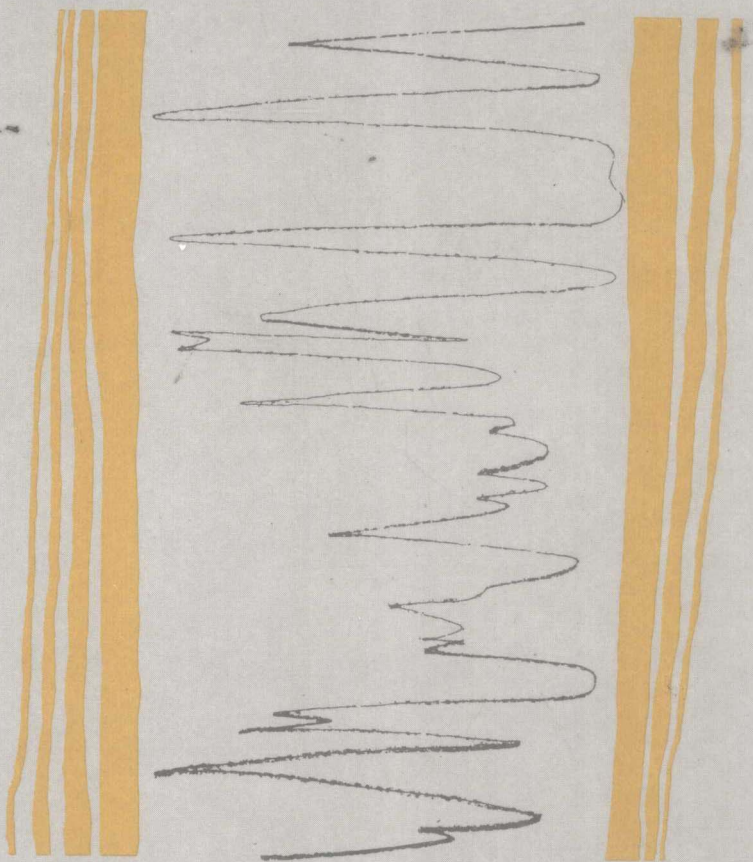


STOCHASTIC STRUCTURAL DYNAMICS

Progress in Theory and Applications

Edited by

S.T. Ariaratnam, G.I. Schuëller & I. Elishakoff



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32
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Progress in Theory and Applications

Edited by

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ELSEVIER APPLIED SCIENCE
LONDON and NEW YORK

ELSEVIER APPLIED SCIENCE PUBLISHERS LTD
Crown House, Linton Road, Barking, Essex IG11 8JU, England

Sole distributor in the USA and Canada
ELSEVIER SCIENCE PUBLISHING CO., INC.
52 Vanderbilt Avenue, New York, NY 10017, USA

WITH 12 TABLES AND 148 ILLUSTRATIONS

© 1988 ELSEVIER APPLIED SCIENCE PUBLISHERS LTD

British Library Cataloguing in Publication Data

Stochastic structural dynamics.

1. Dynamics. Stochastic processes

I. Ariaratnam, S. T. II. Schuëller, G. I.

III. Elishakoff, Isaac

531'.11'015192

ISBN 1-85166-211-1

Library of Congress Cataloging-in-Publication Data

Stochastic structural dynamics: progress in theory and applications/
edited by S. T. Ariaratnam, G. I. Schuëller, I. Elishakoff.

p. cm.

Bibliography: p.

Includes index.

ISBN 1-85166-211-1

1. Structural dynamics. 2. Stochastic processes. 3. Lin, Y. K.

(Yu-Kweng), 1923- I. Ariaratnam, S. T. II. Schuëller, Gerhart I.

III. Elishakoff, Isaac.

TA654.S755 1988

88-7268 CIP

624.1'71—dc19

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*Contributions in honor of the sixty-fifth birthday of Yu-Kweng Michael
Lin on October 30, 1988*



Professor Y. K. Lin

Dedication to Professor Y. K. Lin

This book, which contains a series of original contributions in the area of Stochastic Dynamics, is dedicated to Professor Y. K. Lin by some of his friends, colleagues and former students on the occasion of his sixty-fifth birthday. It is a token of appreciation for the valuable things he has taught all of us by his lectures, discussions and writings.

