangement of the elements of the structural system in the landscape, the types and locations of appurtenant mechanical equipment, and, if applicable, the most feasible power source. Also, cost studies and an economic feasibility examination are to be made.

(1) Hydraulic design is to be sufficient to select alignment, grade, size, and critical elevations for each evaluated alternative.

(2) Foundation conditions are to be analyzed and the embankments designed in enough detail to satisfy seepage control and stability requirements.

(3) Structural details of alternate designs are to be developed sufficiently to prepare reasonable quantity and cost estimates.

(4) Landscape resource objectives and preliminary landscape resource designs and conceptual plans are to be developed sufficiently to determine feasibility and prepare preliminary cost estimates.

(5) Specifications of material and work requirements are to be outlined, and a schedule of work and payment items is to be included.

(6) Cost estimates are to be determined by estimating construction costs. Alternate designs are to be compared according to the average annual cost of installation, operation, and maintenance, including costs of land, easements, rights-of-way, and relocation of roads and/or utilities.

(7) A report is to be compiled including all information necessary to permit reviewing.

(e) Stage three is the final design, which consists of:

(1) Checking the adequacy of the surveys and investigations and the accuracy of the layout chosen in the preliminary design.

(2) Refining and revising the preliminary design information.

(3) Detailing the layout and hydraulic design.

(4) Completing the structural design.

(5) Refining the landscape resources design.

(6) Preparing the construction drawings, contract specifications, bid schedule, engineer's estimate, and construction schedule.

(7) Preparing the design report.

(8) Preparing the operation and maintenance plan.

511.03 Operating procedures.

(a) The operating procedures to be followed depend on the organizational level at which the design is done. If design is done by many offices or by offices that are remote from one another, the need for an established documented procedure is greater. Designs made at field and area offices are usually processed by simple informal procedures.

(b) The more complex designs often require technical assistance and/or approval by the TSC. The design may be prepared:

(1) By the SCS state engineering staff (field, area, or state office)

(2) By the TSC design section using data collected by state staffs.

(3) By the engineering staff of a sponsoring local agency under an agreement for engineering services.

(4) By a private engineer under a contract for engineering services negotiated either by SCS or the sponsoring local agency.

(c) If it is anticipated that design will require assistance or approval by the TSC, the state conservation engineer is to evaluate the design scope of the engineering program in the state and prepare a realistic design and construction schedule. In addition, in cooperation with the head of the TSC engineering staff, the state conservation engineer is to develop operating procedures for preparing designs, construction drawings, and specifications and for accomplishing their orderly and timely review and approval (see 501.04). Each TSC is to keep the Director of Engineering informed about the operating procedures. Operating procedures are to comply with the following:

(1) The state engineering staff is responsible for all surveys and investigations. The TSC engineering staff is to provide technical assistance in planning the scope and nature of such surveys and investigations if the TSC is to prepare the final design.

(2) The work is to be done by the state engineering staff if qualified design engineers are available.

(3) If the TSC is requested to furnish design assistance, the state ordinarily is to complete the preliminary design.

(4) TSC assistance may be requested at any stage in the preparation of the design.

(5) If local sponsoring agencies or consultants participate in the preparation of design requiring TSC approval the specifications for engineering services contracts and agreements are to be prepared jointly by the state staff and the TSC engineering staff.

(i) Engineering services specifications, payment schedules, and performance time are to have TSC concurrence.

(ii) Performance time is to be adequate to permit timely reviews at state and TSC levels.

(iii) Reviews are to be scheduled so that the responsible state makes its review before the TSC review.

(6) Construction drawings and specifications are to be prepared concurrently so that they can be properly coordinated.

(7) Contract specifications are to be compiled by the office responsible for the design of the work.

(d) Operating procedures for continuity between employees performing site investigation, design, and construction are not complicated for small or simple jobs if the work is done at one or two offices. However, if there are several offices and employees involved or segments of the work are done by specialists, maintaining continuity is much more difficult. In these more complex operations, coordination and communication is to be facilitated between engineers, geologists, and others during stages two and three of design and during construction. This is to be done by the designer and/or soil engineer assisting the geologist in planning and evaluating the site investigation. Field reviews during the investigation may be necessary to be sure all information needed for design is obtaind. Likewise, the designer is to arrange for transfer of information to the construction inspection staff. For more complex projects, the design and soil engineers, geologist, construction engineer, and inspector may meet to exchange information. This preconstruction meeting should cover critical interpretation and assumptions dealing with design features and those items that need verification during construction.

