ELASTO-PLASTIC STRESS ANALYSIS OF A HIGH STRESS REGION OF SARAS AIRCRAFT WING

Dr. S. Sridhara Murthy [1] and R. Narayana [2]
Structures Division, National Aerospace Laboratories
Bangalore 560017, India

Abstract

This paper addresses the problem of high local stress observed during the SARAS structural wing test under Design Limit Load (DLL) at a stress concentration point in the Main Landing Gear (MLG) cutout of SARAS transport aircraft wing. The description of the problem is followed by the stress analysis results from a local two-dimensional finite element stress analysis. The two-dimensional model deployed was a fused model, where the parts of the wing which are riveted together are modelled through a single finite element by specifying their combined thickness. The latter analysis predicts a maximum von Mises stress and strain of 31 kg/mm^2 and 3062 με respectively (Material: 2024-T351 alloy; Yield strain: 4500 με). During the structural test, however, a strain gauge near the same location recorded a recoverable elastic strain of 8753 με under loading, unloading and re-loading up to DLL. This was much higher than the material yield strain and thus points to the local plastic yielding. The problem was addressed by taking recourse to a local three-dimensional elasto-plastic stress analysis by deploying HEXA8 solid elements of MSC/NASTRAN. The bi-linear material model, von Mises yield criterion and isotropic hardening were deployed in the E-P simulation. The analysis results are presented as load vs. strain and load vs. stress and growth of plastic zones near high stress point up to DUL (1.5 times DLL) with unloading and reloading at DLL. These results show that the local von Mises strain at DLL is 14060 με, with 9818 με as the plastic component. The recoverable elastic strain upon unloading at DLL is 8243 με which is close to the test value of 8753 με.

[1] Scientist F & Head, Stress Analysis and Design Group
[2] Scientist, presently on deputation for graduate studies at IISc

The E-P analysis results at DUL show a von Mises stress of 40.55 kg/mm^2, and a corresponding strain of 32765 με with a plastic component of 28016 με. These values are to be compared against the ultimate allowable values of 43.5 kg/mm^2 and 4% (40,000 με) plastic strain at ultimate stress. At 1.8 times DLL the corresponding values are 43.07 kg/mm^2 and 43421 με with a plastic component of 38379 με.

Thus, it is concluded that the high-stress region of the wing yields locally under DLL, but notwithstanding the same, is safe up to DUL and even beyond up to 1.8 times DLL. These high values of stress and strain are local peaks with local plastic yielding, and rapidly fall within a short distance. The plastic zones are also highly localized, and are not affecting the gross strain distribution in the wing.

Dr. S. Sridhara Murthy graduated in BE Civil Engineering from Bangalore University in year 1973. He obtained his M.E. in Aeronautical Engineering from IISc, Bangalore in 1975 and PhD in engineering mechanics from University of Arizona, USA in 1983.
Since, 1976, he is working at National Aerospace Laboratories, Bangalore as Scientist in Structures Division and presently he is heading the Stress Analysis and Design Group in Structures Division and also heads the Computer Network Services Unit. He is also Deputy Project Director for SARAS aircraft development project. Dr. Murthy's areas of interest are finite elements for composite shells, expert systems, stress analysis, computational vibro-acoustics, He has more than 50 publications to his credit and has been awarded the Government of India National Scholarship award to study abroad in 1980 and NAL Outstanding performance award for project execution three times. He is also fellow of Aeronautical Society of India and elected member of Tau-Beta-Phi, The Engineering Honour Society of America.

Shri R Narayana obtained his BE in Mechanical Engineering from Bangalore University in the year 1999. He joined the Structures division of NAL in the year 2001 and has worked on dynamic analysis of Saras aircraft using component mode synthesis approach, development of software tools for the design of Structural ceramics subjected to thermo mechanical loads, finite element analysis of Radio controlled Blimp and mathematical modeling of grain separation. Shri R Narayana's areas of interest are Structural analysis and design of aerospace structural components and vibro acoustics. He is presently doing his Masters degree in Aerospace Engineering at IISc, Bangalore.