# INVESTIGATION OF THE TWO BUCKLING

C. TEPHANY[a], J. GILLIBERT[a*], D. SOULAT[b],P. OUAGNE[a]

[a] *Laboratoire Prisme, Université d'Orléans, 8, rue Léonard de Vinci, F-45072 Orléans cedex 2*
[b] *Laboratoire GEMTEX, ENSAIT, Université de Lille 1, 2 Allée Louise et Victor Champier, BP 30329, F-59056 Roubaix*
**jean.gillibert@univ-orleans.fr*

**Keywords:** twos buckling, flax fabric

**Abstract**
*During the forming, tow buckling (out of plane bending of tows) was observed in specific zones of the shape. This defect is highly depending of the process parameters and of the fabric. In order to predict the process parameters to avoid the tow buckling during the forming, it is necessary to identify precisely the different mechanisms at the origin of this defect. For this reason an experimental setup has been designed.*

## 1. Introduction

Natural fibres, of animal or vegetable origins, are the object of numerous studies as for their potential as reinforcement for composite applications [1, 2]. This growing interest is due to their environmental properties, their low density compared to glass and carbon fibres, but also their tensile mechanical properties [3]. Consequently numerous publications dealt with the identification of their mechanical characteristics [4-6].

This study concerns the manufacturing process of composite material from flax reinforcement and specifically the preforming stage, first step of the RTM process. During this stage several defects can qualify this step as successful or unsuccessful drape. At the scale of the preform, it is possible to investigate if the preform shape is well obtained (if the preform fits to the tool in the case of sheet forming process), if wrinkles appear [8-11], if there is non-homogeneity of the fibre density in tows, or if a discontinuity of the preform due to sliding of tows takes place.

All these defects have a strong influence on the resin flow impregnation and specifically on the in-plane and through-the thickness permeability components [12, 13]. They consequently impact the performance of the composite part [14, 15].

Hover some defect like the twos buckling has been observed experimentally on complex shape forming [16-17]. But the identification of the different parameters that will control the buckling is not clearly identified, making impossible the prediction of defects. In order to study the twos buckling, an experimental device was design.

## 2. Experimental design

In order to define the specification of the equipment, it is necessary to identify the different parameters that will influence the twos buckling. As it has been showed by Ouagne *et al.* [1] that the two buckling will appear in the region where the curvature of the twos occurred as shown on figure 1. The bulk intensity will depend of the curvature and of the tension in the different yarn.

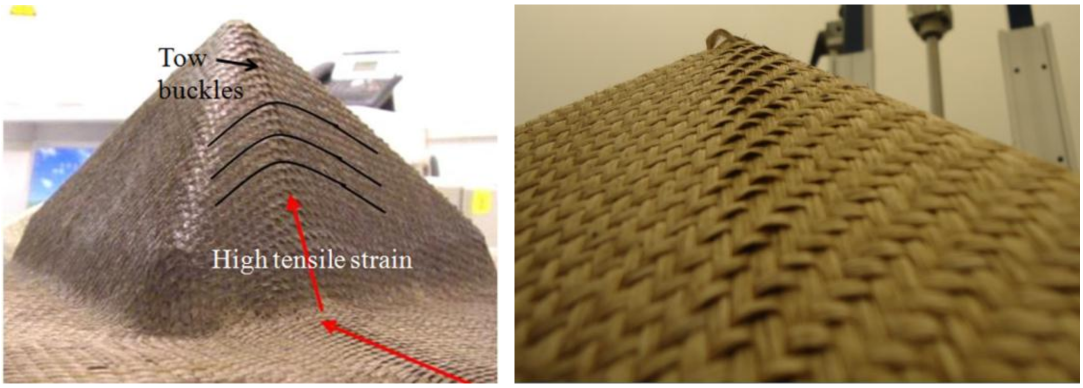

Figure 1 Localization of the twos buckling [1]

For this reason, the kinematic of the experimental setup must be able to impose different curvature to the twos and to amply different tension in both directions.

