



## CLIPSO PRODUCTIONS SAS

Study of the mechanical behaviour of  
coated knitted fabrics and attachment  
structures

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CLIPSO produces coated textile supports for constructing stretched ceilings. The purpose of this study is to evaluate the mechanical behaviour of four separate coated knitted fabrics with six structural attachments.

The study can be broken down into five stages:

- Part 1: Evaluation of breaking strength of the coated knitted fabrics - Biaxial tests;
- Part 2: Study of stresses perpendicular to the fabric - Triaxial tests;
- Part 3: Evaluation of the effectiveness of structural attachments at ambient temperature;
- Part 4: Evaluation of the effectiveness of structural attachments at -40 °C;
- Part 5: Evaluation of the effectiveness of structural attachments at +40 °C.

## I. Part 1: Evaluation of the breaking strength of coated knitted fabrics

For this initial study, the aim was to evaluate the mechanical behaviour of coated knitted fabrics alone. To ensure experimental conditions as close as possible to those of normal use, biaxial traction tests were performed to rupture point. Force-extension curves were then produced. To evaluate the reproducibility of the measurements, three repetitions were performed for each reference.

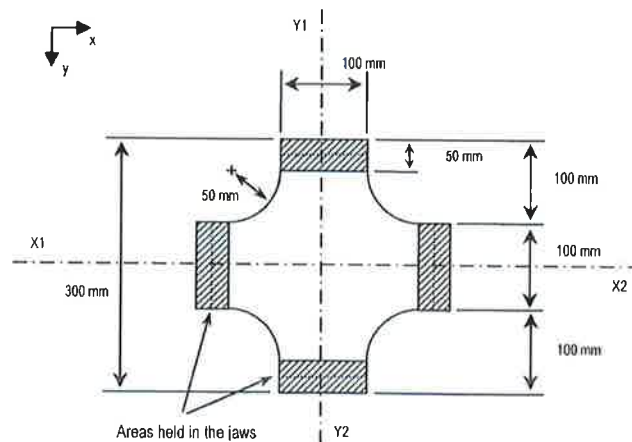


Figure 1: Cruciform geometry of the samples.

Sample preparation was identical in all five parts of the study. Figure n° 1 shows the cruciform geometry and dimensions of the samples. To facilitate interpretation of the measurements, the samples

were taken according to the columns and rows of knitted fabric. Thus, the columns were systematically organised along the Y axis.

Forces and deformation at rupture point were measured from the force-extension curves and are shown in figure n°2. For each reference, the graphs show the mean values and standard deviations calculated from three repetitions. Reference **7953A** appears to be the strongest reference with a breaking strength of more than 600 N (figure n°2a). The other references recorded roughly equivalent values at around 400 N. Deformation on rupture varied from 10 to 13 %.

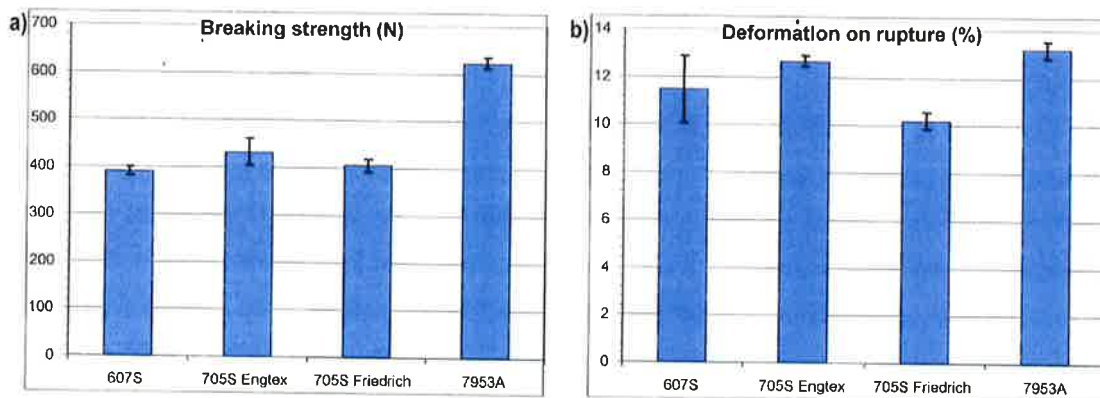


Figure 2: Evaluation of breaking strength (a) and deformation (b) on rupture for the four coated knitted fabrics studied.

