# 410 - GRADE STABILIZATION STRUCTURES (No)

## Definition

A structure to control the grade and head cutting in natural or artificial channels.

## Scope

This standard applies to all types of grade stabilization structures, including a combination of earth embankments and mechanical spillways and full-flow or detention-type structures. This standard also applies to channel side-inlet structures installed to lower the water from a field elevation, surface drain, or waterway to a deeper outlet channel. It does not apply to structures designed to control the rate of flow or to regulate the water level in channels (578).

## Purpose

To stabilize the grade and control erosion in natural or artificial channels, to prevent the formation or advance of gullies, and to reduce environmental and pollution hazards.

## Conditions Where Practice Applies

In areas where the concentration and flow velocity of water require structures to stabilize the grade in channels or to control gully erosion. Special attention shall be given to maintaining or improving habitat for fish and wildlife, where applicable, and the visual resource.

## Planning Considerations for Water Quantity and Quality

This practice may contribute to ground water recharge due to ponding under certain geologic conditions. Full flow non-detention structures will cause very little change in recharge. Following are additional planning considerations:

1. Structures will trap sediment, nutrients, and chemicals and improve downstream water quality.

2. Structures will stop head cutting gully erosion and reduce the volume sediment downstream, thus improving water quality.

3. Reduced discharge and increased infiltration and nutrients will improve vegetative growth in the reservoir area.

4. Structures may cause some solvable material to leach into the ground water.

## Design Criteria

The structure must be designed for stability after installation. The crest of the inlet must be set at an elevation that stabilizes upstream head cutting.

Embankment dams - Class “a” dams having a product of storage times the effective height of the dam of 3,000 or more, those more than 35 ft. in effective height, and all Class “b” and Class “c” dams shall meet or exceed the requirements specified in Technical Release No. 60 (TR-60).

Class “a” dams having a product of storage times the effective height of the dam of less than 3,000 and an effective height of 35 feet or less shall meet or exceed the requirements specified for FOTG Standard Ponds - 378.

The effective height of the dam is the difference in elevation, in feet, between the emergency spillway crest and the lowest point in the cross section along the centerline of the dam. If there is no emergency spillway, the top of the dam is the upper limit.

Pond size dams. If mechanical spillways are required, the minimum capacity of the principal spillway shall be that required to pass the peak flow expected from a 24-hour duration design storm of the frequency shown in the Table 1, less any reduction because of detention storage.

If the effective height of the dam is less than 20 ft. and the emergency spillway has a stable grade throughout its length with no overfalls and has good vegetation to its reentry into the downstream channel, the principal spillway capacity may be reduced but can be no less than 80 percent of the 2-year frequency, 24-hour duration storm.

If criteria values exceed those shown in Table 1 or the storage capacity is more than 50 acre-feet, the 10-year frequency, 24- hour duration storm must be used as the minimum design storm.

Grade stabilization structures with settled fill height of less than 15 feet, and 10-year frequency, 24-hour storm runoff less than 10 acre-ft., shall be designed to control the 10-year frequency storm without overtopping. The mechanical spillway, regardless of size, may be considered in design and an emergency spillway is not required if the combination of storage and mechanical spillway discharge will handle the design storm. The embankment can be designed to meet the requirements for Water and Sediment Control Basins (638) rather than the requirements for FOTG Standard, Ponds-378.

Full-Flow open structures. Drop, chute, and box inlet drop spillways shall be designed according to the principles set forth in the Engineering field Manual for Conservation Practices, the National Engineering Handbook, and other applicable SCS publications and reports. The minimum capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2, less any reduction because of detention storage. If criteria values exceed those shown in Table 2, the minimum design 24-year storm frequency is 25 years for the principal spillway and 100 years for the total capacity. Structures must not create unstable conditions upstream or downstream. Provisions must be made to insure reentry of bypassed storm flows.

Toe wall drop structures can be used if the vertical drop is 4 ft. or less, flows are intermittent, downstream grades are stable, and tail water is at or near the crest of the weir at design flow.

The ratio of the capacity of drop boxes to road culverts shall be as required by the responsible road authority or as specified in Table 2 or 3, as applicable, less any reduction because of detention storage. The drop box capacity (attached to a new or existing culvert) must equal or exceed the culvert capacity at design flow.

