DEAD LOAD SEAM TESTING METHODS

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This paper discusses seam testing methods with particular emphasis on dead load testing methods. The topic is of particular relevance in predicting long term seam performance of seams under permanent prestress load as occurs with architectural fabric structures.

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1. INTRODUCTION

Architectural Fabric Structures are designed to maintain tensile stresses in the fibres of the fabric for the duration of their working lives. This level of stress is a relatively small ratio of the tensile strength of the fabric, however the period of loading is up to 15 years and with recent fabric developments, much longer.

What happens to seams at these extended time spans is of importance to designers and specifiers alike, and methods to predict seam performance are the subject of this paper.

2. SEAM CONSTRUCTION

The most common method of seaming polymeric materials is by heat welding, whether by high frequency induction or thermal heating. Other methods include solvent bonding and mechanical means such as sewing.

Other than mechanical methods, the strength of the seam depends on the adhesion of the coatings to the base yarn of the mating fabrics.

No matter what the coating type or base yarn type, seam strength depends on adhesion ie. the "glue" which holds the coating to the base yarn.

A minor exception to this rule occurs in very open weave fabrics where coatings on opposite sides of the base yarn can mechanically bond together. This is of limited use if the adhesion of the yarns to the coating cannot transmit the loads in the yarns across the joint.

In all types of architectural fabric, be it PVC-Polyester, PVF-PVC-Polyester, PTFE-fibreglass or other combinations, the adhesion of coating to base yarn is achieved by chemical means ie. an adhesive primer or other treatment bonds the yarn to coating.

Through this mechanism, it could be said that all the seams in such fabrics are "glued" together.

3. SEAM TESTING METHODS

Three primary test methods are considered here:

- Peel Testing.
- Tensile Testing.
- Dead Load Testing.

Peel Testing

Peel Testing usually involves a test sample taken from shop fabrication (usually a HF welder bar length) which has unwelded tongues which are manually pulled at 180^{o} to each other.

The test is usually qualitative being used to visually examine the degree of removal of the coating from the base yarn. When the coating is completely removed from either surface, the weld is deemed to have 100% adhesion.

The Peel Test can be quantitative by holding one tongue in each jaw of a tensile tester and measuring the load during Peel Test for a given width of seam.

Quoted values of load in peeling range from 1.75-2.5 KN/m width of seam. The minimum figure must be met to ensure proper seam strength.

Typically the load required to initiate a peel is much higher than the load measured while the seam is peeling at a steady rate. Peel testing is a useful quality control method and a fairly reliable predictor of dead load performance.

Typical apparatus is shown in Photo 1.

