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Biographical Sketch

Keh-Chih Hwang

Keh-Chih Hwang (黄克智) was born on 21 July 1927, in Nanchang, the capital of Jiangxi Province, China, in a family deeply rooted in Confucian tradition. His great-grandfather was a famous medical doctor in Fuzhou, the capital of Fujian Province. His grandfather, Xie Huang, passed the imperial examination in the late Qing Dynasty and was awarded the title Xiu-Cai (秀才), as well as a lectureship in English and basic sciences at Nanchang Normal College. This position brought the family to Nanchang, where later K.C.'s father, Yi-Cheng Huang, would work at a post office for more than 40 years. K.C.'s mother, Shen-Xiu Gong, was a traditional Chinese wife with an intellectual background. She left no stone unturned to ensure a good education for her nine children, on the meager salary of her husband.

K.C.'s long life has been intertwined with major events in a turbulent world. During the Japanese invasion (1937–1945), the large Huang family was forced to drift from place to place in Jiangxi Province. K.C. had just finished primary school and had to switch middle schools in three counties. The first school, Yangming School in Ji'an, was destroyed in an air raid in 1938. He often could not afford tuition and had to walk 50 km to school. The harsh life only made him more determined to excel. He finished middle school a year early and entered the Provincial High School.

In 1943, at the age of 16, K.C. earned the second highest score in Jiangxi Province in the National University Entrance Examination and was enrolled in National Zhong Zheng University to study civil engineering. The University had to move from one county to another and returned to Nanchang only after the war. At the University, he was influenced by a renowned civil engineer, Professor Fang-Yin Cai, and acquired a solid foundation in engineering and mechanics. In 1947, K.C. graduated No. 1 in his class. At the recommendation of Professor Cai, K.C. became an assistant lecturer in the Department of Civil Engineering at Beiyang University in Tianjin, the first Modern University in China.

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K.C. enrolled as a graduate student in the Department of Civil Engineering at Tsinghua University in 1948. Thus began his 60-year association with Tsinghua to this day. His advisor, Professor Wei Zhang, a prominent solid mechanician, would become the founder of the Department of Engineering Mechanics, as well as a vice president of Tsinghua University. Zhang became a life-time mentor and close friend of K.C.'s. Upon graduation in 1952, K.C. was appointed as a lecturer in the Department of Basic Sciences. By then he had gained attention for his work on the theory of thin shells, a field to which he would return many times later.

In 1955, K.C. was sent by the Chinese government to study for three years in the Department of Mathematics and Mechanics at the University of Moscow under Yu. N. Rabtnov (Ю. Н. Работнов), a mechanician of great international reputation on creep of structures and a member of the Academy of Sciences of the former Soviet Union. The young and enthusiastic K.C. must have impressed his Soviet professors; they made an unusual decision to let him prepare to defend a thesis of a doctorate degree, rather than an associate doctorate degree, a degree in former Eastern Europe that was equivalent to a Doctor of the State in France at that time.

The Soviets shocked the world by launching *Sputnik* on 4 October 1957. Around the same time the relation between the Soviet Union and China turned sour. In October 1958, just before finishing his thesis, K.C. was asked by the Chinese government to return immediately to help build a new department at Tsinghua University – The Department of Engineering Mechanics and Mathematics. K.C. gave up the opportunity to obtain a doctorate degree and returned. He plunged into teaching and research with great enthusiasm, serving successively as the secretary of teaching and the deputy director of the Division of Solid Mechanics. In a span of seven years, he taught courses on elasticity, plasticity, creep, thin-walled structures, heat transfer, thin shells, and so on. The graduates of this first Department of Engineering Mechanics in the country later played a prominent role in developing the field of mechanics in China. K.C.'s achievements were reported in an influential newspaper, *China Youth Daily*, on 28 November 1961, with the title "Many small steps can make a 1000-mile journey—The story of a rising young teacher K.C. Hwang." In 1963, K.C. was promoted to an associate professor.

