EBE

CHEMICAL ENGINEERING AT UCT

UNIVERSITY OF CAPE TOWN

IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

PROJECT 11: WIND TUNNEL CALIBRATION FOR SIMULATED MINE DUST GENERATION

01 INTRODUCTION

- Wind tunnel calibration provides a tunnel with air flow of known characteristics to be used for experimentation.
- Most information known about wind-erosion and atmospheric dust is through wind tunnel-based experimentation.
- Calibration requires the development of an artificial atmospheric boundary layer (ABL) in tunnel that shows agreement with the Power/Log-law.
- The ABL is the lowest part of the atmosphere where turbulent winds cause wind-erosion.
- An artificial ABL mimics the atmospheric conditions that cause atmospheric dust movement.

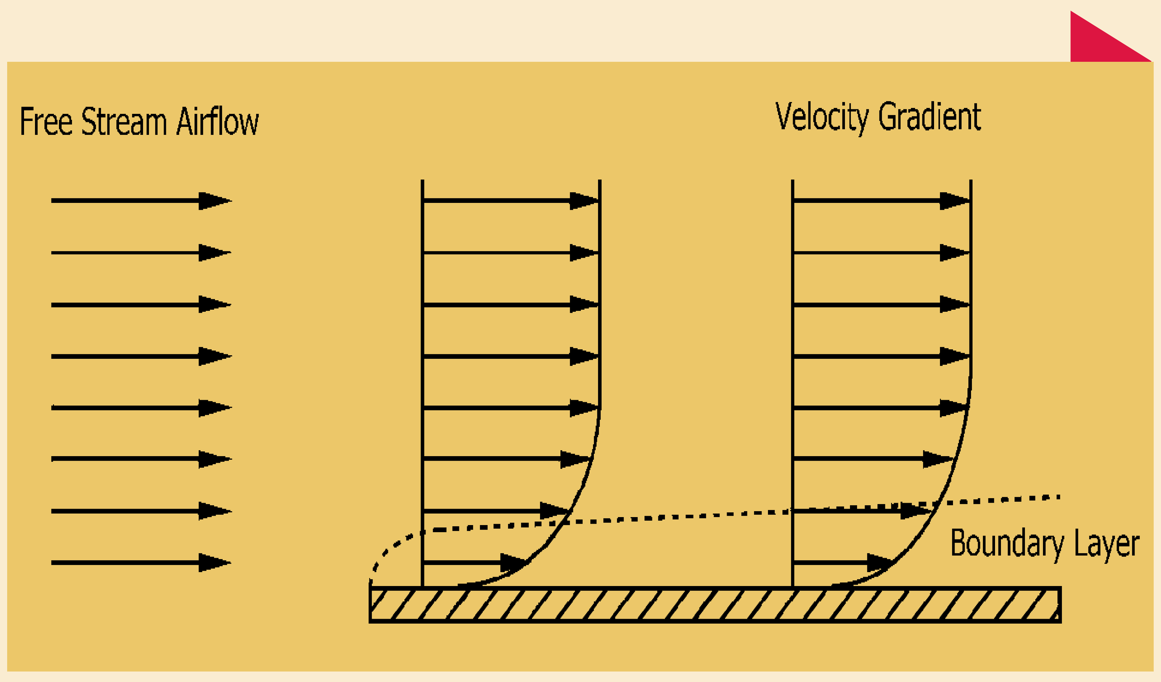

Figure 1: Diagram showing the development of a boundary layer near a surface

02 EXPERIMENTAL

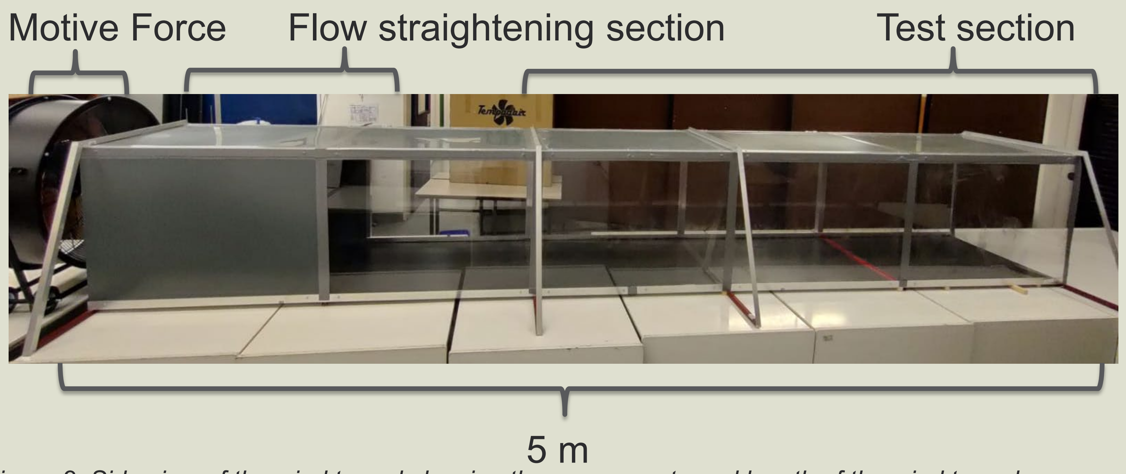