### *2.1 Design of the experimental setup*

Due to the heterogeneity of flax fabric, both in mechanical properties and geometry, the observation zone should include different twos. In order to have homogenous deformation in this zone, the mechanical linkage of the experimental design was define as a circular translation, see figure 2. This motion will apply the same displacement to the different twos.

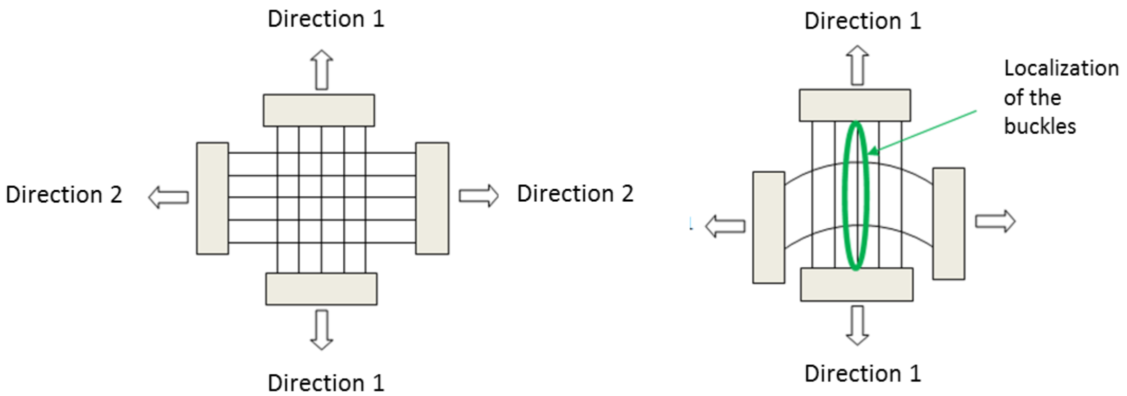

Figure 2. Mechanical linkage of the experimental set-up

In order to apply different tension into the twos, all the different grip have mobility in translation following one specific direction. Four load cells are used to measure and to control the applied tension. The displacement of the grip is measured using LVDT sensors.

Different optical measurement is used in order to measure the displacement fields of the sample and to observe evolution the surface during the test. The figure 3 represents the experimental device with the different sensor.

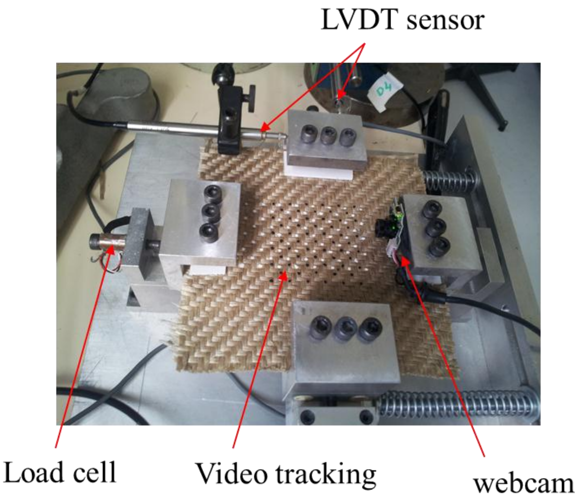


Figure 3. Experimental device with the different sensor

One of the main difficulties of this test is to observe and if possible to measure the evolution of the height of the two. Indeed the height's evolution of the two will depend directly of the width of a two.

In a firth step, we will focus only on an identification of the main parameters that will control the apparitions of the buckles. For this reason we have used a webcam to observe the surface of the sample. This CMOS camera has the advantage to be small and so it can be place very close of the observation area. However the distortion of this lens is very high, and will forbid any quint of measurement.

## 3. Result and discussion

### *3.1 Validate test*

In order to detect precisely the main parameter of the apparition of the buckles, it is necessary to validate the experimental setup.
The kinematic of the device was verified using various LVDT sensors. The main difficulty is located in the junction between the sample and the grip. In deed the grip must be able to apply sufficient pressure to avoid sliding during the test, but adequate to allowed the two to frilly rotate to following the direction of the tow.

