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# Standard Guide for
# Analysis and Interpretation of Test Data for Articulating Concrete Block (ACB) Revetment Systems in Open Channel Flow[1]

This standard is issued under the fixed designation D7276; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 The purpose of this guide is to provide recommended guidelines for the analysis and interpretation of hydraulic test data for articulating concrete block (ACB) revetment systems under steep slope, high velocity flow conditions in a rectangular open channel. Data from tests performed under controlled laboratory conditions are used to quantify stability performance of ACB systems under hydraulic loading. This guide is intended to be used in conjunction with Test Method D7277.

1.2 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which adequacy of a given professional service must be judged, nor can this document be applied without considerations of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.3 The values stated in inch-pound units are to be regarded as standard. The user of the standard is responsible for any and all conversions to other systems of units. Reporting of test results in units other than inch-pound shall not be regarded as nonconformance with this test method.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data

D6684 Specification for Materials and Manufacture of Articulating Concrete Block (ACB) Systems

D6884 Practice for Installation of Articulating Concrete Block (ACB) Revetment Systems

D7277 Test Method for Performance Testing of Articulating Concrete Block (ACB) Revetment Systems for Hydraulic Stability in Open Channel Flow

## 3. Terminology

3.1 For definitions of common terms used in this standard, see Terminology D653.

## 4. Summary of Guide

4.1 The analysis and interpretation of data from hydraulic tests of articulating concrete block (ACB) revetment systems is essential to the selection and design of a suitable system for a specific application. This guide provides guidelines for assisting designers and specifiers in developing a correspondence between the test data and the stability parameters used for design.

4.2 This standard addresses the analysis of hydraulic test data that is generated from a test or series of tests conducted in accordance with Test Method D7277.

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.25 on Erosion and Sediment Control Technology.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

## 5. Significance and Use

5.1 This standard is intended for use by researchers and designers to assess the stability of articulating concrete block (ACB) revetment systems in order to achieve stable hydraulic performance under the erosive force of flowing water.

5.2 An articulating concrete block system is comprised of a matrix of individual concrete blocks placed together to form an erosion-resistant revetment with specific hydraulic performance characteristics. The system includes a filter layer compatible with the subsoil which allows infiltration and exfiltration to occur while providing particle retention. The filter layer may be comprised of a geotextile, properly graded granular media, or both. The blocks within the matrix shall be dense and durable, and the matrix shall be flexible and porous.

5.3 Articulating concrete block systems are used to provide erosion protection to underlying soil materials from the forces of flowing water. The term "articulating," as used in this standard, implies the ability of individual blocks of the system to conform to changes in the subgrade while remaining interconnected by virtue of block interlock or additional system components such as cables, ropes, geotextiles, geogrids, or other connecting devices, or combinations thereof.

5.4 The definition of articulating concrete block systems does not distinguish between interlocking and non-interlocking block geometries, between cable-tied and non-cable-tied systems, between vegetated and non-vegetated systems or between methods of manufacturing or placement. This standard does not specify size restrictions for individual block units. Block systems are available in either open-cell or closed-cell varieties.

## 6. Procedure

6.1 *Data Analysis:*

6.1.1 This section describes the analysis and interpretation of the data collected during a test, including the determination of hydraulic conditions, qualitative observations and descriptions of any damage to the revetment system, and quantification of threshold hydraulic stability values resulting from this analysis that are characteristic of the tested system.

6.1.2 Typical test environments incorporate a flow regime that is supercritical, characterized by high velocities with relatively shallow depths of flow. In supercritical flow, small variations in measured depth can result in relatively large variations in calculated energy and shear stress. The analytical methods suggested in this section have been selected based on their suitability to analyze these hydraulic conditions.

6.2 *Hydraulic Conditions:*

6.2.1 Accurately quantifying the hydraulic conditions that existed during the test is fundamental to the establishment of stability performance thresholds. The important hydraulic variables that characterize open channel flow include total discharge $Q$, section-averaged velocity $V$, flow depth $y$, slope of the energy grade line $S_f$, resistance coefficient (for example, Manning $n$-value), and boundary shear stress $\tau$.

6.2.2 *Total Discharge, Q,* is determined by use of a primary flow measurement device such as an in-line flow meter, weir, Parshall flume, or other device appropriate to the facility's means for delivering water to the test section. Alternatively, the discharge may be computed at each of the measurement cross-sections by the continuity equation:

$$Q = A\left(V_{0.6}\right) \tag{1}$$

where:

$V_{0.6}$ = centerline point velocity at six-tenths of the depth of flow at each station, ft/s, (L/T), and
$A$ = the cross-sectional area of flow at the same station, measured perpendicular to the direction of flow, ft$^2$ (L$^2$).

6.2.2.1 The accuracy of the discharge measurement shall be reported as described in Section 7 of this standard.

6.2.3 *Flow Depth, y,* is computed as the difference in the measured centerline water surface elevation and the elevation of the revetment surface, corrected for the slope angle $\theta$ as appropriate, at each measurement station:

$$y_i = \left(h_i - z_i\right)\cos\theta \tag{2}$$

where:

$y_i$ = depth of flow at station $i$ (perpendicular to the bed), ft (L),
$h_i$ = water surface elevation at station $i$, ft (L),
$z_i$ = bed elevation (top of blocks) at station $i$, ft (L), and
$\theta$ = slope angle measured from the horizontal.

6.2.4 *Energy Grade Slope, $S_f$,* at each measurement station is calculated from other measured or computed variables as:

$$S_{fi} = \left[\frac{n\left(V_i\right)}{K_u}\right]^2 \frac{1}{y_i^{4/3}} \tag{3}$$

where:

$S_{fi}$ = slope of the energy grade line at station $i$, ft/ft (L/L),
$n$ = Manning's resistance coefficient,
$V_i$ = velocity at station $i$, ft/s (L/T), and
$K_u$ = units conversion coefficient, equal to 1.486 for U.S. Customary Units and 1.0 for SI Units.

6.2.4.1 Eq 3 assumes that the flume walls are significantly smoother than the revetment surface, such that the total resistance is due solely to the roughness of the bed.

6.2.5 *Step-Forewater Analysis*—Knowing the total discharge $Q$, flume width $b$, and the elevations of the water surface and revetment surface at each of the measurement stations, a forewater calculation can be performed to obtain the optimal value of the Manning's $n$ coefficient.

6.2.5.1 For supercritical flow, it is recommended that the water surface profile be computed by solving the momentum equation using the standard step method and proceeding in the downstream direction:

$$h_2 = h_1 + \frac{1}{2g}\left(v_1 + v_2\right)\left(v_1 - v_2\right) - \frac{L}{2}\left(S_{f1} + S_{f2}\right) \tag{4}$$

where:

$h_1$, $h_2$ = upstream and downstream water surface elevations at stations 1 and 2, ft (L),
$v_1$, $v_2$ = upstream and downstream velocity at stations 1 and 2, ft/s (L/T),
$Ls$ = slope length between stations 1 and 2, ft (L), and