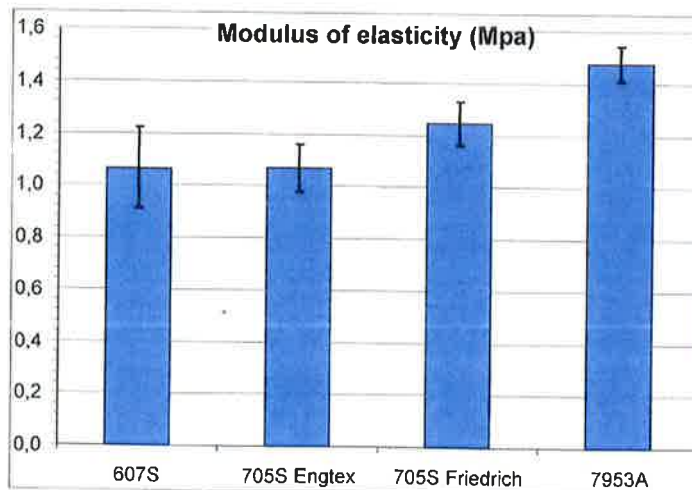


Figure 3: Comparison of the mean moduli of elasticity relative to the four coated knitted fabrics

To eliminate geometric effects from the samples (thickness, in this case), we evaluated the mean modulus of elasticity for each reference (see figure n°3). Reference **7953A** thus appears to be 40 % more rigid than references **607S** and **705S Engtex**. Reference **705S Friedrich** displays intermediate rigidity 17% higher than that of references **607S** and **705S Engtex**.

In other words, for a given constraint, references **607S** and **705S Engtex** deform more than references **705S Friedrich** and **7954A**.

## II. Part 2: Study of stresses perpendicular to the knitted fabric

The purpose of this second study was to evaluate normal deformation in the centre of the samples. For this, the characterisation instrument was used in its triaxial configuration. The procedure used was as follows. The samples were fixed directly by the jaws in the biaxial plane of the instrument (see figure n°4). A pretension of 35 N was applied along the X and Y axes in this plane (see appendix n°1). The third axis (Z axis), perpendicular to the surface of the coated knitted fabric, was equipped with a hemispherical pusher 100 mm in diameter. The test consisted of measuring the force exerted by the coated knitted fabric on the pusher during a 40 mm deformation in the Z axis (see figure n°5 and 6). After returning to the initial position of the pusher, the remanent deformation of the knitted fabric was noted (see figure n°8). This remanent deformation (or plastic deformation) corresponds to the irreversible deformation of the fabric after the test (i.e. after the initial deformation of 40 mm).

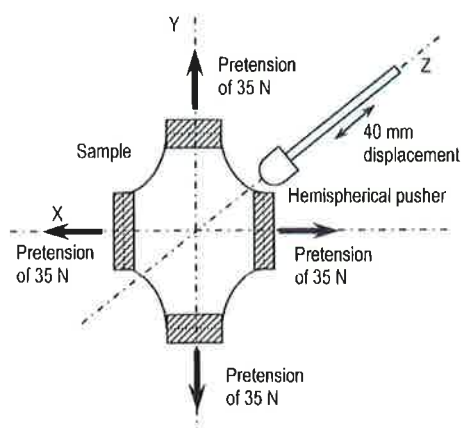


Figure 4: Diagram showing the stresses applied to the sample.

