Elastic body impact on sandwich panels at low and intermediate velocity

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The impact and damage behavior is in general an essential topic for sandwich panels and treated in many scientific studies. Investigated effects are e.g. the influence of the impactor's velocity, the impactor-structure mass ratio [1], the structural stiffness and boundary conditions, the impactor's geometry [2], appearing failure modes [3, 4, 7] and many more. These studies are based on statistical evaluations of experimental data as well as on rather complex non-linear Finite Element investigations [5, 6, 7, 8]. However, commonly they are based on a fundamental simplification: The impactor is assumed to be rigid [3, 5, 6, 7].

For a wide range of applications this assumption is useful in order to simplify the evaluation and to focus on the impact behavior of the sandwich structure. However, it is obvious that there are applications where this assumption does not deliver satisfying results. A typical example, which is our main motivation, is the accidental impact of a human body on the interior sandwich structure of a civil aircraft during a crash situation. Beside the damage behavior of the sandwich structure this case of the blunt impact of an elastic impactor raises a new, and an of course even more important aspect: How is the deformation and the deceleration of the elastic impactor? It is crucial to human safety to investigate realistic impact loading conditions on structural parts as well as to minimize the risk of at least severe injuries during crash conditions.

The current investigation focuses on the influence of the initial impact velocity and the elastic properties of the impactor on:

(i) the change of the initial failure mode of the sandwich structure (e.g. fracture or wrinkling of the impacted face layer, shear failure of the core material or tensile rupture of the lower face layer [4]) due to a stress distribution shift [9].

(ii) the deceleration of the elastic impact body. Regarding the example of a crashing aircraft the so-called Head Injury Criterion (HIC, [10]) is used to evaluate the injury level on the human body due to inertia forces.

The study is accomplished numerically with non-linear Finite Element models using a dynamic solver. The considered geometries are a quadratic sandwich plate with simple supported boundaries for the structure and a sphere for the impactor. The dimensions of the impactor and the structure are based on the afore named crash case of a civil aircraft. The sandwich structure is modeled by an orthotropic, linearly elastic material while the impactor is considered to be isotropic, linearly elastic. The impacting sphere as well as the core material are discretized by linear solid elements and the sandwich face layers by linear shell elements. Contact is modeled as "hard contact" without friction and geometric non-linearities are considered.

For the study the material parameter of the impactor is varied from "soft" to "rigid" at different initial impactor velocities, ranging from 5 to 15 m/s. The conclusions drawn from the simulation results are essentially found by the discussion of the element stresses and the dynamic responses of the structure and the impactor.

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