FDM 10-10-1 Devices and Measures Available

April 27, 2011

1.1 Introduction

Various geometric measures can be implemented to minimize erosion and sediment loss. Erosion control during construction is dependent on the timely installation of the temporary and permanent devices. By placing sod, mulch, and seed promptly as the project progresses, the length of time that areas are left unprotected and the amount of area exposed is reduced.

Erosion control devices such as vegetation or erosion mat hold the soil in place and act as protective covers shielding the soil from wind and water forces. Sediment control devices such as erosion bails, silt fences, sediment traps and basins, trap sediment only after the soil has eroded. A combination of both sediment and erosion control devices should be used when designing an effective erosion control plan.

Temporary devices must be used during construction to contain and control erosion until the permanent measures are firmly established. This includes sufficient measures to carry the project through the winter and the spring-thaw season.

In general, control measures can be categorized into three areas of effort:

1. Erosion control
2. Sediment control
3. Runoff diversion

1.2 Devices Available

1.2.1 Erosion Control Devices

Erosion control devices provide direct protection to the soil surface therefore, are considered one the best measures for preventing erosion. They blanket the soil, protecting it from wind and water forces. The devices include ground covers and channel liners such as:

1. Vegetation (see FDM 10-10-3, FDM 10-10-6, FDM 10-10-8, FDM 10-10-9 and FDM 10-10-10).
2. Mulch (see FDM 10-10-13).
3. Erosion mat (see FDM 10-10-15).
4. Riprap (see FDM 10-10-19).

Vegetation is the most cost-effective form of erosion control. In addition, vegetation helps to improve water quality by helping to slow down the velocity of runoff, thereby, removing sediment particles. Methods for quickly revegetating exposed soils include using temporary seed, permanent seed and sod. Where possible, existing vegetation should be preserved.

Using vegetation to stabilize the soil will be effective only if the site is stable and engineered properly (see FDM 10-5-25). Other devices may be needed to initially stabilize the soil until vegetation becomes established. Therefore, designers should become familiar with these other devices and how they should be used.

1.2.2 Sediment Control Devices

Sediment control devices help remove sediment by filtering or slowing the velocity of the sediment laden water to such an extent that it can no longer keep the particles in suspension. Examples of sediment control devices include:

1. Temporary Ditch Checks (see FDM 10-10-22 and SDD 8E8).
2. Silt fence (see FDM 10-10-23 and SDD 8E9).
3. Stone or rock ditch checks (see FDM 10-10-25).
4. Sediment traps and basins (see FDM 10-10-51).

Sediment traps and basins, when designed properly, are one of the most effective measures for trapping sediment and improving water quality. When possible, designers should try to incorporate them into their project.

1.2.3 Runoff Diversion Devices

Runoff diversion devices are used to keep off-site runoff from entering a construction area or to redirect on-site runoff to an acceptable area. Examples of such devices are listed below.

1. Channels/ditches (see FDM 10-5-25, FDM 10-5-30 and FDM 13-30.
2. Diversion dikes/intercepting embankments (see FDM 10-10-37).
3. Slope drains (see FDM 10-10-57).
4. Flumes (see FDM 10-10-57).

These devices are typically used in combination, such as the use of intercepting embankments with slope drains or sod flumes to divert sheet runoff. They are considered to be very economical. Once diverted, the sediment-laden runoff should be discharged to a safe outlet structure, energy dissipation device and/or sediment trapping facility.

1.3 Devices Required on All Grading Projects

To help avoid change orders and give the construction project engineer the necessary bid items to address ever changing field conditions, the following seven bid items are required on all grading projects unless deemed inappropriate.

1. Temporary seed (see FDM 10-10-6).
2. Permanent seed (see FDM 10-10-6).
3. Fertilizer (see FDM 10-10-12).
4. Mulch (see FDM 10-10-13)
5. Erosion mat (see FDM 10-10-15)
6. Temporary ditch checks (see FDM 10-10-22)
7. Silt Fence (see FDM 10-10-23)
8. Soil Stabilizer Type B (see FDM 10-10-47)
9. Erosion Control Mobilizations
10. Emergency Erosion Control Mobilizations

Note: Sod was not included in the above list due to problems with adaptability on certain soil types. Use as appropriate.

1.4 Temporary vs. Permanent Measures

1.4.1 Temporary Measures

Many of the erosion and sediment control devices are used as temporary measures until permanent protection is firmly established. Due to their high potential for erosion during construction, temporary erosion protection is of particular concern for projects with the following characteristics:

1. In steep rolling topography.
2. Where most of the drainage from the highway construction limits enters directly into streams, lakes, ponds, water courses and adjacent land.
3. With highly erosive soils.

Ground covers are one of the best measures for preventing erosion. Temporary ground covers frequently used are vegetation, mulch, or a combination of the two. They are generally used:

1. On disturbed areas that are not to final grade and will be exposed for a period of time.
2. In areas where seasonal limitations or a delay in final construction preclude permanent seeding.

A common type of temporary vegetative cover is a combination of a quick growing native grass such as rye, with a straw or hay mulch to provide protection to the surface and seeds until the permanent vegetation is established (see FDM 10-10-6). In some instances, a heavy application of mulch such as wood chips, wood fibers, or cellulose is used in conjunction with the seeding as a temporary protective cover. To be effective, these ground covers must be routinely inspected to ensure that they are functional and in good repair.

In order for temporary erosion control items to be successful, they must be available in adequate quantities and must be used in a timely manner. When determining adequate quantities, designers should include an extra amount, known as an "undistributed quantity", to each of the devices. Undistributed quantities should be provided for use by the contractor as directed by the engineer. This undistributed quantity is usually 25% of the total bid item quantity.

1.4.2 Permanent Measures

Permanent control measures are those design features that are incorporated into a project to reduce long-term sediment yield. They include, but are not limited to:

1. Vegetation (see FDM 10-10-3, FDM 10-10-6 and FDM 10-10-9).
2. Special slope designs such as benching (see FDM 10-10-39).
3. Geometric features such as rounding and blending with the natural terrain (see FDM 10-5-25).
4. Special channel linings such as riprap or the higher classes of erosion mat (see FDM 10-10-19, FDM 10-10-15).
5. Subsurface drains to intercept groundwater (see FDM 10-10-33).

Timely implementation of permanent measures may reduce or eliminate the need for temporary actions.

Attachment 1.1 is a summary of advantages and disadvantages of various erosion control measures addressed in this section. Attachment 1.2 is a list of applications for these devices. Attachment 1.3 is an example of how a combination of erosion control measures can work together.

LIST OF ATTACHMENTS

Attachment 1.1	Erosion Control Measures
Attachment 1.2	Summary of Control Measure Applications
Attachment 1.3	Example of Selected Control Measures Used in Combination

FDM 10-10-3 Vegetation

May 15, 2019

Vegetation is the most cost-effective form of erosion control and includes items such as grass, legumes, grains, trees, shrubs and flowers. Since effective erosion control is a form of risk management, to reduce that risk it is important to make every effort to revegetate sites as quickly as possible. Where possible, existing vegetation should be preserved.

Since vegetation helps prevent erosion, it is considered an erosion control device as opposed to a sediment control device. Vegetation reduces erosion by:

1. Having an extensive root system that binds the soil particles together with the roots;
2. Reducing runoff by increasing water infiltration into the soil;
3. Transpiring water back into the atmosphere, thereby reducing the possibility for over saturation of the soil;
4. Absorbing the energy from falling rain;
5. Decreasing runoff velocities.

Using vegetation to stabilize the soil will be effective only if the site is engineered properly (see FDM 10-5-25) and if atmospheric conditions (temperature, moisture, sunlight) will support growth.

Embankment slopes adjacent to streams, rivers, etc., should be adequately protected against erosion. Where practical, a protective buffer of undisturbed vegetative cover should be left or established between the highway embankment and adjacent watercourse along with other erosion control measures or devices as necessary.

In the absence of adequate rainfall, watering is needed until a good root system develops.

FDM 10-10-6 Seeding

May 15, 2019

6.1 Definition

Seeding is the establishment of vegetative cover on disturbed areas by planting seed.

6.1.1 Temporary Seed

Temporary seeding is the establishment of a temporary vegetative cover on disturbed areas by seeding with an annual herbaceous plant, which is quick to germinate.

6.1.2 Permanent Seed

Permanent seeding is the establishment of a perennial vegetative cover; this cover can include grasses and forbs.

6.1.3 Native Seed

Native seeding is the establishment of permanent vegetative cover using seeds of species that are native to the region, thus are more adapted to the regional growing conditions. Native plants tend to have much stronger, deeper and more fibrous root systems that help hold the topsoil and subsoil in place and allow better percolation of water into the soil.

6.1.4 Borrow Pit Seed

Borrow pit seeding is the establishment of perennial vegetative cover on areas that have been used as borrow or waste sites on grading projects.

6.1.5 Dormant Seed

Dormant seeding is a method of seeding using any non-native seed mix where the seed is applied when soil temperatures will remain consistently below 53 degrees Fahrenheit. The seed will not germinate until the soil temperatures rise in the spring. This method does not provide immediate erosion protection but does prepare the seed to germinate in the spring.

6.2 Application

6.2.1 Temporary Seeding:

1. Disturbed areas that will not have construction activity for more than 14 days.
2. Other disturbed areas where quick vegetation is desired such as sides of sediment basins, temporary road banks, intercepting embankments, stockpiles, etc.

6.2.2 Permanent Seeding:

1. Disturbed areas where permanent, long-lived vegetation cover is needed to stabilize the soil.
2. Rough-graded areas that will not be brought to final grade for a year or more.

6.2.3 Native Seeding:

1. The soils would benefit from a deeper root structure.
2. Native vegetation is requested for aesthetic purposes.
3. Adjacent land has an existing native vegetative stand.
4. Is required as part of the environmental documentation process.

6.2.4 Borrow Pit Seeding:

1. Disturbed areas including the borrow pits and the haul routes for the borrow location.
2. Material disposal sites and the haul routes for the disposal site.

6.3 Design Guidance

6.3.1 Temporary Seeding

Measured quantities should be included for temporary applications even though it is more difficult to estimate since it depends on the contractor's methods and schedule of operations. Designers should communicate with other sections if necessary and use their engineering judgment and/or experience to estimate this temporary seeding quantity as it will vary depending on the length of the contract and project conditions. Seeding rates can be found in section 630 of the standard specifications.

In addition to measured quantities, undistributed quantities should also be called for in the plan to aid in unforeseen circumstances. A rule of thumb in estimating the undistributed quantity is to add approximately 25% of the calculated temporary seeding quantity to use as the undistributed amount (small quantities may require larger percentages).

Temporary seeding should be fertilized and mulched. Designers should refer to FDM 10-10-12 to determine the type of fertilizer to be used. Depending on the site conditions, erosion mat may be needed instead of mulch (see FDM 10-5-35).

In the absence of adequate rainfall (approximately 1-inch per week), watering may be needed until a good root system develops.

The temporary seed mixes can be found in Standard Spec 630.

6.3.2 Permanent Seeding

Permanent seeding should be included on all projects where exposed soils are expected, or revegetation is required.

In addition to measured quantities, undistributed quantities of permanent seed should also be called for in the plan to aid in unforeseen circumstances. A rule of thumb in estimating the undistributed quantity is to take approximately 25% of the calculated permanent seeding quantity to use as the undistributed amount (small quantities may require larger percentages).

The use of salt tolerant seed or sod should be considered in urban median areas, between the curb and the sidewalk and within the first 5 feet behind the curb, especially if the outer lane is a traffic lane on a high volume rural roadway. The designer should contact WisDOT's landscape architect (see FDM 27-1-1 for contact information) for guidance.

Permanent seeding should be fertilized, mulched, and watered as necessary. Designers should refer to FDM 10-10-12 to determine the type of fertilizer to use. Depending on the site conditions, other erosion control devices such as soil stabilizer or erosion mat may be needed in place of mulch (see FDM 10-5-35).

Proper preparation and maintenance of the seedbed is needed to help ensure germination. Special preparation may be desired for areas where lawn type turf is to be established. For more guidance refer to Standard Specifications and FDM 10-10-11.

In the absence of adequate rainfall (approximately 1-inch per week), watering is needed until a good root system develops.

Though wildflowers are desirable in erosion control seed mixes, they do not develop as fast or initially provide as much soil protection as grasses. They should not be used on steep slopes or where grass seed and fertilizer application is heavy, as this will promote grass competition. Since special care needs to be taken to ensure their growth, the designer should contact WisDOT's landscape architect for additional guidance. Also, refer to FDM 27-25-15.

Permanent seed mixes and their appropriate uses can be found in WisDOT’s Standard Specifications for Highway and Structure Construction, section 630. If a specialty mix is required/desired the WisDOT landscape architect can assist in developing one.

