NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

GRADE STABILIZATION STRUCTURE

(No.)
CODE 410

DEFINITION

A structure used 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, a surface drain, or a 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.

PURPOSES

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

CRITERIA

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

Embankment dams

Class (a) dams that have 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 that have a product of storage times the effective height of the dam of less than 3,000 and an effective height of 35 ft or less shall meet or exceed the requirements specified for 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 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 along 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-ft, the 10-year frequency, 24-hour duration storm must be used as the minimum design storm.

Grade stabilization structures with a settled fill height of less than 15 ft 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 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 NRCS 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 site conditions exceed those shown in table 2, the minimum design 24-hour 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 slope is 4 ft or less, flows are intermittent, downstream grades are stable, and tail water depth at design flow is equal to or greater than one-third of the height of the overfall.

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, whichever is greater. 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 headwall extensions of the mechanical spillway. Provision 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. If site condition values exceed 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 considerations 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 reflection 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 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 provison is made for periodic cleanout.

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The earth embankment pond structures are potentially hazardous and 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 structures, earthfill, 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.

Protection

The exposed surfaces of the embankment, earth spillway, borrow area, and other areas disturbed during construction shall be seeded or sodded as necessary to prevent erosion. If climatic conditions preclude the use of vegetation, non-vegetative covering such as gravel or other mulches may be used.

ROCK DROPS

Site Conditions

Rock drops shall apply to channels with grades less than five percent and width less than 50 feet, or with grades less than eight percent and width less than 25 feet. Flows shall not exceed 3 ft. over the drop for a 50-year frequency storm.

These structures are limited to a maximum drop (F_T) of 4 feet measured from weir to downstream toe; except structures in series, the structures are limited to a drop (F_T) of 4 feet measured from weir to weir.

Design Criteria

Design considerations shall be given to the following points:

(a) Grade of channel
(b) Stability of downstream channel
(c) Rock size and gradation (percent passing)
(d) Existing channel cross-section
(e) Soil material of banks
(f) Filter requirements to prevent piping
(g) Height of drops
(h) Flow depth over drop
(i) Vegetation to be re-established.

Loose rock drops shall be designed according to the principles set forth in National Engineering Handbook, Section 5, Hydraulics, and Figure 2 attached.

Filter blankets will be provided by placement of Geotextile fabric on all interfaces of earth and rock riprap.

The rock size shall be determined by using the empirical relationship shown by the curve in **Figure 2**. D_{75} (percent passing) size rock placed in a row along the downstream crest provides greater stability. Rock should be fairly well graded with no more than 10 percent smaller than 3 inches in size. The total thickness of the rock riprap in the completed structure shall be D_{100} (T). All rock shall be angular or subangular. Subrounded and rounded rock is not permitted.

Structures

Add the following for rock drop structures:

Rock checks may be constructed to control the grade of small channels (or gullies) to prevent further degradation.

a. Flow Design: the design flow shall be the smaller of either the 5-year flow or the full bank capacity flow.

b. Capacity: the drops are to be constructed of loose rocks with sufficient capacity over the weir to pass the design flow.

c. Location: Starting at a given stream channel control point, checks or drops are to be positioned to provide grade control. The structures are to be placed along the channel to provide no more than a 4-foot drop, F_T, from the weir to the downstream toe.

For structures in series the drop will be measured weir to weir, (F_T). The upstream slope of the structure shall be no steeper than 2:1. The top width shall be three feet or greater. The downstream slope shall be no steeper then 6:1 for drops to 3 feet. For drops over 3 feet the downstream slope shall be no steeper than 8:1. The length of the apron (A) of the drop shall be a minimum of $2F_T$. The larger rocks shall be placed in the weir section of the drop. The downstream slope and the apron shall be the same width as the weir.

