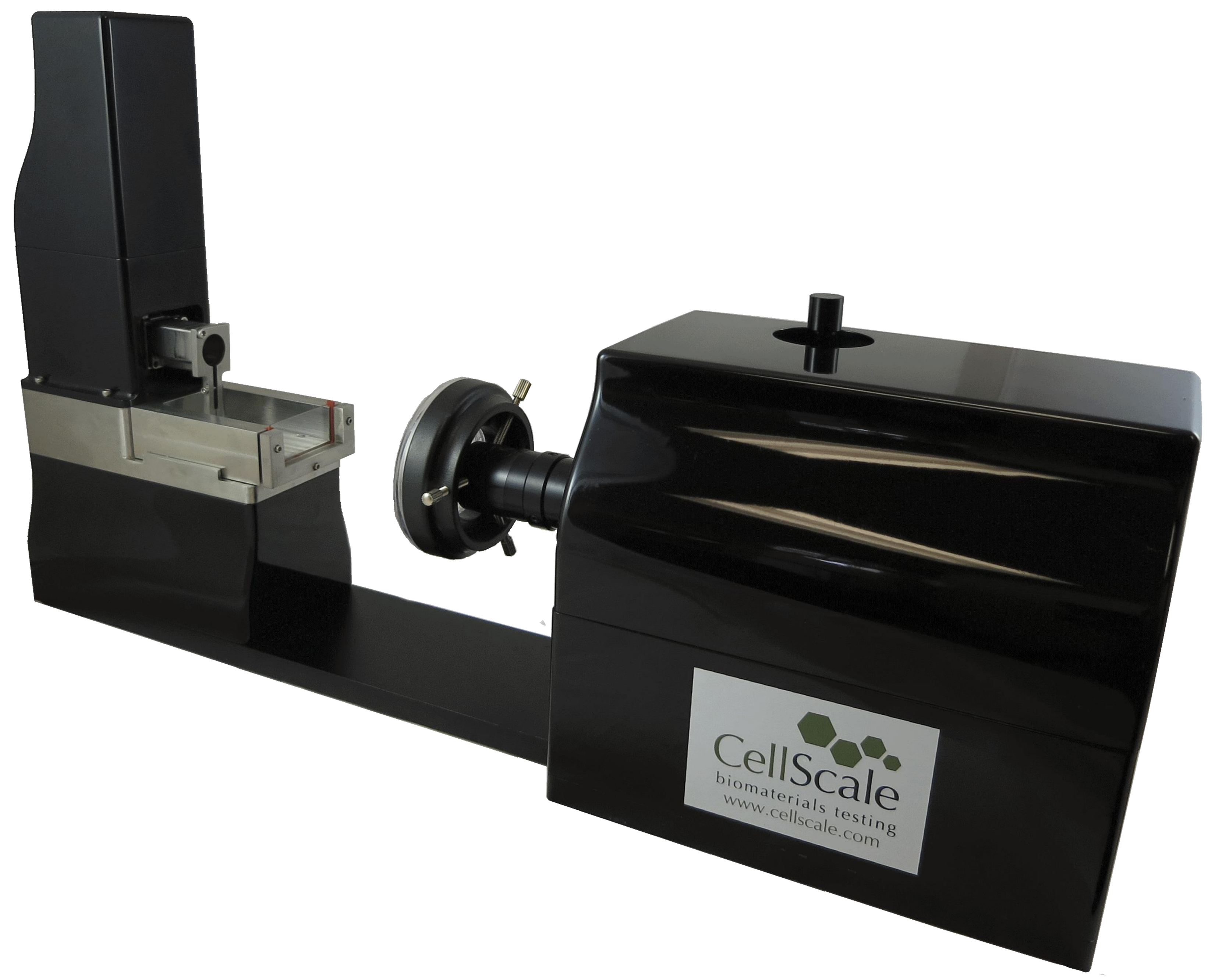
# Tension Testing of Soft Materials

## Overview

The MicroSquisher has been designed to perform tension and compression testing at low forces. The most difficult part of tension testing of small specimens of soft materials is affixing the test specimen to the test device. The clamps that are often used for stiffer materials can easily crush the specimen and are often too heavy to be used without overloading the force sensor. Adhesive attachments are often ineffective with soft materials due to their aqueous nature. In all cases it is necessary to minimize the amount of manual handling of the small delicate specimens.