511.04 Design analysis.

(a) The design analysis defines the scope of the design and evaluates the relationships of the principles that determine the design. It consists of a step-by-step description of the procedures used. Each step is to be described concisely and completely.

(b) The design analysis is to include the data used, the criteria, and procedures. The design analysis is to be technically sound, performed in a logical manner, and documented.

511.05 Design checking and review.

(a) Checking during design is essential. Checking consists of an examination of narrative, computations, and drawings for accuracy, conformation with procedures, and consistency between the various parts of the design. The checker is to be experienced in the type of design, the criteria, and the procedures. The checker is to initial each sheet completed and verify:

(1) That the basic data and assumptions were used in the computations.

(2) That mathematic computations are accurate.

(3) That details are consistent from sheet to sheet.

(4) That drawings comply with the design.

(5) That drawings comply with the specifications.

(6) That computed critical elevations, costs, and quantities are accurate.

(7) That construction drawings are complete.

(b) Reviews are to be made during design to ensure technical quality. All designs, drawings, and specifications are to be reviewed (see Part 501). Reviews are to be made progressively by the responsible design office through an examination of narrative, computations, and drawings. The reviewer assumes responsibility with the designer for the functional adequacy and structural soundness of the structure or structural system. The reviewer's capability is to be equal to that needed to do the design. The review is to determine whether:

(1) The design provides for the planned purpose.

(2) The basic data are adequate.

(3) The design assumptions are valid.

(4) The methods of analysis are valid.

(5) Alternatives evaluated are equal in meeting minimum performance requirements.

(6) The solution is appropriate to the problem or site condition.

(7) The design complies with policy and criteria.

(8) The design is consistent with sound engineering practice.

(c) The review procedures depend upon the operating procedures used for Class I through VIII jobs. The review procedures for Class VI, VII, and VIII jobs are to be agreed on by the state conservation engineer and the head of the TSC engineering staff. The state conservation engineer is to ensure that the design schedule provides enough time for review by the appropriate authorities at the various design stages. Review schedules are to reflect a realistic consideration of the locations of the reviewing offices, time needed to transmit material, and coordination of the work with the rest of the workload of the offices.

511.06 Independent reviews.

Consideration is to be given to the need for an independent review of dams and other engineering structures which, when installed, will become a potential hazard to human life in case of failure. See 520.26 for the procedure to be used for dams. When necessary, a similar procedure should be used for other structures.

§511.07 Design criteria.

(a) Design criteria established by policy directives are often of a general nature. The criteria provide guidance in obtaining the quality of work acceptable. Designs are to be prepared to satisfy the functional purpose in a safe and stable manner, which may often result in requiring more restrictive limits than the established minimum criteria. In other words, meeting minimum engineering criteria will not, in all cases, insure adequate designs.

(b) Minimum design criteria established by policy are to be met.

(c) Criteria used in preparing project plans are normally used in the design and construction of structural measures. At the time of final design, the individual having the engineering job approval authority (see 501.04) is to reaffirm that all aspects of the engineering plans are legally permissible and that the structure will perform its assigned function in a normal manner during its service life. The design criteria are to be changed from that used in planning if:

(1) The planned design is not acceptable in light of new engineering knowledge as reflected in the revised criteria. In this situation, the measure is to be designed to meet new criteria.

(2) Downstream development requires a change in structure classification before construction. In this situation, the structure is to be reclassified and designed in accordance with the latest criteria.

(d) The sponsors or landowners are to be informed of changes that increase the cost or require alterations in landrights.

511.08 Construction plans.

(a) The preparation of construction plans is the final step in the design process. The construction plans consist of drawings and specifications. The drawings are a graphical description and the specifications are the narrative description of the works to be constructed. The plans are to provide descriptive information on the quantity and quality of the completed work. The work is to be clearly described so that the owner and constructor will understand the requirements. This provides a mutual understanding when the requirements are met.

(b) Construction drawings are to be prepared and assembled in a clear and logical manner. The minimum requirements are contained in Part 541.

(c) Construction specifications are to include both materials and construction methods. The minimum requirements are contained in Part 542. Requirements are to be established in terms of a specified end product, not in terms of a method.

