Channel Stabilization (CS)

Practice Description
Channel stabilization is stabilizing a channel, either natural or artificial, in which water flows with a free surface. The purpose of this practice is to establish a non-erosive channel. This practice applies to the stabilization of open channels and existing streams or ditches with drainage areas less than 1 square mile. Methods of channel stabilization include rock riprap lining, concrete lining, grade stabilization structures, and bioengineered treatments, i.e., combinations of structural and vegetative materials. Vegetative-based structural reinforcements are preferred, especially in cases with fisheries resources and/or water quality issues.

Note: The design of open-channel conveyance structures other than Grass Swale is beyond the scope of this edition of the Mississippi Erosion and Sediment Control Manual, Volume 1, and should be done by a qualified design professional and should meet applicable state, federal, and local regulatory requirements.

Planning Considerations
This practice applies to the improvement or stabilization of open channels and existing streams or ditches with drainage areas less than 1 square mile. Channels with drainage greater than 1 square mile will be designed with appropriate criteria. In all cases, channel stabilization design should be done by a qualified design professional experienced in hydrology and hydraulics.

An adequate outlet for the channel must be available for discharge by gravity flow. Construction or other improvements to the channel should not adversely affect the
environmental integrity of the area and must not cause significant erosion upstream or flooding and/or sediment deposition downstream.

The alignment and design of channels and stabilization structures shall give careful consideration to the preservation of valuable fish and wildlife habitat and trees of significant value for aesthetic purposes.

Where construction will adversely affect significant fish or wildlife habitat, mitigation measures should be included in the plan. Mitigation measures may include in-stream structures such as pools, riffles, and woody structures, or streamside measures such as trees, shrubs, and other features that enhance wildlife habitat.

Due to the varied nature of these considerations, an interdisciplinary team consisting of engineers, soil bioengineers, hydrologists, and fishery biologists should prepare the design of streambank protection for each unique channel reach. If instability is occurring over a significant length of stream, the team should consider performing a geomorphic analysis of the stream. All local, state and federal laws, especially laws relating to 404 permits, should be followed during the design and construction process.

**Design Criteria and Construction**

Prior to the start of construction, channel stabilization should be designed by a qualified design professional. Plans and specifications should be referred to by field personnel throughout the construction process.

Consider the following guidance as construction proceeds.

**Realignment**

The realignment of channels should be kept to an absolute minimum. Where realignment is unavoidable, the realigned channel should be designed to have a stable grade considering the soil type, vegetation, and new channel length.

**Channel Capacity**

The design capacity of open channels and stabilization structures should be determined by procedures applicable to the purposes to be served.

**Hydraulic Requirements**

Manning’s formula should be used to determine velocities in channels. The “n” values for use in this formula should be estimated using currently accepted guides along with knowledge and experience regarding the conditions. Acceptable guides can be found in hydrology textbooks.

**Channel Cross Section**

The required channel cross section of new or realigned channels is determined by the design capacity, the bed and bank materials, vegetation, and the requirements for maintenance. A minimum depth may be required to provide adequate outlets for subsurface drains and tributary channels. To enhance fisheries and wildlife, consider a channel cross section configuration that will ensure concentrated and unobstructed flow during periods of low flow, but one that incorporates bioengineered treatments with adequate habitat features to ensure refugia, etc., for fish and wildlife.
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Drop Structure
Drop structures are used to reduce or prevent excessive erosion by reduction of velocities in the watercourse or by providing structures that can withstand and reduce the higher velocities. They may be constructed of concrete, rock, masonry, steel, aluminum or non-toxic treated wood.

These structures are constructed where the capability of earth and vegetative measures is exceeded in the safe handling of water at permissible velocities, where excessive grades or overall conditions are encountered, or where water is to be lowered structurally from one elevation to another. These structures should generally be planned and installed along with or as part of other erosion-control practices. The structures must be designed hydraulically to adequately carry the channel discharge and structurally to withstand loadings imposed by the site conditions, but must allow fish to traverse if the stream has fish inhabitation. Therefore, a fisheries biologist should be consulted before the design is finalized and the structure installed.

Channel Stability
All channel construction, improvement and modification should be in accord with a design expected to result in a stable channel that can be maintained.

Characteristics of a stable channel are:

- It neither aggrades nor degrades beyond tolerable limits.
- The channel banks do not erode to the extent that the channel cross section is changed appreciably.
- Excessive sediment bars do not develop.
- Excessive erosion does not occur around culverts, bridges or elsewhere.
- Gullies do not form or enlarge due to the entry of uncontrolled surface flow to the channel.
- The determination of channel stability considers “bankfull” flow.
- Bankfull flow is defined as the flow in the channel which creates a water surface that is at or near normal ground elevation for a significant length of a channel reach. Excessive channel depth created by cutting through high ground, such as might result from realignment of the channel, should not be considered in determinations of bankfull flow.

