CHAPTER 3. STRUCTURAL EROSION CONTROL MEASURES

3.1 BENCH

Figure 3.1. Bench cut, upper level (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

*Description:* Slightly reverse sloping steps, 8 to 10 ft wide horizontally, on a back slope at intervals of 20 to 25 feet in vertical height.

*Problem identification:* The combination of precipitation, steep slopes, and erosive soils can cause sheet and gully erosion.

*Design purpose:* Reduce runoff volume and increase infiltration.

*Associated practices:* Requires provision for runoff disposal and slope protection.

*Installation:* Constructed as a part of the grading operation. As soon as possible, the exposed soil should be fertilized, seeded, and mulched.

*Maintenance/inspection:* The site should be inspected after each precipitation event, both slope areas and down drains from each bench. All problem areas should be repaired as soon as possible; it may be necessary to reseed, remulch, or repair some of the down drains.

*Design life:* Permanent.

*Estimated cost:* Included in grading.
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Figure 3.2. Bench cut, profile view (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Figure 3.3. Bench cut, interchange application (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
3.2 COMPOST FILTER BERMS

![Image of Berm]

**Figure 3.4. Berm (Source: Urban Resources and Borderland Alliance Network)**

**Overview**

**Description:** A temporary or permanent ridge of soil located in such a manner as to channel water to a desired location.

**Problem identification:** Sheet and gully erosion occurs on slopes where runoff velocities and outlet locations are not controlled.

**Design purpose:** To prevent runoff from going over the top of a cut and eroding the slope; may be used to direct runoff away from a construction site, divert clean water from a disturbed area, or reduce the size of a drainage area.

**Associated practices:** Requires adequate down drains to dispose of runoff when used on slopes.

**Installation:** Compaction of the soil is necessary. The minimum recommended grade is 1%. As soon as the compost filter berm is completed, it should be fertilized, seeded, and mulched. Earth berms shall have an outlet that functions with a minimum of erosion. The runoff shall be conveyed to a sediment trapping device.

**Table 3.1. Maximum filter berm spacing for berm size of 1’ x 2’ (height x width)**

<table>
<thead>
<tr>
<th>Slope</th>
<th>Slope length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%–2%</td>
<td>125’</td>
</tr>
<tr>
<td>2%–5%</td>
<td>75’</td>
</tr>
<tr>
<td>5%–10%</td>
<td>50’</td>
</tr>
</tbody>
</table>

**Maintenance/inspection:** Inspect after each precipitation event for erosion. Repairs must be done after each precipitation event. The outlets always need protection. Vegetation provides the best protection.

**Design life:** Six months.

**Estimated cost:** $2.80 per linear ft for small compost filter berms (2004); $8.40 per linear ft for large compost filter berms.
Figure 3.5. Temporary berms (Source: West Virginia DOT)
Figure 3.6. Temporary berm and temporary slope drain system (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
3.3 CHECK DAM

![Image of check dam](image)

Figure 3.7. Check Dam (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

**Description:** A small, temporary barrier or dam constructed across a drainage ditch.

**Design purpose:** To prevent erosion by reducing the velocity of storm water in areas of concentrated flow and lengthening the detention time.

**Associated practices:** Used as a temporary or emergency measure to limit erosion by reducing the velocity; used with riprap and silt fences.

**Installation:** Several materials can be used. Check dams are constructed by installing selected material at right angles to the direction of flow. Dam height should be 6 in. lower than the outside edge of the channel. Materials that can be used are 5- to 10-inch riprap or silt fences.

**Maintenance/inspection:** Periodic inspection is required. Sediment should be removed when it reaches one half the original dam height. Any material damage to the check dams should be corrected before the next precipitation event.

**Design life:** Stone has a life of one year, maybe permanent; manufactured has a life of six months.

**Estimated cost:** Riprap costs $25.20 per ton (2004); silt fence costs $2.80 per linear ft (2004).
Figure 3.8. Spacing between check dams (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
3.4 TEMPORARY SLOPE DRAIN (PIPE OR ROCK)

Figure 3.9. Temporary slope drain (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

**Description:** A temporary structure, either metal or flexible pipe, placed from the top of a slope to the bottom of a slope.

**Problem identification:** Limited construction areas, steep slopes, and large drainage areas create a need to control concentrated flows down a slope face.

**Design purpose:** To carry a concentrated flow of runoff water down a slope without causing erosion.

**Associated practices:** May be used on benched back slopes, with diversion structures, or where runoff is conveyed down fill sections.

