

Fig. 2. Tension configuration (a): screwed or riveted joint, (b): bonded joint

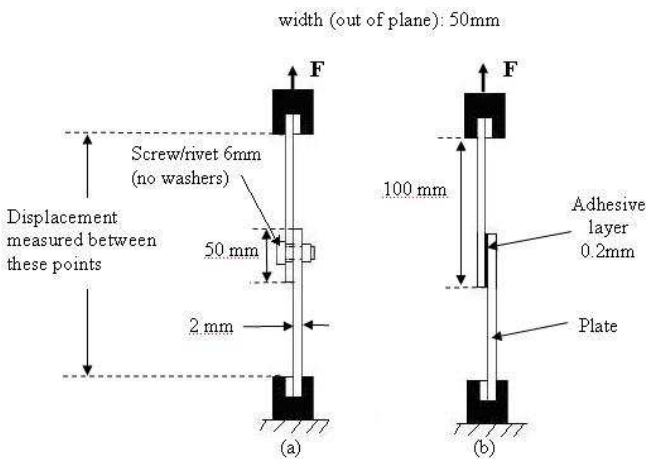


Fig. 3. Shear configuration, (a): screwed or riveted joint, (b): bonded joint

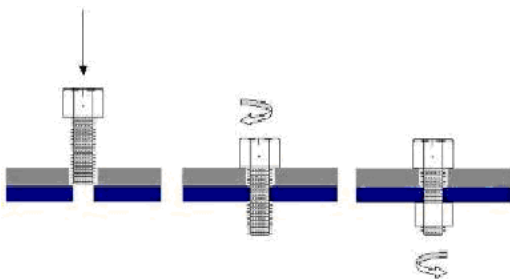


Fig. 4. Screw forming + nut Nylstop®

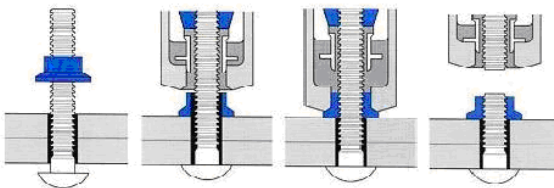


Fig. 5. Magna-grip® Rivet

### III. STATIC BEHAVIOUR OF THE JOINTS

Fig. 6 and 7 show the results of the static behaviour of the joints with the tension and shear configurations respectively. The curves that show the results of screwed/riveted joints

(Fig. 6a, 7a), we note that the linear zone is identical, it is the zone where we can quantify the rigidity of the connection (load divided by displacement) [4]. The nonlinear zones are synonymous with a high deformation of plates of the specimens. During the shear test, we can note a small linear zone that we can explain by a relative sliding of plates before the beginning of the load transfer on the fastener [5]. In the linear zone of the bonded joints, the joints represent a high rigidity compared to the screwed/riveted joints. The elastic zones observed on the curves load-displacement now enable us to better target the loads to be applied during fatigue tests.

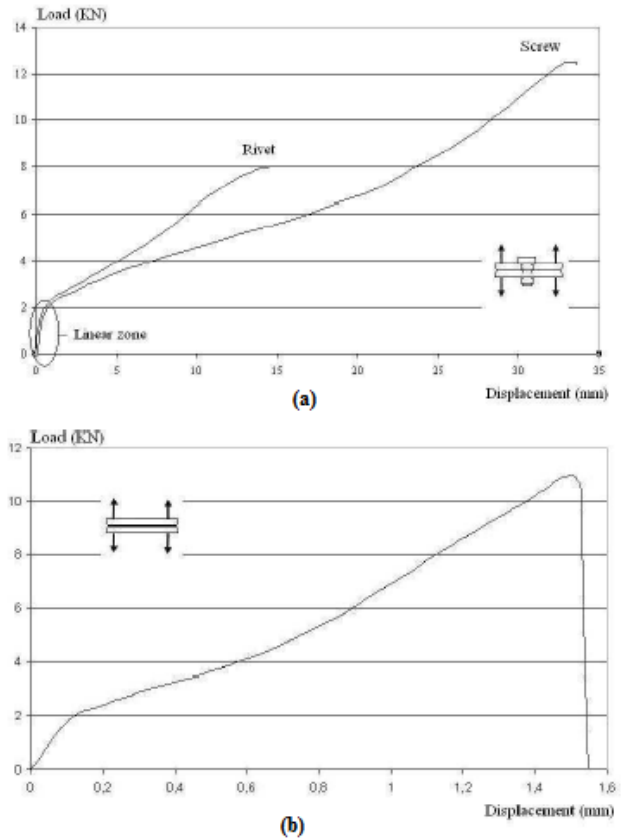
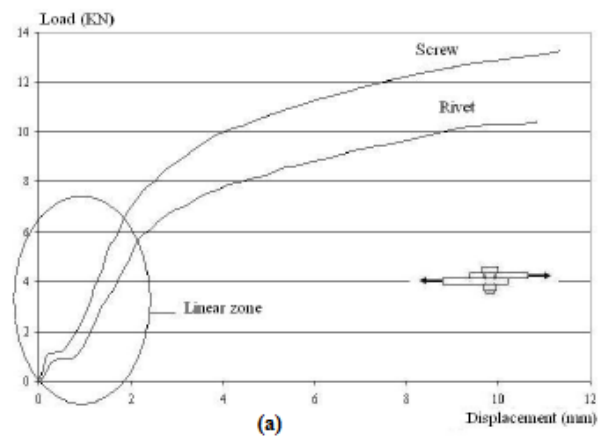


