

# AKELLA KAMESWARA RAO

(17 September 1929 – 1 December 2005)

*Biog. Mem. Fell. INSA, N. Delhi* 31 131-140 (2007)





Akame Swamish





# AKELLA KAMESWARA RAO

(1929-2005)

Elected Fellow 1987

## EARLY LIFE, EDUCATION AND FAMILY

**A**KELLA KAMESWARA RAO ("AKR" to his students and colleagues in India and "Kamesh" to his friends abroad) was born on 17<sup>th</sup> September, 1929, in Madras, India. His parents, Akella Kasipati and Venkatalakshamma, moved from Kakinada to Madras where his father, a self-taught entrepreneur, built a successful family business in pharmaceuticals, banking, exports and imports. Born in well to do circumstances, AKR had to deal with the double tragedy of losing his father and the family holdings by the age of 12. This seminal event shaped AKR: a rare generosity, tremendous self-confidence, a "can-do" attitude, and an entrepreneur's eye that always looked at both the technical and business aspects of a problem. AKR often recollected that his father molded him during this brief period - instilling a love of books and a strong sense of fairness and integrity.

AKR had his schooling in Madras and Andhra. A brilliant student, he was first in the Madras Presidency in the SSLC exam. He then topped the Andhra University in the Intermediate exam in 1945 and was awarded the Sir R Venkataratnam Naidu Gold Medal. He earned a dual degree in Mechanical and Electrical Engineering from the Banaras Hindu University in 1949. Independence era heroes Pt. Madan Mohan Malaviya and Vice-Chancellor Sir Sarvepalli Radhakrishnan helped combine the can-do attitude with a fierce sense of national pride that defined the adult AKR. AKR then earned his post-graduate DIISc in Aeronautics from the Indian Institute of Science (IISc) in 1951, topping his class again. He worked in the Department of Civil Aviation under his mentor, Dr PS Nilakantan. Deputed by the Government of India on an Assam Oil Co. scholarship in 1954, AKR received his DIC and Ph D in 1958 from London University's Imperial College of Science and Engineering. His thesis on Load Diffusion and Stress Concentration was advised by Professor JH Argyris, who pioneered the development and use of the Energy Theorems and Finite Element Methods in solving structural engineering problems.

AKR married Challa Krishna Kumari, the daughter of Mahalakshmi and CVS Narasimha Rao (a PWD Superintending Engineer), in 1953. Mrs AKR played a crucial role through the rest of his life - unhesitatingly supporting AKR as he took on numerous challenges and welcoming his students and their young spouses into the AKR's extended family. As Professor AKR's first doctoral student, Professor NS





Venkataraman, put it at AKR's retirement party: "... A recollection that stands out in my mind of my doctoral days is that of the excellent coffee that Mrs Rao would ply us with as we regularly worked into the early hours of the day! Without the coffee, I am sure the quality of my thesis would have suffered..."

Mrs and Professor AKR had three sons and a daughter: Ramakrishna (married to Janaki) is a Professor at the University of California, Santa Cruz, Vasanta (married to Sesi; son Anjaney) is a Software Engineer at Cisco, Prasad (married to Surekha; son Chirag, daughter Pooja) is Chief Technology Officer at Cydelity, and Srinivas (married to Jayasri; son Pranav) is an Assistant Professor at Rensselaer (RPI). To the kids growing up on the IISc campus, Professor AKR's Structures Lab was an extension of their home – especially since AKR spent long hours at work and loved to have them around him.

## PROFESSIONAL CAREER

AKR joined the Government of India's Department of Civil Aviation as a Technical Officer, Grade I, in 1951 and worked there till 1954. In this period he worked very closely with Dr PS Nilakantan who subsequently founded the National Aerospace Laboratories and became its first Director. In his first job, AKR was responsible for type certification procedures for new aircrafts and their components. It is here that he got his first exposure to the complexity of aerospace structures.

