AIAA JOURNAL
Vol. 31, No. 12, December 1993

# Book Reviews

## *Finite Element Methods in Dynamics*

Y. K. Cheung and A. Y. T. Leung, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1991, 295 pp., $109.00.

Although brief, this book provides a rather comprehensive treatment of the computational aspects of using the finite element method in problems in structural dynamics. Modal methods are emphasized and only viscous damping is considered. An adequate knowledge of classical methods is presumed; e.g., the reader is presumed familiar with the solution of single-degree-of-freedom systems, conversant with the eigenvalue problem, capable of formulating the strain energy of a system, and able to model boundary conditions.

The division of attention is approximately as follows: 15% to a summary of discrete vibrations and the development of shape functions for discretizing continuous systems, 35% to the development of element and system matrices, 20% to solution techniques, 10% to dynamic response and advanced topics, and 20% to a microcomputer package (1000 elements) for the natural vibration and dynamic substructure analysis of frames.

Throughout, the book goes well beyond the introductory level, including, for example, 21 DOF plate elements; three-dimensional isoparametric elements; constant, lumped, continuous and average mass elements; and storage techniques (skyline array). FORTRAN subroutines for stiffness and consistent mass matrices of higher order plane, three-dimensional, and plate elements are given.

The chapter on solution techniques discusses difficulties in root-extraction and treats a number of methods (Gauss, power, and inverse iteration, subspace iteration, and the Lanczos method). Among other computer listings given (all in FORTRAN) are routines for Jacobi rotations, Householder transformations, and a routine for eigenvalues and eigenvectors of a symmetric tridiagonal matrix by Cholesky algorithms.

The final chapter briefly mentions time-step integration and introduces Ritz vector, Lanczos vector, and direct methods for finding the steady-state response. An approach applicable to a heavily, non-proportionally, damped system is also given. Several methods for substructure analysis are developed.

Although probably not well suited as a first introduction to the finite element method, for which a number of suitable texts are available, this book should prove useful as a reference for engineers having some familiarity with structural dynamics and the finite element method who find a need to "get into the details" of structural dynamics analysis. It also might well be considered as a text for a course to be given to students with some knowledge of discrete and continuum vibrations and finite element methods, in which the intent is to focus on the computational aspects of structural vibrations.

A few small weaknesses in the preparation of the volume detract slightly, especially in consideration of the price/size ratio; e.g., the typewriter print face, marginally legible reproductions of computer printouts, and a major section heading found on the page previous to the first line of text. This reviewer never did find Table 5.4.1.

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## *The Universal Man: Theodore von Kármán's Life in Aeronautics*

Michael H. Gorn, Smithsonian Institution Press, Washington, D.C., 1992, 202 pp., $24.95.

Von Sköllöskislaki Kármán Todor was born in Budapest on May 11, 1881. Todor, meaning gift of God in Hungarian, was the third son to Maurice de Kármán and Helen Kohn (spelled Konn in several other publications). His father was a prominent philosopher and educator in the Austro-Hungarian Empire, and his cultured mother descended from a long line of distinguished scientists, theologians, and scholars. Theodore von Kármán, as he became known around the world, was educated as a mechanical engineer in the Royal Joseph University of Polytechnics and Economics, Budapest, and earned his doctoral degree in solid mechanics at the prestigious Georgia Augusta University in Göttingen, where he worked under the supervision of Ludwig Prandtl.

Theodore von Kármán, along with William Prager, Ludwig Prandtl, and Geoffrey I. Taylor, represent perhaps the four greatest applied mechanists of the 20th century. Although he thought of himself as an engineer first, von Kármán was much more than that. As William R. Sears remarked during a 1964 address to the Society for Industrial and Applied Mathematics and again while reviewing the present book for *Physics Today*, von Kármán, the engineer, physicist, mathematician, rocketeer, teacher, businessman, organizer on an international

scale, adviser to governments, bon vivant, raconteur and many others, was so broad as to puzzle most journalists and lay persons. In a world that likes concise labels for its heroes, von Kármán is very difficult to define; he is indeed the universal man.

Popular magazines and newspapers wrote about von Kármán as early as the 1920s, but especially after World War II when he attained a best-spokesman-for-science status. *Time* magazine and the *New York Times* called him rocket expert and physicist, respectively, while the *Saturday Evening Post* entitled von Kármán's life story "He Tamed the Wind."

