Simulation of Atmospheric Boundary Layer in a Wind Tunnel with a Contracted Inlet using Cowdrey Method

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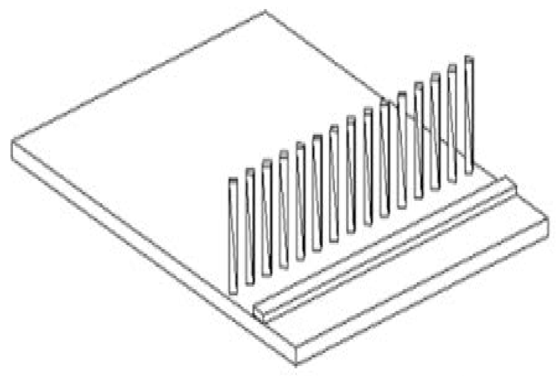
Why Simulate ABL?

ENGINEERING DIVISION	APPLICATION
STRUCTURAL	• Local and overall fluctuating pressures on cladding • Wind forces on structures • Manner in which these structures affect the winds
ENVIRONMENTAL	• Studies of diffusion from chimney stacks
WIND ENGINEERING	• Estimate the wind loads acting on the ship • To further impact its performance • Obtain a safe operating envelope

ABL Simulation Techniques

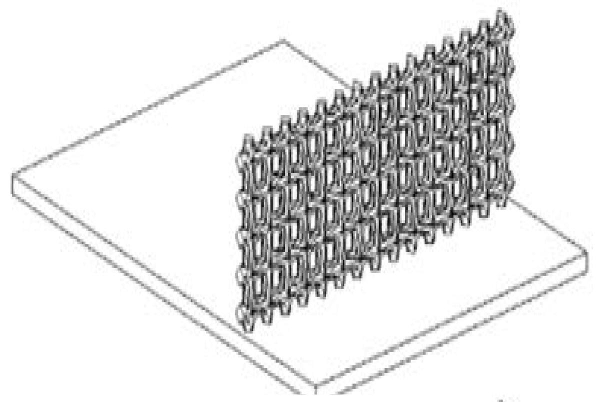
•Rods with a Leading Trip

- Law of the wall for smooth surfaces not obtained.
- Flow did not have sufficient mixing to produce thick boundary layer.



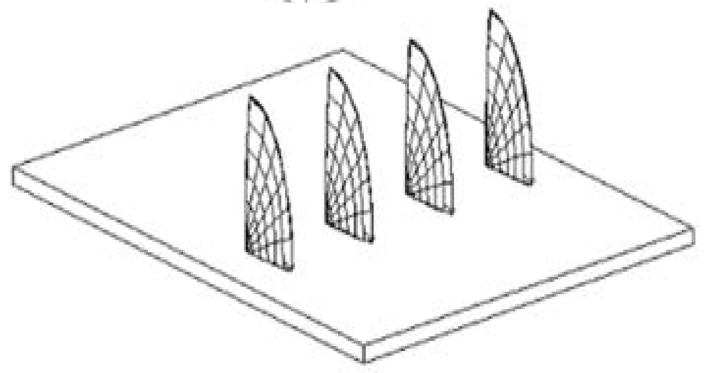
•Grids

- Very distorted velocity profile.
- Aerodynamic drag too high.
- Blockage effect was observed.



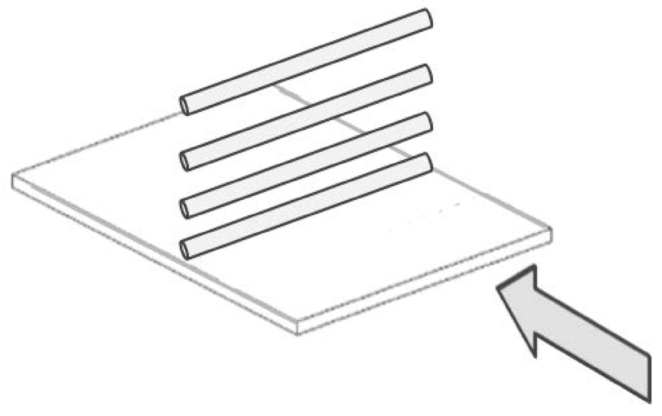
•Elliptical Wedge Generators

- Complex method.
- Flow with exaggerated wake was observed downstream.



