CHAPTER 1

INTRODUCTION

1-1. Purpose. Provisions for the design of sheet pile cellular cofferdams are set forth in ER 1110-2-2901. This manual is intended to provide guidance for the design of these structures. Geotechnical considerations, analysis and design procedures, construction considerations, and instrumentation are discussed. Special emphasis is placed on all aspects of cellular cofferdams, such as planning, hydraulic considerations, and layout.

1-2. Applicability. The provisions of this manual are applicable to all divisions and districts having civil works responsibilities.

1-3. References. References and bibliographical material are listed in Appendix A. The references are referred to by the official number and bibliographical items are cited in the text by numbers (item 1, 2, etc.) that correspond to items in Appendix A-2.

1-4. Definitions. A list of symbols with their definitions relating to Chapter 4, Paragraph 4-9, is shown in Appendix B.

1-5. Types and Capabilities.

a. Uses. Sheet pile cellular structures are used in a variety of ways, one of the principal uses being for cofferdams.

(1) Cofferdams. When an excavation is in a large area overlain by water, such as a river or lake, cellular cofferdams are widely used to form a water barrier, thus providing a dry work area. Cellular structures are economical for this type of construction since stability is achieved relatively inexpensively by using the soil cell fill for mass. Ring or membrane tensile stresses are used in the interlocking steel sheet piling to effect a soil container. The same sheet piling may be pulled and reused unless it has been damaged from driving into boulders or dense soil deposits. Driving damage is not usually a major problem since it is rarely necessary to drive the piling to great depths in soil.

(2) Retaining Walls and Other Structures. Sheet pile cellular structures are also used for retaining walls; fixed crest dams and weirs; lock, guide, guard, and approach walls; and substructures for concrete gravity superstructures. Each of these structures can be built in the wet, thus eliminating the need for dewatering. When used as substructures, the cells can be relied upon to support moderate loads from concrete superstructures. Varying designs have been used to support the concrete loads, either on the fill or on the piling. When danger of rupture from large impact exists, the cells should be filled with tremie concrete. In the case of concrete guard walls for navigation locks, bearing piles have been driven within the cells to provide added lateral support for the load with the cell fill. Precautions must be taken to prevent loss of the fill which could result in instability of the

pile-supported structure. Bearing piles driven within the cells should never be used to support structures subjected to lateral loads.

b. Types. There are three general types of cellular structures, each depending on the weight and strength of the fill for its stability. For typical arrangement of the three types of cells, see Figure 1-1.

(1) Circular Cells. This type consists of a series of complete circular cells connected by shorter arcs. These arcs generally intercept the cells at a point making an angle of 30 or 45 degrees with the longitudinal axis of the cofferdam. The primary advantages of circular cells are that each cell is independent of the adjacent cells, it can be filled as soon as it is constructed, and it is easier to form by means of templates.

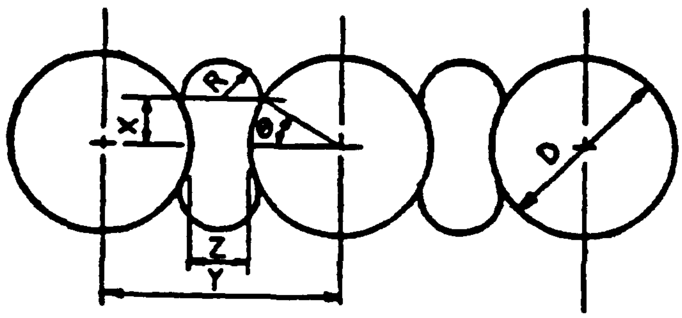
(2) Diaphragm Cells. These cells are comprised of a series of circular arcs connected by 120-degree intersection pieces or crosswalls (diaphragms). The radius of the arc is often made equal to the cell width so that there is equal tension in the arc and the diaphragm. The diaphragm cell will distort excessively unless the various units are filled essentially simultaneously with not over 5 feet of differential soil height in adjacent cells. Diaphragm cells are not independently stable and failure of one cell could lead to failure of the entire cofferdam.