Mike Lin was born on 30 October 1923 in Fukien Province, which now belongs to The People's Republic of China. After receiving his basic University education in China, he studied at Stanford University, California, USA where, in 1957, he earned a Ph.D. in structural engineering. During this period, he also worked as stress engineer for the Vertol Aircraft Corporation. From 1957 to 1958 he joined the Faculty of the Imperial College of Engineering in Ethiopia. Returning to the US he went to work with the Transport Division of the Boeing Company as research engineer. In 1960 he accepted an appointment as professor of aeronautical and astronautical engineering and of civil engineering at the University of Illinois at Urbana-Champaign where he stayed until 1983. He then accepted the Charles E. Schmidt Eminent Scholar Chair at the Florida Atlantic University in Boca Raton, Florida. Here he also serves as Director of the Center for Applied Stochastics Research (CASR).

During the period 1967–8 he was a National Science Foundation (NSF) Senior Post-Doctoral Fellow and Visiting Professor at the Massachusetts Institute of Technology. He also taught at two NSF sponsored institutes for college teachers, one at the University of New Mexico in 1966 and the other at the University of Illinois in 1970. In

1976 he was a Senior Visiting Fellow at the Institute of Sound and Vibration Research at the University of Southampton. In 1984 he was awarded the Alfred M. Freudenthal Medal for outstanding contributions to random vibration by ASCE.

Mike Lin's academic career was accompanied by consulting to major companies and US government laboratories including General Motors Corp., General Dynamics Corp., Boeing Co., TRW Corp., Air Force Material Laboratory, NASA and the General Thomas J. Rodman Laboratory. He is a registered PE in the states of Florida and Illinois and a fellow of many professional societies, including the Acoustical Society of America, the American Academy of Mechanics and ASCE.

The papers contributed to this volume demonstrate the impact of Mike Lin's research and teaching in the area of random vibration and structural dynamics. In particular, his book on *Probabilistic Theory of Structural Dynamics* has developed into an indispensable reference book for students, researchers and practising engineers working in this field. Most important, his valuable contributions in the application of Markov process theory to structural dynamics in stochastic stability and in nonlinear stochastic dynamics are considered to be landmarks in the development of the field.

The great number of publications which are still in press attest to his admirable continued activities. We consider ourselves fortunate to be able to share with him his findings in the years to come and wish Professor Lin health and strength in the continuation of his work.

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Books or Monographs

Probabilistic Theory of Structural Dynamics, McGraw-Hill Book Company, New York, 1967. Reprint with revisions, R. E. Krieger Publishing Company, 1976.

Papers Published in Books

Random vibration of periodic and almost periodic structures. In *Mechanics Today*, ed. S. Nemat-Nasser. Pergamon Press, Oxford, 1976, pp. 93–124.

Dynamic characteristics of continuous skin-stringer panels. In *Acoustical Fatigue in Aerospace Structures*, ed. W. J. Trapp & D. M. Fornay, Jr. Syracuse University Press, 1965, pp. 163–84.

Response of linear and nonlinear continuous structures subject to random excitation and the problems of high level excursions. In *Structural Safety and Reliability*, ed. A. M. Freudenthal. Pergamon Press, Oxford, 1972, pp. 117–30.

Stochastic aspects of dynamic systems. In *Stochastic Problems in Mechanics*, ed. S. T. Ariaratnam & H. H. E. Leipholz. Solid Mechanics Division, University of Waterloo, 1974, pp. 145–63.

Response of periodic beam to supersonic boundary-layer pressure fluctuation (with S. Maekawa, H. Nijim, L. Maestrello). In *Stochastic Problems in Dynamics*, ed. B. L. Clarkson. Pitman Publishing Ltd, London, 1977, pp. 468–85.

