

WISCONSIN CONSTRUCTION SPECIFICATION

20. Soil Bioengineering

1. SCOPE

The work shall consist of selecting, harvesting, and installing live, dormant, or rootable vegetative cuttings into the ground creating a living root mat that stabilizes the soil by reinforcing and binding soil particles together.

2. LIVE MATERIALS

- a. Live stakes – The stakes generally are 0.5 to 2.0 inches in diameter and 1.5 to 4 feet long. They should be long enough to be tamped sufficiently into the ground. The materials must have side branches cleanly removed with the bark intact. The basal ends should be cut at an angle or point for easy insertion into the soil. The top should be cut square.
- b. Live fascines – Live fascines are bundles of long, thin, straight, live branch cuttings, normally 5 to 30 feet in length bound together in cylindrical structures. The materials must have side branches cleanly removed with the bark intact. The completed bundles should be 6 to 8 inches in diameter, with all of the growing tips oriented in the same direction. Stagger the cuttings in the bundles so that tops are evenly distributed throughout the length of the uniformly sized live fascine.
- c. Live Branches – Live branches may range from 0.5 to 2.0 inches in diameter. They should be long enough to achieve their intended purpose, normally 4 to 9 feet long. The side branches shall not be trimmed (brushy material).
- d. Dormant post plantings – Cut live rootable vegetative posts approximately 7 to 9 feet long and 3 to 5 inches in diameter. The materials must have side branches cleanly removed with the bark intact.
- e. Preparation of Materials
 - i) Harvesting
 - (a) Materials should be harvested when the plants are dormant.
 - (b) Live, healthy materials shall be obtained from specified sources or sources approved by the Technician (local or native source preferred).
 - (c) The materials shall be taken from vigorous, undamaged, disease and insect free stock.
 - (d) All cuts must be clean with no splits. The cutting tools should be appropriately sized for the material being cut.
 - (e) The cutting length should be long enough to reach the lowest water table at the site during the growing season.
 - ii) Storage – If materials are not installed 24 hours after they are harvested, the cuttings must be stored in a dark, moist, and cool environment until planting. (For the best chance of success, plant the material within 5 to 7 days after harvest.)
 - (a) Short Term: Cutting planted within 5 to 7 days shall not be allowed to dry out.

- (b) Long Term: The temperature should be maintained between 34 and 40 degrees Fahrenheit. Cutting can be stored for several months if the above conditions are maintained. If cuttings are stored at higher temperatures, a fungicide should be applied to prevent damage caused by pathogens and saprophytes.

iii) Pre-plant Soaking of Cuttings

Prior to planting, all cuttings shall be soaked for a minimum of 24 hours. Only the portion of the cutting that will be below ground needs to be soaked. Soaking the entire cutting is not detrimental. Soaking can be accomplished in a garbage can, stream, pond, lake, or any body of water that is deep enough as long as the cuttings are protected from sun and wind exposure.

3. INERT MATERIALS

- a. *Dead stout stakes* shall be a minimum 2.5-foot long, untreated, 2-inch by 4-inch lumber. Each length should be cut again diagonally across the 4-inch face to make two stakes from each length. Only new, sound lumber shall be used, and any stakes that shatter upon installation should be discarded.
- b. *String* used for bundling should be untreated twine free from preservatives.
- c. *Smooth wire* shall be 16-gauge wire. The wire shall be new and free from rust and defects.
- d. *Geotextile materials* shall meet the required class in Wisconsin Construction Specification 13, Geotextiles.
- e. *Wooden stakes* should be 5 to 8 feet long and made from 3- to 4-inch diameter poles or 2- by 4-inch lumber, long enough to be driven vertically 3 to 4 feet into the undisturbed ground.
- f. *Wooden timbers* should be: 4- to 8-inch diameter logs or square wooden timbers. Peeled logs are typically more resistant to rot than logs with bark. Timbers such as eastern white cedar, red pine, jack pine, or spruce should be utilized.
- g. *Rebar or spikes* should be 3/8 to 1/2 inch diameter for securing logs.

4. SITE PREPARATION

Grade the bank to the slope specified in the construction plan.

5. PLACEMENT

Treatment measures should be installed in the locations shown on the construction drawings. Several treatments may be installed in combination to achieve the desired conditions.

a. Live Stakes

- i) Erosion control fabric should be placed on slopes if shown on the construction drawings.
- ii) Placement should be made in the locations shown on the construction drawings. The buds should be oriented in the upward position.
- iii) Tamp the live stake into the ground at right angles to the slope with a dead blow hammer.
- iv) The live stakes should be installed 2 to 3 feet apart using triangular spacing. The density of the installation will range from 2 to 4 stakes per square yard.
- v) Four-fifths of the length of the live stake should be installed into the ground, and soil should be firmly packed around it after installation.
- vi) Do not split the stakes during installation. Stakes that split should be removed and replaced.
- vii) An iron bar can be used to make a pilot hole in firm soil.