The design for channels in natural materials shall be considered stable if the check velocity is less than the allowable velocities shown in Table CS-1. The check
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velocity is defined as the lesser of the bankfull velocity or the 10-year frequency peak discharge velocity.

Table CS-1 Allowable Velocities for Various Soil Textures

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Allowable Velocity (ft/sec.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand and Sandy Loam (noncolloidal)</td>
<td>2.5</td>
</tr>
<tr>
<td>Silt Loam (also high lime clay)</td>
<td>3.0</td>
</tr>
<tr>
<td>Sandy Clay Loam</td>
<td>3.5</td>
</tr>
<tr>
<td>Clay Loam</td>
<td>4.0</td>
</tr>
<tr>
<td>Stiff Clay, Fine Gravel, Graded Loam to Gravel</td>
<td>5.0</td>
</tr>
<tr>
<td>Graded Silt to Cobbles (colloidal)</td>
<td>5.5</td>
</tr>
<tr>
<td>Shale, Hardpan and Coarse Gravel</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Scheduling

Installation scheduling should be phased according to the following considerations. Hard structures such as rock and other inert materials could be installed during a period not suitable for vegetative establishment whereas vegetation could be planted during the appropriate time for more assurance of its survival. For instance, vegetation would be better established in the late winter/early spring after hard structures have been installed or concurrent with hard structure installation, depending on the design plan. Hard structures could be installed during a construction season prior to vegetative establishment with the vegetation being installed the following spring. For vegetation on high banks (those areas used for the adjoining Streambank Protection), schedule that installation during a planting period tailored for optimum survival of the plant species used. In addition, use local weather forecasts to avoid installation activities during rain events that can potentially create abnormal flows and flooding.

Site Preparation

Follow all local, state and federal government regulations on stream modifications.

Determine exact location of all underground activities.

Remove trees, brush, stumps and other objectionable materials according to the design plan. Where possible, vegetation will be left standing and stumps will not be removed.

Spoil material resulting from clearing and grubbing should be disposed of according to the design plan.

The foundation for structures should be cleared of all undesirable materials prior to the installation of the structures.

Channel Linings and Structural Measures

Where channel velocities exceed safe velocities for bare soil, channel linings of rock, concrete, or other durable material may be needed. Grade stabilization structures may also be needed.
Total channel linings covering the entire cross section of the stream are discouraged if the stream is inhabited by fisheries and other biota. Alternatively, a bioengineered stream is preferred that incorporates a zoned approach, such as a rocked toe and then vegetative treatments on the mid- and upper-banks. For more information, please review “Appendix B–Bioengineering for Streambank Erosion Control, Guidelines” of The WES Stream Investigation and Streambank Stabilization Handbook referenced at the end of this section. Total covering of ditches with channel linings may be appropriate if they are used solely for drainage and erosion control.

One or more of the following methods can be used to stabilize channels or portions of channels given the above considerations, i.e., whether a stream or a ditch.

**Rock Riprap Lining**

Rock riprap should be designed to resist displacement when the channel is flowing at the bankfull discharge or the 10-year 24-hour frequency discharge, whichever is the lesser. Rock riprap lining should not be used when channel velocities exceed 10 feet per second unless a detailed engineering analysis is performed using appropriate guidelines.

Use Figure CS-1 to determine the stable basic stone weight \((d_{100})\). Using the \(d_{100}\) size as a \(d_{90}\), select a commercially available riprap gradation as classified by the Mississippi Department of Transportation, from Table CS-2.

Dumped and machine-placed riprap should be installed on slopes flatter than 2 horizontal to 1 vertical. Where riprap is placed by hand, the slopes may be steeper. Stone for riprap should consist of field stone or rough unhewn quarry stone of approximately rectangular shape. The stone should be hard and angular and of such quality that it will not disintegrate on exposure to water or weathering, and it should be suitable in all other respects for the purpose intended. The specific gravity of the individual stones should be at least 2.5.

A filter blanket should be placed between the riprap and base material, if needed. A filter blanket is a layer of material placed between the riprap and the underlying soil surface to prevent soil movement into or through the riprap. A filter blanket should be considered where soils have a high piping potential and/or there is significant seepage of groundwater from the bed or banks.
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Figure CS-1  Ishbash Curve

Procedure
1) Determine the design velocity.
2) Use design velocity and Figure CS-1 to determine $d_{100}$ rock size.
3) Use $d_{100}$ from Figure CS-1 as $d_{90}$ to select rock gradation from Table CS-2.