Structural response under turbulent flow excitations. In *Random Excitations of Structures by Earthquakes and Atmospheric Turbulence*, ed. H. Parkus, Springer-Verlag, Wien, CISM 225, 1977, pp. 238–307.

Stochastic analysis of bridge motion in large scale turbulent winds. In *Wind Engineering*, ed. J. E. Cermak. Pergamon Press, Oxford, New York, 1980, pp. 887–97.

Random vibration of a cooling tower under earthquake excitation. In

- Stochastic Methods in Structural Mechanics*, ed. F. Casciati & L. Faravelli. Servizio Arti Grafiche, December 1983, pp. 63–78.
- A physical interpretation of Markov approximation. In *Probabilistic Mechanics and Structural Reliability*, ed. Y. K. Wen. ASCE, January, 1984, pp. 410–13.
- Applications of cumulant closure to random vibration problems (with W. F. Wu). In *Random Vibration*, ed. T. C. Huang & P. D. Spanos. AMD-65, ASME, 1984, pp. 113–25.
- On modeling earthquake as nonstationary random process (with Y. Yong). In: *Structural Safety and Reliability*, ed. I. Konishi, A. H-S. Ang & M. Shinozuka. IASSAR, 1985, pp. II-207–16.
- Orthogonal expansion of nonstationary random processes (with Y. Yong). In *Methods of Stochastic Structural Mechanics*, ed. F. Casciati & L. Faravelli. University of Pavia Press, 1986, pp. 49–67.
- Some observations on spectral analysis (with Y. Yong). In *Random Vibration*, ed. I. Elishakoff & R. Lyon. Elsevier Science Publishers, Amsterdam, 1986, pp. 193–200.
- Application of Markov process theory to nonlinear random vibration problems. In *Stochastic Methods in Structural Dynamics*, ed. G. I. Schuëller & M. Shinozuka. Martinus Nijhoff Publishers, Dordrecht/Boston/Lancaster, 1987, pp. 134–53.
- Exact and approximate solutions for response of nonlinear systems under parametric and external white noise excitations (with Y. Yong, G. Q. Cai & A. Brückner). *Proceedings of IUTAM Symposium on Nonlinear Stochastic Engineering Systems*, ed. F. Ziegler & G. I. Schuëller. Springer Verlag, Berlin, 1988, pp. 323–34.
- Energy dissipation balancing—An approximate solution for non-linearly damped system under random excitations (with G. Q. Cai). In *Developments in Theoretical and Applied Mechanics*, Vol. 14. School of Engineering, The University of Mississippi, Mississippi, 1988, pp. 381–8.

Papers Published in Technical Journals

- Coupled vibrations of open thin-walled beams (with J. M. Gere). *Journal of Applied Mechanics*, **25** (3) (September 1958) 373–8.
- Approximate buckling loads of open columns. *Journal of Engineering Mechanics*, *ASCE Proceedings*, EM 4, Paper 1793, October 1958, pp. 1793-1–1793-22.
- Free vibrations of continuous skin-stringer panels. *Journal of Applied Mechanics*, **27** (4) (December 1960) 669–76.
- Coupled bending and torsional vibrations of restrained thin-walled beams. *Journal of Applied Mechanics*, **27** (4) (December 1960) 739–40.
- Vibrations of thin paraboloidal shells of revolution (with F. A. Lee). *Journal of Applied Mechanics*, **27** (4) (December 1960) 743–4.
- Stresses in continuous skin-stiffener panels under random loading. *Journal of Aero/Space Sciences*, **29** (1) (January 1962) 67–86.
- On torsion analysis of multicell tubes. *Journal of Aero/Space Sciences*, **29** (April 1962) 475–6.

