
Egor P. Popov

EGOR P. POPOV

1913–2001

Elected in 1976

"Contributions in mechanics of solids and the inelastic cyclic behavior of structural systems."

BY ROBIN K. McGUIRE

EGOR PAUL POPOV passed away on April 19, 2001, in Berkeley, California, at age 88. He was born February 6, 1913, in Kiev, then part of the Russian Empire. He and his family escaped to Manchuria in 1921 during the Bolshevik Revolution, and from there went to Shanghai before emigrating to the United States in 1927.

His family settled in San Francisco, and in 1929 Popov entered the University of California, Berkeley, where he studied civil engineering and graduated with honors in 1933. He received a scholarship for graduate studies at the Massachusetts Institute of Technology and obtained his MS degree in civil engineering in 1934. He was then awarded a scholarship to the California Institute of Technology and moved to Pasadena to pursue his doctoral degree.

He studied under Theodore von Kármán and taught courses as a graduate student from 1935 to 1937. He was advised, however, that his approach to engineering was more mathematical than practical and that he would be better suited to study under Stephen Timoshenko at Stanford University. He left Caltech and worked for eight years in southern California, doing structural analysis and design for numerous public and private concerns. This work experience qualified him for registration in California as a mechanical engineer and a civil engineer with structural authority as well as a general contractor. Using the latter credentials, he constructed his own house in San Gabriel.

In 1945 he contacted Timoshenko and explained that he wanted to pursue a dissertation in civil engineering. The Stanford faculty accepted his graduate course work at MIT and Caltech as sufficient, and Popov immediately began work on his dissertation under Timoshenko. He received his PhD degree in civil engineering and applied mechanics in the summer of 1946 and was offered and accepted a position as assistant professor at UC Berkeley.

Popov was instrumental in establishing a PhD program in civil engineering at Berkeley. Mihran Agbabian was the first PhD graduate in civil (structural) engineering in 1951 and founded his own consulting engineering company and become chair of civil engineering at the University of Southern California. Popov was promoted to professor in 1953 and mentored 34 PhD students during his tenure at UC Berkeley.

In his early efforts developing engineering course material, Popov perceived that available textbooks were not sufficient in engineering mechanics, so he wrote and published *Mechanics of Materials* (Prentice Hall) in 1952. It was adopted as an engineering textbook at many universities in the United States and was translated into several languages for use in foreign engineering programs. A second edition was published in 1976.

Burgeoning interest in structural mechanics education prompted the Civil Engineering Department at UC Berkeley to create a new division in 1958 for structural engineering and structural mechanics, of which Popov was the first chair. He was also the director of the Structural Engineering Laboratories in the Civil Engineering Department, indicating his interest in evaluating theoretical results using test structures.

He developed theoretical methods to predict the behavior of shell structures, particularly for buckling failures, and these methods led to advances in the design and construction of water storage tanks and airplane hangars. He became active in the International Association for Shell Structures and organized and chaired the 1962 World Conference on Shell

Structures in San Francisco, attended by more than a thousand engineers from around the world.

His work on shell buckling prompted the National Aeronautics and Space Administration to ask him to resolve buckling problems related to its large (120 ft tall, 60 ft diameter) vacuum chamber in Houston in the 1960s. The chamber was designed to mimic conditions expected during a moon landing and to test equipment that would be used in that effort. At the time, finite element solutions were not available for three-dimensional curved structures, but Popov achieved a solution using a finite element analysis for a flat surface with ribs and calculating the equivalent forces for a curved surface with ribs. NASA implemented the solution and the vacuum chamber performed as required.

In 1968 he published a second book, *Introduction to Mechanics of Solids* (Prentice Hall). He also published numerous technical papers on nonlinear mechanics and constitutive properties. Among these were "Constitutive Relations for Generalized Materials" and "Cyclic Metal Plasticity: Experiments and Theory," both coauthored with PhD student Hans Petersson in the *Journal of Engineering Mechanics*, in 1977 and 1978 respectively.

Popov continued applied research on nonlinear response of structures, initially studying the cyclic, nonlinear behavior of reinforced concrete structural members and systems, and then steel structural members and systems. For the latter he conducted experiments and analyzed the connections of steel beams and columns, both welded and bolted. He also developed methods to use friction devices to retrofit existing structures, thereby increasing their seismic safety. His methods to avoid structural failures were adopted in the design of the Alaska pipeline and the San Francisco–Oakland Bay Bridge. The American Iron and Steel Institute supported much of his research and published his results in its *Bulletins*.