Island-type structures. If the mechanical spillway is designed as an island-type structure, its minimum capacity shall equal the capacity of the downstream channel. For channels with very small drainage areas, the mechanical spillway should carry at least the 2-year, 24-hour storm or the design drainage curve runoff. The minimum emergency spillway capacity shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 2 for total capacity without overtopping the mechanical spillway headwall extensions. Provisions must be made for safe reentry of bypassed flow as necessary.

Side-inlet drainage structures. The design criteria for minimum capacity of open-weir or pipe structures used to lower surface water from field elevations or lateral channels into deeper open channels are shown in Table 3. The minimum principal spillway capacity shall equal the design drainage curve runoff for all conditions. For site condition values larger than those shown in Table 3, the 50-year frequency storm shall be used for minimum design of total capacity.

Landscape resources. In highly visible public areas and those associated with recreation, careful consideration should be given to landscape resources. Landforms, structural materials, water elements, and plant materials should visually and functionally complement their surroundings. Excavated material and cut slopes should be shaped to blend with the natural topography. Shorelines can be shaped and islands created to add visual interest and valuable wildlife habitat. Exposed concrete surfaces may be formed to add texture or finished to reduce reflectiveness and to alter color contrast. Site selection can be used to reduce adverse impacts or create desirable focal points.
General criteria. Earth embankment and emergency spillways of structures for which criteria are not provided under the standard for FOTG Standard, Ponds-378 or in TR-60

must be stable for all anticipated conditions. If earth spillways are used, they must be designed to handle the total capacity flow indicated in Tables 2 or 3 without overtopping the dam. The foundation preparation, compaction, top width, and side slopes must ensure a stable dam for anticipated flow conditions. Discharge from the structure shall be sufficient that no crop damage results from flow detention.

Necessary sediment storage capacity must equal the expected life of the structure, unless a provision is made for periodic cleanout.

The earth embankment pond structures are potentially hazardous and safety precautions must be taken to prevent serious injury or loss of life. Protective guardrails, warning signs, fences, or lifesaving equipment shall be added as needed.

If the area is used for livestock, the structure, earth fill, vegetated spillways, and other areas should be fenced as necessary to protect the structure. Near urban areas, fencing may be necessary to control access and exclude traffic that may damage the structure or to prevent serious injury or death to trespassers.

**Table 1. - Design criteria for establishing minimum capacity of the principal spillway for dams with storage capacity of less than 50 acre-feet.**

| Maximum drainage area for indicated rainfall | | | Effective Height of dam | Frequency of minimum design, 24- hour duration storm |
|---|---|---|---|---|
| 0-3 in. | 3-5 in. | 5+ in. | | |
| acres | | | ft. | yr. |
| 200 | 100 | 50 | 35 or less | 2 |
| 400 | 200 | 100 | 20 or less | 2 |
| 400 | 200 | 100 | 20-35 | 5 |
| 800 | 400 | 200 | 20 or less | 5 |

*In a 5-year frequency, 24-hour duration storm.

**Table 2. - Design criteria for establishing minimum capacity of full-flow open structures.**

| Maximum drainage area for indicated rainfall* | | | Vertical drop | Frequency of minimum design, 24-hour duration storm | |
|---|---|---|---|---|---|
| | | | | Principal spillway capacity | Total capacity |
| 0-3 in. | 3-5 in. | 5+ in. | | | |
| acres | | | ft. | yr. | yr. |
| 1,200 | 450 | 250 | 5 or less | 5 | 10 |
| 2,200 | 900 | 500 | 10 or less | 10 | 25 |

*In a 5-year frequency, 24-hour duration storm.

**Table 3. - Design criteria for establishing minimum capacity of side-inlet, open-weir, or pipe-drop-drainage structure.**

| Maximum drainage area for indicated rainfall* | | | Vertical drop | Frequency of minimum design, 24-hour duration storm | |
|---|---|---|---|---|---|
| | | | | Receiving channel depth | Total capacity |
| 0-3 in. | 3-5 in. | 5+ in. | | | |
| acres | | | ft. | yr. | yr. |
| 1,200 | 450 | 250 | 0 - 5 | 5 - 10 | --- |
| 1,200 | 450 | 250 | 5 - 10 | 10 - 20 | 10 |
| 2,200 | 900 | 500 | 0 - 10 | 0 - 20 | 25 |

*In a 5-year frequency, 24-hour duration storm.

