Research on the aircraft structures and advanced composite materials

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Abstract

Application of the composite materials will contribute to improving the performance of aircraft and spacecraft components. JAXA conducts researches for overcoming weaknesses of current composite materials, clarifying unknown aspects such as fracture mechanisms, improving performance and enabling application to design technology.

Ref. URL: http://www.aero.jaxa.jp/eng/research/basic/structure-composite/

Reasons for using JSS2

We performed damage simulation of CFRP under impact loading in order to assess the design safety of CFRP structure. For precise simulation, each CFRP lamina must be modeled separately, and huge number of DoFs are needed. Application of the supercomputer system makes such high-computational-cost calculation possible.

Achievements of the Year

Precision of the low-velocity impact damage simulation for the CFRP laminate was improved by using multiscale calculatiuon method. Low-velocity impact tests were performed based on the ASTM D7136 standard, and damage was measured by non-destructive inspection (NDI). Simulation was performed using ABAQUS/Explicit 2016 on JSS2 system. Each ply of the CFRP laminate was modeled by one continuum shell element in the thickness direction. ECDM model was implemented using usersubroutine of ABAQUS.

In the macroscopic model (Fig. 1), the CFRP laminate was modeled by one continuum shell element in the thickness direction. The damage was simulated by using ECDM model, which was developed in JAXA in the last year. Microscopic model consists of solid elements and cohesive elemtns (Figs. 2, 3). Macroscopic strain which was calculated in the macroscopic model was applied to the microscopic model, and microscopic damage can be predicted. Figure 4 compares the simulated damage and the damage mesasured by the micro-focus X-ray CT.

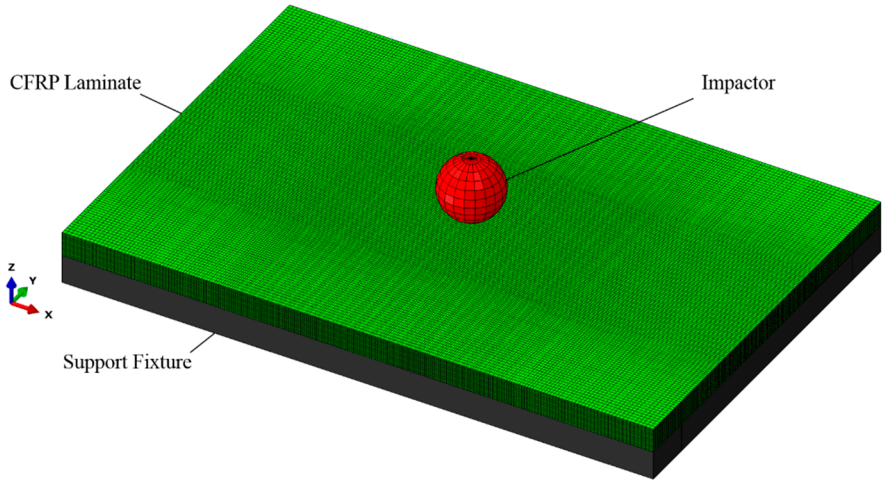

Fig. 1: Model overview of the low-velocity impact simulation (Macroscopic model)

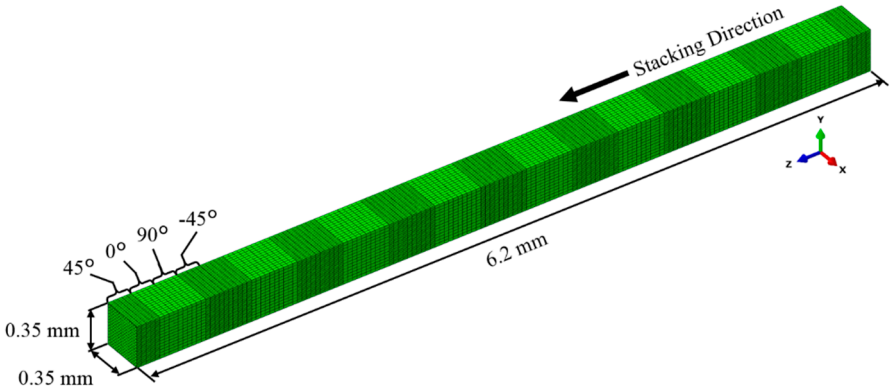

Fig. 2: Model overview of the low-velocity impact simulation (Microscopic model)

