Kamal C Das

Curriculum Vitae

Computational Geomechanics Laboratory
Department of Mining Engineering
IIT Kharagpur - 721302, India
✆ *947–647–6316*
✉ *iitiankamal@gmail.com*
`http://www.geomechanicskgp.org`

Education

2008–2012 **Indian Institute of Technology Kharagpur**, *Ph.D. in Applied Mathematics*.

Dissertation: Enriched Finite Element Method (EFEM) and Applications in Reinforced Jointed Rock Mass

My thesis work presents a novel numerical procedure incorporating the interaction between rock, joint, grout and bolt to gain a better understanding of the behaviour of rock bolts leading to an improvement in ground support. I have developed extended finite element method (XFEM) in order to incorporate rock joints so as not to force the mesh to stick to the joints surface. The method is extended in such a way that multiple number of discontinuities can be considered and external traction force can be applied on any arbitrary boundary including the surface of the discontinuity. I have invented a new rock-bolt element, called 'enriched finite element (EFE)' for the analysis of coupled and decoupled grouted rock bolt within the finite element procedures. In EFE procedures, mesh refinement and realignment along the bolt axis is not required and thereby, it improves the accuracy of the solution and reduce computational time. In order to study discontinuous rock mass reinforced by fully grouted bolts, a new bolt-crossing joint element, called 'doubly enriched finite element (DEFE)' procedure within the framework of XFEM has been developed by introducing strong displacement discontinuities in the form of rock joints and reinforcement affect in the form of rock bolts.

Advisors: Prof. Debasis Deb and Prof. G. P. Raja Sekhar
Committee: Prof. S. K. Barai, Prof. PVSN Murthy, Prof. S Bhattacharyya

2005–2007 **Indian Institute of Technology Kharagpur**, *M.Sc. in Mathematics*.

2002–2005 **North Bengal University**, *B.Sc. in Mathematics (Honours)*.

Research Interests

Computational Geomechanics.

My research interests lie in the areas of computational solid mechanics and applied mathematics, with emphasis on method development for problems involving fracture and failure of geomaterials and fluid-structure interaction. I have been involved in the development of extended and enriched partition of unity finite element methods for reinforced jointed rock mass. I am particularly interested in developing multiscale methods and their application to computational materials design. Other areas of interest and current research emphasis include

Constitutive Modelling

Material Instabilities, Fracture, Strain Localization

Numerical Methods (FEM, XFEM, Meshfree Methods and Boundary Element)

Computational Fluid-Structure Interaction (flow through porous media)

Experimental Rock Mechanics and Engineering

Research Positions

2007-2010   **Senior Research Fellow**, *Indian Institute of Technology Kharagpur*, Under the supervision of Dr. Debasis Deb.

Development and implementation of extended finite element method (XFEM) for modelling cohesive discontinuities in rock mass. XFEM code is develop at Department of Mining Engineering, IIT Kharagpur for elasto-plastic analysis of jointed rock mass.

2010-2011   **Senior Research Fellow**, *Indian Institute of Technology Kharagpur*, Under the supervision of Dr. G. P. Raja Sekhar.

Boundary integral work bench for viscous flows through porous media. Developed boundary element method (BEM) code at Department of Mathematics, IIT Kharagpur for coupled Stokes and Darcy (or Brinkman) flows.

2011-till date   **Project Manager**, *Indian Institute of Technology Kharagpur*, Under the supervision of Dr. Debasis Deb.

Investigations of bolt behaviour in development and depillaring panels under blast induced dynamic loading. Responsible for theoretical formulation (code development) and experimental validation (laboratory as well as field experiment). Computational inelasticity to develop a more mathematically consistent framework for geomaterials under dynamic loading condition.

Publications

Journal Papers

Deb, D., and **K.C. Das**, 2012. *A new doubly enriched finite element for modelling grouted bolt crossed by rock joint.* International Journal for Numerical and Analytical Methods in Geomechanics, under review.

Deb, D., and **K.C. Das**, 2011. *Generalized symmetric formulation of tangential stiffness for nonassociative plasticity.* ASCE Journal of Engineering Mechanics, DOI. 10.1061/(ASCE)EM.1943-7889.0000487, Article in press.

