Estudo numérico e experimental do impacto lateral em componentes feitos de material composto

English title

Numerical and experimental study of the lateral impact on composite components

Abstract

The present project plan (project 2020-366) consists of three different studies under investigation at the GMSIE laboratory. The main core of this project is the ballistic lateral impact (213.4 m/s) on the composite sandwich panels and aluminum sheets for Embraer. The second part of this project that was added to the main core is the static and dynamic material characterization of polymeric composite (HDPE and glass-fiber compound) with application in railway sleepers manufacturing for Braskem company. The third project added to this project is an undergoing numerical and experimental study of the impact safety of Brazilian motorcycle helmets at the GMSIE laboratory. All these three studies will consider safety and material response under dynamic loading.

The second part of this project (material characterization of polymer for Braskem company) had been completed and the ballistic impact on the sandwich composite panel for Embraer company has been developed by 70 %. The helmet safety study will be started after the completion of the ballistic impact study. Thus, the same project plan will be submitted for project renewal.

Keywords: Dynamic response, Material characterization, Composite railroad sleeper, Motorcycle helmet, Lateral impact; Impact safety.

Part (a): Ballistic impact on composite and aluminum plates (Embraer)

This study is aimed to investigate the dynamic response of flat plates, made of Aluminum and sandwich composite, impacted by cubical projectiles. The effect of cube orientation on the impact behavior and failure modes will be considered in detail. The general overview of impact test configuration is presented in Fig. 1. Three different cube orientations will be considered against the flat plates, see Fig. 2. The number of valid tests for each orientation is presented in Table.1. A tolerance of ±5° is acceptable for the debris orientation.

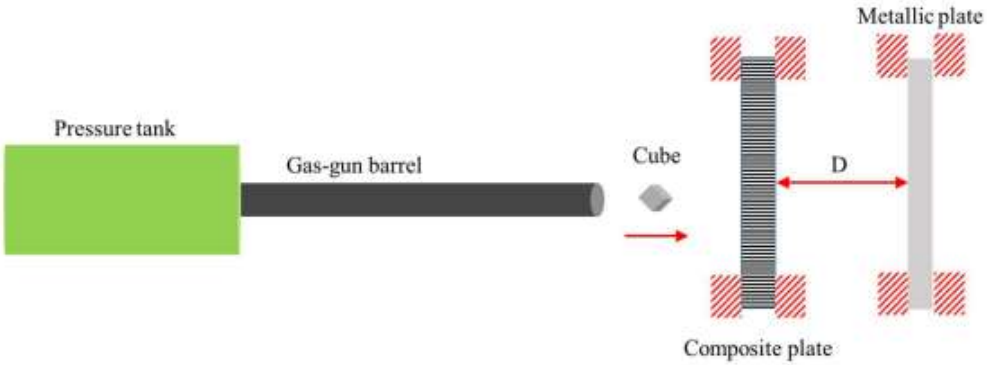


Fig.1. Overview of lateral impact test on plates.

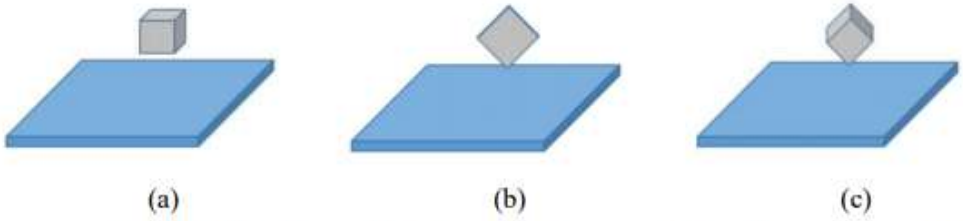


Fig. 2. Cubical impactor orientation; (a) Side-on, (b) Edge-on and (c) Corner-on (Jordan and Naito 2014).

Table. 1. Required valid tests for each cube orientation.