Fig. 6. Static tests for the tension configuration assembled by (a) screw/rivet and by (b) adhesive



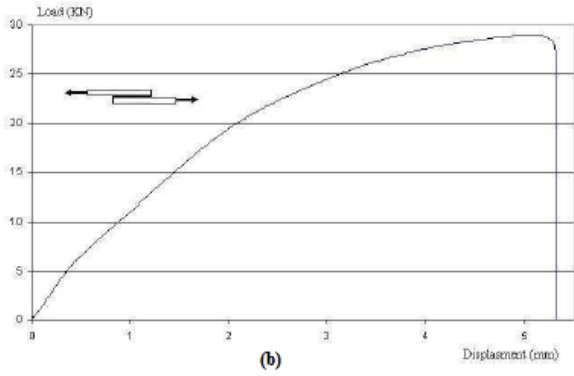


Fig. 7. Static tests for the shear configuration assembled by (a) screw /rivet and by (b) adhesive

#### IV. DYNAMIC CHARACTERIZATION OF THE JOINTS

The principal objective of the fatigue tests is to obtain the endurance limit of the screwed/ riveted joint [6] and the bonded joint [7]. The following curves show the results of the dynamic tests with tension configuration (Fig. 8) and shear configuration (Fig. 9) using the Wöhler method ( maximum load in term of number of cycles before failure).

In the screwed and riveted joints we can notice that the results in fatigue are very similar, and the endurance limite is around 1.5 KN in tension configuration and 3.8 KN in shear configuration. The endurance limite for the bonded joint is approximately the double with respect to riveted and screwed joints with more important numbers of cycles.

During these tests with the screwed and riveted joints, we note the same degradation, with a rotation of the fastener under the effects of the effort, then the appearance of crack in plates until total breaking (Fig. 10a, 10b, 11a, and 11b). We note that the failure of the bonded joints in tension configuration, is always adhesive on the interface between the adhesive layer and the plate (Fig. 10c) while in shear configuration is mixed, cohesive failure in the medium and adhesive failure on the edges of the surface of cover (Fig. 11c).

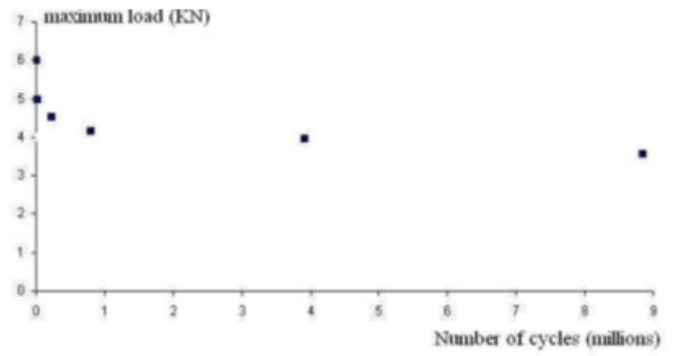


Fig. 8. Wöhler's curves in tension configuration, screwed/riveted joints & bonded joint

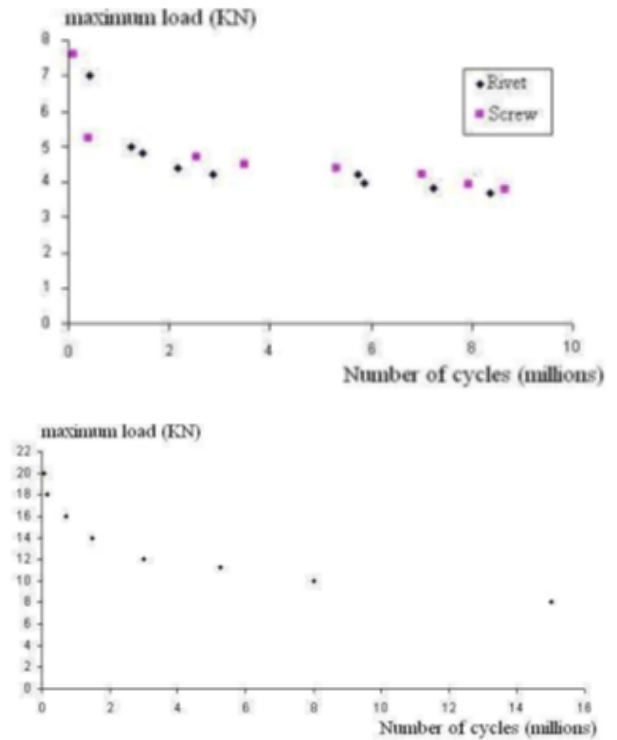


Fig. 9. Wöhler's curves in shear configuration, screwed/riveted joints & bonded joint