6.3.3 Native Seeding

Native seed can offer a more sustainable vegetative cover than other non-native permanent seed mixtures due to their much deeper root structures. They should be specified in areas not subject to routine mowing.

Seed mixtures 75 and 80 should be specified where a cost-effective mixture of natives is desirable for erosion control. These mixtures contain native grasses only.

Seed mixtures 70 and 70A should be specified in areas where it is desirable to incorporate wild flowers into the mix, however keep in mind that these mixtures are much more costly and should be specified only where conditions warrant.

Consult with the Regional Stormwater Engineer or department landscape architect before specifying the native seed mixtures. There is an established period associated with native seed mixes, refer to the Standard Specifications for Highway and Structure Construction for timelines.

Also refer to FDM Chapter 27 Planting and Aesthetic Design for further guidance.

6.3.4 Borrow Pit Seeding

Borrow pit seeding should be included on all grading projects having borrow or waste as a bid item. The designer should incorporate sufficient quantities of borrow pit seed mixtures to cover the approximate area anticipated.

In addition to measured quantities, undistributed quantities of permanent borrow pit seed should also be called for in the plan to aid in unforeseen circumstances. A rule of thumb in estimating the undistributed quantity is to take approximately 25% of the calculated permanent seeding quantity to use as the undistributed amount (small quantities may require larger percentages).

Borrow pit seeding should be fertilized and mulched. Designers should refer to FDM 10-10-12 to determine the type of Fertilizer to be used. Depending on the site conditions, other erosion control devices such as soil stabilizer or erosion mat may be needed in place of mulch (see FDM 10-5-35).

FDM 10-10-8 Water

May 15, 2019

8.1 Definition

Water can be used as an erosion control bid item to help maintain or establish vegetation.

8.2 Application

Application of water should be considered on all areas that utilize seed or sod. Consider factors such as watering equipment accessibility especially in sensitive areas, typical material and equipment storage locations such as on bridge projects which can preclude access, height of slopes (how far the water can be sprayed), etc., in the use of this item.

8.3 Design Guidance

Water is used in the compaction of embankments, base aggregates and controlling dust. Include the bid item for water (item 624.0100 Water) when these tasks are anticipated. Refer to FDM 14-5-1.1 for guidance on including water when placing base aggregates. For additional information on dust control, refer to FDM 10-10-41. Also, “Watering Plant Materials” is used in the standard specifications to describe watering of plants such as trees and is incidental to the plant bid item.

To properly estimate and bid other erosion control watering items, with different types of equipment and operator hours, it is necessary to use bid items unique to the given type of watering.

8.3.1 Seed Water

The bid item “Seed Water” should be included on all projects that have a seed bid item. Sufficient quantity of water should be included to maintain soil moisture for 30 days after the seed has germinated.

8.3.2 Sod Water

Watering sod is incidental to the item of “sod” for a period of 30 days if the contract does not include the bid item “631.0300 Sod Water”. If the project is in a sandy area it may be desirable to water sod for longer than the required 30 days by including the “Sod Water” bid item. Note that if this item is included it will cover payment for all sod watering, including the first 30 days.

8.4 Estimating Quantities

For estimating the quantity of water for either sod or seeded areas, provide the equivalent of one inch of rain per week for 2 to 4 weeks depending upon the time of year that the work will be ongoing. Use 2 weeks as a minimum for spring and fall, and 4 weeks for the summer. Since designers often are unable to determine exact letting dates or when this work will be done, error on the safe side if unsure. The construction project manager can adjust as necessary to meet varying construction schedules or weather conditions.

The following is an example that can be used to calculate quantities of Seed or Sod Water;

- $Quantity\ of\ Seeded\ Area\ (SY)\ X\ 1\ \frac{inch}{week}\ X\ \frac{0.0278\ yard}{1\ inch} = \frac{XX\ CY\ Water}{1\ Week}$
- $\frac{XX\ CY\ Water}{1\ Week}\ X\ \frac{201.97\ Gal}{1\ CY}\ X\ \frac{1\ Mgal}{1000\ Gal} = \frac{XX\ Mgal}{1\ Week}$
- $\frac{XX\ Mgal}{1\ Week}\ X\ \#\ of\ weeks = XXX\ Mgal\ Water$

FDM 10-10-9 Sodding

April 27, 2011

9.1 Definition

Sod is a thin cut layer of grass-covered topsoil that is held together by matted roots and used to stabilize fine graded disturbed areas.

9.2 Application

Conditions where sod is generally used are:

1. In urban or suburban settings for boulevard or terrace areas, or adjacent to residential or commercial

lawns where quick use is desired.

2. In disturbed areas requiring immediate vegetative cover, or where sod is preferred to other means of grass establishment.
3. Sod reinforced with Class II Type A (jute) erosion mat may be used in:
   - Channels with intermittent flows.
   - Behind inlet grates.
   - At culvert inlets and outlets.

9.3 Design Guidance

1. The use of sod should generally be limited to urban or suburban areas where an immediate turf cover and an aesthetic appearance are desired. It is generally more costly compared to other means of vegetative cover.
2. Requires additional maintenance effort to establish and maintain growth by the contractor, adjacent property owner, or municipality.
3. Requires additional effort and cost to repair areas that do not establish.
4. Sod is usually limited in the blends of turf grass that it is comprised of and can be more susceptible to disease.

Sod for special purposes, such as salt tolerant sod, or upland sod is available in some areas and may be an alternate to what is normally used. The use of salt tolerant sod should be considered in urban median areas, between the curb and sidewalk or within the first 5 feet behind the curb, especially if the outer lane is a traffic lane on a high-volume roadway. Upland sod may be desirable in rural sandy applications as it is more drought tolerant. Designers should contact WisDOT's landscape architect (refer to FDM 27-1-1 for contact information) for guidance.

In addition to measured quantities, undistributed quantities should also be called for in the plan to aid in unforeseen circumstances. Since measured quantities should be relatively well defined for urban and suburban areas, the undisturbed amount can normally be limited to 5 - 10% of the computed sod quantity. For example, given a sod quantity of 2000 yd2, at 10%, the undistributed quantity would be 200 yd2, for a total of 2200 yd2.

Sod requires fertilizer but not mulch. Designers should see FDM 10-10-12 for the recommended fertilizer type given the project's soil conditions.

When necessary, sod may need to be reinforced with Class II Type A (jute) erosion mat (see FDM 10-5-35). Lightweight plastic netting should be avoided for use over sod since it increases the risk of small animals being caught and causes damage to maintenance equipment.

Proper ground preparation and maintenance are needed to ensure that the sod will be firmly rooted in the soil. Until such time that a good root system becomes developed, watering should be required for a specified period of days (20 to 30 days suggested) to maintain moist soil. Watering may be the responsibility of the contractor, property owner, or municipality. Designers need to ensure, through bid items, public involvements, or project agreements, that the proper entity is fully aware of that responsibility.

9.4 Limitations

Sod requires more maintenance to establish than seeded areas due to its need for water during the establishment period when the roots are going down into the topsoil. It is also more susceptible to winter damage the first year. The designer should ensure that sodded areas will be adequately maintained through the use of public involvement or project agreements.

FDM 10-10-10 Mowing *April 27, 2011*

10.1 Definition

Mowing vegetation is a method used to help establish dense permanent vegetation and control invasive plant species.

10.2 Application

Applicable for larger projects where mowing can be accomplished in stages under contract or for other projects where invasive species are present on the areas to be striped for salvaged topsoil.

10.3 Design Guidance

Mowing can aid in the establishment of desirable turf species along roadways by cutting the initial growth of temporary grain seed “nurse crop” vegetation that has served to protect the permanent seed during germination but can overly shade that permanent growth if not cut.

Mowing also helps control invasive plant species that germinate on projects from the existing seed bank found in the salvaged topsoil. The designer, with assistance from the environmental coordinator or landscape architect, should asses the existing vegetation in areas that will be striped for salvaged topsoil. Where that vegetation contains a high percentage of invasives, including a bid item for mowing may be desirable.

If mowing is determined to be used on the project, it is necessary to use a special provision and bid item. Mowing height should be specified as between 6 and 8 inches.

10.4 Considerations

Consider factors such as the duration of the project and if the slopes may be too steep on parts of the project for mowing equipment to safely reach.

10.5 Estimating Quantities

To estimate the quantity for mowing, use the quantities obtained for topsoil, or salvaged topsoil, and adjust for areas where access to steep slopes is a factor.

FDM 10-10-11 Topsoil *April 27, 2011*

11.1 Definition

Topsoiling is a method of preserving and using the surface layer of undisturbed soil, often enriched in organic matter, to obtain a more desirable planting and growth medium. It should be noted that for purposes of this subject, topsoiling refers to the bid items of Topsoil or Salvaged Topsoil.

11.2 Application

In areas where permanent vegetation is to be established, WisDOT requires topsoil on all disturbed areas unless other protective measures, such as riprap or other hand non-erodible surfaces are specified. Compost incorporated with subsoil may be utilized as a substitute for topsoil.

11.3 Design Considerations

Topsoil is the surface layer of the soil profile, generally characterized as being darker than the subsoil due to the presence of organic matter. It is the major zone of root development, carrying much of the nutrients available to plants, and supplying a large share of the water used by plants.

If topsoiling is to be done, the following items should be considered:

1. Salvage native topsoil to the extent possible since topsoil is a natural resource. Designers should consult the soils report for existing topsoil depths.
2. Determine if there is there an adequate volume of native topsoil on the site. Topsoil should be spread to a minimum depth of 4 inches in rural areas and a minimum depth of 6 inches in urban areas.
3. Preliminary underground utility work may impact available salvageable topsoil, thereby increasing the need for the use of the “topsoil” bid item.
4. By supporting vegetation topsoil can be used to help improve water quality and reduce the amount of runoff. Topsoil should not be wasted if possible. Where excess topsoil exists, designers should discuss possible uses with the stormwater or soils engineer. Unless otherwise specified in the special provisions, excess topsoil can be used by the contractor in the outer fill slopes of the roadway or disposed of as waste.
5. Consider agricultural limestone for soils having a low pH level. Check the soils report or consult with the Regional stormwater engineer or Department landscape architect regarding the pH level and limestone application rates.
6. In areas where a lawn type turf is desired, it may be beneficial to include special provisions to enhance the topsoil preparation requirements.

FDM 10-10-12 Fertilizer
April 27, 2011

12.1 Definition

Fertilizing is a method of adding nutrients to established vegetation or to a prepared seed bed, or sod bed, to aid in the establishment of vegetation. Generally, WisDOT only applies fertilizer during the initial seed/sod bed preparation and establishment.

12.2 Application

In areas where permanent vegetation is to be established, WisDOT uses fertilizer on all disturbed areas in conjunction with permanent seeding. Follow section 629 of the Standard Specifications for Highway and Structure Construction for application methods and rates.

To minimize nutrient entry into surface and groundwater resources it is important to follow proper application methods and guideline

12.3 Design Considerations

WisDOT uses two types of fertilizer, Type A and Type B. They differ by the amount of potash included and should be specified based on the soil region in which the project is located and a soil test. Consult the regional soils engineer to determine the project soil type and in turn the recommended fertilizer type.

1. Consider agricultural limestone for soils having a low pH level. Check the soils report or consult with the regional soils engineer regarding the pH level and limestone application rates.
2. In areas where a lawn type turf is to be established or next to sensitive areas where the resulting runoff could add nutrients to waterways, it may be beneficial to include special provisions to utilize a slow release turf type fertilizer.
3. Consider using a phosphorous free fertilizer alternative where restricted by local ordinance, unless soil testing indicates otherwise.
4. Do not apply fertilizer to saturated soils, wetlands, surface waters, frozen ground, or impervious surfaces.
5. Do not apply fertilizer within 20 feet of a water body or wetland.
6. Do not apply fertilizer when a runoff event is expected within 24 hours.

FDM 10-10-13 Mulching
April 27, 2011

13.1 Definition

Mulch is a degradable, protective ground cover usually composed of straw, hay, woodchips, or wood fibers. It is used in conjunction with seeding to prevent erosion by protecting the soil surface from raindrop impact. In addition, it helps to foster the growth of vegetation by increasing available moisture and providing insulation against extreme heat and cold.

13.2 Application

Mulch should be applied:

1. To all disturbed areas, unless another cover such as erosion mat is used, including borrow pits and waste areas, which are seeded with either temporary or permanent seed. Seeded areas should be mulched immediately following seeding.
2. In areas that cannot be seeded because it is too late or early in the season mulch may be able to provide some protection to the soil surface depending on the site conditions (see FDM 10-5-35). The application of a Soil Stabilizer Type B along with mulch is recommended for late season stabilization (see FDM 10-10-47). If applicable, organic mulch should be used and the area over seeded as soon as weather or seasonal conditions permit, or dormant seeded if it is past the germination date.
3. Together with plantings of trees, shrubs, or certain ground covers which do not provide adequate soil stabilization by themselves.
4. At the recommended rates per the specifications.