After his Ph D in Imperial College, London, UK, AKR worked for two years as a Senior Design Engineer in Folland Aircraft Ltd. UK. He was responsible for developing design standards to meet fatigue performance requirements – techniques that were used in the design of the GNAT fighter and trainer aircraft (and, subsequently, to the Harrier V/STOL attack fighter). For one who remembers the Indo-Pak wars of the 1960s, Indian Air Force pilots made this tiny aircraft out-manoeuvre the US made Sabre Jets.

In 1959, AKR returned to the Indian Institute of Science as an Assistant Professor in Aerospace Engineering, becoming a Professor in 1967, a Senior Professor in 1973 and the KSIIDC Chair in the 1980s; he continued to work there till his retirement in 1990. During this period, he developed an outstanding school of graduate studies in structural engineering and design. The group working with him was known for its exceptional contributions to teaching, research and consultation on structures in aerospace, nuclear, and many other engineering fields. He developed new lines of research and a series of new graduate courses. In the 1960s, he collaborated with Professor AA Lebedinsky of the Moscow Aviation Institute to create an extensive course in Aircraft Design and developed this into a textbook still in use. During 1970-71, he worked as Dean of Faculty of Engineering at IISc and during this period he initiated changes in evaluation methods and a novel system of course credits. He supervised 25 Ph D theses and more than 50 Masters' theses at





IISc. He was a Commonwealth Special Visitor Invitee in Australia through the Colombo Plan in 1966 and a Leverhulme Fellow in Australia in 1970. He traveled extensively abroad as a Visiting Professor and to attend international conferences. Special mention should be made of the close links he established with Lockheed International Research Institute, Atlanta; NASA Langley Research Center, Hampton; and Boeing Aircraft Company, Seattle, all in USA.

In the post-retirement period, Professor AKR worked as a CSIR Scientist Emeritus at the National Aerospace Laboratories, Bangalore, as Director of the Engineering Staff College of India, Hyderabad, and as Advisor, Learning Technologies, Satyam Computer Services Limited, Hyderabad. The last few years of his life were spent with his children and grandchildren in California's Silicon Valley and working with the IISc Alumni Association of Silicon Valley. Interestingly, his last contribution to IISc was sparking the spin-off of IISc technology via two Silicon Valley startups: Trident Metrology and Zepher.

## RESEARCH ACHIEVEMENTS

Professor AKR distinguished himself in the field of Aerospace Engineering at the National and International level. He was a passionate researcher who exhibited remarkable width and depth in his understanding of the science and technology relevant to the Aerospace field and versatility in his approach to problem solving. He benefited immensely from the in-depth knowledge of the needs of the Aerospace industry he acquired while working in Civil Aviation (DGCA) and during his post-PhD work at Folland Aircraft Ltd., UK. With this background, he decided that his research in engineering should enhance the quality of technology and benefit the nation. He always advocated and personally chose research areas of interest where he could demonstrate a basic understanding of physical phenomenon and quickly translate this understanding to solve the practical issues of the industry. His teaching and research career in Aerospace Structures and Design in IISc's Department of Aerospace Engineering was full of scientific excitement created by a team of his students and colleagues. He inspired his students to rise beyond personal interests and work for the benefit of Aerospace in our country. A large number of his master's and doctoral students rose to occupy leading positions in National projects over the past 3-4 decades.

### Basic Elasticity Solutions

Professor AKR's thesis work at the Imperial College, London, was on the development of basic elasticity solutions for aerospace components; he continued this work with his first few students. His thesis was on load diffusion in the stiffened panels and identified stress singularities in the domain. His first few students worked on the torsion of non-circular bars, bending of thin plates and orthotropic





panels under in-plane loading. He extensively employed the well known corner functions for the analysis of singular fields in these domains. He extended this work to analyze singularities as interface corners between dissimilar materials. Fundamental studies here led to the identification of a polygon – circle paradox in the theory of bending of plates. These were extensively published in 1960s and early 1970s.