After different test, the both condition could not be fulfill in the same time. For this reason only the sliding between the twos and the grip was study. The frilly rotation of the two could be neglected using full field measurement.

In a firth step, an experiment was carrying out, in order to validate the different hypothesis made during the design. On figure 4 we can observe the sample at end of the test.

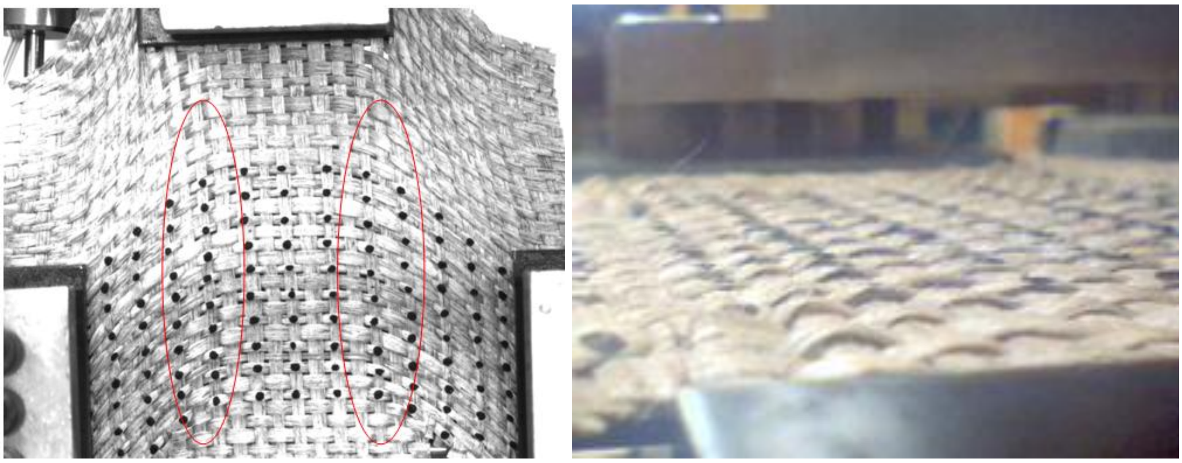

Figure 4 Sample after deformation (a) top view (b) side view

On figure 4 the red ellipses represent the area were the buckles are located. The presence of these two areas is due to the size of the grip. This separation of the interest area will reduce the intensity of the buckle; however it will allow us to verify the homogeneity of the flax fabric.

### *3.2 Primary results*

The main parameter, which control the buckling, identify by [16 – 17] is the tension in the two. In order to compare our result with their observation, different test was managed on a taffeta, with very low initial tension (1.5 N/Yarn) and high tension (15N/Yarn). The figure 5 represents the side view of this two test.

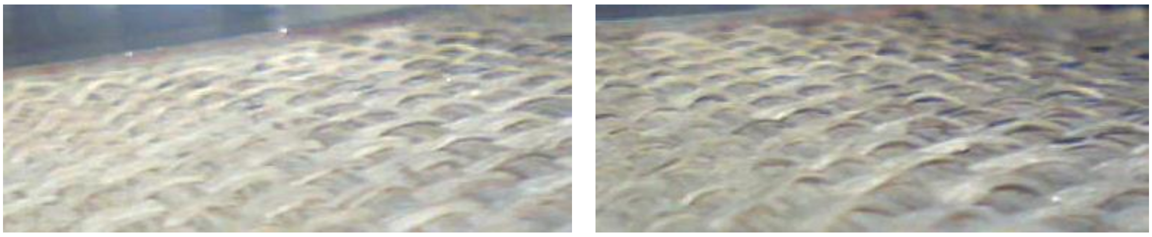

Figure 5. Side view of the sample (a) with a low tension (b) high tension

It can be notice that the buckles are more significant with a high initial tension. These results confirm the observation of [16-17].
However the detection of the buckle is very sensitive to the experimenter, who will carry out the observation, making the definition of a criterion of appearance of the buckles difficult and uncertain.

