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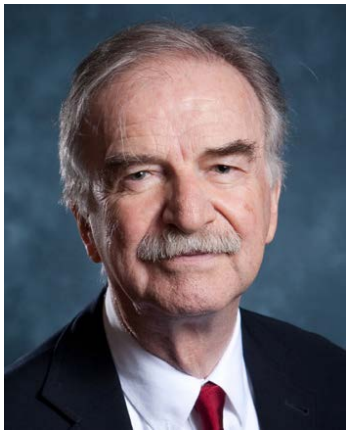

KASPAR J. WILLAM

December 20, 1940 – January 7, 2024

Elected to NAE in 2004

Josef Eberhardsteiner[1], Herbert A. Mang[1], Ekkehard Ramm[2], Stein Sture[3], Yunping Xi[3], Ignacio Carol[4], Roberto Ballarini[5] and Zdeněk P. Bažant[6]

[1]Vienna University of Technology, [1]Stuttgart University of Technology, [3]University of Colorado, Boulder, [4]Polytechnic University of Catalunya, Barcelona, [5]University of Houston and [6]Northwestern University, Evanston

Kaspar Jodokus Willam, an eminent professor of civil engineering at the University of Colorado, Boulder, passed away on January 7, 2024, in Bezau, Austria. Renowned for his seminal contributions to computational mechanics, failure analysis of structures, and constitutive modeling of brittle and quasibrittle materials, with special emphasis on concrete, he was an intellectual spearhead in the wide area of structural engineering. His work significantly advanced the quality of predictive modeling of material behavior and structural failure. His theoretical and computational advancements in the area of finite element analysis had a great impact on engineering applications globally, shaping modern approaches to material and structural integrity assessment.

Kaspar was born in Vienna, Austria, on December 20, 1940. During World War II his family moved to Bezau, in the westernmost part of Austria. Kaspar Willam's formative years were deeply intertwined with the rigorous traditional education of his homeland. He grew up in an environment that attached great significance to school education as the basis for successful academic studies with emphasis on the sciences. Kaspar studied civil engineering at the Vienna University of Technology (TU Wien), where he obtained in 1964 the degree of Dipl.-Ing., comparable to an M.S. degree. TU Wien, renowned for its academic excellence, housed

leading scholars in the area of civil engineering, such as Ernst Melan, Karl Girkmann, and Otto Karl Fröhlich, all of them members of the Austrian Academy of Sciences, whose work left a profound impression on Kaspar's intellectual trajectory. During his time at TU Wien, he engaged in advanced research on structural mechanics, elasticity, and plasticity, refining his expertise in continuum mechanics and laying the groundwork for his latter success in the area of numerical simulations. His rigorous analytical approach and commitment to interdisciplinary research became hallmarks of his later work.

Driven by a surging interest in computational methods, Kaspar Willam relocated to the United States to deepen his expertise in numerical analysis and structural mechanics. He earned an M.S. degree from the California State University, San Jose, in 1966, where he concentrated on numerical approaches to nonlinear material behavior. This period marked the beginning of his lifelong engagement with finite element methods, leading to his doctoral studies at the University of California, Berkeley. Under the mentorship of Alex Scordelis, Kaspar completed his Ph.D. studies in 1969, focusing on finite element analysis of box girder bridges. This eventually led to the program CELL used at Caltrans, Sacramento. His research at Berkeley was instrumental in the early application of computational methods to complex engineering problems, integrating novel numerical strategies to enhance the predictive accuracy in structural performance analysis. Further mentors of his doctoral research were Ed Wilson and Karl Pister. Their support laid the groundwork for his later advances in nonlinear material modeling and multiscale simulations.

Returning to Europe, Kaspar Willam joined the University of Stuttgart, Germany, as a research scientist under John H. Argyris. His work in Stuttgart was integral to the development of the SMART finite element code, a pivotal tool in the analysis of prestressed concrete reactor vessels. The intellectually demanding environment at the University of Stuttgart provided a platform for Kaspar to delve into challenging new subareas of nonlinear mechanics, eventually leading to his habilitation, in 1980, with the scientific work "Finite Element Discretization of Quasistatic Problems in Space and Time". Tenure at the University of Stuttgart also allowed him to expand his research on adaptive numerical methods, furthering the accuracy of computational simulations in engineering applications.