- Expansion of Jacobian elliptic functions about the modulus (with F. A. Lee). *Mathematics of Computation*, **XVI**(79) (July 1962) 372-5.
- Response of a non-linear panel under periodic and randomly varying loading. *Journal of Aero/Space Sciences*, **29** (9) (September 1962) 1929-34.
- Free vibrations of continuous beams on elastic supports. *International Journal of Mechanical Sciences*, **4** (September-October 1962) 409-23.
- Nonstationary response of continuous structures to random loading. *Journal of Acoustical Society of America*, **35** (February 1963) 222-7.
- Free vibrations of a finite row of continuous skin-stringer panels (with I. D. Brown & P. C. Duetschle). *Journal of Sound and Vibration*, **1** (January 1964) 14-27.
- Probability distributions of stress peaks in linear and non-linear structures. *AIAA Journal*, **1** (5) (May 1963) 1133-8.
- Application of nonstationary shot noise in the study of system response to a class of nonstationary excitations. *Journal of Applied Mechanics*, **30** (4) (December 1963) 555-8.
- On nonstationary shot noise. *Journal of Acoustical Society of America*, **36** (1) (January 1964) 82-4.
- Random vibration of a Myklestad beam. *AIAA Journal*, **2** (8) (August 1964) 1448-51.
- Transfer matrix representation of flexible airplanes in gust response study. *Journal of Aircraft*, **2** (1965) 116-21.
- Nonstationary excitation and response in linear systems treated as sequences of random pulses. *Journal of Acoustical Society of America*, **38** (1965) 453-60.
- Dynamics of beam-type periodic structures (with T. J. McDaniel). *Journal of Engineering for Industry, ASME Transactions*, **91**(13-4) (November, 1969) 1133-41.
- A brief survey of transfer matrix techniques with special reference to the analysis of aircraft panels (with B. K. Donaldson). *Journal of Sound and Vibration*, **10** (1) (1969) 103-43.
- On first-excursion failure of randomly excited structures. *AIAA Journal*, **8** (4) (February 1970) 720-5.
- On first-excursion failure of randomly excited structures, II. *AIAA Journal*, **8** (10) (October 1970) 1888-90.
- Response of flight vehicles to nonstationary atmospheric turbulence (with L. J. Howell). *AIAA Journal*, **9** (11) (November 1971) 2201-7.
- Spatial decay in the response of damped periodic beam (with R. Vaicaitis & K. Doi). *Journal of Aircraft*, **9** (1) (January 1972) 91-3.
- Response of finite periodic beam to turbulent boundary layer pressure fluctuation (with R. Vaicaitis). *AIAA Journal*, **10** (8) (August 1972) 1020-4.
- Analysis of airplane response to nonstationary turbulence including wing bending flexibility (with Y. Fujimori). *AIAA Journal*, **11** (3) (March 1973) 334-9.
- Analysis of airplane response to nonstationary turbulence including wing bending flexibility, Part II (with Y. Fujimori). *AIAA Journal*, **11** (9) (September 1973) 1343-5.

