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**AN EXPERIMENTAL INVESTIGATION OF BEAD STIFFENED COMPOSITE PANELS  
SUBJECTED TO SHEARING IN THE RANGE OF POST BUCKLING STATE**

**EXPERIMENTÁLNÍ VÝZKUM KOMPOZITNÍCH OBDÉLNÍKOVÝCH DESEK,  
VYZTUŽENÝCH LEMY, KTERÉ JSOU NAMÁHÁNY SMYKEM V OBLASTI POKRITICKÉHO  
PŮSOBNÍ**

**Abstract**

The paper presents the results of experimental researches of bead stiffened composite rectangular plates subjected to shearing. As a result of loading, the structures sustain initially local loss of the stability, accepted in the integral form as the load increases. The tests were made for several variants of stiffeners, different stiffness of the plates and fibre reinforcement orientation.

The results of investigation constitute the base for elaboration of the mathematical and numerical models to obtain correct solution of geometric non-linear problems..

**Abstrakt**

V příspěvku jsou prezentovány výsledky experimentálního výzkumu kompozitních obdélníkových desek, vyztužených lemy, které jsou namáhány smykem. V důsledku zatížení dochází zpočátku k místní ztrátě stability, což je přijato v integrální formě jako nárůst zatížení. Zkoušky byly prováděny pro několik variant vyztužení, různých tuhostí desek a orientací vláken vyztuže. Výsledky výzkumu jsou základem pro vypracování matematického a numerického modelu pro získání řešení problémů s geometrickou nelinearitou.

**1 INTRODUCTION**

Composites are modern constructional materials, applied in many disciplines of the technology, also in to aviation. They are posing the popular group of composites especially laminate, being marked by the high relation of durability exceptionally to the mass, in comparison with constructional materials applied generally so like steel and alloys of aluminium.

The chance to design is permitting the property of laminate through the suitable selection of characteristic parameters to shape rational material properties. It requires however applying effective tests and calculations.

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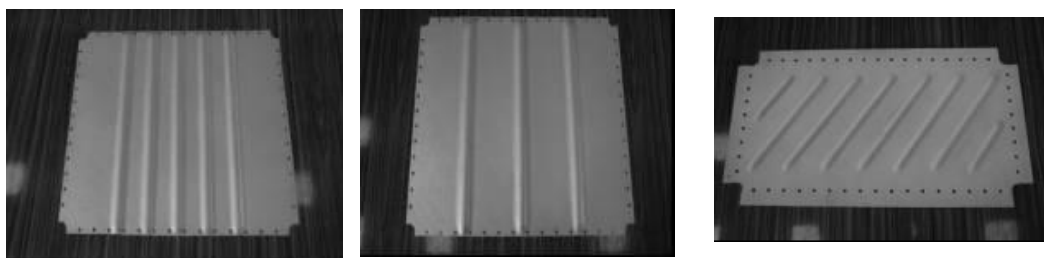
The suitable selection of materials is permitting to find the justified compromise between sometimes with conflicting purposes, how e.g. with durability properties and the price of the design.

Elements of composite structure are being produced not infrequently individually which it is causing the need to lead examinations heading towards identification of such parameters how e.g. material constants. It is creating potential chances to diagnose durability and the life of the design.

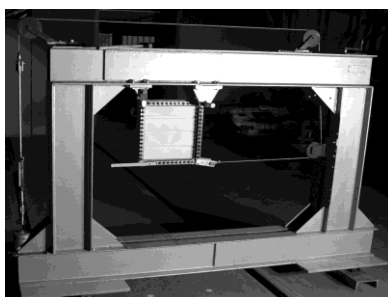
Elaboration of methodology of examinations and numeric durability computation is the purpose of the task taken up of chosen solutions to constructional composite structures. The realization of the task is being illustrated on examples finding the direct application in aviation of constructional solutions. We hope, the results will be posing the terminal effect directly in the process of designing of air composite structures.

## 2 SUBJECT OF EXAMINATIONS

Composite rectangular plates with bead stiffened subjected to shearing constituted the subject of investigation. Glass cloth and the epoxy resin constituted the material components of the composites. Geometry of the plates were keeping the similarity to elements applied to real constructional solutions of airframe structures. An influence of stiffening elements on the behaviour of structure was the purpose examinations in post buckling state. This kind of investigations turn out very helpful, and necessary in many cases during the creation of numerical model adequate for the study. The numerical model, which the path of the balance is conforming for experiment is making possibility to determine the stress state of the extreme deformation conditions, necessary to assign the fatigue life on the numerical way.

