Cellular Confinement Systems

DRAINAGE CONTROL TECHNIQUE

Low Gradient		Velocity Control		Short Term	✓
Steep Gradient	✓	Channel Lining	✓	Medium-Long Term	✓
Outlet Control		Soil Treatment		Permanent	✓

Symbol

Photo 1 – Expandable, perforated sidewall, cellular confinement system

Photo 2 – Cellular confinement system integrated with rock mulching used as a form of erosion control

Key Principles

1. Critical design parameter is the allowable shear stress or allowable flow velocity for the contained material (e.g. rock mulch). This design parameter will decrease with increasing bank/channel slope. Thus bank slope is a critical component in material stability when surface flow is possible.
2. It is critical to ensure the upper surface of the cellular confinement system (CCS) is set flush with, or slightly lower than, the adjacent terrain to avoid the approaching surface flow being diverted along the up-slope edge(s) of the matrix. This includes any lateral inflow that may enter the chute.

Design Information (for information on erosion control applications, refer to separate Erosion Control fact sheet on Cellular Confinement Systems)

Step 1 Determine the type of cell wall: smooth, textured, or perforated. Textured or perforated surfaces are required when the CCS matrix is installed with a concave profile that may cause the matrix to lift from the ground. Perforated cell walls are required when the CCS matrix is to be grassed on channel banks or chutes steeper than 10%. Textured surfaces are used with non-vegetated aggregate, and concrete infill.

Step 2 Determine the design shear stress or average flow velocity of the water passing down the treated surface. Consult manufacturer for design of cell depth and infill material. A general guide (non-critical locations) is provided in Table 1.

Table 1 – General recommendations on infill material (non-critical locations)

Infill material	Peak flow velocity (m/s)	Maximum duration of near peak flow conditions
13mm aggregate (d_{10}) [1]	0.6m/s	N/A
65mm aggregate (d_{10}) [1]	1.2m/s	N/A
100 to 150mm aggregate [2]	1.8m/s	N/A
Vegetated (grassed) earth	1.0m/s	50 hours
Vegetated (grassed) earth	3.0m/s [3]	10 hours
Concrete with 100mm cell depth	6.0m/s	N/A
Concrete with 150mm cell depth	7.0m/s	N/A

[1] d_{10} represents approximately the minimum rock size (actually: the size of which 10% is smaller)

[2] Minimum 150mm cell wall depth.

[3] Maximum design velocity should **not** exceed 2m/s for grass unless well maintained, 100% coverage, mat-forming (Kikuyu, Pangola) grasses exist on erosion-resistant, infill soil.

Step 3 Specify the required cell opening size and cell wall depth. Table 2 provides general recommendations. In critical locations, always confirm cell size and depth with manufacturer's advice.

Table 2 – Recommended <u>minimum</u> cell size and depth (non-critical locations)

Location	Cell opening size	Cell wall depth
Slopes flatter than 26 degrees (<2:1, 50%)		75mm
Slopes steeper than 26 degrees (>2:1, 50%)		100mm
Vegetated chutes/channels	200 x 200mm	
Arid and semi-arid areas		100mm [1]

[1] Greater depth may be required in certain conditions – seek expert advice.

Step 4 If the CCS-lining in the chute follows a curved (concave) profile as shown in Figure 1, then design a suitable anchorage system as to prevent the honeycomb matrix lifting from the ground.

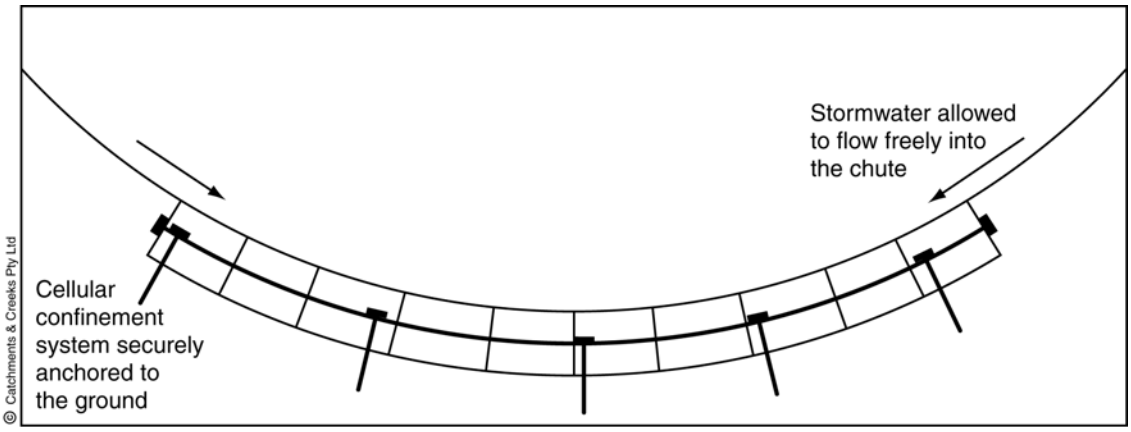

Figure 1 – Placement of cellular confinement system within a chute with concave profile

Description

Expandable, three-dimensional, open honeycomb-like mesh manufactured from a synthetic material and filled on-site with soil, sand, small rocks, or low slump concrete.

Products manufactured from rigid, high-density polyethylene (HDPE) are generally preferred for placement within drainage channels and chutes.

Some products have pre-drilled drainage holes to allow the lateral movement of surface groundwater and to increase the shear resistance of the mesh to uplifting forces. The latter reduces the risk of the product lifting from the ground when placed over a concave surface.

