

A-Jacks[®] Abutment 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, coupled with decades of project installations have resulted in design guidelines of the A-Jack system in multiple hydraulic environments. This Technical Note presents the design approach, developed in accordance with procedures presented in NCHRP Report 587 (TRB 2007), for utilizing A-Jack concrete armor units for bridge abutment scour mitigation.

Bridge abutments commonly border swift, turbulent flow through bridged waterways, and therefore risk failure by scour. Scour of bridge abutments is a common cause of bridge failure and entails hydraulic erosion of a channel bed surface around an abutment and the potential geotechnical failure of the soil comprising the embankment at an abutment. Two principal types of bridge abutment forms are wing-wall abutments and spill-through abutments. Figures 1a and 1b illustrate the main features of spill-through and wing-wall abutment forms, respectively.

Spill-through abutments are formed as sloped fill placed fully around an abutment support and are typically implemented to increase flow capacity through a bridge. Wing-wall abutments have vertical walls that retain the material comprising the embankment approach to the abutment. Walls typically are angled from 45 degrees to 90 degrees to the direction of flow.



Figure 1a. Spill-Through Abutment Figure 1b. Wing-Wall Abutment

Design variables for an A-Jack countermeasure at an abutment include A-Jack size, protection limits, and bedding/filter layer requirements. Figures 2 and 3 illustrate A-Jack layout schematics for spill-through and wing-wall abutments.

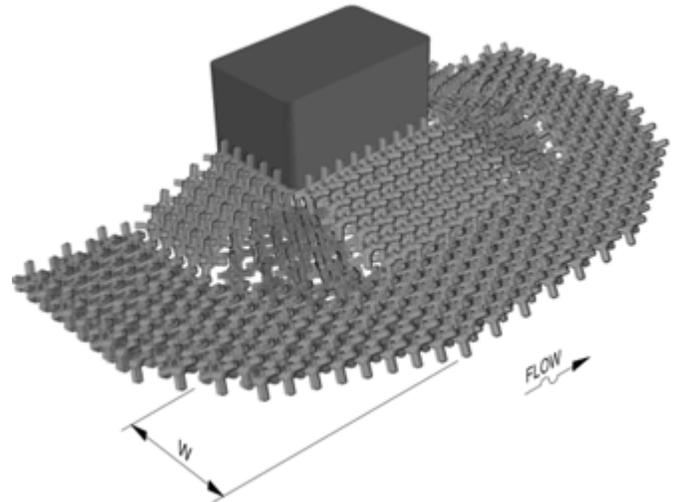


Figure 2. A-Jacks Spill-Through Abutment Schematic

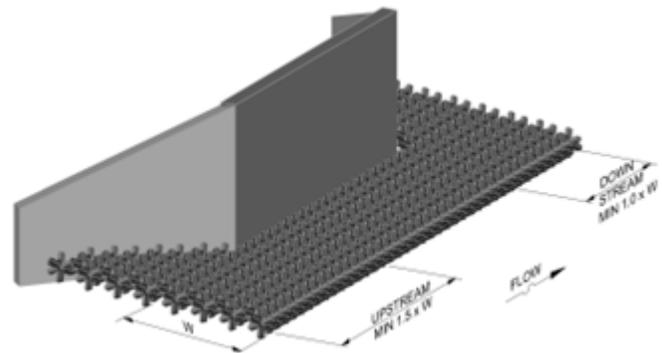


Figure 3. A-Jacks Wing-Wall Abutment Schematic

Design nomographs developed by Ayres Associates (Ayres, 1999), illustrated in Figure 4, are used to determine the appropriate A-Jack size as a function of the approach velocity at the bridge opening. The extent of coverage of the A-Jack system (W) is determined based on recommendations presented in the NCHRP Report 587 (TRB 2007) and calculates at 1.25 times the predicted depth of scour. When design conditions require, the A-Jack system may be excavated, at a maximum 1:1 (H:V) slope, to the depth of potential scour. Abutment scour countermeasure designs for wing-wall abutments should extend a minimum of $1.5W$ upstream and $1.0W$ downstream of the abutment wall. It is noted that coverage layout may vary with project constraints and objectives and engineering judgment should be applied.

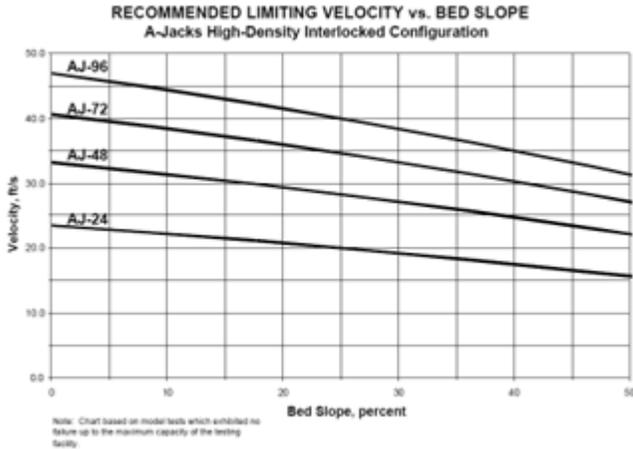


Figure 4. A-Jack Sizing Nomograph

Bedding/filter design includes incorporation of a stone bedding layer, geotextile, or both. When bedding stone is used as a filter, it must meet the average size and gradation requirements to retain the native bed material. Requirements are presented in HEC-23 (FHWA, 2009), 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 to satisfy all the criteria. In lieu of using multiple layers of stone bedding material, a suitable geotextile may be placed directly on the channel bed with A-Jack modules placed directly on top of the geotextile. It is recommended that A-Jacks embedded at least 2/3 of the unit height during installation will have greater sustainability.

