



# Types of Composite Damage

*Effects of different impact energies on composite damage implications*

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# Composite Damage: Implications & Causes

Composite parts and structures deliver enormous benefits across a range of industries, offering the mechanical properties of metal and the light-weight and versatile ones of plastic.

A composite in this sense is defined as one which combines a reinforcement material (e.g. carbon fibre fabric) with a resin matrix (e.g. two-part epoxy) to create a carbon fibre composite.

Composite damage exists in a range of states, ranging from fibre breakage through to dents and delamination.

A well-studied area, it has been estimated in some sectors to account for over 80% of composite damage occurs as a result of impact – specifically collisions with stationary objects, falling objects and other moving objects<sup>1</sup>.

Other reasons for damage centre on environmental factors (e.g., UV radiation, moisture ingress, erosion) and scenarios where the mechanical properties of the composite are exceeded.

This presentation is intended to provide a basic overview of composite damage in aircraft and is adapted from a prior publication<sup>2</sup>. It is specific to thermoset composites.

<sup>1</sup> <https://www.cambridge.org/core/journals/aeronautical-journal/article/abs/study-of-accidental-impact-scenarios-for-composite-wing-damage-tolerance-evaluation/8B0A702157DCC48CA9B5B6996E0F6820>

<sup>2</sup> <https://www.tandfonline.com/doi/full/10.1080/20550340.2022.2057137>

# Composite Damage: Effects of Impact

Categories of damage experienced by thermoset polymer carbon fibre composites have been detailed based on US FAA composite repair guidelines<sup>3</sup>.

These included delamination and impact-induced matrix cracks.

In terms of impact, the type of damage experienced depended on speed and energy:

- High-energy impact at low speed = delamination in larger areas without visible damage to the exterior
- Low-energy impact at high speed = penetration of the part without delamination.

The following section will look at various types of damage that could be caused by different impact energies.

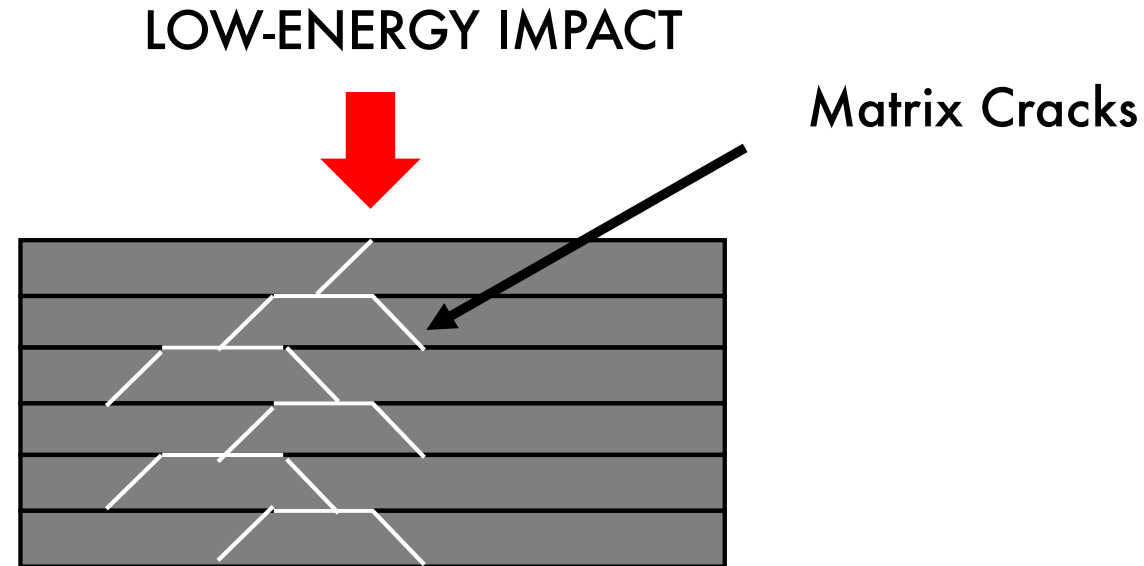
<sup>3</sup> <https://www.tc.faa.gov/its/worldpac/techrpt/ar0854.pdf>

# Matrix Cracking Due to Low-Energy Impact

Matrix cracking is believed to occur as a result of low- and medium-energy impact in a direction parallel to the to the fibre arrangement.

Crack formation does not adversely affect the residual strength or stiffness of the composite, but can expose material to environmental factors (e.g., water/moisture ingress).

