ENGINEERING STANDARD

356 - DIKE

Definition

An embankment constructed of earth or other suitable materials to protect land against overflow or to regulate water.

Scope

This standard applies to dikes or levees used to prevent or reduce flood damage to land and property, for flow control in conjunction with floodways or to impound or regulate water for fish and wildlife management.

Dikes are divided into classes determined by the value of the land, crops and other improvements and by the hazard to life within the area to be protected.

Purpose

To permit improvement of agricultural land by preventing overflow and allowing better use of drainage facilities, to prevent damage to land and property, and to facilitate water storage and control in connection with wildlife and other developments. Dikes can also be used to protect natural areas, scenic features, and archeological sites from damage.

Conditions Where Practice Applies

Class I dikes are those constructed on sites where:

1. Failure may cause loss of life or serious damage to homes, industrial and commercial buildings, important public utilities, main highways or railroads, and high value land, crops, or other improvements.

2. Unusual or complex site conditions require special construction procedures to ensure satisfactory installations.

3. Protection is needed to withstand more than 12 ft. (3.7 m) of water above normal ground surface, exclusive of crossings of sloughs, old channels or low areas.

Class II dikes are those constructed in highly developed and productive agricultural areas where:

1. Failure may damage isolated homes, highways or minor railroads, or cause interruption in service of relatively important public utilities.

2. The maximum design water stage against the dike is 12 ft. (3.7 m).

Class III dikes are those constructed in rural or agricultural areas where:

1. Damage likely to occur from dike failure is minimal.

2. The maximum design water stage against the dike is 6 ft. (1.8 m) for mineral soils and 4 ft. (1.2 m) for organic soils. (Exclude channels, sloughs, swales, and gullies in determining the design water stage.)

Planning Considerations for Water Quantity and Quality

This practice is used to prevent water flowing onto or off of an area. Where the channel is diked on both sides water is prevented from flowing onto an area and the time of peak flow downstream may be decreased. It will increase sedimentation and the headwater elevation in and above the channel, often moving the flooding upstream. If one side of a channel is diked, flood flows will be forced onto the other side increasing water depth, velocity, and the potential of soil scour erosion. Dikes may also be used to contain water within specific areas such as rice production and levee type catfish ponds. Following are additional planning considerations:

1. Dikes installed to prevent water from flowing onto the flood plain may cause temporary wetlands.

2. Sediment and related materials may be deposited thereby improving the quality of water leaving the area.

3. Diked-or-levee ponds located in floodplains for catfish ponds should be located so as to pass, as a minimum, the runoff from the 25-year, 24-hour storm without significant damage to the structure or to adjacent upstream or downstream properties.

Design Criteria - All Dikes

In locating dikes, careful considerations shall be given to preserving natural areas, fish and wildlife habitat, woodland, and other environmental resources. If dike construction will adversely affect such values, concerned public agencies and private organizations shall be consulted about the project.

Protection

A protective cover of grasses shall be established on all exposed surfaces of the dike and other disturbed areas. Seedbed preparation, seeding, fertilizing, mulching, and fencing shall comply with recommendations in the FOTG Standard 342 - Critical Area Planting and other applicable standards.

If vegetation will not control erosion, manufactured mulches, riprap, or other measures shall be installed.

Operation and Maintenance All Dikes

All dikes must be adequately maintained to the required shape and height. Erosion-controlling vegetation shall be established on dikes as required by climatic conditions and the need for protection against wave action. The maintenance of dikes must include periodic removal of woody vegetation that may become established on the embankment or by burning every 3 years. Design of the project shall include provisions for maintenance access must be provided.

Design Criteria - Class I Dikes

Location

Conditions to be considered in designing Class I dikes are foundation soils, property lines, exposure to open water, adequate outlets for gravity or pump drainage, and access for construction and maintenance. Mineral soils that will be stable in the dike embankment must be available.

Height

The design height of a dike shall be the design water depth plus 2 feet (0.6m) of freeboard, or 1 foot (0.3 m) of freeboard plus an allowance for wave height, whichever is greater. Design elevation of high water shall be determined as follows:

1. If dike failure is likely to cause loss of life or extensive high-value property damage, the elevation of design high water shall be that associated with the stage of the 100-year-frequency flood or of the maximum flood of record, whichever is greater.

2. If dike failure is unlikely to result in loss of life or extensive high-value property damage, the elevation of design high water shall be that associated with the peak flow from the storm that will insure the desired level of protection or the 50-year-frequency flood, whichever is greater.

3. If the dike will be subject to stages from more than one stream or source, the criteria indicated shall be met for the combination that causes the highest stage.

4. If the dike will be subject to tidal influence as well as streamflow, the streamflow peak shall be assumed to occur in conjunction with the mean high tide to determine the design high water depth.

