Durability of Polymer Composites

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ABSTRACT

Durability study and mechanical property characterization of various FRP composites are being carried out including strength and stiffness properties under tension, compression, bending and creep at different environmental conditions of varying temperature and moisture. Data will be used to determine the service life of the composites in terms of life prediction theories such as Accelerated Testing Methodology (ATM) and Micromechanics of Failure (MMF).

Introduction

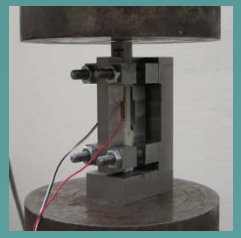
Composites offer significant advantages when compared to traditional materials in infrastructure. A significant concern about the reliable and cost effective use of these materials is the question of their durability over the span of many years. Hence a durability study is being performed on several types of FRP composites manufactured from different processes with a wide range of fiber architectures. The results shown here are based on pultruded unidirectional E-glass/vinyl ester system.

Experimental Set Up

Tensile creep frame

Three point bending creep frame

Creep under 80C water

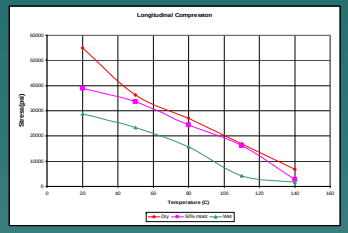


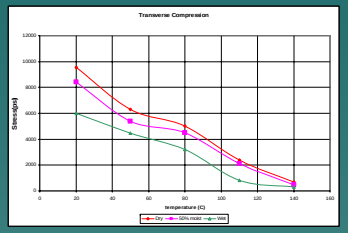
Compression test jig

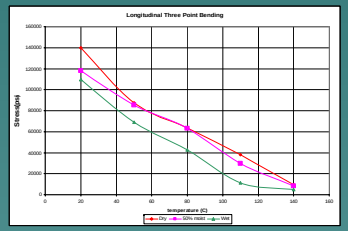
Results

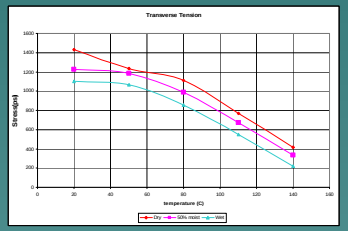
The following data are for pultruded unidirectional E-glass/vinyl ester laminates.

Effect of temperature and moisture on static material properties



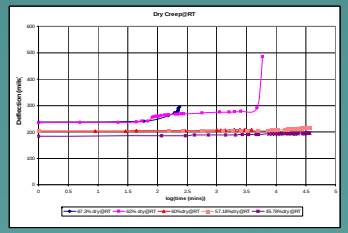


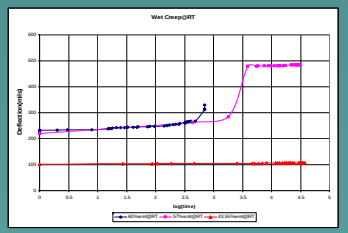


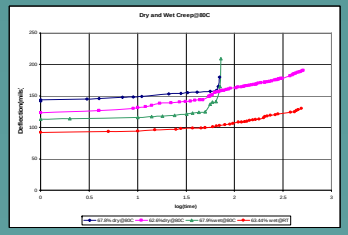


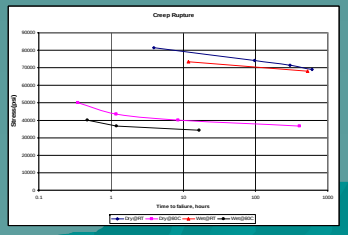
* All static tests were performed on Instron 8501

Time dependent creep data for longitudinal samples at different loadings and conditions (moisture and temperature) to predict the life of composite

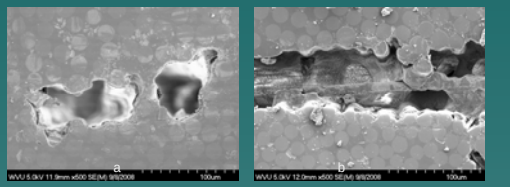








SEM Characterization



SEM pictures showing voids due to poor wet-out during manufacturing

Conclusions

- Strength varies dramatically with conditioning parameters due to voids as seen from SEM picture.
- At lower temperatures the effect of moisture on strength is significant, showing a reduction of 25-40%, possibly due to high void content.
- At higher temperatures the effect of temperature on strength is more significant than the effect of moisture, showing a reduction of 70-90%.
- It appears that for this composite system studied the material shows a threshold value of about 58% of ultimate load as seen from creep data beyond which the creep rupture occurs shortly.
- Higher temperatures reduce the time to failure (creep rupture) significantly as compared to RT under similar loadings.
- Wet samples also show faster creep rupture as compared to dry samples due to voids.

Future Work

- Expand the test methodology to a range of composites made of different fiber architectures and different manufacturing techniques such as Vacuum Assisted Resin Transfer Molding (VARTM) and Resin Infusion.
- Conduct long term creep tests to give better insight on the life of the composite and establish a master curve.
- Develop a model for life prediction

Acknowledgement

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