NCMA TEK

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ARTICULATED CONCRETE BLOCK FOR EROSION CONTROL

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Pavers (2004)

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INTRODUCTION

An articulated concrete block (ACB) system is a matrix of individual concrete blocks placed together to form an erosion-resistant overlay with specific hydraulic performance characteristics. The system includes a filter layer underlay that allows infiltration and exfiltration to occur while providing particle retention of the soil subgrade. The filter layer may be comprised of a geotextile or properly graded aggregate or both. The blocks within the matrix must be dense and durable while providing a matrix that is flexible and porous.

Articulated concrete block systems are used to provide protection to underlaying soil materials. The term "articulated" implies the ability of individual blocks of the system to conform to changes in subgrade while remaining interlocked or otherwise restrained by virtue of the block geometric interlock and/or additional system components such as cables, ropes, geotextiles, or geogrids. The interlocking property provided by the special shapes of ACBs also allow for expansion and contraction. They are either hand-placed or installed as preassembled mats on top of a filter layer on prepared subgrade, and act as a soil revetment.

Articulated concrete blocks (ACBs) are an effective erosion control system used to solve a wide variety of erosion problems:

- drainage channels
- river fronts
- coastal shorelines
- pipeline protection
- boat ramps
- lake shorelines
- low water crossings
- wildlife habitat
- bridge abutments / piers
- dikes and levees
- spillways
- retention basins
- overflow channels
- dam overtopping

The systems are easy to install, simple to produce, and environmentally friendly. ACB systems are often used as an alternative to cast-in-place concrete bulkheads and slope paving, gabions, soil cement, roller compacted concrete, or rock riprap. ACBs can also be used as grid pavers. However, grid pavers manufactured according to ASTM C 1319 are not considered ACBs.

Articulated concrete blocks are produced in accordance with ASTM D 6684 (ref. 3). They can be made in a variety of shapes and thicknesses, and may even be colored according to preference. ACBs have excellent resistance to hydraulic shear and overtopping conditions. Federal studies and guidelines are available to design engineers (ref. 2).