**Installation:** The slope drains shall have a minimum grade of 3%. The top of the dike shall be at least 1 ft higher than the top of the inlet. All inlets shall be fitted with an apron and attached with a watertight connection. When flexible pipes are used, they shall be securely anchored with grommets placed 10 ft on center. A sediment trapping device may be placed at the outlet if deemed necessary. Riprap may be required at the outlet.

**Maintenance/inspection:** Inspection shall be performed after each storm. All problem areas should be corrected as soon as possible.

**Design life:** Temporary, until vegetation is established.
3.5 ENERGY DISSIPATOR

![Image of Energy Dissipator](Source: Iowa DOT)

**Overview**

*Description:* An obstacle placed at the outlet of drainage pipes or where a rapid flow of water needs to slow down in order to prevent erosion.

*Problem identification:* Excessive flow quantities and velocities cause erosion at the outlet of drainage structures. Control measures are needed to reduce water velocities at this location.

*Design purpose:* To control erosion and reduce the velocity of runoff water.

*Associated practices:* Used with measures that carry water and sediment; reduces velocity for streambank protection; used at outlets of pipes.

*Installation:* A wide range of materials can be used as energy dissipators, depending on the flow. Lighter to heavier flows can be handled with seeding, excelsior mats, or sod. In more demanding areas, control may be achieved by using riprap, boulders, or gabions. Regular construction procedures must be followed to achieve success.

*Maintenance/inspection:* Review control measure after each precipitation event.

*Design life:* Permanent.

*Estimated cost:* Riprap costs $32.20 per ton (2004).
3.6 FLOTATION SILT CURTAIN

Figure 3.11. Flotation silt curtain (Source: Minnesota DOT)

Overview

Description: A silt barrier for use within a pond or lake. This device consists of a heavy-duty filter fabric that is weighted at the bottom and attached to a flotation unit at the top.

Problem identification: When construction occurs near open bodies of water, measures must be taken to retain and remove sediment and floating debris at the water’s edge.

Design purposes: To isolate a construction area within a pond or lake to prevent silt-laden water from migrating out of the construction area; to limit and control the migration of suspended sediment within a pond or lake.

Associated practices: Not used with other control measures.

Installation: Flotation silt curtains are divided into three types, Type I, Type II, and Type III, based on the flow conditions within the water body. The information provided here applies to minimal and moderate flow conditions, where the velocity of flow is five fps or less. For situations in which the flow is greater than this, additional investigation is required, and a qualified manufacturer should be consulted.

The three types of silt curtains are differentiated by the strength and flow-through rate of the fabric and by the strength of the connecting materials used.

1. Type I curtains are considered light-duty and are intended for areas where there is no current and where the area is protected from wind and wave action.
2. Type II curtains can be used in areas with moderate running current (up to 3.5 fps) or where the wind and water currents can affect the curtain.
3. Type III curtains are used in areas with considerable current (up to 5 fps) or where the curtain is subject to more severe wind and wave action.

A flotation carrier should be at the top of the curtain. The carrier may be a floating plastic tube 6 in. in diameter and filled with marine-quality polyethylene foam. A 5/16 in. diameter coated steel cable should be centered in the floating tube to carry the weight of the curtain. The bottom of the curtain should be weighted by a chain or cable that weights 1.1 lbs per linear ft. Every 100 ft of the curtain requires a 24 lb anchor. When the curtain is made of more than one section, the sections should be overlapped so that silt cannot migrate through the connection.

**Maintenance/Inspection:** Inspect after heavy winds that may create waves; also check anchors and their attachments. Weekly checks should be made on each installation to determine the curtain’s condition and the remaining capacity for sediment and debris retention. When the remaining capacity falls below 50% or the vegetation is established adjacent to the curtain, the sediment and debris shall be removed in conjunction with curtain removal. Allow 24 hours for sediment to settle before removing the curtain. Any problem or failure of the curtain must be repaired immediately.

**Design life:** One construction season. Do not leave in place during winter months.

**Estimated cost:** $28.00 per linear ft.
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3.7 ROCK CHUTES AND FLUMES

Figure 3.12. Flume (Source: Urban Resources and Borderland Alliance Network)

Overview

**Description:** A device to carry water in an open structure to a lower level without erosion.

**Problem identification:** Permanent control devices are required to convey runoff along the bottom of slopes without causing erosion and sedimentation. These devices must reduce velocities and maintain discharge.