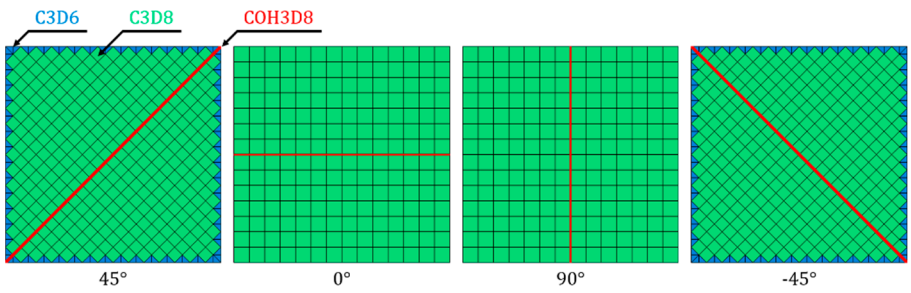

Fig. 3: Cohesive elements embedded in the microscopic model

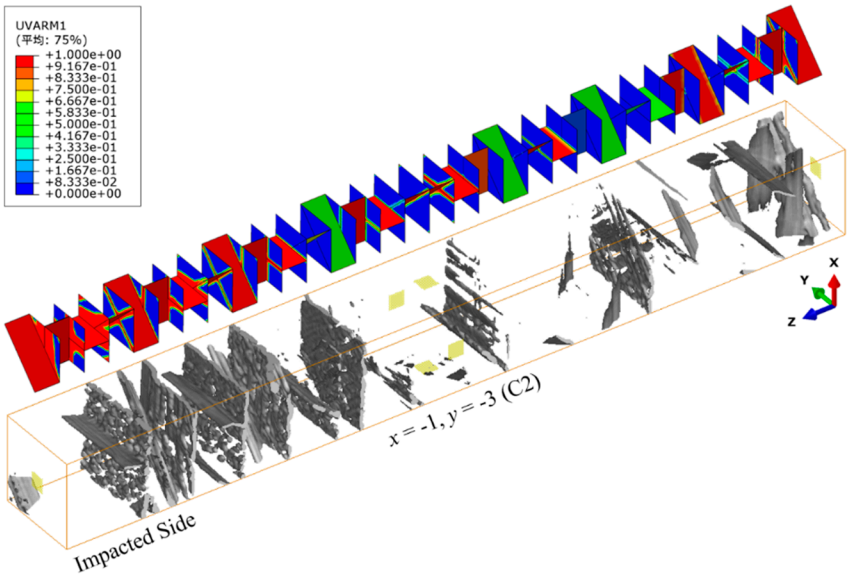

Fig. 4: Comparison between simulated damage and damage measured by the micros-focus X-ray CT

Publications

- Peer-reviewed papers

Masaya Ebina, Akinori Yoshimura, Kenichi Sakaue, Anthony M. Waas. “High fidelity simulation of low velocity impact behavior of CFRP laminate”, Composites Part A, 113, 166-179, 2018

- Oral Presentations

Masaya Ebina, Akinori Yoshimura, Kenichi Sakaue, Yuichiro Aoki, ‘Low Velocity Impact Simulation of CFRP Laminates Considering Microscopic Damage Interaction’, 33rd American Society for Composites Technical Conference, Sep. 2018, Seattle, WA, USA

Usage of JSS2

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	1 - 120
Elapsed Time per Case	20 Hour (s)

Resources Used

Fraction of Usage in Total Resources[*1] (%): 0.20

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage*2 (%)
SORA-MA	0.00	0.00
SORA-PP	282,092.60	2.25
SORA-LM	0.00	0.00
SORA-TPP	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage*2 (%)
/home	36.56	0.04
/data	49,193.72	0.87
/ltmp	7,486.98	0.64

Archiver Resources		
Archiver Name	Storage Used (TiB)	Fraction of Usage*2 (%)
J-SPACE	0.00	0.00

*1: Fraction of Usage in Total Resources: Weighted average of three resource types (Computing, File System, and Archiver).

*2: Fraction of Usage: Percentage of usage relative to each resource used in one year.