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REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER: ARO 21817.23-EG	2. GOVT ACCESSION NO.: N/A	3. RECIPIENT'S CATALOG NUMBER: N/A
4. TITLE (and Subtitle): Sliding and Debonding Inclusions		5. TYPE OF REPORT & PERIOD COVERED: Final Report June 15, 1985 - June 30, 1988
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): T. Mura		8. CONTRACT OR GRANT NUMBER(s): DAAG29-85-K-0134
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of Civil Engineering, Northwestern University, Evanston, IL 60208		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: N/A
11. CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Research Office, Post Office Box 12211, Research Triangle Park, NC 27709		12. REPORT DATE: August 15, 1988
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report): Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

NA

18. SUPPLEMENTARY NOTES

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

sliding inclusions, composite materials, DeBonding, inclusions, shear stress, Linear Theory.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Research results performed during this research contract are summarized in the following pages.

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ARO 21817.23-EG

SLIDING AND DEBONDING INCLUSIONS

Final Report

T. Mura

August 15, 1988

U.S. Army Research Office

Grant Number DAAG29-85-K-0134

Department of Civil Engineering
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List of Publications Published under ARO Sponsorship during this period

1. R.R. Castles and T. Mura, The analysis of eigenstrains outside of an ellipsoidal inclusion, Journal of Elasticity, 15 (1985) 27-34.

2. T. Mura, General Theory of Inclusions, In Fundamentals of Deformation and Fracture, Eshelby Memorial Symposium, ed. by B.A. Bilby, K.J. Miller and J.R. Willis, Cambridge University Press, Cambridge (1985) 75-89.

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31. T. Mura, Micromechanics of Defects in Solids, second, revised edition, Martinus Nijhoff Publ., The Hague (1987).

Scientific Personnel Supported by this project:

I. Jasiuk (Ph.d. earned), D. Kouris (Ph.D. earned) Dr. E. Tsuchida, Dr. K. Saito, Dr. S.J. Chang, Z. Gao (Ph.D. earned), Dr. Y. Hirose, Dr. E. Tsuchida, Dr. N. Yamashita, Dr. R. Furuhashi, Dr. H. Sekine, K. King, A. Safadi, W. Yeih

Statements of Problems and Summary of Results:

It was found by Mura and Furuhashi, [J. App. Mech. 51 (1984) 308-310], when an ellipsoidal inclusion undergoes a uniform shear eigenstrain in the principal axis directions and the inclusion is free to slip along the interface, the stress field vanishes everywhere in the inclusion and the matrix. This finding is the main result of the ARO research grant DAAG29-81-K-0090.

The main objective of the present grant DAAG29-85-K-0134 is to give more theoretical investigation on this amazing finding and to find applications to composite materials.

This anomaly of sliding inclusions is based upon the fact that an ellipsoid is transformed into an identical ellipsoid by the uniform shear in the principal axis directions of the ellipsoid in the framework of linear theory as demonstrated by Mura [2,4][1].

When the ellipsoidal inhomogeneity embedded in an infinite medium is subjected to an applied shear stress at infinity in the directions of the principal axes of the ellipsoid, the inhomogeneity behaves like a void if the interface can slide freely. When the ellipsoid is degenerated into a spheroidal, the shear eigenstrains introduce the stress field and the spheroidal inhomogeneity does not behave like a void. The elastic solution of circular inhomogeneity under shear can not be obtained as a limiting case of the elliptical inhomogeneity [14].

When the eigenstrains inside the ellipsoidal inclusin are not of the shear type, non-zero stress fields are introduced. The associated solutions are completely different from Eshelby' solution. By using the Papkovich-Neuber potentials, we obtained various solutions corresponding to the type of applied loads and of non-shear eigenstrains [8,11,23].

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1. The reference numbers in the List of Publications Published under ARO Sponsorship during the grant period.

These solutions are applied to investigate mechanical behavior of composite materials when constituents can slide [5,15,21,22,25,26].

Along the research of sliding inclusions, the perfectly bonded inclusions were also investigated for non-uniform eigenstrains [1,12,19]. These results are further extentions of Eshelby's inclusions.

Another research was conducted to investigate fracture and fatigue of alloys. The interest of the research is to evalute the interaction between the dislocation pile-up and imperities (particles) [6,7,10.13,18,20]. More microscopic approach was employed by solving Schrödinger's equation in quantum mechanics to evaluate the eigenstrain (misfit strain) caused by a hydrogen atom in the iron lattice [20,27,29]. Series of experiments for the crack initiation time due to the stress corrosion and the corrosion fatigue were perfomred and compared with the theory of dislocation pile-up model [6,10]. The reasoning of the detached crack initiation at notch roots and the depending of the notch radii were explained with satisfaction when the result of quantum mechanics is used.

Finally, literature research was performed concerning publications on sliding and debonding inclusions. The work is summarized in [24,31].