Among von Kármán's numerous scientific breakthroughs and pioneering fields of research are the theory of buckling, theory of specific heats of solids, von Kármán vortex street, turbulent boundary-layer momentum equations and the logarithmic law for skin friction, laminar boundary layer on rotating disks, mechanics of the rolling process to produce sheet metals, similarity laws of transonic flows, resistance of slender bodies at supersonic speeds, statistical theory of turbulence, theory of evolution and quenching of flames, jet propulsion systems and solid-propellant rocketry, aerothermochemistry, and magnetogasdynamics. von Kármán continued to be an inspiring leader of scientific thought for an amazing half-century.

Nobody knows the exact way the mind of a genius works, but it seems that von Kármán's innovations began with intuitive inspiration followed by rather simple mathematical calculations. He formulated ideal models by omitting much of the cumbersome practical details in order to expose the underlying physics. von Kármán seemed always to be able to simplify a complex problem to its most essential elements. After testing the theory in the laboratory, the results were often applied to real engineering problems. von Kármán humbly claimed that he was never trained formally in sophisticated mathematics. Leslie Howarth literally had to teach von Kármán tensor analysis in order for them to write their seminal paper on the fundamentals of the statistical theory of turbulence, which was published in 1938 and is still being cited some 55 years later.

von Kármán directed and brought to prominence the Aerodynamics Institute at the Technical University in Aachen and the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT). For the latter job, he was Cal Tech's first choice, followed by G. I. Taylor and L. Prandtl!

As a foreigner living in Germany, America, and France, von Kármán witnessed prejudice first hand. Often it was the inconsequential, subtle variety, as for example when he overheard a conversation between two Cal Tech faculty members about the new professor with "those things over the a's in his name." Although von Kármán was leaning toward removing the accents over the a's when he came to his new country, it is reported that he decided to keep them as a result of that snobbish comment. von Kármán also experienced the more serious, sometimes deadly type of bigotry as a Hungarian Jew living in the embryonic Nazi Germany. He seemed to take it all in stride, never showing any sign of bitterness, resentment, or self-pity. Despite the negative experience, or perhaps because of it, von Kármán's lifelong goal was to foster international cooperation in science and engineering. While he spoke fluently a half-dozen languages, von Kármán skillfully used what he described as his bad English together with his ready wit to soothe abrasiveness due to national rivalries and unlike temperaments and to consistently win arguments.

The von Kármáns' home in Pasadena was frequently the site of evening gatherings of an often overflowing group of friends with different languages, nationalities, and occupations. Students, professors, actresses, priests, spiritualists, artists, and military men all mingled in harmony, mixing business and pleasure all night long with the help of a generous allotment of hard drinks and heavily spiced food. Everyone present got the full attention of, and was of great personal interest to, the gracious host and his mother and sister.

In the United States and abroad, von Kármán played a major, often singular, role in establishing numerous government, academic, and private institutions. Among these are the International Congress for Applied Mechanics, the International Union of Theoretical and Applied Mechanics, the Aerojet Engineering Company, the Jet Propulsion Laboratory, the U.S. Air Force Scientific Advisory Board, the Advisory Group for Aeronautical Research and Development (AGARD) with NATO, the International Congress of the Aeronautical Sciences, the Air Force Institute of Technology, the Arnold Engineering Development Center, and the International Academy of Astronautics.

During his lifetime, von Kármán won 35 awards (including the U.S. Medal of Freedom in 1956 and the first U.S. National Medal of Science in 1963), 33 honorary degrees and titles, and 10 decorations and orders. This prolific and imaginative scholar published four books and 170 articles, many of which are pioneering in nature as well as lasting in significance, and opened the way to whole new areas of research.

von Kármán knew the degree of his intellect and appeared to be conscious of his place in history. He sought the journalist Lee Edson to help in writing his autobiography *The Wind and Beyond: Theodore von Kármán Pioneer in Aviation and Pathfinder in Space*, which was completed four years after von Kármán's death. Although he never practiced self-praise (on the contrary, von Kármán was often self-deprecating), he tremendously enjoyed other people's praise. While genuinely disliking self-congratulation, he took great pleasure in tributes and awards that were earned honestly and legitimately bestowed.

von Kármán was as comfortable being in the presence of a king as with an elevator boy; both would be treated with the same courtesy and the same degree of bona fide interest. As W. R. Sears observed, von Kármán had a special kind of humility: he knew he was a special person, while genuinely believing that being a great scientist was not really more important, in itself, than being a taxi driver. In his will, von Kármán designated none of his money for self-perpetuation—no endowed chairs, no fellowships, and no scientific prizes. After he died, the bulk

of von Kármán's estate went to Cal Tech as a non-restricted gift.