Deb, D., and **K.C. Das**, and S. Kavala, 2012. *Analysis of excavation shapes on fully grouted rock bolt using EFEM.* Journal of Rock Mechanics and Tunnelling Technology, Vol. 18, No. 1, pp. 15–30.

Deb, D., and **K.C. Das**, 2011. *Modelling of fully grouted rock bolt based on enriched finite element method.* International Journal of Rock Mechanics and Mining Sciences, Vol. 48, pp. 283–293.

Deb, D., and **K.C. Das**, 2010. *Enriched finite element procedures for interaction between fully grouted decoupled rock bolts and rock mass.* International Journal for Numerical and Analytical Methods in Geomechanics, Vol. 35, No. 15, pp. 1636–1655.

Deb, D., and **K.C. Das**, 2010. *Extended finite element method for the analysis of discontinuities in rock masses.* Geotechnical and Geological Engineering, Vol. 28, pp. 643–659.

Deb, D., and **K.C. Das**, 2010. *Bolt-grout interaction in elasto-plastic rock mass using coupled FEM-FDM techniques.* Advances in Civil Engineering, DOI:10.1155/2010/149810.

Deb, D., and **K.C. Das**, 2009. *Extended finite element method (XFEM) for the analysis of cohesive rock joints.* Journal of Scientific and Industrial Research, Vol. 68, No. 7, pp. 575–583.

Deb, D., V.N. Deshpande, and **K.C. Das**, 2008. *Assessment of Water quality around surface coal mines using principal component analysis and fuzzy reasoning techniques.* Mine Water Environment, Vol. 27, pp. 183-193.

Conference Proceeding Papers

Das, K.C., D. Deb, and A.K.Jha, 2012. *An enhanced eumerical pocedure for modelling fully grouted bolts intersected by rock joint.* Proceedings of the 7th Asian Rock Mechanics Symposium (accepted), Paper ID: ARMS2012-104.

Deb, D., **K.C. Das**, and S. Kavala, 2011. *Excavation shape opening effect on fully grouted rock bolt through EFEM procedure.* Proceedings of the 3rd Indian Rock Conference by ISRMTT, INDOROCK-2011, 13th - 15th October, Roorkee, pp. 279–290.

Das, K.C., D. Deb, and G.P. Raja Sekhar, 2011. *Analytical model for fully grouted rock bolts considering movements of rock joints.* Proceedings of the 3rd Indian Rock Conference by ISRMTT, INDOROCK-2011, 13th - 15th October, Roorkee, pp. 187-200.

Das, K.C., D. Deb, and G.P. Raja Sekhar, 2011. *An enriched-FEM model for fully grouted decoupled rock bolts.* Proceedings of the 45th U.S. Rock/Geomechanics Symposium, San Francisco, Paper ID No. ARMA-11-492.

Deb, D., and **K.C. Das**, 2010. *Analysis of fully grouted rock bolt based on enriched finite element method.* Proceeding of ISRM International Symposium 2010 and 6th Asian Rock Mechanics Symposium - Advances in Rock Engineering, October 23-27, 2010, New Delhi.

Deb, D., **K.C. Das**, and S.M.Lee, 2009. *Finite element formulations of fully grouted decoupled rock bolts in Mohr-Coulomb media.* Proceedings of the INDOROCK, Second Indian Rock Conference by ISRMTT, INDOROCK-2009, 12th -13th November, New Delhi, pp. 330-345.

Deb, D., and **K.C. Das**, 2009. *An extended finite element method for modeling cohesive discontinuity in underground excavations.* Proceedings of the INDOROCK, Second Indian Rock Conference by ISRMTT, INDOROCK-2009, 12th -13th November, New Delhi, pp. 316-329.

Deb, D., G.P. Raja Sekhar, and **K.C. Das**, 2008. *Extended finite element method: a novel technique for the analysis of joints and fractures.* Proceedings of the 53rd Congress of The Indian Society of Theoretical and Applied Mechanics (ISTAM-2008), 25th -28th December, Hyderabad, pp. 1-12.