The design height of the dike shall be increased by the amount needed to insure that the design top elevation is maintained after settlement. This increase shall not be less than 5 percent.

Interior Drainage

If inflow from the area to be protected by the dike may result in loss of life or extensive high-value property damage, provisions shall be included in the plans to provide interior protection against a 100-year-frequency inflow hydrograph, plus base flow and an allowance for seepage, and may include storage areas, gravity outlets, or pumping plants, alone or in combination.

If inflow from the area to be protected by the dike is unlikely to result in loss of life or extensive high-value crops or property damage, storage areas, gravity outlets, or a pumping plant, alone or in combination, shall be included in the plans and designed to handle the discharge from the drainage area based on drainage requirements established for the local area or the peak flow from the storm that will insure the desired level of protection, whichever is greater.

In sizing outlet works in combination with available storage, the minimum design storm duration for interior drainage shall be 10 days. If outlet works are designed using peak flood frequency flows without considering storage, the minimum design storm duration shall be 24 hours.

Embankment and Foundation

The embankment shall be constructed of mineral soils which, when placed and compacted, will result in a stable earth fill. No organic soil shall be used in the dike. Soils must have high specific gravity and be capable of being formed into an embankment of low permeability. The design of the embankment and specifications for its construction shall give due consideration to the soil materials available, foundation conditions, and requirements for resisting the action of water on the face of the dike and excessive seepage through the embankment and the foundation. The design of the embankment and the foundation requirements shall be based on the length of time and height that water will stand against the dike.

Minimum requirements for certain features of the embankment, the foundation, and borrow pits are as follows:

Minimum top width of Class I dikes shall be 10 feet (3 m) for embankment heights of 15 feet (4.6 m) or less and 12 feet (3.6 m) for heights more than 15 feet (4.6 m). If maintenance roads are to be established on the dike top, “turn-arounds” or passing areas shall be provided, as needed.

Side slopes shall be determined from a stability analysis, except that an unprotected earth slope on the water side shall not be steeper than 4 horizontal to 1 vertical if severe wave action is anticipated.

If dikes cross old channels or have excessively porous fills or poor foundation conditions, the landslide toe shall be protected by a banquette or constructed berm. Banquettes shall be used to provide construction access and added stability if channel crossings are under water or saturated during construction. Banquettes shall be designed on the basis of site investigations, laboratory analysis, and compaction methods. The finished top width of the banquettes shall not be less than the height of dike above mean ground. The finished top of the banquettes shall not be less than 1 foot (0.3 m) above mean ground and shall be sloped away from the dike.

A cutoff shall be used if foundation materials are sufficiently pervious to be subject to piping or undermining. The cutoff shall have a bottom width and side slopes adequate to accommodate the equipment to be used for excavation, backfill, and compaction operations. It shall be backfilled with suitable material placed and compacted as required for the earth embankment. If pervious foundations are too deep to be penetrated by a foundation cutoff, a drainage system adequate to insure stability of the dike shall be used.

Ditches and Borrow Pits

Landslide ditches or borrow pits shall be located so the hazard of failure is not increased. Ditches for borrow pits when excavated on the water side of dikes shall be wide and shallow. Plugs, at least 15 feet (4.6 m) in width, shall be left on the ditches at intervals not greater than 400 feet (121.9 m) to form a series of unconnected basins.

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill Height	Minimum berm width
Less than 6 ft. (1.8 m)	12 ft. (3.7 m)
More than 6 ft. (1.8 m)	18 ft. (5.5 m)

Drainage Systems

A drainage system shall be used if necessary to insure the safety of a dike. Toe drains, if used, shall be located on the landslide and shall have a graded sand-gravel filter designed to prevent movement of the foundation material into the drain.

Subsurface drains shall not be installed, or permitted to remain without protection, closer to the landslide toe of a dike than a distance three times the design water height for the dike. If subsurface drains are to be installed or remain closer than the distance stated, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Pipes and Conduits

Dikes shall be protected from scour at pump intakes and discharge locations by appropriate structural measures. A pump discharge pipe through a dike shall be installed above design high water, if feasible, or be equipped with antiseep collars.

All conduits through a dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibration of the pumping plant from being transmitted to the discharge conduits.

Design Criteria - Class II Dikes

Design Water Stage

The maximum design water stage permitted is 12 feet (3.6 m) above normal ground level exclusive of crossings at channels, sloughs, and gullies.

If the design water depth against dikes, based on the required level of protection, exceeds 4 feet (1.2 m), the design shall be based on at least a 25-year-frequency flood. If this degree of protection is not feasible, the design shall approach the 25-year flood level as nearly as possible, and planned fuse plug sections and other relief measures shall be installed where appropriate.

Height

The design height of an earth dike shall be the design water depth plus a freeboard of at least 2 feet (0.6 m) or freeboard of 1 foot (0.3 m) plus an allowance for wave height, whichever is greater.

