New Omni-directional Scour-Resistant Design for Bridge and Pier Circular Monopiles

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Countermeasures for Scour and Erosion

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Example of Tidal Surge Washout: Hurricane Ian, Sept. 2022, Cherry Grove Pier, North Myrtle Beach, SC, USA

Introduction and Background of Dr. Simpson

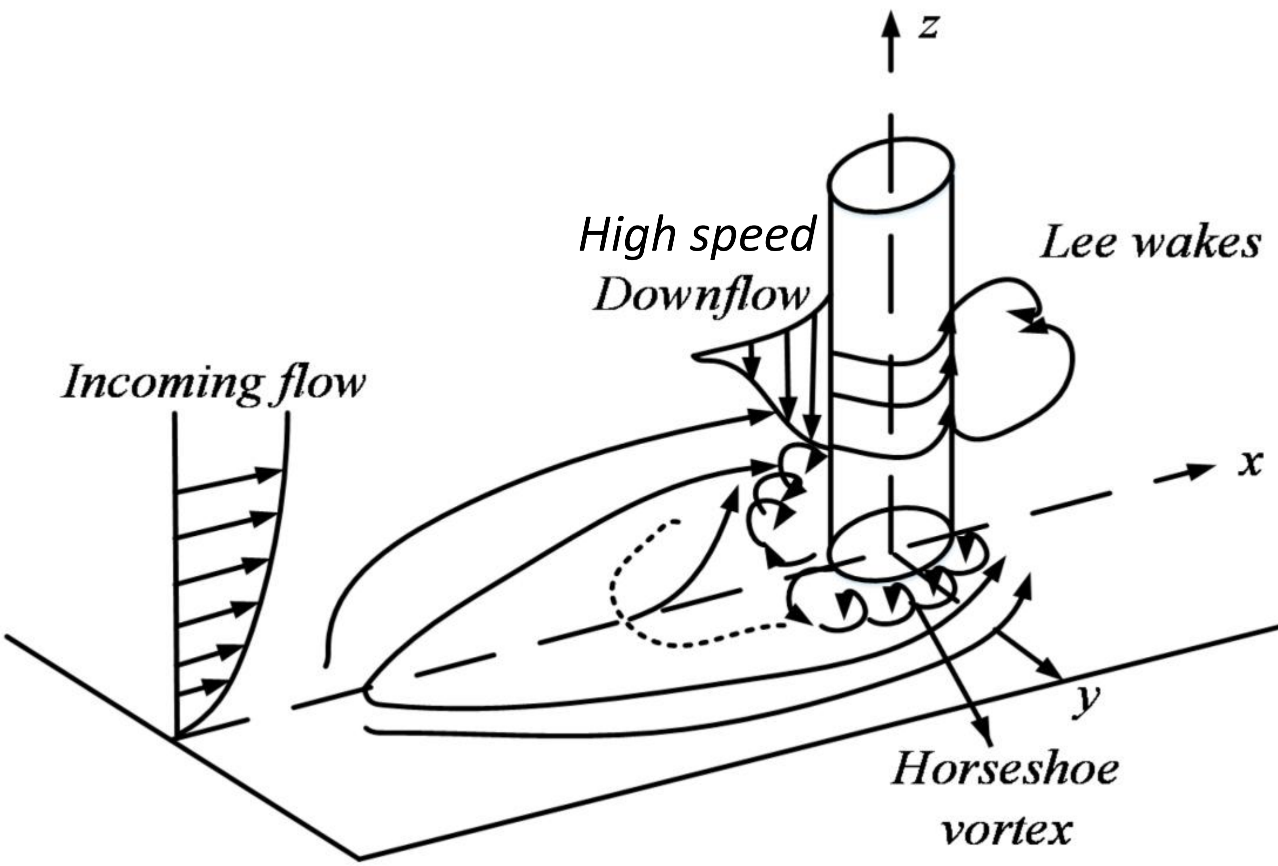
- An internationally recognized fluid dynamics researcher, inventor, and author on vortex producing "juncture flows", such as those that occur in bodies of water around hydraulic structures such as bridge piers and abutments, and surface roughness effects on flow. Past President & Fellow AIAA; Fellow ASME, M. ASCE.
- Consultant and advisor to NASA on reducing adverse aspects of "juncture flows" between airplane wings and a fuselage.
- For over 30 years his US Navy sponsored research at Virginia Tech, where he was the Jack E. Cowling Professor of Aerospace and Ocean Engineering, provided much data for the prevention of acoustic noise producing vortices on submarines.
- Over the last years, he has applied this fluid dynamics background to designing and testing the scouring-vortex preventing streamlined fairings **scAUR**™ for bridge piers and abutments.
- Novel tetrahedral vortex generators **VorGAUR**™ create counter-rotating vortices that oppose the effects of scouring vortices & prevent debris collection.
- **US Patents 8348553, 8434723, and 9453319 awarded.**
- Model and full-scale tests under the sponsorship of the National Co-operative Highway Research Program **(NCHRP-IDEA Report 162)** have proven these designs.
- Cost-effective stainless steel retrofits for existing bridges and concrete forms for new bridges are available for various bridge and river-bed situations.

