Chapter 2
Design

2-1. Design Process

The structural design of closure structures for openings in levees and floodwalls should be planned in detail to ensure that the elements of the structural design responsibility are properly executed during the reconnaissance phase through the operations phase of projects. These elements include: coordinating the required input from the project manager, project engineer, and other engineering disciplines and functional members of the design team; incorporating general design provisions into the design process and resulting solutions which pertain to operational, functional, maintenance, aesthetics, safety, security, construction, and economical considerations; examining and comparing pertinent features of closure types, selecting the appropriate closures and suitable alternatives for particular applications, and defining the preferred general design concept which provides a basis for estimating the construction cost; and performing the required structural analyses and design of structural features and ensuring design quality through design review and other methods of verification. Appendix A provides a checklist of design functions required during each phase of the design process.

2-2. Design Coordination

Full coordination of the total design process should be considered as the most essential element for ensuring design quality. The structural engineer must operate within the prescribed role and functional relationships established between the structural discipline and the project manager, project engineer, engineering disciplines, and other functional elements engaged in the design process to effectuate the coordination required for the design of closures.

a. Project manager. Throughout the design process, the project manager is responsible for coordinating with the local sponsor, communicating input from the local interests to the project engineer and design engineers, and ensuring that the major design features of closure structures are acceptable to the local interests. The project manager must also obtain agreement with agencies or entities which own and maintain utilities and facilities which would be impacted by the construction of the closure structures. Such facilities include pipe lines, transmission lines, streets, highways, bridges, and railroads.

b. Project engineer. The project engineer, in managing the design of closure structures, is responsible for interacting with the project manager to obtain the agreed local sponsor requirements and acceptance of proposed design solutions for closure structures and communicating these to the functional elements engaged in the project including real estate, planning, engineering, construction, and operations.

c. Structural engineer. The structural engineer is responsible for coordinating with the project engineer and other engineering disciplines engaged in the design of closure structures, including civil, geotechnical, hydraulic, mechanical, coastal, environmental, construction, and operations engineers, to ensure all pertinent engineering considerations are properly integrated into the structural design.

2-3. General Design Provisions

General design provisions which must be integrated into the design process for the design and construction of closure structures for LFPP include operational, functional, maintenance, aesthetics, safety, security, construction, and economical considerations. These provisions must be fully and appropriately addressed in the design process and the resulting project documents.

a. Operational. The required lead time for closing the structures in the event of flooding is controlled by the rate of rise of the flood waters. The accuracy of advanced forecasting of flooding determines the length of time which should be scheduled for the mobilization of operations personnel and equipment required to close the structures. Also, the accuracy of forecasting determines the number of times traffic is inconvenienced by a closed structure when flooding does not occur. The scheduled time for closure of structures should include a cushion to ensure that closure is completed well before the arrival of flood waters. The required lead time and the types of operating equipment and operations personnel available to the local sponsor are the primary factors in determining the type of closure structures suitable for particular applications.

b. Functional. Functional requirements for facilities, such as roadways and railroads, affect the design of closure structures. Existing site topography and clearance requirements for roadways (highways and streets) and railroads are primary functional considerations which must be incorporated into the design of closure structures.

(1) Site topography. Existing grades parallel to roadways and railroads affect the required site distances along these facilities. Variation of grades along roadways and railroads affects the selection of the type of closure structures and the design of sills and supports for these facilities. For example, multiple sets of railroad tracks occurring at different grade elevations require a hinged bottom seal arrangement to provide an effective seal.

(2) Clearances.

(a) Roadways. The opening widths provided for roadways shall comply with the requirements of the American Association of State Highway and Transportation Officials (AASHTO) (1989). The width of closure openings should not be less than 30 ft for roadways with two lanes of traffic. The minimum vertical clearance between the crown of roadways and fixed overhead components of closures should not be less than 14 ft. Clearances should be coordinated and approved by the facility owner.

(b) Railroads. Minimum horizontal and vertical clearances shall not be less than that required by the AASHTO (1989). The normal minimum width of opening provided for railroads is approximately 20 ft for each set of tracks involved in the closure. Clearances should be coordinated with and approved by the facility owner.

c. Maintenance. Proper maintenance of closure structures is essential to the continuous satisfactory performance of the structures. The required maintenance provisions must be included in the agreement with the local sponsor. Current agreements with local sponsors require annual periodic inspections of the closure structures and the adjoining levee or floodwall. Inspections must be thorough so that any deficiencies that are critical to the function of the project are detected and promptly corrected. Designs should incorporate materials, systems, and features which are economically feasible and require minimal maintenance.

d. Aesthetics. The requirements for incorporating aesthetic quality into the design of LFPP have been established. EM 1110-2-38 provides guidance for aligning flood control channels, landscaping along channels, and the aesthetic treatment of channel linings. EM 1110-2-301 also provides guidance for landscaping. In some LFPP floodwalls, an open view of the waterway was made an aesthetic requirement. These projects incorporate closures with bottom hinged walls which can be stored in the lowered position and raised for protection during flood periods.

e. Safety. The design of closures must include safety provisions for the public and the operations personnel. Local sponsors are responsible for the safe operation of closure structures; therefore, designers must coordinate with sponsors so that the appropriate design provisions are incorporated to ensure safe operation. General safety provisions include providing railings on the top of gates and adjacent walls for public protection and providing ladders for access by operations personnel. Additional safety features could include warning signs and barriers which prevent access by unauthorized persons.

f. Security. The design of closure structures must include security provisions which prevent vandalism and the impairment of operating capability. Locked storage facilities which are inaccessible to the public should be provided for the storage of stoplogs, removable posts, and other unsecured parts of closure structures. In areas subject to vandalism, masonry buildings should be used. Latching devices which hold gates in the stored position should be provided with adequate locks.

g. Construction.

(1) Procedures and methods. Construction procedures and methods should be considered during design to facilitate the general constructibility of closure structures. All phases of construction and erection procedures, particularly for gated closure structures, should be considered and design details developed which minimize complexities.

(2) Assurance of design integrity. The structural designer must identify, in the project documents, the design assumptions, details, and specifications essential to design integrity. This is necessary to make certain that the closure features receive assurance inspection during construction to verify that actual construction methods are in compliance with the design assumptions, details, and specifications.

h. Cost comparisons. The costs of previously constructed closure structures vary according to the closure type and opening size. These variations should be considered in making cost-effective decisions in the selection of the closure type and the design of closure structures for openings in levees and floodwalls of LFPPs.