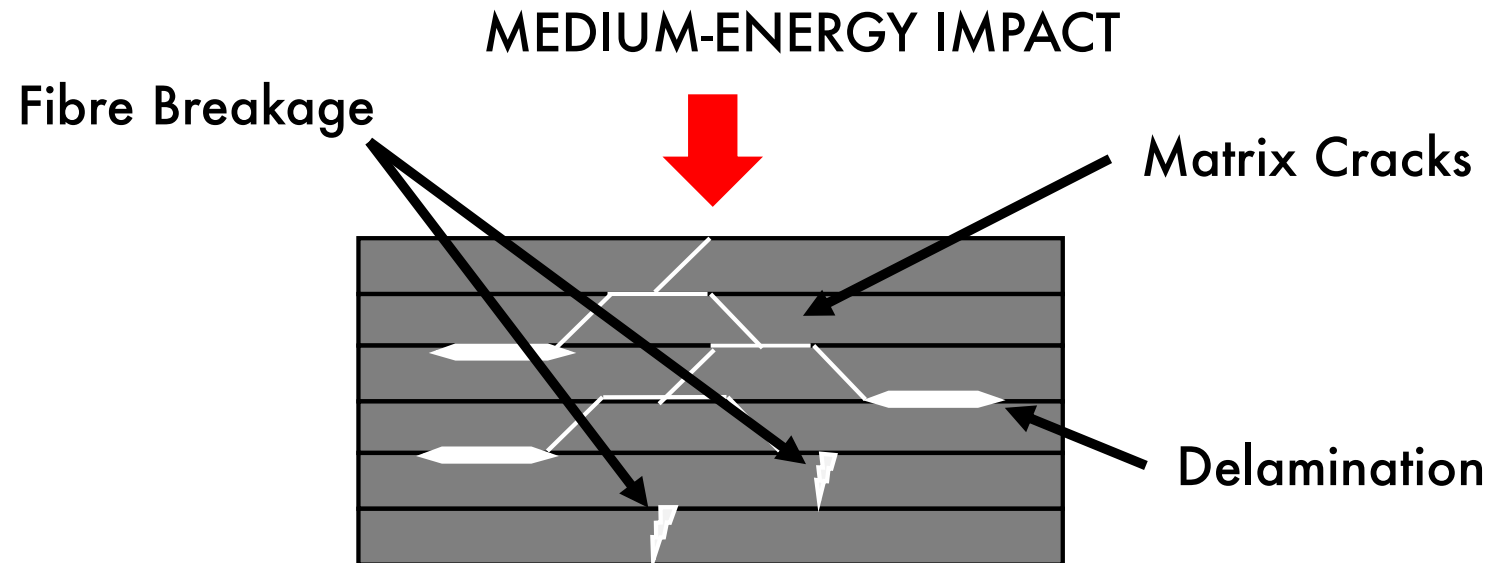
This can accelerate the matrix degradation (e.g. interlaminar shear and compression strength)<sup>4</sup>.



<sup>4</sup> <https://cds.cern.ch/record/439501/files/HDBK17-3F.pdf>

# Fibre Breakage Due to Medium-/High-Energy Impact

Breaks in the fibres occur when subjected to medium-energy impact. Conversely, high-energy impact across a large area can lead to damage inside the structure, in spite of there being no external damage.