Design Example A

A bridge crosses a 75-ft wide river where scour countermeasures are needed at the abutments. This spill-through abutment with a bed slope of 0.005 ft/ft has a HEC-18 computed design scour of 18-ft and a design approach velocity of 6.7-ft/s. Select an appropriate A-Jack unit size for the project conditions and calculate the limits of protection.

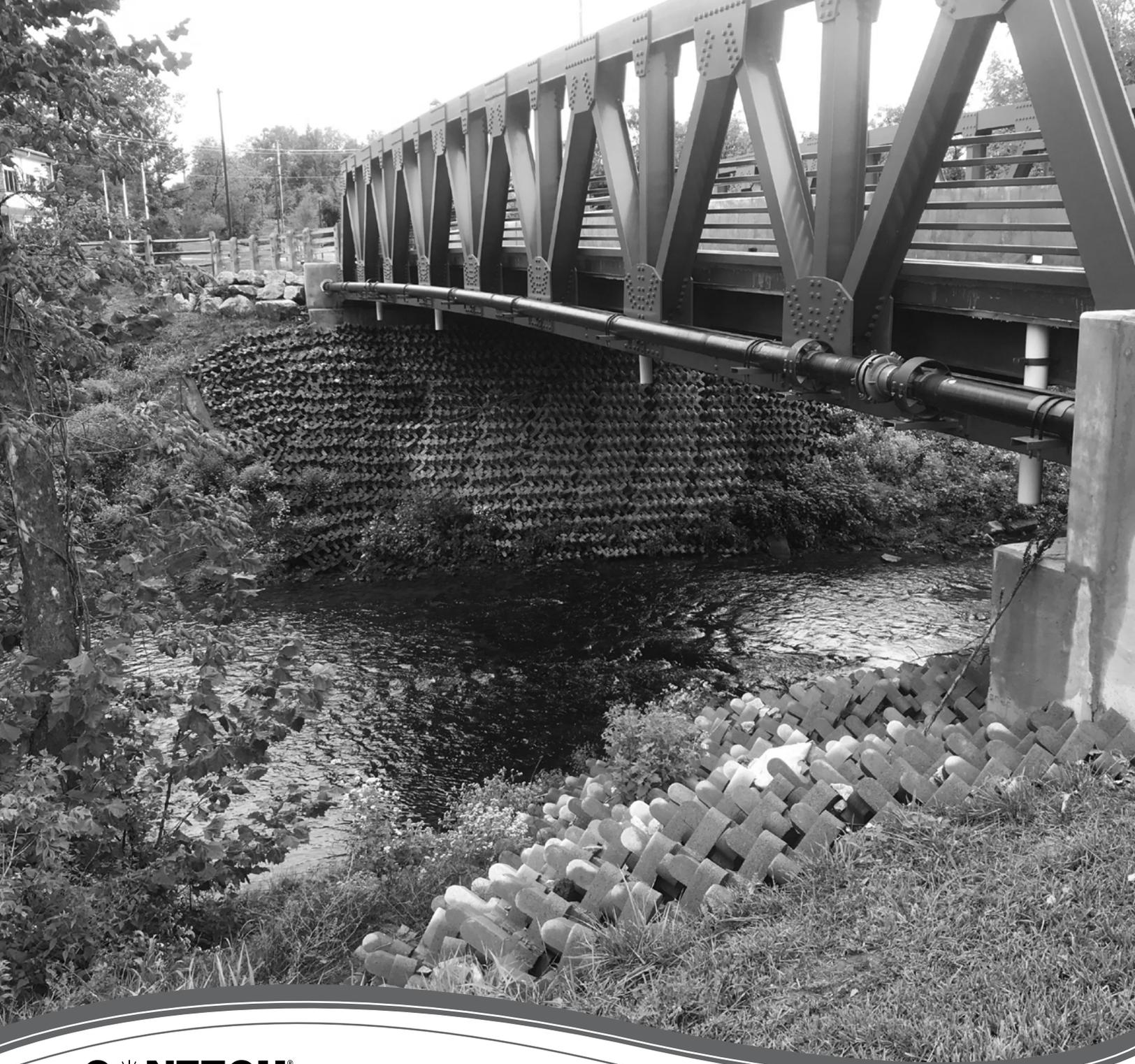
- Use Figure 4 to determine the required A-Jack size.
 - Bed Slope = 0.005-ft/ft = 0.5%
 - Design Velocity = 6.7-ft/s
 - From A-Jacks Nomograph (Fig.4)
 - Limiting Velocity for 24" units = 23.5-ft/s
 - Design Velocity 6.7-ft/s < 23.5-ft/s
 - ✓ Use 24" A-Jacks

- Determine the coverage limits for the 24" A-Jack units.
 - Design Scour = 18-ft
 - ✓ Limits (W) = 1.25 x 18-ft = 23-ft

Design Example B

Determine the A-Jack unit size and limits for scour protection at a wing-wall abutment for a bed slope of 2%, a design approach velocity of 26-ft/s, and a HEC-18 computed scour of 32-ft.

- Use Figure 4 to determine the required A-Jack size.
 - Bed Slope = 2%
 - Design Velocity = 26-ft/s
 - From A-Jacks Nomograph (Fig.4)
 - Limiting Velocity for 24" units = 23.5-ft/s
 - Limiting Velocity for 48" units = 33-ft/s
 - 23.5-ft/s < 26-ft/s < 33-ft/s
 - ✓ Use 48" A-Jacks
- Determine the coverage limits for the 48" units.
 - Design Scour = 32-ft
 - ✓ Width, W = 1.25 x 32-ft = 40-ft
 - ✓ Upstream = 1.5 x 40-ft = 60-ft
 - ✓ Downstream = 1.0 x 40-ft = 40-ft



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