Outline of Topics

Bridge failures due to scour show that scouring-vortex-preventing designs of AUR would have prevented the scour failures and will prevent future failures at all flow speeds. See Simpson and Byun (2021), ICSE-10 Proceedings and www.noscour.com for details on scAUR™ and VorGAUR™ Designs. This new approach to prevent scour at all flow speeds is to prevent scouring vortices and create counter-rotating vortices. The axisymmetric design presented here is for flow-direction changing tidal, surge, and tsunami cases.

- **The Nature of Scouring Horseshoe Vortices Around Monopiles**
- **New Omni-directional Scour-resistant Design for Bridge and Pier Circular Monopiles with the Proven scAUR™ and New picscAUR™**
- **Permanent and Cost-effective Solution for Tidal and Surge Omni-Directional Flows**
- **Conclusions**

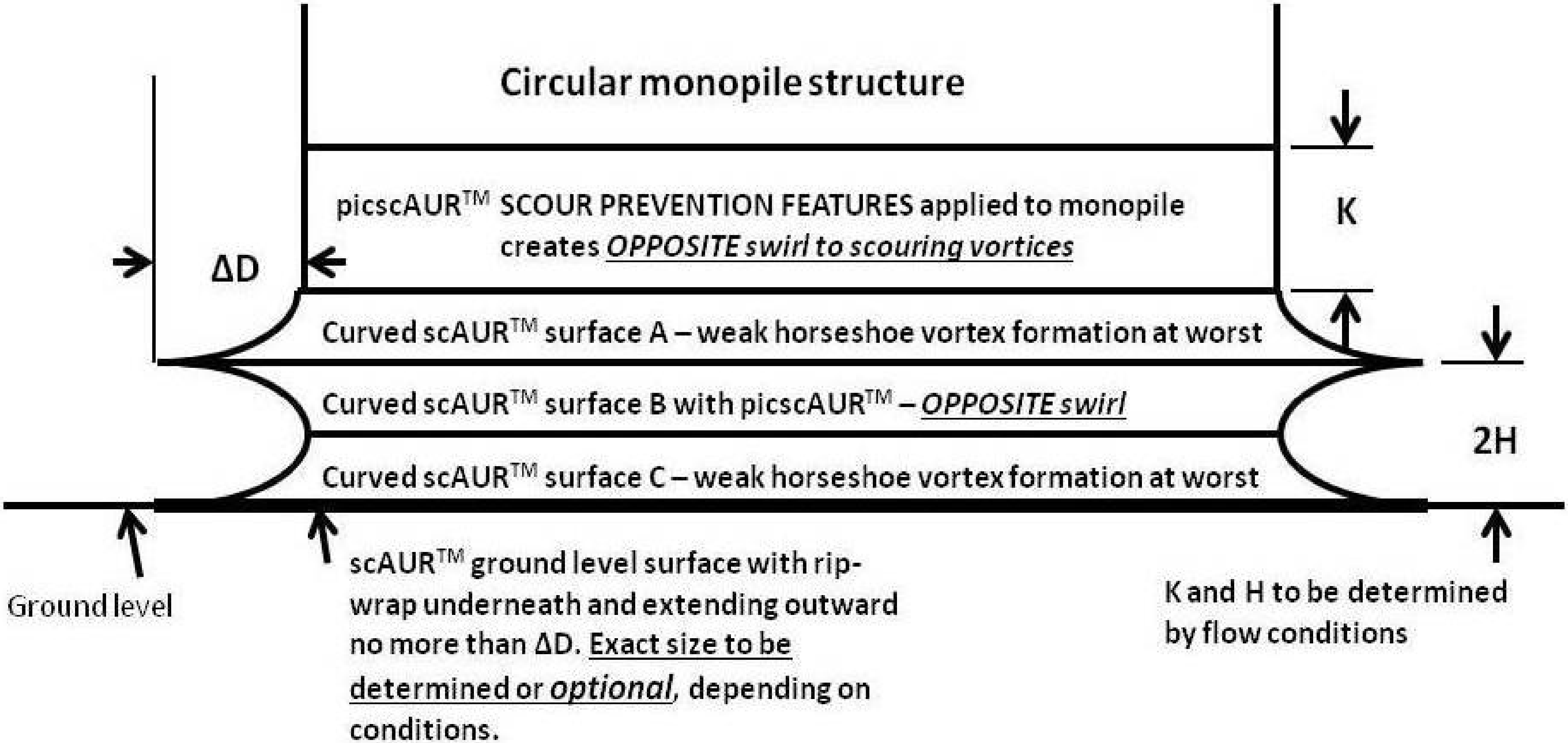
The Nature of Scouring Horseshoe Vortices Around Monopiles