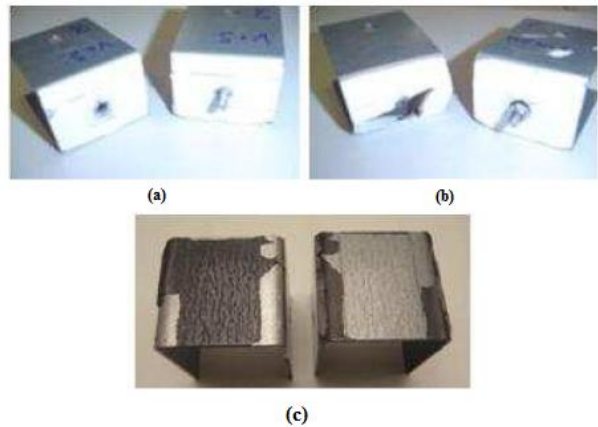
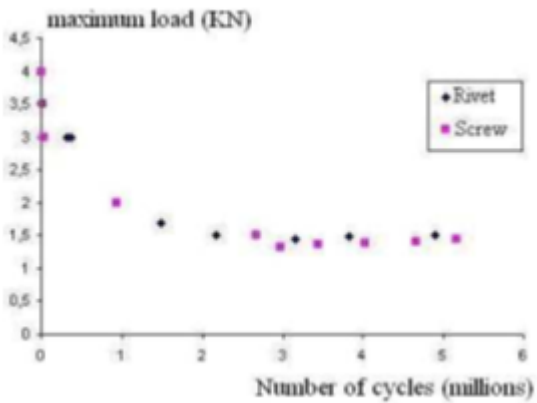


Fig. 10. failure for the joints with tension configuration: riveted joint (a), screwed joint (b), bonded joint (c)

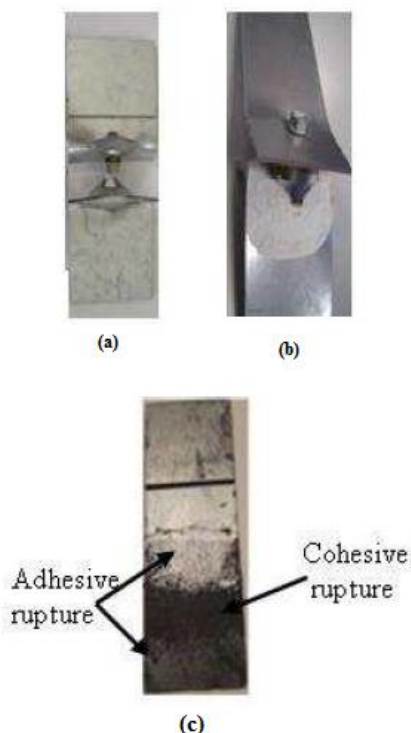


Fig. 11. failure for the joints with shear configuration: riveted joint (a), screwed joint (b), bonded joint (c)

## V. CONCLUSIONS

This paper is prepared to analyse the mechanical joints (screwed/riveted and bonded) under static and dynamic loads. The static tests allows to obtain the global behaviours of the joints. In the screwed/riveted joints the failure is always in plates and not in the fasteners (screw or rivet). In the bonded joints the failures are adhesives in the interface between the adhesive layer and one of two plates. This adhesive failure is caused by the presence of an organic layer Easyfilm® used to protect the used metal plates from corrosion [8]. The degreasing we used for the preparation of surfaces does not remove this layer.

The endurance limit and the numbers of the cycles, in tension and shear configurations are more important in bonded joints than in the two other types of joints, so structural adhesive can be an alternative solution in the assemblies of the frame. This result is obtained with a cyclic loading at ambient temperature and the next stage is to show the obtain the behaviour of the bonded joints with a high temperature than the ambient temperature.

## REFERENCES

- [1] Technical data of 3M® scotch weld epoxy adhesive 7240 B/A.
- [2] D. GLEICH, stress analyses of structural bonded joints, DUP science, Delft university press, the Netherlands, 2002, 75-77.
- [3] ESDU data items 92041, Stress analysis of single lap bonded joints, Engineering Sciences Data Unit, UK, 2001, 8-11.

- [4] Koffi K., Etude numérique et expérimentale des éclissages aéronautiques soumis à des chargements de traction et flexion, PHD Thesis, mechanical department, INSA, Toulouse, French, 1999, p. 35 - 42.
- [5] Ali M., Lorrain B., Karama M., Puel B., Etude du comportement d'une liaison mécanique par éléments de fixation. 8th National conference in calculation of the structures. Giens, French, 21-25 May 2007.
- [6] R.S. BIRCH, M.ALVES, Dynamic failure of structural joint systems, Thin-Walled Structures 36 (2000) 137-154.
- [7] A. J. CURLEY, H. HADAVINIA, A. J. KINLOCH, A. C. TAYLOR, Predicting the service-life of adhesively-bonded joints, International Journal of Fracture 103: 41-69, 2000.
- [8] User Manual Metallic Coated, Arcelor®.