Figure n°5 shows the transverse forces measured for all four fabrics studied. Reference **7953A** recorded the most resistance to this deformation with a force of 440 N. Next were references **705S Friedrich**, **705S Engtex** and **607S** with 270, 254 and 245 N respectively. The measurements were naturally correlated with the evaluation of moduli of elasticity shown in figure n°3. It therefore appeared that reference **7953A** shows greater resistance to consecutive load, for example the addition of a sound insulation material.

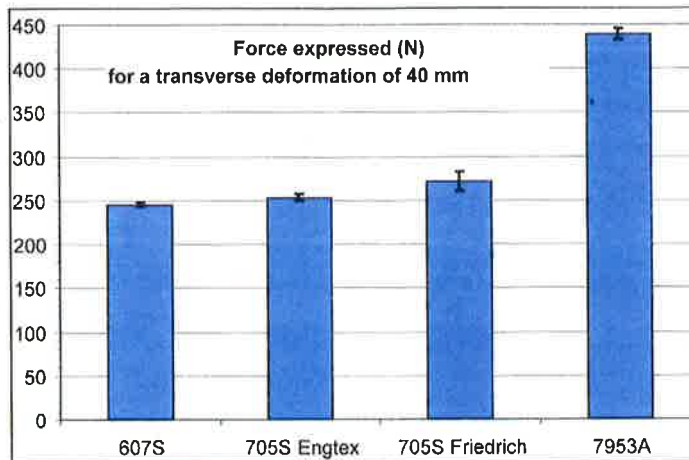


Figure 5: Evaluation of force consecutive to deformation applied to the centre of the sample for the four references studied.

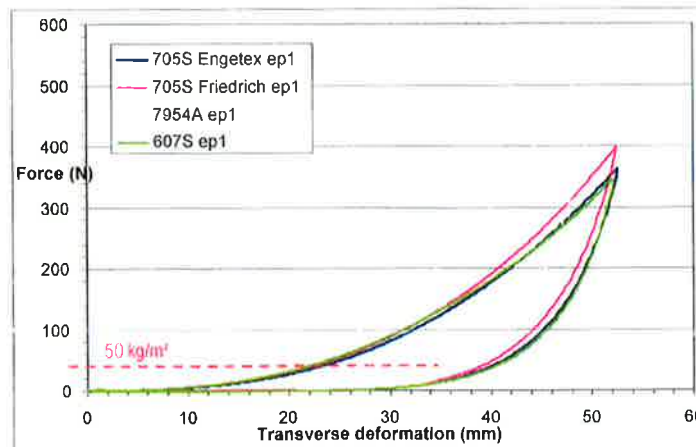


Figure 6: Example of force-extension curves for transverse deformation relative to samples n°1 for each reference.

To complete this analysis, transverse deformation under a given load was extracted from these measurements. Thus, for a load of 27 kg.m<sup>-2</sup>, the mean deformations and their respective standard deviations are given in figure n°7.

Remark: Considering the chosen hypothesis, (surface load treated as a single load in the centre of the sample), the test process over-estimated the transverse deformation recorded.

Analysing these measurements revealed the greatest rigidity in reference **7953A** with a deformation about 10% less than that of the other references. These measurements also demonstrate that, for low loads, deformation tends towards equivalent values. A load of around 50 kg.m<sup>-2</sup>, i.e. a force of about 40 N, symbolised the limit beyond which the greater rigidity of reference **7953A** could be seen (see figure n°6).

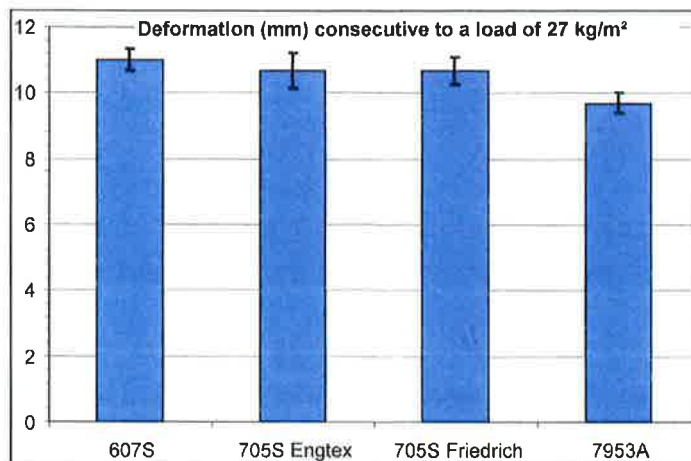


Figure 7: Evaluation of transverse deformation under a load of 27 kg/m<sup>2</sup>.