**Design Purpose:** To carry storm water runoff on a permanent basis without erosion.

**Associated practices:** Used with other control measures to dispose of storm water runoff.

**Installation:** A variety of materials can be used, depending on the volume of water that needs to be transported. For a small volume of water, a sod flume can perform satisfactorily. Other materials include half-round pipe, riprap underlaid with filter fabric, and paved flumes. Each needs to be constructed on firm, well-compacted soil.

**Maintenance/inspection:** All types of flumes need to be inspected after precipitation events for any necessary repairs or adjustments.

**Design life:** Permanent.

**Estimated cost:** Sod costs $49.00 per square (2004); riprap costs $32.20 per ton (2004).
3.8 GABION

Figure 3.13. Gabion (Source: Modular Gabion Designs)

Overview

Description: Gabions are rectangular wire mesh boxes that are filled with rock. They are used for channel revetments, retaining walls, check dams, bridge abutments, culvert headwalls, and almost any place where a heavy, flexible reinforcement is necessary.

Problem identification: Erosion measures are needed on steep banks adjacent to waterways, on buildings where right-of-way is limited, or where erosive soils are present.

Design Purpose: To use a material that is strong, flexible, and effective in the control of erosion.

Associated practices: For use in waterways, bank stabilization, and areas needing a permeable building block.

Installation: The mesh boxes or baskets are available in a wide range of sizes. The gabion is normally filled with four- to eight-inch rock, which usually is dumped mechanically and filled in place. The filled gabion becomes a large, flexible, and permeable building block. The baskets are corrosion-resistant, strong, and durable, and when filled they become flexible blocks from which a wide range of structures can be built.

Maintenance/inspection: Periodic inspection should be done to look for signs of undercutting or excessive erosion at the transition areas. Make necessary adjustments for problem areas.

Design life: Permanent.

Estimated costs: Cost varies with rock material selection and excavation costs.
3.9 INLET PROTECTION

Overview

Description: A manufactured protective device or barrier used to trap sediment at a storm drain surface or curb inlet.

Problem identification: During grading operations, measures are required to prevent sediment from moving from the work area into surface drains in the pavement curb or from area drains into the work area.

Design purpose: To trap sediment carried in stormwater runoff from disturbed areas and to prevent sediment from moving out of the work area.

Associated practices: Small basins should be used extensively around earth surface areas during construction and on a day-to-day basis as construction proceeds near where runoff will take place.

Installation: A number of practices provide storm drain inlet protection. Ideally, the drainage area is limited to one acre or less. Each practice will be reviewed separately below.

1. Curb drop inlet protection: Wire mesh of sufficient strength to support filter fabric with stone shall be placed so it extends 2 ft beyond the inlet in both directions. The 2-inch-sized stone should be placed against the filter fabric to a depth of 10 to 12 in. To ensure that runoff does not bypass the inlet, install temporary dikes directing the flow into the inlet.

2. Excavated drop inlet protection: The side slopes should be no steeper than 2:1. The excavated basin should be 1–2 ft deep. The basin should be shaped with the longest dimension oriented toward the longest inflow in order to result in maximum trap efficiency. The capacity of the basin should be 900 cu ft per acre. Weep holes protected with filter fabric and stone should be provided for draining the temporary pool.
3. Silt fence drop inlet protection: A 3 ft square frame, reinforced with wire mesh and covered with filter fabric on the sides, should be installed around an intake with the bottom edge sealed. The maximum height of the fabric should not exceed 18 in. Steps must be taken at the site and upstream to prevent water or sediment from overtopping the silt fence.

4. Sod drop inlet protection: Place the sod to form a turf mat completely covering the soil surface for a minimum distance of 4 ft on each side of the intake where runoff water will flow. The slope where the sod is placed should not exceed 4:1. During the first four weeks, the sod should be watered twice a week. The ground should be wet to a depth of 4 in. This method should only be applied in urban areas with a drainage area of less than 1/4 acre.

5. Compost filter tubes: Compost filter tubes can be placed around the perimeter of an area intake or in the throat or around the grate of a curb inlet.

6. Raise inlet of structure to provide a natural silt basin.

7. Keep elevation of fill one ft below inlet flow line.

8. Place silt basin approximately 200 ft ahead of entrance pipes in ditch grades 1% to 2%.

**Maintenance/inspection:** These structures should be inspected after every storm. Any sediment should be removed and disposed of on the site. Any damage should be repaired.