- Free vibration of disordered periodic beams (with J. N. Yang). *Journal of Applied Mechanics*, **41** (2) (June 1974) 383–91.
- Frequency response functions of a disordered periodic beam (with J. N. Yang). *Journal of Sound and Vibration*, **38** (3) (1975) 317–40.
- Statistical analysis of longevity of prosthetic aortic valves (with D. N. Ghista). *Journal of Applied Mechanics*, **43** (1) (1976) 2–7.
- Decomposition of turbulence forcing field and structural response (with S. Maekawa). *AIAA Journal*, **15** (5) (May 1977) 609–10.
- Deterministic stability analysis of a wind loaded structure (with P. J. Holmes). *Journal of Applied Mechanics*, **45** (1) (1978) 165–9.
- Stochastic analysis of wind-loaded structures (with P. J. Holmes). *Journal of Engineering Mechanics Division, ASCE*, Em 2, **104** (April 1978) 421–40.
- Rotor blade stability in turbulence flow, Part I (with Y. Fujimori & S. T. Ariaratnam). *AIAA Journal*, **17** (6) (June 1979) 545–52.
- Rotor blade stability in turbulence flow, Part II (with Y. Fujimori & S. T. Ariaratnam). *AIAA Journal*, **17** (7) (July 1979) 673–8.
- Motion of suspension bridges in turbulent winds. *Journal of Engineering Mechanics Division, ASCE*, **105** EM 6 (December 1979) 921–3.
- Stability of bridge motion in turbulent winds (with S. T. Ariaratnam). *Journal of Structural Mechanics*, **8** (1) (1980) 1–15.
- Tall building response to earthquake excitations (with J. N. Yang & S. Sae-Ung). *Journal of Engineering Mechanics Division, ASCE*, **106** (EM 4) (August 1980) 801–17.
- Column response to horizontal vertical earthquakes (with T. Y. Shih). *Journal of Engineering Mechanics Division, ASCE* (December 1980) 1099–109.
- Along-wind motion of multi-storey buildings (with J. N. Yang). *Journal of Engineering Mechanics Division, ASCE*, **107** (EM 2) (April 1981) 295–307.
- Coupled motion of wind-loaded multi-storey building (with J. N. Yang & B. Samali). *Journal of Engineering Mechanics Division, ASCE*, **107** (EM 6) (December 1981) 1209–26.
- Vertical seismic load effect on hysteretic columns (with T. Y. Shih). *Journal of Engineering Mechanics Division, ASCE*, **108** (EM 2) (April 1982) 242–54.
- Vertical seismic load effect on building response (with T. Y. Shih). *Journal of Engineering Mechanics Division, ASCE*, **108** (EM 2) (April 1982) 331–43.
- Variability of tall building response to earthquake with changing epicenter direction (with J. N. Yang & S. Sae-Ung). *Journal of Earthquake Engineering and Structural Dynamics*, **10** (2) (March–April 1982) 211–23.
- Rotor blade lead-lag stability in turbulent flows (with J. E. Prussing). *Journal of American Helicopter Society*, **27** (2) (April 1982) 51–7.
- Concepts of stochastic stability in rotor dynamics (with J. E. Prussing). *Journal of American Helicopter Society*, **27** (2) (April 1982) 73–4.
- Multimode bridge response to wind excitations (with J. N. Yang). *Journal of Engineering Mechanics, ASCE*, **109** (2) (April 1983) 586–603.
- On statistical moments of fatigue crack propagation (with J. N. Yang). *Journal of Engineering Fracture Mechanics*, **18** (1983) 243–56.
- Coupled flap-torsional response of a rotor blade in forward flight due to atmospheric turbulence excitations (with J. S. Fuh, C. Y. R. Hong & J. E. Prussing). *Journal of American Helicopter Society*, **28** (3) (July 1983) 3–12.

