General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

FRACTURE MECHANICS IN FIBER REINFORCED COMPOSITE MATERIALS, TAKING AS EXAMPLES B/Al AND CFRP

P. W. M. Peters

Translation of "Bruchmechanik an Faserverbundwerk-
stoffen am Beispiel von B/Al und CFK", In: Deutsche
Forschungs- Und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne
(West Germany), Colloquim on Composite Materials -- Conference,
Cologne, 3 December 1980, 2 pp.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546   NOVEMBER 1982

STANDARD TITLE PAGE

1. Report No. NASA TM-76988	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle FRACTURE MECHANICS IN FIBER REINFORCED COMPOSITE MATERIALS, TAKING AS EXAMPLE B/Al AND CFRP		5. Report Date November 1982
		6. Performing Organization Code
7. Author(s) P. W. M. Peters		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address SCITRAN Box 5456 Santa Barbara, CA 93108		11. Contract or Grant No. NASw 3542
		12. Type of Report and Period Covered Translation
12. Sponsoring Agency Name and Address National Aeronautics and Space Administration Washington, D.C. 20546		
		14. Sponsoring Agency Code

15. Supplementary Notes

Translation of "Bruchmechanik an Faserverbundwerkstoffen am Beispiel von B/Al und CFK". In: Deutsche Forschungs- Und Versuchsanstalt fuer Luft- und Raumfahrt, Cologne (West Germany), Colloquim on Composite Materials -- Conference, Cologne, 3 December 1980, 2 pp.   (N82-14290)

16. Abstract   The validity of linear elastic fracture mechanics and other fracture criteria was investigated with laminates of boron fiber reinforced aluminum (R/Al) and of carbon fiber reinforced epoxide (CFRP) Cracks are assessed by fracture strength Kc or Kmax (critical or maximum value of the stress intensity factor). The Whitney and Nuismer point stress criterium and average stress criterium often show that Kmax of fiber composite materials increases with increasing crack length; however, for R/Al and CFRP the curve showing fracture strength as a function of crack length is only applicable in a small domain. For R/Al, the reason is clearly the extension of the plastic zone (or the damage zone in the case of CFRP) which cannot be described with a stress intensity factor.

17. Key Words (Selected by Author(s))	18. Distribution Statement
	Unlimited - Unclassified

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 5	22. Price

FRACTURE MECHANICS IN FIBER REINFORCED COMPOSITE MATERIALS TAKING AS EXAMPLES R/AI AND CFRP

P. W. M. Peters

The use of composite fiber materials is only being accepted gradually. One of the reasons for this is insufficient knowledge about the mechanical behavior. This is also true for fracture mechanics which is supposed to describe the effect of cracks in fiber composite materials. The problem is complex because depending on the design and the load, different kinds of damage can occur. Up to the present time, at the Institute for Materials Research of the DFVLR, primarily the effects of holes and cracks have been investigated which can develop between connection holes. Failure criteria is sample fracture and not crack propagation among individual layers.

The validity of the linear-elastic fracture mechanics laws (LEBM) another fracture criteria has been investigated in laminates of boron fiber reinforced aluminum (B/Al) and carbon fiber reinforced epoxy (CFK). In the LEBM, a crack is evaluated using the stress intensity factor K which reaches a critical value K_c or K_{max} upon sample fracture.

Using the crack resistance K_c or K_{max}, the cracks which occur in components can be evaluated and one can then determine whether they are permissible or not. In the case of fiber composite materials in the form of thin sheets, often it has been established that the crack resistance K_{max} increases with increasing crack length (Figure 1, [1-4]).

This is not only specific for fiber composite materials but also occurs in conventional materials. The increase in the crack resistance can be explained in conventional materials using the R curve concept, but not for CFK [3]. In 1974, Whitney and Nuismer [1] introduced the point stress criterion and the average stress criterion (P.S.K, M.S.K), which in the meantime has been accepted widely

1

because the increasing crack resistance can be described with constant material parameters (d_o for the P.S.K, a_o for the M.S.K). Figure 1, however, shows that using the material parameter a_o, the crack resistance can only be covered over a small range. The reason in the case of B/Al apparently is the expansion of the plastic zone (or the damage zone in the case of CFK) which does not have to be described using a stress intensity factor [4].