Figure 2: Side view of the wind tunnel showing the components and length of the wind tunnel

Figure 3: Retort stands holding the testo anemometers inside the tunnel to measure wind speeds at different heights

Figure 4: Fan setup at the entrance of the tunnel with channelling plastic- blowing set up

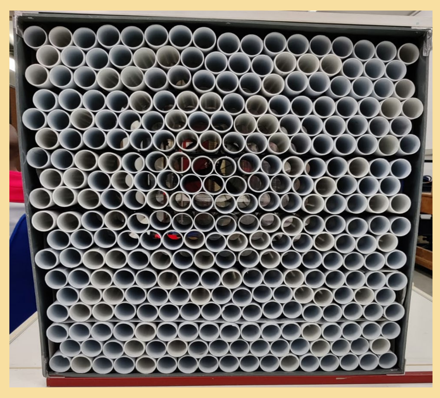

Figure 5: Air straightening PVC pipes in the entrance of the tunnel

Setup 1:

Empty tunnel with only straighteners determine ideal test section

Setup 2:

Full depth spires
Development of the boundary layer

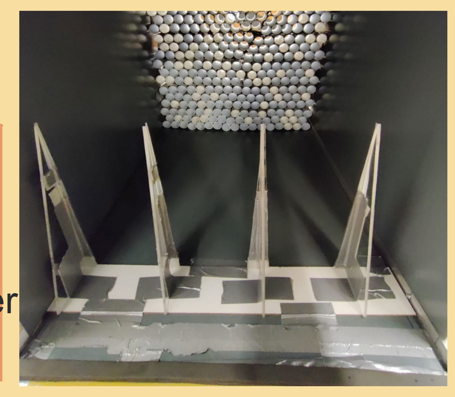

Figure 6: Flat triangular spires set up in the wind tunnel used for setup 2 and 3

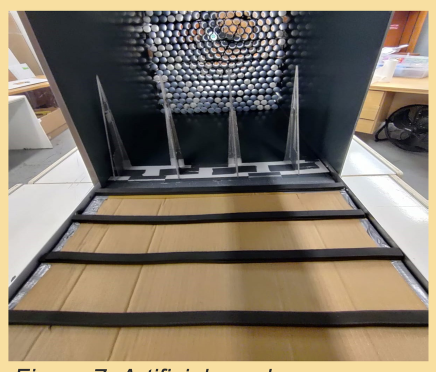

Figure 7: Artificial roughness elements for setup 3

Setup 3:

Full depth spires and roughness elements
Power-law agreement and boundary layer development

03 RESULTS

Blowing:

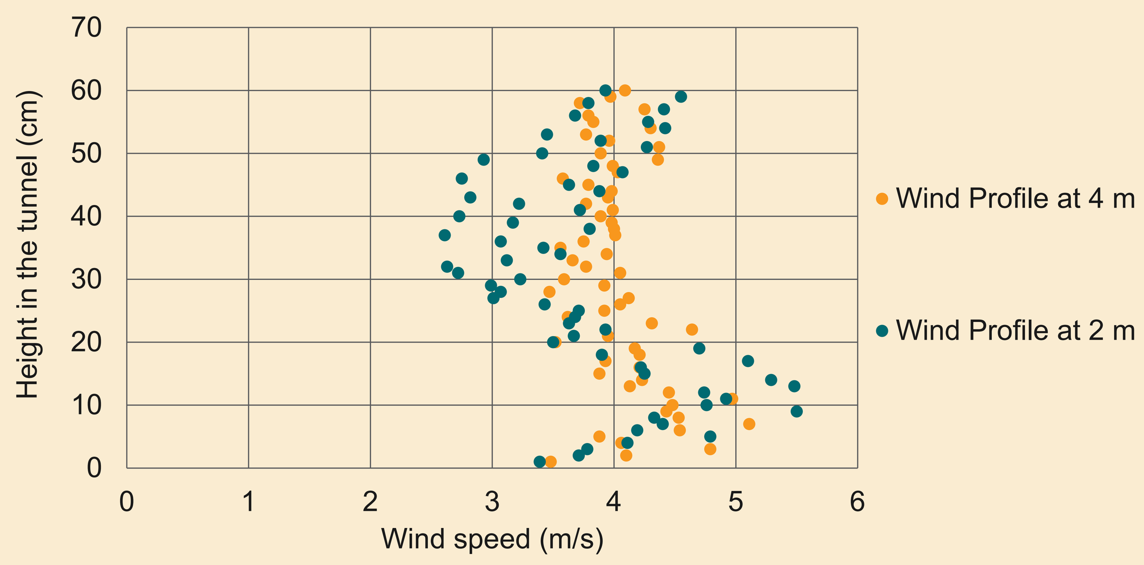

Figure 8: Wind speed profile using a blowing fan setup taking measurements at 2 and 4 m from the straighteners

Suction:

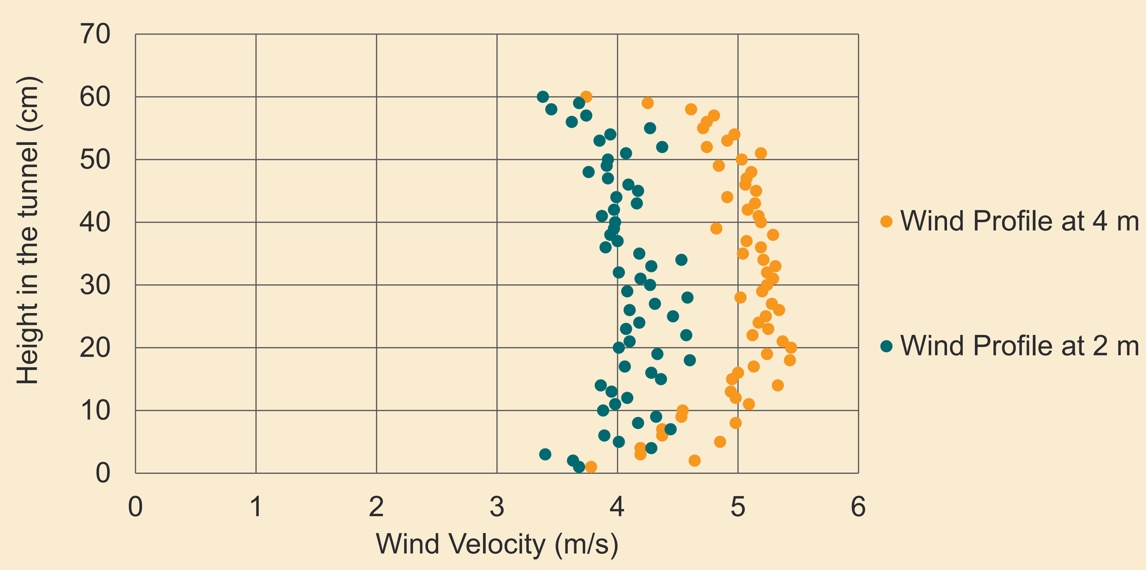

Figure 11: Wind speed profile using a suction setup taking measurements at 2 m and 4 m from the straighteners