The constructed height of the dike shall be the design height plus an allowance for settlement necessary to insure that the design top elevation is maintained but shall be no less than 5 percent of the design height.

Interior Drainage

Provisions must be made for adequate discharge for the area to be protected by the dike.

Cross Section

The minimum requirements for the cross section of the dike where fill is compacted by hauling or special equipment shall be as follows:

Design water height		**Minimum top width**		**Steepest side slope**
ft.	(m)	ft.	(m)	
0-6	(0-1.8)	6	(1.8)	1-1/2:1
6-12	(1.8-3.7)	8	(2.4)	2:1

If soils or water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and shall have minimum cross section dimensions incorporated in the fill as follows:

Design water height	**Minimum top width**	**Steepest side slope**

ft.	(m)	ft.	(m)	
0-6	(1.8 - 3.7)	8	(2.4)	2:1
6-12	(1.8 - 3.7)	10	(3.0)	2-1/2:1

Side slopes of 3 horizontal to 1 vertical on waterside and 2:1 on landside may be used instead of 1-1/2:1 for both slopes.

The cross sections shall be strengthened or increased as required to provide additional protection against floods of long duration. The top width shall not be less than 10 feet (3.0 m) if a maintenance road is planned on top of the dike. "Turnarounds" or passing areas shall be provided as required on long dikes.

The side slopes shall be 3:1 or flatter on the waterside if severe wave action is expected or if a steeper slope would be unstable under rapid drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity, such as SM and ML, are used in construction.

A banquette (or constructed berm) shall reinforce the landside toe if a dike crosses an old channel or if excessively porous fill or poor foundation conditions justify such reinforcement. Such banquettes shall be used if, during construction, the channel crossing is under water or saturated. The top width of the banquette shall be equal to or greater than the fill height of the dike above the top of the banquette unless a detailed investigation and analyses show a different design is adequate.

Foundation Cutoff

A cutoff shall be installed if there are layers of permeable soils or layers creating a piping hazard through the foundation at a depth less than the design water depth of the dike below natural ground level. The cutoff trench shall be of sufficient depth and width and filled with suitable soils to minimize such hazard.

Ditches and Borrow Pits

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be:

Fill height	Minimum berm width
Less than 6 ft. (1.8 m)	10 ft. (3 m)
More than 6 ft. (1.8 m)	15 ft. (4.6 m)

A landside ditch or borrow pit shall be far enough away from the dike to minimize any hazard to the dike because of piping through the foundation.

For dikes having a design water depth of more than 5 feet (1.5 m), the landside ditch or borrow pit shall be far enough away from the dike so that a line drawn between the point of intersection of the design waterline with the waterside of the dike and the landside toe of a dike meeting minimum dimensional requirements shall not intersect the ditch or borrow pit cross section.

Pipes and Conduits

The dike shall be protected from scour at a pump intake and discharge by appropriate structural measures. A pump discharge pipe through the dike shall be installed above design high water, if feasible, or else equipped with anti-seep collars.

All conduits through the dike below the design high waterline shall be equipped with antiseep collars designed to increase the distance of seepage line along the conduit by at least 15 percent. Discharge conduits of pumps placed below the designed waterline shall be equipped with a Dayton or a similar coupling to prevent vibrations of the pumping plant from being transmitted to the discharge conduits.

Drainage Systems

Drains shall be used where necessary to insure safety of dikes and shall be located on the landside, have a graded sand-gravel filter, and be designed and installed in accordance with the applicable FOTG standard for such drains.

Field subsurface drains shall not be installed or permitted to remain without protection closer to the landside toe of a dike than a distance of 3 times the design water height for the dike. If such drains are to be installed or remain closer than the distance stated above, protection shall consist of a graded sand-gravel filter, as for a toe drain, or a closed pipe laid within the specified distances from the dike.

Design Criteria - Class III Dike

Design criteria shall be based on site conditions for mineral soils as determined from engineering surveys and investigations. The design shall be based on measured or computed stage for a 5-year-frequency flood. If this degree of protection is determined to be uneconomical or not physically feasible, the design shall approach this frequency as nearly as possible and planned fuse plug sections and other relief measures installed where appropriate. Adequate and timely operations and maintenance of dikes shall be assured.

Freeboard

The design height of the dike shall be the design water depth plus a minimum freeboard of 1 foot (0.3 m). An allowance for wave height of 0.5 feet (0.15 m) will be added in locations where the dike is subject to wave action.

The constructed height of the dike shall be increased by the amount necessary to insure that the settled top is at design elevation but not less than 5 percent.

Foundation Cutoff

A cutoff shall be installed if necessary to insure dike stability.