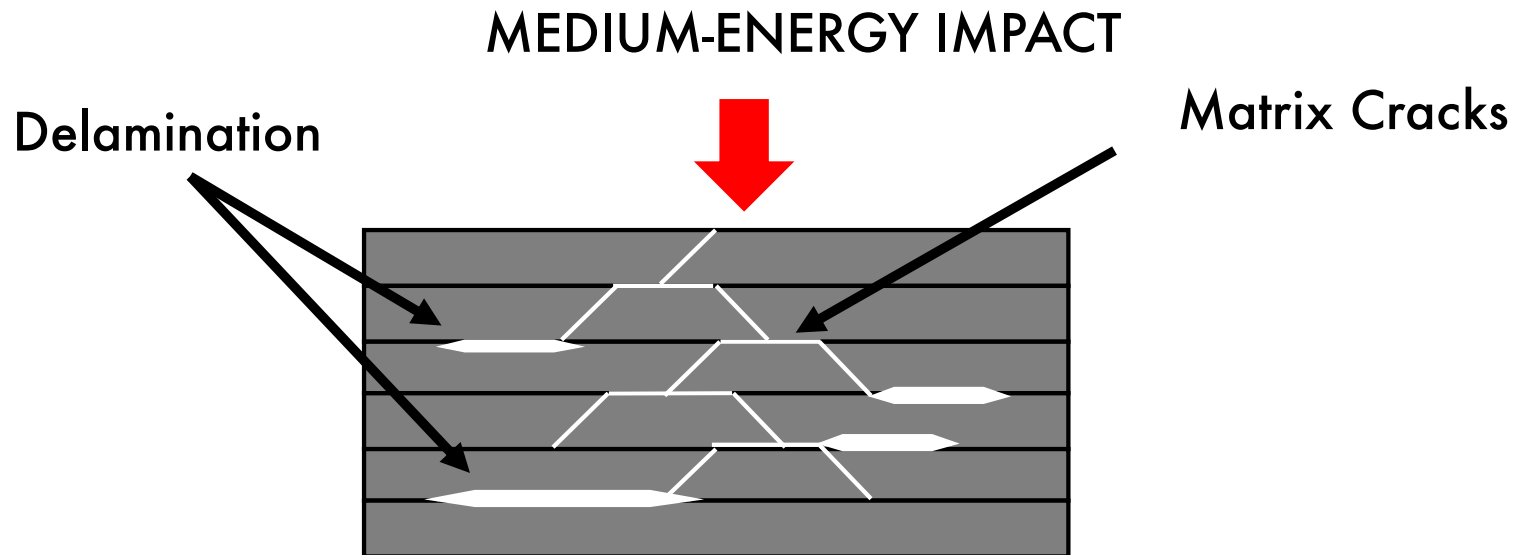


In such instances, cracks may occur which involve both fibre and matrix damage as well as delamination, resulting from impact, but also overloading<sup>5</sup>. Scratches are typically cosmetic and usually involve only the outer layer of the resin.

<sup>5</sup> <https://www.tc.faa.gov/its/worldpac/techrpt/ar0854.pdf>

# Delamination Due to Medium-Energy Impact

Delamination taking place at the interface between each layer (or along joined components) exhibits a reduction in stiffness and structural integrity<sup>6</sup>.

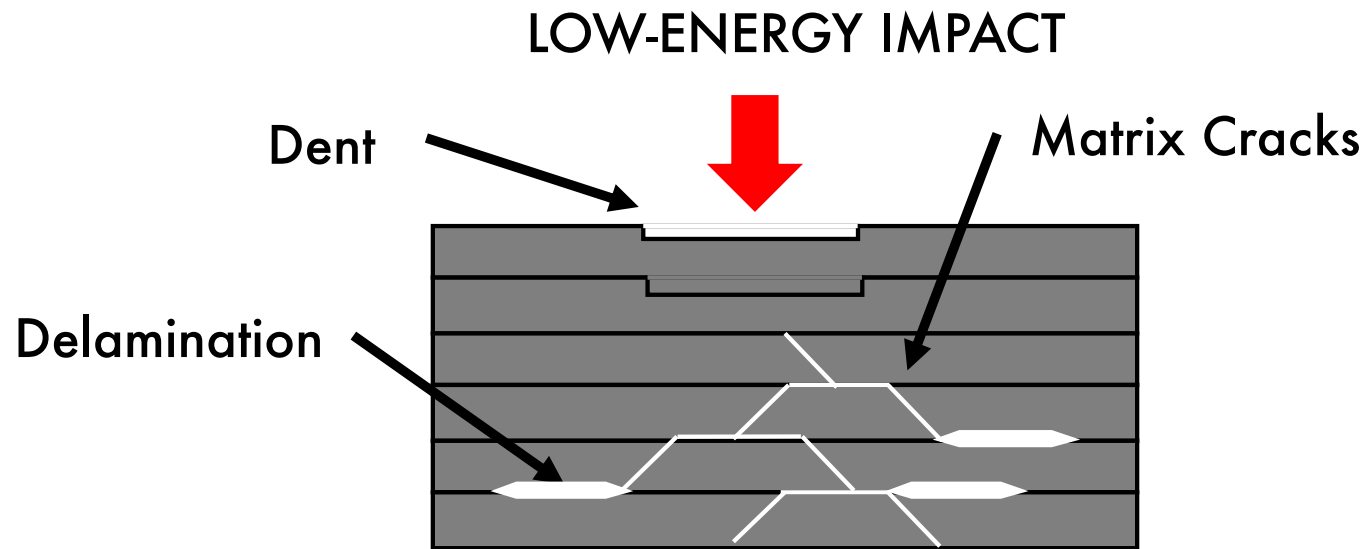


Matrix cracking often occurs with this type of delamination and results from the subsequent differences in properties of each layer.

