GRADE STABILIZATION STRUCTURE

(Number)

CODE 410

DEFINITION
A grade stabilization structure is used to control the grade in natural or constructed channels.

PURPOSE
The purpose of a grade stabilization structure is to stabilize grade, reduce erosion, or improve water quality.

CONDITIONS WHERE PRACTICE APPLIES
This practice applies where channels require a structure to stabilize the grade or to control gully erosion.

CRITERIA

General Criteria.  Plan, design, and construct this practice to comply with all federal, state, and local regulations.  Regulations of particular concern include those involving water rights, pollution control, property easements, wetlands, preservation of cultural resources, and endangered species.  The owner is responsible for securing necessary permits, complying with all laws and regulations, and meeting legal requirements applicable to the installation, operation, and maintenance of this practice.

Set the crest of the inlet at an elevation that will stabilize the channel and prevent upstream head cutting.

Design earthen embankments and auxiliary spillways to handle the total capacity flow indicated in Tables 1 or 2, without overtopping any embankment.  The foundation preparation, compaction, top width, and side slopes must ensure a stable earthen embankment for anticipated flow conditions.

Provide a minimum sediment storage capacity equal to the expected life of the structure or provide for periodic cleanout.

Provide measures necessary to prevent serious injury or loss of life, such as protective guardrails, warning signs, fences, and/or lifesaving equipment.

Seed or sod the exposed surfaces of earthen embankments, earth spillways, borrow areas, and other areas disturbed during construction in accordance with Kansas Conservation Practice Standard 342, Critical Area Planting.  If climatic conditions preclude the use of seed or sod, use Kansas Conservation Practice Standard 484, Mulching, to install inorganic cover material, such as gravel.

Embankment dams.  Low hazard dams that have a product of storage multiplied by the effective height of the dam of 3,000 acre-feet² or more, those more than 35 feet in effective height, and all significant and high hazard dams must meet or exceed the criteria specified in Engineering Technical Release TR-210-60, Earth Dams and Reservoirs.
Low hazard dams that have a product of storage multiplied by the effective height of the dam of less than 3,000 acre-feet² and an effective height of 35 feet or less must meet or exceed the requirements specified in Kansas Conservation Practice Standard 378, Pond.

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

Storage is the capacity of the reservoir in acre-feet below the elevation of the crest of the lowest auxiliary spillway, or the elevation of the top of the dam if there is no open channel auxiliary spillway.

Sediment storage will be provided whenever detention storage is used to size the principal spillway conduit. Sediment storage will be based upon the estimated life of the structure and will be allocated to a sediment pool or partially to the detention pool.

**Pond sized dams.** If mechanical spillways are required, the minimum capacity of the principal spillway must convey the peak flow expected from a 24-hour duration design storm of the frequency shown in Table 3, less any reduction from detention storage. For dams with effective height less than 20 feet, a stable auxiliary spillway with no overfalls, and good auxiliary spillway vegetation along its reentry into the downstream channel, the designer may reduce the principal spillway capacity to no less than 80 percent of the 2-year frequency, 24-hour duration storm.

For dams with a storage capacity more than 50 acre-feet, or criteria values exceeding those shown in Table 3, use the 10-year frequency, 24-hour duration storm as the minimum detention design storm. Use the 50-year frequency, 24-hour duration storm as the total capacity design storm.

When the effective height of the dam is 15 feet or greater and the effective storage of the dam is 50 acre-feet or more, provide filter diaphragms to control seepage on all pipes extending through the embankment with inverts below the peak elevation of the routed design hydrograph. Design filter diaphragms or alternative measures as needed to control seepage on pipes extending through all other embankments or for pipes with inverts above the peak elevation of the routed design hydrograph.