Figure n°8 shows the evaluation of remanent deformation for the four references studied. Analysis of these measurements showed that this deformation is constant, no matter which coated knitted fabric was concerned, with a mean deformation of around 23 mm, i.e. 57 %.

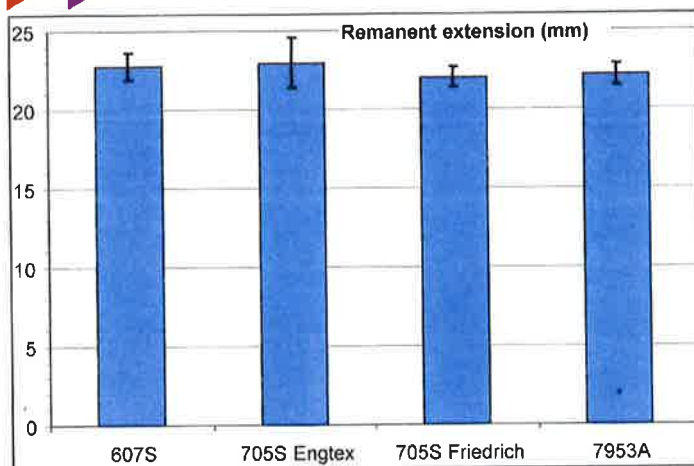


Figure 8: Evaluation of remanent deformation, expressed in mm, resulting from deformation of the sample for the four references studied.

For the next three studies, the power of attachment of the structural attachments was studied as a function of the sample's temperature and that of its environment for reference **705S Friedrich**.

### III. Part 3: Evaluation of the effectiveness of structural attachments at ambient temperature

In this third study, the power of attachment of the structures was evaluated at ambient temperature. The procedure was similar to that used for the first study except that the sample was fixed to the traction axes by structural attachments (**C6**, **CC**, **CW** and **DK27+CCA**). The force-extension curves were then recorded until the assembly disintegrated, i.e. the coated knitted fabric slipped. Tensile strength and extension were extracted from these curves (see figure n°9).

If the knitted fabric did not rupture, the breaking strength was the limit at which the fabrics were held by the attachments. Extension at rupture point was defined by superposing several events. During the first moments of traction, extension mainly involved deformation of the fabric. This was followed, inevitably, by deformation of the attachment and slippage of the fabric. Extension at rupture point was therefore difficult to interpret.

Analysis of the measurements show that attachments **C6** and **DK27** were the best performers, with resistance thresholds of more than 160 N. At the other end, attachment **CW** was the poorest, with a resistance of the order of 60 N. Note that good reproducibility characterised the limit force relative to attachment **CC**.

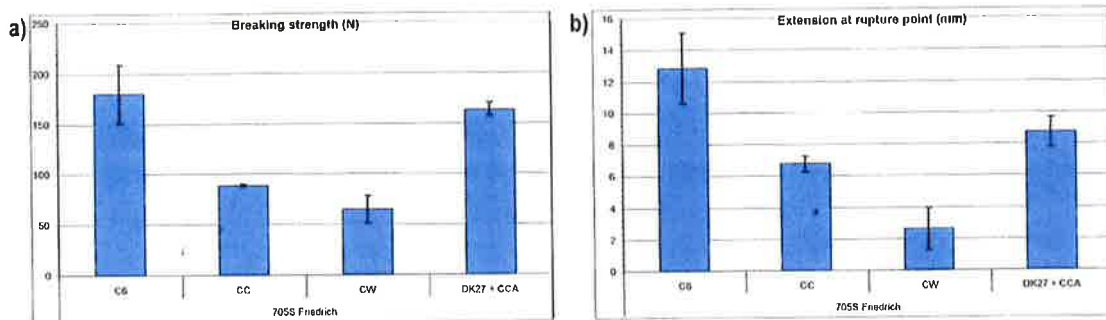


Figure 9: Evaluation of breaking strength and extension limits for the knitted fabric for types of attachment at ambient temperature.