### **Studies on Structural Integrity**

The advent of composite materials for aerospace structural applications and fracture mechanics as a mandatory design requirement provided him the opportunity to utilize his mastery of finite element methods (developed while working with his Guru Professor Argyris) in an emerging technology. As early as 1970-72, he supervised a thesis on the exact three-dimensional solution for laminated composite structures using displacement solutions, work that has been extensively cited over the past 30 years.

Structural integrity of large scale aerospace structures is primarily dependent on the strength of joints. Fastener (or riveted) joints are the most common types of detachable joints and bonded joints are the most preferred semi-permanent joints. Bonded joints became more popular with the advent of composite structures. Professor AKR, along with his colleagues, worked with a number of research students to develop a basic understanding of the mechanics of these joints, and to develop prescriptive solutions to these problems which were considered intractable till then. They also conducted essential experimental studies to validate these solutions and the assumptions behind them. The stunning development of the inverse formulation for pin joints is the highlight of this work. This formulation cleverly presented the analysis and results for interference, push and clearance fits in fastener joints in a unified manner. This has been acclaimed as an outstanding development by his peers. Effects of friction in fastener joints, concise presentation of the behaviour of joints subjected to thermal environments, design concepts such as tapered adherends and controlled non-linearity of the adhesive and use of bonded pin are typical examples of useful developments in the comprehensive study on structural joints.

### **Acoustic Emission**

Professor AKR realized in the early 1970s that online monitoring using non-destructive testing was crucial for ensuring structural integrity. Picking up Acoustic Emission (AE) as a possible technique for this purpose, he quickly recognized the inadequacies of current methodologies. The studies conducted by Professor AKR and his associates led to the use of signal analysis and pattern recognition to enhance





the capability of AE and increase the confidence of this technique in a variety of applications.

### ***Finite Element Methods***

Professor AKR pioneered research and teaching in the field of finite element methods in India. Starting with his experience in continuum mechanics and FEM, he developed an excellent hybrid – continuum finite element approach that was found to be effective for problems of stress concentrations, fracture mechanics, and short fibre composites. He carried out convergence studies leading to establishing bounds on errors for approximate finite element solutions. Industrial interactions led to the development and transfer of customized software to Bharat Electronics Ltd, Nuclear Power Corporation and Vikram Sarabhai Space Centre.

### ***National and International Acclaim***

Lockheed Aircraft Company, USA, sought out Professor AKR to be a valued and distinguished consultant to develop Acoustic Emission for in-flight monitoring, as did Boeing Aircraft Company on aspects related to Aircraft Design; both these requests were based on studying his research publications. In the 1970s, Lockheed funded an International research project on mechanically fastened joints in Professor AKR's laboratory at the Indian Institute of Science. It is interesting that such an international project as early as the 1970s was a forerunner to the present day outsourcing of engineering services to India. Professor AKR firmly believed, and proved with his work and that of his team, that India could do high quality work with Indian facilities on an Indian budget.

The Chief of the Air Staff of Indian Air Force recognized the value of Professor AKR's pragmatic approach to high quality research and posted, for the first time, two senior officers to work towards their Ph D degrees. They did outstandingly well developing new lines of work for the Air Force. Viewing certain aspects related to systems engineering in relation to aircraft, Professor AKR developed lines of research dealing with the interaction of maintainability, reliability and design.

### ***Work in Later Years***

In later years, Professor AKR concentrated on engineering education and improved the methods used in continuing education. He developed the Engineering Staff College of the Institution of Engineers at Hyderabad into an institution for training working engineering officers via new courses on the modern developments in Science and Technology. Satyam Computers Services Limited, looking to develop large numbers of good software engineers arriving from diverse backgrounds, had the benefit of his advice on learning technologies for a couple of years.