One of the environmental benefits of ACB erosion

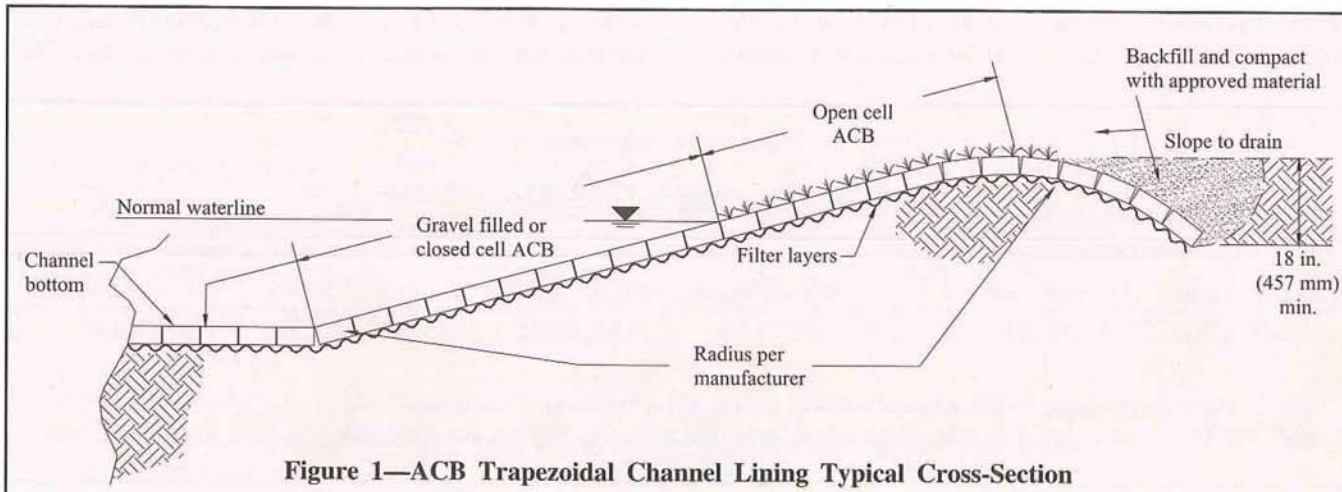

Figure 1—ACB Trapezoidal Channel Lining Typical Cross-Section

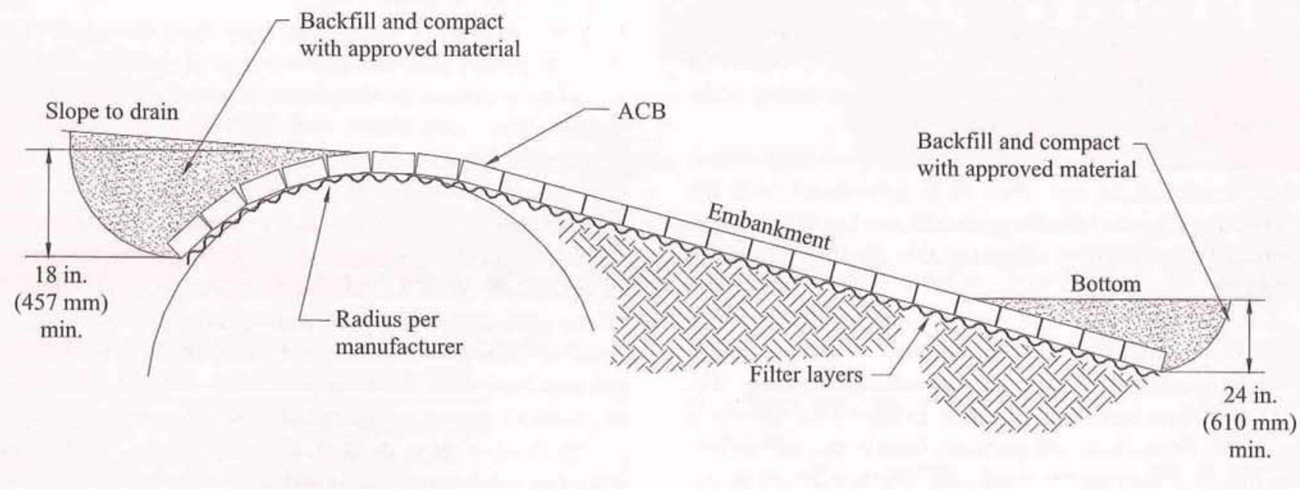

Figure 2—ACB Embankment Typical Cross-Section

typical block layout is oriented in the application's centerline position. These blocks make it possible to install ACBs in areas that are restrictive to large construction equipment.

ACBs without cables can be suited to projects where complex site geometries and limited access are present. These non-cabled ACBs offer comparable shear resistance and some systems offer a higher percentage of open surface area when desired. These blocks are typically delivered in palletized cubes and are hand-placed at the job site. Since there are no cables involved, the material costs can be considerably less. ACBs without cables can be constructed in virtually seamless fields.

DESIGN CONSIDERATIONS

Existing and proposed project characteristics combined with the hydraulic design objectives will determine, through a factor of safety analysis, the ACB product that will best serve the project's erosion control needs. A 1.5 factor of safety is common.

Guidelines for the selection and design of the appropriate ACB product are provided by the Federal Highway Administration (FHWA) publication – *Hydraulic Engineering Circular 23* (ref. 2) and NCMA TEK 11-12 *Articulating Concrete Block Revetment Design - Factor of Safety Method* (ref. 1). The publication presents a procedure to develop hydraulic design criteria given the hydraulic testing performance data for an ACB product.

The hydraulic forces which are considered in the design of erosion control projects using this technology are hydraulic lift, drag, and impact. High velocity flows are usually associated with drainage channels, water control structures, dam spillways, and fast flowing rivers. While many of the forces created by water can be readily calculated, particularly uplift and drag, each project application has separate design considerations.

