

# **INFLUENCE OF BARELY VISIBLE IMPACT DAMAGES ON STABILITY AND LOAD CARRYING CAPACITY OF THIN-WALLED STRUCTURES SUBJECTED TO COMPRESSION**

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## **1. INTRODUCTION**

Barely visible impact damages (BVID) are mainly generated by the low velocity impact (LVI) and can be induced by falling tools and equipment during repair or maintenance work, bird strikes, foreign objects thrown from the airplane wheels during take-off or landing, hailstones from under the airplane tires or by raining hail, collisions with other aircraft and ground vehicles on the taxiway or during loading. Inside the composite material, in the area of impact, a net of delamination and transverse cracks of the layers occur. However, a significant areas of fiber failure are not appear. On the impacted surface a small impact mark appear but on the opposite surface the damage area is considerably more extensive. The current state of the art and the authors own studies [1] justify the thesis that there are dependencies between the type of damage, its size and location, and the load-carrying capacity and the failure mechanism of the thin-walled composite structures subjected to LVI.

## **2. OBJECTS OF THE ANALYSIS**

The objects of the analysis were plates predefined to compression after impact (CAI) tests and thin-walled channel section profile made of eight-layer GFRP laminate. The research was carried out on CAI plates as well as on the flanges and webs of the investigated channel section profiles. The intention of the authors was to analyze the influence of the geometrical position of the impact on the damage area, failure mechanism, load capacity reduction in comparison to non-degraded structures and the behaviour of the analyzed objects in the postbuckling range also in relation to standardized procedures of standard CAI studies.

## **3. ANALYSIS OF RESULTS**

In the light of the performed research, it can noticed that the LVIs have a different influence on the behaviour of analyzed systems in relation to arrangement of layers and energy and velocity rate but, particularly to the geometrical location of the impact which is also connected with the boundary conditions. It turns out that the damaged areas induced by LVIs on the CAI plates and the flanges and webs of investigated profiles are in high compliance as long as the impact energy is small (10J) (cf. Fig. 1). According to the CAI tests, regardless of the analyzed arrangements of layers, the increase of the

impact energy (20J) results in a significant increase of the damage areas while for the channel section profiles, the BVID areas do not change significantly (cf. Fig. 1). Moreover, it is easy to notice that the damage areas of the webs are always bigger than the degraded webs areas of the channel section profiles. Moreover, in some cases of higher impact energies applied to flanges of the C-shaped profiles, the complex forms of damage have been emerged. Then, the part of the impact energy was absorbed by the structure directly at the impact place, and a some extent of energy was accumulated in the form of substantial delamination, propagating towards the web. Additionally, the local degradation of the stiffness of the composite introduced asymmetry or change of buckling modes and can lead to several percent increase or even reduction of the capacity.

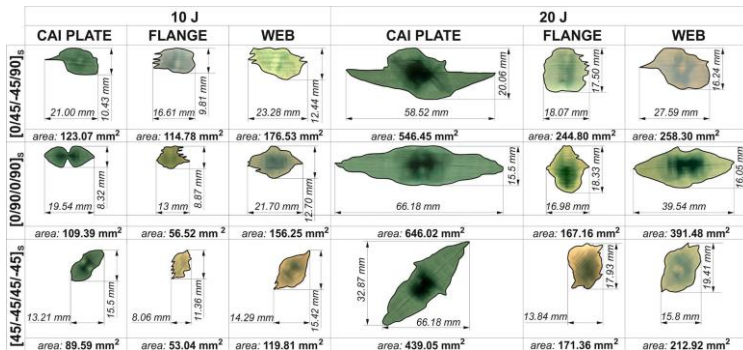


Fig. 1. Barely visibly impact damages determined from experimental research

#### 4. CONCLUSION

The vital implication of the obtained results is the possible re-establishment of the definition of LVI that should be focused on the areas and the constituents of the post-impacted damages. Although the undertaken research has mainly cognitive character, it is extremely important to understand the mechanisms of degradation of composite structures in the complex states of stresses, also from the perspective of the defects tolerance problems in highly-efficient composite structures. Conducted research can provide a basis to develop the assessment procedures of composite components in terms of reliability for further work depending on the type and the size of the recorded damage.

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#### REFERENCES

- [1] Gliszczynski A., Kubiak T., Borkowski L., Experimental investigation of pre-damaged thin-walled channel section column subjected to compression, *Comp. Part B* 2018:147;56-68.