WATER SERVICES
ASSOCIATION OF AUSTRALIA

MONASH University

Humidity effects on tensile creep testing (CIPP and spray liners)

Introduction

Creep is the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stresses. It can occur as a result of long-term exposure to high levels of stress that are still below the yield strength of the material. CIPP liners and spray liners are susceptible to creep. Creep testing in CRC-P project was conducted at Monash University using laboratory manufactured CIPP and spray samples. The creep tests followed ASTM D2990 (2001) and ISO 899-1 (2017) standard, using AS 1145 (2001) and ASTM D638 (2014) for specimen sizes. The effect of humidity was studied on multiple liners

Creep testing set-up at Monash University

Creep testing rigs were designed and manufactured at Monash University (see [tensile creep testing apparatus fact sheet]() for further information).

Methods

During creep testing, temperature and humidity were monitored throughout. The room was not controlled for either temperature or humidity, however readings for temperature were between 16 to 24°C and humidity was between 30 to 90 %, throughout the test period. Tests for CIPP were also conducted on specimens saturated in tap water (100 % humidity) to compare the creep rates. Testing data was monitored and recorded at least every 30 minutes.

Creep testing was conducted at various initial stress levels in specimens of CIPP and spray lining. A minimum of two stress levels were applied to each sample. Specimens were tested in both hoop and axial directions. Specimens were left for different time intervals to creep.

Results

Figure 1 compares testing of a CIPP product under water and in-air. The in-air specimen shows lower tensile creep strain results than the in-water specimen. Both specimens were exposed to the same stress level (7.5 MPa). The nominal tensile creep strain at 3000 hours in this case was about 20% higher for the in-water specimen than that for the in-air specimen. Similar trends were found for CIPP specimens and spray lining specimens.

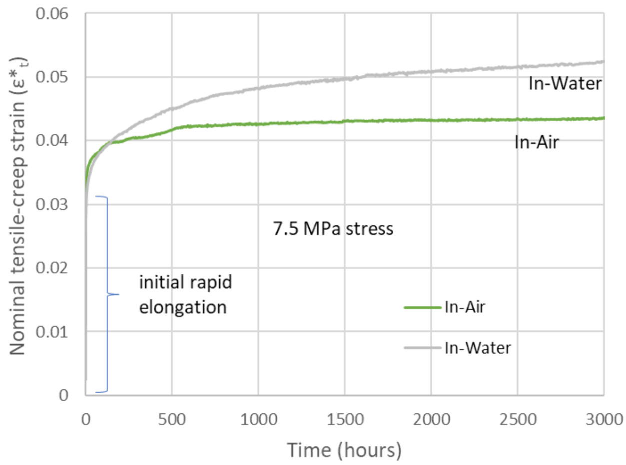

Figure 1. CIPP comparison with in-air and in-water specimens.

Figure 2 shows raw results of a test on a CIPP specimen in-air and compares that with the recorded humidity. The fluctuations marked by red arrows show the effects of humidity spikes (increase and decrease in humidity) on displacement, where the displacement (or strain) is increased when humidity increases, and slowed or decreased when humidity decreases.

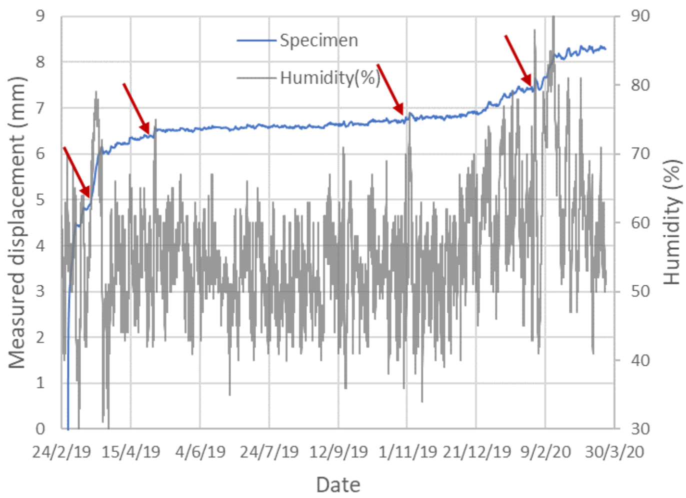

Figure 2. Measured displacement and humidity vs. date. Arrows show increase in displacement with increased humidity.

