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The Permeability of a Soil Termite [*Macrotermes gilvus (Hagen, 1858)*] Fungus Comb as a Porous Medium

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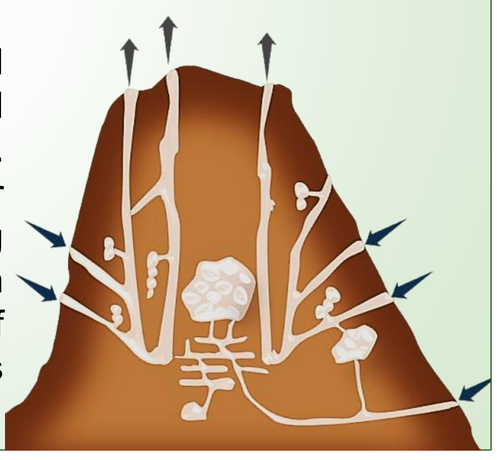
INTRODUCTION & AIM

In the field of biomimicry, termite mounds serve as a source of inspiration for engineers and architects involved in designing environmentally friendly buildings. Termite mounds has been studied for years due to its amazing designs and features. However, it also leads to gaps in underexplored systems of one of the components of the termite nests, particularly the termite fungus comb.

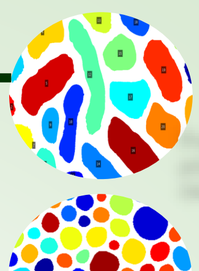
For this study, baseline data were collected on the permeability properties of a biological porous material, the termite fungus comb. This study aimed to determine the air permeability of the comb by conducting experiments involving an airflow through an internal pipe and analyzing the effects of different air flow velocities with Reynolds number ranging from 15,000 to 71,000.



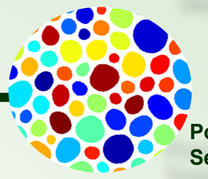
METHOD

In **analyzing** the permeability, the physical properties of the termite fungus comb including porosity and pore geometry were identified using MATLAB image analysis.

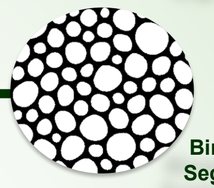
Physical Properties



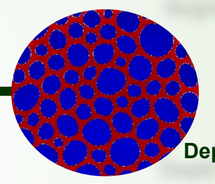
Pore ID placement identifier



Pore Space Segmentation



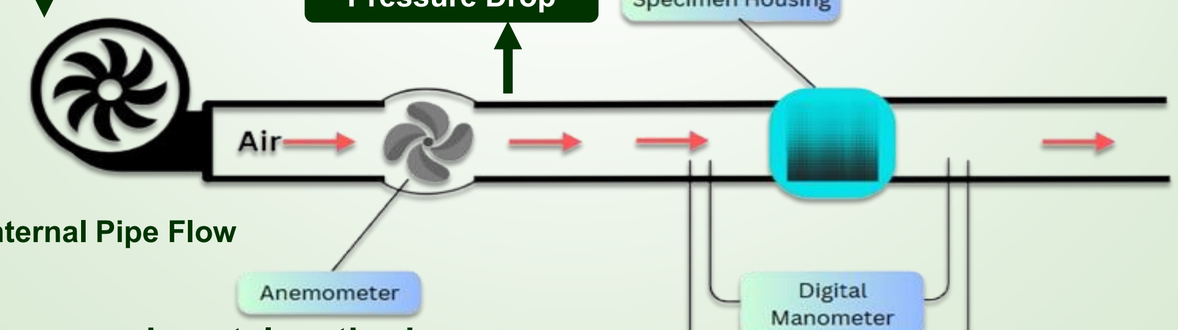
Binary Segmentation



Depth Map

Forchheimer Equation

$$\frac{\Delta P}{L} = \frac{\mu}{k}U + \rho\beta U^2$$

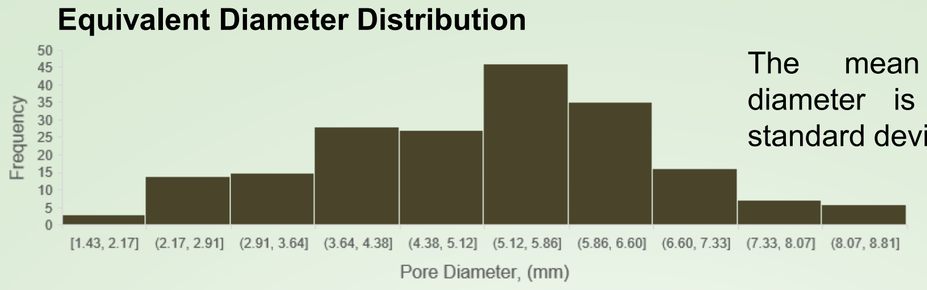


Internal Pipe Flow

Using **experimental method** of airflow in internal pipe, the pressure drop is also measured with varying wind velocities. Data from the two process is used to compute and estimate the permeability using Forchheimer's equation.

