Appendix B
Design and Construction Planning

B-1. Introduction

Information provided in Appendix B of EM 1110-2-2602 contains guidance on structural and project engineering responsibilities as well as details of the life cycle project management process as applied to a large scale civil works project. This guidance is also applicable to navigation dams. A reiteration of the structural and project engineering responsibilities is provided below.

B-2. Structural and Project Engineering Responsibilities

a. General. The Corps of Engineers operates in partnership with the Inland Waterways User Board (IWWUB), which shares the cost of designing and building navigation lock projects. Increased emphasis is being place on the key roles of the structural engineer (SE) and the project engineer (PE) in achieving high-quality products on schedule and within budget. To facilitate project development, a project management office was established in HQUSACE and in each division and district. In the project management system, the project manager (PM) is the primary point of contact for project coordination between the local sponsor and the Corps. The PM manages the project scope, schedule cost, and budget, and facilitates the resolution of existing or potential problems. The PM is also responsible for reporting the project's status to higher authorities and the local sponsor. This guidance should enable the SE and PE position to better support the PM. An important link in the cooperative relationship between engineering division (ED) and the PM is the individual designated as the PE. This individual should be a registered professional engineer and should be an SE in the case of a navigation lock project. However, the PE could come from other technical disciplines in ED. The PE position should not be filled by any other technical manager (TM). One PE is assigned to the overall project. The PE's role on the design team is to assist in the technical management of the project. Because a successful PE generally requires broad design experience and technical leadership, such assignments must be made to senior designers who have been delegated authority to perform their interdisciplinary responsibilities.

b. Structural engineering responsibilities. Structural design is a creative process that generally begins with a vague definition of the client's problems and proceeds to a practical solution using basic engineering principles and modern technology. A navigation lock project is executed by a multidisciplinary team that may include several structural engineers. The SEs must determine the appropriate level of analysis required for each phase of the life cycle process. The analysis performed during the reconnaissance phase relies on engineering judgment with abridged numerical modeling. During this phase, the SEs will examine a minimum number of possible structural solutions that are mutually acceptable to local and federal interests. In contrast, during the preconstruction engineering and design phase, detailed analyses will be performed and structural features designed to the degree necessary to prepare quality contract documents. During the construction phase, the only analyses performed are those required to resolve field problems. Analyses during the operation and maintenance phase may be required for deficiencies, repairs, modifications, or replacement. The responsibilities for the structural design can be categorized as described below.

c. Design and analysis. One of the SE's primary responsibilities is to develop a structural solution that meets the design objectives. The SE will draw upon past experience to develop design concepts or examine new and innovative solutions. The SE will combine engineering judgment with engineering principles to develop a reliable basis for design. Depending on the project phase, the analyses may require manual computations that capture the general structural behavior or in-depth computer modeling using software developed by the Computer-Aided Structural Engineering (CASE) project.

d. Design quality. The engineering design team's performance influences the quality of each design phase. Quality is affected by the SE's ability to communicate, apply sound judgment, advise, plan, analyze, and review designs.

e. Cost estimating. The SE should help develop the cost estimate at each phase of the project. The level of this participation may vary; at whatever level, it is essential to developing a reliable cost estimate. (Public Law 99-662 limits projects authorized by the act to a 20 percent increase in the baseline cost, excluding increases due to inflation and changing legal requirements.) The SE should consider the reliability of engineering and other data available when developing contingency factors.

f. Design schedule and budget. Throughout the project's life, SEs should prepare and maintain their design schedules and budgets. This information is provided to the PE for preparing the engineering schedule

and budget. Individual schedules and budgets should be based on reliable data and information available from other disciplines. Contingencies should be included to account for uncertainties. An overly conservative budget or design schedule can result in termination of the study or require reauthorization of the project. On the other hand, overly optimistic estimates result in insufficient funding to complete the project. After the schedule and budget are approved, the SE should complete the design within that schedule and budget. Changes can be made only with written approval by the PM. Throughout the project, the SE should make comparisons between scheduled and actual progress, and budgeted and expended dollars, to assess performance. The SE should provide the results of these comparisons to the PE.