Strength of the vortex varies with the approach velocity and the monopile width.

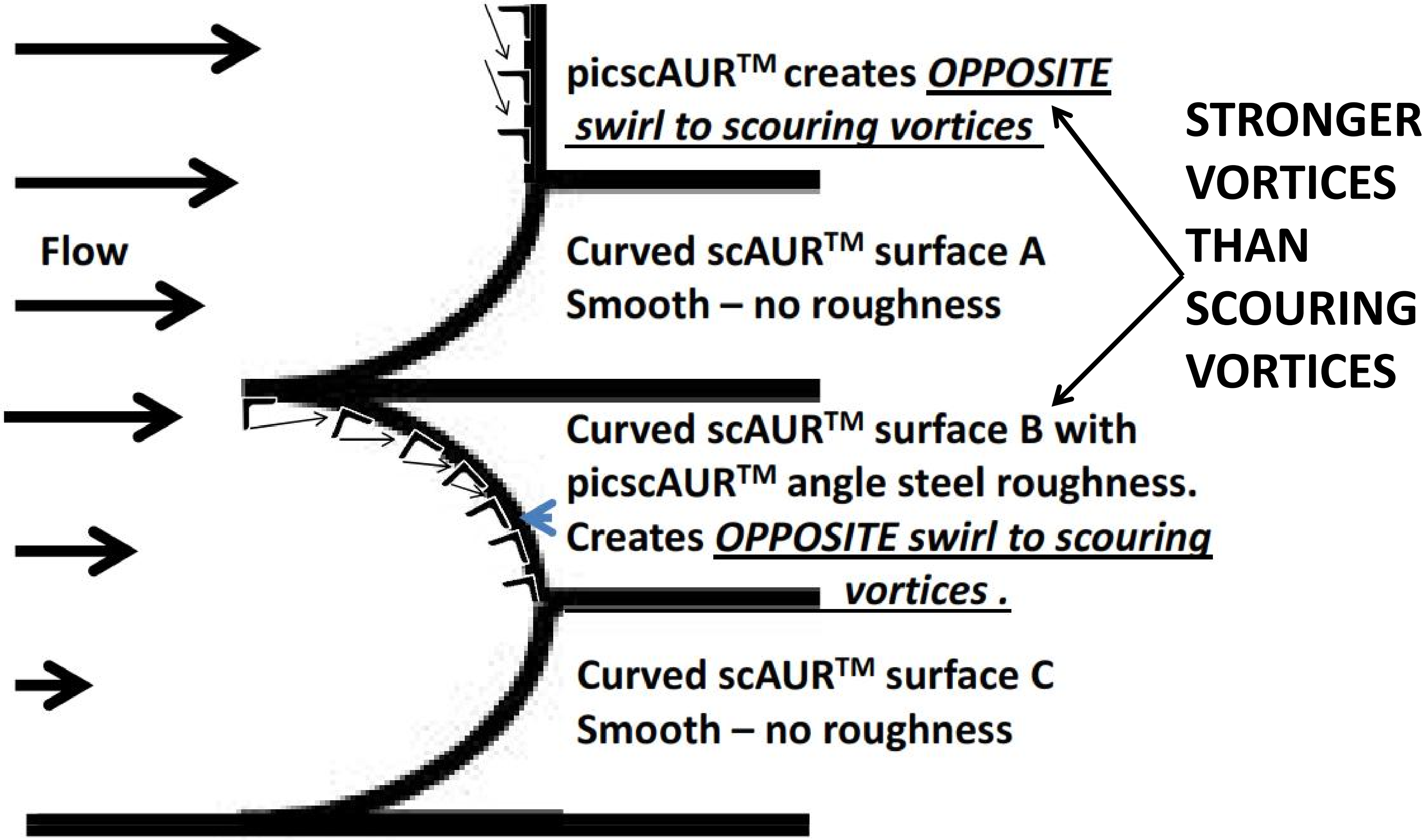
- ***Formed at upstream pile-bed junction.***
- ***Brings higher velocity water down to the bed.***
- ***Stretched around pile increasing scouring velocities.***
- ***Produces high turbulent shear stress on bed.***
- ***Removes rock and soil, leaving a scour hole.***