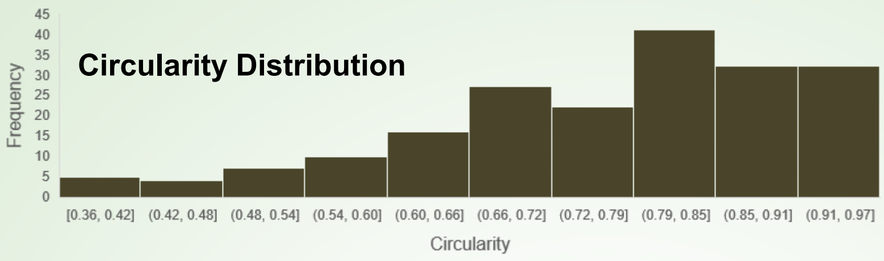
RESULTS & DISCUSSION

Equivalent Diameter Distribution



The mean pore equivalent diameter is 5.16 mm with a standard deviation of 1.47 mm

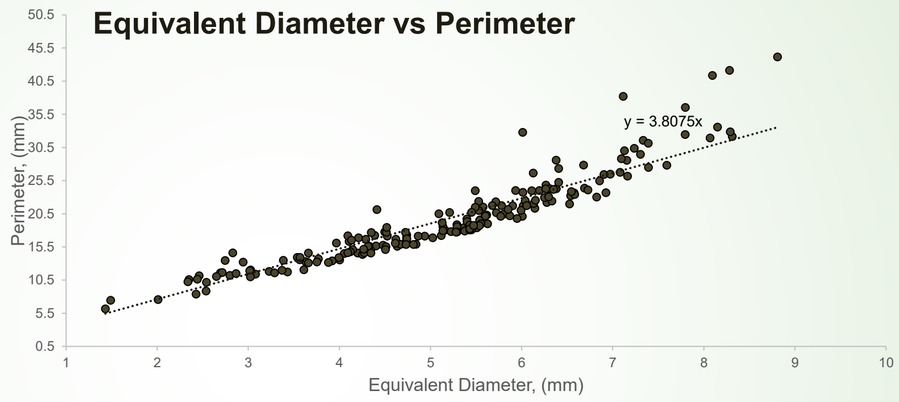
Circularity Distribution



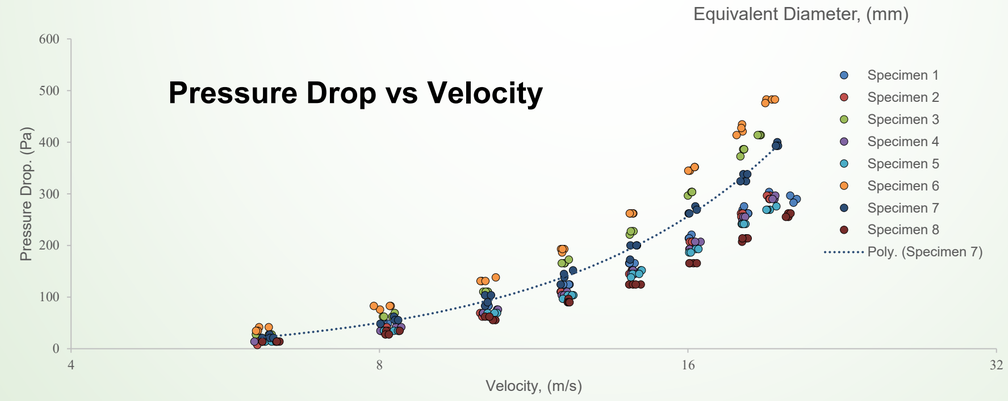
Across specimens, it ranges from 0.36 to 0.96, with most between 0.66 and 0.9, averaging 0.76.

The plotted dots for the equivalent diameter vs perimeter shows that the trendline slope leads to a value of 3.8075 as compared to perfectly circular (3.14 or π).

Equivalent Diameter vs Perimeter

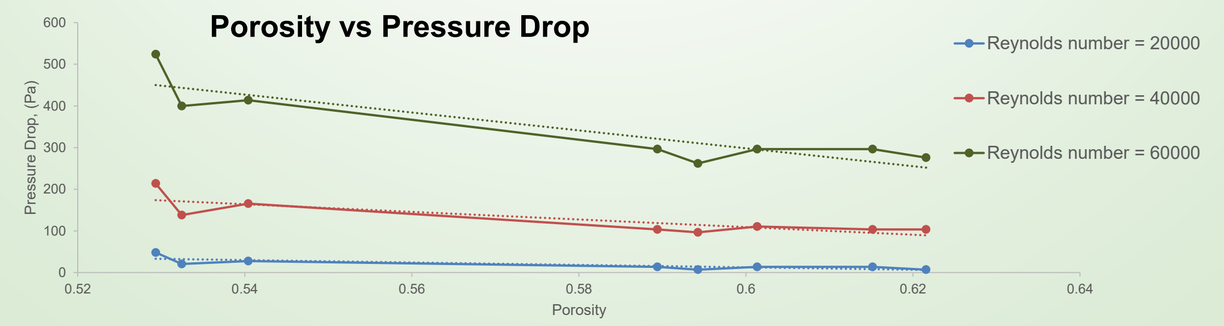


Pressure Drop vs Velocity



Pressure drop value of the specimen is influenced by the varying values of air velocity and porosity.

Porosity vs Pressure Drop



MATLAB image analysis for the termite fungus comb resulted its porosity ranging from 52% to 61%.
Termite fungus comb permeability, as modelled using Forchheimer's equation leads to values ranging from 1.2724×10^{-7} to 3.9828×10^{-7}.

CONCLUSION

- High porosity (average of 57.71%) confirm termite fungus comb as a lightweight, highly porous material.
- Nonlinear flow behavior, modeled by Forchheimer's equation, ensures accurate permeability estimates (average of $2.235 \times 10^{-7}\ m^2$).
- MATLAB image analysis provides reliable small-scale measurements, with an average equivalent diameter of 5.16 mm.
- Pressure drop increases with airflow velocity, showing strong turbulent effects at higher Reynolds numbers.

FUTURE WORK

- Explore architectural uses, designs, and correlation with engineering principles.
- Conduct microstructure analysis.
- Investigate mechanical testing integration.
- Explore ventilation and filtration applications.