The Cultural Revolution (1966–1976) once again disrupted all aspects of normal life in China. Faculty members of Tsinghua University were sent to work on farms and in factories in Jiangxi and Sichuan Provinces, to be "re-educated" by farmers and workers. Teaching and research were no longer possible. K.C. was sent to Jiangxi to work on a farm like a peasant. In 1973 he was allowed to return to Tsinghua to work on applied projects. He led a group, including his close colleague Ming-De Xue in particular, to establish the National Standards of pressure vessels. This effort resulted in an innovative design method of tube plates in heat exchangers. The method has since been used to design tube plates in thousands of power, chemical, oil, and other industrial plants. Similar method and national standards came a few years later in France (1982) and in the United States (1992). More recently, K.C. and his co-workers developed analytical solutions of cylindrical thin shells with large hatches under internal pressure. These solutions formed a theoretical basis for the standards of pressure vessels. The work was recognized with the McGrattan Award (1997) and Zamrik Award (2006) from the American Society of Mechanical Engineer (ASME).

The downfall of the "Gang of Four" in October 1976 marked the end of the Cultural Revolution. After centuries of turmoil, China was once again brimming with energy and optimism. The turn of events unleashed K.C.'s own energy as a prolific researcher, inspiring teacher, and charismatic leader. Of his 317 scientific papers to date, 302 were published after his 50th birthday. In 1977, the national university entrance examination resumed, and soon afterward graduate students also entered Tsinghua. K.C. immediately taught advanced courses on tensor analysis, nonlinear continuum mechanics, constitutive models, mathematical physics, and theory of thin shells. He founded a series of weekly colloquiums, which have continued to this day and have played a remarkable role in developing the discipline of solid mechanics at Tsinghua University. When academic ranks were restored in 1978, K.C. was appointed a full professor. He and his colleagues Professors Wei Zhang, Qing-Hua Du, Fu-Long Dai, and Zhao-Chang Zheng developed the first doctoral program at Tsinghua University. Their sustained effort was honored in 1993 by the highest award from the State Education Commission of China. The award was prestigious, only given to three recipients nationwide every four years.

In the last three decades, K.C. has gained an international reputation for his research in diverse areas in solid mechanics, including nonlinear fracture mechanics, plasticity and phase transformation, strain gradient plasticity, and nanomechanics. His main accomplishments are outlined below.

1. Nonlinear fracture mechanics

As the list of his publications shows, in the late 1970s through 1980s, K.C. led a large team of colleagues and students working on nonlinear fracture mechanics. The team established the singular field and theoretical resistance curve for a crack extending in steady state in a power-law hardening material. The results enabled an in-depth understanding of the growing crack and linked the theory of crack growth to the assessment of structural integrity. The team also obtained the asymptotic solution around a crack tip in a material with the Bauschinger effects. The paper made it to the top 10 papers among over 400 papers at the 6th International Conference on Fracture. The work of the team also clarified the structure of the singular fields at the tip of steadily growing crack in an ideal elastoplastic material. The result was presented in an invited talk at the 1988 IUTAM Symposium on Advances in Nonlinear Fracture Mechanics and was recognized in a letter from James R. Rice. The work of the team led to a National Natural Science 3rd Prize in 1987.

2. Plasticity and phase transformation

Starting in the late 1980s, K.C. turned his attention to finite-deformation theory of plasticity and phase transformation. On the basis of his graduate courses, K.C. published two textbooks, *Tensor Analysis* and *Nonlinear Continuum Mechanics*. He obtained basic results on Cauchy's mean rotation and objective derivatives. Materials undergoing stress-assisted phase transformation have important engineering applications. K.C. and his co-workers developed micromechanical models of shape memory alloys, transformation-toughened ceramics, and ferroelectrics. In a two-part paper published in *Journal of the Mechanics and Physics of Solids* (JMPS) in 1993, K.C. (with Q.P. Sun) proposed a model for shape memory alloys on the basis of thermodynamics, micromechanics, and kinetics of phase transformation. These papers received the ISI Citation Classic Award in 2000. K.C. also extended and improved the BHL (Budiansky, Hutchinson, Lambropoulos) model of transformation-toughening ceramics — now known as the SHY (Sun, Hwang, Yu) model. The team was invited to write an extended review article on the topic in the 1994 issue of *Advances in Applied Mechanics*. They also received a National Natural Science 3rd Prize in 1994, and a 2nd Prize in 2005.