ACBs are not designed to add structural strength to the

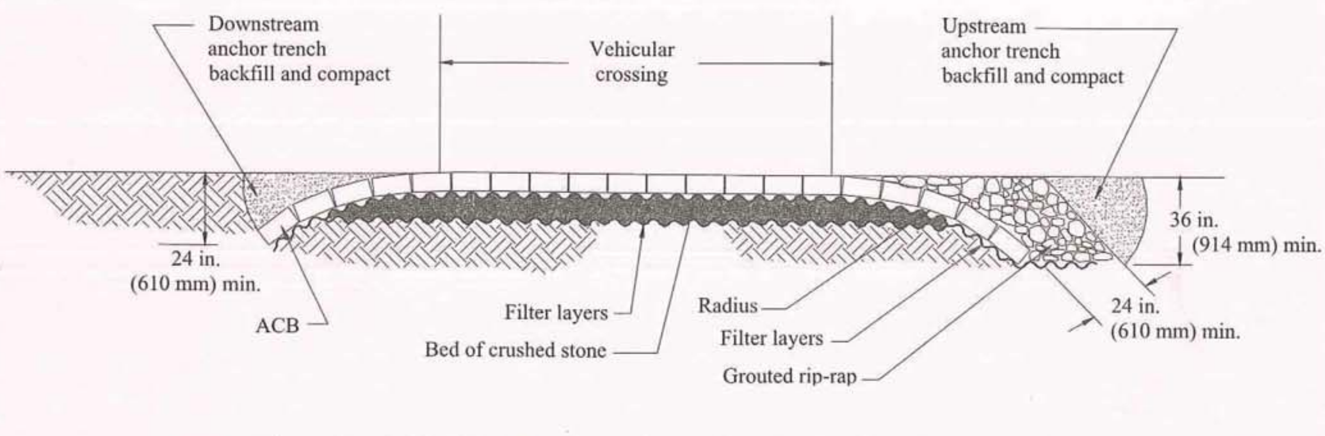

Figure 3—ACB Boat Ramp or Creek Crossing Typical Cross-Section

control systems is that vertical cores and spaces can be incorporated in the blocks throughout the system, which allow vegetation to grow. Properly selected plant species can almost completely cover the entire hard surface of the ACBs, allowing them to blend in with the natural look of the project. During peak storm events, the ACB layer beneath the vegetation will protect the soil from erosion. The ability to support the ecosystem's habitat is a major advantage of ACB systems over other erosion control methods. Additional advantages of ACB systems are:

- serviceability
- pedestrian safety
- cost effectiveness
- aesthetics
- ecological
- flexibility

ACB UNITS

ACB units complying with ASTM D 6684 (ref. 3) are produced as dry-cast (in a block machine) or wet-cast (with concrete and molds). Sampling and testing of dry-cast ACB units are performed in accordance with ASTM C 140 *Standard Test Method for Sampling and Testing Concrete Masonry and Related Units* (ref. 6) for conformance with the requirements in Table 1. Sampling and testing of wet-cast units is performed in accordance with ASTM C 39, *Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens* (ref. 4) and ASTM C 42 *Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete* (ref. 5).

ACB INSTALLATION

Articulated concrete blocks can be installed by small construction crews with a modest amount of equipment. Installations are fast and are easy to inspect due to the visibility of all components.

ACBs are installed on top of a layer of filter layer over a prepared subgrade. The filter acts to protect and hold the subgrade in place while allowing bi-directional water penetration. Final subgrade elevation should be 0 to + ½ in. (12.7 mm) under a 10 ft. (3.05 m) straight edge. After the ACB installation is complete, the open cell voids or closed cell joints in the ACB units are filled with granular material or soil. Unit to unit vertical offset should be limited to the value utilized in the design. If vegetation is required, hydraulic seeding or mulching provides a low cost and highly effective method of establishing commonly used grasses and plants. In applications subject to continually flowing water, solid units should be used below the normal waterline or the voids of hollow units should be filled with gravel.

