

APPENDIX B

EVALUATING COASTAL  
FLOOD PROTECTION STRUCTURES

(From Reference 28)

## Criteria for Evaluating Coastal Flood Protection Structures

### Background

Many property owners and communities along the U.S. coast are resorting to the construction of coastal flood control structures to protect existing or new development from potential damage associated with hurricanes and other major coastal storm events. Flooding and erosion caused by natural processes, sea level rise, and/or man-made influences are factors contributing to the decision to construct structures such as seawalls, revetments, bulkheads, and coastal levees/dikes. Although there is continued debate on the overall impact of these coastal structures, their construction and use requires that FEMA evaluate their effectiveness for reducing flood risk and their viability as an alternative to the non-structural flood loss reduction approaches required for community participation in the National Flood Insurance Program (NFIP).

The areas protected by coastal flood protection structures are frequently designated as Coastal High Hazard Areas (V zones) on the Flood Insurance Rate Maps (FIRMs) published by FEMA. FEMA is often requested to revise FIRMs to reflect the protection provided by a coastal structure against the base (100-year) flood. Because of the different types of coastal structures, materials, and construction methods, FEMA must perform a detailed review of these requests to assure that the structure is adequately designed and constructed to provide the stated level of protection, and to withstand the 100-year flooding event.

Part 65 of the NFIP regulations requires that any requestor of a FIRM revision based on flood protection structures provide an analysis of the revised flood hazards, demonstrate and certify that the structure is designed and constructed for 100-year flooding conditions, and provide assurance that the structure will be maintained. Revision requests based on coastal structures are currently reviewed on a case-by-case basis using these regulations. A wide variation has been found in the quality of data submitted. Some possible reasons for this variation include the requestor's inexperience or unfamiliarity with the different types of structures, the available design guidance, and/or the base (100-year) flood considered by the NFIP. In order to improve the quality of information submitted, and the ability of FEMA to review revision requests based on coastal structures, FEMA has decided to establish minimum design criteria that must be addressed in the request.

FEMA commissioned the U.S. Army Corps of Engineers, Waterways Experiment Station (WES), Coastal Engineering Research Center to identify or develop criteria for evaluating the effectiveness of all types of coastal flood protection structures in preventing or reducing damages and flooding from the 100-year event. This study identified and defined the different coastal structures that provide protection against flooding to property landward of the structure, and documented successful and unsuccessful cases for each structure type. The minimum criteria, considerations, and/or conditions applicable to the 100-year flooding event that are necessary for an evaluation of a coastal structure were also identified. The WES study recommended a procedure using these criteria to evaluate the adequacy, of a coastal flood protection structure to survive the 100-year flooding event, and to provide protection against flooding, wave runup and overtopping, wave forces, and erosion.

The WES Technical Report CERC-89-15 "Criteria for Evaluating Coastal Flood

Protection Structures" was used as the basis for these criteria. These criteria will also be used to resolve appeal challenges and in the conduct of flood insurance studies, when sufficient design and construction data are available.

Mapping of areas protected by coastal flood protection structures.

(a) General. For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those coastal flood protection structures that meet, and continue to meet, minimum design and maintenance standards that are consistent with the level of protection sought through the comprehensive floodplain management criteria established by 44 CFR Part 60.3. Accordingly, this procedure describes the types of information FEMA needs to recognize, on NFIP maps, that a coastal flood protection structure provides protection from the base flood. This information must be supplied to FEMA by the community or other party seeking recognition of such a coastal flood protection structure at the time a flood risk study or restudy is conducted, when a map revision under the provision of Part 65 of this subchapter is sought based on a coastal flood protection structure, and upon request by the Administrator during the review of previously recognized structures. The FEMA review will be for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and shall not constitute a determination by FEMA as to how a structure will perform in a flood event.

(b) Design Criteria. For coastal flood protection structures to be recognized by FEMA, sufficient evidence must be provided that adequate design, construction, and maintenance have been undertaken to provide reasonable assurance of durable protection from the base flood. The following requirements must be met:

(1) Design Parameters. A coastal flood protection structure must be designed using physical parameters that fully represent the base (100-year) flooding event, including the following:

(i) Design water levels evaluated should range from the mean low water level at the site to the 100-year stillwater surge elevation. The full range of elevations must be examined to determine the critical water level since the most severe conditions may not occur at either extreme.

(ii) Wave heights and periods must be calculated for each water level analyzed. At a minimum, significant wave height and periods should be used for "flexible" structures such as revetments, with larger wave height, up to the one-percent wave height (1.67 times the significant wave height), used for more rigid structures such as seawalls and bulkheads. The U.S. Army Corps of Engineers (USACE) Shore Protection Manual (1984 or later edition), provides guidance and procedures for determining appropriate wave heights and periods.

(iii) Breaking wave forces under structure-perpendicular loading must be considered in the design unless it can be demonstrated that the structure will not be subject to breaking waves. The very high, short duration "shock" pressures must be used for low mass structures such as bulkheads, while only the secondary "non-shock" pressures need to be used for massive structures such as gravity seawalls. Analyses of the breaking wave forces using methods such as those identified in the COE report "Criteria for Evaluating Coastal Flood Protection Structures," (WES TR CERC-89-15) must be submitted.

(2) Minimum Freeboard. The minimum freeboard for coastal flood protection structures to be recognized on FEMA flood maps for protection against the storm surge component of the base flood shall be two feet above the 100-year stillwater surge elevation.

