CONTECH®
ENGINEERED SOLUTIONS
A QUIKRETE® COMPANY

A-Jacks® Pier Scour
Design Guide

Overview

The ability of an A-Jacks matrix to dissipate energy and resist the erosive forces of flowing water allows the system to protect channel boundaries from scour and erosion. Extensive laboratory testing has been performed on both model and full-scale units to determine hydraulic properties and evaluate the stability of the A-Jack units. Field tests confirmed that the A-Jacks system provides a flexible, non-erodible barrier between the channel subgrade and potentially damaging flow of water. This A-Jack Pier Scour Design Technical Note reviews the design approach as outlined in FHWA Hydraulic Engineering Circular No. 23 (HEC-23), Design Guideline 19: Concrete Armor Units. An example is included to illustrate the design procedure.

FHWA HEC-23

The design approach detailed in HEC-23 (FHWA, 2009) examines the A-Jack system in modules, also called bundles. Modules are created by banding individual A-Jacks together in a densely interlocked matrix as shown in Figure 1. Multiple module sizes can be configured and evaluated to meet project specific needs by varying the length (L) and width (B) as defined and illustrated in Figure 1 where L is parallel to flow.
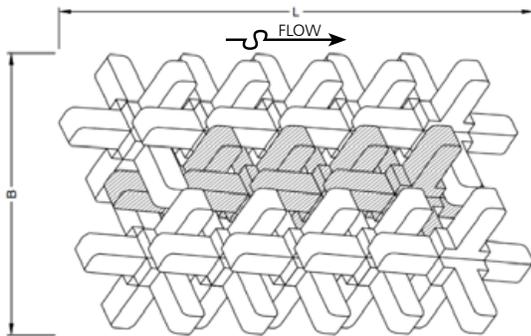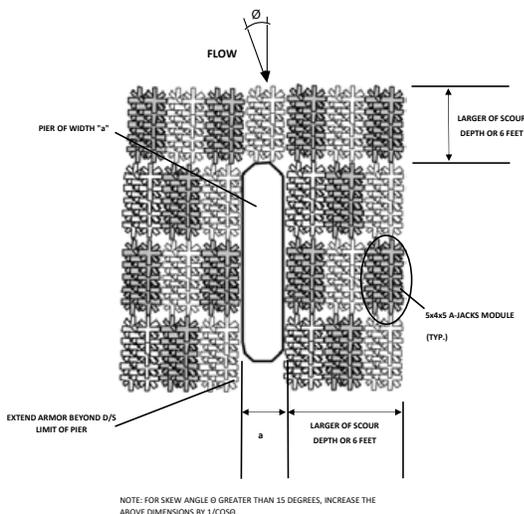

Figure 1: A-Jacks Module Plan View

Figure 2: FHWA HEC-23

Placement

Placement of the A-Jack modules around piers is best accomplished using a rectangular pattern as illustrated in Figure 2. Orientation of the modules is recommended to be with the long dimension of the module parallel to the flow whereby providing the module a greater resisting moment. Embedment of the units will also provide greater stability since the exposed height (H_d), as defined in Figure 3, of the unit is smaller further reducing the overturning moment.

Hydraulic Stability

Hydraulic stability of an A-Jack module is estimated by setting the overturning moment, imparted by drag, equal to the resisting moment, a function of submerged weight (WS) and specific gravity (SG) of the module as illustrated in Figure 3 and defined in Equation 1. The drag coefficient (Cd) of 1.05 has been confirmed through physical hydraulic testing (FHWA, 2009).

$$F_d \, H_d \; = W_s \, (L/2) \underline{\hspace{2cm}} (EQ.1)$$

$$F_d \; = 0.5 C_d \rho A_f v^2$$

$$A_f = B \times H_d$$
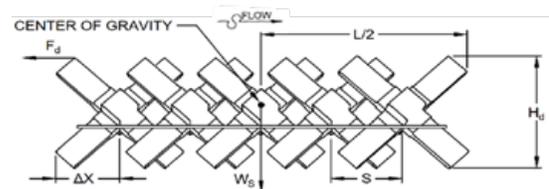
$$W_s \; = W \times ((SG - 1)/SG)$$

Figure 3: A-Jacks Section View with Force Diagram

Table 1 can be used to create custom module sizes to accommodate specific project needs. The dimensions for length and width can be designed using the Center-to-Center Spacing, S, and the ΔX dimension as defined in Equation 2 and shown in Table 1 and Figure 3.