<sup>6</sup> <https://www.semanticscholar.org/paper/Fracture-mechanics-concepts%2C-stress-fields%2C-strain-Raju-O%27brien/0024a386861223d5c5ce6e5ec91294597c5bb69a>

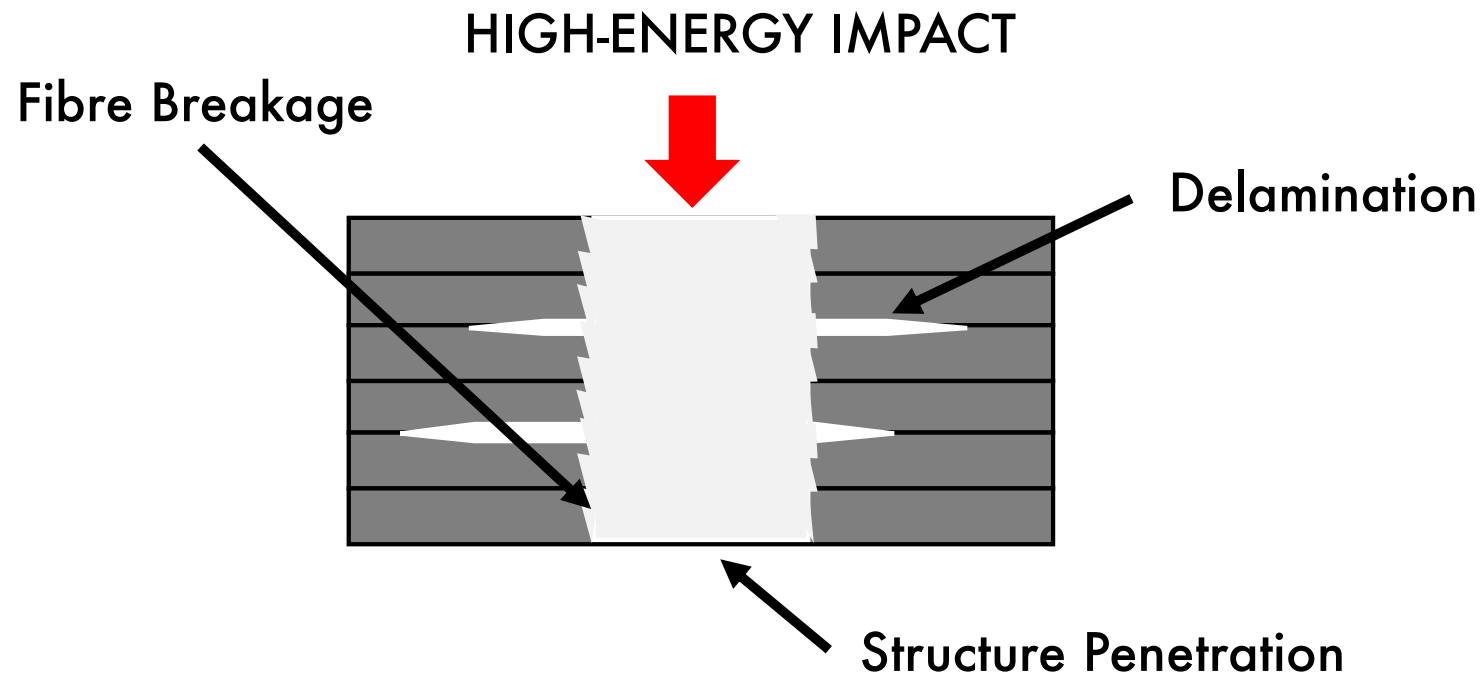
# Dents Due to Low-Energy Impact

Whilst dents result from impact, they could result from underlying damage to the composite due to a compromised interior exhibiting prior damage or defective laminating (e.g., matrix cracking, broken fibres, delamination).



# Puncturing Due to High-Energy Impact

Punctures result from high-energy impact or impact with an object that has a small surface area. The result can be a penetration of the composite and more extensive damage elsewhere.



Different impact energies impart different types of damage to a composite.

Careful consideration needs to be given to determine the type of damage incurred by impact to a composite.

Non-Destructive Imaging (NDI) can be used to help evaluate the extent of any damage to a composite which may or may not be visible.

A wide range of factors should be considered when making a repair to any composite. The quality of the repair and expertise utilise should increase proportionally with the safety implications of a failure in that repair. In some cases, a replacement of the composite may be more desirable in spite of economic costs.

[Carbon fibre repair](#) kits can be used to address these limitations. For repairs to the surface of the composite, such as very superficial damage, an [epoxy repair resin](#) can be used prior to additional surface treatment. Alternatively, dents and punctures can be restored using [repair pastes](#). Similarly, a [fibreglass repair kit](#) can be used in instances where greater flexibility is desired.

Note: the content on this site is for general informational purposes only. It is not to be considered professional advice. Resin Library is not liable for any outcomes. Please consult a professional prior to conducting any repair work.

# About Resin Library

Resin Library specialises in the supply of resins, reinforcements and other materials to support work in the composites industry.

Our products include carbon fibre and fibreglass materials, kits and tools.

We aim to equip our customers with the products, expertise and knowledge needed to excel in the fibreglass industry.



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