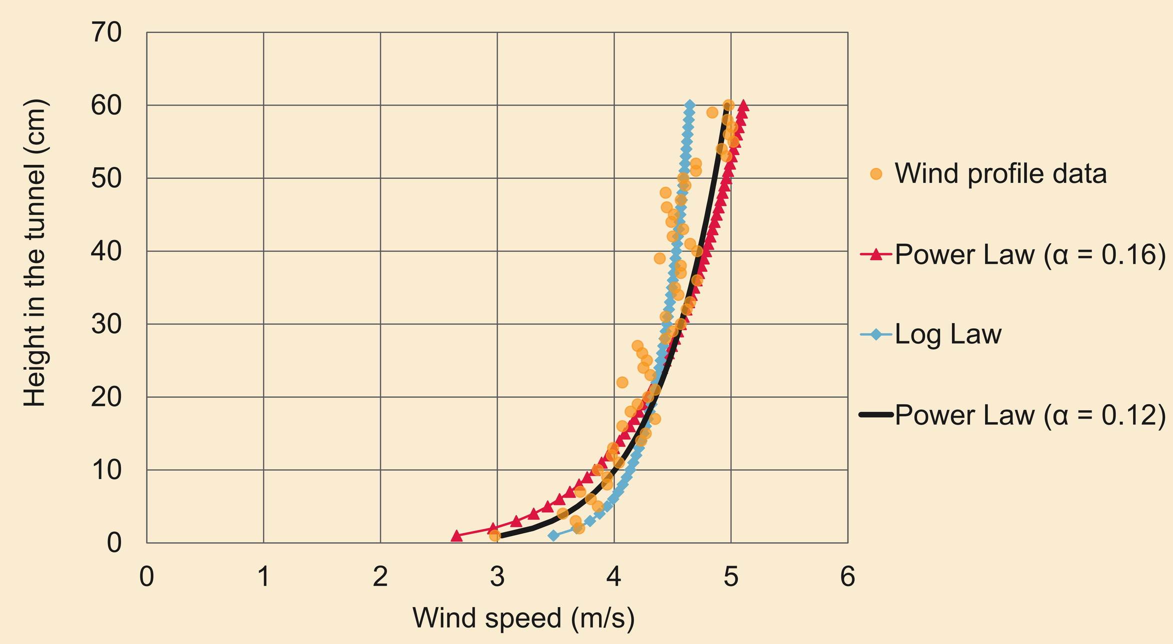

Figure 9: Wind speed profile using polycarbonate spires while using a blowing setup compared to the power law (α=0.16) and log law (z_0=1.5x10^{-6}), measurements taken 4 m from the straighteners