Popov was one of the few faculty members at UC Berkeley who was a registered structural engineer in California (in addition to being a registered civil engineer and mechanical engineer). His relationships with other practicing engineers—among them Navin Amin, Henry Degenkolb, Nick Forell, Ron Hamburger, Clarkson Pinkham, and Mark Saunders—led to his election as president of the Structural Engineers Association of Northern California (1983–1984).

Through these contacts, Popov developed an interest in analyzing and testing eccentrically braced frames (EBFs) and applied that knowledge to evaluate and improve the seismic design of numerous structures. He recognized that EBFs had been used for many years in structures to provide lateral resistance to wind loads, but those applications required the braces to perform elastically. The use of EBFs to resist lateral loads from earthquake shaking was first investigated by Popov and Charles Roeder, one of his PhD students, in the 1970s. They recognized that EBFs had an advantage over other methods of lateral-load resistance by both absorbing energy through inelastic response and reducing nonstructural damage by limiting interstory displacements.

Popov's interactions with practical engineers revealed several important lessons for his research. One was that testing specimens using numerous low-strain nonlinear tests did not give good predictability of structural behavior during large-strain, limited cycle motions. Another was that large-scale, not just small-scale, specimens needed to be tested in the laboratory. A third was that steel beam-column assemblages need to be joined with full-penetration welds. These lessons provided insights into how real structures perform when subjected to high loading conditions inducing large strains, conditions that were not well understood.

Testing EBFs at UC Berkeley was limited by the size of testing equipment to one-third scale frames. Popov participated in a joint US-Japan research effort, with US funding from the National Science Foundation, in which full-scale testing was conducted at a test laboratory in the Japanese city of Tsukuba. There, a full-scale EBF connection was constructed where the brace was attached to the beam using a welded T-connector. Popov predicted that the web of the T-connector would fail under compression and thus would be the weak link in the EBF. This failure mode was confirmed by full-scale testing at the Tsukuba test facility, leading to changes in the seismic provisions of building codes for EBF steel structures.

Popov retired from UC Berkeley in 1983 and was subsequently recognized with the title Professor of the Graduate School, which allowed him to continue research with funding from the university. He studied methods to improve the behavior of steel and reinforced concrete structures during earthquakes, using improved design of both structural connections (by welding and high-strength bolts for steel structures, and details of steel reinforcing for concrete structures) and structural bracing. He published his third book, *Engineering Mechanics of Solids*, in 1990, with a 2nd edition in 1999 (both published by Prentice Hall).

Popov's students and colleagues recall his dedication and passion for teaching.[1] In 1977 he received UC Berkeley's Distinguished Teaching Award, presented to "individual faculty for sustained performance of excellence in teaching . . . [that] incites intellectual curiosity in students, inspires departmental colleagues, and makes students aware of significant relationships between the academy and the world at large." That same year his colleagues organized a symposium on structural engineering and structural mechanics, supported by the NSF, to honor his 30 years of teaching at UC Berkeley. And in 1983 he was awarded the Berkeley Citation, which recognizes individuals "whose attainments significantly exceed the standards of excellence in their fields and whose contributions to UC Berkeley are manifestly above and beyond the call of duty."

For his many contributions to the field of structural engineering, Popov was elected to the National Academy of Engineering in 1976 and received many awards for his research, including the American Society of Civil Engineering's Nathan N. Newmark Medal (1981) and Norman Medal (1987), and the Earthquake Engineering Research Institute's George W.

[1] The author became acquainted with Prof. Popov in 1968–1969 while a graduate student in the SESM Department at UC Berkeley, and was impressed with his friendly, caring approach toward all graduate students, even those not studying under him.

Housner Medal (its highest honor) in 1999. In 2006 the Applied Technology Council posthumously recognized him as Top Seismic Engineer of the 20th Century.

All who knew Egor Popov remarked on his strong marriage with Irene, whom he met in Los Angeles and married in 1939. Irene provided personal support as well as secretarial services for Egor, typing his manuscripts for books and papers. This was no small effort, in the days when typing was done with a manual typewriter and she had to insert Popov's many (handwritten) equations. Egor and Irene Popov raised two successful children, Kathy and Alex.

Irene passed away in 1994. Popov was survived by a brother, Nicholas Popov of Santa Rosa, California (recently deceased); daughter Katherine Crabtree of Medford, Oregon; son Alexander Popov of Anna, Illinois; six grandchildren; and eleven great-grandchildren (there are now 16 great-grandchildren).