13.3 Design Considerations

Mulches are applied to the soil surface to prevent erosion and to promote plant growth. Surface mulch can be one of the most effective means of controlling runoff and erosion on disturbed land.

Mulches can increase the infiltration rate of the soil, reduce soil moisture loss by evaporation, prevent crusting and sealing of the soil surface, modify soil temperatures, and provide a suitable microclimate for seed germination. Organic mulch materials have been found to be the most effective.

The choice of materials for mulching depends on site conditions, season and economics. It is especially important to mulch liberally in mid-summer and prior to winter, and on steep slopes and southern slope exposures.

If wood chips, wood fibers or similar materials are used for mulching, treat areas with one pound of available nitrogen per 1000sf either before or after applying the mulch, because decomposing wood fiber uses and thereby decreases available nitrogen in the soil.

Certified weed seed free mulch is available but should be reserved for mulching next to native areas due to cost. The certification is through the Wisconsin Crop Improvement Association. When used this should be a separate bid item.

The use of mulch behind curb and gutter areas is not recommended when adjacent to live traffic lanes due to turbulence from the traffic that displaces the mulch. Consider the use of erosion mat or sod as an alternative.

There are three approved methods of anchoring mulch; netting, tacking, and crimping. These are at the option of the contractor unless otherwise specified. Details can be found in Chapter 627 of the Standard Specifications for Highway and Structure Construction.

Tackifiers are used to bind organic mulches together to prevent displacement. They are generally spray applied and act like glue over the mulch, holding it in place. In areas where lawn type turf will be established, the use of tackifiers is the preferred anchoring method and should be specified. Crimping will tend to leave an uneven surface and plastic netting can become entangled in mowing equipment.

Crimping the mulch into the soil is the most common method chosen by contractors. It is done with a pull behind crimper that looks like a disc with teeth and crimps the mulch to a depth of at least 1 ½ inches.

Placing netting, like erosion mat netting, over the mulch is the least common method chosen.

FDM 10-10-15 Erosion Mat *April 27, 2011*

15.1 Definition

Erosion mat is a general term for any rolled protective soil covering mat or soil retention blanket that is installed on a prepared planting area of a slope, channel or shoreline. Erosion mats are made from straw, wood, coconut, or synthetic fibers, and are held together by plastic or biodegradable netting on one or both sides, and/or stitched together. They have varying life spans depending upon the type of fiber used.

An "Erosion Control Revegetative Mat" **(**ECRM), is a blanket-like covering laid on top of a prepared seed bed to protect the soil and seed from the erosive forces of nature.

A "Turf Reinforcement Mat" (TRM), helps to permanently stabilize the soil by acting as reinforcement for the roots of the vegetation. This open-weaved, synthetic mat is installed on top of soil and then filled with topsoil and seeded. As the vegetation grows, the roots intertwine into the mat, "reinforcing the turf." In vegetated channels, this reinforcement helps to raise the channel's maximum permissible shear stress.

In addition to this procedure, designers should refer to FDM 10-5-35 and Chapter 13 for further guidance on placement and design considerations.

15.2 Application

Many of the permanent erosion mats are cost effective when compared with structural channel lining. For slope protection applications, erosion mats are excellent in preventing the loss of topsoil, thereby reducing surface erosion and promoting a rapid establishment of permanent grass cover on cut or fill slopes.

Conditions warranting the application of erosion mat are:

1. On vegetated channels where additional reinforcement is necessary. See FDM 10-5 Attachment 35.1.
2. On steep slopes or roadway embankments where the erosion potential is high, and planting is likely to be too slow in providing adequate protective cover. Erosion mat should be considered to help stabilize and revegetate sensitive slopes steeper than 3:1. See FDM 10-5 Attachment 35.2.
3. On stream banks or channels where moving water is likely to wash out new plantings. Refer to Chapter 13 and consult with the Hydraulic, Stormwater or Soils Engineer when designing for these conditions.

4. In areas where the forces of wind or traffic turbulence prevent standard mulching practices from remaining in place until vegetation becomes established.

5. Whenever typical revegetation measures do not provide the desired degree of erosion control or revegetation emphasis.

6. As an alternative to slope paving or structural channel linings. Note: With the exception of bridge applications, slope paving and paved channels are not recommended since they promote rapid runoff, are prone to undermining and are susceptible to frost heave.

See FDM 10-15 Attachment 5.10 and FDM 10-15 Attachment 5.11 for illustrations of the proper application of erosion mat.

15.3 Design Guidance

Erosion mats should be selected so that they last long enough for the grass or other vegetation to become densely established.

Use Urban grade erosion mats in locations where shortly mowed turf or lawn grasses are to be established. These mats do not have plastic netting that can wrap around the blades of lawn mowers, or snag in the shoes and trip pedestrians.

Consider using Class I Urban Type A, Class I Urban Type B, or Class II Type C mats in or next to sensitive areas where the plastic netting on other categories of mat may trap small animals, snakes, or frogs. Select the type based on calculated shear values. Since Class II Type C mats tend to be expensive, they should only be specified for environmentally sensitive areas where Class I Urban mats do not have sufficient shear values for the site.

Class III mats may be appropriate as a replacement for riprap as a channel liner especially in areas where infiltration is desired or there are clear zone concerns. Check the shear stress criteria for the channel to determine mat applicability.

It may be difficult to establish permanent vegetation and adequate erosion protection in a channel with continuous flow. Consider using riprap, articulated concrete blocks (ACB's), or wetland species with a coconut or synthetic ECRM.

Because of the variety of erosion mats available on the market, installation varies depending on the mat used. As per the Product Acceptability List, prior to actual installation of the mats, contractors will be required to provide the construction project engineer with one full set of the manufacturer's literature and installation instructions for each erosion mat product selected. This information will be used to verify conformance with the Department's approved materials list and for use by the construction erosion control inspector.

For channels not conforming to the typical section showed in FDM 10-5 Attachment 35.1 or those having a depth of flow greater than 6 inches the designer must compare the CALCULATED MAXIMUM SHEAR STRESS of their channel to the PERMISSIBLE SHEAR STRESS of the erosion mat. See FDM 10-5-40 for the Procedure and an example of its application.

If the calculated maximum shear stress exceeds the permissible shear stress of the mat being considered, the design should be adjusted. This may involve one or more of the following:

1. Specify a higher class or type of erosion mat.

2. Modify the channel's cross section, e.g., widen the ditch bottom to decrease the depth of flow.

3. Choose another device such as riprap or articulated concrete block.

Once vegetation is established, the permissible shear stress of the channel increases. Engineering judgment should be used based on the sensitivity of the area prior to vegetation establishment as well as long term performance requirements.

When erosion mat is the desired alternative for flexible channel lining and the calculated maximum shear stress is greater than 5.0 lbs/ft2, the designer should contact the regional erosion control specialist, stormwater or drainage engineer to assist in the design. FDM 19-1-5 should be used to specify the product in a special provision. With high stress values, there is no substitute for a thorough understanding of the manufacturer's instructions and recommendations. In addition, a site visit by the designer, soils engineer, and manufacturer is recommended to verify the product's appropriateness.

Caution: Even though the calculated shear stress may be less than the permissible shear stress, designers should still use their engineering judgment to decide whether the mat is appropriate given their project-specific conditions. For example, if the calculated shear stress value falls just under the permissible shear stress for the mat, it may be appropriate to use a higher-class mat or a different type of channel liner, if the project is adjacent to a critical environmental or customer sensitive area such as a wetland or residential property.

Erosion mats that are made out of organic materials will degrade after a period of time, leaving a naturally vegetated channel. Organic erosion mats are used in channels that are expected to withstand a shear stress not exceeding 2.0 lbs/ft2.

Erosion mats made of synthetic materials generally do not degrade and often remain as a permanent element within the drainage channel. Synthetic materials are generally used in channels that are expected to withstand shear stresses greater than 2.0 lbs/ft2 or on unstable or highly erodible slopes of 1:1 or flatter.

Costs should be analyzed to compare the erosion mat selected to other erosion and sediment control devices that would perform similarly. This analysis should be weighed against the risks associated should another device be chosen.

15.4 Erosion Mat Classes and Types

There are eleven erosion mat types listed below which fall under three different classes. These erosion mat classes are also outlined in Attachment 15.1. When erosion mat is the preferred alternative, care must be taken to choose the type of mat which is most appropriate for the specific needs of the project. For additional guidance in determining the location of these devices, designers should refer to FDM 10-5-35.

15.4.1 Class I

Class I erosion mats are light-duty, organic ECRM mats. Non-organic, photodegradable or biodegradable netting is allowed for the non-urban mats. They are short term in duration (6-month minimum duration). There are four types of Class I erosion mats.

Type A (Minimum Permissible Shear Stress: 1.0 lbs/ft2: For use on slopes 2½:1 and flatter with a C factor from the Revised Universal Soil Loss Equation of 0.20 or less. Not to be used in channels.

Type B (Minimum Permissible Shear Stress: 1.5 lbs/ft2: This is a double netted product for use on slopes 2:1 or flatter with a C factor from the Revised Universal Soil Loss Equation of 0.20 or less, or in channels where the calculated shear stress is 1.5 lbs/ft2 or less.

15.4.1.1 Class I Urban

In addition to the requirements under Class I, the urban mats must be 100% organic and biodegradable, this shall include parent material, stitching, and netting. Urban mats are to be used where mowing may need to be accomplished within two weeks with little or no snagging of the netting or mat. *Recommended for use in environmentally sensitive areas that have a high probability of entrapping animals in plastic netting such as near streams or wetlands.* Not to be used in channels.

*Urban, Type A (*No Minimum Permissible Shear Stress Required for netted products, Minimum Permissible Shear Stress: 1.0 lbs/ft^2 for non-netted products): For use on slopes 4:1 and flatter with a C factor from the Revised Universal Soil Loss Equation of 0.20 or less.

Urban, Type B (Minimum Permissible Shear Stress: 1.0 lbs/ft^2): For use on slopes 2.5:1 and flatter with a C factor from the Revised Universal Soil Loss Equation of 0.20 or less.

15.4.2 Class II

Class II erosion mats are long lasting (3 years minimum), organic ECRMs. Class II Type B and C mats are intended for use on slopes 2:1 or flatter or in channels where the calculated shear stress does not exceed the permissible shear stress. Slopes steeper than 2:1 may have to consider other alternatives such as using the mat in combination with other erosion control devices or measures, modifying the slope, etc.

Type A: 100% jute fiber mats used for reinforcing sod. This item shall confirm to Section 628.2.2 of the Standard Specifications, no products are identified in the Product Acceptability List.

Type B (Minimum Permissible Shear Stress: 2.0 lbs/ft2): These are intended for use on slopes 2:1 or flatter or where vegetation may be slower to establish such as shady locations.

Type C (Minimum Permissible Shear Stress: 2.0 lbs/ft2): Type C erosion mats are high-strength, 100% organic fiber mats which include the coconut fiber mats. Woven mats are allowed with a maximum opening of ½ inch. *Recommended for use in environmentally sensitive areas that have a high probability of entrapping animals in plastic netting such as near streams or wetlands.*

15.4.3 Class III

Class III erosion mats are synthetic mats that are primarily used to stabilize steep channels or slopes permanently. Compared to Classes I and II, they have the greatest strength and survivability. They do, in many instances, offer a cost-effective alternative to structural devices such as riprap or grouted riprap. Class III mats area required to provide a C factor from the Revised Universal Soil Loss Equation of 0.20 or less.

Type A (Minimum Permissible Shear Stress: 2.0 lbs/ft2): This is an ECRM mat for use on slopes 2:1 or flatter or in channels where the calculated shear stress does not exceed the permissible shear stress. Class III, Type A mats tend to be quite dense. In addition, because they are a synthetic mat, they do not decompose. Decomposition helps to promote good grass germination by creating additional void space as the grass begins to grow. Therefore, designers should use caution when selecting these mats since they may be slow in producing vegetation.

Type B (Minimum Permissible Shear Stress: 2.0 lbs/ft2): This is a TRM for use on slopes 2:1 or flatter or in channels where the calculated shear stress does not exceed the permissible shear stress.

Type C (Minimum Permissible Shear Stress: 3.5 lbs/ft2): This is a TRM for use on slopes 2:1 or flatter or in channels where the calculated shear stress is less than the permissible shear stress.