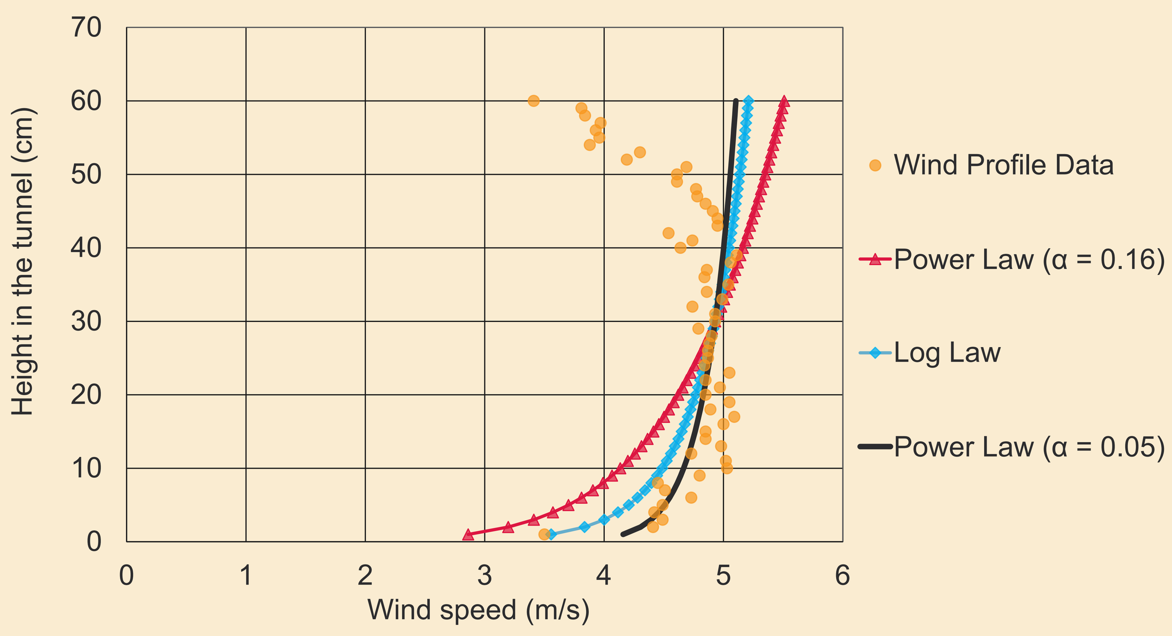

Figure 19: Wind speed profile using polycarbonate spires while using a suction setup compared to the power law (α = 0.05 and α = 0.16) and log law (z_0 = 1.5x10^{-6}), measurements taken 4 m from the straighteners.

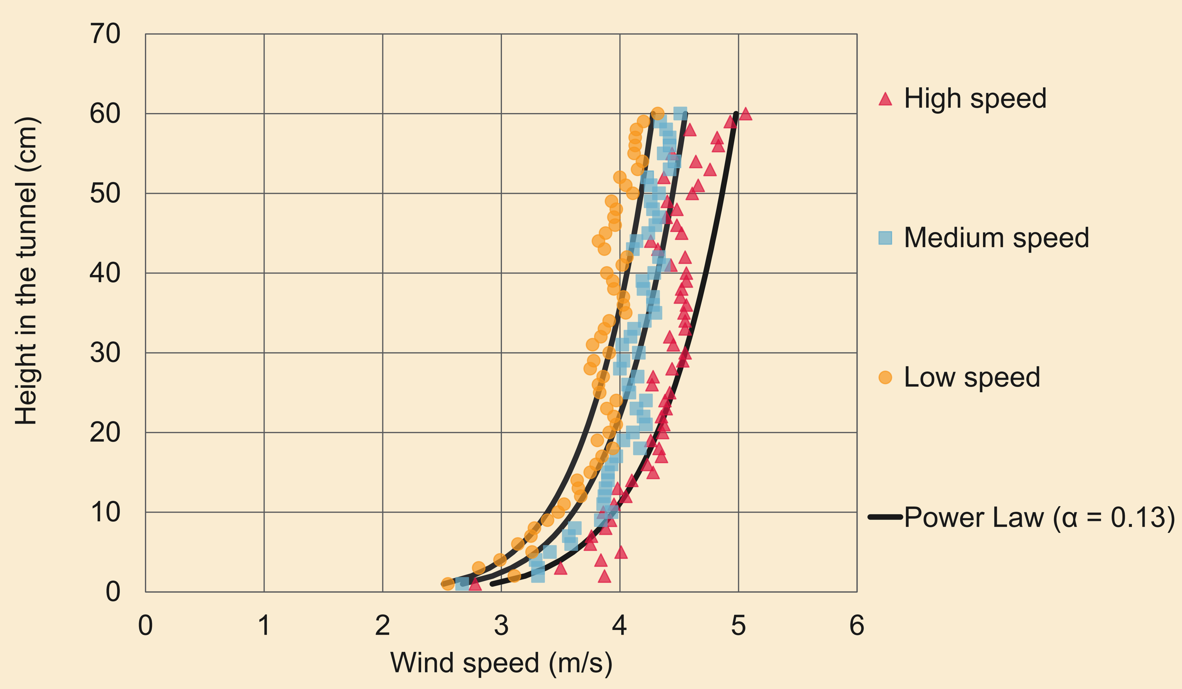

Figure 10: Wind speed profiles using spires and roughness elements at different wind speeds compared to the Power Law (α=0.13) while using a blowing setup. Measurements taken at 4 m from the straighteners.