REFERENCES:

[1] J. M. Whitney, R. J. Nuismer. J. Composite Materials, Vol. 8, July 1974, pp 253-269.

[2] J. Awerbuch, H. T. Hahn. J. Composite Materials, Vol. 13, April 1979, pp 82-107.

[3] S. Ochiai, P. W. M. Peters. will be published in J. Mat. Science.
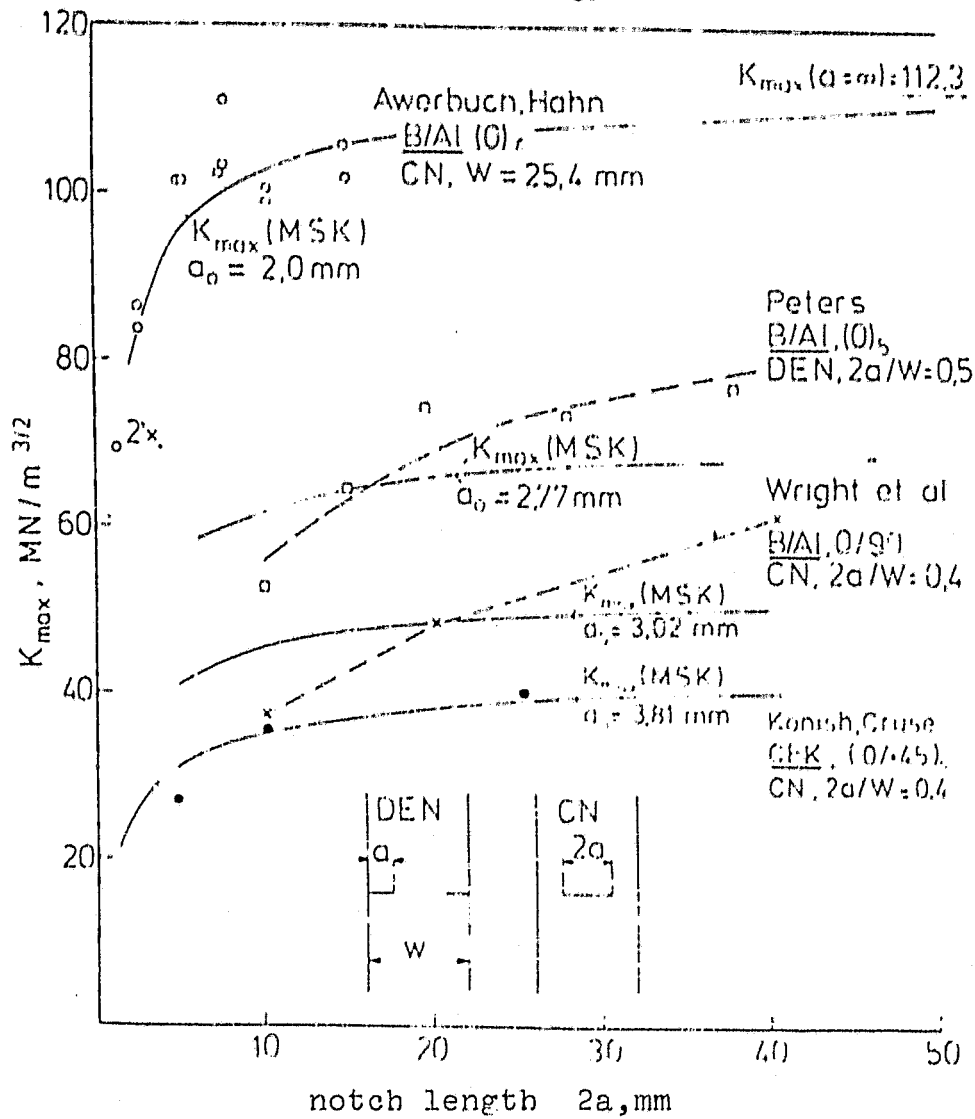
[4] P. W. M. Peters. submitted dissertation.

Figure 1. The dependence of crack resistance K_{max} on crack length for several B/Al and CFK laminates.

3