Type D (Minimum Permissible Shear Stress: 5.0 lbs/ft2): This is a TRM for use on slopes 1:1 and flatter or in channels where the calculated shear stress is less than the permissible shear stress.

Class III, Types B, C and D mats are open weaved TRMs installed prior to seeding. The voids are then filled with soil. Though their open weave allows grass to germinate, this openness can create a tendency for some initial soil loss which interferes with the establishment of vegetation. To prevent this, the specification requires either the application of an approved soil stabilizer type A or ECRM over the TRM on slopes, or an ECRM over the TRM in channels, after installation is complete. Installed in this manner, these mats provide superior erosion protection and offer long-term turf reinforcement

Compared to Class I and II mats, conditions that may benefit from the use of Class III mats include:

1. Unstable soils.
2. Highly erodible soils.
3. Areas where vegetation may be difficult to establish such as in shady areas.
4. In some constant flow conditions. Depending on the velocity of flow and/or wave action, alternative measures such as heavy riprap, interlocking cells, gabions or structural devices may be necessary.

Designers should refer to Chapter 13 and consult with the Stormwater, Hydraulic and/or Soils Engineers to help determine appropriate stabilization measures.

15.5 General Performance Measures

The following general performance measures are included for information purposes only.

15.5.1 Maximum Acceptable Sediment Loss Standards

All approved erosion mats are tested to meet the minimum product C factor in the Revised Universal Soil Loss Equation as specified for each category of mat in WisDOT's Product Acceptability List (PAL).

15.5.2 Minimum Acceptable Vegetation Density Standards

All approved erosion mats in the PAL are required to allow vegetation to achieve the following minimum vegetation density standards.

- Clay Soils: 80%
- Sandy Soils: 70%

Density is compared to undisturbed areas within one year from the date of installation.

15.5.3 Netting

All plastic-netted products listed in the PAL are to be bonded sufficiently to prevent separation of the net from the parent material for the life of the product. This is particularly important as the vegetation starts to grow. If not sufficiently bonded, the net tends to "float" or “tent” which causes damage to maintenance equipment when slopes are mowed and increases the risk of small animals being caught.

LIST OF ATTACHMENTS

Attachment 15.1 Erosion Mat

FDM 10-10-17 Interlocking Cells

April 27, 2011

17.1 Definition

Interlocking cells (cellular confinement structures and articulated concrete blocks) are manufactured cellular devices which are usually filled with a granular material. They consist of two main types, cellular confinement structures, and articulated concrete blocks.

17.2 Application

These devices would generally be used as a replacement for riprap but are not cost effective for large areas. Cellular confinement systems generally have lower shear capabilities than articulated concrete blocks. They have merit in certain situations:

1. To protect erodible slopes or channels that are subject to vehicular or pedestrian traffic.
2. On some streambanks or in channels where constant flow conditions may wash out new plantings.

Designers should consult with their stormwater, hydraulic or soils engineer, as well as contact various manufacturers for product literature, when designing for these conditions.

Due to their cost, careful consideration should be given to the location, placement, and design of these measures as compared to other devices.

17.3 Design Guidance

As with many erosion control-type products, there is no substitute for a thorough understanding of the manufacturer's literature and recommendations. Therefore, it is recommended that guidance be obtained from various manufacturers of the product to help assist in the design of this device. In addition, a site visit by the designer, soils engineer, and manufacturers should be made in order to verify the product's appropriateness.

Interlocking cells are broken down into two main categories:

1. Cellular Confinement Structures.
2. Articulated Concrete Blocks.

17.3.1 Cellular Confinement Structures (Plastic or Fabric Pavers)

Cellular Confinement Structures are interconnected, grid-like structures usually made from a high-density polyethylene or 9-ounce non-woven polyester. Once expanded, they have dimensions of approximately 4 feet wide, 20 feet long and 3 inches high. These cells need to be bonded together in a consistent orientation in order to keep them from separating. The cells are placed over a subgrade layer and filled with aggregate. When subjected to heavy loads, they help reduce the stress exerted on the subgrade.

17.3.2 Articulated Concrete Blocks

Articulated concrete block revetment systems are a flexible manufactured erosion control system that is able to expand and contract with the subgrade. The systems are made of individual concrete block units, which are physically integrated through mechanical interlock, cables, grids, or other means to produce an erosion resistant lining. They are available in both open and closed cell types. The open cell types are designed to be filled with gravel or topsoil and be vegetated.

Articulated concrete block systems are particularly useful where vehicles or bicycles need to cross intermittent streams, or for sediment removal access areas of stormwater ponds, because of their pavement like surface.

They are organized into 5 types based on shear stress. Refer to the Erosion Control Product Acceptability List for additional information on these products.

The articulated concrete block system must be approved by the department and listed on the Erosion Control Product Acceptability List and be approved by the engineer prior to the start of mat fabrication.

FDM 10-10-19 Riprap or Grouted Riprap

January 24, 1997

19.1 Definition

Riprap is a flexible lining having a loose assemblage of relatively large rocks or stones that vary in size.

Grouted riprap is a rigid lining which consists of riprap with all or part of the voids filled with portland cement.

19.2 Application

Riprap and grouted riprap are used:

1. To protect the soil from the erosive forces of concentrated runoff.
2. To slow the velocity of water.
3. To protect embankments that are subject to current or wave actions such as those adjacent to a stream or a lake.
4. To dissipate energy at the outlet end of culverts or rigid channel linings.
5. To stabilize slopes or channels with seepage problems or non-cohesive soils.

For advantages and disadvantages of flexible versus rigid linings, see FDM 13-30-10.

See FDM 10-15 Attachments 5.12 – 5.24 for examples of the proper use of riprap.

19.3 Riprap

Riprap is considered a flexible lining since it can adjust to foundation changes. This flexibility eliminates many of the hydrostatic pressure problems associated with rigid linings. It is also porous, allowing infiltration and exfiltration of the protected soil. As water passes over the riprap, sediment fills the voids and, over time, vegetation may begin to grow, giving the channel or embankment a more natural appearance.

While rock riprap can be an effective erosion resistant lining, it does have limitations of use and is susceptible to damage due to:

1. Displacement of individual stones by the forces of water or ice.
2. Loss of foundation stability by leaching of the underlying soil through the riprap layer.
3. Undermining by scour.

The size of the individual riprap stones is important in combating displacement damage. Of as much importance as the individual stone size is the provision of a well-graded, interlocking mass of stone. This multi-stone contact and interlock within the layer provides greater resistance of the mass to displacement than could be provided by the individual stones. Thus, it is important that riprap stone be sized to resist displacement and also be well-graded within the selected size range. A well-graded, interlocking mass of riprap stone will also present fewer voids through which the flow can attack the foundation soil.

For design information on how to size riprap, designers should consult Chapter 13.

In some situations, such as reservoir shore protection, steep graded ditches, or highly erosive foundation soils, a loss of foundation stability by leaching of the underlying soil through the riprap layer can occur. The most common methods of providing protection against this leaching action are one or a combination of the following:

1. Increase the thickness for the riprap layer.
2. Provide a stone filter blanket between the riprap and underlying soil.
3. Place a geotextile under the riprap stone to serve as a filter.
4. Grout the riprap with portland cement concrete.

For stream and lakeshore protection - velocity, wave height, soil type, and slope should be considered along with FDM 13-30-25, when determining whether, and to what extent, riprap or heavy riprap should be used. Riprap should extend from the streambed to two feet (600 mm) above high water, the minimum requirements being three feet (900 mm) below normal water to two feet (600 mm) above high-water elevation. Refer to environmental website (https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/environment/formsandtools.aspx) for guidance on 404 permit requirements for riprap placed below ordinary high water.

19.4 Grouted Riprap

Grouted riprap can take the place of riprap when velocity, soil and climate conditions make it necessary to have a rigid channel lining. Leaving the upper portion of the riprap ungrouted has proven successful in enhancing the riprap's ability to act as an energy dissipater. Though grouted riprap is less prone to movement in severe situations, it is more susceptible to frost heave damage due to its inflexibility to move with the soil.

19.5 Design Guidance

Caution: Clear zone requirements must be examined and the possibility of damage by vandals throwing stones evaluated when considering these devices.

To determine the minimum channel and riprap (grouted or ungrouted) size that will be stable under flow conditions, designers should see FDM 13-30-10.

To help prevent slippage, riprap for channel or slope stabilization should be designed so that the natural angle of repose of the stone mixture is greater than the gradient being stabilized (see FDM 13-30-10).

A lining of geotextile filter fabric should be placed between the riprap or grouted riprap and the underlying soil surface to prevent soil movement into or through the riprap. Designers should refer to the Wisconsin Standard Specifications for Road and Bridge Construction for the types of filter fabric needed for a given size. However, filter fabric may encourage slippage on steep slopes, especially on those greater than 1.5:1. Designers should consult with their Soils Engineer for guidance.

FDM 10-10-21 Erosion Bale Barriers *April 27, 2011*

21.1 Definition

Erosion bale barriers are temporary sediment barriers consisting of a row or rows of entrenched and anchored straw or hay bales.

21.2 Application

When properly installed and maintained, erosion bale barriers can provide effective, temporary erosion control protection during grading operations.

Erosion bales are used:

1. To intercept and detain small amounts of sediment from disturbed areas.
2. At the base of a slope.
3. Along a street or sidewalk to prevent silt from reaching the pavement.
4. Next to wetlands where silt fence may not stand due to soft soils.

21.3 Limitations

1. Not to be used in intermittent or perennial stream channels.
2. Not to be used on rock or other areas where the barrier cannot be entrenched as required and firmly anchored.

21.4 Design Guidance

A single or double row of erosion bales can be used for sheet flow application.

To be effective, erosion bale barriers need to be spaced at intervals not exceeding one barrier for every 25 feet for 10 to 33% slopes, every 50 feet for 5 to 10% slopes, and 100 feet for 2% slopes.

For sheet flow applications, erosion bales can be used as an alternative to silt fence at perimeter locations such as the base of a disturbed slope. As with silt fence, an effort should be made to locate them at least 5 to 7 feet from the base of the slope. Sometimes erosion bales are used along the contours of a slope to catch the sediment before it reaches the bottom. However, other measures such as mulch, erosion mat, intercepting embankments, slope drains, etc., may be more effective.

The ends of the barrier should be extended up the slope to help ensure that sediment-laden runoff will be maintained in the barrier and not flow around the ends.

21.5 Estimating Quantities

Erosion bales are paid for by “each” bale.

To estimate the quantity of erosion bales, first determine the total length of slope where bales are needed. Then, based on an average length of 3 feet per bale, determine the number of bales needed.

Since the estimated useful life of erosion bales is 3 months, the bales will require replacement depending on the length of the contract. Therefore, designers should provide enough quantity for adequate maintenance.

FDM 10-10-22 Temporary Ditch Checks *April 27, 2011*

22.1 Definition

Temporary Ditch Checks are temporary sediment barriers, for use in channels.

22.2 Application

When properly installed and maintained, temporary ditch checks can provide effective, temporary erosion control protection during grading operations through the time of permanent vegetative cover. Sufficient quantities of these devices should be provided.

Temporary ditch checks are used:

1. To intercept and detain small amounts of sediment from disturbed areas in channelized flows,
2. To decrease the velocity of low volume channel flows.

Unless otherwise specified in the contract, either temporary ditch check products approved and listed in the departments Erosion Control Product Acceptability List, or straw or hay erosion bales, may be used for this bid item.

Log-type manufactured products (wattles) shall be entrenched a minimum of 2 inches and staked per manufacturers recommendations. All other installation requirements, including stakes, shall be as per SDD 8E8.

22.3 Limitations

1. Not to be used in intermittent or perennial stream channels.
2. Not to be used on rock or other areas where the barrier cannot be entrenched as required and firmly anchored.

22.4 Design Guidance

If erosion bales are used by the contractor a double row of bales is required per SDD 8E8. The maximum flow for a double row channel application is 3 ft^3/sec.

To be effective, Temporary Ditch Checks need to be spaced at intervals not exceeding one ditch check for every two feet drop in elevation in the channel, with a maximum spacing of 200 feet. (see FDM 10-5-35, for additional information).

The barrier should extend up the slope to such a length that the bottoms of the end barriers are higher in elevation than the top of the lowest middle barrier to help assure that sediment-laden runoff will flow either through or over the barrier but not around it (see SDD 8E8).

Temporary ditch checks need to be designed to fit the cross-section of the ditch to allow for proper installation and help prevent a washout from occurring. If the bales cannot be designed to fit the cross-section of the channel, another control measure should be used.

22.5 Estimating Quantities

Temporary ditch checks are paid for by the linear foot measured across the ditch. If the contractor uses erosion bales for this item a double row of bales is required however only the total length across the ditch is measured for the basis of payment, not the length of each row, therefore the designer only needs to adequately estimate the total linear feet needed for the ditch checks.