- A closed-form analysis of rotor blade flap-lag stability in hover and low-speed forward flight in turbulent flow (with J. E. Prussing). *Journal of American Helicopter Society*, **28** (3) (July 1983) 42–6.
- A closed-form earthquake response analysis of multi-storey building on compliant soil (with W. F. Wu). *Journal of Structural Mechanics*, **12** (1) (January 1984) 87–110.
- Along-wind motion of building on complaint soil (with W. F. Wu). *Journal of Engineering Mechanics, ASCE*, **110** (1) (1984) 1–19.
- Cumulant-neglect closure for nonlinear oscillators under random parametric and external excitations (with W. F. Wu). *International Journal of Nonlinear Mechanics*, **19** (4) (1984) 349–62.
- Rotor blade flap-lag stability and response in forward flight in turbulence flows (with J. E. Prussing & T. N. Shiau). *Journal of American Helicopter Society*, **29** (4) (October 1984) 81–7.
- A stochastic theory of fatigue crack propagation (with J. N. Yang). *AIAA Journal*, **23** (1) (Jan. 1985) 117–24.
- Free and random vibrations of column supported cooling towers (with Y. Yong). *Journal of Sound and Vibration*, **98** (4) (1985) 539–63.
- Some observations on the stochastic averaging methods. *Probabilistic Engineering Mechanics*, **1** (1) (1986) 23–7.
- Methods of stochastic structural dynamics (with F. Kozin, Y. K. Wen, F. Casciati, G. I. Schuëller, A. Der Kiureghian, O. Ditlevsen & E. H. Vanmarcke). *Structural Safety*, **3** (1986) 167–94.
- Stochastic response of flexible rotor-bearing system to seismic excitations (with Ki Bong Kim & Jann N. Yang). *Probabilistic Engineering Mechanics*, **1** (3) (1986) 122–30.
- On random pulse train and its evolutionary spectral representation. *Probabilistic Engineering Mechanics*, **1** (4) (1986) 219–23.
- Evolutionary Kanai-Tajimi earthquake models (with Y. Yong). *Journal of Engineering Mechanics, ASCE*, **113** (EM 8) (August 1987) 1119–37.
- Exact stationary-response solution for second order nonlinear systems under parametric & external white-noise excitations (with Y. Yong). *Journal of Applied Mechanics*, **54** (1987) 414–18.
- Generalization of the equivalent linearization method for non-linear random vibration problems (with A. Brückner). *International Journal of Nonlinear Mechanics*, **22** (3) (1987) 227–35.
- Application of complex stochastic averaging to nonlinear random vibration problems (with A. Brückner). *International Journal of Nonlinear Mechanics*, **22** (3) (1987) 237–50.
- A note on spectral moments in nonstationary random vibration (with C. G. Bucher). *Journal of Probabilistic Engineering Mechanics*, **3** (1) (1988) 53–5.

Invited Papers Published in Proceedings of Congresses, Symposia or Handbooks, etc.

- Random processes. *Applied Mechanics Reviews*, **22** (8) (August 1969) 825–31.
- Stochastic stability of wind loaded structures. *Proceedings of Second Annual Engineering Mechanics Division Specialty Conference*, Raleigh, North Carolina, May 23–27, 1977, pp. 59–62.

- Stochastic theory of rotor blade dynamics. *Transactions of the 24th Conference of Army Mathematicians*, ARO Report 79-1, 1979, pp. 377-94.
- On stochastic cross-wind structural stability (with S. T. Ariaratnam). *Proceedings of Third US National Conference on Wind Engineering*, Gainesville, FL, February 26-March 1, 1978, pp. V5.1-4.
- Self excited bridge motion in turbulent wind (with S. T. Ariaratnam). *Proceedings of Third US National Conference on Wind Engineering*, Gainesville, FL, February 26-March 1, 1978, pp. V6.1-4.
- Dynamics of structures under random loadings. *Proceedings of International Conference on Probabilistic Safety of Structures*, Paris, France, September 8-9, 1980, pp. 29-54.
- Coupled translational and rotational motions of a multi-storey building under wind excitations (with J. N. Yang). *Proceedings of Fourth US National Conference on Wind Engineering Research*, Seattle, WA, July 27-29, 1981, pp. 224-33.
- Random vibration of some civil structures. *Proceedings of ASCE EMD/SID Symposium on Probabilistic Methods in Structural Engineering*, St. Louis, MO, October 26-30, 1981, pp. 210-28.
- Turbulence-excited flapping motion of a rotor blade in hovering flight (with C.Y.R. Hong). In *Advances in Aerospace Structures and Materials*, ed. S. S. Wang & W. J. Renton. AD-01, ASME, 1981, pp. 149-53.
- A stochastic theory of fatigue crack propagation (with J. N. Yang). *Proceedings of AIAA/ASME/ASCE/ASH 24th Structures, Structural Dynamics and Materials Conference*, Lake Tahoe, NV, May 1983, Part I, pp. 555-62.
- Examples of physical systems stabilized and destabilized by random parametric excitations. *Proceedings of International Workshop on Stochastic Structural Mechanics*, University of Innsbruck, Inst. Engr. Mech., Report 1-83, June 1983, pp. 62-6.
- Along-wind response of tall buildings on compliant soil (with W. F. Wu). *Proceedings of 4th International Conference on Applications of Statistics and Probability in Soil and Structural Engineering*, Vol. 1, June 13-17, 1983, pp. 527-38.
- Random vibrations of structural systems. *Proceedings of 44th International Statistical Institute Meeting*, Madrid, Spain, September 12-22, 1983, I.P. 30.1-19.
- Stochastic modeling of fatigue crack propagation (with W. F. Wu & J. N. Yang). *Proceedings of IUTAM Symposium on Probabilistic Methods in Mechanics of Solids and Structures*, Stockholm, June 19-21, 1984, Springer Verlag, Berlin-Heidelberg, pp. 103-10.
- Response of cooling tower or containment shell structures under seismic and wind excitations. *Transactions of 8th International Conference on Structural Mechanics in Reactor Technology*, Brussels, Belgium, Aug. 19-23, 1985, Vol. M1-M2, pp. 129-34.
- Turbulence effects on vortex-induced vibrations (with K. She). *Proceedings of International Conference on Vibration Problems in Engineering*, ed. Du-Qing Hua, 1986, pp. 481-6.
- Structural stability in turbulent wind. In *Recent Trends in Aeroelasticity*,