**Design life:** The life of an earth surface inlet protection is estimated to be three to six months, and that of a curb inlet protection is one year.

**Estimated cost:** Silt fence costs $2.80 per linear ft (2004); crushed rock costs $15.40 per ton (2004).
Figure 3.15. Inlet protection diagram (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
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Figure 3.16. Inlet sediment control (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Figure 3.17. Filter fabric drop inlet protection (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
Construction specifications

1. Filter fabric or burlap may be used for short-term applications.
2. Cut fabric from a continuous roll to eliminate joints. If joints are needed, they will be overlapped at the next stake.
3. Stake materials will be standard 2 by 4 in. wood or an equivalent. Metal stakes may be used with a minimum length of 3 ft.
4. Space stakes evenly around the inlet 3 ft apart and drive them a minimum of 18 in. deep. Spans greater than 3 ft may be bridged with the use of wire mesh behind the filter fabric for support.
5. Fabric shall be embedded a minimum of 1 ft below ground and backfilled. The fabric shall be securely fastened to the stakes and frame.
6. A 2 by 4 in. wood frame shall be constructed around the crest of the fabric for overflow stability.
7. Maximum drainage area = 1 acre.
Construction specifications

1. Bring the area to be sodded to final grade elevation with topsoil. Add fertilizer and lime, and install sod in accordance with the practice on sodding.
2. Lay all sod strips perpendicular to the direction of flow.
3. Maintain a minimum width of 4 ft in all flow directions.
4. Sod strips shall be staggered so adjacent strip ends are not aligned.
5. Maximum Drainage Area = .25 acres
Figure 3.19. Curb gutter inlet protection (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Construction specifications

1. Wooden frame shall be construction of 2 by 4 in. construction-grade lumber.
2. Wire mesh across throat shall be a continuous piece with a 30 in. minimum width and a length 4 ft longer than the throat. The mesh shall be shaped and securely nailed to a 2 by 4 in. weir.
3. The weir shall be securely nailed to 2 by 4 in. spacer, 9 in. long, and spaced no more than 6 ft apart.
4. The assembly shall be placed against the inlet and secured by 2 by 4 in. anchors, 2 ft long and extended across the top of the inlet and held in place by sandbags or alternate weights.
5. Maximum drainage area = 1 acre.
Figure 3.20. Excavated drop inlet protection (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Construction specifications

1. Clear the area of all debris that will hinder excavation.
2. Grade approach to the inlet uniformly around the basin.
3. Weep holes shall be protected by gravel.
4. Upon stabilization of the contributing drainage area, seal weep holes and fill the basin with stable soil to final grade. Compact it properly and stabilize with permanent seeding.
5. Maximum drainage area = 1 acre.
3.10 JETTIES

Figure 3.21. Jetty (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: Used to deflect water currents away from selected sections of a streambank.

Problem identification: A streambank under stress from water currents needs to be protected from erosion.

Design purpose: To redirect stream currents away from the streambank to reduce erosion.

Associated practices: Used where one waterway meets another on new construction or where there is a shift in alignment.

Installation: Logs or planks are installed to move the current, and riprap underlaid with filter fabric, boulders, or gabions is installed. The material must be sized for the conditions at the distressed area.

Maintenance/inspection: Protected or repaired areas should be inspected after precipitation events for any damage or displacement of material. Any problem area must be repaired or reinforced as soon as possible.

Design life: Permanent.

Estimated cost: Riprap costs $32.20 per ton (aggregate material cost only).
Figure 3.22. Jetties (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
3.11 LEVEL SPREADER

Figure 3.23. Level spreader installation (Source: William B. Umstead State Park)

Overview

Description: A storm flow outlet device constructed at zero grade across a slope to allow concentrated runoff to empty at a non-erosive velocity onto an area stabilized by existing vegetation.

Problem identification: Runoff at the outlet of diversion ditches must be controlled to prevent sheet erosion as the runoff spreads out and reduces in velocity.

Design purpose: To change storm runoff at the outlet to non-erosive sheet flow.

Associated practices: Used at the terminal end of waterways or diversion structures.

Installation: A transition section 10–20 ft long should be constructed from the width of the channel to the width of the spreader to ensure uniform flow. The transition section will blend the channel grade to zero grade at the beginning of the spreader. The spreader will have the level lip constructed on a 0% grade. The level spreader must be constructed on undisturbed soil. The lip of the spreader should be protected with an erosion-resistant material, such as excelsior matting, to allow vegetation to become established.