CONSIDERATIONS

Water Quantity

1. Effects on volumes and rates of runoff, evaporation, deep percolation and ground water recharge.

2. Effects of the structure on soil water and resulting changes in plant growth and transpiration.

Water Quality

1. Ability of structure to trap sediment and sediment-attached substances carried by runoff.

2. Effect of structure on the susceptibility of downstream stream banks and stream beds to erosion.

3. Effects of the proposed structure on the movement of dissolved substances to ground water.

4. Effects on visual quality of water resources.

Endangered Species Considerations

Determine if installation of this practice with any others proposed will have any effect on any federal or state listed Rare, Threatened or Endangered species or their habitat. NRCS's objective is to benefit these species and others of concern or at least not have any adverse effect on a listed species. If the Environmental Evaluation indicates the action may adversely affect a listed species or result in adverse modification of habitat of listed species which has been determined to be critical habitat, NRCS will advise the land user of the requirements of the Endangered Species Act and recommend alternative conservation treatments that avoid the adverse effects. Further assistance will be provided only if the landowner selects one of the alternative conservation treatments for installation; or at the request of the landowners, NRCS may initiate consultation with the Fish and Wildlife Service, National Marine Fisheries Service and/or California Department of Fish and Game. If the Environmental Evaluation indicates the action will not affect a listed species or result in adverse modification of critical habitat, consultation generally will not apply and usually would not be initiated. Document any special considerations for endangered species in the Practice Requirements Worksheet.

Some species are year-round residents in some streams, such as, freshwater shrimp. Other species, such as steelhead and salmon, utilize streams during various seasons. Be aware that critical periods, such as spawning, eggs in gravels, and rearing of young may preclude activities in the stream that may directly affect the stream habitat during those periods. For example there should be no disturbance of stream gravel beds that may have eggs in them. That could include any equipment in the stream or even walking in the stream or work upstream that may result in sediment depositing in the gravel beds. Document any special considerations for endangered species in the Practice Requirements Worksheet.

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.

Tables 1, 2, and 3 available upon request.

OPERATION AND MAINTENANCE

An operation and maintenance plan must be prepared by the Designer for use by the owner or other responsible for operating this practice. The plan should provide specific instructions for operating and maintaining the system to insure that it functions properly. It should also provide for periodic inspections and prompt repair or replacement of damage components.

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	Freq. of minimum design, 24-hr 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	20-30	5
600	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	Freq. 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	Freq. of minimum design, 24-hour duration storm: Receiving channel capacity	Total capacity
0-4 in	3-5 in	5+ in			
,,,,,,,,,,acres,,,,,,,,,,			ft	ft	yr
1,200	450	250	0-5	0-10	--
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 storm.

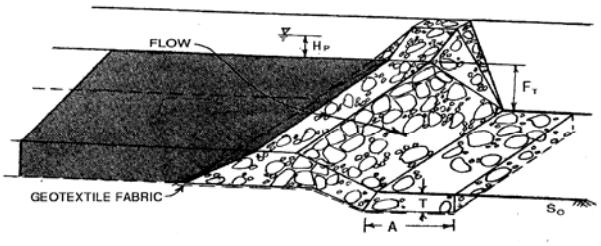

FIGURE - 1 LOOSE ROCK DROP

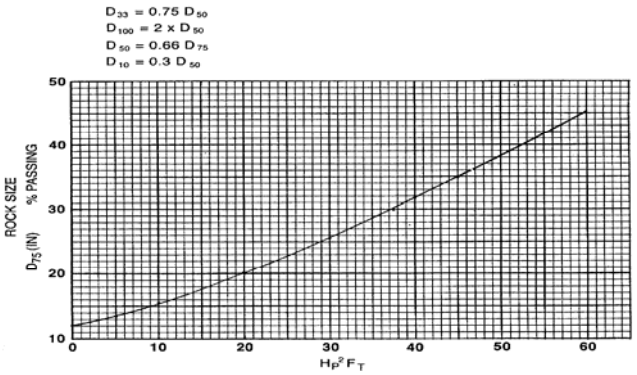

FIGURE - 2 DETERMINATION OF ROCK SIZE