Cross Section

The minimum requirements for the cross sections of the dike where fill is compacted by hauling or special equipment is given below:

Compacted Fills

Design water height		Minimum top width		Steepest side slope
ft.	(m)	ft.	(m)	
0-3	(0 - 0.9)	4	(1.2)	1:1
3-6	(0.9 - 1.8)	6	(1.8)	1-1/2:1

Where dikes are constructed from channel spoil and water conditions make it impractical to compact the dike with hauling or special equipment, dumped fill may be used and the dike shall have minimum cross section dimensions as given below:

Dumped Fills

Design water height		Minimum top width		Steepest side slope
ft.	(m)	ft.	(m)	
0-3	(0 - 0.9)	4	(1.2)	1:1
3-6	(0.9 - 1.8)	6	(1.8)	1 1/2:1

The above cross sections shall be strengthened as required to provide additional protection against floods of long duration.

The top width should not be less than 4 feet (1.2 m) or not less than 10 feet (3.0 m) where a maintenance road is planned on top of the dike.

The side slopes shall be 3:1 or flatter on the waterside where severe wave action is expected or where a steeper slope would be unstable under drawdown conditions. Side slopes shall be 3:1 or flatter on both sides where permeable soils of low plasticity are used in construction.

Ditches and Borrows Pits

Minimum berm widths between the toe of the dike and the edge of the excavated channel or borrow shall be 2 times the depth of the ditch but not less than 8 feet (2.4 m).

Pipes and Conduits

All conduits through the dike shall be equipped with anti-seep collars designed to increase the distance of the seepage line along the conduit by at least 15 percent.

Vegetative Cover and Riprap

A protective cover of vegetation shall be established on all exposed surfaces of the dike. Vegetation shall be established in accordance with the Field Office Technical Guide Standard 322, Channel Vegetation. A vegetative plan with specifications for vegetative treatment will be made for each dike system.

Riprap shall be used and placed according to SCS standards and specifications when required to control erosive velocities.

All areas will be fenced when required to protect the dike, vegetation, and for controlled grazing.

Plans and Specifications

Plans and specifications for constructing dike shall be in keeping with this standard and shall describe the requirements for applying the practices to achieve its intended purpose.

References: National Engineering Handbook
National Engineering Field Manual for Conservation Practices

CONSTRUCTION SPECIFICATION

356 - DIKES

CLASSES II AND III

Scope

This item shall consist of the clearing, excavation, backfill, other appurtenances, and the disposal of all cleared and excavated materials required in the construction of the embankment for dikes. Construction shall be carried out in such a manner that erosion and water, air, and noise pollution will be minimized and held within legal limits as established by local, state, or federal regulations.

Foundation Preparation

The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod, and debris before construction begins. All cleared material shall be disposed of by burning, burying, or otherwise removing from the site and stacked. All burning shall conform to all federal, state, and local laws and regulations.

All channel banks and sharp breaks shall be sloped to the requirements in the plan. Topsoil which is high in organic material shall be removed. The surface of the foundation area will be thoroughly scarified before placement of the embankment material.

The cutoff trench, where used, shall be excavated to lines and grades as shown on the plans. It shall be backfilled with suitable material in a manner as specified for earth embankment. The necessary degree of compaction shall be obtained by using equipment adapted to site conditions. The trench should, if feasible, be kept free of standing water during backfill operations. The material from cutoff trench excavation may be placed within the dike section if suitable.

Conduit Installation

All conduits through a dike shall be placed on a firm foundation to the lines and grades shown on the plans. Anti-seep collars shall be installed according to the plan and manufacturer's instructions. Selected backfill material shall be placed in layers around the conduits and their component parts and each successive layer shall be thoroughly compacted.

Embankment Construction

The embankment material may be obtained from a selected borrow area or from channel excavation. In the construction of borrow trenches on the waterside of the dike, an unexcavated plug at least 25 feet wide shall be left at intervals not to exceed 1,320 feet.

The fill material shall be free of organic matter and other objectionable material. Placing and spreading of fill shall begin on the lowest part of the working area and continue in horizontal layers of approximate uniform thickness, preferably 6-inches thick but not more than 18-inches thick, depending on the equipment used. Where the borrow yields materials of varying texture and gradation, the more impervious material shall be placed toward the waterside of the dike.

The construction equipment shall be operated over the area of each layer in a manner to break up large clods and obtain compaction.

Vegetation

Vegetative treatment will be applied as shown on the plans and in the specifications. Vegetation will include seedbed preparation, liming, fertilizing, seeding, and either mulching or netting when needed.

A maintenance program will be established to maintain the dike capacity, storage, embankment height, and the outlets. Dike embankments can be hazardous to farming equipment, and such hazards should be brought to the attention of the responsible land user. All woody vegetation will be controlled by the use of chemicals, mowing, burning, or other mechanical means.