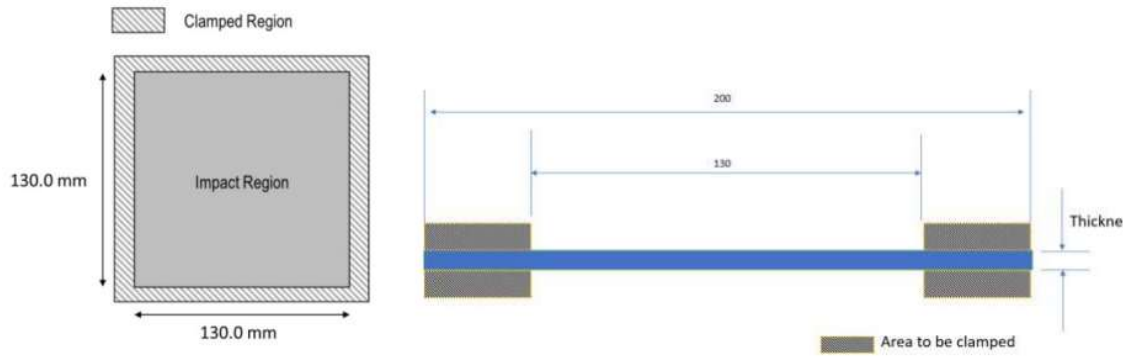
Test Specimen Configurations	Debris Orientation		
	Side-on	Edge-on	Corner-on
01	07	07	07
02	07	07	07
03	07	07	07

This test is relevant to impact the airplane structure due to engine failure. Embraer has proposed two types of square plates to the GMSIE laboratory to be tested. One to represent the wing-fuselage fairing (sandwich composite) and another to represent the wing stub lower skin (Aluminum) of the airplane (Fig. 3). For both plates, a free impact area of 130 mm x 130 mm should be provided by the test fixture, Fig.4. A new fixture is designed the last year to clamp the plates, Fig 4. A new safety cage with five large viewports (made of 12mm polycarbonate plates) was designed to record images of impact with high-speed cameras). A horizontal light gas gun with a barrel of 3 m length was developed to reach 213 m/s velocities of debris. The new gas gun can launch a light projectile with about 230 m/s.

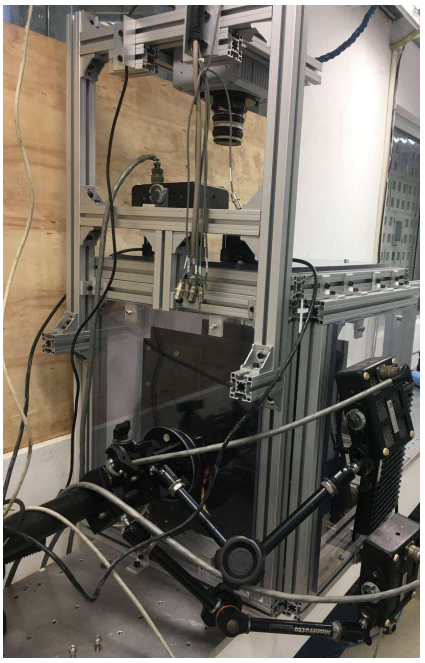
The sandwich panel provided by Embraer

The aluminum sheet provided by Embraer

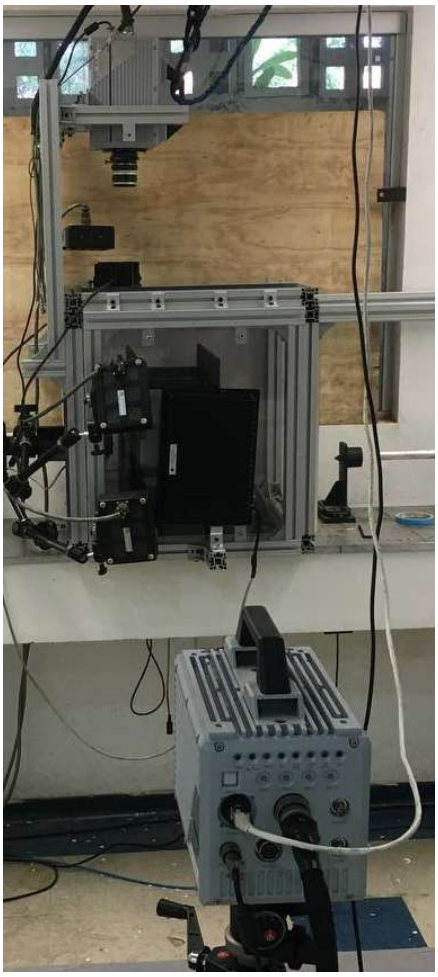
Fig. 3. Sandwich panel and aluminum sheet.