- Structures and Structural dynamics*, ed. P. Hajela. Papers from the Professor R. L. Bisplinghoff Memorial Symposium, University of Florida, Feb. 6-7, 1986, University of Florida Press, 1987, pp. 259-70.
- Exact solutions for nonlinear systems under parametric and external white-noise excitations (with Y. Yong & G. Cai). *Lecture Notes in Engineering*, No. 31, Springer-Verlag, Berlin 1987, pp. 264-76.
- Application of stochastic averaging for nonlinear dynamical systems with high damping (with N. Sri Namachchivaya). *Lecture Notes in Engineering*, No. 31, Springer-Verlag, Berlin 1987, pp. 277-306.
- Evolutionary Kanai-Tajimi type earthquake models (with Y. Yong). *Lecture Notes in Engineering*, No. 32, Springer-Verlag, Berlin, 1987, pp. 174-203.
- Effect of turbulence on flow induced oscillations (with N. Sri Namachchivaya). *Proceedings of the 20th Midwestern Conference*, Purdue University, W. Lafayette, IN, Aug. 31-Sept. 2, 1987.
- Recent advances in nonlinear random vibration, *Proceedings of the Third International Conference on Recent Advances in Structure Dynamics*, Southampton, England, July 18-22, 1988.

Technical Reports with Wide Distribution

- Free vibration of continuous skin-stringer panels with non-uniform stringer spacing and panel thickness (with T. J. McDaniel, B. K. Donaldson, C. F. Vail & W. J. Dwyer). Report AFML-TR064-457, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 48 pp. February 1965.
- Response of multi-spanned beam and panel systems under noise excitation, Part I. Report AFML-TR-064-458, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, 41 pp., February 1965.
- Approximate correlation function and spectral density of the random vibration of an oscillator with nonlinear damping. AFML-TR-66-62, 11 pp, Wright-Patterson Air Force Base, Ohio, March 1966.
- A method for the determination of the matrix of impulse response functions with special reference to applications in random vibration problems. *Proceedings of Conference on Matrix Methods in Structural Mechanics*, Report AFFDL-TR-66-80, Wright-Patterson Air Force Base, Ohio, pp. 743-51, November 1966.
- Response of nonlinear structures to random excitations (with T. C. Chen & C. Y. Yang). AFML-TR-66-416, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, March, 1967.
- Response of multi-spanned beam and panel systems under noise excitation (with T. J. McDaniel), Part II, Report AFML-TR-64-348, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, September 1967.
- Spatial decay in the response of damped periodic structures (with K. Doi). Report AFML-TR-69-308, November 1969, 52 pp. Air Force Materials Lab., Air Force Systems Command.
- Spatial decay in the response of damped periodic structures, Part II (with R. Vaicaitis). Report AFML-TR-69-308, Air Force Systems Command, Wright Patterson Air Force Base, Ohio, March 1970, 23 pp.