b. Branchpacking

- i) Starting at the lowest point, drive the wooden stakes vertically 3 to 4 feet into the ground. Set them 1 to 1.5 feet apart.
- ii) Place an initial layer of living branches 4 to 6 inches thick in the bottom of the hole between the vertical stakes, and perpendicular to the slope face. They should be placed in a criss-cross configuration with the growing tips generally oriented toward the slope face. Some of the basal ends of the branches should touch the undisturbed soil at the back of the hole.
- iii) Subsequent layers of branches are installed with the basal ends lower than the growing tips of the branches.
- iv) Each layer of branches must be followed by a layer of compacted soil to ensure soil contact with the branches.
- v) The final installation should conform to the existing slope. Branches should protrude only slightly from the filled installation.
- vi) Divert over bank water from the new branch packing installation.
- vii) Seed and mulch area between brush layers.
- viii) Brushpacking layers should be 3 to 5 feet apart

c. Brush Layering

- i) Remove loose, failed, or failing soil from face of the bank.
- ii) Excavation and installation begins above a stable toe structure.
- iii) Excavate benches on contour, 2 to 3 feet wide.
- iv) Benches should be sloped approximately 15 to 25 degrees down from the front outer edge to the back excavation into the bank .
- v) Place branches in an over-lapping criss-cross configuration. Typically 12 to 24 stems per foot of constructed bench (measured on the contour) depending upon the size of material and branching.
- vi) Orient the stems such that the basal ends touch the back of the undisturbed excavated bank. Approximately ¼ of the branch stem should extend beyond the completed bank face.
- vii) Install the brushlayer in three courses: Live cut branch layer 1 orients to the left, Layer 2 orients to the right, and the final layer is installed straight out. Between each layer of branches a few inches of soil should be placed. This soil layer should be compacted by foot or a manually directed tamper to remove air pockets. In rare circumstances, ameliorated soil (soil that has been nutrient tested and fertilizer, lime, etc., has been added to enhance growth) may be used in these layers. Each course has 5 to 15 live cut branches. The completed brushlayer measure is made up of 15 to 45 branches per foot. The determination of density is made according to the amount of available sunlight, soils, steepness, moisture, and live cut branch material available. Repeat until desired thickness is reached. Use the soil material from the next, upbank terrace to fill the one beneath.
- viii) Trim the terminal bud so that stem energy will be routed to the lateral buds for more rapid root and stem sprouting.
- ix) Construct at spacing shown in Table 1.

Table 1: Brush Layer Spacing

Slope Steepness	Slope Distances Between Benches		Maximum Slope Length (Feet)
	Wet Slopes (Feet)	Dry Slopes (Feet)	
2.0:1 to 2.5:1	3	3	15
2.5:1 to 3.0:1	3	4	15
3.0:1 to 4.0:1	4	5	20

d. Live Fascines (Wattles)

- i) Tie the live fascine bundle immediately before installation. Tie the bundles at 12 to 15 inch intervals.
- ii) Beginning at the base of the slope, dig a trench on the contour approximately 10 inches wide and deep.
- iii) Excavate trenches up the slope at intervals specified in Table 2.
- iv) Install erosion control fabric and secure as per manufacturer recommendations.
- v) Place the live fascine into the trench.
- vi) Drive the dead stout stakes 2 to 3 on-center directly through the live fascine. Bundles shall be overlapped 12 inches. Extra stakes should be used at bundle overlaps. Leave the top of the dead stout stakes flush with the installed bundle.
- vii) Live stakes are generally installed on the down slope side of the bundle. Tamp the live stakes below and against the bundle between the previously installed dead stout stakes, leaving 3 inches to protrude above the top of the ground.
- viii) Place moist soil along the sides of the bundles. The top of the live fascine should be slightly visible when the installation is completed.

Table 2: Live Fascine Spacing

Slope Steepness	Slope Distance Between Trenches (Feet)	Maximum Slope Distance (Feet)
1.0:1 to 1.5:1	3-4	15
1.5:1 to 2.0:1	4-5	20
2.0:1 to 2.5:1	5-6	30
2.5:1 to 3.0:1	6-8	40
3.0:1 to 4.0:1	8-9	50
4.0:1 to 5.0:1	9-10	60

e. Vegetated Geogrids

- i) Excavate a trench that is 2 to 3 feet below the streambed or lakebed elevation and 3 to 4 feet wide. Place the geotextile in the trench, leaving a foot or two overhanging on the streamside/lakeside face. Fill this area with rocks 2 to 3 inches in diameter.
- ii) Beginning at the bankfull elevation/ordinary high water mark, place a 6- to 8-inch layer of live branch cuttings on top of the rock-filled geogrid with the growing tips at right angles to the streamflow/parallel to the wave direction. The basal ends of branch cuttings should touch the back of the excavated slope.

