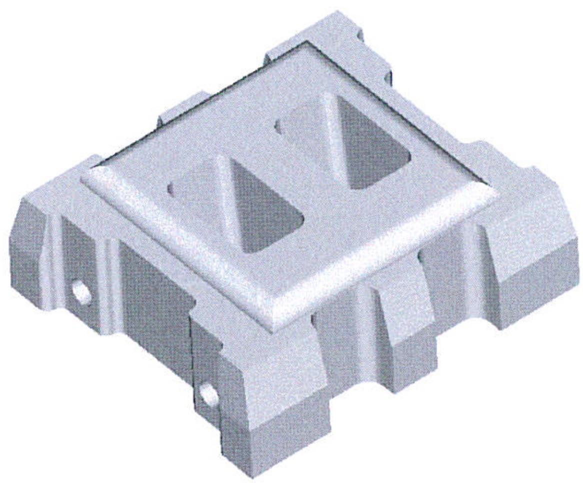
ARMORTEC
Erosion Control Solutions

ArmorFlex Design Manual

ABRIDGED VERSION 2002

Design Manual for ArmorFlex® Articulating Concrete Blocks



1. INTRODUCTION

This document is an abridged version of the full ArmorFlex® Design Manual, available from Armortec. This manual was developed specifically to supplement the ArmorFlex Design Package and includes only the supporting documentation for the design equations used by the software application. Subsequent sections present development of the design equations, a design example, and references.

Subjects that have been omitted from this manual, which are included in the full version, include open channel hydraulics, laboratory testing, installation, and other special topics. The user is encouraged to contact Armortec for a full version of the ArmorFlex® Design Manual for discussion of subjects beyond the scope of this document.

2. DESIGN EQUATIONS AND EXAMPLE

2.1 Hydraulic Stability of the ArmorFlex® Systems

Due to the mode of failure exhibited by articulating concrete block revetment systems, the most vulnerable component of an ArmorFlex® revetment system is an individual block located at the toe of a channel side slope. The approach used to determine the stability of the block is similar to the approach used by Simons and Senturk for riprap sizing (ref.6).

The forces acting on a block placed on the side slope of a channel are shown in **Figure 2.1**. The following list contains a description of the major variables:

λ	=	angle (in degrees) of the channel bed
θ	=	angle (in degrees) of the side slope
β	=	angle (in degrees) between the weight vector and the resultant force vector in the plane of the side slope
δ	=	angle (in degrees) between the drag vector and the resultant force vector in the plane of the side slope
F_D	=	drag force acting on the block (lbs)
F_L	=	lift force acting on the block (lbs)
$\ell_1, \ell_2, \ell_3, \ell_4$	=	moment arms for respective forces (ft)
W_s	=	buoyant (submerged) weight of the block (lbs)

As can be seen in Figure 2.1, the moments of overturning will act along the resultant force, R, about the point O. Point O in this case is the downstream and downslope corner of the block. If the block is in equilibrium, the sum of moments about point O along R must equal zero. The summation of the moments about O results in:

$$\Sigma M_o = 0 = \ell_2 W_s \cos\theta - \ell_1 W_s \sin\theta \cos\beta - \ell_3 F_D \cos\delta + \ell_4 F_L \qquad (2.1)$$

The factor of safety, SF, is the ratio of the resisting moments to the overturning moments. For the ArmorFlex® block the factor of safety is:

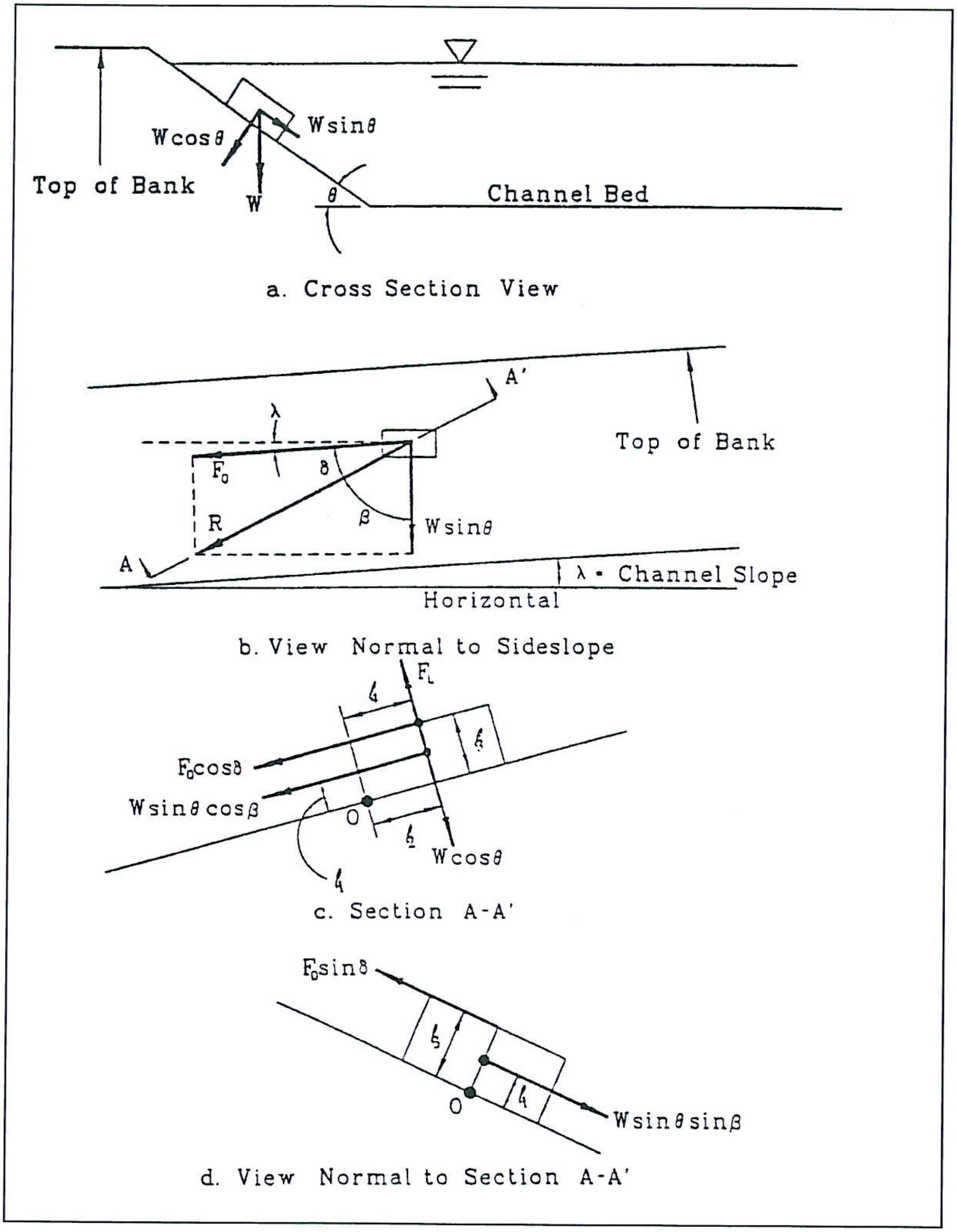


Figure 2.1. Force diagrams for an ArmorFlex® block on a channel side slope.

$$SF = \frac{M_{resisting}}{M_{overturning}} = \frac{\ell_2 W_s \cos\theta}{\ell_1 W_s \sin\theta \cos\beta + \ell_3 F_D \cos\delta + \ell_4 F_L} \tag{2.2}$$

by dividing both the numerator and the denominator by $\ell_1 W_S$:

$$SF = \frac{\frac{\ell_2}{\ell_1}\cos\theta}{\sin\theta\cos\beta + \frac{\ell_2}{\ell_1}\eta'} \tag{2.3}$$

with η' being:

$$\eta' = \frac{\ell_3 F_D \cos\delta}{\ell_2 W_s} + \frac{\ell_4 F_L}{\ell_2 W_s} \tag{2.4}$$

For motion along R, the moments of the forces perpendicular to R (Figure 2.1d) must balance. This result is:

$$\ell_3 F_D \sin\delta = \ell_1 W_s \sin\theta \sin\beta \tag{2.5}$$

solving Equation 2.5 for $\sin\beta$:

$$\sin\beta = \frac{\ell_3 F_D \sin\delta}{\ell_1 W_s \sin\theta} \tag{2.6}$$

from the definition of δ in Figure 2.1 and basic geometric relations

$$\cos\delta = \cos(90 - \lambda - \beta) = \sin(\lambda + \beta) \tag{2.7}$$

$$\sin\delta = \sin(90 - \lambda - \beta) = \cos(\lambda + \beta) \tag{2.8}$$

$$\sin\delta = \cos\lambda\cos\beta - \sin\lambda\sin\beta \tag{2.9}$$

substituting Equation 2.9 in Equation 2.6:

$$\sin\beta = \frac{\ell_3 F_D \cos\lambda\cos\beta - \ell_3 F_D \sin\lambda\sin\beta}{\ell_1 W_s \sin\theta} \tag{2.10}$$

dividing both sides by $\sin\beta$ and rearranging terms:

$$\frac{\ell_3 F_D \cos\lambda\cos\beta}{\sin\beta} = \ell_1 W_s \sin\theta + \frac{\ell_3 F_D \sin\lambda\sin\beta}{\sin\beta} \tag{2.11}$$

substituting $\tan\beta$ for $\sin\beta/\cos\beta$ and solving for $\tan\beta$: