

SRIKANT ANNAVARAPU, Ph.D., P.E., RM-SME, FIE(I), LM-MEAI

Professional summary

- Extensive background in and in-depth understanding of mining and geotechnical engineering, and underground and surface mining methods and operations, including ground stabilization instrumentation, monitoring, and analysis.
- 40 years of experience includes computer assisted ground condition and support system modeling, mine design, and mine planning. He prioritizes safety for all projects and provides a diversity of cost-effective geotechnical and mining method engineering services for mine development and expansion projects in the pre-feasibility stage through to operations phases.
- Areas of specialty include project-specific mine design and evaluation, assessment of appropriate mining technologies and methods, assessment of appropriate ground support and control systems, and preparation of technical reports under CRIRSCO guidelines.
- Core team member of the National Committee for the Reporting of Resources and Reserves in India (NACRI) which developed the Indian Mining Industry Code (IMIC) under the CRIRSCO guidelines.
- Mentor to several entrepreneurs in the application of innovation and technology in mining and geosciences.

Contact Information

Address : 502, Bldg 39C Leverage Greens, Koradi Road, Nagpur, 441111, India
Phone : +91-89459-75548 (Mobile)
e-mail : mgsrikant@gmail.com

Education

- Ph.D., Mining, Geological and Geophysical Engineering, University of Arizona, USA, 2013 – “*Estimating primary fragment size distributions from drill core data*”
- M.S., Mining and Geological Engineering, University of Arizona, 1998
- B. Tech. (Mining Engineering), Indian Institute of Technology, Kharagpur, India, 1980

Affiliations

Society for Mining, Metallurgy and Exploration
Mining Engineering Association of India
Mining, Metallurgical and Geological Institute of India
Indian Society for Rock Mechanics and Tunneling Technology
Institution of Engineers (India)

Major Underground Mining Project Experience (2011-present)

Geotechnical Field Support for Churcha underground coal mine, India (2017-2019): Assessment of ground conditions with instrumentation and site visits for the planning of safe depillaring operations in Churcha underground coal mine. (Project lead: SRK Consulting, India).

Geotechnical Audit of Chuquicamata underground project, Chile (2017): Assessment of stability of underground excavations and adequacy of ground support for large and medium sized excavations at Chuquicamata underground project development under the Chuquicamata Open Pit Copper Mine.

(Project lead: Master Geotech Services LLC, USA)

Geotechnical and Mine Planning assistance for San Rafael Tin Mine, Peru (2015): Assessment of ground conditions for safe recovery of ore pillars in San Rafael Tin Mine. The project involved assessing availability of mineral resources for extraction based on field visits for evaluating the ground conditions in existing workings, planning for extraction sequence to optimize metal recovery from the mine. Debottlenecking to improve ore flow in the mine including suggestions for ore pass path optimization. (Project lead: Amec Foster Wheeler, USA)

Geotechnical Analysis for Stability Evaluation and Mine Planning in Arenal Deep Mine, Uruguay (2014): Development of numerical models for assistance in mine planning and scheduling for underground gold mine extension. (Project lead: Amec Foster Wheeler, USA)

Ground Stability Assessment and Remediation in Cortez Underground Project, Nevada, USA (2011-2015): Evaluation of ground conditions and recommendations for ground support for underground cut-and-fill mine. (Project lead: Amec Foster Wheeler and Stantec, USA)

Geotechnical Feasibility Evaluation of the Minago Deposit (2008), Desktop study for slope design for sublevel stoping operations in Minago Nickel Deposit, Canada (Project lead: Wardrop Engineering Inc., Canada)

Work Experience and Major projects

2008-present

Director, Master Geotech Services Pvt Ltd, Nagpur, India

Independent Mining Consultant

- Teaching Mine Design at VNIT, Nagpur.
- Field Projects
 - Technical support for exploration and mining for iron ore prospects in Raub, Malaysia – MAM Minerals Sdn Bhd., Malaysia
 - Technical Advisor and Mentor, Cojag Smart Technologies Pvt Ltd, Nagpur, India

2015-2018

Associate Professor, Department of Mining Engineering, IIT, Kharagpur, India

- Teaching Mine Design, Bulk Materials Handling Systems and Mineral Economics.
- Field Projects
 - Development of Procedural and Contractual Frameworks for Enabling Exploration Activities in India – SBI Capital Markets Limited
 - Geotechnical Support for Continuous Miner Operations at Churcha Colliery – SRK Consulting
 - Design of Ventilation Systems for 5 MTPA Malanjkhand Copper Project

2008-present

President, Master Geotech Services, Arizona

- Edumine, BC, Canada, 2009-date: Guest Lecturer responsible for the development of an online course on “Introduction to Block Cave Mining” and a webcast on “Geotechnical Inputs to Block Cave Mine Design and Operations.”
- Geotechnical Audit for Chuquicamata Block Cave Project, CODELCO, Chile, 2016
- Turner Gold Project, Josephine Mining, Oregon, 2009-2010: Preparation of the mining section of a NI 43-101 compliant Preliminary Economic Assessment for the project.
- Minago Project, Victory Nickel, MB, Canada, 2008: Preparation of a technical report to support Waldrop Engineering lead studies evaluating the feasibility of various mining methods for developing this orebody.

- Resolution Copper Mine, BHP Billiton / Rio Tinto JV, AZ, USA, 2008: Preparation of a technical report for in-situ / primary fragmentation estimates. The report supported evaluating the feasibility of block caving methods to develop a deep orebody below an inactive mine.

2012-2015

Principal Engineer, AMEC Engineering & Consulting Services, Mesa, Arizona

- Geotechnical and mining engineering review for several projects in surface and underground mining and surface facilities.
- Geotechnical design support for bulkhead in tunnel for Bingham Canyon Mine, Utah
- Geotechnical support for development of a ventilation shaft using ground freezing technique for Leeville Gold Mine, Nevada
- Engineering audit of proposed block cave mine operation at Bingham Canyon, Utah.
- Confidential Project in Arizona, 2012-2013: Project Manager responsible for evaluation of synergy opportunities between a surface heap leach operation and an in-situ leaching project.
- Goldrush project, Barrick Gold, Nevada, 2012-2015: Project Manager responsible for managing a team of engineers in the development of suitable geotechnical information for a scoping level study.
- Johnny Lee Project, Tintina Resources, Montana, 2012-2015: Geotechnical and mining support for scoping level study.
- Project Management for an Exploration project in Zambia, 2014-2015

2010-2012

Consulting Engineer (Geotechnical), Stantec Mining, Tempe, Arizona

- Providing geotechnical engineering support for projects in surface and underground excavations in mining and civil engineering.
- Roosevelt Irrigation District, 2011-2012: Slope stability analyses for excavations around pumping assemblies and assessment of potential damage around pump station and irrigation channels.
- Cortez Hills Underground Project, Barrick, NV, USA, 2011-2012: Project Manager responsible for geotechnical training and evaluation and managing a team of engineers in the development of suitable mine designs and cost estimates for a prefeasibility study. Preparation of mining section of the study report.
- Kamoia Underground Project, Ivanhoe Minerals, Congo, 2011: Project Manager responsible for managing a team of engineers in the development of suitable mine designs and cost estimates for a scoping level study. Development of the mining section of a NI 43-101 compliant technical report.
- Platreef Platinum Project, Ivanplats, South Africa, 2011: Project Manager responsible for managing a team of engineers in the development of suitable mine designs and cost estimates for a scoping level study.
- Pebble East Underground Mine Facilities Definition and Estimation Study, Pebble Partnership, AK, USA, 2010: Responsibilities included preparation of order-of-magnitude evaluations at two production rates for the underground block cave mine at Pebble East and guiding engineers in the development of mine designs and cost estimates for the project.

2008-2012

University of Arizona, Tucson AZ

- Teaching Introduction to Mine Engineering, Underground Mine Design, Mine Surveying and Equipment Operations Technology to undergraduate students.
- Research in fragmentation in block cave mines as part of the dissertation work for the advanced degree in Mining Engineering.

2004-2007

General Superintendent (Underground Geotech), PT Freeport Indonesia, Tembagapura, Indonesia

- Responsible for all geotech activities in the underground mining operations of PT Freeport Indonesia, including ground stability monitoring, rock mass characterization, ground support and excavation design, interaction with mine planning and operations, design and monitoring of dewatering programs
- Responsible for geotechnical data collection for MLZ and Grasberg Block Caves
- Design inputs provided for feasibility reports for DOZ 50K expansion, DOZ 80K expansion and Grasberg Block cave
- Assessment of interaction between planned large mining projects in the district.
- Interaction with universities and government officials regarding geotechnical matters related to underground mines.
- Training of field geotechnical engineers
- Management and administration of 12 engineers and 14 technicians.