Australian Government
Department of Industry, Innovation and Science

Business Cooperative Research Centres Program

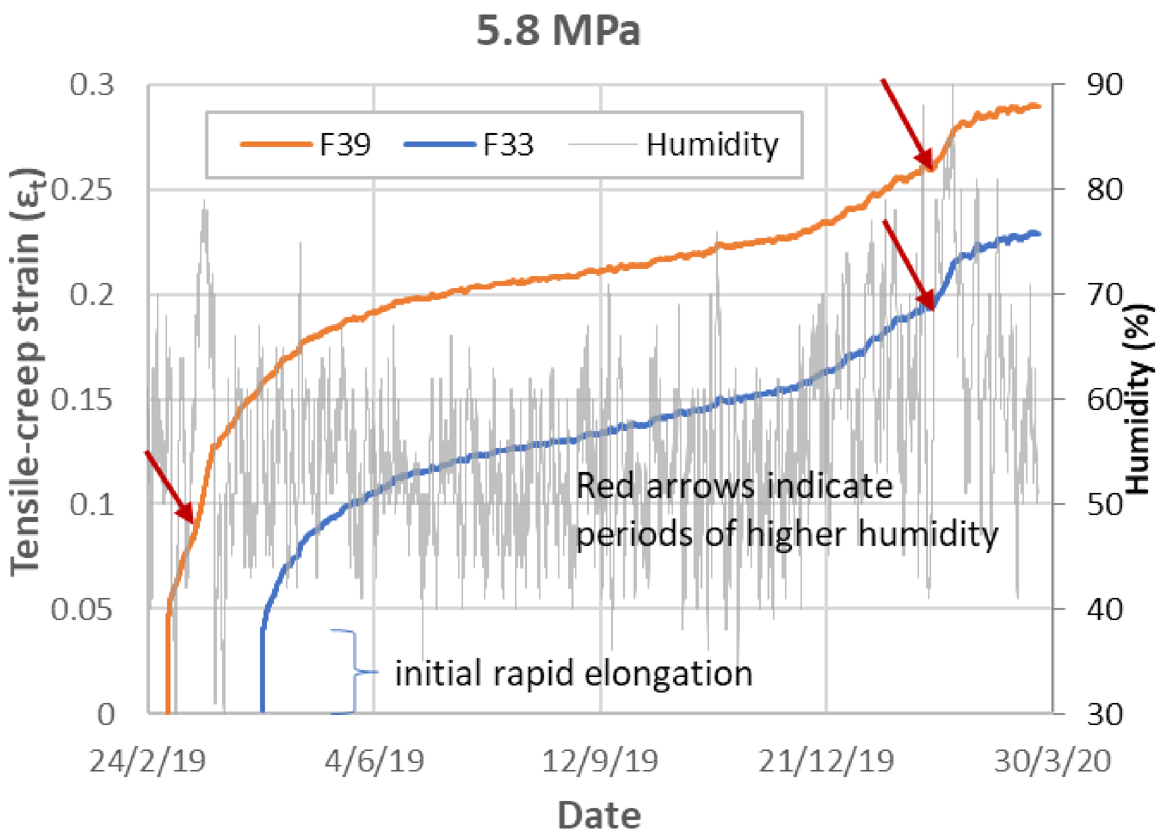

Figure 3. Tensile-creep strain vs time for spray liner specimens tested at different times. The red arrows indicate periods of high humidity at specific times.

Figure 3 shows the difference that humidity can make on spray liner specimens subjected to tensile creep. The red arrows indicate periods of high humidity (>65%) for higher amount of time. The blue line specimen was initiated later than the grey specimen and was subjected to lower humidity at the beginning, hence lower tensile creep strain. Both specimens experience higher humidity (>65%) at the later red arrows (at the 5500 to 6400-hour mark).

Humidity effects were shown to increase the creep, when humidity increased, and reduce when humidity decreased. Therefore, constant humidity is required when running creep testing.

The change in temperature needs to be examined further with higher temperature changes to draw conclusions of non-constant temperature effect.

Recommendations

All creep related results should be conducted in constant humidity; therefore, we highly recommend testing to be conducted underwater. This will also give the higher creep values in testing, which would also be of benefit in creep rupture or hydrostatic design basis testing. The downside of testing underwater is it requires more elaborate sensors and different equipment setup. However, testing underwater would give a conservative approach (worst case scenario) to the amount of tensile creep that would be measured in the field.

Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Program

References

AS 1145 (2001). Determination of tensile properties of plastic materials. Standards Australia, Sydney, Australia.

ASTM D638 (2014). Standard test method for tensile properties of plastics. *In* ASTM D638. ASTM International, West Conshohocken, PA, USA, pp. 1–17.

ASTM D2990 (2001). Standard test methods for tensile, compressive, and flexural creep and creep rupture of plastics. *In* ASTM D2990. ASTM International, West Conshohocken, PA, USA, pp. 1–20.

ISO 899-1 (2017). Plastic - Determination of creep behavior - Part 1: Tensile creep. International Standard Organization, Geneva, Switzerland, pp. 1–14.