3. Strain gradient plasticity

Manfred Ruhle and his co-workers, of the Max-Planck Institute for Metals Research, in Stuttgart, Germany, observed experimentally that an interface between sapphire and Nb debonded by the extension of an atomistically sharp crack, even though Nb deformed plastically. This observation was puzzling because classical theories of plasticity cannot predict a stress level high enough to break atomic bonds. Using the theory of strain gradient plasticity, K.C. and his collaborators successfully explained concurrent decohesion and plastic flow. They applied the strain gradient plasticity theory to studying the fracture of bimaterial interfaces and showed that a stress level high enough to trigger cleavage cracking can be achieved as a result of the presence of geometrically necessary dislocations. This work, published in JMPS, made it to the top 10 most cited papers among all papers in mechanics published in 2001.

4. Nanomechanics

K.C. started his work on nanomechanics in 2001. He and his collaborators developed a continuum theory by incorporating the interatomic potential into the constitutive model. Predictions of this atomistically informed continuum theory agree well with those of direct atomistic simulations, but take much less time than the atomistic simulations. The first paper of K.C. and his collaborators on the topic was awarded the Melville Medal from the ASME in 2004, and their second paper, published in the *International Journal of Solids and Structures* (IJSS), is so far the most cited paper among nearly 9000 papers in the field of mechanics published in 2002.

K.C. was elected to the Chinese Academy of Sciences (CAS) in 1991, and became a foreign member of the Russian Academy of Sciences in 2003. He was elected a vice president in 1989 and honorary fellow in 2001 of the International Congress of Fracture (ICF), a council member of the International Congress of Theoretical

and Applied Mechanics (ICTAM), and a member of the standing committee of the International Congress of Materials. K.C. is a founder of the Far East Oceanic Society of Fracture. He served as a vice president of the Chinese Association of Theoretical and Applied Mechanics (1989–1993), the editor-in-chief of *Acta Mechanica Sinica* (1990–1994), the chair of the State Council for academic degrees in mechanics (1985–2003), and the chair of the academic committee of Tsinghua University (1995–1999). He received the first Most Distinguished Contribution Award (2004), the highest honor bestowed on a member of the faculty of Tsinghua University.

K.C. has had over 70 graduate students. Many of them have gone on to have distinguished careers themselves. For example, Shou-Wen Yu served as a vice president of Tsinghua University, Yu-Chen Gao was elected to the CAS, Wei Yang was elected to the CAS and is now the President of Zhejiang University, and Quan-Shui Zheng is the current chair of DEM of Tsinghua University.

K.C.'s style of work is known to many. He checks every formula in articles prepared by his students, and improves all sentences. No one can forget the impact of sitting down with K.C. for hours to refine an article. As the editor-in-chief of *Acta Mechania Sinica*, he developed a review model that every article was finally assessed at a monthly meeting of standing members on the editorial board. He read and questioned every paper in detail.

In 1955, K.C. married Pei-Ying Chen, a fellow civil engineering student at Tsinghua University. Their daughter, Qiong Joan Huang, earned a bachelor's degree from Tsinghua and a Ph.D. in solid mechanics from MIT. Many in the community of mechanics were deeply saddened when Joan died of leucocythemia over 10 years ago. K.C.'s elder son, Yonggang Young Huang, earned a bachelor's degree from Beijing University and a Ph.D. in solid mechanics from Harvard. Young is now a professor at Northwestern University, a successful academic himself and a frequent collaborator of K.C.'s. The younger son, Yongqiang John Huang, earned both the bachelor's and Ph.D. in computer science from Stanford and is now an engineer at Google, traveling between the Google campuses in San Francisco and Beijing.

Among his friends, K.C.'s extended family is fondly known as a dynasty of mechanics. Joan's husband, Kun Jimmy Hsia, is professor of mechanics and materials at the University of Illinois. K.C.'s brother-in-law, Yu-Qiu Long, is professor of structural mechanics at Tsinghua University and a member of the Chinese Academy of Engineering. Pei-Ying's two brothers, Yao-Song Chen and Guo-Ping Chen, are emeritus professors of fluid mechanics at Beijing University and of experimental mechanics at Northwestern Polytechnic University.

The regulations of Tsinghua University place some restrictions on how many students K.C. can take after his 80th birthday. He has also begun to ease out from many of his responsibilities. On a typical day, K.C. gets up at 4:00 a.m., reads academic papers for a few hours until dawn, and then plays tennis with his wife for more than an hour. During the day he works for hours and practices piano. These activities keep him in excellent health, body and mind. The flow of his papers shows no sign of diminishing, and his friends are planning to celebrate his 90th birthday.

Guest Editors
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