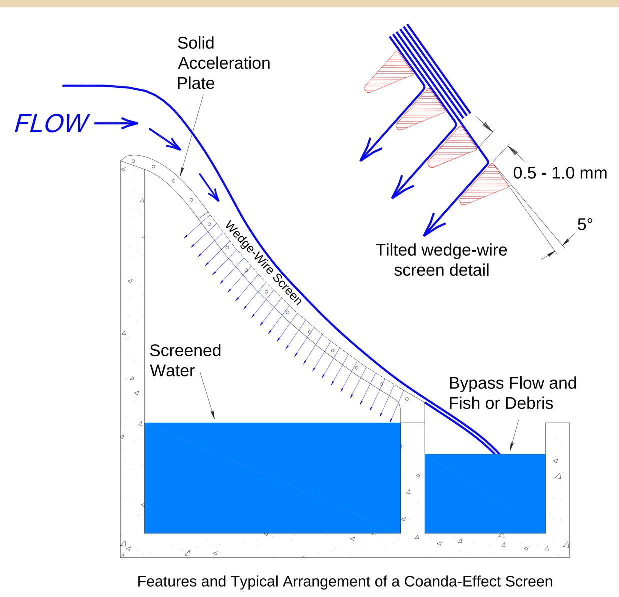
NEW TESTING OF COANDA-EFFECT SCREEN CAPACITIES

Tony L. Wahl, P.E. -- Bureau of Reclamation Hydraulics Laboratory -- Denver, Colorado

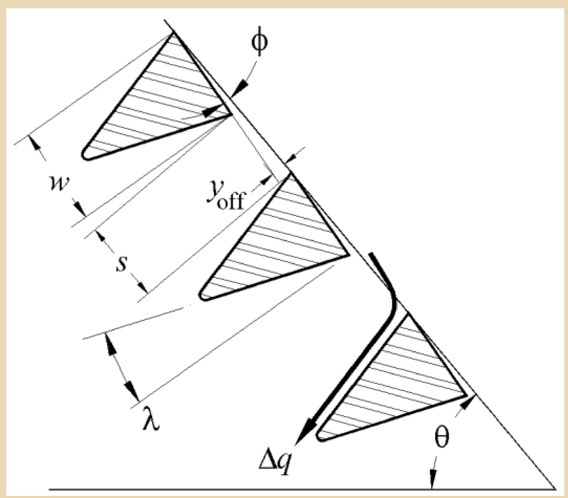
Background

Coanda-effect screens are used in high-capacity, self-cleaning intake systems for small hydroelectric facilities and other water diversions. Their ability to remove fine debris also makes them useful for in-line debris removal in irrigation systems, wastewater facilities, and industrial applications.

The screens separate clean water from a debris-laden supercritical flow that passes over a wedge wire screen panel whose wires are oriented horizontally, perpendicular to the flow direction. The individual wires are tilted along their axes so that the leading edge of each wire projects into the flow, causing the screen to shear a thin layer of the flow from the bottom of the water column at each slot opening.



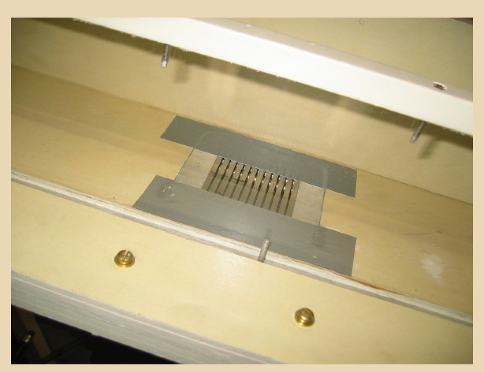
Features and Typical Arrangement of a Coanda-Effect Screen



Research performed in 2001 developed a method for predicting discharge coefficients of Coanda-effect screens

The Bureau of Reclamation's initial research related screen capacity to the Froude, Reynolds, and Weber numbers of the flow over the screen. Recent investigations showed that this method for predicting screen discharge coefficients was inaccurate when extended to flow conditions outside of the range of the original tests (higher velocities and Reynolds numbers).

A new laboratory facility was recently constructed to test a variety of Coanda-effect screen materials over a wide range of flow conditions. This testing led to improved methods for predicting screen capacity.