In 1981, Kaspar Willam joined the University of Colorado, Boulder, where he would spend most of his academic career. Briefly serving as Head of the Institute of Mechanics at the University of Karlsruhe (1988-1990), he returned to Boulder to continue his pioneering work in the areas of constitutive modeling, failure mechanics, and multiscale analysis of materials. His contributions to computational mechanics were transformative, particularly in the realm of the modeling of concrete. His development of the widely adopted 'Willam-Warnke' five-parameter failure model for concrete under multiaxial stress [1] became a cornerstone in the field. In the 1980s, it was extensively used at many institutions—including, at his alma mater, the Institute of Strength of Materials of TU Wien—for the mechanical modeling of concrete subjected to three-dimensional states of stress. His extensive research on fracture-energy-based constitutive formulations enabled engineers to predict structural failure with high accuracy.

Among his most consequential contributions was the refinement of failure models for quasibrittle materials, including the "Pramono-Willam" model (1989) [2] and the "Extended Leon Model" (1990,1994) [3,4], named after Alfons Leon, Professor at Graz University of Technology, Austria. One endeavor, with Pramono and Sture (1989) [5] was what became known as the Willam Test, clarifying the rotating vs. smeared crack concepts. Tensile loading up to the strength limit was followed by a second load stage of tension with the principal strains in the ratio 1 : 1.5 : 1, in which the principal axes first rotate fast and then slow down until approaching the angle of 52°. This test has at that time become a benchmark for anisotropic softening models of quasi-brittle materials ([6], part II). These models offered enhanced predictive capacity in simulating failure mechanisms under extreme loading conditions, significantly influencing engineering design and safety standards. Kaspar's pioneering work in computational plasticity introduced innovative numerical integration algorithms for complex material models [7,8], vastly improving the efficiency and reliability of finite element analysis. His research on adaptive computational frameworks provided a pathway for optimized engineering designs, enabling a rigorous assessment of material durability and structural resilience. Frequent visits of Zdeněk Bažant on the way from Evanston to skiing or hiking always led to animated technical discussions.

During 1998-99, while spending his sabbatical at the University of Stuttgart in the group of professor Ekkehard Ramm, Willam extended his work to failure modeling of elastoplastic materials at different levels of observation [9]. Willam's research on localization analysis had a profound impact on the understanding of fracture propagation and damage mechanics. His work contributed to the development of mesh-independent numerical techniques, ensuring the reliability of computational models in engineering applications [10]. Kaspar's investigation of thermomechanical degradation of concrete under high-temperature conditions played a critical role in the advancement of fire-resistant design methodologies and the development of robust nuclear containment structures [11]. His work on fracture propagation and multiscale material modeling led to significant advancements in seismic-resistant infrastructure, with a direct impact on contemporary earthquake engineering practices.

Willam, with Steinmann, Dietsche and Iordache (1995) [12], has also made a significant contribution by extending micropolar continuum to finite strain plasticity with von Mises and Drucker -Prager yield criteria, and extended the traditional localization analysis based on the acoustic tensor by a second localization condition (1991) [13]. In 1998 he made a novel proposal to characterize nonsymmetric stress by a Mohr circle centered outside the horizontal axis [14]. In 1989 he pioneered micromechanical material simulations for structural analysis, which led to a doctoral dissertation at UCB by T. Stankowski (1991) [15]. Although central to his work, experimental studies have been germane to some of Willam's contribution – including direct tension and triaxial compression testing (1986,1989) [16,17] and ultrasound measurement of progressive damage of concrete (1996) [18]. Willam's influence in earthquake, nuclear and aerospace engineering enhanced the safety and durability of critical infrastructure worldwide. His collaborations across disciplines facilitated the integration of theoretical frameworks with real-world engineering applications, bridging fundamental research with technological innovation. Willam's contribution with Carol and Rizzi (1994) [19]

to continuum damage mechanics and its extension in 2001 and 2002 to anisotropic damage via his new concept of pseudo-log tensor rate was also noteworthy [6,20]. So was Willam's (1996) analysis of the associated localization properties [21] and their 1996 extension to energy conservation upon cycles of principal stress axis rotation [22], later also combined with plasticity (Hansen et al. 2001 [23] and Salari et al. 2004 [24]).

