CHAPTER 3

DROP IMPACT DAMAGE AND DROP IMPACT TEST

(Courtesy: www.nptel.iitm.ac.in/courses, Webcourse-contents/IISc-BANG)

Composite materials are those in which two or more materials are combined together to obtain a set of specific performance characteristics in terms of mechanical, chemical or thermal properties or a combination of two or more of them.

Composite materials generally have two constituents, namely, the reinforcement phase and the matrix phase. Based on the matrix material, composites are classified into polymer matrix composites, metal matrix composites and ceramic matrix composites. Composite materials are anisotropic and heterogeneous in nature. Two kinds of defects normally occur in a composite material; one is fabrication defects such as porosity, voids, inclusion, etc., and the other is service induced damages such as matrix cracks, interface debonds, delaminations, fibre breakages, etc. Drop impact loads create internal damage in a composite structure that often cannot be identified by visual inspection.

The impact damage induced in the composite laminate will affect the overall residual life of the composite structure. Hence, an attempt has been made to the assess drop impact damage by the Ultrasonic Technique (UT) and Acoustic Emission Technique (AET). In this chapter, the various types of
impact damage modes in composite laminates and the types of drop impact tests are explained in detail.

3.1 DROP IMPACT DAMAGE MODES IN COMPOSITE MATERIAL

Drop impact damage may develop the following kinds of modes, such as matrix cracking, delamination and fibre breakage. These damage modes generally degrade the strength of the composite laminates.

Matrix cracking

Matrix crack is induced in a complicated pattern, which is very difficult to predict. Matrix cracking is a primary cause of failure in a composite structure, and is shown in Figure 3.1. This damage may occur during in-service, as a result of low velocity impact load, due to natural drop weights. The strength of a damaged composite component is reduced significantly by matrix cracking.

![Pyramid pattern matrix crack from impact](image)

Figure 3.1 Matrix cracking

(Courtesy: ASM Hand Book published in year 2001)
Delamination

Delamination is the debonding between adjacent laminae, and is one of the most commonly occurring damage mode in a composite material. Delamination damage is frequently encountered in composites as a result of low energy impact and cyclic thermo-mechanical loading. Delamination is a dangerous kind of failure as it develops inside the material, without being visible above the surface of the composite materials. Delamination appreciably reduces the strength of the laminate; hence, it should be identified, and necessary actions are taken to eliminate or repair it; otherwise, it may lead to major accidental failure. The schematic diagram of delamination, fibre fracture and matrix cracking happening due to drop impact damage, is shown in Figure 3.2.

![Delamination Diagram](image)

**Figure 3.2 Delamination**
(Courtesy: ASM Hand Book published in year 2001)

Fibre breakage

Most of the bending stiffness loss is observed due to the fibre breakage damage present within the material. In the case of graphite and epoxy, the fibres conduct electricity and the resin does not; thus, it seems
likely that an increase in the electrical resistance to the direction of the fibres will indicate the presence of broken fibres due to fatigue damage. The breaking of the fibres leads to a reduction of the ultimate strength of the material. It is important to know which damage mode affects the composite residual performance the most.

3.2 TYPES OF DROP IMPACT TEST

A composite structure is expected to undergo impacts by foreign objects during manufacture, use, and maintenance operations, when the tools are being dropped on the structure. Impact is defined as the relatively sudden application of an impulsive force, to a limited volume of material or part of a structure. The impact force can be dissipated as heat, light and sound through the material, and can also create permanent damage. This internal damage can cause a severe decrease in the strength, and the size of damage, which can grow under load. Drop impact tests are classified into low velocity impact, high velocity impact and hyper velocity impact, based upon the velocity of the impactor.

Low velocity impact

The term ‘low velocity’ can be used to describe the velocity of impact, which is less than 70m/s. Low velocity impacts are associated with delamination damage, especially the one which is caused by blunt headed projectiles. Low velocity impacts have also been shown to reduce the strength of the composite materials.

High velocity impact

The term ‘high velocity’ can be used to describe a range of values from 70m/s to 70km/s. The high velocity impact such as bird strike, and a
piece of the engine's fan blade can cause severe damage to the structures in spite of a very small mass. A wide variety of damage modes such as matrix cracking, delamination and fibre breakage in composites can be easily created by a high velocity impact.

**Hyper velocity impact**

The term ‘hyper velocity’ can be used to describe the velocity of an impact greater than 70km/s. The hyper velocity impacting particle produces an irregular shaped ‘hole’ or ‘crater’ on the first hitting of a laminate. The damage spreads in a spherical or tear-drop pattern in the material due to hyper velocity. Hyper velocity impact conditions are most likely to occur on spacecraft at low earth orbit.

### 3.3 SELECTION OF A SUITABLE TEST FOR THE PRESENT WORK

The selection of a suitable test was made very carefully, to produce the real time impact damage experienced in common applications. Drop impact damages are mainly induced in composite material during maintenance, collisions between different structures, dropping of tools, dropping of heavy luggage, etc. Drop impact damage due to the above said drop weight replicates ‘Low Velocity Impact’ on aircraft parts. Drop-weight tests are used to simulate the low-velocity impacts problem, in which a large object falls onto the structure at a low velocity. Hence, the drop-weight test resembling a low velocity impact test was selected for the present experimental work.