Maintenance/inspection: The device should be inspected periodically to ensure the intended purpose is accomplished. Maintain as necessary so that the level spreader functions.

Design life: One year.
3.12 ROCK OUTLET PROTECTION

Overview

Description: A structurally lined apron or other energy dissipating device placed at the outlet of a drainage pipe.

Problem identification: Scour at pipe outlets needs to be prevented and the potential for downstream erosion needs to be reduced by slowing the velocity of concentrated storm water flow.

Design purpose: To reduce the velocity of the flow from the outlet of a pipe before the water enters the receiving channel to reduce erosion and prevent scour.

Associated practices: This condition applies to all pipes and paved channel sections where the outlet’s velocity of flow at design capacity exceeds the velocity of the receiving channel. This method can also be used as way to reduce water energy and velocity in the case of level spreaders.

Installation: Structurally lined aprons at the outlets of pipes and paved channel sections should be designed according to the guidelines found in the SUDAS Design Manual, Chapter 7, Section 7E-18, Rock Outlet Protection.

Maintenance/inspection: Periodic inspection is required. Repair as necessary.

Design life: Temporary or permanent.

Estimated cost: Riprap costs $32.20 per ton.
3.13 RETAINING WALL

Figure 3.25. Retaining Wall (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: A wall constructed to assist in the stabilization of a cut or fill slope, where maximum permissible slopes are not attainable without the use of the wall.

Problem identification: Additional slope reinforcement is needed because of unstable material or space limitations.

Design Purpose: To construct an attractive slope that will provide a safe area below.

Associated practices: Used in areas of unstable soils where earth slides may occur, where the slopes are steeper than the angle of repose, or where the horizontal distance is limited.

Installation: A number of materials are available for stabilizing steep slopes. For the most part, they are permanent in nature. The following materials can make satisfactory walls: concrete masonry, concrete cribbing, gabions, precast stone, reinforced earth, steel piling, stone drywall, rock riprap, and treated wood timbers.

Many factors must be taken into account in the design of a retaining wall. Some of those factors include thickness, stress, foundation design, bearing value of the soil, height of the wall, and drainage. Since each situation requires a specific design, a qualified designer is recommended.

Maintenance/inspection: Inspection is recommended on a monthly basis for the first year and then immediately after a severe precipitation event. Correct problems as soon as possible.

Design life: Permanent.

Estimated cost: Unit costs vary with the surface materials selected.
3.14 STABILIZED CONSTRUCTION ENTRANCE

Figure 3.26. Temporary stabilized construction entrance to construction site (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: A crushed rock- or gravel-stabilized pad located at points of vehicular ingress and egress on a construction site.

Problem identification: Sediment in the form of mud can be transported by vehicles to adjacent public or private property. Steps need to be taken to minimize that transport.

Design purpose: To reduce the amount of mud on vehicle tires before vehicles enter a public road.

Associated practices: Used where traffic leaves a construction site and moves directly onto a public road or other paved or granular surface.

Installation: The entrance should be located to provide for maximum use by all construction vehicles. The aggregate layer must be at least 6 in. thick. The pad must be the full width of the vehicle entrance and exit area. The length of the entrance must be at least 50 ft. If conditions on the site are such that the majority of the mud is not removed when vehicles travel over the aggregate, then vehicle tires should be washed before entering a public road. Wash water should be carried away from the entrance to a settling basin to remove the sediment.

Maintenance/inspection: The condition of the aggregate needs to be monitored daily. The entrance should be maintained in a condition that will prevent tracking or flow of mud onto a public road. Any accumulation of mud must be removed and more aggregate added as needed. This may require top dressing with two-inch stone as conditions demand.

Design life: Varies, based on site conditions and traffic volume.

Estimated cost: Costs vary with aggregate size, source, and transportation charges.
3.15 RIPRAP

Figure 3.27. Riprap (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: A permanent, erosion-resistant ground cover of large, loose, angular stone.

Problem identification: The surface of the soil needs to be protected from the erosive forces of concentrated stormwater runoff.

Design purpose: To provide a protective, non-erosive cover and to slow the velocity of concentrated runoff.

Associated practices: This control measure is used at the outlet of drain pipes, in areas of high velocities and concentrated flow, or where waterway bottoms are eroding. Riprap may also be used as revetment.