## HONOURS AND AWARDS

Professor AKR was elected an Honorary Fellow of the Aeronautical Society of India (AeSI), the Astronautical Society of India, the Indian Society for Non-Destructive Testing (ISNT), and the Indian Society for Advancement of Materials and Process Engineering (ISAMPE); Fellow of the Indian National Science Academy, the Indian National Academy of Engineering, Institution of Engineers, India, and the Andhra Pradesh Academy of Science; and an Associate Fellow of the American Institute of Aeronautics and Astronautics. He contributed significantly to the Aeronautical Society of India (AeSI), growing the reputation of its Journal as the Editor and serving as President of this premier professional society during 1990-1992. He was awarded the National Aeronautical Prize by the AeSI in 1989 in recognition of his exceptional contributions to Research and Teaching in the field of Aeronautics. He was also the Founding President of ISAMPE, Founding Chairman of the Acoustic Emission Working Group of India, President of the Indian Society for Theoretical and Applied Mechanics and of the Indian Society for Non-Destructive Testing.

In the Indian Institute of Science (IISc), Professor AKR held the prestigious KSIIDC Chair for Mechanical Sciences for 3 years. He delivered several endowment and keynote lectures: the Biren Roy Lecture at the Aeronautical Society of India in the presence of the Prime Minister of India, the BR Seth Memorial Lecture at the Indian Society for Theoretical and Applied Mechanics (ISTAM), and at the UNESCO-COSTED Conference on Technical Education. His contributions to the development of modern India were recognized by the Watmull Foundation which awarded him its *Honour Summus* Gold Medal and the Acoustic Emission Working Group which awarded him its First Gold Medal.

## AKR AS A PERSON

Professor AKR provided abundant confidence to anyone who approached him with issues, problems or requests for advice in organizing events or for planning their professional career. His uncanny ability to discuss the pros and cons of a variety of situations made him a most desirable person to talk to for a wide range of people. His students, colleagues, friends, neighbours and relatives all greatly valued a discussion with him, even if short, particularly when they needed to take critical decisions in their lives. Professor AKR often sacrificed his personal time to talk to people, providing them an opportunity to be heard and helping them execute their chosen solution. For a large number of students of Professor AKR, he was an ICON. He helped several students in need.

For his thesis students, it was always a great pleasure spending time with Professor AKR on their work. In between serious discussions on their research topic every one of his students marveled at their Guru analyzing a high level mundane topic such as the stock market, assessing quality of diamonds, traveling efficiently





with Visit USA (VUSA) tickets, issues in education, politics or problems facing the nation, and the role of organizations such as Rotary. He could quickly size up any situation and his masterly and insightful analyses left the listener with the sense of interacting with a maestro who had worked at various levels and for several years on these very divergent issues.

Professor AKR was a Rotarian in the prestigious Rotary Club of Bangalore North, serving as its President and as a Paul Harris Fellow. He was highly regarded by his distinguished business colleagues in the club for his professional brilliance. He contributed generously to the activities of Rotary Bangalore North. When he sold some of his property in Bangalore, he generously contributed to IISc's Department of Aerospace - instituting a medal and supporting its academic activities.

He loved children and photography and combined these interests by capturing the moods of young children in his pictures. He loved gadgets, collecting the best in audio-visual equipment and kids toys.

### ACKNOWLEDGEMENTS

The author takes this opportunity to thank Mrs Krishna Kumari and her children Ramakrishna, Vasanta, Prasad and Srinivas for providing information about Professor AK Rao's early life and helping in the preparation of the manuscript. Special thanks to Prasad who provided timely information.

B DATTAGURU, FNAE

Department of Aerospace Engineering

Indian Institute of Science

Bangalore-560 012

E-mail: datgur@aero.iisc.ernet.in

### BIBLIOGRAPHY

During his career, Professor AKR published nearly 150 scientific papers in journals and refereed conference proceedings. The author has selected a sub-set of AKR's publication which he felt best exemplified the novel and innovative concepts that he developed:

- 1968 (With RAJIAH K) Polygon-circle paradox of simply supported thin plates under uniform pressure *AIAA Vol 6 No 1* pp 155-156
- Stress concentration at interface corners *12th Int Cong of Appl Mech Stanford USA*
- 1969 Accurate determination of interference in pin joints *Experimental Mechanics Vol 9 No 1* pp 45-48
- (With DATTAGURU B) Stress Concentration and load diffusion in rectangular panels with constant stress flanges *Appl Sci Res Vol 20 No 1* pp 326-337
- 1970 (With SRINIVAS S and JOGA RAO CV) An exact analysis of vibration of simply supported homogenous and laminated thick rectangular plates *J Sound and Vibration Vol 12 No 3* pp 187-199