Pipe conduits. Pipe conduits and other structural materials used for grade control structures shall be in accord with the applicable FOTG Practice Standards 378 or 638.

## Protection

The surface layer of soils (topsoil) should be stockpiled from the foundation, spillway, and borrow areas and be used to topdress the embankment, emergency spillway and borrow areas to facilitate establishment of vegetation.

A protective cover of vegetation is required to minimize soil erosion and stream channel pollution and to improve maintenance. A vegetative plan with specifications for vegetative treatment and mulch will be made for each structure. Embankments, spillways, borrow areas, and critical area will be seeded or sodded to adapted perennial vegetation. A perennial vegetative filter strip will be provided above the impoundment area. A strip of adapted perennial vegetation, at least 50 feet wide, will be seeded or planted above all impounded areas that are not already protected by a good sod or other protective type vegetation. Vegetative treatment shall be applied in accordance with specifications for Critical Area Planting (342). The embankment, borrow area, and spillways shall be fenced when needed to control grazing and protect the vegetation.

## Operation and Maintenance

An operation and maintenance plan and program will be worked out with the landuser to ensure a useful life for the structure. Emphasis will be placed on maintenance of vegetation and for sediment and erosion control that will maintain the effectiveness of the structure and appurtenances.

## Plans and Specifications

Plans and specifications for installing grade stabilization structures shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

References:

1. Engineering Field Manual for Conservation Practices, Chapters 6 and 10.

2. Engineering Technical Note ENG-SL-10.

# CONSTRUCTION SPECIFICATIONS

# FOR

# 410 - GRADE STABILIZATION STRUCTURES

This item shall consist of the clearing, excavation, backfill, concrete, and other appurtenances required for the construction of the Grade Stabilization Structure (Code 378) and the disposal of all cleared and excavated materials.

Construction operations shall be carried out in such a manner that erosion, air, water, and noise pollution will be minimized and held within legal limits as established by State or local regulations.

## Clearing and Grubbing

Spillway and borrow areas - On areas from which fill materials are to be obtained, all trees, brush, logs, and other debris larger than 1 inch in diameter shall be removed.

The structure site - All trees, brush, and other debris shall be removed from the area on which fill is to be placed. All stumps and roots 1 inch in diameter and larger shall be removed from the fill site to a depth of 12 inches.

Disposal of cleared and grubbed material - All combustible material cleared and grubbed from the site shall be disposed of by burning, burying at approved locations, or removing from the site and stacking. All burning shall conform to Alabama laws and regulations. All non-combustible materials cleared and grubbed from these areas shall be removed from the site or buried with a minimum cover of two (2) feet. Topsoil, where available, should be stockpiled in a convenient location for use on the embankment, emergency spillway, and other disturbed areas to facilitate establishment of vegetative cover.

## Foundation Preparation

Surface Treatment - The foundation area shall be cleared of all trees, stumps, roots, brush, boulders, sod, and debris. All channel banks and sharp breaks shall be sloped to no steeper than 1:1. All topsoil containing excessive amounts of organic matter shall be removed. The surface of the foundation area will be thoroughly scarified before placement of the embankment material. The surface layer of soils will be salvaged from the foundation, emergency spillway, and borrow areas and stockpiled. The salvaged material will be spread over the completed structure and spillway area to facilitate the establishment of vegetation.

## Excavation

Excavated and Backfill of Cutoff Trench - The cutoff trench shall be excavated to the depths, bottom width and side slopes shown on the plans. All standing water shall be removed from the trench and it shall be backfilled using thin layers (maximum 8 inches) to ground surface with suitable material by the same methods hereinafter prescribed for "embankments construction".