(3) Toe Protection. The loss of material and profile lowering seaward of the structure must be included in the design either through the incorporation of adequate toe protection or an evaluation of structural stability with potential scour equal to the maximum wave height on the structure. Engineering analyses such as those recommended in the COE's "Geotechnical Engineering in the Coastal Zone" (WES IR CERC-87-1) or "Design of Coastal Revetments, Seawalls, and Bulkheads" (COE EM 1110-2-1614) must be submitted for the toe protection, or an analysis of scour potential such as found in "Criteria for Evaluation Coastal Flood Protection Structures" (WES TR CERC-89-15) must be submitted.

(4) Backfill Protection. Engineering analyses of wave runup, overtopping, and transmission must be performed using methods provided in the USACE report "Criteria for Evaluating Coastal Protection Structures" (WES TR CERC-89-15). Where the structure height is not sufficient to prevent overtopping and/or wave transmission, protection of the backfill must be included in the design. This should address prevention of loss of backfill material by rundown over the structure, by drainage landward, under, and laterally around the ends of the structure; as well as through joints, seams, or drainage openings in the structure.

(5) Structural Stability, Minimum Water Level. Analyses of the ability of the structures to resist the maximum loads associated with the minimum seaward water level, no wave action, saturated soil conditions behind the structure, and maximum toe scour must be submitted.

(i) For coastal dikes and revetments, a geotechnical analyses of potential failure in a landward direction by rotational gravity slip must be submitted.

(ii) For gravity and pile-support seawalls, engineering analyses of seaward sliding, of seaward overturning, and of foundation adequacy using the maximum pressures developed in the sliding and overturning calculations must be submitted.

(iii) For anchored bulkheads, engineering analyses of shear failure, moment failure, and the adequacy of the tiebacks and deadmen to resist the loadings must be submitted.

(6) Structural Stability - Critical Water Level. Analyses of the ability of the structure to resist the maximum loads associated with the critical water level, which may be any water level from the mean low water level to the 100-year stillwater elevation, including hydrostatic and hydrodynamic (wave) loads, saturated soil conditions behind the structure and maximum toe scour, must be submitted.

(i) For coastal dikes and revetments, geotechnical analyses of potential failure in a seaward direction by rotational gravity slip and of foundation failure due to inadequate bearing strength must be submitted.

(ii) For revetments, engineering analyses of the rock, riprap, or armor blocks' stability under wave action; uplift forces on the rock, riprap, or armor blocks; toe stability, and adequacy of the graded rock and geotechnical filters must be submitted.

(iii) For gravity and pile-supported seawalls, engineering analyses of landward sliding, of landward overturning, and of foundation adequacy using the maximum pressures developed in the sliding and overturning calculations must be submitted.

(iv) For anchored bulkheads, engineering analyses of shear and moment failure using "shock" pressures must be submitted.

(7) Material Adequacy. Documentation and/or analyses must be submitted that demonstrate that the materials used for the construction of the structure are adequate and suitable including life expectancy considerations, for the conditions that exist at the site.

(8) Ice and Impact Alignment. Where appropriate, analyses of ice and impact forces must be submitted.

(9) Structure Plan Alignment. A shore protection project should present a continuous structure with redundant return walls at frequent intervals to isolate locations of failure. Isolated structures or structures with a staggered alignment must submit analyses of the additional forces from concentrated, diffracted, and/or reflected wave energy on the different sections and ends.

(10) Other Design Criteria. FEMA will require that flood protection structures, regardless of type described above, be evaluated on the basis of how they may react structurally to applied forces. Therefore, analyses normally required of one structure type may also be required by another type which would react in a similar manner to applied forces. In unique situations, FEMA may require that other design criteria and analyses be submitted to show that the structure provides adequate protection. In such situations, sound engineering practice will be the standard on which FEMA will base its determinations. FEMA will provide the rationale for requiring any additional information.

(c) Adverse Impact Evaluation. All requests for flood map revisions based upon new or enlarged coastal flood control structures shall include an analysis of potential adverse impacts of the structure on flooding and erosion within, and adjacent, to the protected area.

(d) Community and/or State Review. For coastal flood protection structures to be recognized, evidence must be submitted to show that the design, maintenance, and impacts of the structures have been reviewed and approved by the affected communities and by any Federal, state, or local agencies that have jurisdiction over flood control and coastal construction activities.

(e) Maintenance Plans and Criteria. For a coastal flood protection structure to be recognized as providing protection from the base flood, the structure must be maintained in accordance with an official adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the structure when recognition is being sought or when the plan for a previously

recognized structure is revised in any manner. All maintenance activities must be under the jurisdiction of a Federal or state agency, an agency created by Federal or state law, or any agency of a community participating in the NFIP that must assume ultimate responsibility for maintenance. This plan must document the formal procedure that ensures that the stability and overall integrity of the structure and its associated structures and systems are maintained. At a minimum, maintenance plans shall specify the maintenance activities to be performed, the frequency of their performance, and the person by name or title responsible for their performance.

(f) Certification Requirements. Data and analyses submitted to support that a given coastal flood protection structure complies with the structural design requirements set forth in paragraphs (b)(1) through (10) above must be certified by a registered professional engineer. Also, certified as-built plans of the structure must be submitted. Certifications are subject to the definition given at § 65.2 of 44 CFR Part 65. In lieu of these certification requirements, a Federal agency with responsibility for design of coastal flood protection structures may certify that the structure has been adequately designed and constructed to provide protection against the base flood.