**Small pond-sized dams.** For dams with an effective height of less than 15 feet and 10-year frequency, 24-hour storm runoff volume less than 10 acre-feet, the designer may use the requirements of Kansas Conservation Practice Standard 638, Water and Sediment Control Basin. Design the grade control structure to control the peak flow from the 10-year frequency, 24-hour duration storm without overtopping. If the combination of storage and mechanical spillway discharge will handle the design storm, an auxiliary spillway is not required. Anti-seep collars may be used for seepage control when a principal spillway conduit is used for the mechanical spillway.

**Full-flow open structures.** Design drop, chute, and box inlet drop spillways to the requirements in the National Engineering Handbook, Part 650, Engineering Field Handbook and other applicable Natural Resources Conservation Service (NRCS) publications and reports. Provide a minimum capacity to pass the peak flow expected from a design storm of the frequency and duration shown in Table 1, less any reduction from detention storage. If site conditions exceed those shown in Table 1, design the minimum principal spillway capacity for the 25-year frequency, 24-hour duration storm and design the minimum total capacity for the 100-year frequency, 24-hour duration storm. Structures must not create unstable conditions upstream or downstream. Install provisions for reentry of bypassed storm flows.

The ratio of the capacity of drop boxes to road culverts must meet the requirements of the responsible road authority or as specified in Table 1 or 2, as applicable, less any reduction from 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.
Toewall drop structures can be used if the vertical drop is four (4) feet or less, flows are intermittent, downstream grades are stable, and tailwater depth at design flow is equal to or greater than 1/3 of the height of the overfall.

Freeboard is the additional height of the headwall extension or sidewall above the flow depth of the design storm at the inlet crest. Include a minimum freeboard in the structure design of 0.25 foot or the amount suggested in the NRCS references.

When auxiliary spillways are used, design the principal spillway and the auxiliary spillway to handle the total capacity indicated in Table 2. Design the flow depth in the auxiliary spillway to provide a minimum freeboard of one (1) foot between the maximum water surface and the top of the embankment.

Design the embankment with a top elevation at least one (1) foot higher than the top of the headwall extension or sidewall. Design the embankment with side slopes no steeper than 3:1 and a minimum top width of six (6) feet.

Excavations must be stable for all anticipated conditions. Design excavated side slopes no steeper than 3:1.

**Island-type structures.** Design the minimum capacity equal to the capacity of the downstream channel. Design the minimum auxiliary spillway capacity equal to that required to pass the peak flow expected from a 24-hour duration storm of the frequency shown in Table 1 for total capacity without overtopping the headwall extensions of the mechanical spillway. Make provision for safe reentry of bypassed flow, as necessary.

**Side-inlet, open weir, or pipe-drop drainage structures.** Table 2 provides the design criteria for minimum capacity of open weir or pipe structures used to lower surface water from field elevations or man-made lateral drainage channels into deeper man-made open main drainage channels. Design the minimum principal spillway capacity equal to the design drainage curve runoff for all conditions. If site condition values exceed those shown in Table 2, use the 50-year frequency, 24-hour duration storm for minimum design of total capacity.

### Table 1. - Design criteria for establishing minimum capacity of full-flow open structures.

<table>
<thead>
<tr>
<th>Maximum drainage area for indicated rainfall in a 5-year frequency, 24-hour duration storm</th>
<th>Frequency of minimum design, 24-hour duration storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3 in.</td>
<td>3 - 5 in.</td>
</tr>
<tr>
<td>1,200</td>
<td>450</td>
</tr>
<tr>
<td>2,200</td>
<td>900</td>
</tr>
</tbody>
</table>
Table 2. - Design criteria for establishing minimum capacity of side-inlet, open weir, or pipe-drop structures associated with a field drainage system.

