TOSHIO MURA
1925–2009
Elected in 1986

“For initiating and promoting micromechanics to bridge the
gap between metal physics and engineering mechanics.”

BY LEON M. KEER

TOSHIO MURA, a leader in the development and promotion of the field of micromechanics to bridge the disciplines of metal physics and engineering mechanics, died on August 9, 2009, at the age of 83.

Toshio Mura, second son of Shinzo and Chie Fujii, was born in Ono, a small port village of Kanazawa, the capital of Ishikawa Prefecture, Japan, on December 7, 1925. Among the locals, the Fujiis are well known as brewers, having a long history in the area. Kanazawa is an old city on the coast of the Sea of Japan, where traditional culture is proudly maintained and appreciated. In Japan, given names often reflect what parents wish their children to be or to become. “Toshio” is written in three characters. “To” stands for outward or abroad, “shi” determination or will, and “o” a man. Thus “Toshio” means a man who is not confined and sets his eyes on the world. Surely, Mura did not disappoint his parents.

After graduation from the Kanazawa Second Middle School (Kanazawa Ni-chu) in 1941, Mura entered the Fourth Imperial High School (Shi-ko).

Although militarism prevailed during this period, students in imperial high schools felt a traditionally observed liberal atmosphere there. Mura must have enjoyed this atmosphere, although at the same time feeling the pressure required to
prepare for higher education. The imperial high schools, which were terminated after the conclusion of World War II, had been established to rear those chosen young who would be leaders in society.

In 1944, during the most difficult time of the war, Mura went to the Imperial University of Tokyo to read aeronautical engineering. After the war, his department was dissolved and changed to the Department of Applied Mathematics at the University of Tokyo. Fascinated by applied mathematics and with the encouragement of faculty members, he pursued his graduate study under the supervision of Tsuyoshi Hayashi in 1949. At that time the department had many outstanding scientists. Among those who had a particular influence upon Mura, either consciously or subconsciously, Kazuo Kondo and Sigeiti Moriguti must be mentioned. The title of his PhD dissertation was “Study on Thermal Stresses.” His work in the dissertation turned out to be one of the earliest papers on the dynamic wave of thermal stresses.

As a graduate student, Mura also began his teaching career as a mathematics professor at Meiji University, where he met and worked with his lifelong friend, Nobuo Kinoshita. Their joint paper, “On the Boundary Value Problem of Elasticity,” which was published during his tenure at Meiji University (1956), agitated some Russian mathematicians in the field of integral equations. At the graduate school, Mura was introduced to his future wife, Sawa, by her sister, Sumi, who had worked in the Department of Aeronautical Engineering. Sawa was the second daughter of Tetsuichi and Hanae Ozaki. During the courtship, Mura often visited the Ozakis and Sumi fondly recalls that he praised Sawa’s cooking. They married in 1953 and their first daughter, Miyako, was born in 1955.

Seizing an opportunity, in 1958 Mura went to Northwestern University’s Department of Materials Science in Evanston, Illinois, to work with John O. Brittain. While at this department, Mura conceived the idea of the periodic distribution of dislocations, which was documented in a paper and published later in the Proceedings of the Royal Society of London in 1964, where, for the first time, the Fourier method was used to
obtain the elastic field of dislocations. In 1961 by encouragement of Morris E. Fine, Toshio joined the Department of Civil Engineering at Northwestern as assistant professor. The pleasant but stimulating atmosphere brewed by his colleagues—John Dundurs, Jan D. Achenbach, and I—also encouraged him. Dundurs and Mura obtained the elastic fields of dislocations parallel to a cylindrical inhomogeneity (1964). Mura and I analyzed a penny-shaped crack with a plastic zone by solving an integral equation, Mura’s first paper concerned with a crack (1963).

In 1963 Mura succeeded in expressing the elastic field of a curved dislocation in a line integral, now known as Mura’s formula (1963). He further explored the line integral expression to obtain an equation, readily applicable to any medium without using the Green’s function, requiring no differentiation and involving only computable integration. In his book *Micromechanics of Defects in Solids* (Springer, 1st edition, 1982), Mura showed that this expression can also reproduce the formulas developed by L.M. Brown, J. Lothe, R.J. Asaro, D.M. Barnett, and J.P. Hirth. Mura and his student, D.R.J. Owen, applied the line integral formula to obtain stress fields of often observed but complexly shaped dislocations (1967). The 1963 paper is also noteworthy for introducing the concept of a dislocation flux tensor, which is useful when the dynamic motion of dislocations is examined. The dislocation density and flux tensors were applied to continuum plasticity theory. Believing that a stress appearing within the framework of continuum plasticity was the sum of external and dislocation stresses, Mura published a series of papers, in the late 1960s, along these lines that emphasized the distribution and stress of dislocations (1967, 1968).

The pioneering work of J.D. Eshelby appears to have inspired and stimulated Mura, as seen in his studies of static and dynamic fields of dislocations in anisotropic media and in dislocation pile-ups. As can be inferred from the preface to *Micromechanics of Defects in Solids*, Mura regards Eshelby’s work on inclusions and inhomogeneities (1957) as being the most important and fundamental. Using the Fourier integration
method, they extended Eshelby’s celebrated ellipsoidal inclusion theory to an anisotropic medium and proved that the stress and strain fields in an ellipsoidal inclusion are uniform. In 1970 Kinoshita joined Mura at Northwestern University. Mura and his student P.C. Cheng derived the stress and strain fields outside an ellipsoidal inclusion with general eigenstrains in an anisotropic medium. In this work they recovered, in an elementary manner, the expressions for the jumps of distortion and stress at an interface with discontinuously changing eigenstrains, the expressions that were first obtained by R. Hill and later discussed by L.J. Walpole in conjunction with the jumps of polyharmonic potentials.

Mura also interacted with experimentalists, who eagerly sought his advice and aid on issues of mathematics and mechanics. In particular, Morris E. Fine and his students in Northwestern’s Department of Materials Science and Engineering benefited from this interaction in their studies of the fatigue of alloys. Mura also gained insight into material properties and structures by the interactions with these materials scientists.

Toshio became professor emeritus at Northwestern in 1996, and the Toshio Mura Graduate Fellowship Fund was established that year.

Because of his attachment to his native country, Mura invited many visiting scholars from Japan. Some were taught, educated, and trained in mechanics; some continued in Japan the research begun at Northwestern. For all of them, Toshio and Sawa’s house in Wilmette, Illinois, was their second home.

In addition to his membership in the National Academy of Engineering Toshio Mura received many awards based on his scientific achievements. In 1992 he received the Materials and Mechanics Award from the Japan Society of Mechanical Engineers, for his contributions to modeling in applied mechanics. In 1998 he was awarded the Order of the Rising Sun, Gold Rays with Neck Ribbon by Emperor Akihito, Japan. He and Mrs. Mura were invited to a special party hosted by Emperor Akihito in the Akasaka Royal Garden, Tokyo, on October 14, 1999.
Toshio was survived by his wife, Sawa (who died in 2014), two daughters, Miyako and Nanako, their daughters’ husbands, Steve Izzo and Vince Kwasniewski, and four grandchildren, Courtney (1984), Stephanie (1986), Kyle (1992), and Eric (1995).

This biography was excerpted in part from a tribute to T. Mori published in *Micromechanics and Inhomogeneity: The Toshio Mura 65th Anniversary Volume* by G.J. Weng, M. Taya, and H. Abe (Springer, 1989), with additions from M. Taya, University of Washington.