Overview
Composite materials derive their name from the fact that they are composed of two chemically different materials. They consist of fibers (generally woven) embedded within a resin matrix. There are many methods of manufacturing composite materials, some popular examples are compression molding, resin transfer molding (RTM), and vacuum assisted RTM.

History of Composite Materials
- 1937 Owens Corning Fiberglass Company began selling fiberglass in the United States.
- 1960s Composite materials first used in aerospace industry.
- 1990s Bio-based composites begin to receive industrial and academic attention.

Purpose
Develop an experiment to measure the through thickness (transverse permeability) of fabrics made from natural fibres.

Motivation
- Natural fibre materials are known to have low permeability, making manufacturing difficult and transverse infiltration more attractive (i.e. resin film infusion).
- With large parts it is not easy determining how much heat and pressure to apply, how much resin to inject, etc.
- Process modeling is necessary to determine aforementioned values.
- Permeability data is necessary for process modeling.
- Investigate unsaturated regime of flow.

Theory
Darcy’s law is used to model fluid flow through a porous medium. It is a relationship between permeability, K, discharge rate, Q, pressure gradient, ΔP/Δx. If the flow is assumed to be unidirectional, it can be represented by,

\[ Q = \frac{AK \Delta P}{\eta \Delta x} \]

Methods
To assure unidirectional fluid flow, stacks of 3” diameter fiber discs will be placed between two permeable walls (of known permeability) and enclosed within a cylinder. Experiment can be performed at constant flow rate or pressure. Constant flow rate will be used in this case. Pressure gradient measured using pressure transducers at inlet and outlet chambers of the test rig. Discharge rate measured using flow meter at inlet. Cross sectional area, fluid viscosity, length of test segment known. Permeability can be isolated and calculated based on Darcy’s law.

Setup
1. A pressure pot (brought to high pressure) is used to flow fluid into the rig.
2. The flow rate is captured and the pressure is taken at the inlet.
3. Fluid flows through the permeable wall, into the fiber pre-forms.
4. Fluid flows through another permeable wall into the outlet chamber where the pressure is again taken.
5. Fluid leaves the rig and is collected in an overflow container.

Future Work
- Investigate the test fluid and natural fibre interaction in the unsaturated regime.
- Investigate in-plane permeability of natural fibres using infusion (resin pulled) and RTM (resin pushed) methods.

Closing Remarks
Permeability is a difficult value to measure. It depends on many factors including fibre architecture, fibre fluid interactions, etc. It is often the case that a material does not behave in practice as it should based on theory. As such, designing permeability test equipment is a constantly evolving field.

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Materials
This experimental procedure will be performed on three natural fibers: flax, hemp, and kenaf. The fibre volume fraction will be varied be turning a screw at the top of the upper chamber compressing the fiber stacks.

- In place of a liquid resin, silicone oil of a similar viscosity will be used.

References