Table CS-2  Commercially Available Riprap Gradations

<table>
<thead>
<tr>
<th>Class</th>
<th>Weight (lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$d_{10}$</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
</tr>
</tbody>
</table>

A filter blanket can be of two general forms: a gravel layer or a geotextile filter cloth. Gravel filter blankets are to be designed in accordance with the criteria below.
Gravel Filter Blanket

The following relationships must exist:

\[
\frac{d_{15 \text{ filter}}}{d_{85 \text{ base}}} < 5 < \frac{d_{15 \text{ filter}}}{d_{15 \text{ base}}} < 40
\]

\[
\frac{d_{50 \text{ filter}}}{d_{50 \text{ base}}} < 40
\]

In these relationships, filter refers to the overlying material and base refers to the underlying material. The relationships must hold between the filter material and the base material and between the riprap and the filter material. In some cases, more than one layer of filter material may be needed. Each layer of filter material should be approximately 6” thick.

Geotextile Filter Cloth

Geotextile filter cloth may be used in place of or in conjunction with gravel filters. Geotextile will meet the requirements of Class I geotextile as shown in Table CS-4.

Filter blankets should always be provided where seepage from underground sources threatens the stability of the riprap.

Rock Riprap Lining Installation

Where excavation is required, channels will be excavated from one side, leaving vegetation on the opposite side.

Excavation should be at the locations and grades shown on the drawings.

Spoil material resulting from channel excavation should be disposed of according to the design plan.

If required by the plans, place geotextile fabric or a granular filter as a bedding material for the riprap. Install riprap of the specified gradation to the lines and grades shown in the design plan. Ensure that the subgrade for the filter and riprap follows the required lines and grades shown in the plan.

Riprap may be placed by equipment. Care should be taken to avoid punching or tearing of the filter cloth during placement of rock. Repair any damage by removing the riprap and placing another piece of filter cloth over the damaged area. All connecting joints should overlap a minimum of 1.5 feet so that the upstream piece of fabric lies on top of the downstream piece of fabric. If the damage is extensive, replace the entire filter cloth.

Installation usually includes some bank shaping. If bank shaping is included, follow details in the design plan and refer to the construction guidelines in Streambank Protection Practice.
Concrete Lining

Concrete linings should be designed according to currently accepted guides for structural and hydraulic adequacy. They must be designed to carry the required discharge and to withstand the loading imposed by site conditions. Concrete linings are generally used when velocities exceed 10 ft/sec. Erosion at the outlet of concrete-lined channels is generally a problem due to the high velocities. Measures should be taken to reduce the velocity and erosion potential at the outlet by use of outlet protection measures (see Outlet Protection Practice).

Concrete Lining Installation

Where excavation is required, channels will be excavated from one side, leaving vegetation on the opposite side.

Excavation should be at the locations and grades shown on the drawings.

Spoil material resulting from channel excavation should be disposed of according to the design plan.

Install concrete lining using concrete of the specified design strength according to the lines and grades in the design plan.

Installation of concrete linings usually includes some bank shaping. If bank shaping is included, follow details in the design plan and refer to the construction guidelines in Streambank Protection Practice.

Place filter material and weep holes according to the plans. Place concrete according to American Concrete Institute standards. Concrete on sloping surfaces should be placed from the bottom of the slope toward the top, at the required thickness, and with good vibration.

As required by the design plan, install expansion joints at the locations shown in the plan.

As required by the design plan, install welded wire fabric in the concrete forms before placing concrete.

Divert flow around the concrete lining until the concrete has reached 75% of its design strength (usually 7 days after concrete placement).
Table CS-4  Requirements for Nonwoven Geotextile