g. Technical coordination. The SE is involved in technical coordination of structural features during all project phases. The SE should coordinate structural design activities with individuals from other functional elements (geotechnical, hydraulic, mechanical, electrical, architectural, construction, operations, cost engineering, real estate, surveying, mapping, etc.) to develop the design of the structural features. Also, the SE should maintain technical coordination with the technical staff of the local sponsor. Technical coordination with a higher authority to reach early agreement on unprecedented or complex problems is encouraged.

h. Project engineering responsibilities. Selection of the PE is one of the most important management decisions for ensuring success. The PE should be a technical leader who has an overview of the project and a general understanding of the various functional elements and thus is able to support the PM by managing the design process.

(1) Management of design process. The PE, working with all appropriate disciplines, should define the engineering design objectives pertaining to customer care, innovation, engineering and design (E&D) costs, operation and maintenance (O&M) costs, modifications, quality, biddability, constructibility, and operability. The PE should identify the specific tasks required to support the design objectives and should integrate the team effort in an efficient and cost-effective manner. The PE should monitor team progress by reviewing the schedules and budgets and by measuring actual production, time elapsed, and funds expended. Changes should be documented and evaluated for impacts.

(2) Design quality. A quality product is the primary objective. Design quality is influenced by the PE's ability to promote a team environment that encourages communication between engineering disciplines. The PE must recognize technical conflicts at an early stage. In addition, the PE should explore alternate designs that could improve quality or reduce costs.

(3) Design schedule and budget. The PE should coordinate and consolidate the budget and provide it to the senior engineering staff. Each discipline should prepare a detailed estimate to ensure that adequate resources are budgeted to perform all engineering functions for all phases.

(4) Cost estimate. The PE should ensure that quantities are being developed in accordance with the code of accounts so that no quantities are omitted or duplicated. Contingencies should be established and justified in terms of available information. The PE should inform the PM if additional engineering information is needed to reduce contingencies that have a significant impact on total cost. A sample template for making the cost estimate with typical-cost items for a navigation dam is provided in section B-4.

(5) Interaction with project manager. The PE should maintain a working relationship with the PM. It is essential that the PE inform the PM about the project status and contacts with the local sponsor. The PE should support the PM in developing the engineering aspects of the project management plan.

B-3. Design Checklist for Navigation Dams

a. Reconnaissance report. Structural analysis in this phase is usually limited to a few basic calculations used together with data from similar projects and proven engineering concepts to establish the project's viability.

(1) Approximate location and consideration or list of alternative sites.

(2) Preliminary determination of controlled and uncontrolled dam width.

(3) Need for navigation pass.

(4) Lift.

(5) Need for model studies.

(6) Preliminary foundation type (for cost purposes).

(7) Preliminary spillway configuration.

(8) Overall structural layout of dam and appurtenant features that is a reliable base for the cost estimate.

(9) Preliminary decision on type of gates (for cost purposes).

(10) Need for a bridge.

(11) Estimate of design effort required for feasibility report.

(12) Preliminary quantities for reconnaissance cost estimate.

(13) Estimate-design criteria.

(14) List of design memoranda.

(15) E & D cost estimate (input).

(16) Coordination with other elements as needed.

b. Feasibility report. A significant amount of structural analysis is accomplished during this phase. The design team examines and compares alternative solutions and then chooses the most suitable and economical solution. Sufficient structural analysis must be performed to ensure that the chosen solution is the appropriate one and that *quantities are reliable enough* to predict the construction cost within 20 percent.

(1) Finalize location.

(2) Determine final controlled/uncontrolled dam width.

(3) Determine overall dam geometry:

- Elevations of spillway crest, navigation pass, and bridge, length of spillway, etc.
- Width of dam piers.
- Type of gate and control elevations such as elevation of trunnion girder.

(4) Finalize type of foundation.

(5) Select type of lock gates based on functional requirements.

(6) Select type of filling and emptying system.