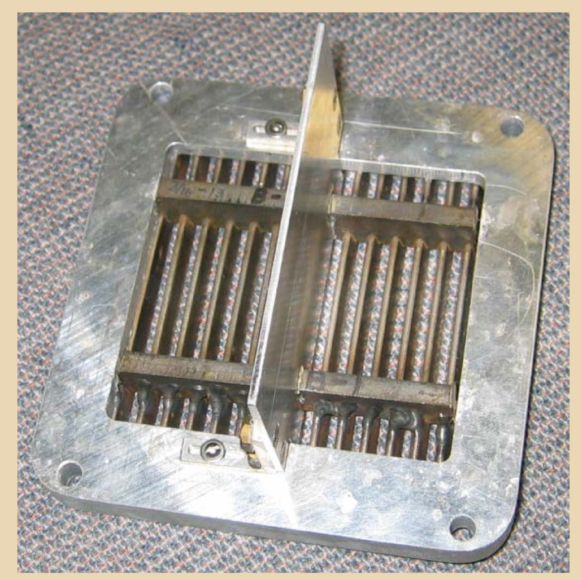
Coanda Screen Test Facility – Denver, Colorado

The 6-inch wide flume at the upper center can be tilted from horizontal to 60°, and screens can be tested at three different overfall heights for a given slope.

Test Facility Details

The test facility allows testing of small, 3-inch square, screen samples under a range of flow conditions

To make each test representative of the performance of a subsection of a large screen panel, only the downstream half of the screen is tested; flow through the upstream half is measured, but discarded. This ensures that flow through the tested section has a fully developed velocity profile.



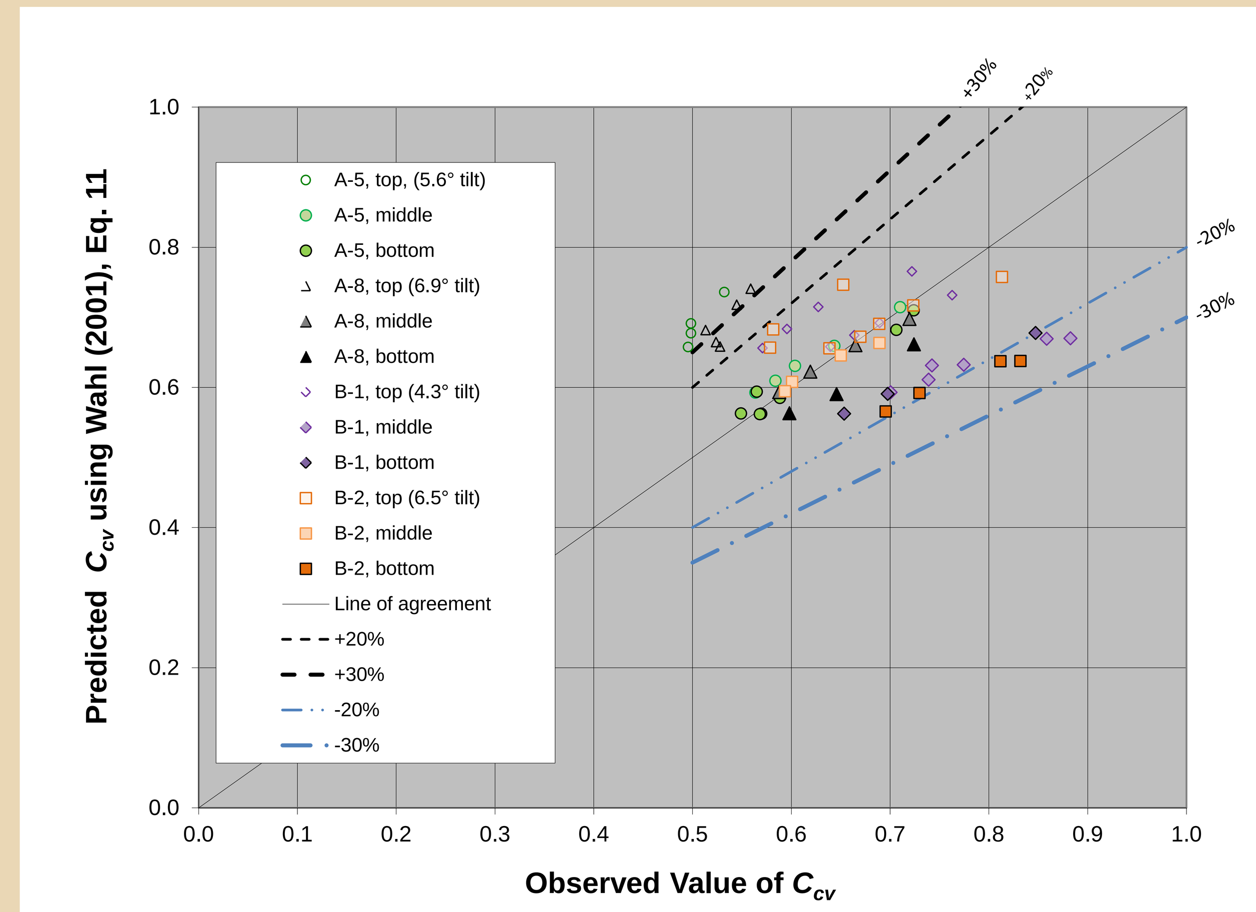
Photos above show screens ready for testing and illustrate the division box below the screens that collects from the upstream and downstream sections. Note the much greater flow through the downstream half of the screen in the bottom-right photo. Flows through each screen section are measured with V-notch weirs. Total flow in the facility is measured with a broad-crested weir and an ultrasonic flow meter.