Installation methods depend on whether the ACB product being used is classified as cabled or as non-cabled.

Cabled Articulated Concrete Mats

Cabled interlocking blocks have preformed horizontal holes cast in them so that high-strength cables or ropes (synthetic or steel) can be installed through the matrix of blocks binding them into a monolithic mattress. The cables or ropes are used to facilitate placement of the mat, normally by a spreader bar and crane.

The blocks are preassembled into cabled mats in a controlled environment on or off the job site. The mats are lifted by the cables' end loops, placed on the back of a flatbed truck, and shipped to the job site where they are again lifted and placed on the prepared slope. The mats can also be fabricated on site near the prescribed area, eliminating the need for additional trucking. The assembly of the blocks into mats makes it possible to install these systems underwater and on steep slopes.

Several commercially available cable systems can be manually placed on a shoreline or channel, and the cables then hand-inserted through the holes. However, for design purposes, cables offer no hydraulic stability or structural value to the ACB mat or block system. An advantage of this process is that revetments with less seams can be constructed. Also, it is easier to hand-place the blocks around a radius or projection on a sloped bank, such as a culvert outlet. To accomplish this with preassembled ACB mats, custom-shaped mats must be fabricated or field piece work insertions are required. Both require careful planning, detailing, and execution in the field.

Non-Cabled Articulated Concrete Mats

Non-cabled blocks are cast in interlocking shapes to provide a positively connected matrix that is individually hand-placed by semiskilled labor. The blocks are individually installed according to the geometry of the product. The

Table 1—Physical Requirements (ref. 3)

Minimum compressive strength psi (MPa)		Maximum water absorption lb/ft³ (kg/m³)		Minimum density (in air), lb/ft³ (kg/m³)	
Avg. of 3 units	Individual unit	Avg. of 3 units	Individual unit	Avg. of 3 units	Individual unit
4,000 (28)	3,500 (24)	9.1 (146)	11.7 (187)	130 (2082)	125 (2002)

NOTE - For units produced by the wet-cast method, tests shall be conducted in accordance with Test Methods ASTM C 39 and C 42. For units produced by a dry-cast method, tests shall be conducted in accordance with Test Method ASTM C 140.

slopes. The protected slope must be geotechnically stable prior to placement of surface protection. Known as "flexible revetments", ACB installations should not be placed on slopes which are steeper than the natural angle of repose of the soil. This is a different technology than retaining walls which resist lateral earth pressures.

Protruding height variances between adjacent blocks should be minimized and must be in accordance with the design value utilized. Grading beneath the block and fabric is critical to establishing an acceptable finished profile of the ACBs.

Filter layers are always placed under the ACBs. The function of the filter is critical, as it must retain the soil in place while letting water pass through without clogging. The filter layer must remain in intimate contact with the block and the soil to preclude soil particles from being transported down the slope beneath the geotextile. The key design points to consider in the filter selection are:

- In most cases, woven mono-filaments are preferred.
- The filter layer must have a long-term permeability capable of handling the required volume of water through a restricted surface area equal to the joint area of the articulated concrete block.
- The permeability of the filter layer must always be equal to or greater than the permeability of the protected soil unless a special bedding layer is provided.
- The filter layer needs only to retain the majority of particles beneath it, thus creating a filter bridge.

Care should be taken in the specification of the underlying geotextile filter layer. Appropriate ASTM test methods are available to characterize soil properties and should be done to develop the retention criteria and proper permeability. The geotextile must possess adequate strength and endurance properties to survive the process of installation and any long-term forces applied to it. ASTM D6684 (ref. 3) provides strength requirements for the geotextile.

In most of these designs, the owner or architect should rely upon the engineering expertise of a qualified engineer to select the appropriate block type, filter layer, soil compaction, and design parameters. Proper material selection and construction practices are required and should be checked during installation.

REFERENCES

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