To estimate the quantity of temporary ditch checks, the designer should first determine the average ditch cross section dimension needed for the ditch checks, then how many ditch checks will be needed based on using one ditch check for every two feet drop in elevation in the channels.

Since the estimated useful life of these products is 3 months, the ditch checks will require replacement depending on the length of the contract. Therefore, designers should provide enough quantity for adequate maintenance.

FDM 10-10-23 Silt Fence — *April 27, 2011*

23.1 Definition

Silt fence is a temporary sediment control barrier consisting of a geotextile filter fabric that is stretched across supporting posts and entrenched or sliced into the ground. Its purpose is to:

1. Intercept and detain small amounts of sediment from disturbed areas during construction operations.
2. Decrease the velocity of sheet flows.

23.2 Application

1. Below disturbed areas where erosion would occur in the form of sheet or rill erosion such as the base of a slope.
2. A round or downslope of soil piles, stock piles, topsoil piles, etc..

3. Where effectiveness is required for one year or less.

23.3 Limitations

Due to its low permeability, silt fence has a damming effect which often causes the fence to collapse in concentrated flow conditions. This damming effect can also cause soil saturation problems during construction, especially around inlets.

Limit to conditions in which only sheet or overland flows are expected where the maximum contributing runoff area does not exceed ¼ acre per 100 ft. of silt fence.

Improper placement, installation, and maintenance will significantly decrease the effectiveness. Silt fence should only be placed in areas where it is applicable. Use other devices, determined by the Erosion Control Matrix, in channels or areas of concentrated flow where silt fence is not the appropriate BMP.

Silt fence should not be used;

1. In locations where the natural overland flow is from an undisturbed area onto disturbed areas of the project in which case the silt fence would be at a higher elevation than the disturbed area and serve no value.
2. Parallel to the direction of flow down a slope since this will promote gullies to form along the fence. Place silt fence along the contour of slopes.
3. For storm sewer inlet protection.
4. As an intercepting embankment to divert flows.
5. In areas where rock or another hard surface prevents full and uniform depth anchoring of the barrier.
6. Closer to tree trunks than the drip line of the tree. Care should be taken to minimize damage to tree roots when possible.
7. In areas where the silt fence serves to protect neither an environmental nor customer sensitive area.
8. To "gift wrap" the project. Silt fence should be placed only in areas where it is applicable, not for “looks” or as a perimeter/safety fence.

23.4 Design Guidance

A common misconception is that silt fence actually “filters” suspended particles from runoff. The effectiveness of silt fence is primarily derived from its ability to pond water behind the silt fence. This ponding action allows particles to settle out on the uphill side of the fence.

Proper installation methods can improve performance and reduce failures. Water must not be allowed to flow under, around, or over the silt fence. In sheet flow applications, such as installation at the base of a slope, sufficient quantities are needed so that the ends of the silt fence can be extended 1 to 2 feet up the slope to help ensure that the sediment laden runoff does not flow around the barrier.

Parallel fences may be needed on steep or long slopes. Since silt fence is a sediment control device, effectiveness is increased when used in conjunction with other upslope erosion control practices.

Attempt to locate silt fence at least 5 to 7 feet beyond the base of disturbed slopes. This allows the sediment to settle out behind the fence and reduce the stress on the fence. When this is not possible, reinforcement measures such as a combination of silt fence and erosion bales may be necessary. Sensitive areas may require additional protection.

23.5 Estimating Quantities

Estimate the quantities of silt fence by looking at the cross sections to determine locations where sheet flow will leave the right of way. Areas with ditches generally do not require silt fence installation.

Estimate "Silt Fence, Maintenance" to occur at least once every 30 days that the silt fence is to be in place.

FDM 10-10-24 Heavy Duty Silt Fence *August 16, 2022*

24.1 Definition

Heavy duty silt fence is a temporary sediment control device that is typically used for perimeter erosion control purposes. It is a composite fence system that is assembled on site by the contractor and consists of a fencing fabric, steel fence posts, and geotextile fabric type HR.

24.2 Application

Heavy Duty Silt Fence is a type of silt fence that is intended to provide more robust protection of sensitive environmental resources compared to standard silt fence. This protection is provided through an increased fence height and stabilizing the fence by backing the geotextile fabric with a metal fence fabric. These combine to allow the heavy duty silt fence to capture and contain greater amounts of sediment compared to standard silt fence. While standard silt fence fabric acts more in a damming effect to allow particles to settle out, the HR fabric allows for sediment filtering as water passes through it.

The support system of the heavy duty silt fence is the steel fence posts and fence fabric. The fence fabric may consist of a variety of different types of fencing material, including woven wire, chain link, or welded wire. In an effort to encourage the use of recycled materials and reduce construction costs, the specification allows for the use of salvaged fence fabrics provided it is free of rust and other structural defects. New fence fabrics may be used as well. The fence fabric is secured to the steel fence posts with at least three ties at each post.

The filtering element of heavy duty silt fence is the geotextile fabric type HR. Once the fence fabric is erected and secured to the steel fence posts, a layer of geotextile fabric type HR is draped over the fence fabric and secured by ties to the fence fabric and/or steel posts. It is important that the geotextile fabric is properly secured to minimize damage or displacement by wind and/or wave actions. To simplify construction, the specification allows for excess geotextile fabric to be draped over the backside of the fence system. The contractor may elect to cut this to the required dimensions.

Similar to standard silt fence, the performance of heavy duty silt fence is predicated on being properly anchored to the ground to prevent undermining. This can be done through trenching in the HR fabric at least six inches and backfilling the trench with the spoils from the trenching operation. In wet conditions, such as standing water, trenching may not be possible and an alternative anchoring method using a continuous line of rock or sand bags may be necessary. In a wet application, it is important to provide a continuous line of bags to properly secure the geotextile fabric through continuous fabric to ground contact. It is the contractor’s responsibility, with consultation of the project staff, to determine which anchoring method will be used.

24.3 Design Guidance

Heavy duty silt fence is recommended in areas where environmental resources are in close proximity to the work site <u>and</u> there is an elevated risk of runoff and overtopping of standard silt fence. Designers may propose the use of this item based on a risk assessment of the work to be performed on the site – the mere presence of a waterway or wetland does not necessarily warrant a need for this item.

Some considerations for the use of heavy duty silt fence:

- Height of embankment construction
- Slope length and steepness
- Soil type(s)
- Size of the drainage area
- Distance from slope intercept to the environmental resource
- Project schedule and exposure risk
- Types of other erosion/sediment control measures to be used in the area
-

Since the cost of heavy duty silt fence is significantly higher than standard silt fence, this item should be limited to areas necessary to properly protect the environmental resource. In most cases, standard silt fence will be used and then transitioned to the heavy duty silt fence for the areas of higher risk.

Designers should consult with the regional Stormwater and Erosion Control Engineer (SWECE) for project specific guidance related to the use of this item.

If using in marsh or wetland areas, the designer should review soil characteristics to determine proper applicability of this product. Marsh and wetland areas can present challenges related to the stability of fence posts or depth necessary to provide adequate support of the heavy duty silt fence system. In these cases, the specification may need to be modified. Consider requiring longer posts with deeper embedment, closer post spacing, or alternative post options. Other erosion control devices, or combinations of devices, may be more effective in these situations.

All projects using the Silt Fence Heavy Duty item shall also include the Silt Fence Heavy Duty Maintenance item in the contract. Since installed quantities are likely to be limited, it is recommended that the entire fence length be included as an undistributed quantity for maintenance purposes. Consider increasing this amount further when the fence will be in place for extended periods of time or over winter months, when there is high risk of erosion, or when other environmental factors present increased risk for maintenance.

FDM 10-10-25 Stone or Rock Ditch Checks

January 24, 1997

25.1 Definition

Stone or rock ditch checks are temporary or permanent stone dams constructed across a swale or drainage ditch. They may be constructed from coarse aggregate, riprap, breaker run, or railroad ballast.

25.2 Application

Stone or rock ditch checks are limited to open channels or swales. They should not be used in streams or live watercourses. Some typical applications for stone or rock ditch checks are:

1. To reduce the velocity of concentrated storm water flows in swales or channels.
2. To trap sediment generated from adjacent areas or from the ditch itself by ponding the storm water runoff.
3. To protect temporary ditches or swales which, because of their short length of service, cannot receive a non-erodible lining but still need protection to reduce erosion.
4. To protect permanent ditches or swales when a permanent, non-erodible lining cannot be placed because, for example, the seed bed is not prepared, or final shaping is not completed.
5. To protect grass linings in either temporary or permanent ditches and swales during the establishment period.
6. To aid in the sediment trapping strategy for a construction site.

See FDM 10-15 Attachment 5.27 and FDM 10-15 Attachment 5.28 for examples of these applications.

25.3 Design Guidance

When constructed of a porous material, such as coarse aggregate #2, stone or rock ditch checks perform more effectively in filtering sediment than other ditch checks (i.e., erosion bales or sod ditch checks) and are commonly referred to as "filter berms".

On channels removed from traffic and under severe flow conditions and erodible soils, these ditch checks are extremely effective. However, since they may pose a traffic hazard, clear zone requirements should be evaluated and alternative measures used, such as continuous sod or erosion mat, where necessary.

If ditch checks are used in grass-lined channels which will be mowed, care should be taken to remove all the stone when the dam is removed. This should include any stone which has washed downstream.

"Breaker Run" is a type of rock that is sometimes used to construct ditch checks. Due to its fracture count, it has proven to be less susceptible to shifting than riprap. However, because of the fines present, it tends to be somewhat dirty. Therefore, it may not be desirable where water quality is a concern, such as near a lake or stream.

Some other design factors that need to be considered are:

1. The drainage area of the ditch or swale being protected should not exceed 2 acres (8100 m2) when filter berms are used alone and should not exceed 10 acres (4.05 hectares or 40,500 m2) when riprap is used. An effort should be made to extend the stone to the top of channel banks.
2. The maximum height of the dam should not exceed 3.0 feet (900 mm).
3. The center of the ditch check should be at least 6 inches (150 mm) lower than the outer edges. Field experience has shown that many dams are not constructed to promote this "weir" effect. Storm water flows are then forced to the stone-soil interface, thereby promoting scour at that point and subsequent failure of the structure to perform its intended function. Regular inspections should be made to ensure that the center of the ditch check is lower than the edges. Erosion caused by high flows around the edges of the dam should be corrected immediately.
4. For added stability, the base of the ditch check should be keyed into the soil approximately 6 inches (150 mm).

5. The maximum spacing between the dams should be such that the toe of the upstream dam is at the same elevation as the top of the downstream dam.
6. Hand or mechanical placement will be necessary to achieve complete coverage of the ditch or swale and to ensure that the center of the dam is lower than the edges.
7. Geotextile may be used under the stone to provide a stable foundation and to facilitate the removal of the stone. Geotextile may also be used over the stone to provide filtration and facilitate maintenance.
8. Ditch checks should be considered permanent whenever practical so as to prevent further disturbance of the soil.
9. Ditch Checks should be inspected for sediment accumulation after each runoff-producing storm event, especially when trying to establish vegetation. If submergence after rainfall is too long or silting is excessive, vegetation may be killed off. Sediment should be removed when it reaches one half of the original height of the ditch check.

FDM 10-10-27 Storm Drain Inlet Protection *April 27, 2011*

27.1 Definition

A temporary barrier installed around a storm drain inlet, drop inlet or curb inlet to reduce sediment from entering storm drains before stabilizing the contributing drainage area.

27.2 Application

This practice applies where runoff from construction sites enters conveyance system structures such as drain inlets, drop inlets, and curb inlets. Inlet protection devices should be considered the last line of defense against sediment transport. Other BMPs should be installed up-gradient from the inlet.

27.3 Design Guidance

This section establishes the minimum standards for design, installation and performance requirements.

The appropriate type of inlet protection barrier shall be installed once the drain, drop, or curb inlet can receive runoff. The device shall remain in place and be maintained until the contributing drainage area is stabilized.

Designers should be aware that more than one type of inlet protection is generally required for each inlet as the job progresses. For example Inlet Protection Type A is generally required in the initial phases of construction, while the same inlet may require Type B, C, or D in the later stages.

Storm drain inlet protection consists of several types of inlet filters and traps and should be considered as only one element in an overall erosion control plan. Each type differs in application with selection dependent upon site conditions and inlet type. Not all designs are appropriate in all cases. The user must carefully select a design suitable for the needs and site conditions.

Use WisDOT’s SDD 8E10 for inlet protection.