Tested Screens	A-5	A-8	B-1	B-2	#1	#3
Relief angle, λ (designated, not measured)	10	10	13	13	17.5	11
TILT ANGLE, degrees	5.6	6.9	4.3	6.5	3.82	6.88
Avg. slot width, s (mm)	1.99	1.96	2.05	2.05	1.02	0.47
Avg. wire thickness, w (mm)	4.72	4.74	4.60	4.62	2.39	1.50
Width, inches	3	3	3.5	3.5	3.66	3.44
Length, inches	3.125	3.125	3.5	3.5	3	2.875
Support bar spacing, inches	2.125	2.125	2	2.0625	2.75	0.53125
Support bars	3/8" round	3/8" round	1/4" square	1/4" square	3/8" round	1/8" square
Notes			sharp wires	sharp wires		

Test Results

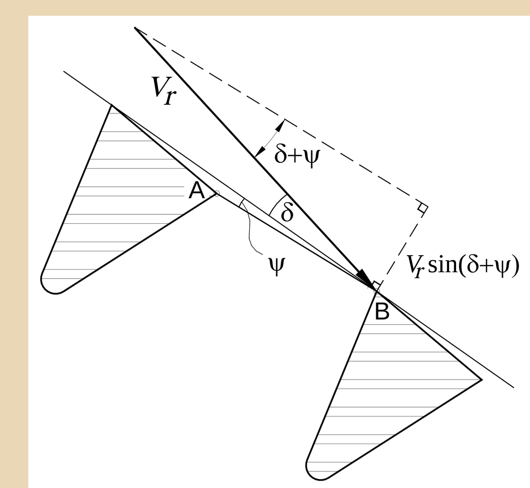
The previously developed method for estimating screen discharge coefficients performed poorly when screens were tested at different overfall heights (different velocities and Froude-Reynolds-Weber numbers)