The strength/extension ratio at rupture point for each type of attachment provided an extra source of comparison. Without being exact, this ratio was similar to a modulus of elasticity. It gave us information on the rigidity of the knitted fabric-attachment complexes. Figure n°10 shows the values of this ratio for the four attachments. In spite of significant dispersion, attachment **CW** appears to be the most rigid attachment. On the other hand, attachments **C6** and **CC** seem to be the most elastic.

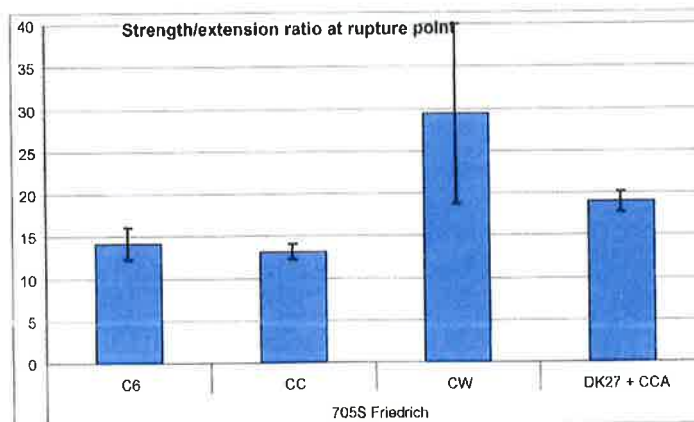


Figure 10: Evaluation of the strength/extension ratio at rupture point at ambient temperature.

#### IV. Part 4: Evaluation of the effectiveness of the attachments at -40 °C

The anchoring power of the structural attachments was now evaluated at a temperature of -40 °C for two types of coated knitted fabric, references **607S** and **705S Friedrich**. The procedure was identical to the previous one. The samples were cooled throughout the test by the diffusion of liquid nitrogen inside the traction enclosure.

Remark: The supply of liquid nitrogen was limited, so some tests were only performed once. This explains the absence of certain levels of uncertainty in figures n°11 and 12. The values presented and their interpretations must thus be considered in consequence of this.

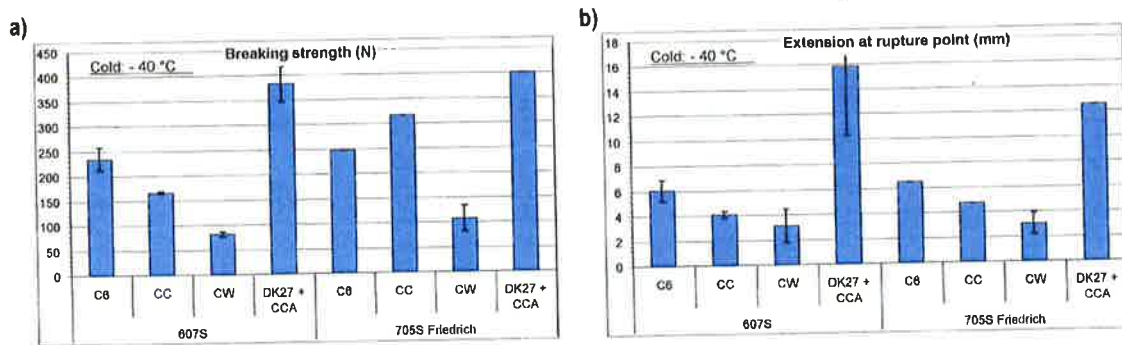


Figure 11: Evaluation of breaking strength and extension limits of the knitted fabric for four types of attachment at -40 °C.