The present book is part of the Smithsonian Institute's History of Aviation Series and is written by a professional historian. The series is intended to contribute to the overall understanding of aviation's science and technology as well as the social, cultural, and political environment in which air travel developed and matured. In that the book succeeds with flying colors.

The author, Dr. Michael H. Gorn, was chief historian of the U.S. Air Force Systems Command and is currently the first historian of the Environmental Protection Agency. The compact, hard-cover book has 202 pages and is organized into nine chapters: His Father's Son; Scientist and Soldier; from Aachen to Pasadena; a Magnet for Aeronautics; the Rocketeers; a Wartime Mission; Advising the Generals; the Elder Statesman; and "His Life Was Full." Additionally, the meticulously researched document contains 28 pages of notes and a seven-page essay on sources. Those useful appendices set the present book apart from other biographies of von Kármán.

In order to prepare this review, I read many of the books and journal and popular-press articles written about the great scientist/engineer. These include the four-volume *Collected Works of Dr. Theodore von Kármán*, published in 1956, and numerous essays composed in memoriam by von Kármán's eminent students, colleagues, and friends, such as H. L. Dryden, S. Goldstein, R. T. Jones, C. B. Millikan, J. L. Pritchard, W. R. Sears, and G. I. Taylor. I have also glanced through the comprehensive, 376-page quasi-autobiography referenced earlier that was written by Lee Edson based on an incomplete manuscript dictated by von Kármán during the last few years of his life. I must admit that I tremendously enjoyed this sidetrack.

According to the author, the present book's intended audience is the general reader of history with a particular interest in biography, science, aeronautics, aviation, air power, rocketry, or space. Being a book for the general readers is, of course, not an excuse for several, rather basic, technical errors; for example, the mix-up between liquid and fluid and the concept of drag in aeronautics (p. 20), blunt-body separation (p. 24), and the mechanism for induced drag (p. 27). Several typographical errors are also sprinkled throughout the text. Some are not trivial, as for example .05 instead of 0.5 on p. 156, which also rather ruined the punch line of the story. The maiden name of von Kármán's mother is listed in *Marquis Who's Who* and many other publications as Konn, while the present book records Kohn. The former spelling could, of course, have been a domino-effect error, but one wishes that Gorn had addressed this discrepancy.

Professional historians use specific formal methodology for their research, and the present author is no exception. An often-heard criticism directed toward journalists, for example, is lack of accuracy in their writings. Even autobiographies are sometimes chastised for lack of objectivity, selective memory lapses, and not seeing the other person's point of view. Michael Gorn relied heavily on von Kármán's own memoirs referenced earlier. Nevertheless, he makes it clear that the autobiography is inaccurate in its sequence of events, is too generous with von Kármán's successes, has incorrect contextual material, and must be viewed with caution. Particularly revealing along those lines are the subtle but significant differences between the memoirs and the present book in accounting for von Kármán's formidable teacher and, ultimately, rival Ludwig Prandtl, and von Kármán's student Hsue-Shen Tsien. The latter is, of course, the brilliant Chinese-American rocket scientist who fell victim to the infamous McCarthy-era communist hunt and ended up helping China build an impressive missile capability.

Perhaps not being fair to the present serious study, I found most of what was previously written about von Kármán more interesting and lively. For example, I can almost hear von Kármán's notoriously heavy accent in his spirited autobiography. Once started on any of this older material, I could not put it aside before completely finishing the text. In contrast, the present prose is austere and less lively. Notwithstanding this criticism, the present book generally offers a careful and studious exposition written by a historian of science. For that alone it is worth reading; get Gorn's book for your office but Edson's for your home so that your whole family can enjoy.

It is obvious from my comments thus far that I wrote little about the book itself but used much of this space to admire its subject. For that I plead guilty. It is very difficult not to be awe-struck by the magnetic personality of this quintessential visionary. Shortly after von Kármán's death in 1963, his long-time friend and colleague Clark B. Millikan wrote that von Kármán was a truly universal man whose like we shall not soon see again. Reading about this outstanding teacher and great humanist made me only regret that I was not fortunate enough to know personally von Sköllöskislaki Kármán Todor.

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