511.10 Scope.

Design folders are to be prepared for all designs within approval categories VI, VII, and VIII (see Part 501) and all dams that have importance for reasons of public safety (see 520.21 (f)).

511.11 Design folders.

(a) The folder is to contain the design analyses, design report, construction drawings, specifications, bid schedule, and plan for operation and maintenance. All notes, computations, drawings, sketches, and other data are to be recorded neatly and organized in a folder in a manner that allows reproduction and incorporation in reports with a minimum of editing. Design drawings, diagrams, graphs, sketches, or other pictorial representations should be incorporated into the computation file if the size and scale permit. Design drawings drawn on larger sheets that cannot be folded to computation sheet size are to be cited at the appropriate place in the computations by a notation that fully identifies the drawing and its file location. The design documents should be kept in a binder to keep them in order.

(1) Design records are to be kept orderly and current to allow for efficient review at any stage. They are to be complete and understandable because they may be used for later actions such as:

(i) Design changes required during construction.

(ii) Structural modification or addition during operation or maintenance.

(iii) Investigation of performance.

(2) Design records are to document completely:

(i) The data gathered to demonstrate the physical, chemical, and biological conditions at the site.

(ii) The purpose and function of works designed.

(iii) The standards, criteria, and limitations used as design guidance.

(iv) The problem conditions to be considered.

(v) The qualitative and quantitative design analysis.

(b) Design resorts summarize in narrative form the design objective, data, criteria, assumptions, procedures, and decisions used in design. Selected structure dimensions, elevations, capacities should be used to augment the narrative, but are not to serve as a replacement.

Previously developed requirements established during the planning phase are to be included by reference. Design reports may vary in length from a brief synopsis to an extensive review. A design report is to address the topics in the following list as appropriate. The report should be commensurate with the design complexity and significance; some items listed may not be relevant, and if not, need not be included.

(1) Summary. A concise statement of the history and status of design, previous reviews disposition of applicable policy items, justification for departure from standards, receipt of waivers, etc.

(2) Description of the job. A brief description of the major features, hazard classification, drainage area, storm frequencies, landscape resources, capacities, etc. Include any variance from project plans.

(3) Design objective. A brief, clear statement that may be a summary from a project plan. Differences identified from plans must be supported by proper approvals.

(4) Basis for design. A listing of reference documents used in design such as handbooks, codes, reports, studies, and criteria.

(5) General basic data. Hazard analyses, seismic assessment, and limiting conditions or restraints that may influence design, construction, or facility operation.

(6) Location and layout. Consideration of site configuration or landscape conditions that had an effect.

(7) Hydrology. The data reference, procedures, spillway operation frequency water yield, reservoir operational studies, and summary of precipitation amount and intensity.

(8) Hydraulic design. A summary of the hydraulic shape and proportioning selected. Include channel stability and sediment transport considerations.

(9) Foundations and/or embankment design. A summary of data, site conditions, assumptions, treatments selected, and design analyses used:

(i) To make seepage analyses and design control measures.

(ii) To make stability analyses and determine material quality and quantity.

(iii) To make foundation design analyses.

(iv) To permit planning instrumentation systems.

(10) Structural design. A summary of assumptions, loading conditions, and design procedures.

(11) Environmental considerations. Features or practices to provide for conservation of visual, biological, and surface and ground water resources that may be affected by the planned measures, both during and after construction.

(12) Construction drawings. Mention of standard detail drawings or any use of previously prepared special drawings.

(13) Specifications. Mention of special specifications and why they were needed. Explain special conditions or the need for special provisions in the construction contract.

(14) Bid schedule. Consideration for selection of lump sum or subsidiary items.

(15) Cost estimate. The considerations used that may be affected by the season or changes in size of contract.

(16) Construction schedule. Explanation of any critical starting, delay, or completion dates.

(17) Operation and maintenance. Explanation of conditions in which design assumptions depend on proper O&M and significant O&M activities are anticipated (for example, grasses in the emergency spillway to protect against erosion during flow). Items identified and evaluated during design that are planned for replacement during the evaluation period are to be noted and described.

(18) Construction review. A summary of those items, conditions, or features encountered during construction that require a field review by the design, geologist, soil engineer, or other specialist to ensure that conditions anticipated during design are verified and are consistent with the design assumptions. Include the request for timely notification. Note whether a preconstruction conference is needed.