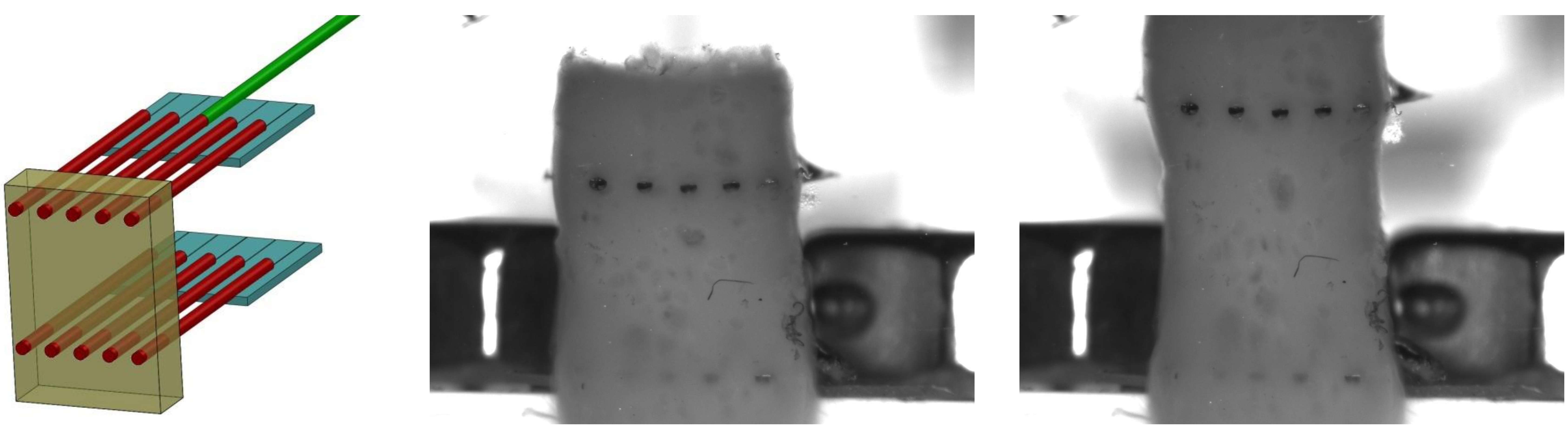
This report outlines the results of tension testing of soft materials using 2 methods: Stretching with puncture fixation, and stretching with stationary end points.




## Stretching with Puncture Fixation

This technique involves attaching a row of puncture tines to the end of the force transducer. Using multiple puncture points distributes the load so that larger deformations can be applied without tearing the specimen.

The gels used in this testing were prepared from edible pudding powder mixed with boiling water (Mango Flavor Pudding Powder, Fairsen Foods Industry Co. Ltd., Taiwan). The powder was mixed with boiling water at 2 different ratios: 0.17g/mL and 0.25g/mL (package recommendation was 0.17g/mL). The hot mixture was poured into a cylindrical tube and placed in the refrigerator to cool. After cooling the tube was used to hold the gels, and slices 1.45-1.78mm were cut using a razor blade. From these slices, rectangular specimens were cut with parallel razor blades so that the specimen width was a constant 3.3mm.