Cowdrey Rod Method (1967)

- Technique generates ABL using horizontal circular rods placed parallel to the wind tunnel floor.
- Major advantage: Theoretical basis to obtain a desired power lav profile.



Results

Wind Tunnel Contraction

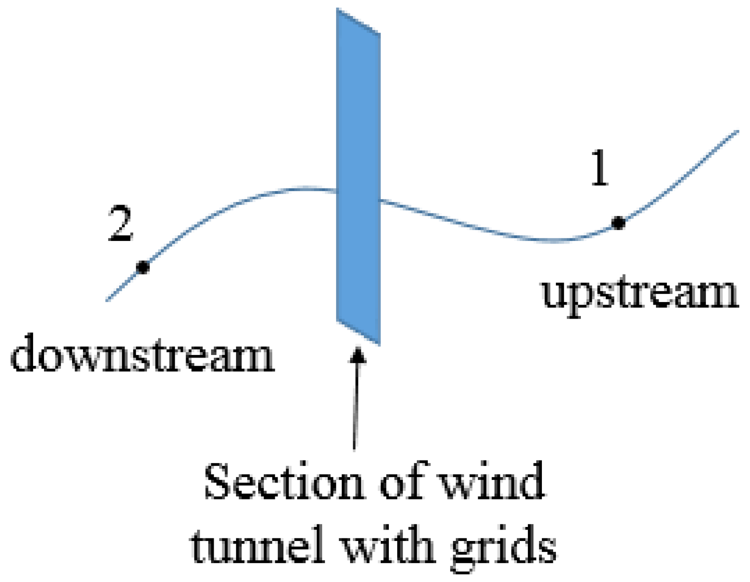


Fig 1: This picture gives a perspective of how Bernoulli's theorem was incorporated with Cowdrey method for calculation of rod dimensions and placement.