(19) Authority. The name (with signature) and title of the designer and approving officer.

511.20 General.

(a) Structures, including foundations, abutments, and the surrounding area of influence, are instrumented to facilitate evaluation of their condition and performance during and after construction.

(b) Instruments are installed to measure water levels or pore pressures, earth or rock loads and pressures, settlements, deflections or other movements, ground motions during earthquakes, leakage rates or volumes, and other important items relating to safety and performance.

(c) Instruments are used if it is determined that information is needed for one or more of the following purposes:

(1) Determining safe rates of earth fill placement.

(2) Determining if structural strength is adequate for backfill placement or for shoring removal.

(3) Determining safe rates or limits of excavation.

(4) Determining water levels and pressures within soil and rock formations.

(5) Determining seepage rates or volumes.

(6) Determining safe rates of reservoir filling.

(7) Determining the instability of natural or constructed slopes.

511.21 Scope.

The use of instrumentation is to be considered for all Class (c) dams over 30 feet in height and any dam that has over 600 acre-feet of storage. Earth dams or other structures with unique or complex foundations, abutment problems, or uncertain soil conditions are to be considered for performance monitoring with instruments.

511.22 Need for reliable instruments.

Many types of instruments are commercially manufactured or can be assembled to perform the measurements needed. Designs are to include only those instruments proven to be reliable and serviceable. If SCS lacks experience in the use of an instrument, it is necessary to check with other users to determine its reliability.

511.23 Use of instrumentation.

(a) The decision on whether to monitor, with instruments depends on:

(1) Reliability and completeness of the investigation information;

(2) Whether soil and rock conditions or criteria used in analyses are sufficiently conservative; and

(3) The consequences of misjudging these items.

(b) In the design folder, document the process by which the decision to instrument or not to instrument was made and the rationale for that decision.

(c) Instrumentation is to be used in all situations in which the effects of treatment have any degree of uncertainty that would result in unsafe conditions or an inadequate structure. All safety conditions including safety to the construction force, are to be considered. The design is to include the details and specifications for the instruments and their installation.

(d) For earth structure, the design analyses are to determine the magnitude of water pressure, physical movement, soil pressure, or other measurable items where potentially unstable or undesirable conditions exist. This information is to be included in the design report and used in the development of a plan for reading the instruments.

511.24 Instrumentation plans.

(a) Instrumentation designs are to include a plan that describes the purpose, the layout and location, type of instruments to be used, and limits of loading, pressures, movement, or volumes for satisfactory structure performance. The plan is to include installation details and sequence. Instructions are to be included that indicate the timing and frequency of reading and recording both during and after construction. Special attention is to be given to the critical periods in the life of the structure such as during the first filling, any rapid raising or lowering of water, and after an earthquake or other disturbance. The plan is to be a part of the design documentation and is to have the same review and approval as the other design items.

(b) As the instruments are installed and reading procedures are started, the instrumentation plan is to be adjusted to include procedures for data reporting and reduction or plotting. Forms for recording data may be developed. Individuals responsible for interpreting the results are to be specified. Emergency procedures are to be developed that indicate those individuals to be notified when critical readings are approached and steps to be taken if necessary.

(c) When the project is completed and the structure is in operation, the plan may need to be supplemented for use by new personnel who will read and evaluate the instruments or for the different operating personnel and conditions. The plan should also include the location and method of data storage.

511.25 Instrumentation monitoring and reporting.

(a) The state conservationist is to provide assistance to ensure that the needed monitoring is performed, recorded, and reported. This can be made a part of the operation and maintenance agreement.

(b) An annual report of the monitoring is to be made to the state conservation engineer until monitoring is terminated. The head of the TSC engineering staff is to receive a copy of this report. The report is to be a summary to update the instrumentation plan.

(c) The monitoring program may be terminated on completion of the intended purpose with mutual consent of the state conservation engineer and the head of the TSC engineering staff for co-approved jobs. A completion report is to be prepared.

(d) A summary of the site condition and structure performance exhibited by the instrumentation readings is to be made on termination of the monitoring program. This summary is to include an appropriate graphical array of the readings and interpretations or conclusions regarding the performance. Additional conclusions and recommendations for improvement may be made regarding the instrument's location, performance, and installation.