Handout

Stability of thin-walled composite structures

Fig.1: DLR Buckling Test Facility

Fig.2: Panel under axial compression load (Photo overlay with DIC image from test)

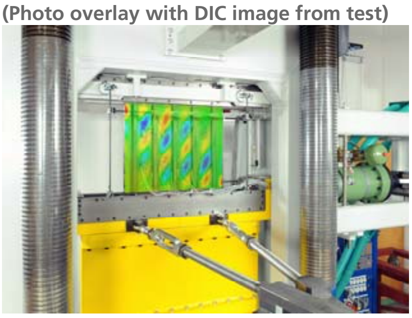

Fig.3: Panel under shear load (Photo overlay with DIC image from test)

Parameter	Value
max. panel radius (extended)	2300 mm (3000mm)
min. panel radius	1550 mm
max. panel length	1400 mm
max. panel width	1200 mm
max. axial force, current	380 kN
max. axial force, extended	1 MN
max. shear force, current	210 kN
max. shear force, extended	500 kN
max. shear stroke	100mm
max. axial stroke	40mm

Tab.1: Parameters of the shear-compression test rig

Thin walled structures that are typically used in lightweight aeronautical and space applications are prone to buckling under in-plane loading. However, stiffened structures are able to carry load beyond the critical buckling load (in most cases skin buckling as shown in Fig. 2 and Fig. 3). Thus, it is crucial for the exploitation of the whole load carrying capacity of those structures, to take the post buckling regime into account. For this purpose, the behaviour of this kind of structure has to be understood in detail up to collapse including different kinds of degradation. Once this is done, analysis tools taking into account these geometric and physical nonlinear effects can be developed and finally validated with appropriate test results. In doing so, the structural behaviour of various configurations can be simulated and the number of expensive and elaborate structural tests can be reduced in the future. This effort also contributes to the objective to establish a design scenario in which local skin buckling is permitted clearly below limit load leading to a weight reduction in primary aircraft structures. In case of metallic fuselage structures, the design approach is already advanced in that sense. However, the characteristic of composite ones is still subject to investigation also in regard to the failure mechanism in the post buckling area.

Most of the recent research work in the field of experimental stability research at DLR was focused on axial compression of stiffened curved panels and cylindrical shells with remarkable results.

Since shear is also one of the dominant load cases, e.g. for fuselage structures, a new test rig (Fig.1) was developed at DLR to extend the current capabilities of the buckling test facility also to in-plane shear and as well as to combined axial compression and shear loading of stiffened curved panels. The main parameters of this test rig are given in Tab.1.

Panels with omega, J- or T-stringers made of carbon fibre-reinforced plastic (CFRP) are used to investigate the stability behaviour (buckling and post-buckling). The panels are considered as representative structural parts of the fuselage, wing or empennage. During the test, the load displacement data, strains as well as DIC images are recorded. An example for a DIC image showing the out of plane deformation in the deep post buckling regime of an omega stringer stiffened panel under axial compression and shear loading is depicted in Fig. 2 and Fig. 3, respectively.

Additional to static collapse tests, cyclic loading can also be applied to study the initiation and progression of damage in the structure. For this purpose measurement systems such as thermography can be utilized to monitor for instance delamination or separation in the skin stringer connection. Moreover, the effect of a pre-damage like an impact on the load bearing capacity is investigated.

In the close future new design concepts such as grid-stiffened panels will be investigated to assess their load bearing characteristic and potential area of improvement.

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