PERGAMON

International Journal of Solids and Structures 39 (2002) 5375–5378

INTERNATIONAL JOURNAL OF SOLIDS and STRUCTURES

www.elsevier.com/locate/ijsolstr

Preface

Jan D. Achenbach

This special issue of the International Journal of Solids and Structures is being published to honor Professor Jan D. Achenbach, the 2001 recipient of the Prager Medal, awarded by the Society of Engineering Science (SES) for "outstanding research contributions in either theoretical or experimental solid mechanics, or both". The issue consists of a selection of invited papers, most of which were presented at the Prager Medal Symposium honoring Professor Achenbach. This Symposium was held during the 40th Annual Meeting of the Society of Engineering Science which formed part of the Joint ASCE–ASME–SES Mechanics Conference at the University of California, San Diego, in June 2001, at which Professor Achenbach delivered the principal plenary lecture entitled "Modeling for Quantitative Non-Destructive Evaluation".

Jan D. Achenbach was born in the Netherlands, in a provincial town, Leeuwarden, where he also received his primary and secondary education. In 1953 he enrolled in what is now called the Technological University of Delft, to study aeronautical engineering. Just before the formal completion of his studies in Delft, he received a fellowship to study a year in the United States at Stanford University. After arrival at

PII: S0020-7683(02)00353-0

Stanford he decided to study for the Ph.D. degree in aeronautics and astronautics with a minor in applied mathematics, which he received in 1962. From 1962 to 1963 he was a post-doctoral fellow at Columbia University. Since 1963 he has been at Northwestern University, except for sabbatical leaves to the University of California (UCSD) and the Technological University of Delft. In March 1981 he was named to the Walter P. Murphy professorial chair at Northwestern University, in the departments of Civil Engineering and Mechanical Engineering. Subsequently, in 1992, he became Distinguished McCormick School Professor, which is a rare appointment of the highest possible distinction at Northwestern University. He was elected a Member of the National Academy of Engineering in 1982, at an unusually young age, subsequently a Member of the National Academy of Sciences in 1992, and then a Fellow of the American Academy of Arts and Sciences in 1994. In 1999 he was elected a Corresponding Member of the Royal Dutch Academy of Sciences. In 1985, Jan established at Northwestern University the Center for Quality Engineering and Failure Prevention, which has become under his directorship a state-of-art laboratory for quality control in structural mechanics, with profound impact on the aircraft industry, particularly the monitoring of aging aircraft.

Jan D. Achenbach has been a preeminent researcher in solid mechanics during the last three decades. He has made major contributions in the field of propagation of mechanical disturbances in solids. He has achieved important results in quantitative non-destructive evaluation of materials, damage mechanisms in composites, and vibrations of complex structures. He has developed methods for flaw detection and characterization by ultrasonic scattering methods. His work has been both analytical and experimental in nature. Early in his career, Jan Achenbach made important advances in dynamic fracture mechanics. He has also achieved valuable results on earthquake mechanisms, on the mechanical behavior of composite materials under dynamic loading conditions, and on the vibrations of solid propellant rockets.

Achenbach's doctoral dissertation at Stanford in 1962 dealt with waves and vibrations in viscoelastic solids, a problem of considerable interest for the dynamic response of solid propellants. He solved the three-dimensional problem by means of a viscoelastic correspondence principle for transient waves, and presented simplified solutions based on a novel viscoelastic constitutive model (Achenbach and Chao, 1962). During 1964–1975, Achenbach's work focused on dynamic behavior of composite materials. In the mid-sixties these inhomogeneous materials were represented by a homogeneous anisotropic material, via the "effective modulus" theory. This representation, however, was often unacceptable at higher frequencies. Achenbach developed a better model for laminated media and fiber-reinforced composites based on a generalized continuum theory, and formulated a method to calculate the material constants from the elastic constants of the constituents and geometrical parameters. His new theory properly represented dispersion of wave motion at high frequencies. He published numerous papers on this subject and eventually summarized them in an influential monograph (Achenbach, 1975) of lasting value.

During the period 1968–1980, Achenbach was one of the first investigators to advance the understanding of the dynamic effects on fracture caused either by high crack propagation speeds or by dynamic external excitation. He derived expressions for elastodynamic stress intensity factors and combined them with energy conditions for the propagation of a crack. His first paper on this subject (Achenbach, 1970) set a new direction, and many others developed his approach further—primarily L.B. Freund, one of his former students. He has also obtained important results on diffraction coefficients. Working with his post-doctoral assistant A.K. Gautesen and student H. McMacken, he generalized the geometrical theory of diffraction (GTD) to elastodynamics by solving two canonical problems, both concerned with the diffraction by a semi-infinite crack of a plane wave incident under an arbitrary angle with the edge of the crack (Achenbach, 1977;Achenbach, 1978). Along with applications to scattering by cracks of finite dimensions, he later consolidated this work in a book (Achenbach et al., 1982).

Achenbach's book on elastic waves was published in 1973 (Achenbach, 1973), the first to appear since the much earlier work by Kolsky. This book, which covered the then state of the art, was extremely well received and is still in print in paperback form. Later numerous other books on elastic waves have been published, but Achenbach's book is still the most frequently referenced book in the general area of waves in elastic solids.