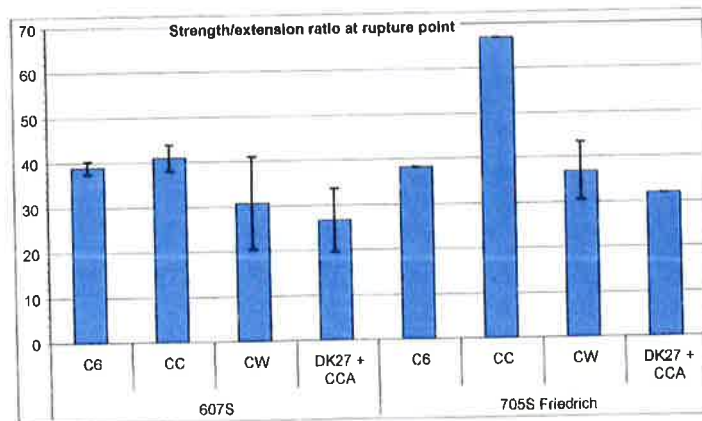


Figure 12: Evaluation of the strength/extension ratio at rupture point at -40 °C.

Comparison of breaking strengths at a temperature of -40 °C (see figure n° 11a) showed that the fabric reference **705S Friedrich** was at least as strong as fabric **607S**. No matter which fabric was

used, except for the **CC + 705S Friedrich** complex, attachments **C6** and **DK27** were distinguished for their greater mechanical strength. Compared with the values obtained at ambient temperature, all breaking strengths seemed to increase with the fall in temperature.

Analysis of the strength/extension ratio at rupture point revealed similar rigidity in the attachment-fabric complexes no matter which fabric was studied. As before, this rigidity seemed to increase with the fall in temperature (see figures n° 10 and 12).

## V. Part 5: Evaluation of the effectiveness of attachments at +40 °C

To complete this study, the anchoring power of the structural attachments was finally evaluated at a temperature of +40 °C. Only coated knitted fabric reference 705S Friedrich was studied in association with the following 6 attachments: **C6**, **CC**, **CW**, **DK27+CCA**, **C10** and **C11**. The procedure was identical to that of the third part. The traction test was performed when the temperature of the measuring enclosure was stable and homogeneous.

As before, the analysis of figure n° 13a shows that the strongest and weakest attachments were references **C6** and **CW** respectively. Attachments **C10** and **C11** showed similar strengths about 25% below those of reference **C6**. Compared to the ambient temperature evaluations, a very slight reduction in the strength of attachments **C6** and **CW** was noted, a more marked reduction for attachment **DK27** and increased strength for attachment **CC**. This difference in evolution can be explained by the slight rise in temperature of the samples (+20 °C compared with the ambient temperature).

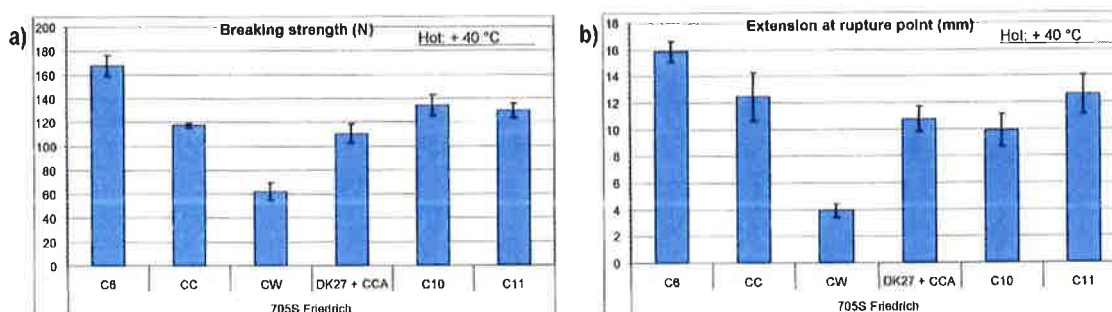


Figure 13: Evaluation of strength and extension limits for the fabric for four types of attachment at +40 °C.