27.3.1 General Criteria Applicable to All Inlet Protection Devices

1. Ponding water to settle sediment is encouraged; however, ponding shall not interfere with the flow of traffic, create a safety hazard, or cause property damage.
2. The contributing drainage area to the inlet protection device shall be one acre or less. In instances where a larger contributing drainage area exists, runoff shall be routed through a properly designed sediment trapping or settling device upstream of inlet.
3. Other than Type D inlet protection devices, no gaps shall be left in the material used that would allow the flow of water to bypass the inlet protection device.
4. All fabrics used as part of an inlet protection device must be selected from the list of approved fabrics certified for inlet protection, Geotextile, Type FF in the current addition of the WisDOT Product Acceptability List (PAL).

27.3.2 Criteria Applicable to Unpaved Areas or the Pre-Paving Phase of Construction

1. Inlet Protection Barriers include, but are not limited to straw bales, sandbags, other material filled bags and socks, and stone weepers. These devices can be used to either settle sediments or divert flows.

   Manufactured bags shall be durable enough to last the intended life of the BMP and allow for removal without breakage.

2. Inlet protection Types A & B are applicable to the pre-paving phase of construction.

   Inlet protection Type A devices shall be utilized around inlets in unpaved areas until permanent stabilization methods have been established. Type A devices shall be utilized on inlets prior to installation of curb and gutter or pavement, and where safety considerations are not compromised on the site.

   Type B may be utilized for yard or parking lot drains after the casting and grate are in place.

27.3.3 Criteria Applicable to Post-Paving/Curbing Phase of Construction

Inlet Protection Types B, C and D are applicable to post paving construction.

1. Type B shall be utilized on inlets without a curb box such as for yard or parking lot drains.
2. Type C shall be utilized on street inlets with curb heads.
3. Type D shall be utilized in areas where other types of inlet protection are identified as incompatible with roadway and traffic conditions, causing possible safety hazards when ponding occurs at the inlet.

   Type D inlet protection shall have a three-inch space between the bag and the sides of the inlet to prevent the inlet sides from blocking the overflow and shall only be used in inlets deeper than 30 inches from the top of grate to bottom of the inlet. If clearance is not available, cinch or tie the sides of the bag (with rope or ties) to provide clearance.

FDM 10-10-29 Culvert Inlet Protection — May 15, 2019

29.1 Definition

Culvert inlet protection usually involves placing a sediment filter or excavated impoundment area at the inlet end of culverts.

29.2 Application

Culvert inlet protection is used to prevent sediment from entering, accumulating in and being transferred by a culvert and associated drainage system prior to permanent stabilization of a disturbed project area. It is also used to provide sediment control protection when elevation or drainage patterns are changing due to construction operations.

29.3 Design Guidance

Like drop and curb inlets, culverts which are made operational prior to stabilization of the associated drainage areas can convey large amounts of sediment to natural drainageways. In cases of extreme sediment loading, the pipe or pipe system itself may clog and lose a major portion of its capacity.

The following measures can help prevent sediment from entering the culvert:

1. Culvert Inlet Sediment Trap: Runoff storage requirements should be in accordance with information outlined under FDM 10-10-51. The maximum area draining to this practice should not exceed 3 acres. This practice has a maximum expected useful life of approximately 18 months.
2. Culvert Pipe Checks: Rock filled bags can also help pond runoff water and trap sediment in front of the culvert pipe inlet. Typical installation would include one layer of rock filled bags placed across the inlet end of culvert or culvert apron endwall. Culvert pipe checks are not recommended in pipes that convey large quantities of water.

The inlet protection devices should be constructed in a manner that will facilitate clean out and disposal of trapped sediment while minimizing interference with construction activities. They should also be constructed such that any ponding of storm water will not cause excessive inconvenience or damage to the structure or adjacent areas.

FDM 10-10-31 Outlet Protection — April 27, 2011

31.1 Definition

Outlet protection involves placing an energy dissipating device at the outlets of pipes or channel sections.

31.2 Application

Outlet protection devices are used to:

1. Prevent scour at storm water outlets.

2. Minimize the potential for downstream erosion by reducing the velocity and energy of concentrated storm water flows.

31.3 Design Guidance

The outlets of pipes and structurally lined channels are points of critical erosion potential. Stormwater which is transported through man-made conveyance systems at design capacity generally reaches a velocity which exceeds the capacity of the receiving channel or area to resist erosion. To prevent scour at stormwater outlets, a flow transition structure is needed which will absorb the initial impact of the flow and reduce the flow velocity to a level which will not erode the receiving channel or area.

Where flow is excessive for the economical use of a structurally lined apron, excavated sediment basins may be used (see FDM 10-10-51).

The design of structurally lined aprons at the outlets of pipes and paved channel sections applies to the immediate area or reach below the pipe or channel and does not apply to continuous rock linings of channels. Notably, pipe or channel outlets at the top of cut slopes or on slopes steeper than 10% should not be protected using just outlet protection given the reconcentration and large velocity of flow encountered as the flow leaves the structural apron. Designers should use a combination of devices and engineering practices to slow down and dissipate this energy.

FDM 10-10-33 Subsurface Drains

January 24, 1997

33.1 Definition

Subsurface drains are perforated conduits such as pipe, tubing or tile installed beneath the ground to intercept and convey ground water.

33.2 Application

Subsurface drains are used to:

1. Prevent sloping soils from becoming excessively wet and sloughing.
2. Improve the quality of the growth medium in excessively wet areas by lowering the water table.
3. Drain stormwater detention areas or structures.

33.3 Design Guidance

Subsurface drainage systems are of two types, relief drains and interceptor drains.

Relief drains are used either 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.

Interceptor drains are used to remove water as it seeps down a slope to prevent the soil from becoming saturated and subject to slippage. They are installed across a slope and drain to the side of the slope. They usually consist of a single pipe or series of single pipes instead of a patterned layout.

To install an effective subsurface drainage system, the soil must be deep and permeable enough. If a gravity outlet is not available, pumping must be provided. Designers should obtain assistance from their Soils Engineer in the design of these devices.

In addition, the following criteria should be met:

Location: Tree roots can often clog subsurface drain systems. Consequently, sub-surface drains should be located such that there are no trees within 50 feet (15 m) of the drains.

Relief drains should be located through the center of wet areas. They should drain in the same direction as the slope.

Interceptor drains should be located on the uphill side of wet areas. They should be installed across the slope and drain to the side of the slope.

Outlets: Subsurface drain outlets should empty into a channel or some other watercourse and should be above the mean water level in the receiving channel. Protection is needed from erosion, undermining, damage from periods of submergence, and the entry of small animals into the drain.

Material: Strength and durability of the pipe should be considerations since crushing of the pipe can occur if the pipe is subjected to heavy vehicle loads such as utility vehicles and maintenance mowing equipment.

Maintenance: Subsurface drains should be checked periodically to ensure that they are free-flowing and not clogged with sediment. The outlet should be kept clean and free of debris. Inlets should be kept open and free of sediment and other debris. Trees located too close to a subsurface drain can often clog the system with their roots. If a drain becomes clogged, the drain should be relocated, or the trees removed. Where drains are crossed by heavy vehicles, the line should be checked to ensure that it is not crushed.

FDM 10-10-37 Diversion Dikes/Intercepting Embankments *January 24, 1997*

37.1 Definition

A diversion dike is a ridge of compacted soil constructed at the top or base of a sloping disturbed area and may be either temporary or permanent.

An intercepting embankment is a type of permanent diversion dike, which is used only along the top of back slopes in cut areas to prevent the adjacent lateral drainage from flowing over or down the back slope.

37.2 Application

Diversion dikes and intercepting embankments can be used whenever storm water runoff must be diverted to protect disturbed areas and slopes or to retain sediment on site during construction. They are considered economical because they use material available on the project site and can usually be constructed with equipment needed for site grading. Their useful life can be extended by stabilizing the dike or embankment with vegetation. They are preferable to silt fence because they are more durable, less expensive, and require less maintenance when constructed properly. Along with a temporary sediment trap or basin they become a logical choice for a control measure once the control limits of the silt fence or erosion bale barrier have been exceeded.

37.3 Design Guidance

Diversion dikes and intercepting embankments are often used as perimeter controls on moderate to large construction sites. Intercepting embankments are highly recommended in areas of large cuts since the embankment prevents severe erosion of the slope and aids in the establishment of a good turf cover.

Note: Diversion dikes and intercepting embankments are generally paid for under the grading bid items. As such they should be shown on the plan cross sections.

To protect adjacent and downstream areas, dikes and embankments should divert overland sheet flow to a stabilized outlet or sediment-trapping facility.

It is very important that temporary or permanent vegetation be installed as soon as possible after construction of the dike or embankment to prevent these devices from eroding. If installed properly and in the first phase of grading, maintenance costs are very low. Often, the cleaning of the sediment-trapping facility is the only associated maintenance requirement. The dike or embankment should have a positive grade to assure drainage. However, if the gradient is too great, precautions must be taken to prevent erosion created from high-velocity channel flows.

Flumes should be used at critical locations on back slopes to carry water from intercepting embankments to roadside ditches. These flumes are normally constructed of erosion mat or sod, but large volumes of water over steep slopes may require the use of riprap or slope drains. Flumes should be spaced so as to prevent large concentrations of water. Refer to SDD 8E5 for sodded back slope flume and intercepting embankment details.

FDM 10-10-39 Benching *January 24, 1997*

39.1 Definition

Benching is a series of permanent, deep cuts that are constructed in steep backslopes in order to:

1. Reduce runoff velocity by reducing the effective slope length.
2. Detain sediment.
3. Provide access to slopes for seeding, mulching and maintenance.

39.2 Application

Benches are an effective method of preventing erosion on large cut slopes. They help to reduce and collect sheet flow so that standard erosion control measures can protect the slope.

39.3 Design Guidance

Benches should be considered whenever cuts exceed 20 feet in depth and required where cuts exceed 25 feet unless other stabilization methods are utilized (see Attachment 39.1).

Therefore, they need to be planned in the early design stages because they increase right-of-way requirements. If right-of-way costs are not prohibitive, they are an effective erosion and sediment control measure.

Special erosion control measures, such as using erosion mat to cover the slope, are an alternative to benches but they do not provide the long-term protection or maintenance benefits that benches provide.

Benching should be done at approximately 15 ft. vertical intervals to collect and channel sheet flow. Benches should slope downward into the slope as to provide a "ditch" and should be a minimum of 8 feet wide for ease of constructability. Treat benches as ditches by using the appropriate channel erosion control treatment. Adjust the elevations of the benches to provide proper drainage. Flumes or slope down drains need to be considered at the termini of these sections.

LIST OF ATTACHMENTS

Attachment 39.1 Benched Slope Examples

FDM 10-10-41 Dust Control

April 16, 2015

41.1 Definition

Dust control includes measures such as:

- water / irrigation
- vegetative cover
- mulch
- surface treatments (spray-on adhesives or chemicals).

They are used to reduce surface and air movement of dust during land disturbing, demolition and construction activities.

41.2 Application

Construction activities inevitably result in the exposure and disturbance of soil. Therefore, dust control measures should be available for use on all construction sites to help reduce the presence of airborne substances that may present health hazards or traffic safety problems.

41.3 Design Guidance

Dust is brought about by excavation, demolition, vehicle traffic and other human activity, as well as wind erosion over the exposed earth surfaces. Large quantities of dust are typically generated in heavy construction activities that disturb significant areas of the soil surface. Construction site research has established an average dust emission rate of 1.2 tons/acre/month for active construction. Earth-moving activities comprise the major source of construction dust emissions, but traffic and general disturbance of the soil also generate significant dust emissions.

In planning for dust control, limiting the amount of soil disturbance at any one time should be a key objective. Therefore, phased clearing and grading operations and utilizing temporary stabilization can significantly reduce dust emissions. It is recommended that the contract documents include a limitation on the amount of erodible surface area that may be exposed at any one time when working near sensitive areas.

Some of the temporary dust control measures that should be considered are:

1. Water / Irrigation: Water application/irrigation is the most commonly used dust control practice and should be included on all projects. In addition to protecting the construction site, it offers fast protection for haul roads and other heavy traffic routes

2. Vegetative Cover: In areas subject to little or no construction traffic, a stabilized, vegetative surface can aid in reducing dust emissions. Where possible, existing vegetation should be preserved. Undisturbed vegetative buffers, having a 50 foot minimum width, are recommended between graded areas and protected areas.

3. Mulch: When properly applied, mulch offers a fast, effective means of controlling dust. However, it is not recommended for areas within heavy traffic pathways. Binders or tackifiers are often used to stabilize organic mulches when wind erosion is the key issue.

4. Surface treatments: Many chemicals have been developed to control dust on construction sites. Standard Spec 623 lists two: calcium chloride and magnesium chloride. Both products should provide

good dust control results when applied properly.