1996-2004

Rock Mechanics Engineer, Call & Nicholas, Inc, Tucson, Arizona, USA

- Geotechnical inputs for feasibility and detailed design projects for DOZ Block Cave, ESZ Block Cave, MLZ Block Cave, Grasberg Block Cave and Kucing Liar Block Cave of PT Freeport Indonesia
- Geotechnical inputs for pre-feasibility and feasibility design projects for Big Gossan Mine, PTFI (sub-level stoping), El Dorado Mine, Pacific Rim Mining Corporation (sub-level stoping), Tazadit mine, SNIM (sub-level stoping), Getchell Mine, Getchell Gold (drift-and-fill mining) and Turquoise Ridge Mine, Getchell Gold (drift-and-fill mine)
- Geotechnical data collection (including structural mapping and core logging)

1995-1996

Graduate Research Assistant,

Dept. of Mining & Geological Engineering, Univ of Arizona, Tucson, Arizona.

- Assisted in design, development, and installation of an image processing system for the analysis of size distribution of material on a conveyor belt at an operating mine.

1990-1995

Project Leader, Mine Design Group, National Institute of Rock Mechanics, Kolar Gold Fields, India

- Geotechnical design of underground excavations, including sublevel stopes, blasthole stopes, room-and-pillar mines and cut-and-fill stopes for a large number of Indian mining companies.
- Introduction of new ground support systems and mining methods for improving safety and production from small underground mines
- Rock mechanics field investigations including rock mass characterization, *in-situ* stress measurement, instrumentation for ground stability, design of ground support systems.
- Numerical modeling software used includes BESOL 2D, 3D, EXAMINE, BE-FE, and UDEC.

1989-1990

Senior Systems Analyst, Mining Division, CMC Limited, Calcutta, India.

- Developed algorithms and marketing software modules for mining industry.

1987-1989

Scientist, Central Mining Research Station, Dhanbad, India.

- Research in the stability of excavations in large and small hard rock mines.
- Involved extensive instrumentation and stress analyses for design of mine pillars and support

systems using numerical, analytical and empirical methods.

- Proposals for improving productivity and safety in underground mines.

1984-1987

Mining Engineer, Hindustan Copper Ltd., Mosaboni Mines, Bihar, India.

- Geotechnical investigations and design and testing of support systems.
- Installation, monitoring, and analysis of instrumentation for assessing stability of underground excavations.
- Incorporation of rock mechanics in planning and scheduling of mine operations for safety and economy.

1980-1983

Graduate Research Assistant, Virginia Tech, Blacksburg, USA

- Assisted in Corps of Engineers project for analysis of stability of earth retaining structures with finite element modeling. Developed subroutines for integration into software developed under the project.

List of Publications

Panda, B.B., and **Annavarapu, S.**, “Relationship between compressive strength and index properties of rock”, ARMA 2015: Proceedings of the 49th US Rock Mechanics conference, San Francisco, CA, USA, 2015.

Annavarapu, S., Kumar, P.G., “Development of Drones to Collect Geotechnical Data in Large Underground Mines”, APCOM 2015: Proceedings of the 37th conference on Applications of Computers in Mining, Fairbanks, AK, USA, 2015.

Annavarapu, S., Nicholas D.E., Pratt R.W., and Wellman, E.C. “Prediction of Fragmentation in Block Cave Mine Design – an update of the Core2Frag Program”, MassMin 2012: Proceedings of the 6th International Conference and Exhibition on Mass Mining, Canadian Institute of Mining, ON, Canada, 2012.

Annavarapu S., Desserault S.D., and Kemeny J.M., “Joint spacing distributions from oriented core data”, International Journal of Rock Mechanics and Mining Sciences, Volume 52, 2012.

Annavarapu, S., Momayez, M., Wilson, T.E., and Cronin, A., ‘Geotechnical considerations for the installation of solar panel arrays on mine tailings’, 2009 National Meeting of the American Society of Mining and reclamation, Billings, MT in June 2009.