<table>
<thead>
<tr>
<th>Property</th>
<th>Test method</th>
<th>Class I</th>
<th>Class II</th>
<th>Class III</th>
<th>Class IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (lb)</td>
<td>ASTM D 4632 grab test</td>
<td>180</td>
<td>120</td>
<td>90</td>
<td>115</td>
</tr>
<tr>
<td>Elongation at failure (%)</td>
<td>ASTM D 4632 ≥ 50</td>
<td>≥ 50</td>
<td>≥ 50</td>
<td>≥ 50</td>
<td>≥ 50</td>
</tr>
<tr>
<td>Puncture (pounds)</td>
<td>ASTM D 4833 80 minimum</td>
<td>80</td>
<td>60</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Ultraviolet light (% residual tensile strength)</td>
<td>ASTM D 4355 150-hr exposure</td>
<td>70 minimum</td>
<td>70 minimum</td>
<td>70 minimum</td>
<td>70 minimum</td>
</tr>
<tr>
<td>Apparent opening size (AOS)</td>
<td>ASTM D 4751 As specified max. #40</td>
<td>As specified max. #40</td>
<td>As specified max. #40</td>
<td>As specified max. #40</td>
<td></td>
</tr>
<tr>
<td>Permittivity sec⁻¹</td>
<td>ASTM D 4491 0.70 minimum</td>
<td>0.70 minimum</td>
<td>0.70 minimum</td>
<td>0.70 minimum</td>
<td>0.10 minimum</td>
</tr>
</tbody>
</table>

Table copied from NRCS Material Specification 592.

1 Minimum average roll value (weakest principal direction).
2 U.S. standard sieve size.
3 Heat-bonded or resin-bonded geotextile may be used for Classes III and IV. They are particularly well suited to class IV. Needle-punched geotextile is required for all other classes.

**Grade Stabilization Structures**

For streams with fish inhabitation, a fisheries biologist should be consulted before the design is finalized and the structure installed, to ensure fish transport will not be adversely affected by the structure.

Where excavation is required, channels will be excavated from one side, leaving vegetation on the opposite side.

Excavation should be at the locations and grades shown on the drawings.

Spoil material resulting from clearing, grubbing and channel excavation should be disposed of according to the design plan.

Install the structure to the lines and grades shown in the design plan.

If earthfill is required, install according to the design plan and refer to the construction guidelines for Sediment Basin embankments.

If rock riprap is required, install according to the design plan and refer to the installation requirements listed earlier for Riprap-Lined Swale.

Other products used, including concrete, masonry, steel, aluminum or treated wood, should be installed according to details in the design plan. Installation usually includes...
some bank shaping. If bank shaping is included, follow details in the design plan and refer to the construction guidelines in the Streambank Protection Practice.

**Erosion Control**

Seeding, fertilizing and mulching of the disturbed areas should be done immediately after construction and should conform to the guidelines in the design plan. If vegetation establishment specifications are not included in the design plan, see the appropriate practice (*Permanent* or *Temporary Seeding*) for guidelines. If planting needs to be deferred until the next planting season, the disturbed areas should be protected with mulch (see *Mulching Practice* if details are not included in the design plan).

**Safety**

Store all construction materials well away from the stream. Consider weather forecasts when determining risks of damage by flooding.

Equipment used to construct channel stabilization measures should be free of leaks of fuel and hydraulic fluids to prevent contamination of surface waters. Operation of equipment in the stream should be minimized. At the completion of each workday, move all construction equipment away from the stream to prevent damage to equipment by flooding. Consider weather forecasts when determining risks of flooding.

*The following precautions should be taken:*

- Exercise caution on steep slopes.
- Fence the area and post warning signs if trespassing is likely.
- All equipment used for practice installation should be free of leaks of gas, oil, and hydraulic fluid. Measures should be in place to prevent accidental spills from entering the stream.
- Equipment should not be operated within flowing water in the stream.

**Construction Verification**

Check material and finished grades to determine if job meets specifications in the design plan.

**Common Problems**

Variations in site conditions indicate practice will not function as intended; changes in plan may be needed.

Design specifications for materials cannot be met; substitution may be required. Unapproved substitutions could result in failure of the practice.

**Maintenance**

All structures should be maintained in an “as built” condition.

Check the stream channel at the construction site after each major event until the job is considered mature and a success.
Structural damage caused by storm events should be repaired as soon as possible to prevent further damage to the structure or erosion of the streambank.

Unwanted brush or excessive sediment that will impede flow should be removed to maintain design conditions.

References

BMPs from Volume 1

Chapter 4
Mulching (MU) 4-48
Permanent Seeding (PS) 4-53
Preservation of Vegetation (PV) 4-64
Shrub, Vine and Groundcover Planting (SVG) 4-80
Temporary Seeding (TS) 4-103
Tree Planting on Disturbed Areas (TP) 4-110
Outlet Protection (OP) 4-199
Riprap-Lined Swale (RS) 4-210
Filter Strip (FS) 4-261
Sediment Basin (SBN) 4-298
Streambank Protection (SP) 4-362

BMPs from Volume 2

Chapter 4
Riparian/Forested Buffer
Vegetated Filter Strip

Additional Resources