Table 1: HEC-23 A-Jacks Parameters

A-Jacks System	Typical A-Jacks Weight (lbs)	Drag Coefficient, C_d	Center to Center Spacing, S (ft)	Height, H_d (ft)	ΔX (ft)
AJ-24	73.6	1.05	0.75	1.3	0.66
AJ-48	590.7		1.5	2.67	1.35

L or B =[(# of A-Jacks) - 1] x S + (2 x ΔX) _____(EQ. 2)

Bedding design considerations include incorporation of a stone bedding layer, geotextile, or both. When bedding stone is used as a filter, it must meet average size and gradation requirements to retain the native bed material. Requirements are given in HEC-23 to ensure that the stone will retain the bed material, dissipate excess pore water pressure, and be large enough to resist being removed through the legs of the A-Jacks. In some cases, multiple layers of stone may be required in order to satisfy all the criteria. A suitable geotextile may be placed directly on the channel bed with A-Jack modules placed atop the geotextile, thus eliminating the need for stone bedding. In strong currents a viable construction technique is to attach the geotextile to the bottom of the A-Jack modules. Design procedures for selecting a geotextile are provided in FHWA HEC-23, Design Guideline 16.

Design Example

A bridge crosses a 75-ft wide river where extensive scour has occurred at the bridge piers. The stream bed is 20-ft below the water surface and the upstream velocity is 16-ft/s. The calculated scour depth for the 100-yr flow is 12-ft. Select an appropriate A-Jack unit size for the project conditions.

Solution:

1. Calculate the Drag Force using a 4x3x4 module of 48" A-Jacks.
$F_d = 0.5C_d \rho Av^2$
   $C_d = 1.05$
   $\rho = 1.94$ slugs/ft^3
   $A = B \times H_d$
   $A = [((3-1) \times 1.5) + (2 \times 1.35)] \times 2.67$
   $A = 5.7 \times 2.67 = 15.22$ ft^2
   $v = 16$ ft/s
$F_d = 3,963$ lbs

2. Calculate the Overturning Moment.
$F_d H_d$ = Overturning Moment
   $H_d = 2.67$ ft
$F_d H_d = 10,569$ lb-ft

3. Calculate the Resisting Moment
$W_s (L/2)$ = Resisting Moment
   $W = 11$ units x 590.7 lbs = 6,498 lbs
   $W_s = 6,498 \times ((2.083-1)/2.083)$
   $W_s = 3,379$ lbs
   $L/2 = 3.6$ FT
$W_s (L/2) = 12,163$ lb-ft

4. Compare the Overturning and Resisting Moments
$F_d H_d < W_s L_w$
10,569 lb-ft $<$ 12,163 lb-ft

The 4x3x4 48" A-Jack module has sufficient capacity to resist the overturning moment.

5. Evaluate a 6x5x6 module of 24" A-Jacks.

   a. Calculate the Drag Force.
   $F_d = 0.5C_d \rho Av^2$
      $C_d = 1.05$
      $\rho = 1.94$ slugs/ft^3
      $A = B \times H_d$
      $A = [((3-1) \times 0.75)+(2 \times 0.66)] \times 1.3$
      $A = 2.82 \times 1.3 = 3.7$ ft^2
      $v = 16$FT/s
   $F_d = 964.7$ lbs

   b. Calculate the Overturning Moment
   $F_d H_d$ = Overturning Moment
      $H_d = 1.3$ ft
   $F_d H_d = 1,254$ lb-ft

   c. Calculate Resisting Moment
   $W_s (L/2)$ = Resisting Moment
      $W = 17$ units x 73.6 lbs = 1,251 lbs
      $W_s = 1,251 \times ((2.083-1)/2.083)$
      $W_s = 650.5$ lbs
      $L/2 = 2.54$ ft
   $W_s (L/2) = 1,649$ lb-ft

   d. Compare the Overturning and Resisting Moments.
   $F_d H_d < W_s L_w$
   1,254 lb-ft $<$ 1,649 lb-ft

   The 6x5x6 24" A-Jack module has sufficient capacity to resist the overturning moment and therefore is also a viable design alternative.

SUPPORT

DRAWINGS AND SPECIFICATIONS ARE AVAILABLE AT WWW.CONTECHES.COM
A-Jacks Design Guide Manual 02/2025