## 4. Conclusion

The twos buckling can occur during the complex sheet forming. This defect will have an influence on the resin flow impregnation. In order to predict the apparition of the defect, an experimental device was design.
This device allow us to carry out twos buckling test, however the measurement of the height of the buckles is the mean difficulty. This measurement will allows us to undoubtedly define criteria for the buckle formation. This criteria coupled with the different measurements will allows us to predict the twos buckling during the sheet forming.

## References


[1] P. Wambua, J. Ivens and I. Verpoest. Natural fibres: can they replace glass in fibre reinforced plastics? *Composites Science and Technology*, (63):1259 – 1264, 2003.

[2] J. Summerscales, N.P. Dissanayake, A.S. Virk and W. Hall. A review of bast fibres and their composites. Part 1: Fibres as reinforcements. *Composites Part A: Applied Science and Manufacturing*, (41):1329 – 1335, 2010.

[3] R. Malkapuram, V. Kumar and S.N. Yuvraj. Recent development in natural fibre reinforced polypropylene composites. *Reinforced Plastics and Composites*, (28):1169 – 89, 2008.

[4] C. Baley. Analysis of the flax fibres tensile behaviour and analysis of the tensile stiffness increase. *Composites Part A: Applied Science and Manufacturing*, (33):939 – 948, 2002.

[5] E. Bodros and C. Baley. Study of the tensile properties of stinging nettle fibres. *Materials Letters*, (62):2143-2145, 2008.

[6] A. Alawar, A.M. Hamed and K. Al-Kaabi. Characterization of treated data palm tree fiber as composite reinforcement. *Composite Part B*, (40):601-606, 2009.

[7] A.S. Virk, W. Hall and J. Summerscales. Failure strain as the key design criterion for fracture of natural fibre composite. *Composites Science of Technology*, (70):995-999, 2010.

[8] L.D. Bloom, J. Wang and K.D. Potter. Damage progression and defect sensitivity: an experimental study of representative wrinkles in tension. *Composites Part B*, (45):449–458, 2013.

[9] P. Ouagne, D. Soulat, G. Hivet, S. Allaoui and D. Duriatti. Analysis of defects during the performing of a woven flax. *Advanced Composites Letters*, (20):105–108, 2011.

[10] J. Lee, S. Hong, W. Yu and T. Kang. The effect of blank holder force on the stamp forming behavior of non-crimp fabric with a chain stitch. *Composites Science and Technology*, (67):357–366, 2007.

[11] H. Lin, L. Wang, A.C. Long, M.J.Clifford and P. Harrison. Predictive modelling for optimization of textile composite forming. *Composites Science and Technology*, (67):3242–3252, 2007.

[12] R. Arbter, J.M. Beraud, C. Binetruy, L. Bizet, J. Bréard, S. Comas-Cardona and al. Experimental determination of the permeability of textiles: a benchmark exercise. *Composites Part A*, (42):1157–1168, 2011.

[13] Y. Hou, S. Comas-Cardona, C. Binetruy and S. Drapier. Gas transport in fibrous media: application to in-plane permeability measurement using transient flow. *Journal of Composite Materials*, 2012 http://dx.doi.org/10.1177/0021998312455676.

[14] S.H. Lee, J.H. Han, S.Y. Kim, J.R. Youn and Y.S. Song. Compression and relaxation behavior of dry fiber preforms for resin transfer molding. *Journal of Composite Materials*, (44):1801–1820, 2010.

[15] A.A. Skordos, C.M. Aceves and M.P.F. Sutcliffe. A simplified rate dependent model of forming and wrinkling of pre-impregnated woven composites. *Composites Part A*, (38):1318–1330, 2007.

[16] P. Ouagne, D. Soulat, J. Moothoo, E. Capelle and S. Gueret. Complex shape forming of a flax woven fabric; analysis of the tow buckling and misalignment defect. *Composites Part A*, (51):1-10, 2013.

[17] E. Capelle, P. Ouagne, D. Soulat and D. Duriatti. Complex shape forming of flax woven fabrics: design of specific blank-holder shapes to prevent defects, *Composites Part B*, 2014, http://dx.doi.org/10.1016/j.compositesb.2014.02.007