# EXPERIMENTAL EVALUATION OF THE IMPACT BEHAVIOR AND DAMAGE EFFECTS IN CARBON FIBRE COMPOSITE FLAT SPECIMENS

I. Babaei [1, 2] *, R. Garg [1, 2], D.S. Paolino [2], G. Belingardi [2], L. Cascone [1], G. Galizia [3], A. Calzolari [3]

[1] Polymers and Glass, Centro Ricerche Fiat, Turin, Italy
[2] Department of Mechanical and Aerospace Engineering, Polytechnic of Turin, Italy
[3] Instron CEAST, Turin, Italy
[*] Presenting authors: iman.babei@crf.it

Carbon fiber reinforced plastics (CFRPs) have shown superior specific energy absorption at the element level of the Building Block Approach (BBA) [1]. However, a lack of understanding of their behaviours from the sub-component level to the final full scale level (Figure 1) has prevented their complete application in energy absorbing components.

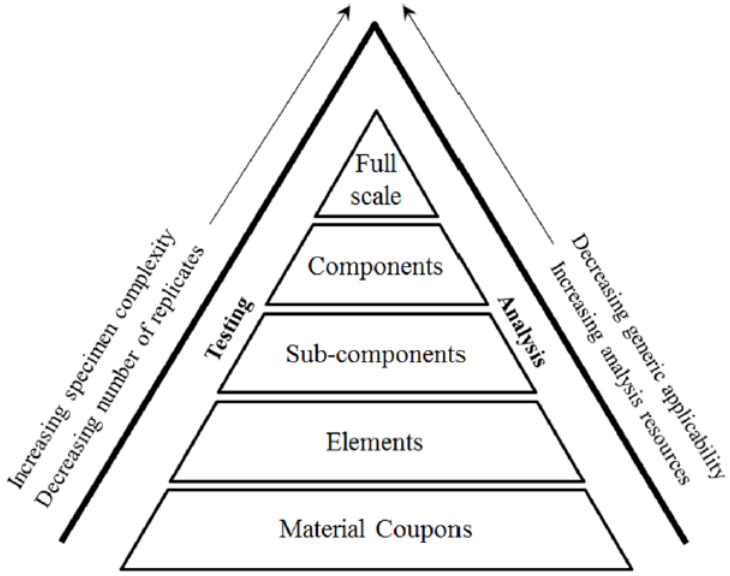


**Figure 1.** Building Block Approach for composite structural development. [2]

Carbon fiber reinforced composite material has been chosen for this study aimed to automotive applications in order to gain all the possible advantages with respect to the vehicle structure lightweight. The performed study is based on an experimental test campaign specifically designed for the scope. At first, standard ASTM characterization tests (quasi-static tensile, compressive, shear and bending tests, as well as dynamic impact tests) were performed on material coupons (1st level of the BBA in Figure 1). Then, based on these results, crashworthiness tests at the element level of the BBA were designed. In particular, 2.5 mm thick flat rectangular 100x150 mm elements were designed with saw-tooth triggers on one side in order to initiate a steady crush for better energy absorption. Furthermore, an anti-buckling fixture was designed and manufactured to perform the crashworthiness tests [3]. Quasi-static and impact tests at different velocities, energies

and masses were performed with the newly designed specimens and fixture for better understanding the crashworthiness of the investigated material, the damage initiation and propagation mechanisms.

After that, to study the effects of in-situ and/or manufacturing slight damages due to various reasons like accidental fall of tools, etc., ball drop tests were performed, and damaged specimens were studied with an ultrasonic C-Scan analysis. Finally, the crashworthiness performance of these samples with barely visible damages or dents were evaluated and compared with those of the undamaged ones. Results show that until the damage reaches the dimension of what we can call "critical delamination", the specific absorbed energy does not change drastically; however, after the cracks start to propagate, the energy absorption decreases evidently.

[1] Department of Defense Handbook. (2002). *Composite materials handbook, volume 3: polymer matrix composites—materials usage, design and analysis*.

[2] Wade, B. (2014). *Capturing the energy absorbing mechanisms of composite structures under crash loading* (Doctoral dissertation).

[3] Garg, R et al, *Simulation Studies on the Crashworthiness of Carbon Fibre Composite Flat Specimens*, (Abstract for the First ECCCS Conference)