Analytical study on stress concentration due to gap in AFP-manufactured laminates

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Abstract

The aim of this study is to clarify the effect of manufacturing defects, such as gaps and overlaps, on the strength of CFRP laminates fabricated by automated fiber placement.

Reasons and benefits of using JAXA Supercomputer System

In order to properly evaluate manufacturing defects in CFRP laminates, precise finite element modeling is required. Also, geometric nonlinearity caused by local large deformation due to local stress concentration needs to be considered. Therefore, it takes long time to obtain analytical results. Parallel calculation of JAXA supercomputer system enables to reduce the total computation time.

Achievements of the Year

A two-dimensional mechanical model of the quasi-isotropic laminates with an arbitrary inclined gap is proposed and analytically solved using a super-position technique as the sum of a global uniform stress field with a virtual force at both ends of the gap and a local stress field caused by the virtual force. The local problem is approximately solved using a Green function technique. The stress field under a unidirectional load are obtained in a closed-form expression in which the effect of the tapered portions typically observed at both sides of the gap is incorporated. The present solution agreeing with the finite element solution shows that significant stress concentration occurs at the end portion of the gap.

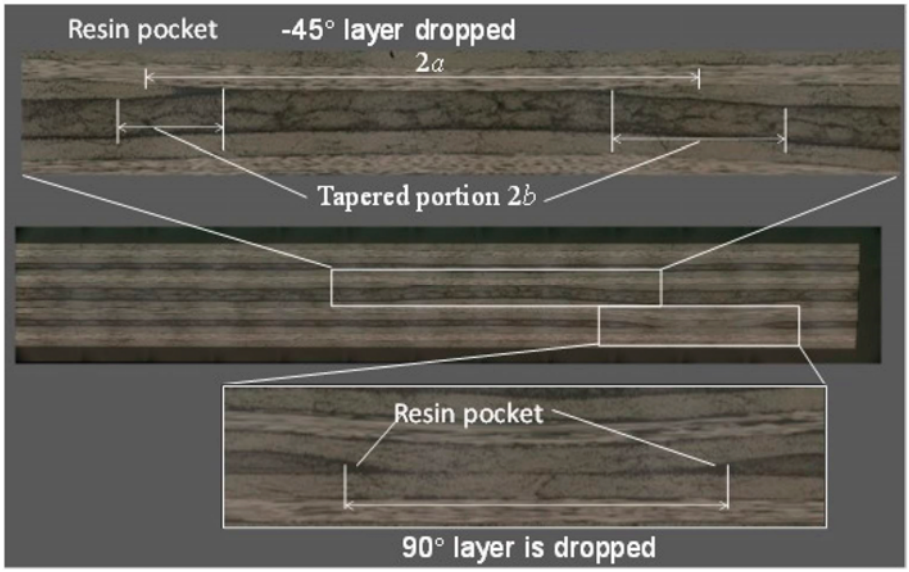

Fig. 1: Cross-sectional observation of a CFRP laminate with gaps

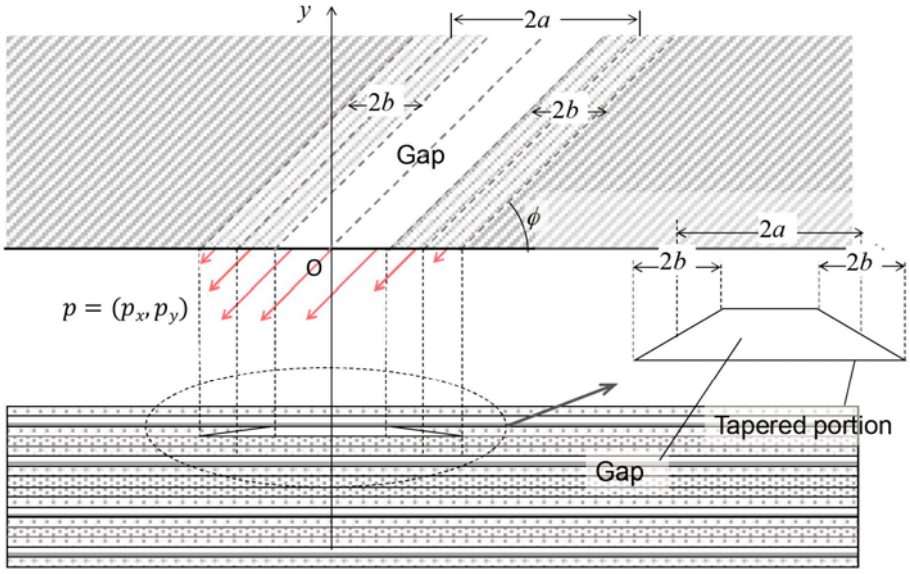

Fig. 2: Overview of the analytical model of the gapped area

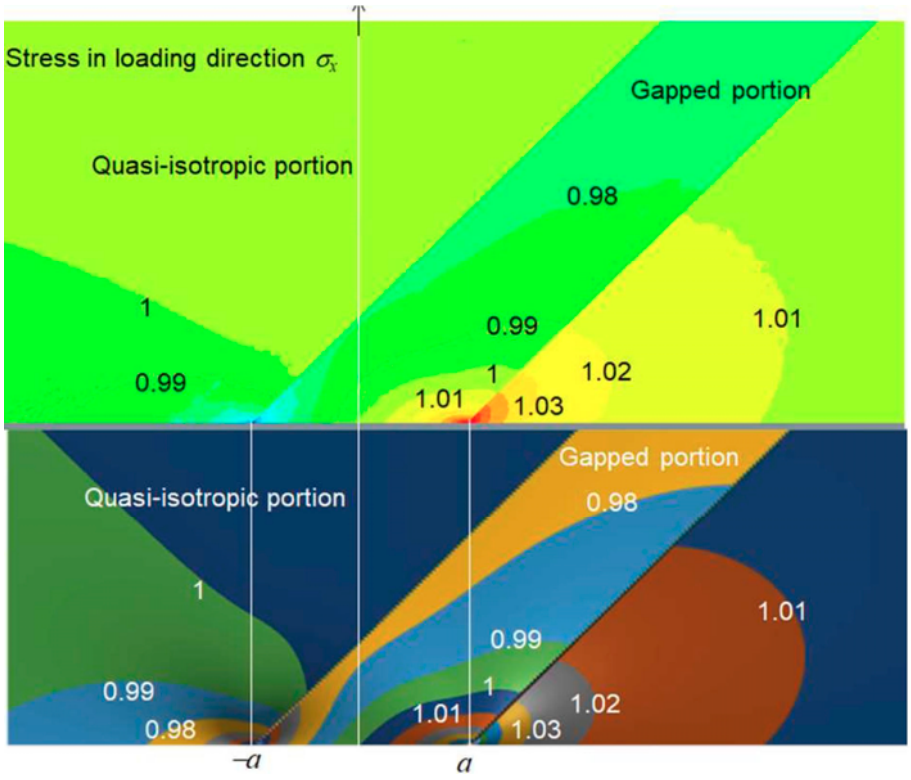

Fig. 3: Comparison of stresses near the side edge: finite element method result (A) and present theoritical result (B)

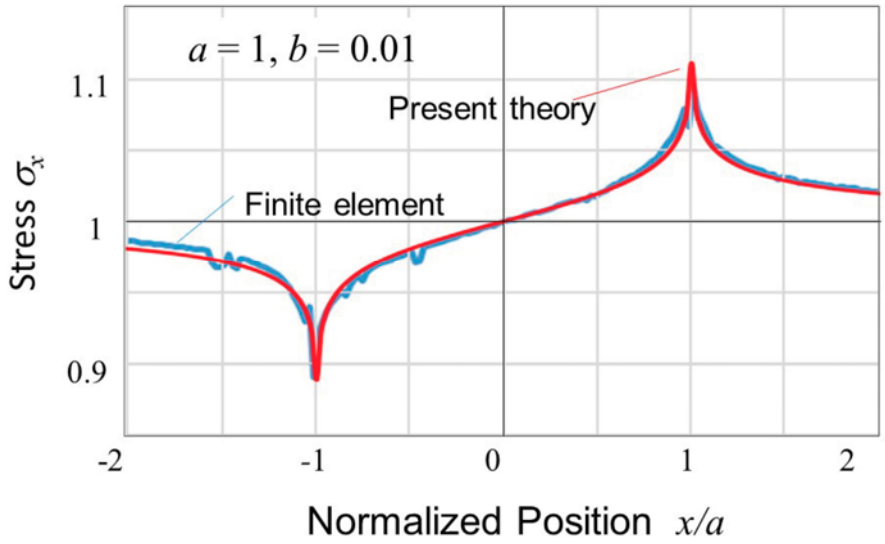

Fig. 4: Stress field along the side edge

Publications

N/A

Usage of JSS

Computational Information

Process Parallelization Methods	MPI
Thread Parallelization Methods	Automatic Parallelization
Number of Processes	2 - 228
Elapsed Time per Case	10 Hour(s)

Resources Used(JSS2)

Fraction of Usage in Total Resources[*1](%): 0.04

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
SORA-MA	33.10	0.00
SORA-PP	12,986.00	0.10
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	23.84	0.02
/data	49,066.57	0.95
/ltmp	4,882.81	0.42

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.

- **Resources Used(JSS3)**

Fraction of Usage in Total Resources[*1](%): 0.03

Details

Computational Resources		
System Name	Amount of Core Time (core x hours)	Fraction of Usage[*2](%)
TOKI-SORA	0.00	0.00
TOKI-RURI	0.00	0.00
TOKI-TRURI	0.00	0.00

File System Resources		
File System Name	Storage Assigned (GiB)	Fraction of Usage[*2](%)
/home	14.31	0.01
/data	48,971.20	0.82
/ssd	143.05	0.07

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.