New Omni-directional Scour-resistant Design for Bridge and Pier Circular Monopiles with the Proven scAUR^{TM} And New picscAUR^{TM}

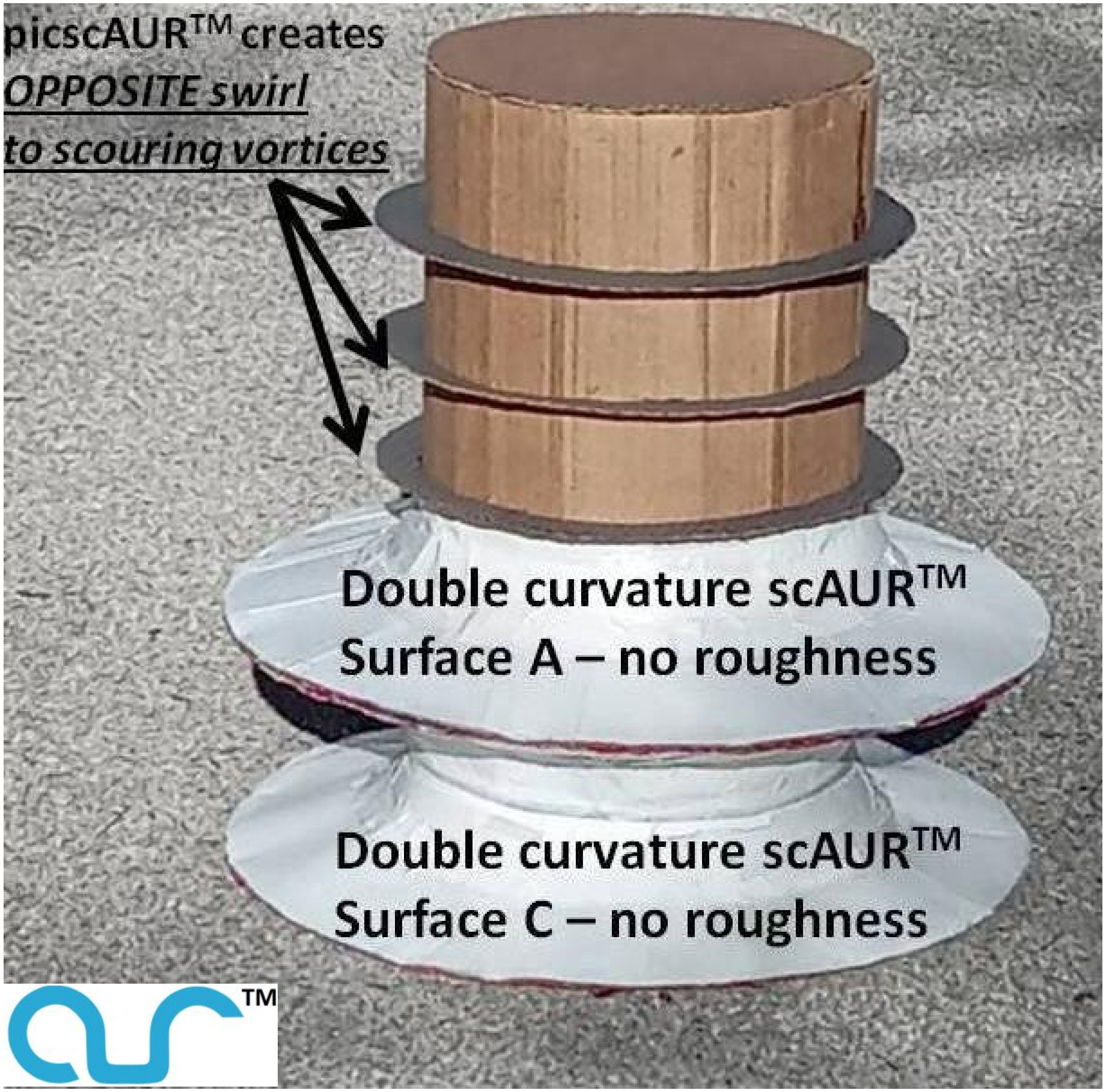


The axisymmetric scAUR^{TM} shape meets the key upstream streamlined fairing design requirement that the surface shape produces surface pressure gradients that limit the flux of new vorticity at the surface so discrete vortices are not formed

Closeup View of One Design for Axisymmetric scAUR™ with Axisymmetric picscAUR™ Scour Prevention Features, 2nd Ed.



Pile test model (0.3048m diameter) for axisymmetric scAUR™ with picscAUR™ scour prevention features, 2nd edition, on a gravel bed.



- Using published calculation methods, the strengths of the shed vortices were calculated.
- Net bed surface speed < 10% of the speed with the monopile only.
- **Test flows:** For the monopile only or Surface A only the 2.5mm gravel moved downstream due to scour: **NO MOVEMENT OF 2.5mm GRAVEL WITH FULL MODEL**

Permanent and Cost-effective Solution for Tidal and Surge Omni-Directional Flows: ScAUR™ with picscAUR™ Designs

➢The cost for one stainless steel (SS) scAUR™ with picscAUR™ unit varies with the size squared with a lifetime of 100 years even in seawater environments. For a 0.3048m diameter pile, the cost is less than several thousand US dollars.

➢Economical retrofits and new units are less costly than deep pile that are used now. At bare minimum, the scAUR™ with picscAUR™ design is cost-effective for much more confidence that the pile will not lose fixity.

➢ Even for bridges with little life left, current temporary countermeasures are much more expensive when the present value of future expenses is considered.

Conclusions

- **Many bridges over water are susceptible to scour of supporting rocks and soil by vortices created at the structure during peak flow events such as floods, tidal events, coastal storm surges, and tsunami situations.**

- **The new omni-directional scour-resistant design for bridge and pier circular monopiles with scAUR™ and a new picscAUR™ design was presented for all flow speeds. *It meets the design requirement that it prevents scour around a circular monopile for any time-varying flow approach direction, like tidal and surge flows.* In these cases, strong high speed flows can occur, first in one direction and then the opposite or another direction.**

Conclusions (Cont)

- **Since strong strength counter-rotating vortices are produced by the picscAUR™ surfaces, the net water bottom bed surface velocity is < 10% of that produced by the horseshoe vortices when there is only the monopile.**
- **The surface force for this scAUR™ and new picscAUR™ design is less than 1/100 of that for a monopile alone, resulting in no movement of small gravel.**
- **The costs associated with the fabrication and installation of the scAUR™ with picscAUR™ design are very favorable compared with other traditional scour protection methods.**

Contact Us for More Information About Other Cases or If You Have Questions

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