FDM 10-10-42 Tracking Pads — April 27, 2011

42.1 Definition

A stabilized pad of stone aggregate, located at any point where construction vehicles will egress a construction site. It is intended to minimize tracking of mud and sediment by vehicle tires. The tires of vehicles traveling across the tracking pad are cleaned by the rolling motion and large aggregate scraping the tires.

42.2 Application

Applicable on projects where construction vehicles enter a paved roadway with live traffic and for waste or borrow sites and tracking of sediment onto the roadway is either a safety or environmental concern. Environmentally, this is of particular concern on urban projects where sediment runoff could run directly into a storm sewer.

42.3 Design Guidance

In most cases the designer will not be able to identify locations where tracking pads will be installed prior to bidding, since each contractor will likely have different locations.

The following design guidance applies and should be incorporated in the specifications:

1. Tracking pads shall be installed prior to any traffic leaving the site.
2. The aggregate for tracking pads shall meet the requirements of Select Crushed Material in Section 312 of the Standard Specifications for Highway and Structure Construction.
3. The aggregate shall be placed in a layer at least 18 inches thick. Stone tracking pads shall be underlain with a WisDOT Type R geotextile to prevent migration of underlying soil into the stone.
4. The tracking pad shall be the full width of the egress point. The tracking pad shall be a minimum of 50 feet long.
5. Surface water must be prevented from passing through the tracking pad. Flows shall be diverted away from tracking pads or conveyed under and around them by using a variety of practices, such as culverts, diversions, or other similar practices.

42.4 Considerations

The locations of tracking pads will be identified on the contractors ECIP. Therefore, the designer will only be able to estimate a rough quantity based on points of egress into live traffic and anticipated borrow or waste site locations.

Rural projects where the roadway is paved, but closed to traffic, thereby not posing safety issues, may not require tracking pads if runoff sediment is contained and cannot enter a waterway.

42.5 Estimating Quantities

To estimate the quantity of tracking pads, the designer should estimate one tracking pad for every balance point or one for every 20,000 square yards of borrow or waste, whichever is less. Each tracking pad will be paid as “each”.

The final plan quantity will be determined upon approval of the ECIP.

FDM 10-10-43 Silt Screen — January 24, 1997

43.1 Definition

Silt screen is a floating geotextile material used to minimize sediment transport within a body of water. Unlike "Turbidity Barriers", they do not touch the bottom of the watercourse. Instead, silt screens float from the surface of the water to approximately 2 feet (600 mm) above the water bed.

43.2 Application

Silt screens are used in watercourses:

1. That are adjacent to or near up-slope land disturbance activities.
2. When dredging and filling is occurring within the watercourse.

See FDM 10-15 Attachment 5.34 for an example of a silt screen application.

43.3 Design Guidance

Soil loss into a watercourse can result in suspended sediments. In time, the suspended sediment may travel long distances and could affect wide-spread areas. Silt screens and turbidity barriers are designed to deflect and contain sediment within a limited area. They provide time for soil particles to fall out of suspension and help prevent these particles from being transported to other areas.

It is imperative that the erosion and sediment control plan provide sufficient measures to keep sediment out of the watercourse. However, silt screens or turbidity barriers provide an excellent "last line of defense" and, therefore, are essential when land disturbing activities are adjacent to or near the watercourse.

It is seldom practical to extend a silt screen or turbidity barrier lower than 10 to 12 feet (3.0 - 3.6m) below the surface, even in deep water. If installed deeper, the force of the water will place strain on the screen materials and mooring system.

Designers should consider the velocity of water and the direction of flow. Silt screens and turbidity barriers are not to be installed perpendicular to channel flows, unless currents are extremely slow or non-existent.

Soil particles trapped by silt screens or turbidity barriers should always be allowed to settle for a minimum of 6 to 12 hours prior to their removal by equipment or prior to removal of the device. However, it is recommended that the sediment only be removed if there has been a significant change in the original contours of the affected area in the watercourse since sediment removal may create more of a sediment problem by resuspending the particles. In addition, accidental dumping of the material by the equipment may occur.

In addition, silt screens:

1. Are not recommended where currents exceed 1.65 ft/second (0.5 meters/second).
2. Should never touch the bottom of the waterway. Instead, a minimum 2-foot (600 mm) "gap" should exist between the weighted lower end of the screen and the waterbed. Movement of the lower skirt over the bottom due to current or wind and wave action on the floatation system may fan and stir sediments already settled out.
3. Have a tendency to "billow up" towards the surface under the pressure of the moving water. This results in an effective depth which is significantly less than the skirt depth. Therefore, when sizing the length of the floating silt screen, allow an additional 10% to 20% variance in the straight line measurements. This will allow for measuring errors, make installation easier and reduce stress from potential wave action during high winds.

For additional guidance on turbidity barriers, see FDM 10-10-45.

FDM 10-10-45 Turbidity Barrier — *April 27, 2011*

45.1 Definition

Turbidity barriers are fence-like structures that are placed within a body of water to barricade sediment from being transported. A geotextile material is stretched on posts from the bottom of the waterbed to an elevation 2 feet above the anticipated high-water mark for the time of year the barrier is to be placed.

45.2 Application

Turbidity barriers are used in watercourses:

1. That are adjacent to or near up-slope land disturbing activities.
2. Where dredging or filling is taking place within the watercourse.

Refer to FDM 10-15 Attachment 5.35 for an example of a turbidity barrier application.

45.3 Design Guidance

Turbidity barriers are not recommended where currents exceed 5 ft/second. If currents exceed these limits, other measures should be considered to divert the water away from the area being worked on or disturbed. This may be accomplished by using diverters such as portable cofferdams, sheet piling, or jersey barrier. Designers should consult with the Hydraulic, Stormwater or Soils Engineer and their DNR liaison when using these other methods.

Barriers are one of the "last lines of defense" and should be used as part of an overall erosion and sediment control plan to help prevent sediment from entering the waterway.

Care should be taken when removing the barrier due to the release of sediment. When possible, the barrier should be released when flow rates are low. Consultation with the DNR liaison and Army Corps of Engineers is recommended.

FDM 10-10-47 Soil Stabilizer, Type B (Land Application of Polymers) *April 27, 2011*

47.1 Definition

The land application of products containing water-soluble polymers as temporary soil binding agents to reduce erosion on construction sites.

47.2 Application

This practice is intended for direct soil surface application. This may be used in conjunction with permanent seed and mulch, to sites where the timely establishment of vegetation may not be feasible, or where vegetative cover is absent or inadequate. Such areas include construction sites where land disturbing activities or winter shutdown prevent establishment or maintenance of a vegetative cover.

Soil Stabilizer, Type B is effective at preventing construction site erosion. This may be especially important where cold weather will likely prevent seed germination, and the site needs to be protected during the winter. This type of application is generally done in conjunction with dormant permanent seeding, followed by an application of mulch. However, if the site will be re-disturbed in the spring the permanent seed application is not warranted.

47.3 Design Guidance

On large grading and land disturbing projects the designer should include this bid item. To estimate the bid quantity application area, include any area that the designer expects to be unvegetated for more than 30 days or estimate how much disturbed area will likely be unvegetated going into winter, and include adequate quantity to cover those areas with soil stabilizer, type B. One way to determine the quantity is to look at the number and anticipated date of mobilizations for erosion control estimated for the project and includes all areas with mobilizations after September 15th. Include all dormant seeded areas in the quantity computation.

Adding mulch to areas treated with Soil Stabilizer, Type B increases the effectiveness. Since Soil Stabilizer, Type B neither increases nor decreases seed germination characteristics, mulch should always be considered a requirement on permanent seed areas, because mulch serves primarily to protect seed from the effects of wind and sun.

Application of Soil Stabilizers, Type B may be particularly effective in the following situations:

- During rough grading operations
- Phased construction projects
- Stockpiles
- After final grading and before paving or final seeding and planting.
- Sites having a winter shutdown.
- Sites receiving final landscaping, but where adequate vegetation cannot be established prior to winter.
- Applied with mulch.

For additional guidance see WisDNR conservation practice standard 1050, Erosion Control Land Application of Polymers. These standards may be found at http://dnr.wi.gov/topic/stormwater/documents/dnr1051.pdf.

Operation and Maintenance

Maintenance should consist of reapplying Soil Stabilizer, Type B to areas subsequently disturbed or graded, to eroded areas, to areas subjected to vehicle traffic, or any other disturbance that breaks the thin protective layer that this practice provides. Soil Stabilizer, Type B may lose its effectiveness in two to six months depending upon weather conditions and ultraviolet light exposure.

FDM 10-10-48 Water Application of Polymers *April 27, 2011*

48.1 Definition

The application of products containing polymers in, or prior to sediment control structures to settle out or remove suspended sediment from water.

48.2 Application

This practice is generally considered incidental to other items of work such as dewatering or would be employed via change order to provide some corrective action to waters contaminated by a construction project. Therefore, a bid item has not been created. In rare cases it could be a special bid item.

This practice shall be used on an emergency or temporary basis with self-contained sediment control structures or settling basins, to restore or improve the sediment removal efficiency of the sediment control structure.

48.3 Design Guidance

Only products meeting the WisDNR conservation practice standard 1051 approval requirements may be used. For questions regarding which products have met these requirements, contact the WisDNR Urban Stormwater Engineer in the Runoff Management Section (http://dnr.wi.gov/topic/stormwater/documents/dnr1051.pdf).

If designers elect to use this as a special bid item, reference must be made to the above approval requirements.

Contractors may only use products receiving a use restriction in Wisconsin by the WisDNR. All materials accepted on the job site shall be accompanied by a copy of the DNR use restriction letter and performance test letter.

In all cases, since this is a practice applied to waterways contact the WisDNR Liaison prior to application.

Where polymer mixtures are used with sediment control structures in a waterway, such as turbidity barrier during bridge construction, the sediment control structure should not be removed until the water is clarified. If the resulting sediment is more than 6 inches deep it may need to be removed.

Where the sediment control structure is not part of a waterway, such as for sedimentation ponds, sediment levels on the bottom should be monitored to measure the loss of storage capacity over time due to the enhanced sedimentation from the polymer mixture.

For additional guidance see WisDNR conservation practice standard 1051, Water Application of Polymers. This standard may be found at http://dnr.wi.gov/topic/stormwater/documents/dnr1051.pdf.

FDM 10-10-49 Intermittent Channels *January 24, 1997*

49.1 Definition

Intermittent channels are temporary or permanent waterways that are shaped, sized, and lined with appropriate vegetation or structural material to safely convey stormwater runoff.

49.2 Application

Intermittent channels are usually man-made channels, such as highway ditches, that are constructed or modified to accommodate flows generated by land development. These channels, whether natural or man-made, are usually the most economical means of collecting and disposing of runoff when concentration of flows cannot be avoided.

49.3 Design Guidance

A well-designed stable channel carries storm water without erosion, does not present a hazard to traffic, and provides the lowest overall construction and maintenance cost.

The size and geometric shape of a channel are important features in determining erodibility.

The design of a channel cross-section and lining is based primarily upon the volume and velocity of flow expected in the channel. Besides the primary design considerations of capacity and velocity, other important factors such as land availability, compatibility with land use and surrounding environment, safety, maintenance requirements, outlet conditions, and the soil erodibility factor should be taken into account when selecting a cross-section and lining.

Designers should refer to FDM 13-30 on how to calculate flow depths based on the amount of water (i.e. discharge) being directed to the area, as well as, how to design alternate channel sections.

The capacity of the channel must be sufficient to convey the 10-year, 24-hour frequency design storm without overtopping the banks. Designers should refer to FDM 13-30 when determining channel capacity and/or the riprap size that will be stable under various flow conditions.

Channels should be designed so that the calculated shear stress of the channel does not exceed the permissible shear stress of the channel lining being used (see FDM 10-5-30 and FDM 10-5-35). Another method that can be used is to design the channel so that the velocity of flow expected from a 2-year, 24-hour design storm does not exceed the permissible velocity for the type of lining used. Permissible velocities for grass-lined channels can be found in FDM 13-30-15.

Roadside ditches generally conform to a standard size and shape that minimizes the shock or impact to errant vehicles and provide a traversable section. Geometric features, such as flat slopes and rounded transitions, help to reduce the erosion potential. Wide channels, such as trapezoidal or parabolic ditches, will generally provide better erosion protection since flow depths are shallower. However, because of their size, right-of-way costs will need to be considered.

Where the quantity of water is relatively small, "V" shaped ditches can be effective. However, because of their shape, flows tend to be more concentrated which causes the channel to be more sensitive to erosion (see FDM 10-5-35).