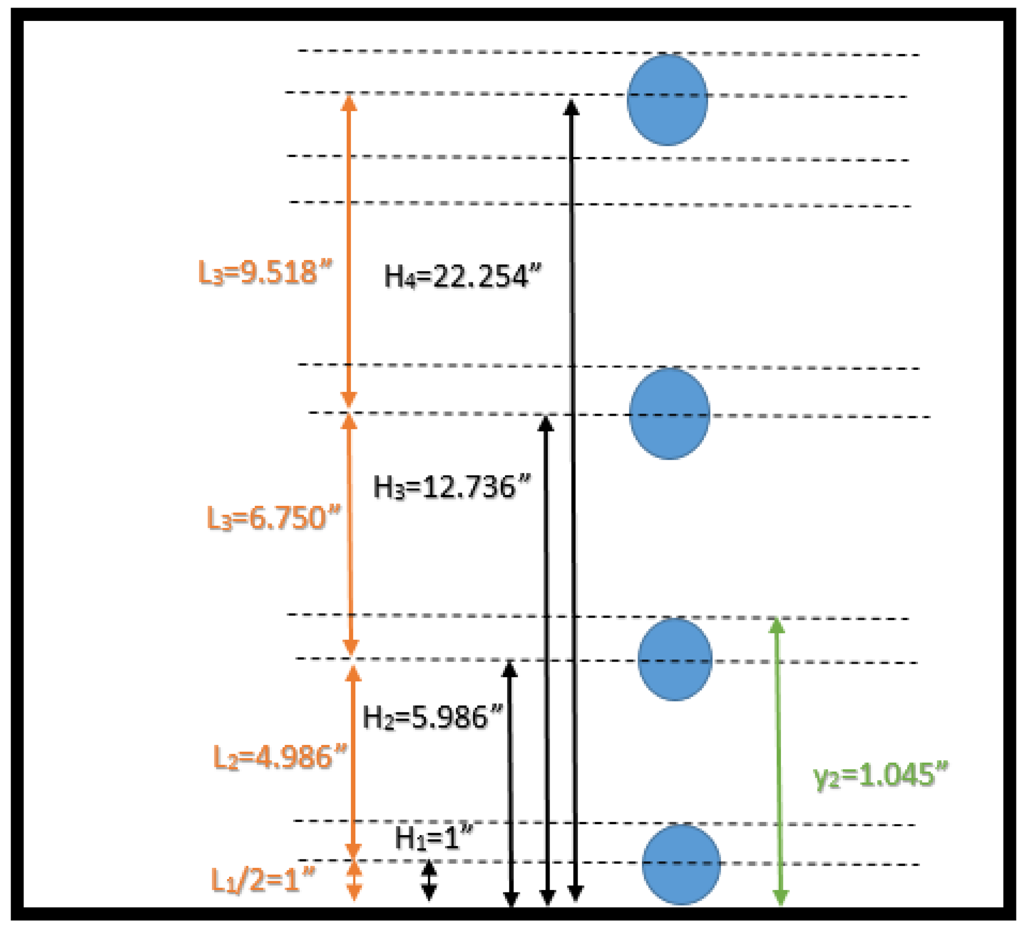


Fig 3: This picture shows the vertical spacing of the rod placement in the wind tunnel for diameter of road as 1 inch.

Cowdrey Grid Comparisons: Increasing K1 values

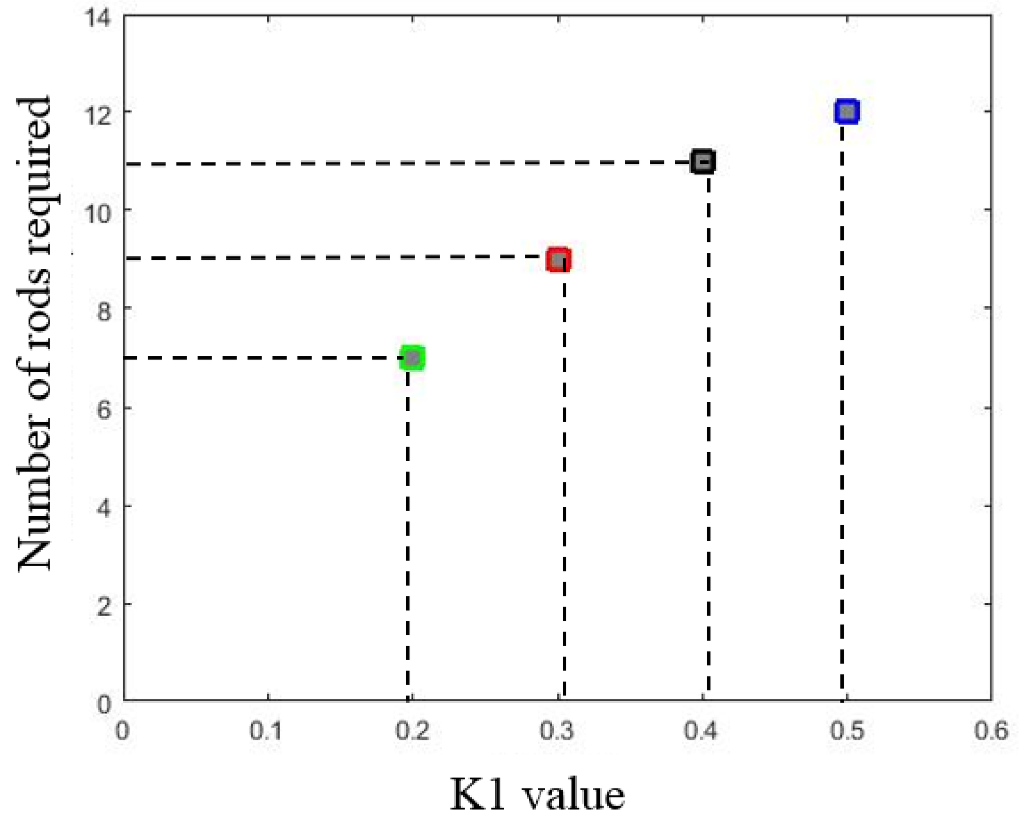


Fig 2: This graph shows that as the K1 value increases, the number of rods required at the inlet of the cross-section increases; for diameter of rod as 1 inch.

