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Experimental investigation on the water impact behavior of composite structures

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Abstract

Within the context of the SMAES European research project funded under the seventh framework programme, an experimental test campaign consisting on drop tests on water was carried out on semi-cylindrical composite structures and it is presented in this work. The main objectives of such test campaign were to improve the knowledge about the water impact behavior of composite structures and to build an experimental database to support the validation of reliable simulation tools to be used during the design and certification process of aircrafts.

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Keywords: water impact; composite materials; ditching.

1. Introduction

Impact on water is an event which can be encountered by all aircrafts since many flights happen partly overseas and many airports are located very close to the sea. As shown by the Civil Aviation Authority (CAA) accident investigation report [1], a not negligible percentage of accidents involving helicopters occur on water. With the developments of seaplanes in the early 1930s, the first significant research programs focused on the impact on water started. A 2D analytical estimation of the load acting on a body impacting on water was made in [2]. Such basic analytical work is still the basis of the calculation tools used to estimate the impact force in the pre-development phase of structure susceptible to impact on water.

Nowadays, the certification authorities impose costly requirements to assure a high safety standard for the different aircrafts operating over sea. Ditching analysis is requested for large transport aircraft by airworthiness authorities, e.g. EASA or FAA. The respective requirements are specified under “CS 25.801 Ditching”. They can be briefly summarized as in the following: the aircraft should be able to land on water as safely as possible to float long

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enough in order to enable the passengers to evacuate. Moreover, the increasing use of composite materials in aerospace applications makes the certification process even more complex, since developing a reliable methodology for fully predicting the performance of composite structures taking into account the several damage mechanisms is a big challenge. Ditching analysis tends to use numerical methods due to manifold reasons [3]. These numerical tools need development and continuous enhancement to cope with the computationally challenges of the problem: highly localized pressure distributions, air cushioning, fluid-structure interaction and hydroelastic coupling, cavitation and ventilation. Research works which testify the relevance of the topic can be found in [4-6].

Within the context of the SMAES European research project funded under the seventh framework programme, an experimental test campaign consisting on drop tests on water was carried out on semi-cylindrical composite structures and it is presented in this work. The main objectives of such test campaign were to improve the knowledge of the water impact behavior of composite structures and to build an experimental database to support the validation of reliable simulation tools to be used during the design and certification process of aircrafts.

The test facility, the test article shape, the impact conditions and the instrumentations were chosen similar to those used for a similar test campaign performed in 2008 on metallic (aluminum and steel) structures [7]. In particular, the test campaign was performed by using the drop tower test facility of the Italian Aerospace Research Centre (CIRA). In order to obtain a complete characterization of the impact event on water, the test articles were instrumented with accelerometers, pressure transducers and strain gages, moreover, high speed cameras were used to record the tests.

2. Drop test campaign

Eight vertical impact tests on water, with different impact velocity and on two different layup configurations, were performed on semi-cylindrical composite structures. In the next sub-sections the test facility, the test articles and the test matrix will be described.

2.1. Test facility

The drop test tower available at CIRA was used for the investigation described in this paper. This facility of the Laboratory for Impact Tests on Aerospace Structures (LISA) consists in an 11.5 m high tower, which is able to guide the descent of a trolley to which the test article is attached. The tower is installed in a corner of the LISA's pool for water impact test. It is able to perform tests with structures up to 2 tons as weight with a maximum impact velocity of 14 m/s. The required impact velocity V_i is obtained by the free fall of the test article. Given the desired velocity, the drop height (h) from the water surface, in absence of any energy loss, would be:

$$h = \frac{V_i^2}{2g} \tag{1}$$

Fig.1 shows a typical test rig with the test article guided by the trolley at the time of contact with water. Such

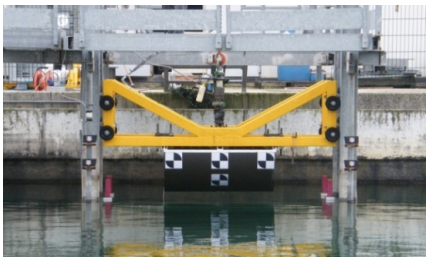

Fig. 1. Typical test rig