Conception of Modular Test Stand for Fatigue Testing of Aeronautical Structures

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Fatigue tests of specimens and components are necessary part of an aircraft development as well as an introduction of new improvements and solutions into aircraft structures. Despite the enormous development of methods of analysis, experimental testing remains the primary method of proving fatigue strength [1]. This is caused by the risk of a crash in the case of failure, as well as a limited ability to properly identify fatigue behaviour through analysis [2]. At the same time fatigue tests are definitely more expensive then static since they are more complicated and last longer. The majority of fatigue tests are conducted on testing machines with simple specimens, usually with loads restricted to tension. Introduction of a more complex state of loads (compression, torsion and bending) requires preparation of a more complicated specimen (e.g. sub-component) and a dedicated testing stand. High cost is a problem especially in the case of low cost projects or students researches, where industry is not involved.

The Modular Test Stand (MTD) was proposed by the authors to decrease cost of fatigue tests and enable simple specimens to be tested in more complex load states. The conception assume that during a one experiment, several specimens are tested and it is possible to test a simple specimen which is mounted in a more complex structure. The MTD consist of three identical sections, which are connected in such a way that each section is loaded in the same manner, as well as of fixing and loading system. The section is a structure similar to airframe, namely wing box, and consist of two spars, ribs and flat skins. The whole section, a structural node, particular joint or a skin can be an object of testing. The one section has a dimension of 600 x 600 x 150 mm. Each of the section can by quite easily disconnected and exchanged. It is also possible to use one or two sections only. Figure 1 presents the model of three sections (wing box) connected with fixings.

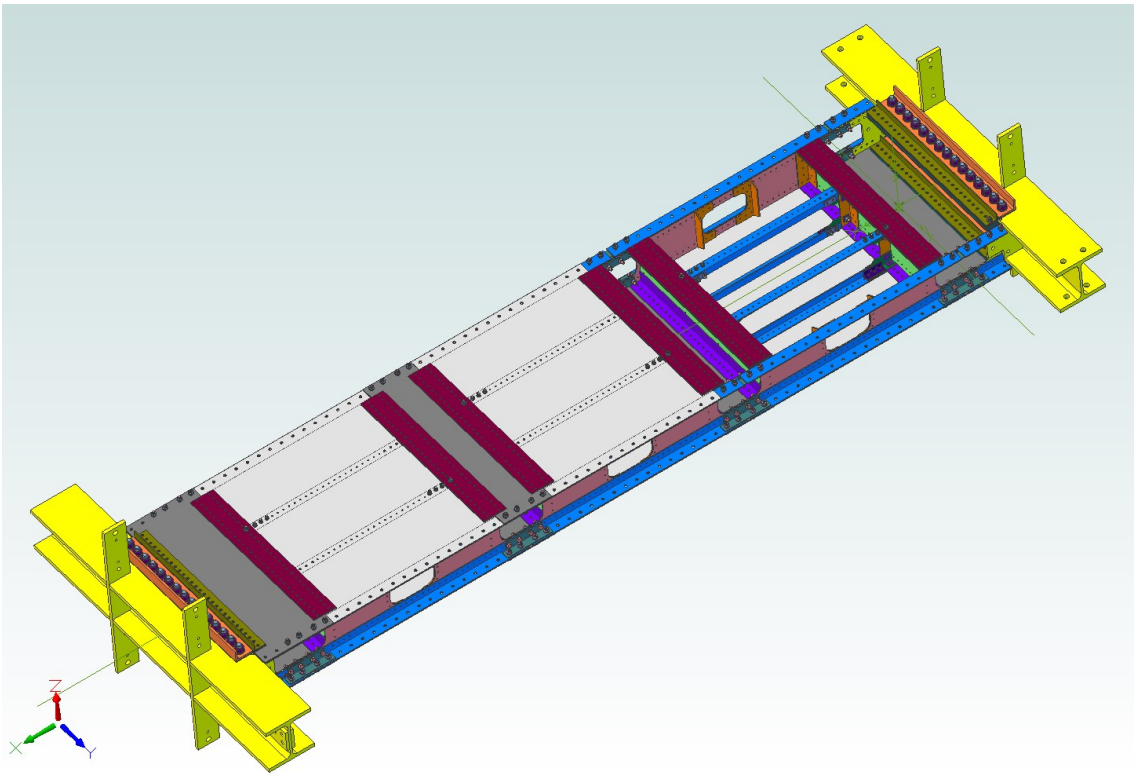

Figure 1. Three sections with fixing

The stand enable to load sections with a bending or twisting moment (not simultaneously). One end is fixed and the second is loaded with a moment induced by two hydraulic actuators. The moment is constant along the wingspan. The wing box and the actuators generating bending are vertical. This configuration facilitates

access to the specimen (e.g. during inspections) and eliminates necessity of balancing vertical actuators. Configuration of the stand is presented in Fig. 2.

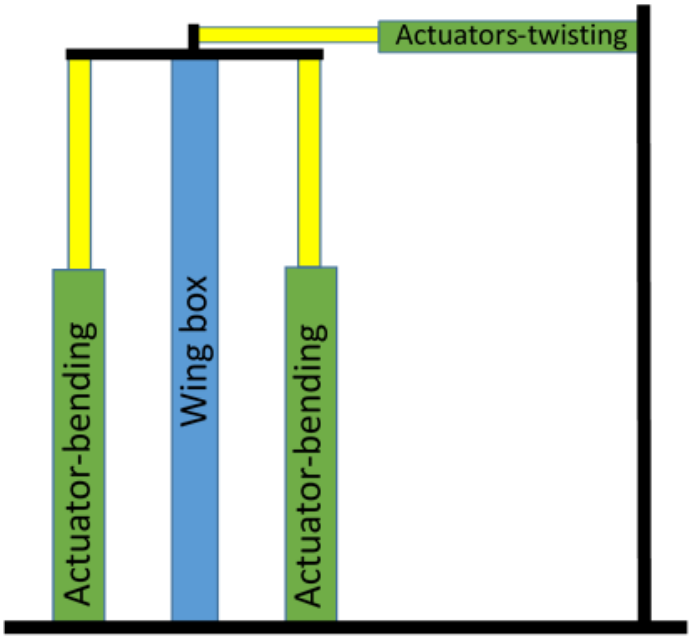

Figure 2. Configuration of Stand

The proposed stand can be used to determine fatigue behaviour of whole sections (e.g. made in various technology), design of selected structural nodes, joining methods (e.g. riveting, bonding, Friction Stir Welding, etc.) or materials (metal, composite, FML). The MTD can be used also for fatigue tests of structures with damages or repairs (e.g. composite patch repairs) as well as with various types of sensors (e.g. used for Structural Health Monitoring). The advantages is a lower cost and a more complex load state compared to simple specimens.

The modular Test Stand has been design with the use of FE analyses in order to obtained quite uniform stress distribution in the tensioned skin under bending, with the assumed level of 120 MPa. Additional limitations were the force and displacement ranges of the selected actuators (25 kN/500 mm). After manufacturing and installation, the stand was statically loaded with a bending moment. The obtained displacements and strain distribution were verified with the use of full-field measurement method (Digital Image Correlation) and strain gauges [3].

References:

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