Plates Fixture



The fixture in the safety cage



Setup of ballistic impact.

New Light gas gun at GMSIE

Fig. 4. Ballistic impact test setup at GMSIE laboratory.

The following results should be prepared at the final of the project and delivered to the Embraer.

- Test setup (gas-gun) and test devices detailed description,
- Test procedure detailed description,
- Equipment calibration sheet,
- Speed and debris angle of impact,
- Mass of the debris,
- Data acquisition files, and
- Inspection reports including photos and damages dimension and description

The setup had been completed and ballistic impact tests (at least 70 correct tests) will be done in a maximum of 3 months (July).

Activities that should be completed

1. Conducting lateral impact tests (tests will be done in the presence of Embraer inspectors)
2. Image analysis and data reduction
3. Conducting leak test on the metallic plates after impact (fig 5 leakage test)

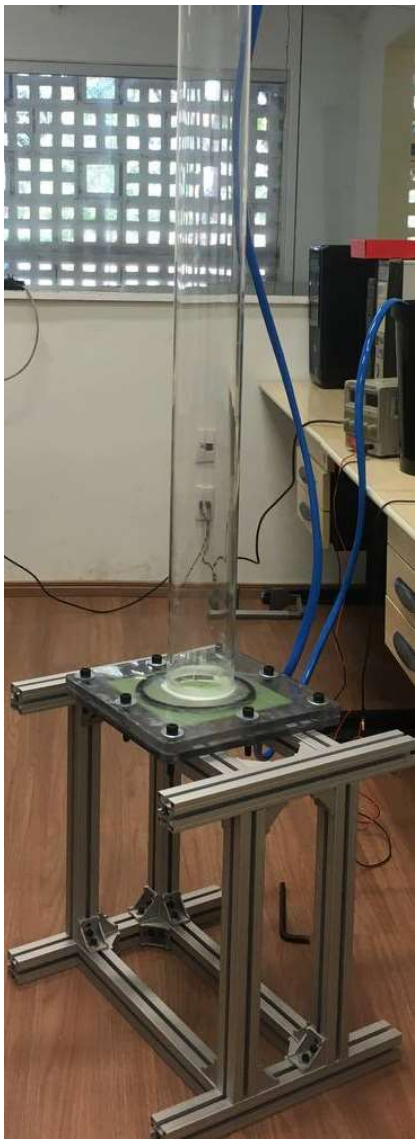


Fig. 5. Leakage test fixture.

Part (b): Material characterization of polymeric material at low temperature (-30 C), room temperature, and high temperature (50 C).

This part of the project had been completed and reports were sent to the Braskem company.

Part (c): Helmet safety study

This study is going to assess the impact safety performance of commercial motorcycle helmets in the Brazilian market, by considering the current standard experimental procedures and numerical study. The Finite Element numerical framework will be validated against different sets of experimental test results. The main test rig was designed (Fig. 6) and used for a previous helmet study at the GMSIE laboratory.