Installation: Stone weight is approximately 165 lbs/cu ft. Riprap should be well-bedded in a stable channel bottom for a depth of 1.5 to 3.0 ft, depending on the size of the stone. The channel side slopes shall be prepared to the required lines and grades. Riprap should be placed over filter fabric. The stone shall be hand-placed around structures. The riprap should extend up the slope to the point at which vegetation will provide adequate protection. The stone should be reasonably well-graded.

Maintenance/inspection: Inspect after severe precipitation events and make repairs immediately. In some cases, riprap may be undersized.

Design life: Permanent.

Estimated cost: Riprap costs $32.20 per ton (2004).
Figure 3.28. Use of riprap to protect streambanks and bottoms (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Table 3.2. Size of riprap stones

<table>
<thead>
<tr>
<th>Weight (lbs)</th>
<th>Mean spherical diameter (ft)</th>
<th>Rectangular shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Length (ft)</td>
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</tr>
</tbody>
</table>
3.16 SEDIMENT BARRIER

Figure 3.29. Silt fence sediment barrier (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: Sediment barriers are temporary structures that filter runoff so the water continues while the sediment stays on the site.

Problem identification: Sediment carried by sheet flow should be prevented from leaving the construction site.

Design purpose: To retain the sediment on construction sites of one-half acre or less.

Associated practices: As soon as the vegetation is removed by construction activity, sediment barriers should be used extensively in drainage ditches and waterways.

Installation: All barriers should be placed on the contour. On-slope barriers should be placed no more than 50 ft apart. The most commonly used materials for sediment barriers are sandbags and silt fences.

1. Sandbags: Sandbags should be installed so that the flow under or between bags is minimal. If the height exceeds two bags, anchoring with stakes may be required.
2. Silt fence: A silt fence is designed to allow water to pass through while retaining the sediment on the site. The silt fence should be installed in accordance with the details set forth in this manual.

Maintenance/inspection: Inspect periodically or after each precipitation event. The sediment barrier must be maintained until the project is vegetated or accepted. If the sediment barrier deteriorates to the point at which it loses its effectiveness, it should be replaced.

Design life: Six to nine months.

Estimated cost: Silt fence costs $2.80 per linear ft (2004).
3.17 SEDIMENT BASIN

Figure 3.30. Sediment basin (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)

Overview

Description: A basin created by building a dam across a waterway, excavating a basin, or a combination of both. A sediment basin usually consists of a dam, a pipe outlet, and an emergency spillway. Sediment basins are much larger than sediment traps, serving drainage areas up to 100 acres.

Problem Identification: All surface water runoff from a construction site should have all sediment removed before the water exits the construction site.

Design purpose: To collect runoff in a manner that will allow the sediment to drop to the bottom of the containment device and clear water to exit the site.

Associated practices: A sediment basin is appropriate in critical areas where physical site conditions, construction schedules, or other restrictions prevent the installation of other erosion control measures that would adequately control runoff, erosion, and sedimentation.

Installation: The sediment basin should be located to allow maximum storage for the site, ease of cleanout, and disposal of the trapped sediment. The basin should be located where it will minimize interference with construction activities. When possible, the basin should be located so that storm drains can be diverted into the basin. Basins should be built in existing drainage ditches and constructed before grading begins.

The size of the sediment basin, as measured from the bottom of the basin to the principal spillway, should provide at least 3,600 cu ft of storage per acre of drainage. This provides storage equal to 1 in. of runoff per acre. Likewise, 1,800 cu ft amounts to 1/2 in. of sediment per acre. The basin should be cleaned when the volume of sediment reaches 900 cu ft per acre. At this time, the cleanout shall be performed to restore the original design capacity of the basin. At no time should the sediment level be permitted to build higher than 1 ft below the principal outlet.
The length of a sediment basin should be more than twice the width of the basin. The length is considered to be the distance between the inlet and the outlet.

The principal outlet should consist of a vertical pipe or box-type riser connected to a pipe that extends through the embankment and outlets beyond the downstream toe of the fill. The minimum capacity of the outlet pipe should be 0.2 cfs per acre of drainage area.

It is recommended that a qualified professional designs the sediment basin.

The next installation regulations should be followed:

1. Drainage area to the basin is 10 acres or less.
2. An emergency outlet is required.
3. One anti-seep collar shall be used and placed 25 ft from the riser.
4. Watertight bands should be used.
5. All pipe material should be good quality with no holes.
6. Volume of storage computed as 3,600 cu ft. per acre of drainage area.