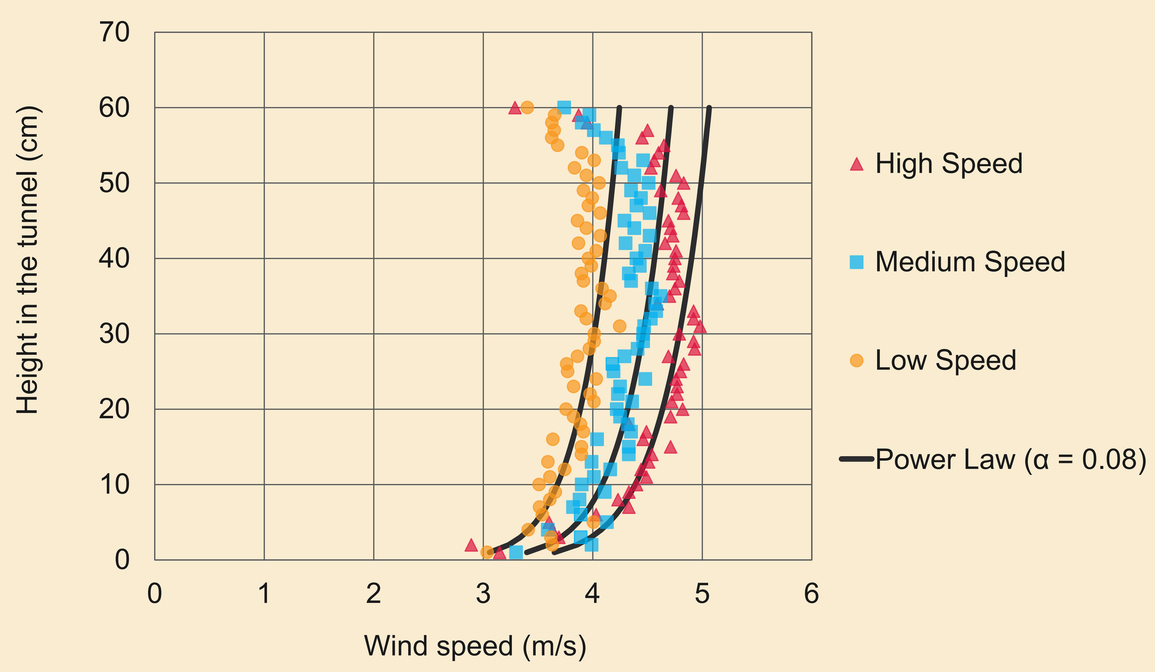

Figure 13: Wind speed profiles using spires and roughness elements at different wind speeds compared to the Power Law (α = 0.08) while using a suction setup. Measurements taken at 4 m from the straighteners.

04 DISCUSSION

- Development of flow allows for a more uniform profile at 4 m.
- A boundary layer was developed with the use of spires.
- The data was fit to the power-law with α = 0.12.
- Roughness elements only increased α to 0.13; a lack of roughness elements along the entire length of the tunnel as stipulated in literature.
- The data begins to deviate from the power-law at heights 40-60 cm, the postulated cause is the roof of the tunnel- shear stress and surface resistance.
- The Froude numbers calculated were mostly below 10, but all below 20, meaning a constant friction condition was achieved.

05 CONCLUSION

- The open-air wind speed profile for the fan showed a relationship expected and observed in literature.
- Wind speed is more developed further down the tunnel.
- Spires increased the uniformity of the data while developing a boundary layer 0.3 m thick.
- Spires also increase the wind speeds measured in the tunnel.
- Roughness elements decreased wind speeds near the surface, which increase the agreement with the power law with a higher exponent value.
- Boundary layer is formed at 0.3 m high with the use of spires and roughness elements.
- The wind tunnel can be used to investigate atmospheric dust movement and settling.

References:

- Barlow, J., Rae, W., & Pope, A. (1999). *Low Speed Wind Tunnel Testing* (3rd ed.). New York: John Wiley & Sons, Inc.
- Irwin, H. (1981). The design of spires for wind simulation. *Journal of Wind Engineering and Industrial Aerodynamics, 7*(3), 361-366.
- Fabbri, C. D. (2018). *Simulation of natural winds in a portable wind tunnel using full-depth and part-depth atmospheric boundary layer approaches for soil erosion research.* Basel: Department of Environmental Sciences University of Basel.
- Van Pelt, R., & Zobeck, T. (2013). *Portable Wind Tunnels for Field Testing of Soils and Natural Surfaces.* doi:10.5772/54141

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