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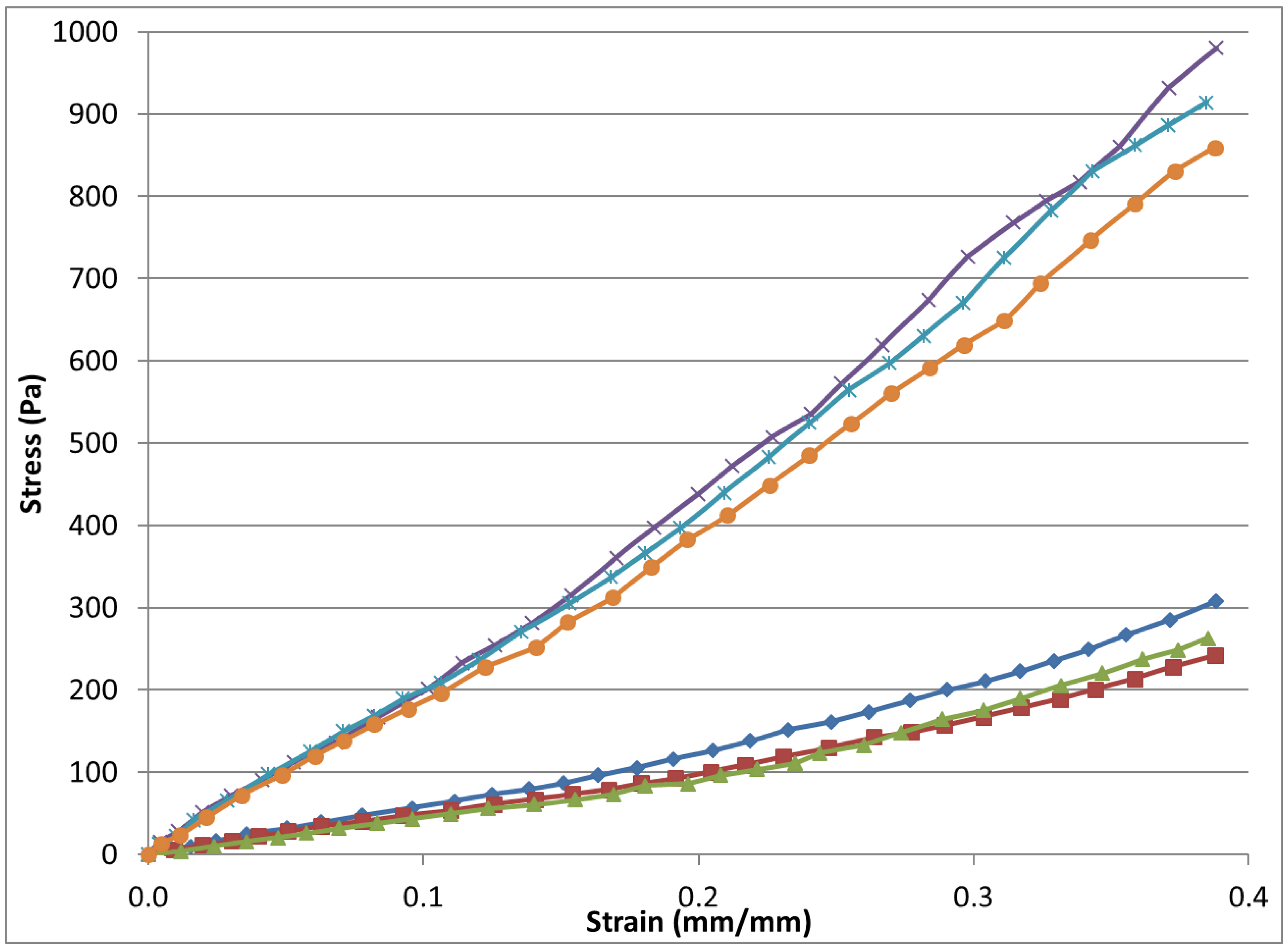
The MicroSquisher test chamber was filled with room temperature distilled water. The specimens were positioned to be resting on the bottom of the chamber with one of the faces against the glass at the front of the chamber. The bottom tines (which were fixed to a weighted block) were then forced through the specimen from behind. The top tines, which were fixed to the moving force transducer wire, were then forced through the specimen as well. Both the upper and lower tines were then backed away from the front glass so that the specimen was no longer subject to sliding friction during the test.