Grass-lined channels provide good protection against erosion and provide an aesthetic setting for conveyance of runoff. However, the velocity that grass linings can handle are much lower than that which can be withstood other liners such as riprap channel liners. If riprap is chosen, filter fabric should be used to act as a separator and stabilizer between the stone and the earth.

The use of concrete channel liners is not recommended. Concrete channels have a poor maintenance history and are susceptible to damage by undercutting, hydrostatic uplift, freeze/thaw and erosion along the interface between the lining and the natural channel surface.

Outlet protection for all channels must be considered (see FDM 10-10-31). This is particularly important when transitioning from a man-made lining, such as riprap, to vegetation or non-vegetative lining. Appropriate measures must be taken to dissipate the energy of the flow to prevent scour of the receiving channel.

FDM 10-10-51 Sediment Traps and Basins *January 24, 1997*

51.1 Definition

Sediment traps and basins are storage areas provided by either excavation or the provision of a dam or barrier. They are constructed for the primary purpose of trapping and storing sediment and are usually constructed in channels and drainageways on, or downslope, from construction sites. They range in size from small excavated traps with a volume of one cubic yard (0.76 m3) or less to large impoundments with volumes measured in acre-feet (hundreds of m3).

51.2 Application

The location and design of sediment basins is determined by the expected sediment-laden runoff and the degree of downstream protection required. Additional information on design criteria can be found in the applicable chapters of AASHTO's Model Drainage Manual. See FDM 1-1-1 for guidance on ordering AASHTO publications.

See the following attachments in FDM 10-15-5 for example applications.

FDM 10-15 Attachment 5.33 and FDM 10-15 Attachment 5.36, Sediment Trap

FDM 10-15 Attachment 5.37 and FDM 10-15 Attachment 5.38, Sediment Basin

51.3 Design Guidance

51.3.1 Sediment Traps

While some sediment traps can be included in the project erosion and sediment control plans, most are located by the construction project engineer and contractor to meet specific needs that develop during grading operations. The contract documents should ensure that the engineer and contractor have this flexibility. Permanent sediment traps should be bid by standard "excavation" bid items.

These small basins are excavated pits, and they are used effectively in many locations. Common sites are:

1. Around drop inlets.
2. In swales and small ditches.
3. At the outlet of temporary slope drains.
4. In conjunction with ditch checks.

Many applications do not require an outlet drain. Trapped water is removed by evaporation or percolation into the adjoining soil. This percolation must be anticipated and considered in areas where soil saturation could present stability problems. Therefore, in order to protect the structural integrity of the roadway, the use of this type of device is discouraged in close proximity to fill slopes or in areas designated for future pavement.

The length, width and depth of the trap can be varied according to project conditions. However, sediment traps should be limited to drainage areas of 15 acres (6 hectares) or less. In severe areas, a series of traps may be placed. Spacing should be a minimum of 300 feet (91 m) between traps when placed in a series. All traps may be fenced to prevent unwanted access. Questions and a review of the adequacy of proposed installations at critical or sensitive locations should be referred to the District Soils Engineer and/or the District Environmental Section.

These small traps should be located as near the source of sediment-laden waters as possible since they are not designed for large flows. Small basins become filled quite rapidly and must be inspected and maintained after each rainfall.

51.3.2 Sediment Basins

Sediment basins serve the same functions as sediment traps but do so on a larger scale. Sediment basins have a longer design life (the length of the construction project or in some cases are permanent) and, therefore, benefit from individual design effort and good construction practices. These designs usually provide flow control section details utilizing durable construction materials. Basins are located where they will not be affected by later phases of construction and are also designed to be cleaned out as required. In some cases, permanent basins may be converted into small recreational lakes and, therefore, may have to be designed with reference to other agency's specifications.

The location of large sediment basins requiring a dam and spillway structure are generally included in the project plans since they are designed for a specific site and usually require additional right-of-way. These structures can be quite costly, and their need and cost effectiveness must be evaluated. This determination begins in the planning stage with the identification of sediment sensitive downstream conditions. It also involves the evaluation of the use of other measures within the construction area that may be more cost effective.

If a large basin is justified, the site must be reviewed for the most effective placement. This would include consideration of access for necessary cleanout and maintenance of the dam and spillway, disposal of the removed sediment, and a reasonable adaptability of a dam and impoundment to the site.

Large impoundments should be designed with public health, safety, and nuisance abatement in mind. This criterion assumes greater importance when locating a basin in or close to a developed area.

There are three general areas of consideration in the design of sediment basins:

1. Adequate storage volume for expected sediment.
2. Adequate retention to allow settlement of suspended particles.
3. A dam and spillway to accommodate expected flows.

Storage volume requirements can best be determined from past experience at similar sites. It is generally not cost-effective to provide a volume sufficient to contain the total expected sediment runoff from an area during the entire construction life of a project. Therefore, a reasonable length of time between cleanouts should be established and a volume chosen to accommodate this period. This volume must be sufficient to provide for a chosen storm event. In most instances, if the basin provides sufficient retention based on a minimum surface area requirement, an adequate volume is established. The shape and location of the basin must be such to facilitate cleanout and disposal of materials.

Required retention time of a basin is dependent on sediment particle size and the desired percent of removal. It is generally acceptable and practicable to remove 70 to 90 percent of particles larger than the very fine sands having diameters greater than 0.062 mm. Silt and clay-sized particles require excessive retention time, so it is generally not feasible to design a trap to remove them, unless costly chemical flocculent is added. Widely used methods of determining suitable size for retention basins are based on particle settling times or a set runoff volume. The use of baffles in the basin to increase the travel path of particles has met with some success in increasing basin settlement efficiency.

While retention determinations are based on small inflows in the range of a mean annual 25-year event, the spillway must be designed to accommodate a much larger event, since failure could result in release of considerable quantities of stored sediment. Spillway design should be based on an economic assessment of potential damages.

Large sediment basins should be inspected after each storm event to determine if any maintenance is required. This inspection should include a review of the outlet structure and emergency spillway to assure that they are free of debris and functioning properly.

FDM 10-10-55 Safety Fence

January 24, 1997

55.1 Definition

A safety fence is a protective barrier installed to prevent access to an erosion control measure.

55.2 Application

Safety fences are applicable whenever any erosion or sediment control measure or series of measures is considered unsafe because of its potential to be accessed by the public.

55.3 Design Guidance

The safety of the public must always be considered at both the planning and implementation phases of a land-disturbing activity. If there is any question concerning the risk of a particular erosion control measure to the general public, the measure should be relocated to a safer area, or an appropriate safety fence should be installed to prevent undesired access. Plastic (polyethylene) fence is used in situations when a temporary barrier is needed.

Many times, the danger posed by a control may not be easily seen by plan designers and reviewers. Therefore, the on-site contractor or inspector needs to be aware of such situations in the field.

Properly designed and installed safety fences prevent people from trespassing into potentially dangerous areas, (e.g. children using a sediment basin or a storm water retention structure as play areas).

Safety fences should be located so as to create a formidable barrier to undesired access, while allowing for the continuation of necessary construction operations. They are usually installed when constructing sediment traps, basins or dams. In use with those structures, safety fences should be located far enough beyond the outer toe of the embankment to allow for the passage of maintenance vehicles. Fences should not be installed across the slope of a dam or dike.

A standardized special provision is available for safety fence (refer to standardized special provisions web site (https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/tools/stsp.aspx). The fence should never be so short as to become an attraction for children to climb over it.

Signs noting potential hazards such as "DANGER-QUICKSAND" or "HAZARDOUS AREA-KEEP OUT" should be posted where they can be easily seen by anyone approaching the protected areas.

FDM 10-10-57 Other Devices

May 15, 2006

57.1 Pipe Down Drains

Pipe down drains, also referred to as "slope drains", and are used to help direct runoff down a slope at a specific location. They are usually used in conjunction with diversion dikes, intercepting embankments, or temporary fill diversions. Also, they are used in place of paved ditches; on long, steep runs in sandy soil; or in cut to fill transition sections. Corrugated metal pipe should be used, with collars (cut-off walls) placed at intervals along the pipe to prevent piping and/or slippage. Endwall protection should be provided at both entrance and discharge ends. In addition, an energy dissipater is necessary at the outlet end to protect the area from erosion and scour.

See FDM 10-15 Attachment 5.39 for an example of a slope drain.

57.2 Preformed Apron Endwalls

Preformed apron endwalls should be used on all culvert pipes, except for special cases. Endwalls are used on both ends of cross drains, side road drains, median drains, and private entrances. For details on preformed apron endwalls for culvert pipes and pipe arches, see the standard detail drawings, https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/rdwy/sdd.aspx.

57.3 Mortar Rubble Masonry or Concrete Masonry

Mortar rubble masonry or concrete masonry should be used for end protection on cattle passes and for special cases such as multiple pipe installations or on pipes where preformed endwalls would not provide the proper inlet or discharge characteristics. For mortar rubble masonry details, see the standard detail drawings.

57.4 Anti-Seepage Collar

Anti-seepage collars are used to prevent the movement of water along the outside of the culvert and the failure by washout of the fill next to the culvert. They are used in sandy fills where the culvert is under high head.

Collars are located at the midpoint and upper quarter on long box culverts. If only one collar is used, it is located far enough from the inlet to prevent seepage over the top of the collar.

A typical collar applicable to all single and twin box structures and corrugated metal pipes is shown in the Bridge Manual 8.4.

An alternate method of preventing seepage would be to use a minimum one-foot thick impervious soil blanket around the culvert inlet, extending five feet over the undisturbed embankment. The same effect can be obtained by designing seepage protection into the endwalls.

57.5 Weep Holes

The need for weep holes should be investigated for clay type soils with high fills and should be eliminated in other cases.

If weep holes are necessary, alternate layers of fine and coarse aggregate should be placed around the holes, starting with coarse aggregate next to the hole.

57.6 Scour Hole

Since it is difficult to estimate the erosion potential at the outlets of proposed culverts, it is best to do a field inspection of the proposed site. This site inspection, along with soil information and maintenance histories of existing structures in similar environments, can be used to estimate the local scour potential.

The U.S. Army Corps of Engineers has developed a method for computing the size of a scour hole when the downstream streambed is composed of easily erodible sand. This is an extreme erosion case, which may be used as a yardstick for evaluating the erosion potential at a culvert outlet. For further details on evaluating the erosion potential at a culvert outlet, see FHWA's Hydraulic Engineering Circular (HEC) No. 14, "Hydraulic Design of Energy Dissipaters for Culverts and Channels", 1975.

57.7 Flumes

Flumes are used at critical locations on back slopes to carry water from intercepting embankments to roadside ditches. These flumes are normally constructed of sod, but large volumes of water over steep slopes may require the use of erosion mat or grouted riprap, or pipe down drains. Flumes should be spaced so as to prevent large concentrations of water.

See FDM 10-15 Attachment 5.6 – 5.9 for examples of flumes.

Refer to the standard detail drawing for sodded back slope flume and intercepting embankment details.

57.8 Gabions

Gabions are large, multi-celled, rectangular wire mesh boxes filled with rock to form flexible monolithic building blocks. They are used as erosion control structures in channels, revetments, retaining walls, abutments, check dams, etc. Erosion control construction design should ensure the following:

1. The foundations are properly prepared to receive gabions.
2. The gabion structure is securely "keyed" into the foundation and abutment surfaces.
3. The rock used is durable and adequately sized to be retained by the baskets.

Maintenance entails periodic inspections of the transition areas for evidence of undercutting or inordinate erosion.

57.9 Bin Type Retaining Walls

Bin type retaining walls are a system of closed-face bins filled with soil to act as a gravity type retaining wall. They are used to construct roadways within narrow rights-of-way, to protect stream and lakeshores from erosion, to construct wingwalls on bridge abutments or headwalls for large drainage structures, etc.

57.10 Sheeting

Sheeting is a lining of wood or steel driven into the subsoil and used to support an embankment or the walls of an excavation. It may be used as a permanent or temporary installation. Some typical applications for sheeting include shore protection, trench protection, low retaining walls, check dams, wash checks, jetties, lagoon baffles, and wingwalls.

57.11 Structure Protection

57.11.1 Surface Drains

Runoff from bridge decks can cause serious erosion of earth embankments around abutments. Normal protection consists of a concrete surface drain inlet to carry the deck runoff to a corrugated metal pipe buried under the embankment. This pipe carries the water down the slope and discharges it onto a concrete, mortar rubble, or riprap apron at the toe of the slope. The apron is generally designed to act as an energy dissipater.

See FDM 10-15 Attachment 5.40 for an example of a surface drain.

57.11.2 Slope Paving

Slopes under grade separation structures are usually protected with either cast-in-place slope paving or concrete, asphalt-treated, gravel or crushed stone slope paving in accordance with the bridge standard drawings in the Bridge Manual.