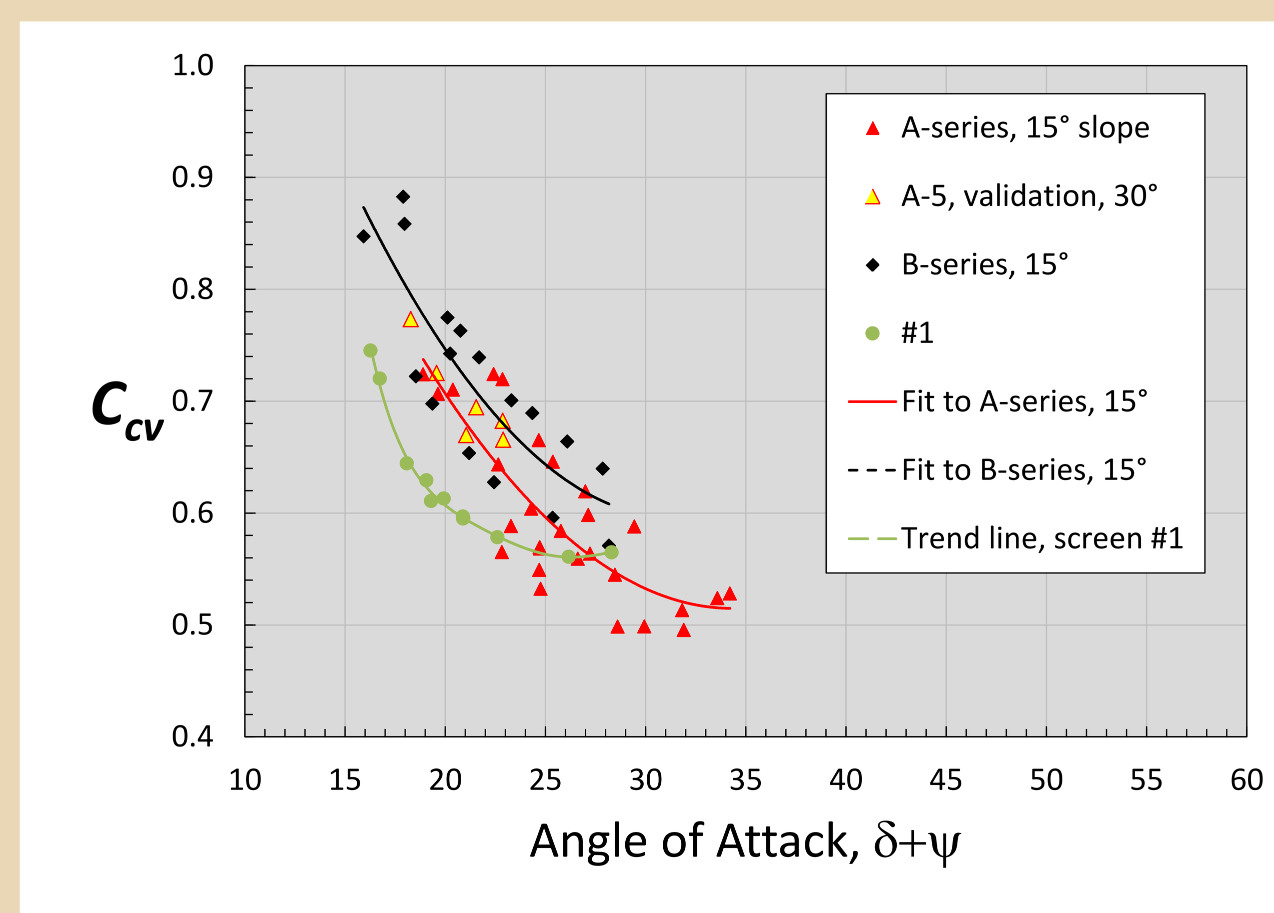
The old method predicted that high velocity flow would cause a reduction of the screen discharge coefficient (all other things held equal). The testing showed that the discharge coefficients were changing in response to another variable.



The 2001 method for predicting discharge coefficients had large errors at some overfall heights

A solution to the problem was found by relating the discharge coefficient to the angle of attack between the approach velocity vector and the screen slot opening, δ+ψ