- 1970 (With SRINIVAS S and JOGA RAO CV) Some results from an exact analysis of thick, laminated plates vibration and buckling *J Appl Mech* **Vol 37** pp 868-870
- (With SRINIVAS S) Bending vibration and buckling of simply supported thick orthotropic rectangular plates and laminates *Int J Solids and Structures* **Vol 6 No 3** pp 1463-1481
- 1971 Stress Concentrations and singularities at interface corners *ZAMM* **Vol 51** pp 395-406
- (With RAJU IS and KRISHNAMURTY AV) A powerful hybrid method in finite element analysis *Int J of Num Meth in Engng* **Vol 3 No 3** pp 389-403
- 1972 (With RAO GV and KRISHNAMURTY AV) Bounds for eigenvalues in some vibration and stability problems *Int J Num Meth in Engng* **Vol 5 No 2** pp 237-242
- 1973 (With DATTAGURU B, RAJIAH K and VENKATARAMAN NS) Determination of stresses due to discontinuities in finite plates of isotropic and orthotropic materials Paper M5/2 **Vol 5-Part M Proc 2nd Int Conf on SMiRT Berlin**
- (With MURTHY MVV and RAO KP) Accurate determination of stress concentrations around elliptical holes in cylindrical shells Paper G2/1 *Proc 2nd Int Conf on SMiRT Vol 5 - Part G Berlin*
- 1976 (With DATTAGURU B) In-plane stresses in Edge stiffened swept panels *AIAA J* **Vol 14 No 8** pp 1038-1041
- Elasto-Mechanics of Composites Invited Lecture at the 18th Polish Solid Mechanics Seminar Wisla
- 1977 (With RAMACHAND K and SARMA VVS) Queueing models for estimating aircraft fleet availability *IEEE Trans on Reliability* **Vol R-24 No 4** pp 253-256
- 1978 (With RAMAMURTHY TS) Shaping of adherends in bonded joints *Int J Mech Sci* **Vol 20** pp 721-727
- 1979 (With ESHWAR VA and DATTAGURU B) Partial loss of contact in interference fit pin joints *Royal Aero Soc* pp 233-237
- (With DATTAGURU B and MURTHY CRL) Multiparameter characterization of acoustic emission signals *Proc of the Int Conf on Fract Mech in Eng Applns* Bangalore pp 26
- (With SARMA VVS and RAMCHAND K) System analysis for planning of airfleets and maintenance facilities *Proc of Ind Acad of Sci Sec C Engng Sci* **Vol 62** pp 243-261
- 1983 (With RAMAMURTHY TS, KRISHNAMURTY AV and RAO GV) Bounds and error control in eigenvalues. Feature Lecture *Proc Tokyo Seminar on Finite Element Analysis* pp 305-322
- 1984 Finite Element analysis of moving contact in mechanically fastened joints *Nuc Engg and Design* **Vol 78 No 3** pp 303-311
- 1985 (With DATTAGURU B and RAMAMURTHY TS) Finite element determination of contact stresses in engineering problems Special Issue dedicated to Prof J H Argyris *J Aero Soc of India* **Vol 17 No 4** pp 347-355
- (With RAMESH CHANDRA, MURTHY MVV and RAMAMURTHY TS) Analytical estimation of stress intensity factors in patched cracked plates *Engg Fract Mech* **Vol 21(3)** pp 479-494
- 1987 (With MANGALGIRI PD, RAMAMURTHY TS and DATTAGURU B) Elastic analysis of pin joints in plates under some combined pin and plate loads *Int J Mech Sci* **29(8)** pp 577-586
- 1992 (With SINGH RIPUDAMAN and RAMAMURTHY TS) Thermomechanical generalization in joints. On axis pin bearing loads *Nuc Engng and Design* **Vol 135** pp 307-314