The analysis of strength/extension ratios at rupture point revealed the greatest rigidity for attachment **CW** at +40 °C. Attachment **C10** recorded about 15% less rigidity. The other four attachments showed similar rigidity levels. Generally speaking, the rigidity of the attachments seemed to fall with the rise in temperature (see figures n° 10 and 14).

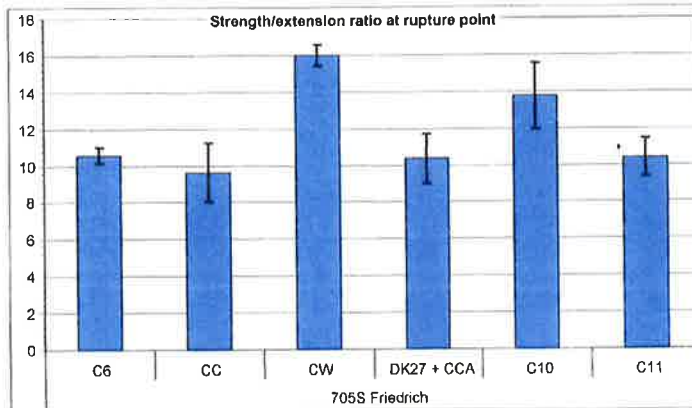


Figure 14: Evaluation of the strength/extension ratio at rupture point at +40 °C

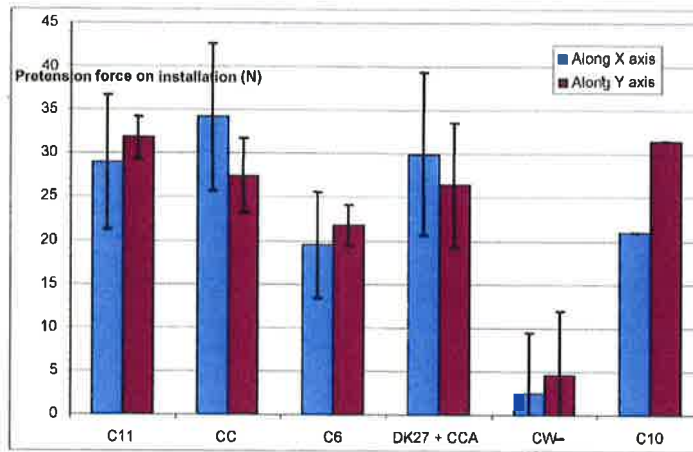
To conclude, these various studies allowed us to:

- Evaluate the strength of the coated knitted fabrics and structural attachments;
- Evaluate the elasticity of the coated knitted fabrics;
- Reveal the evolution of these properties according to temperature.

## Appendix n°1

### Evaluation of stresses consecutive to the installation of the fabrics in the attachments

The purpose of this appendix is to present the evaluation of forces exerted on the coated knitted fabrics as a result of their incorporation in the structural attachments. These forces were evaluated when the samples were installed in the 3D Dynamometer relative to parts 3 and 4 of the present study. The values shown in figure n°10 therefore apply for a fabric width of 100 mm (see figure n°1). Apart from attachment **C10**, the forces along the X and Y axes were evaluated three times. For this study, only reference **705S Friedrich** was used.



**Figure 15: Evolution of the force exerted on three coated knitted fabrics after their installation in the structural attachments.**

No matter which axis was studied, the measurements showed a high level of dispersion of the forces exerted on the coated knitted fabrics. Apart from the negligible values obtained with attachment **CW**, the mean pretension force was evaluated at around 27 N. Analysis of all the measurements revealed that occasionally the pretension force can reach 49 N.

For the needs of the second part, a maximum force objective of 35 N was used to place all the coated knitted fabrics under pretension. This prestressing of the fabrics was necessary to study their transverse deformations.