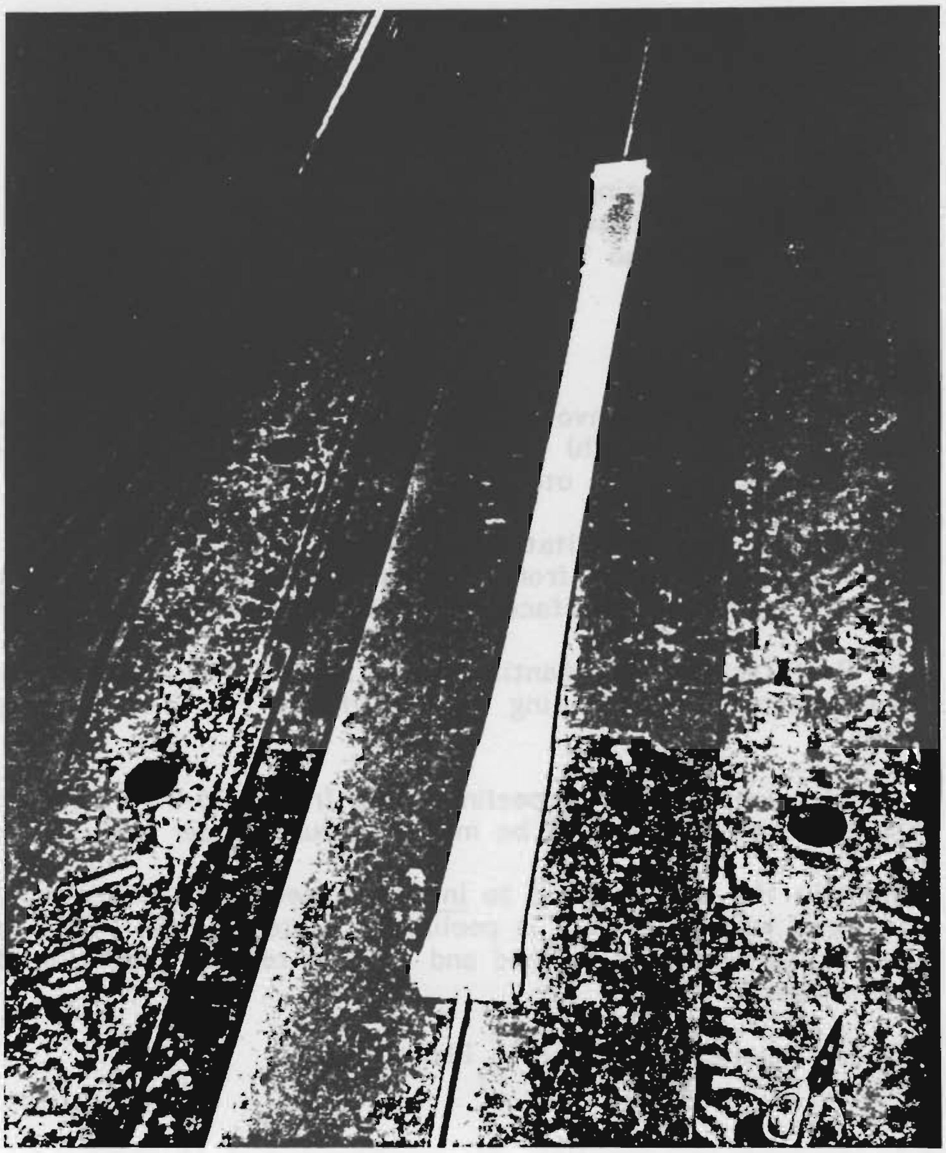

Photo 1: Tensile Peel Testing

Tensile Testing

Tensile testing usually involves pulling a particular width strip of fabric in the warp or weft direction at a steady rate. Tensile tests measure the short term performance of the seam and a seam without 100% adhesion can produce good tensile test results, or at least similar results to a full adhesion seam.

Therefore, Tensile Testing is not a completely reliable indicator of seam strength or long term performance.

Tensile Testing is usually undertaken on 25mm or 50mm wide samples.

Wide sample testing of seams (120mm) has been developed by Vesl using large testers. Loads involved over 10KN and widths of 120mm give a better representation of strip tensile behaviour in actual membranes.

4. DEAD LOAD TESTING

In general, Dead Load Testing consists of loading a sample of seamed strip in the warp or weft direction.

The seam is usually perpendicular to the direction of loading.

The essential differences between Tensile Testing (by short term loading) and Dead Load Testing are the duration of the load, and the rate of loading.

Dead Load Tests subject the sample to a fixed load over a defined period of time.

United States Military Specification procedure for Dead Load Seam Testing of fabricated membranes is shown in FIG 1.

STRENGTH OF SEAMS - DEAD LOAD

1. SCOPE

To determine the dead load resistance of coated fabric seams.

2. TEST SPECIMEN

The specimen size 25 x 200mm with the heat sealing or cement applied to an interface of fabric face to fabric back across the 25mm width of the specimen. Specimens are to be cut after cementing or heat sealing full width of heat seal bar.

3. PROCEDURE

A designated load shall be carefully affixed to the free end of the 25mm wide specimen and maintained at the designated temperature for twenty-four (24) hours.

4. REPORTING OF RESULTS

The time of the test, the dead load weight, the temperature, and the length of over-lap of the seam shall be reported, along with "Pass" or "Fail".

5. DEAD LOAD TEST APPARATUS

Dead Load Test apparatus is designed to provide a fixed load, non variable over time.

This normally employs weights placed directly on the sample or via a lever arm.

Photo 2 shows a tester operated in Sarasota Florida. A similar tester is being built in Brisbane.