(3) Cloverleaf Cells. This type of cell consists of four arc walls, within each of the four quadrants, formed by two straight diaphragm walls normal to each other, and intersecting at the center of the cell. Adjacent cells are connected by short arc walls and are proportioned so that the intersection of arcs and diaphragms forms three angles of 120 degrees. The cloverleaf is used when a large cell width is required for stability against a high head of water. This type has the advantage of stability over the individual cells, but has the disadvantage of being difficult to form by means of templates. An additional drawback is the requirement that the separate compartments be filled so that differential soil height does not exceed 5 feet.

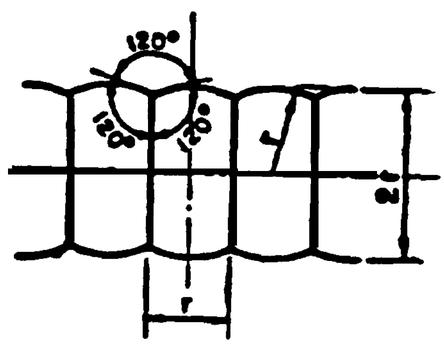
c. Design Philosophy.

(1) Cellular cofferdams, in most instances, serve as a high head or moderately high head dam for extended periods of time, protecting personnel, equipment, and completed work and maintaining the navigation pool. Planning, design, and construction of these structures must be accomplished by the same procedures and with the same high level of engineering competency as those required for permanent features of the work. Adequate foundation investigation and laboratory testing must be performed to determine soil and foundation parameters affecting the integrity of the cofferdam. Hydraulic and hydrologic design studies must be conducted to determine the most economical layout.

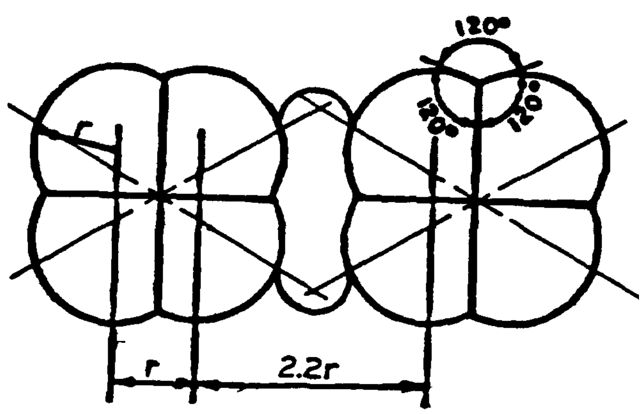
(2) The analytical design of cellular cofferdams requires close coordination between the structural engineer and the geotechnical engineer. Close coordination is necessary, not only for the soil and foundation investigations noted above, but also to ensure that design strengths are applied correctly



a. Plan circular cell



b. Plan arc and diaphragm cell



c. Plan clover leaf cell

Figure 1-1. Typical arrangement of circular, diaphragm, and cloverleaf cells and that assumptions used in the design, such as the saturation level within the cell fill, are realistic. Though cofferdams are often referred to as temporary structures, their importance, as explained above, requires that they be designed for the same factors of safety as those required for permanent structures.

(3) To ensure compliance with all design requirements and conformity with safe construction practices, the cellular cofferdam construction should be subjected to intensive inspection by both construction and design personnel. Periodic and timely visits by design personnel to the construction site are required to ensure that: site conditions throughout the construction period are in conformance with design assumptions, contract plans, and specifications; project personnel are given assistance in adapting the plans and specifications to actual site conditions as they are revealed during construction; and any engineering problems not fully assessed in the original design are observed and evaluated, and appropriate action is taken. Coordination between construction and design should be sufficient to enable design personnel to respond in a timely manner when changed field conditions require modifications of design.

(4) Not all features of a construction cofferdam will be designed by the Government. In particular, the design of the dewatering system, generally, will be the responsibility of the contractor so that the contractor can utilize his particular expertise and equipment. However, the dewatering system must be designed to be consistent with the assumptions made in the cofferdam design, including the elevation of the saturation level within the cell fill and the rate of dewatering. To achieve this, the requirements for the dewatering system must be explicitly stated in the contract specifications, and the contractor's design must be carefully reviewed by the cofferdam designer to ensure that the intent and provisions of the specifications are met.