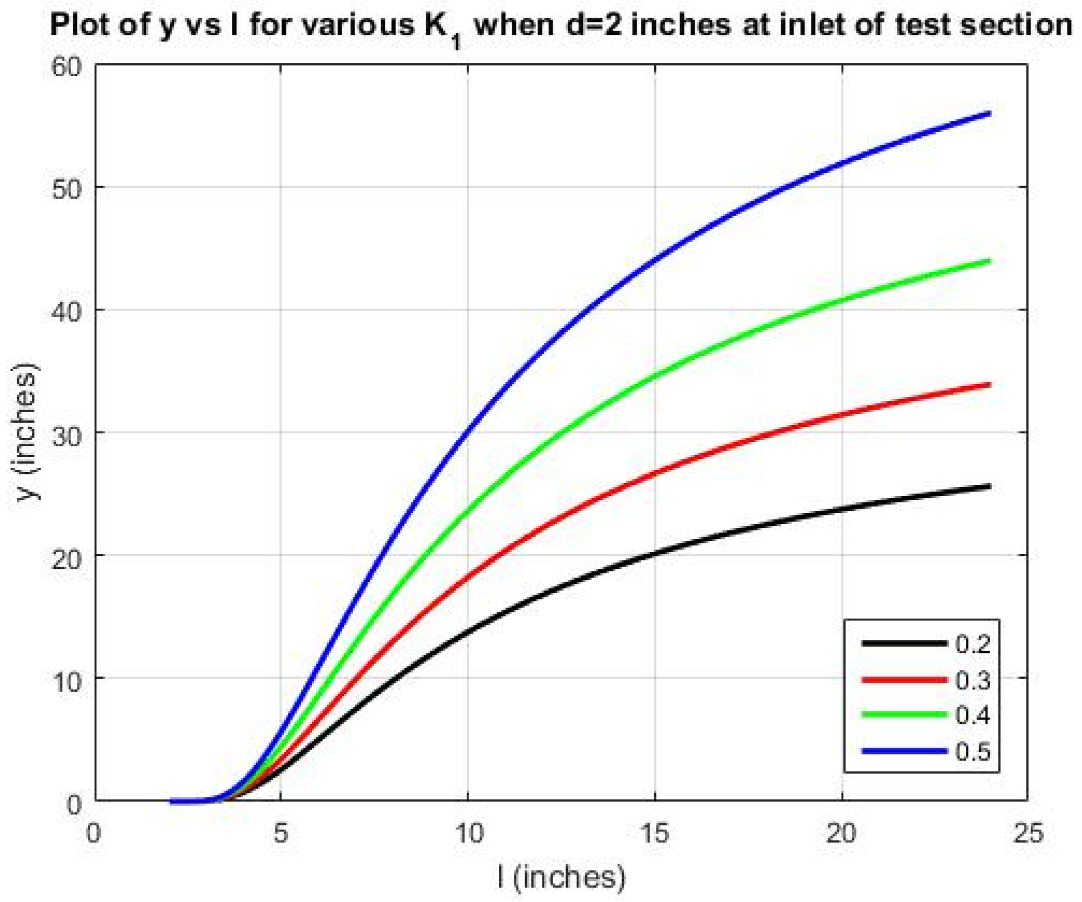


Fig 4: Graphical display of the ABL profile.

Conclusions

- With increasing the K1 values, more number of rods were required while the spacing between axes of consecutive rods decreased.
- Also, the total number of rods required increased with decreasing the diameter of the rods.
- These observations were used to deduce the optimal placement of rods in the wind tunnel.

References

- Barbosa, P. H. A., M. Cataldi, and A. P. S. Freire. "Wind Tunnel Simulation of Atmospheric Boundary Layer Flows." Journal of the Brazilian Society of Mechanical Sciences 24.3 (2002): n. pag. Web.