Excavation and Backfill of Stream Channels - Existing stream channels crossing the foundation area shall be deepened and widened as necessary to remove all stones, gravel, sand, sediment, stumps, roots, organic matter, and other objectionable material and to accommodate compaction equipment. Side slopes shall be left no steeper than 1:1. All water shall be removed from the channels, and they shall be backfilled in the same manner as prescribed for the cutoff trench.

Spillway and Borrow Excavation - The completed spillway excavation shall conform as nearly to the lines, grades, bottom width, and side slopes shown on the plans as skillful operation of the excavating equipment will permit. The channel bottom shall be left transversely level and the side slopes uniform. All borrow areas shall be graded and left in such a manner that they are well drained and protected from erosion by the use of diversions or other conservation measures. Side slopes of borrow areas shall be left in such condition that establishment of vegetation, mowing, and maintenance operations will be facilitated.

## Embankment Construction

Selecting, Placing, and Spreading of Material - The material placed in the fill shall be free of all sod, roots, frozen soil, stones more than 6 inches in diameter, and other objectionable material. The placing and spreading of the fill material shall be started at the lowest point of the foundation and the fill shall be brought up in approximately horizontal layers not exceeding 8 inches in thickness.

These layers shall be of approximately uniform elevation and shall extend over the entire area of the fill. The construction equipment shall be operated over the area of each layer in a manner that will result in the specified compaction of the fill material. Special compaction equipment shall be used when the required compaction cannot be obtained by routing of the construction equipment.

The distribution and gradation of materials throughout the fill shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use material of varying texture and gradation, the more impervious material shall be placed in the upstream and center portions of the fill.

Moisture Control - The moisture content of fill material shall be such that the specified compaction can be obtained with the equipment used. The moisture content of the fill shall be maintained within the limits to:

1. prevent the bulking or dilatence of the material under the action of the hauling or compaction equipment,

2. prevent adherence of the fill material to the equipment, and

3. ensure the crushing and blending of the soil clods and aggregation into a homogenous mass.

Fill material moisture is considered satisfactory when a sample molded in the hand will retain its shape. The material is too wet for placement if water escapes from the sample when hand rolled and too dry when the sample falls apart.

The completed fill shall conform as nearly to the lines and grades, top width, and side slopes shown on the plans as skillful operation of the construction equipment will permit.

## Pipe Conduit Installation

The pipe conduit barrel shall be placed on a firm foundation to the lines and grades shown on the plans. The strength of lightweight, flexible PVC, corrugated steel and aluminum pipe is highly dependent on the bedding and backfill (See Engineering Technical Note ENG AL-10 for full details). It must be carefully jointed together, bedded, and backfilled. The backfill to be used in the vicinity of the pipe should be the most impervious fine grained material available and have proper moisture content to assure good compaction around the conduit. The pipe conduit should be cambered to prevent breaking or joint separation when the dam is built. That is, the pie should be laid essentially level to centerline of dam, then laid essentially straight to the exit end elevation. Then when the earthfill load is applied over the pipe, the pipe will flatten to a smooth uniform grade and tighten the joint. Flexible bedding and flexible anti-seep collars should be used to avoid stress concentrations in the pipe as it deflects. The bottom of the bedding trench will be shaped as a minimum to fit the lower 120° of the pipe. Flexible anti-seep collars may be constructed of 6 mil or thicker plastic or rubber sheeting attached to the pipe with stainless steel clamps, waterproof tape, or closet flanges and caulk material to ensure water tightness. The flexible collars will be held in place during installation with wire or light wood framing. Proper inspection of the installation is essential, especially during the bedding of the conduit and backfilling adjacent to the conduit and anti-seep collars.

All of the component parts of the conduit including barrel, riser, trashrack, anti-seep collars, support posts or brace and hardware for mounting shall be as specified on the plans and shall be attached in a workmanlike manner.

Anti-seep collars are to be of materials compatible with the pipe and installed so as to be watertight. The pipe shall be installed in accordance with the manufacturer's instructions and to the lines and grades as shown on the drawings.

## Concrete Installation

The work shall consist of furnishing, forming, placing, finishing, and curing Portland cement concrete as required in the construction of the work.

When concrete is used for footings under risers, anti-seep collars, and bedding for asbestos-cement or reinforced concrete pipe barrels, the mixture shall contain not less than five (5) bags of cement per yard. The consistency of the concrete shall be such as to allow the concrete to be worked into place without segregation or excessive laitance.