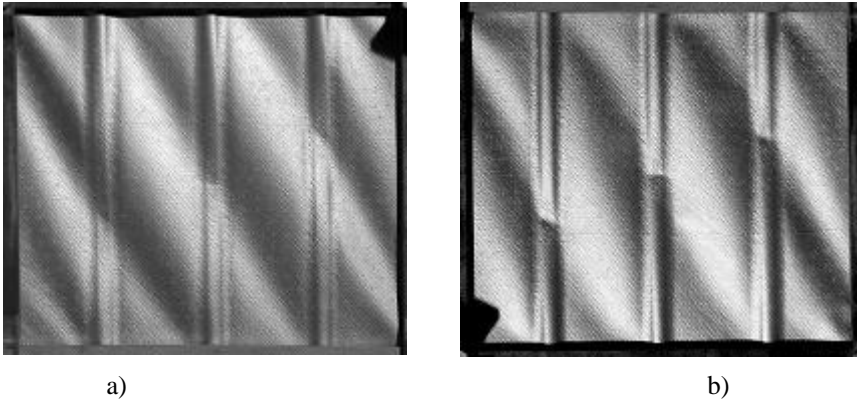


**Fig. 1** Three kinds of plates intended for examinations

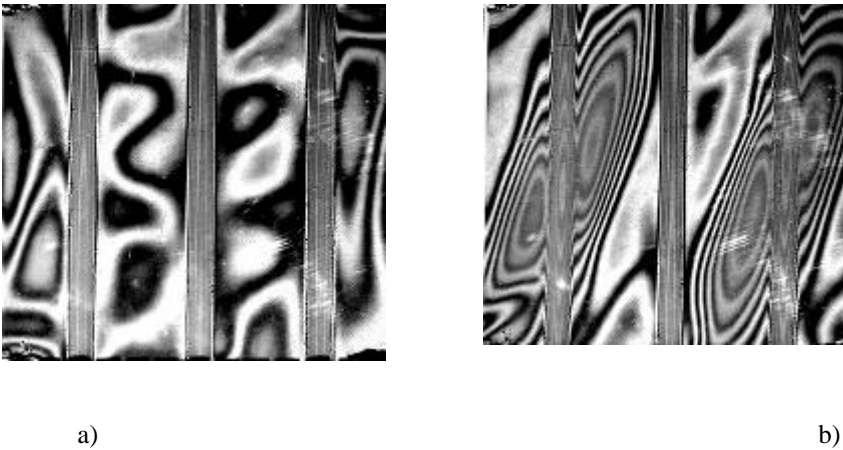


**Fig. 2** The plate on the station prepared to investigation

In this paper methodology and results the first stage of examinations of the plate with three bead stiffeners are presented. On the fig. 1 three kinds of plates prepared to tests are presented. Fig. 2 shows the station of investigation. Fig. 2 presents the complete station to examinations, with the fixed plate.



**Fig. 3** General view of the plate in post buckling state:  
a)- front size of the plate    b)- back size of the plate

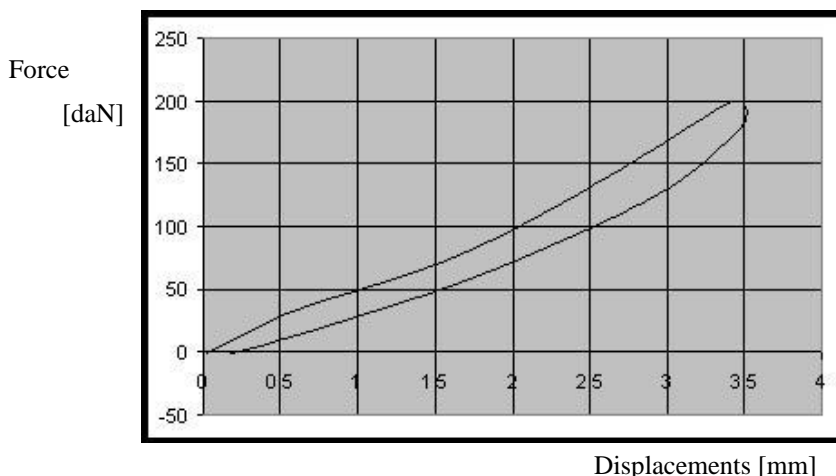


**Fig. 4** Contour line distribution obtained by shadow moiré method:  
a) contour line in neutral state  
b) contour line received in the range of the loading

The plate in advanced post buckling state (front and back side) is shown on the fig. 3.

In order to express deflection distributions of the plate in quantitative form the shadow moiré method were applied. The effects presented on the fig. 4b turned out highly useful in elaboration of the adequate numerical model in FEM point of view.

A plot of dependence of the transverse dislocation of the lower, horizontal edge of the plate was made on the basis of examinations carried out vs. cutting forces. (See fig. 5) This dependence to be treated perhaps as the representative path of the balance.



**Fig. 5** The path of the balance for the plate with three bead stiffeners (loading and lightening)

### 3 CONCLUSIONS

Presented effects are posing the preliminary stage of examinations intended extensively of composite structures from bead stiffeners. Numerical analyses based on the geometrically non-linear theory are being managed simultaneously with experimental examinations. Compatibility both of results as regards of the character of deformation and the path of the balance is giving grounds for the estimation to accuracy of numerical FEM model. It is necessary to underline that calculated tensions are making possibility to determine the fatigue life of structure, before expensive and time-consuming executing of the prototype solution.

### REFERENCES

- [1] LANZI, L. A numerical and experimental investigation on composite stiffened panels into post-buckling. *Thin-Walled Structures*. 2004.Nr.42. pp. 1645-1664. ELSEVIER
- [2] HOSSEINI-TOUDESHPY, H. & LOUGHLAN,J. & KHARAZI,M,D. The buckling characteristic of some integrally formed bead stiffened composite panels. *Thin- Walled Structures* . 2003.Nr.43. pp. 629-645. ELSEVIER
- [3] TREBUŇA, F.& ŠIMČÁK, F.& JURICA, V. *Pružnost a pevnost*. Strojnicka fakulta Technicka Universita v Košicach. Viena, Košice 2000.

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