Jan Achenbach has become widely known for his ground-breaking contributions to acoustic microscopy. Around 1985, he started a laboratory in quantitative ultrasonics. Among the advanced instrumentation that he used and further developed was a line-focus acoustic microscope. He supplemented the experimental work on measurement of the $V(z)$ curve by a theoretical analysis based on measurement models. His theoretical and experimental researches, particularly on the determination of the elastic constants of thin films, resulted in a number of significant papers (written jointly with graduate students). A novel feature was Achenbach's use of an accurate measurement model with all the systemic features of the actual measurement process, but based on rigorous analysis. Achenbach's model made it possible to obtain the material parameters with great accuracy by systematically minimizing the difference between the measured and calculated $V(z)$ curves. Achenbach eventually summarized his results in an influential review paper (Achenbach et al., 1995).

Jan Achenbach has also been very successful in practical applications of his results on quantitative ultrasonics. With his co-workers, he has made major contributions to practical applications of ultrasonics to detection and sizing of cracks and corrosion in metal structures. An example is the detection of corrosion and stress-corrosion cracks in the wing box of the DC-9. In the mid-nineties, Northwest Airlines had in operation more than 125 DC-9 aircrafts older than 20 years. These aircrafts needed periodic check-ups for corrosion in the inner layers of the wing box, which is a fuel compartment. The old way was to enter the wing box for visual inspections or to disassemble the wing from the fuselage. This procedure took 800 hours. Achenbach was the leader of a team that developed an ultrasonic technique for non-destructive testing of the wing, from the outside of the wing, without wing box entry or disassembly. This reduced the inspection time to 50 hours and saved Northwest Airlines millions of dollars. The technique is now also being used by other airlines and by the US Air Force. The vital details were published in (Achenbach et al., 1995), and his team was awarded the 1995 Medal of Excellence Award by the McDonnell-Douglas Company.

In his recent work, Jan Achenbach has returned to classical elastodynamics. He derived a new formulation to express Lamb waves in terms of a carrier wave propagating in the mid-plane of the layer. The carrier wave, which is the solution of a simple reduced wave equation, carries the thickness motion of the layer (Achenbach, 1998). This information, in conjunction with a novel application of elastodynamic reciprocity, was extremely useful in deriving expressions for wave motion in an elastic layer (generated by a time-harmonic point load of arbitrary direction) in terms of superposition of wave nodes.

The importance of Achenbach's work is attested by high research funding that he received from NSF (Solid Mechanics Program, Earth Sciences Division, RANN), Office of Naval Research, Army Office of Research (Durham), Air Force Office of Scientific Research; ERDA, Wright-Patterson AFB, DARPA, Rockwell International Science Center; Los Alamos Scientific Laboratory, Ames Laboratory, Department of Energy (BED), National Institute for Standards and Technology, and Federal Aviation Administration, as well from the industry (e.g. McDonnell-Douglas, Bandag, Inc.).

During the last three decades, Achenbach has been a leading personality in our mechanics research community. As president of two societies, member of the ASME-AMD Executive Committee and of US National Committee on Theoretical and Applied Mechanics, editor and founder of the Journal of Wave Motion, research center director, and holder of other important offices, he provided leadership to our research community.

References

Achenbach, J.D., 1970. Extension of a crack by a shear wave. Zeitschrift fur angewandte Mathematik und Physik (ZAMP) 21, 887–900.

Achenbach, J.D., 1973. Wave Propagation in Elastic Solids. North Holland Publishing Co./American Elsevier, Amsterdam/New York.

Achenbach, J.D., 1975. A Theory of Elasticity with Microstructure for Directionally Reinforced Composites, CISM Monograph 167. Springer, Vienna.

Achenbach, J.D., 1977. Geometrical theory of diffraction for 3-D elastodynamics. J. Acoust. Soc. Am. 61, 413–421.

Achenbach, J.D., 1978. Surface wave rays in elastodynamic diffraction of cracks. J. Acoust. Soc. Am. 63, 1824–1831.

Achenbach, J.D., 1998. Lamb waves as thickness vibrations superimposed on a membrane carrier wave. J. Acoust. Soc. Am. 103, 2283–2286.

Achenbach, J.D., Chao, C.C., 1962. A three-parameter viscoelastic model particularly suited for dynamic problems. J. Mech. Phys. Solids 10, 245–252.

Achenbach, J.D., Gautesen, A.K., McMaken, H., 1982. Ray Methods for Waves in Elastic Solids–with applications to Scattering by Cracks. Pitman Advanced Publishing Program, Boston.

Achenbach, J.D., Kim, J., Lee, Y.C., 1995. Measuring thin-film elastic constants by line-focus acoustic microscopy. In: Briggs, A. (Ed.), Advances in Acoustic Microscopy, vol. 1. Plenum Press, pp. 153–208.

Achenbach, J.D., Komsky, I., Andrew, G., Grills, B., Register, J., Linkert, G., Huerto, G., Steinberg, A., Asbaugh, M., Moore, D., Weber, H., 1995. An ultrasonic technique to detect corrosion in DC-9 wing box: from concept to field application. Materials Evaluation 52 (7), 848–852.

Zdenek P. Bazant
Jianmin Qu
Georgia Institute of Technology
Northwestern University
USA