The test protocol was set to stretch the specimens by 40% nominal strain at a constant rate in 30 seconds. Images and data points were collected every second.

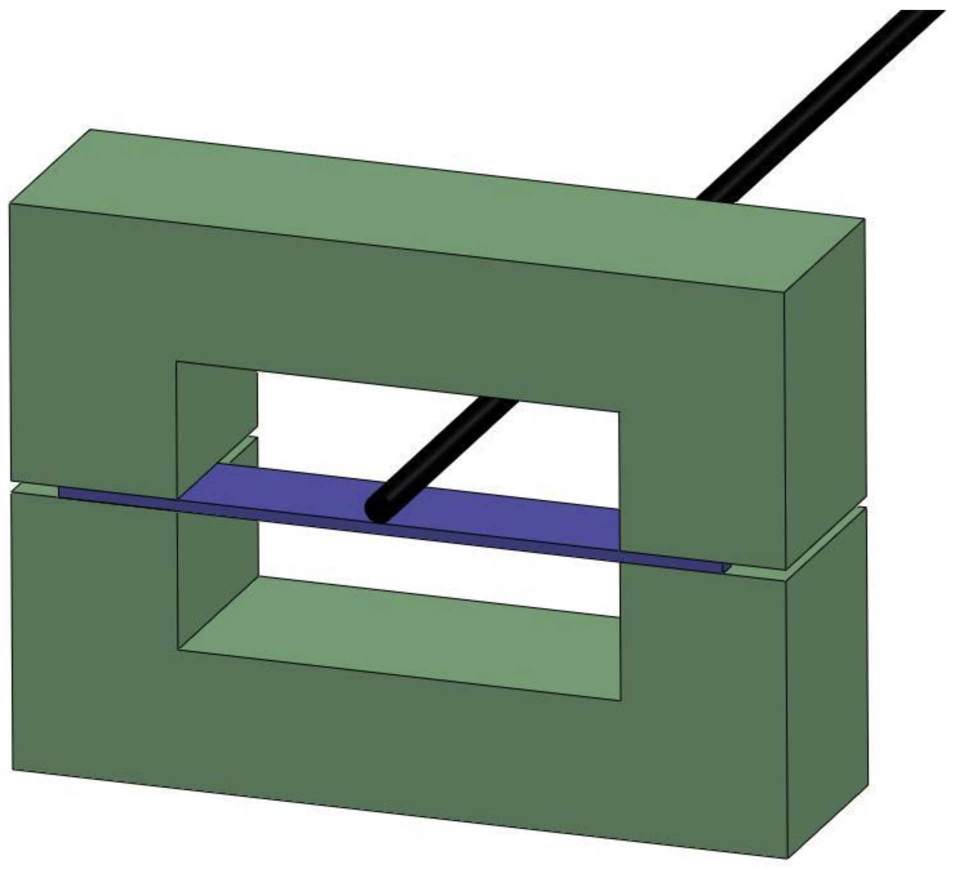
The average modulus for the 0.17g/mL and 0.25g/mL specimens were 490Pa and 1908Pa respectively when measured using a linear curve fit for the data points between 0 and 15% nominal strain. The complete stress/strain data for all 6 tests is plotted in the graph below.