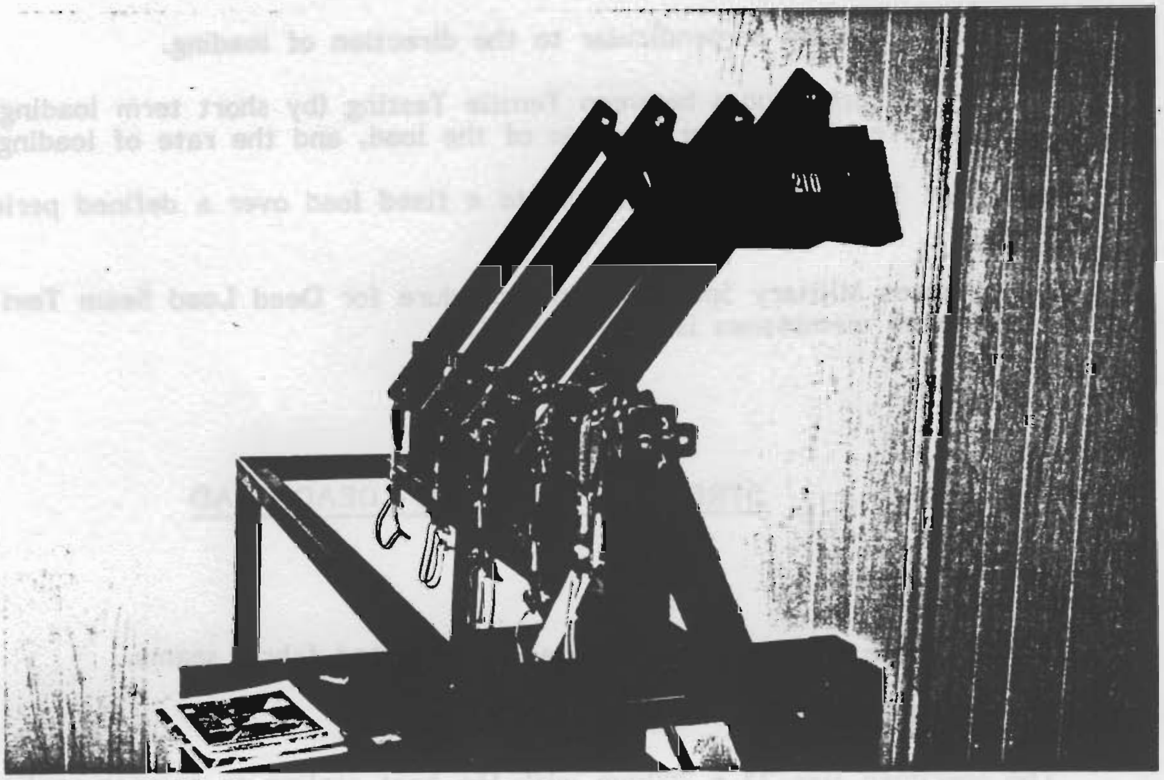

Photo 2:

The lever arm of 10:1 reduces the size of the weights required and extends the range of the tester to wider sample width.

The tester in Photo 2, can test several samples at once, and the sample width is normally 25mm (1").

Loads applied range from 25 KN/m to 50 KN/m.

For a typical Class III material with a Tensile Strength of 90-100 KN/m, this dead load test represents 25% to 50% of the tensile strength.

6. DEAD LOAD PROCEDURES

The procedure in Military Spec (Mil-T-43211[GL]) has been adopted as a standard for U.S.A. based fabric manufacturers.

The basic criterion is a minimal extension of the seamed sample over a 24 HR test at room temperature.

Such extension represents the slippage of the bond between the two substrates ie. the permanent deformation due to shear in the interface between coating and substrate.

Past a certain point the coating shears and the seam fails.

While the test might not appear severe compared with the tensile test, it should be noted that architectural fabrics are nominally tensioned to no greater than 15 KN/m, and typically 2-5 KN/m, and under maximum load combination (prestress + wind) the load is not designed to exceed 25% of tensile strength, typically 20-25 KN/m, and usually 10-15 KN/m. Maximum loads are only applied for very short periods of time (gust loads in wind cases).

Therefore a continuous load of 50% of tensile strength is a form of accelerated strength testing in a similar way that weatherometers accelerate exposure to atmospheric conditions.

What the factor of acceleration is for a particular material and duration is not readily determined, as such criteria as a 24 HR test appear to be quite arbitrary.

Room Temperature Test

The basic criteria for a room temperature test sample to pass are:

Seam Width	:	50mm
Temperature	:	20^{o}C
Dead Load	:	46 KN/m
Duration	:	24 HR
Extension (200)	:	2.5mm

Elevated Temperature Test

Seam performance at elevated temperatures is of major importance to architectural fabric structures.

Temperatures of the fabric surface have been measured up to 65°C depending on fabric colour and dirt condition.

A test at 70°C is specified with basic criteria as follows:

Seam Width	:	50mm
Temperature	:	70°C
Dead Load	:	23 KN/m
Duration	:	24 HR
Extension (200)	:	2.5mm

This test has been adopted by the U.S.A. manufacturers as proof of the elevated temperature performance of architectural fabrics.

During the life of a fabric structure it is likely that in certain locations the temperatures 55-65°C could be achieved for up to 6 HRS on a summer day. Loads would never exceed 15 KN/m in the pretension case, and it is highly unlikely that maximum wind loads could coincide with maximum temperatures excepting in perhaps desert storm conditions.

The cumulative effect is of interest, however it appears that if the fabric seam passes the above test criteria, the seam will perform satisfactorily in the field.

Duplication of the 70°C test with local apparatus is currently under development and test results on a variety of fabrics shall be available in the near future.

8. CONCLUSION

Dead Load Testing is a useful indicator of long term performance. Further experimentation with elevated temperature tests is most relevant for Australian Summer Conditions is warranted and apparatus is under development to reliably simulate these conditions. The precise "accelerator" factor for dead load levels compared with real life prestress loads is the aim of future research.