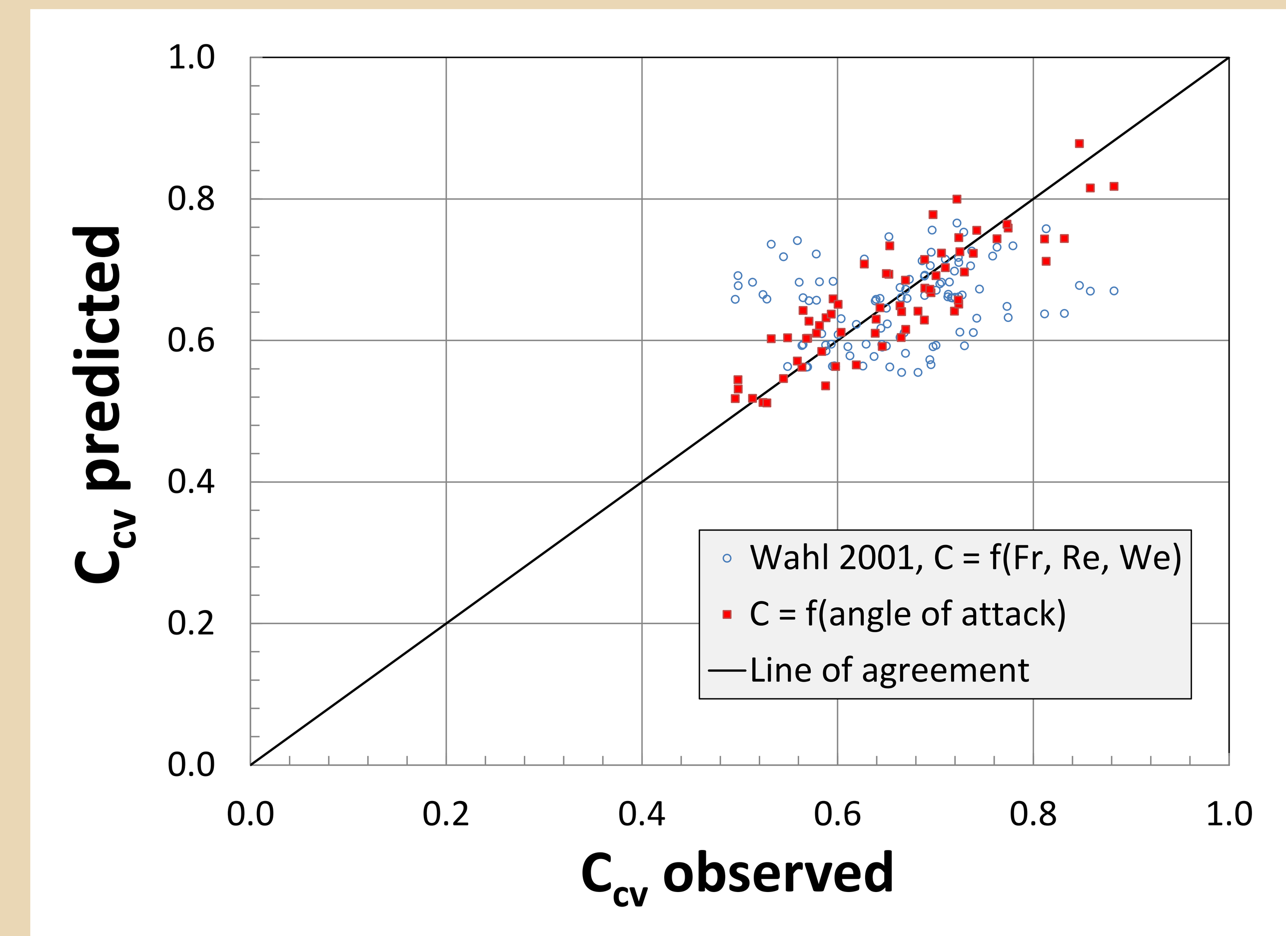




New Method for Estimating Screen Capacities

Each screen material has its own unique relation between the discharge coefficient and the angle of flow attack

The reason for the different relations is not yet known, but may be related to differences in wire edge sharpness, the ratio of slot width to wire width, or the relief angle of the screen. To determine the "rating curve" for a given screen material, it should be tested in a facility like the one used for this research.



Applying a relation customized to each screen produces improved accuracy when predicting discharge coefficients.

Practical Implications

The old method of predicting screen capacity tended to underpredict capacity in high-velocity situations, so when applied to prototype-size structures, the new method usually indicates greater screening capacity.

Other factors that might cause reduced screen capacity over time should still be accounted for (wear of wire edges, debris clogging, etc.). This testing considered only the performance of "clean" screens.

Software Update

The Coanda design software distributed by the Bureau of Reclamation has been updated to permit modeling of screens based on angle of attack.

For screens that have not been specifically tested, a "default" relationship between C_{cv} and angle of attack can be assumed, but best results will be obtained by conducting physical tests of prototype screen materials.

Research Needs

Testing of additional screen types could help determine why some screen wire types outperform others, and might lead to a way to predict the C_{cv} vs. angle of attack relationship without the need for physical testing.

Author Contact

The author can be contacted by e-mail at twahl@usbr.gov

HydroVision 2013
July 24, 2013 — Denver, Colorado