In 2010 Willam moved to University of Houston where he was Hugh Roy and Lillie Cranz Cullen Distinguished Professor until his retirement in 2017. He also served as the Interim Department Chair during 2013-2014. In Houston, with Reza Mousavi and Giovanna Xotta (2018) [25], he extended his results on the effect of the third stress invariant on plasticity to the modeling of structural steel.

Throughout his career, Kaspar Willam played a pivotal role in international research collaborations. He chaired the ASCE/ACI Committee 447 on Finite Element Analysis of Reinforced Concrete Structures and served on the editorial boards of several leading scientific journals. Willam's numerous projects were funded by NSF, AFOSR, WES, FHWA, DFG, CASI and the European Commission. He was very active in ASCE, ACI, ASME, USACM and EURO-C. In 1999, Willam organized the US National Congress on Computational Mechanics (USNCCM) in Boulder and in 1984 he was the organizer of FraMCoS-5 in Vail, Colorado (the conference skiing competition that he organized had to be cancelled because of rain). He published over 160 peer-reviewed journal articles and presented more than 140 keynote and invited lectures. His leadership in the USNCCM, in the EURO-C conference series hosted by TU Vienna in top mountain resorts, and in the international conferences on Fracture Mechanics of Concrete Structures (FraMCoS), fostered global research partnerships. Kaspar Willam's impact was recognized through several prestigious awards, including the Nathan M. Newmark Medal (2003), the Alexander von Humboldt Research Award (1998), Science Award of the Japan Society for the Promotion of Science, Japan (1992) and the election to the US National Academy of Engineering in 2004. The University of Houston established the Kaspar J. Willam Professorship in the Civil Engineering Department.

Beyond his scholarly achievements, Kaspar was a mentor and a visionary educator. Known for his intellectual generosity and unwavering dedication to his students, he inspired a generation of engineers and researchers. He was a very kind and charming person with a great charisma. Always friendly and smiling, never one word too sharp, even in scientific disagreements. He made everyone around him feel better while encouraging hard work. His passion for knowledge extended beyond academia – his love for the mountains and skiing was a lifelong pursuit, and he often merged academic conferences with alpine adventures, typically including technical discussions on ski lifts. Skiing or hiking in Colorado where the snow resembles dry champaigne and the skies are blue, he shared adventures with his friends who, without his company, would not have risked skiing the out-of-bound bowls in Breckenridge, going down the untouched powder snow bowls at Whistler or make it safely in the summer to the top of Longs Peak. At the EURO-C conferences, regularly held in top Austrian mountain resorts, Willam always participated in the mid-conference ski competition, placed among the top three in his age category, and draw laughter with anecdotes during the apres-ski in a bier pub.

Many scientific colleagues came to celebrate his 60th birthday in December 1960 in his hometown Bezau (where the locals still called him “Kashpi”). Subsequently, in March 2001, Ekkerhard Ramm, with colleagues from Evanston, TU Kaiserslautern and UPC Catalonia, organized in his honor a 60th birthday workshop at the Soellerhaus in Hirschegg, Kleinwalsertal, Austria (also a skiing destination). All the papers presented there were published in a special issue of IJES edited by Bažant, Steinmann and Carol. At the occasion of USNCCM-9 in San Francisco in 2007, Ekkehard Ramm and Karl Pister organized a Dinner in Willam’s honor.

Willam’s ability to cultivate an environment of collaboration and inquiry ensured that his legacy would continue through the work of his students and colleagues. He will be remembered for his kindness, mentorship, and passion for advancing knowledge. The FraMCoS XII conference, held in April 2025 at TU Wien under the chairmanship of Bernhard Pichler, is dedicated to his legacy, ensuring that his pioneering work remains at the forefront of engineering science.