- iii) Cover this layer of cuttings with geotextile leaving an overhang. Place a 12-inch layer of soil suitable for plant growth on top of the geotextile before compacting it to ensure good soil contact with the branches. Compaction may be done with equipment or by hand tamping. Wrap the overhanging portion of the geotextile over the compacted soil to form the completed geotextile wrap.
 - iv) Continue this process of excavated trenches with alternating layers of cuttings and geotextile wraps until the bank is restored. The top layer may be a non-wrapped topsoil layer
 - v) The final installation should match the existing slope. Branch cuttings should protrude only slightly from the geotextile wraps.
- f. Live Cribwall – Live cribwalls may be pre-built or built at the stabilization site. Materials:
 - i) Front and rear long beams should be 20 feet long.
 - ii) Cross beams should be 6-7 feet long.
 - iii) Starting at the base of the streambank to be treated, excavate 2 to 3 feet below the existing streambed until a stable foundation 5 to 6 feet wide is reached.
 - iv) Excavate the back of the stable foundation (closest to the slope) 6 to 12 inches lower than the front to add stability to the structure.
 - v) Place the first course of logs or timbers at the front and rear of the excavated foundation, approximately 4 to 5 feet apart and parallel to the slope contour.
 - vi) Place the next course of logs or timbers at right angles (perpendicular to the slope) on top of the previous course to overhang the front and back of the previous course by 3 to 6 inches. Each course of the live cribwall is placed in the same manner and secured to the preceding course with spikes or reinforcement bars.
 - vii) Place rock fill in the openings in the bottom of the crib structure until it reaches the approximate existing elevation of the streambed. In some cases it is necessary to place rocks in front of the structure for added toe support, especially in outside stream meanders.
 - viii) Place the first layer of cuttings on top of the rock material at the baseflow water level, and change the rock fill to soil fill capable of supporting plant growth at this point. Ensure that the basal ends of some of the cuttings contact undisturbed soil at the back of the cribwall.
 - ix) When the cribwall structure reaches the existing ground elevation, place live branch cuttings on the backfill perpendicular to the slope, then cover the cuttings with backfill and compact.
 - x) Live branch cuttings should be placed at each course to the top of the cribwall structure with growing tips oriented toward the slope face. Follow each layer of branches with a layer of compacted soil. Place the basal ends of the remaining live branch cuttings so that they reach to undisturbed soil at the back of the cribwall with growing tips protruding slightly beyond the front of the cribwall.

- g. Joint Planting (geotextile integrity should not be compromised)
 - i) Tamp live stakes into the openings of the rock during or after placement of riprap. The basal ends of the material must extend into the backfill or undisturbed soil behind the riprap.
 - ii) A steel rod or hydraulic probe may be used to prepare a hole through the riprap.
 - iii) Orient the live stakes perpendicular to the slope with growing tips protruding slightly from the finished face of the rock.
 - iv) Place the stakes in a random configuration.
- h. Brushmattress
 - i) Grade the unstable area of the streambank/shoreline uniformly to a maximum steepness of 3:1.
 - ii) Tie the live fascine bundle immediately before installation.
 - iii) Beginning at the base of slope, near the streamforming flow stage/bank lip, excavate a trench on the contour large enough to accommodate a live fascine and the basal ends of the branches.
 - iv) Install an even mix of live and dead stout stakes at 1-foot depth over the face of the graded area using 2-foot square spacing.
 - v) Place branches in a layer 1 to 2 branches thick vertically on the prepared slope with basal ends located in the previously excavated trench.
 - vi) Stretch No. 16 smooth wire or strong biodegradable twine diagonally from one dead stout stake to another by tightly wrapping wire around each stake no closer than 6 inches from its top.
 - vii) Tamp and drive the live and dead stout stakes into the ground until branches are tightly secured to the slope.
 - viii) Place live fascines in the prepared trench over the basal ends of the branches.
 - ix) Drive dead stout stakes directly through into soil below the live fascine every 2 feet along its length.
 - x) Fill voids between brushmattress and live fascine cuttings with thin layers of soil to promote rooting, but leave the top surface of the brushmattress and live fascine installation slightly exposed.
- i. Live Siltation Construction (Lakeshore)
 - i) Beginning at the toe of the shoreline bank to be treated, excavate a trench 2 to 3 feet deep and 1 to 2 feet wide, with one vertical side and the other angled toward the shoreline. The maximum length water ward is shown on the construction drawings.

- ii) Ideally live siltation systems are approximately perpendicular to the prevailing winds. The branch tips should slope upwards at 45 to 60 degrees.
- iii) Parallel live siltation rows should vary from 5 to 10 feet apart, as shown on the construction drawings.

6. SITE EROSION CONTROL

Practices shall be installed, or the work performed in such a manner that will minimize site erosion, and the production of sediment. They include but are not limited to project staging, diversions, waterways, seeding, mulching, sediment basins, in channel sediment control, and silt fence