Purpose

Used for the lining of temporary, low to medium velocity *Diversion Channels* and *Chutes*.

Can be used as an alternative to concrete reinforcing in temporary drainage chutes such as the emergency spillway of a *Sediment Basin*.

Can also be used as part of a vegetated structural soil for the lining of permanent dam and basin bywash/spillway chutes.

Can also be used as a form of erosion control and for the stabilisation of temporary watercourse crossings (refer to appropriate erosion control fact sheet).

Limitations

In areas of high flow velocity, cellular confinements systems filled with non-vegetated small rocks are generally not a suitable replacement the appropriate placement of suitable large rock.

Advantages

May be used as an alternative to traditional rock armouring in areas that have limited supply of suitable large rock.

Long-term stability is not necessarily dependent on the establishment of vegetation; however, the incorporation of vegetation generally results in a significant increase in the allowable shear stress.

Easy to transport.

Disadvantages

Displacement of the infill material can occur on an ongoing basis if not suitably stabilised with vegetation.

Common Problems

The mesh can lift from the channel surface when placed on a concave surface and inadequately anchored.

Can promote waterlogging of the ground unless adequate drainage exists.

Special Requirements

The mesh needs to be well anchored if placed on a concave surface.

Required good surface preparation with the removal of all major surface irregularities.

Location

Surface lining of low to medium velocity *Chutes* and dam/basin spillways.

Site Inspection

Check for the displacement of infill material.

Ensure cellular grid is not lifting from the ground.

Ensure surface flow can freely enter the CCS-lined area. Check for water scour along the up-slope edges of the matrix.

Check for successful vegetation cover (if required).

Material

- Cellular confinement matrix: high-density polyethylene (HDPE) (stiff cell wall).
- Tendons: steel cable, or bright, high-tenacity, industrial-continuous-filament polyester yarn woven into round braided cord.
- Anchors: wooden stakes, or 500mm steel J-pins. Wooden takes used only as a temporary anchor during the placement of the infill material.
- Infill: topsoil, earth, aggregate or concrete. Maximum aggregate size no greater than 75% of the sidewall depth of the CCS matrix.

Installation

The following specification applies to the surface placement of a cellular confinement system within a drainage channel, spillway or chute for temporary purposes only. For the placement of permanent installation, or earth reinforcement applications, refer to manufacturer's advice.

1. Refer to approved plans for location, extent, and application details. If there are questions or problems with the location, extent, or method of application contact the engineer or responsible on-site officer for assistance.
2. Clear the treatment area of any debris that may interfere with placement of the cellular confinement system (CCS), or prevent good contact between the CCS matrix and the subgrade.
3. Ensure the surface is free of deep track marks of other features that may result in stormwater or groundwater passing in a concentrated form under the CCS matrix.
4. Shape and compact the subgrade surfaces to the shape and elevation shown on the Construction Drawings. When determining the elevation of the subgrade, ensure allowance is made for the thickness of the CCS matrix such that the top of the matrix will be flush with, or slightly lower, than the adjacent terrain.
5. Where necessary, excavate the subgrade such that when placed, the upper surface of the CCS matrix will be flush with, or slightly lower, than the adjacent terrain.
6. Remove any unstable subgrade, replace with suitable material and compact to achieve a stable surface.
7. If the material is to be placed on a slope steeper than 10%, then excavate an anchoring trench along the top of the treatment area 200mm deep and 500mm wide.
8. Where practical, roughen any excessively smooth, compacted subgrade to improve the eventual bonding between the subgrade and applied CCS matrix.
9. If specified, install the required geotextile underlay on the prepared surface, ensuring that required overlaps are maintained and that the upper edge of the geotextile is anchored (pinned) within the formed anchoring trench.
10. Spread out (expand) individual panels uniformly across the treatment area as specified by the manufacturer. Expand and stretch the panels down the slope instead of across the slope.
11. Along the top edge of the treatment area, anchor every other cell into the formed anchor trench using steel U-shaped or J-pins.
12. On slopes steeper than 10%, anchor every other cell using steel J-pins at 2m intervals down the slope.
13. On slopes not steeper than 10%, anchor the individual panels along all four sides with wooden stakes, or steel J-pins to prevent movement while placing infill.
14. Interleaf or overlap the edges of adjacent panels according to which sidewall profile abuts. In all cases, ensure that the upper surfaces of adjoining panel sections are flush at the joint and that adjoining cells are fully anchored (stapled).
15. Fill and compact (if necessary) the anchoring trench.
16. Fill the honeycomb panels mechanically or manually. Ensure earth fill and small aggregate (<75mm) is placed from a drop height not exceeding 1m, and large aggregate (>75mm) from a drop not exceeding 0.15m.
17. Place the fill evenly and slightly overfill such that when compacted, the fill will be level with the upper surface of the panel.
18. Lightly tamp or roll topsoil or earth fill, level aggregate fill with a plate tamper or mechanical (backhoe) bucket.

Additional specification for attachment of tendons for anchorage:

1. Feed pre-cut lengths of tendon material through the aligned holes in the cell walls of the matrix at 800mm intervals prior to expanding individual panels into position.
2. Tie off the ends of the tendons so that the knot cannot pass through the hole in the cell walls. Ensure the knots are tied to provide full tendon strength and will not slip when tensioned.
3. Attach restraining clips to the tendons at regular intervals to achieve the necessary load transfer.
4. Anchor the tendons and restraining clips with 500mm steel J-pins at 1m intervals. At each internal anchor location, form a loop in the tendon, insert the anchor, and drive into the subgrade.