Kaspar J. Willam was laid to rest in Bezau. His legacy will continue to inspire future generations of researchers and practitioners in civil engineering.

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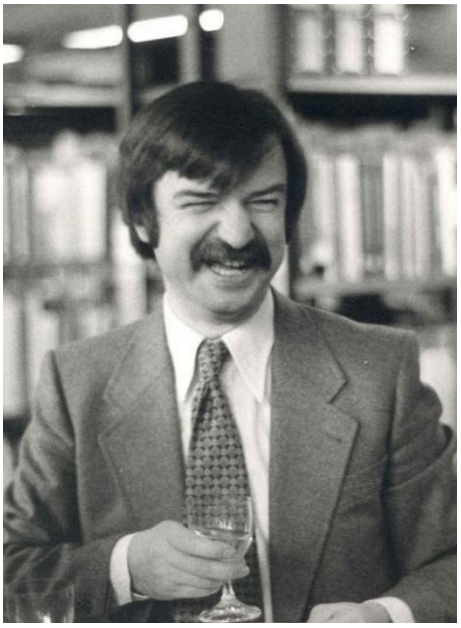
A few images.



1 At ISD 1991

2 With Argyris, 1971

3 With his students and co-workers in front of Engineering Bldg, CU-Boulder, Fall of 1992

4 At the top of Peak 8, Breckenridge (CO), early 90s

5 With some students, co-workers and colleagues outside Two-Elk Cafeteria at Vail (CO), Early 90s.


6 At the top of Whistler Mountain (Canada) after the Vancouver ACI Spring convention, 1993.

7 With Farhat & Felippa IASS- IACM Conf. Salzburg 2005

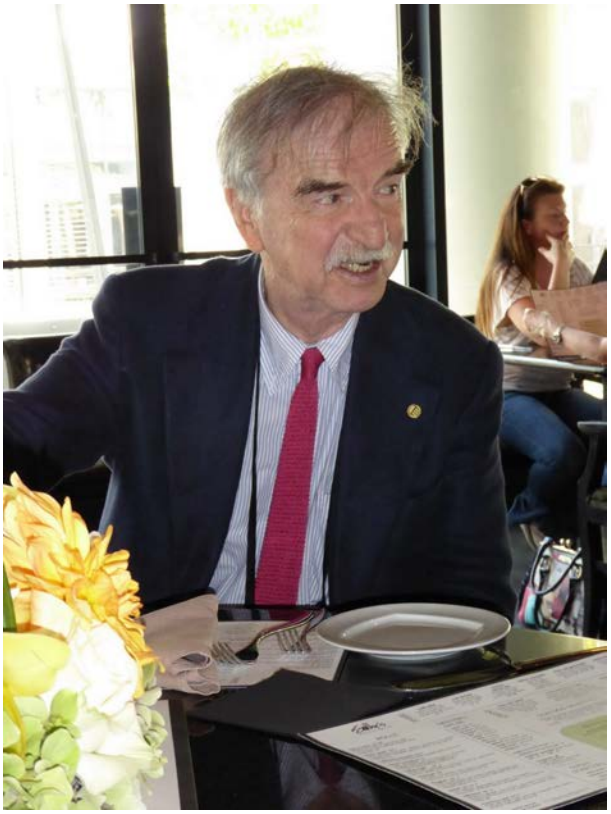

8 With Pister, Farhat and Belytschko, 2007 USNCCM San Francisco.

9 With Carol, Etse, Cervenka V. and Ozbolt, EURO-C 2010 Schladming.

10 Getting ready for ski race in EURO-C 2010 Schladming

11 With Oliver, Bazant and wife, and Ramm, EURO-C 2010 Schladming.

12 With Meschke, Carol, Huespe, Gálvez, Oliver and Ramm, EUR O-C 2014 St Anton.



13 At Karl Pister 90 USNCCM San Diego 2015