The components of the mix shall be as follows: A standard known brand, type I Portland cement, washed sand and gravel. Clean water shall be used in the mix. (Suggested ratio in mix: 94 lbs. cement (1 bag), 6 gals. water, 170 lbs. clean dry sand, 315 lbs. dry gravel. Smaller batches, 1 part cement, 2 parts sand, and 3 parts gravel, and water at the rate of 1 gal. per 16 lbs. of cement.)

Concrete shall not be placed when the atmospheric temperature may be expected to fall below 40° F at the time concrete is delivered and placed at the work site. Concrete temperature should not exceed 90°F during mixing, delivery, and placing.

All exposed surfaces of concrete shall be protected from the direct rays of the sun for at least the first seven (7) days. All concrete shall be cured by keeping continuously moist for at least seven (7) days after being placed or spraying with two coats of curing compound when other concrete will not be bonded to the concrete surface. Concrete shall not be exposed to freezing temperature during the curing period.

## Materials

Principal Spillways, Trash Racks, and Fittings - The pipe and pipe connecting bands shall conform with the following specifications and requirements:

Corrugated Steel Pipe - Federal Specification WW-P-405; helical corrugated or close reveted annular corrugated; asphalt coated; and, watertight connections as specified below:

Rubber "O" Ring type: all types and diameters of pipe.
Flanged Type: for pipe diameters 12 inches and under.
Conventional Connecting Bands: all diameters annular corrugated pipe only. 12-inch minimum band width with rods and lugs required.

Corrugated Aluminum Alloy Pipe - Federal Specification WW-P-402; lock or welded seam helical corrugated with watertight connections as specified above for corrugated steel pipe.

Steel Pipe - ASTM A 120 standard weight (Schedule 40). Used pipe is satisfactory provided it is wall thickness has not been reduced by corrosion.

Asbestos Cement Pressure Pipe - ASTM C296; Class 100; requires concrete bedding (minimum 3 inch thickness) under bottom third of pipe.

Concrete Pipe - AWWA C 300, C 301, C 302, or ASTM C 76 Class II; with joint sealed with rubber gaskets. Requires concrete bedding (Minimum 3 inch thickness) under bottom third of pipe.

Plastic Pipe - Polyvinyl chloride pipe, PVS, 1120 - or PVC 1220, conforming to ASTM D 1757 or ASTM D2241.

Bearing piles shall be structural steel H-piles conforming to the requirements of ASTM Specification A 36.

Steel sheet piles shall conform to the requirements of ASTM Specification A 328.

Wood piles shall conform to the requirements of Federal Specification MM-P-371 for the specified types and classes of piles.

Treatment of timber and wood piles shall conform to Federal Specification II-W571.

Rock for riprap shall conform to gradation as shown on the drawings.

Steel bars for concrete reinforcement requiring bends shall be deformed billet-steel bars conforming to ASTM Specification A 615, Grade 40, or Grade 60.

Straight steel bars shall be deformed bars conforming to one of the following specifications:

Deformed Billet-Steel Bars for Concrete Reinforcement (Grade 40 or Grade 60) ASTM Designation A 615.

Rail-Steel Deformed Bars for Concrete Reinforcement (Grade 50 or Grade 60) ASTM Designation A 616.

Axle-Steel Deformed Bars for Concrete Reinforcement (Grade 40 or Grade 60) ASTM Designation A 617.

Welded steel wire fabric reinforcement shall conform to the requirements of ASTM Specification A 185.

## Vegetation

Vegetation will be established as specified on the plan or according to written recommendations. The embankment, spillway, borrow areas, and other areas disturbed during construction will be topsoiled, fertilized, seeded or planted to adapted perennial close growing cover and mulched to insure establishment.

In come cases temporary vegetation or mulching will need to be used until conditions are favorable for seeding and planting permanent vegetation. Specifications for Critical Area Planting, Code 342 will be used for plant selection, seedbed preparation, liming, fertilizing, seeding and mulching for both temporary and permanent vegetation. Treated areas will be fenced when needed to protect the vegetation.