<table>
<thead>
<tr>
<th>Maximum drainage area for indicated rainfall in a 5-year frequency, 24-hour duration storm</th>
<th>Vertical drop</th>
<th>Receiving channel depth</th>
<th>Total capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 3 in.</td>
<td>3 - 5 in.</td>
<td>5+ in.</td>
<td>feet</td>
</tr>
<tr>
<td>1,200</td>
<td>450</td>
<td>250</td>
<td>0 - 5</td>
</tr>
<tr>
<td>1,200</td>
<td>450</td>
<td>250</td>
<td>5 - 10</td>
</tr>
<tr>
<td>2,200</td>
<td>900</td>
<td>500</td>
<td>0 - 10</td>
</tr>
</tbody>
</table>

Table 3. - Design criteria for establishing minimum capacity of the principal spillway for embankment structure dams with storage capacity of less than 50 acre-feet.

<table>
<thead>
<tr>
<th>Maximum drainage area for indicated rainfall in a 5-year frequency, 24-hour duration storm</th>
<th>Effective height of dam</th>
<th>Frequency of minimum design, 24-hour duration storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3 in.</td>
<td>3 - 5 in.</td>
<td>5+ in.</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
<td>50</td>
</tr>
<tr>
<td>400</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>400</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>600</td>
<td>400</td>
<td>200</td>
</tr>
</tbody>
</table>

Terrace outlet structures. Design structures with the minimum capacity to pass the peak flow expected from a 10-year frequency, 24-hour duration storm. Structures may be constructed of reinforced concrete or modular concrete blocks. Utilize standard drawings or other approved procedures to document the capacity and structural integrity of the design. For structures in series, design downstream structures with equal or greater capacity than the structure immediately upstream.

Design the outlet channel and channels between structures to be stable during passage of the peak flow. The channel shall be at least as wide as the structure notch, if the channel slope is less than or equal to 0.3%. Design the channels between structures as annually vegetated waterways using effective stress computations when the channel slope is greater than 0.3%. The maximum allowable slope between structures is 0.6%.

VEGETATION

The exposed surfaces of the embankment, auxiliary spillway, outlet channel, borrow area, spoil, and other areas disturbed during construction shall be seeded. Seedbed preparation, seeding, fertilizing, and mulching shall comply with Kansas Conservation Practice Standard 342, Critical Area Planting.

CONSIDERATIONS

Provide sufficient discharge to minimize crop damaging water detention.
In highly visible public areas and those associated with recreation, give careful consideration to landscape resources. Landforms, structural materials, water elements, and plant materials should complement their surroundings visually and functionally. Shape excavated material and cut slopes to blend with the natural topography. Shape shorelines and create islands to add visual interest and wildlife habitat. Form and finish exposed concrete surfaces to add texture, reduce reflection, and to alter color contrast. Select sites to reduce adverse impacts or create desirable focal points.

Consider the effect of the grade control structure on aquatic habitat. For channels supporting fish, consider the effect of the structure on fish passage.

In natural channels, consider the effect of the grade control structure on fluvial geomorphic conditions.

Provide fences to protect structures, earth embankments, and vegetated spillways from livestock. Near urban areas, provide fencing as appropriate to control access and exclude traffic. Add protective guardrails, warning signs, or lifesaving equipment as needed.

**PLANS AND SPECIFICATIONS**

Prepare plans and specifications for installing grade stabilization structures that describe the requirements for applying the practice according to this standard. At a minimum, include the following items in the plans and specifications:

1. A plan view of the layout of the grade stabilization structure and appurtenant features.
2. Typical profiles and cross sections of the grade stabilization structure and appurtenant features, as needed.
3. Structural drawings, as needed.
4. Seeding requirements, as needed.
5. Safety features.
6. Site specific construction requirements.

**OPERATION AND MAINTENANCE**

Prepare an operation and maintenance plan for the operator. At a minimum, include the following items in the operation and maintenance plan:

1. Require periodic inspections of all structures, earthen embankments, spillways, and other significant appurtenances.
2. Require prompt repair or replacement of damaged components.
3. Require prompt removal of sediment when it reaches predetermined storage elevations.
5. Require periodic inspection of safety components and immediate repair, if necessary.
6. Require maintenance of vegetative protection and immediate seeding of bare areas, as needed.

**REFERENCES**