**Maintenance/inspection:** Inspect daily for damage caused by rodents or soil erosion. The basin should be maintained until the disturbed areas are protected against erosion by permanent stabilization. The sediment shall be removed when it reaches the cleanout level. The sediment shall be spread on the construction site in such a location that it does not reenter the sediment basin.

When the structure has served its intended purpose and the contributing drainage has been stabilized, the embankment and sediment deposits should be disposed of in an approved method, and the area should be seeded.

**Design Life:** Eighteen months; can be converted to permanent.

**Estimated Cost:** Costs vary with size of the basin and size of dam construction.
3.18 STREAMBANK PROTECTION

Figure 3.31. Streambank protection (Source: International Erosion Control Association)

Overview

Description: A permanent structural control measure to stabilize an eroding streambank.

Problem identification: Special erosion control measures are needed where stream velocities exceed six fps.

Design purpose: To stabilize eroding streambanks permanently.

Associated practices: Streambank protection is often necessary when flow velocities are more than six fps or where vegetative protection is not appropriate. Excessive runoff or construction activities may cause an erosion problem to develop.

Installation: See the Iowa DNR Streambank Erosion Control Manual for details on installing bioengineering or structural methods of control.

Maintenance/inspection: Inspect the stabilized streambank sections after every high-water event. Make any needed repairs immediately to prevent any further damage to the streambank.

Design life: Permanent.

Estimated cost: Costs will vary with method used (from bioengineering to structural sections).
Figure 3.32. Streambank protection measures (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)


3.19 STREAM CHANNEL ENHANCEMENT

![Figure 3.33. Stream channel enhancement (Source: Natural Resources Conservation Service)](image)

**Overview**

*Description:* The use of vegetation to improve the visual qualities of stream channels and banks.

*Problem identification:* Creek channels and banks may have been adversely affected by excess runoff or excavation from construction activities.

*Design purpose:* To protect the streambank from erosion by use of bioengineering techniques and to improve bank aesthetics.

*Associated practices:* Increased storm frequency and excessive runoff may destroy the natural beauty of a stream. With streambank plantings, the area can be enhanced. The protection provided by natural vegetation is also more reliable and effective when the cover consists of natural plant communities adapted to their site.

*Installation:* Four vegetative zones exist along most waterways. They include the aquatic, reed bank, shrub, and tree zones. The aquatic plant zone is difficult to establish artificially. The reed bank plants include reed canary grass, bulrush, and cattail. These deep- and strong-rooted plants tend to bind the soil together. Shrubs provide good bank protection. Willow shrubs are easy to plant and are fast growers. They can be started with cuttings just pushed into the soil, where they will root and grow.

If the area receives a good deal of sun, permanent seeding can be done. A seed mixture containing a high percentage of Kentucky 31 fescue is a desirable grass.
Chapter 3. Structural Erosion Control Measures

**Maintenance/inspection:** Inspect after each high-water event. Streambanks are vulnerable to damage, and repairs are needed periodically. Repair gaps in vegetative cover at once with new plants or cuttings. Trees that become established on the bank should be removed.

**Design life:** Twenty-five years or more.

**Estimated cost:** Costs vary with channel length and initial condition of the channel.
3.20 SUBSURFACE DRAINAGE

Overview

Description: A perforated conduit, such as a pipe, tubing, or tiles, installed beneath the ground to intercept and convey ground water.

Problem identification: Soils may become excessively wet and subject to sloughing.

Design purpose: To remove excess water from the soil.

Associated practices: To remove excessive water that collects during the excavation phase of construction or to improve plant growth by lowering the water table.

Installation: The three types of subsurface drainage systems are sump pit drains, relief drains, and interceptor drains.

1. A sump pit drain consists of one or more pits to intercept ground water. The pit is dug so that the bottom is 12 in. lower than the depth that needs to be dewatered. A perforated vertical standpipe is placed in the center of the pit, which is backfilled with 2 in. rock or gravel. The water is pumped from the center of the pipe to a suitable discharge area.

2. Relief drains are used to lower the water table or to remove surface water. They are installed along a slope and drain in the direction of the slope. They can be installed in a gridiron pattern, a herringbone pattern, or a random pattern. Relief drains should be located through the center of the wet areas. This system is similar to agricultural systems. Gravity outlets must be provided for relief drains.

3. Interceptor drains remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. Interceptor drains should be located on the uphill side of the wet areas. The drains should be installed across the slope and drain to the side of the slope. Gravity outlets must be provided for interceptor drains.