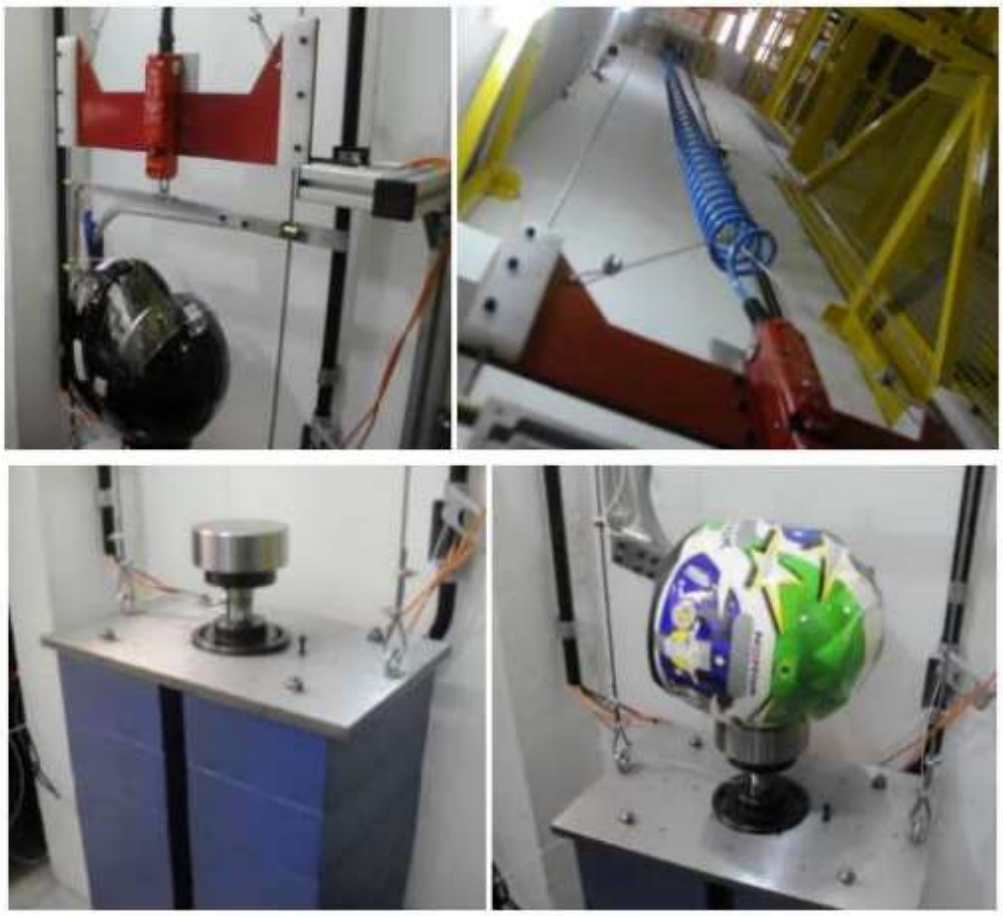


Fig. 6. Helmet test rig at GMSIE laboratory.

The main objective of this part of the study is to investigate the impact behavior of motorcycle helmets in the Brazilian market. Several new experimental tests will be done in the

present study (part C) considering rotational head form and brian during the impact that is reported to be responsible for brain injury during an accident. Besides, numerical finite elements and 3D modeling of helmets will be conducted here. The three-dimensional model will consist of a headform, brain, helmet exterior shell, and protective foam of the helmets.

Some detailed objectives of the present study are listed below.

1. Developing 3D scanning of helmet (photo metrology)
2. Developing finite element model of helmets and simulating impact scenarios.
3. Minor modification of the present helmet test rig (at GMSIE laboratory).

Part (d): Friction test at high velocity

Activities plan and timetable

The research duration is divided into three periods (four months), P1, P2, and P3 as listed in the following timetable.

Table 2. Timetable for one year.

<table>
<tr><th></th><th colspan="2">P1</th><th colspan="2">P2</th><th colspan="2">P3</th></tr>
<tr><td>Ballistic impact study (Embraer)</td><td colspan="2"></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Material characterization of polymeric railway sleeper (Braskem)</td><td colspan="6">Completed
A paper is submitted to Mechsol 2022
And a journal paper will be submitted</td></tr>
<tr><td>Helmet safety study</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Publications</td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td></tr>
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