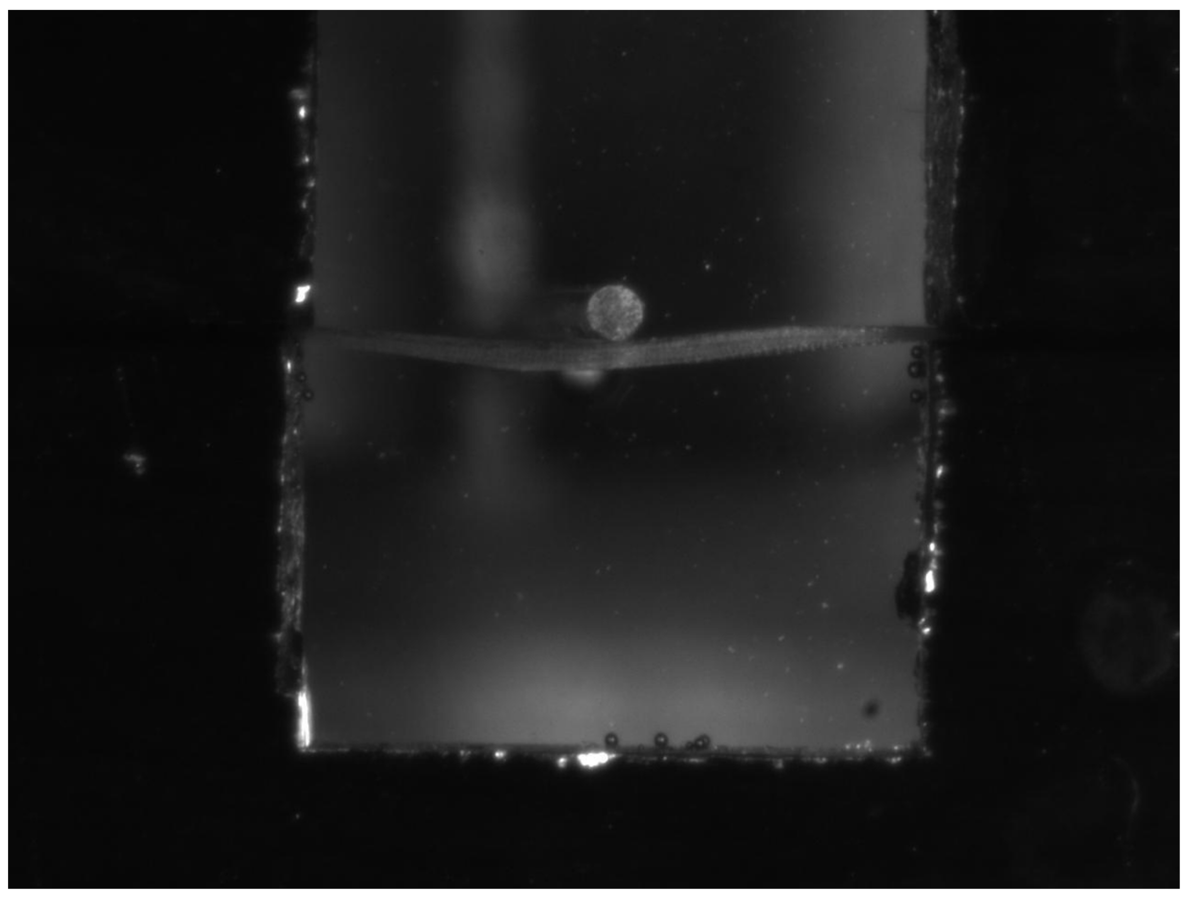


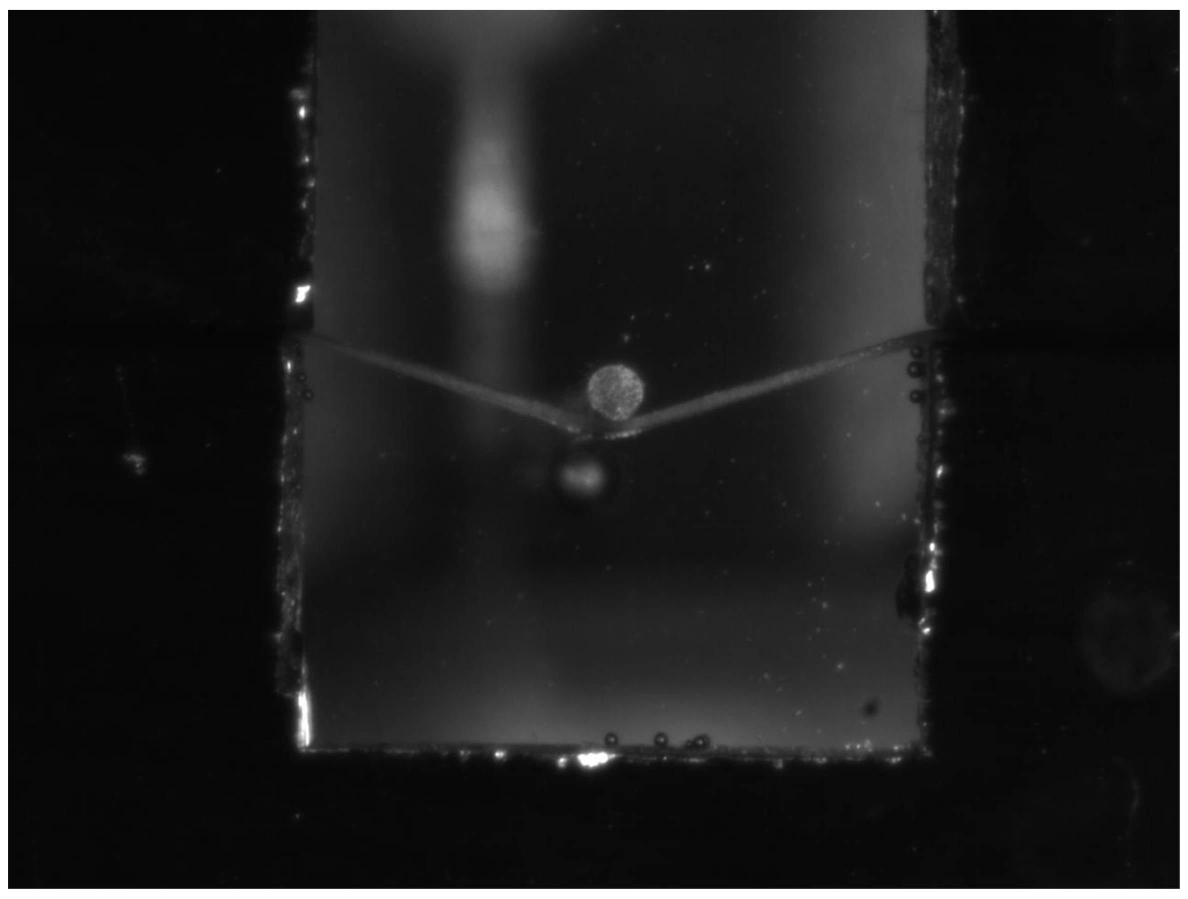

## Stretching with Stationary End Points

This technique involves placing the specimen on a “U”-shaped fixture and then clamping it with an inverted “U”-shaped clamp. The clamping pressure can be increased by placing additional weight on top of the upper fixture. Tension can be applied to the specimen by using the force probe to apply vertical force at the midline of the horizontal strip that is now fixed at both ends.

For this testing 2 different PEGDA hydrogels were used. The specimen strips were 3mm wide by 0.1mm thick by 15mm long. The clamping force was achieved by a total weight of 30 grams and this was sufficient to anchor the specimens during the loading phase of the test (peak force probe loads of 30mN). The specimens were tested in room temperature distilled water.