(7) Establish requirements for operations buildings (control stands, etc.).

(8) Decide on maintenance unwatering facilities.

(9) Compute quantities for feasibility cost estimate.

(10) Establish preliminary design criteria.

(11) Establish list of guide specifications.

(12) Provide input for:

- Outline of VE studies.
- Detailed schedule and budget for E & D.
- Project Management Plan (PMP).

(13) Describe special analyses or Feature Design Memoranda (FDM) required.

(14) Coordinate with other elements as needed.

c. Design memorandum (DM) phase. Most of the structural analysis will be performed in the DM phase. The design of all the representative structural components should be accomplished in the individual DMs as identified in the PMP. The DM should address the following issues:

(1) Need for detailed soil information.

(2) Final design criteria.

(3) Final loads.

(4) Loading conditions and critical cases.

(5) Final structural analysis of all gates, bulkheads, etc.

(6) Structural analysis and determination of areas of steel for all critical reinforced concrete members.

(7) Layout of dam accessories and embedded metals.

(8) Parapet-versus-hand-rail selection.

(9) Public access.

(10) Esplanade.

(11) Control houses.

(12) Level of coverage for FDM presentation.

(13) Drawings to be presented in FDM and what will be shown on each.

(14) Preparation of FDM drawings.

(15) Proposed instrumentation relative to structural safety.

(16) Preparation of FDM text.

(17) Quantities for FDM cost estimate.

(18) Input for Critical Path Method (CPM) on materials and equipments.

(19) Coordination with other elements as needed.

d. Plans and specification phase (PED). In this phase, the team performs minimal structural analysis (main structural members) besides revisions needed to finalize the design. This phase consists mainly of designing the details, placing them on the drawings, and writing the specifications.

(1) Identify standard details to be used.

(2) List all drawings and what to present on each.

(3) Identify all details remaining to be designed.

(4) Prepare reinforcing steel layouts.

(5) Prepare contract drawings.

(6) Research previous similar jobs for specifications.

(7) Mark up guide specs and specs from other jobs.

(8) Write specifications as required.

(9) Prepare quantities for government estimate.

B-4. Detailed Cost Estimate

Cost Account	Item	Qty.	Unit	Unit Price	Total Cost
04	**DAM**				
	FOUNDATION				
	Excavation, common		cu yd		
	Excavation, rock		cu yd		
	Excavation, foundation		cu yd		
	Deep compaction of foundation fill		job		
	Fill, backfill		cu yd		
	Piling, steel bearing				
	HP 14x73, vertical		lin ft		
	HP 14x117, vertical		lin ft		
	HP 14x117, batter		lin ft		
	Pile tips for HP 14x73		each		
	Pile tips for HP 14x117		each		
	Steel, reinforcement (welded to tension pile)		lb		
	Pile load and driving tests		each		
	Piling, steel sheet (PZ22)		lin ft		
	Subtotal for Foundation				
	Contingencies				
	TOTAL FOR FOUNDATION				

Cost Account	Item	Qty.	Unit	Unit Price	Total Cost
04	**DAM, Continued** **CONCRETE** **STRUCTURE** Concrete, reinforced Dam monolith bases Dam piers Service bridge piers Non-overflow walls Stilling basin Steel, concrete reinforcement Waterstop Preformed joint filler **Subtotal for concrete structure** **Contingencies** **TOTAL FOR CONCRETE**		 cu yd cu yd cu yd cu yd cu yd cu yd lb lin ft sq ft		
	STRUCTURAL STEEL Steel, tainter gates Steel, emergency bulkheads Steel, maintenance bulkheads Steel, miscellaneous, embedded Line hooks and mooring rings **Subtotal for structural steel** **Contingencies** **TOTAL FOR S. STEEL**		 lb lb lb lb lb		
	SERVICE BRIDGE Concrete Concrete, precast I-Beams Concrete Reinforcement **Subtotal for Service Bridge** **Contingencies** **TOTAL FOR SERVICE BRIDGE**		 cu yd lin ft lin ft lb		