Maintenance/inspection: Inspect outlets monthly to ensure they are not plugged, and unplug if necessary. Repair any erosion that may be present.
Design life: Sump pit: For the life of the project construction.
Relief drains: Permanent.
Interceptor drains: Permanent.

Estimated Cost: Unit cost varies with drainage layout, depth of placement, material selection, installation method, and outlet control selection.

Figure 3.35. Subsurface drainage patterns (Source: Department of Civil, Construction, and Environmental Engineering, Iowa State University)
3.21 DIVERSION STRUCTURE

Overview

Description: An excavated swale, berm, or combination of the two, constructed in such a manner as to direct water to a desired location or temporarily divert water around an area that is under construction or is being stabilized. Specific applications include perimeter control, diversion away from disturbed slopes, and diversion of sediment-laden water to treatment facilities. This is accomplished by constructing a swale and/or berm at the top of the slope, and conveying it to a letdown structure or stable outlet. On long slopes, diversion structures can be placed at regular intervals to trap and divert sheet flow before it concentrates and causes rill and gully erosion.

Problem identification: During construction, it is often necessary to divert upstream waters around the construction site, thereby reducing the erosion potential. Clean water passing through the site needs to be separated from the sediment-laden water, thus reducing the required size of the sediment removal structure at the downstream end of the construction site.

Diversion structures are also needed to keep upstream water off disturbed slopes or to carry water down the slope without attracting sediment.

Design purpose: To intercept surface and shallow subsurface flows and divert this water away from disturbed areas, active gullies, and critically eroding areas. Diversion structures can also be constructed along slopes to reduce the slope length, intercepting and carrying runoff to a stable outlet point or letdown structure.

The advantages of diversion structures include the following:
- Reduces the volume of flow across disturbed areas, thereby reducing the potential for erosion
- Breaks up the concentration of water on long slopes
- Allows sediment basins and traps to function efficiently by maintaining a separation between clean water and sediment-laden water
- Easily constructed with equipment found on most construction sites

The limitations of diversion structures include the following:
- High flow velocities can cause erosion in the diversion structure
- Diversion structures must be stabilized immediately after installation

Associated practices: Used with slope drains.

Installation: Diversion structures should be used around the perimeter of sites to prevent run-on of offsite flows over disturbed ground. If diversion structures are constructed during times when vegetation cannot be established to stabilize the surface, alternative stabilization methods such as sodding or matting may be required.

Each structure should be designed to carry peak flows from the 2-year, 24-hour storm. The maximum drainage area conveyed through a diversion structure should be 5 acres. The depth of the diversion should be based on the design capacity plus an additional 4 in. of freeboard. The minimum depth provided should be 18 inches. This may be provided solely by a berm or swale.
or may be developed with a combination of berm and swale. The shape of the diversion may be
parabolic, trapezoidal, or V-shaped, with side slopes of 2:1 or flatter.

The allowable velocity within the diversion structure is based on the soil characteristics of the
site. Silty and sandy soils are more prone to erosion than clay soils. However, with the proper
design and stabilization methods, diversion structures may be used in all appropriate locations.

The minimum slope of the diversion structure should be sufficient to carry the design flow. The
maximum slope of the diversion is limited by the permissible velocities of flows within the
structure, as shown in Table 3.3. Since any stabilizing vegetation will likely be destroyed upon
construction of the diversion structure, the bare surface situation should be considered for most
applications.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Permissible velocity, fps for varying channel vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand, silt, sandy loam, and silty loam</td>
<td>Bare 1.5, Poor 1.5, Fair 2.0, Good 3.0</td>
</tr>
<tr>
<td>Sandy clay and sandy clay loam</td>
<td>Bare 2.0, Poor 2.5, Fair 3.0, Good 4.0</td>
</tr>
<tr>
<td>Clay</td>
<td>Bare 2.5, Poor 3.0, Fair 4.0, Good 5.0</td>
</tr>
</tbody>
</table>

After construction of the diversion structure, it is important to stabilize the surface immediately
with seed and mulch, sod, or other materials.

**Maintenance/inspection:** Inspect every seven days and after any one-half in. or greater rainfall.
Any damage to the vegetated lining should be repaired. All debris should be removed and
properly disposed of to provide adequate flow conveyance.

**Design life:** One year.

**Estimated cost:** Cost varies with the length and sizing of the diversion structures.