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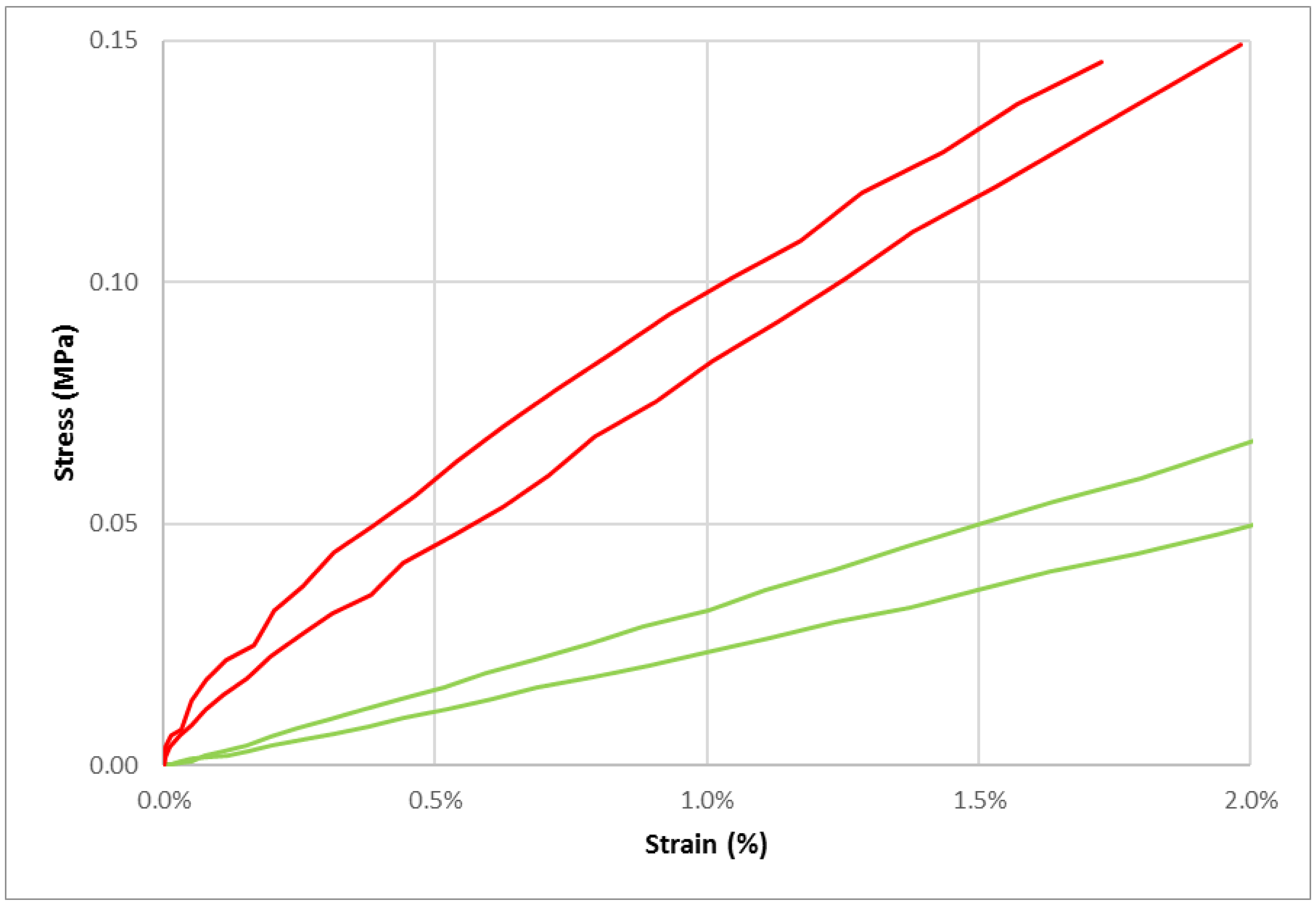
To calculate strain, trigonometry is first used to calculate the current length of the specimen given the spacing of the anchor points and the current vertical travel of the force probe tip. The nominal strain definition of change in length divided by original length can then be applied. To calculate stress., trigonometry is first used to resolve the vertical force applied by the probe tip into the force applied along the current orientation of the specimen. This force is then divided by the cross sectional area of the specimen.

The average modulus for the specimens were 3.0MPa and 7.0MPa respectively when measured using a linear curve fit for the data points between 0.5% and 2% nominal strain.

Note that these specimens failed at about 30mN of force at between 2 and 4% strain.




## Conclusions

This testing shows that the MicroSquisher is capable of measuring the tensile stiffness of both soft gels (~2kPa) and stiffer thin membranes (~5MPa) using at least 2 different techniques.