Deb, D., and **K.C. Das**, 2008. *Analysis of joints using extended finite element method.* Proceedings of the Indo-Korean Joint International Symposium on Geoscience and Technology: Utilization of Geospace as a Solution for Energy and Environment (GTEE-2008), 12th -14th February, IIT- Kharagpur, pp. 227-241.

Other papers

Das, K.C., 2011. *Enriched finite element procedures for analyzing coupled and decoupled bolts installed in elasto-plastic rock mass.* Proceedings of the 56th Congress of The Indian Society of Theoretical and Applied Mechanics (ISTAM-2011), 19th -21th December, Surat.

Das, K.C., D. Deb, and G.P. Raja Sekhar, 2010. *An enriched-FEM Model for Fully Grouted Decoupled Rock Bolts.* In *Oral presentation on the 55th Congress of the Indian Society of Theoretical and Applied Mechanics (ISTAM-2010).* 17th -20th November, 2010, NIT Hamirpur.

Das, K.C., and G.P. Raja Sekhar, 2012. *Boundary element formulation for coupled Stoke-Brinkman equation for frees fluid flow through a porous medium.* In *In progress.*

Software Proficiency

2007–2012	**Code Developer**.	Developed a code for analysis of reinforced jointed rock mass. The code is implemented in C++ environment and capable to solve reinforced jointed geo-structure probelm, for example, slope stability, underground excavation etc.
5 years	**Computer Programming**.	Advanced coding skills in C, C++, Mathematica, Maple and Matlab.
5 years	**Modelling**.	Comprehensive knowledge about FEM and experience of finite element programming and very familiar to finite element softwares, including ANSYS, ABAQUS and LS-DYNA.

Teaching assistant

Fall 2009 and 2010   **Computational Geomechanics**, *MI60001*, Department of Mining Engineering, IIT Kharagpur.
This course comprises of various numerical tools for solving problems in rock mechanics and geomechanics. Students gain knowledge about FEM and other computing techniques as a solution to various problems.

Fall 2009 and 2010   **Mathematics I**, *MA10001*, Department of Mathematics, IIT Kharagpur.
Elementary real analysis, Ordinary differential equation, and Complex analysis.

Fall 2010 and 2010   **Mathematics II**, *MA10002*, Department of Mathematics, IIT Kharagpur.
Vector algebra, proper and improper integration, double and triple integration, elementary numerical methods.

Awards

2011   **Young Scientist Award**, *Indian Society of Theoretical and Applied Mechanics (IS-TAM)*.

2010   **Second Best Paper Award in Applied Mathematics**, *Research Scholars' Day, held at Department of Mathematics, IIT Kharagpur*.

2005-2007   **Merit Cum Means Scholarship (MCM)**, *Government of India*.

References Available to Contact

Dr. D. Deb (e-mail:deb.kgp@gmail.com; phone:+91-322-228-3724)
Professor, Department of Mining Engineering, IIT Kharagpur-721 302, India
Dr. Deb was my graduate adviser.

Dr. G. P. Raja Sekhar (e-mail:rajas@maths.iitkgp.ernet.in; phone:+91-322-228-3684)
Professor, Department of Mathematics, IIT Kharagpur-721 302, India
Dr. Raja Sekhar also was my graduate adviser.

Dr. K.U.M. Rao (e-mail:umr@mining.iitkgp.ernet.in; phone:+91-322-228-3716)
Professor, Department of Mining Engineering, IIT Kharagpur-721 302, India
Dr. Rao was head of the department when I was a graduate student.

Dr. PVSN Murthy (e-mail:pvsnm@maths.iitkgp.ernet.in; phone:+91-322-228-3646)
Professor, Department of Mathematics, IIT Kharagpur-721 302, India
Dr. Murthy was a member of my doctoral committee and he coordinates Integral Equations and Variational Methods for Master program in which I was a student.

Dr. S. K. Mukhopadhyay (e-mail:subirm@mining.iitkgp.ernet.in; phone:+91-322-228-3712)
Professor, Department of Mining Engineering, IIT Kharagpur-721 302, India
Dr. Mukhopadhyay has been a valuable interdisciplinary resource to me.