Momayez, M., **Annavarapu, S.**, Cronin, A., and Wilson, T.E., ‘Use of tailings ponds as solar photovoltaic farms’, 2009 National Meeting of the American Society of Mining and reclamation, Billings, MT in June 2009.

Sahupala, H., Brannon, C., **Srikant, A.**, and Osborne, K., ‘Recovery of Extraction Level Pillars in the Deep Ore Zone (DOZ) Block Cave, PT Freeport Indonesia’, MassMin 2008, Lulea.

Sahupala, H.A., and **Srikant, A.**, ‘Assessment of Pillar Damage at the Extraction Level in the Deep Ore Zone (DOZ) Mine, PT Freeport Indonesia’, 1st Intl Conf on Block and Sub-level Caving, Cape Town, 2007.

Syaifullah, T., Widijanto, E. and **Srikant, A.**, ‘Water issues in DOZ block cave mine, PT Freeport Indonesia’, Water in Mining, Brisbane, 2006.

Arsana, N., Widijanto, E. and **Srikant, A.**, ‘Geotechnical challenges in the DOZ block cave mine’, Asian Rock Mechanics Symposium, Singapore, 2006.

Sinaga, F., Qudraturrahman, I. and **Srikant, A.**, ‘Geotechnical concerns during the development of the AB Tunnels in PT Freeport Indonesia’, Asian Rock Mechanics Symposium, Singapore, 2006.

- Srikant, A.**, 'Fragment size estimation and measurement in the DOZ block cave', Mining Engineering, October, 2006.
- Srikant, A.** and Nicholas, D.E., 'Incorporating reliability based geotechnical engineering into slope design', Advances in Mining Technology and Management, Kharagpur, 2005.
- Srikant, A.** and Nicholas, D.E., 'Assessment of primary fragmentation from drill-core data', MassMin 2004, Instituto de Ingenieros de Chile, Santiago, 2004.
- Srikant, A.**, Nicholas, D.E. and Rachmad, L., 'Visual estimation of fragment size distributions in the DOZ block cave', MassMin 2004, Instituto de Ingenieros de Chile, Santiago, 2004.
- Srikant, A.**, 'Prediction of the limits of the caved zone above a block cave operation', M.S. Thesis, University of Arizona, Tucson, 1998.
- Girdner, K.K., Kemeny, J.M., **Srikant, A.** and McGill, R., 'Split system for analyzing the size distribution of fragmented rock', Measurement of Blast Fragmentation, eds John Franklin et al, A.A. Balkema, Rotterdam, 1996.
- Srikant, A.**, 'New Approaches for the Design of Large Spans in Open Stopes', 6th National Symposium on Rock Mechanics, 15-17 Oct, 1992, Bangalore.
- Srikant, A.**, 'Numerical Modeling for Improving Recovery from In-situ Reserves in Underground Mines' MGMI Paper Session, Chavara, Aug, 1992.
- Srikant, A.**, Babu Rao, Y.V.S., Venkateswarlu, V. and Raju, N.M., 'Rock Bolting and Cable Bolting in Hard Rock Mines in India', Intl Seminar on Roof Support Technology, Calcutta, May 7-8, 1992.
- Srikant, A.**, 'Calibration of Numerical Models in Rock Excavation Design', Workshop on Numerical Methods in Rock Excavation Design, Kolar Gold Fields, Nov 29-30, 1991.
- Raju, N.M., Dasgupta, B. and **Srikant, A.**, 'Geotechnical Considerations in Development of Underground Space', Indo-US workshop on Underground Space, New Delhi, Oct 30 - Nov 2, 1991.
- Niyogi, S.C., **Srikant, A.**, et al, 'Introduction of Split Set Stabilizers in Indian Mines', National Seminar on Underground Metal Mining Practice, Kharagpur, Dec 27-29, 1989.
- Srikant, A.** and Raju, N.M., 'Application of Rock Mechanics in the Planning of Underground Non-Coal Mines', National Symposium on Mine Planning and Design, Varanasi, Nov 3-6, 1988.
- Talwar, A.K., **Srikant, A.** Chattopadhyay, J. and Balbir Singh 'Support of Mine Workings with Cable Bolts', Symp. Innovations and New Technologies for Copper Production in India, New Delhi, Aug 22, 1985.