Aalok Kumar Jha

Research Interests

Directionally enriched FEM; approximation, error estimation and adaptivity; dynamic brittle fracture; phase-field modeling; high-strain rate behavior; multiscale modeling of composites; cohesive interfacial modeling; structural dynamics; thermo-viscoplasticity under extreme environments.

Education and Training

Johns Hopkins University, Baltimore, Maryland, USA
Postdoctoral Fellow, Nov 2025
Project title: Micromechanical dynamic fracture propagation in heterogeneous composites using a phase-field model coupled with smeared cohesive interfaces.
Advisor: Prof. Somnath Ghosh (*Department of Civil and Systems Engineering*)

Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh, India
Doctor of Philosophy (Ph.D.), May 2023
Thesis title: Geometrically conforming and directionally enriched FEM (GCFEM) for three-dimensional slender structures under thermo-mechanical loads
Advisor: Prof. C. S. Upadhyay (*Department of Aerospace Engineering*)

Indian Institute of Technology Delhi, New Delhi, Delhi, India
Masters of Technology (M.Tech.), May 2011
Thesis title: Analyses of fully flooded & starved hydrodynamically lubricated point contacts
Advisor: Prof. R. K. Pandey (*Department of Mechanical Engineering*)

Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, Madhya Pradesh, India
Bachelor of Engineering (B.E.), June 2007
Mechanical Engineering

Research Experience

Postdoctoral Researcher, Johns Hopkins University (Nov, 2023 - Nov, 2025)
Advisor: Prof. Somnath Ghosh

- Developed a robust finite deformation computational framework for high strain-rate crack nucleation and propagation in fiber-reinforced composites.
- Employed dynamic brittle phase-field fracture model for bulk damage and smeared cohesive law to capture discontinuity at interfaces.
- Studied stress wave propagation and interactions, effects of microinertia and competition between interfacial decohesion and matrix cracking.
- One of the first studies in literature to experimentally validate very high strain-rate composite material behavior, with potential applications in ballistic protection and automotive crash simulations.

Senior Research Fellow, IIT Kanpur (Jan, 2023 - Nov, 2023)
Principal Investigator: Prof. Abhishek

- Extended my Ph.D. framework to capture torsional modes effectively along with flap, and lag mode in thin, slender structures such as swept helicopter blades.
- Supervised a master's student in performing simulations for design of wing structure in glider assemblies.

Ph.D. Researcher, IIT Kanpur (Jan, 2014 - Jan, 2023)
Advisor: Prof. C. S. Upadhyay

- Conceptualized a novel 3D geometrically conforming and directionally enriched FEM (GCFEM) to reduce analysis error in slender structures by using same mesh for both geometry representation and FE simulations.
- Implemented an efficient Matlab based three-dimensional vectorized code that can handle computations for high resolution meshes.
- Developed a novel adaptive FE-based approximation of geometry for any real-world engineering extruded members, with guaranteed precision.
- Proposed practically relevant novel directionally enriched higher order elements.
- Incorporated general material libraries capable of performing thermo-elasto-viscoplastic analysis, for even high temperature and damage applications.
- Implemented novel tools for a-posteriori smoothing of stress field, adaptive resizing of load-steps and data management.
- Integrated state-of-the-art data visualization features that match any commercial code.
- Nominated for *Best Software Award* and recommended for *Outstanding Thesis Award* for this exceptional work.

M.Tech. Researcher, IIT Delhi (Jul, 2010 - May, 2011)
Advisor: Prof. R. K. Pandey

- Investigated role of lubrication, generation and distribution of pressure in lubricants in concentrated contact regions arising from geometric non-conformity of mating parts.
- Analyzed performance parameters under fully flooded and starved conditions using the finite difference method implemented in Fortran.

Teaching Experience

Assistant Professor, IMS Engineering College, Ghaziabad (Aug, 2011 - Dec, 2013)

- Instructed undergraduate-level courses on Engineering Mechanics, Engineering Graphics, Basic Manufacturing Processes, Fluid Mechanics, and CAD & FEM.
- Developed courses in an interactive manner to encourage student participation while emphasizing concepts through real-world industrial applications.
- Managed classes of approximately 60 students from diverse backgrounds; provided academic support and mentoring to foster inclusion and a strong sense of belonging.

Tutor, IIT Kanpur (Dec, 2016 - Apr, 2017)

- Served as a tutor for ESO202A: Mechanics of Solids for class of 30 students.
- Mentored students in understanding key concepts during tutorial sessions and graded examinations.

Teaching Assistant, IIT Kanpur (Dec, 2014 - Apr, 2018)

- Served as teaching assistant for undergraduate and graduate courses on Mechanics of Solids, Introduction to FEM, Composite Materials, and Design of Aircraft Structures.
- Conducted viva evaluations for course projects involving computational work.

Teaching Assistant, IIT Delhi (Dec, 2009 - Dec, 2010)

- Served as teaching assistant for graduate courses on Bearing Lubrication and Materials for Tribological Elements.

Mentoring Experience

M.Tech. Thesis Mentor, IIT Kanpur (Dec, 2020 - Jul, 2023)

- Co-supervised master's students in collaboration with their faculty advisors
  1. "Structural dynamic analysis of helicopter rotor blade using geometrically conforming FEM"
  2. "Smeared multi-scale thermal analysis of blades with multiple cooling channels"
  3. "Design, analysis, and fabrication of range extension kit for MIG-21 drop tank"
- Provided a detailed walkthrough of my code to support seamless continuation and extension of the work.
- Mentored students by providing conceptual guidance, implementation support, and debugging assistance through regularly scheduled meetings.

Industrial Experience

Engineer, Heavy Engineering Corporation Limited, Ranchi (Jun, 2008 - Jun, 2009)

- Designed critical components and subsystems for Coke Oven units, Wagon Handling Equipment, and Industrial Cranes.
- Reviewed and revised part and assembly drawings to ensure compliance with engineering standards and manufacturing feasibility.
- Processed procurement and marketing inquiry files, supporting supply chain workflow.
- Assessed the technical feasibility of manufacturing as per customer specifications and requirements; performed material estimation for cost analysis and budgeting.
- Contributed to the preparation and publication of monthly planning schedules and performance reports.

Intern, Tata Motors (Jun, 2006 - Jul, 2006)

- Investigated valve leakage in engine test beds in collaboration with the Quality Control team of the Engine Division.
- Identified slight camshaft bending as a major root cause, contributing to possible effective rectification of machining and storage inaccuracies.

Industrial Trainee, Steel Authority of India Limited (Jul, 2005)

- Gained comprehensive exposure to key technical processes across the entire steelmaking chain, from Blast Furnace to final product output.

Honors and Awards

MHRD Scholarship (Jul, 2009 - May, 2011; Jan, 2014 - Dec, 2018)

- Awarded by MHRD, Government of India, while pursuing M.Tech. and Ph.D. studies.

Outstanding Ph.D. Thesis Recommendation (May, 2023)

- Recognized by thesis examination committee for exceptional research contributions.

Best Software Award Nomination (May, 2023)

- Nominated by the Department of Aerospace Engineering, IIT Kanpur, for outstanding software development and innovation in the field.

Leadership, Mentorship and Service

- Communication Chair, Homewood Postdoctoral Association, JHU (2024 – 2025)
- Mentored three Master's students on thesis research during my PhD at IIT Kanpur (2020 - 2023)
- Led Coke Oven Bureau at HEC Ltd., Ranchi; managed operations, process improvements, and team coordination (2008 – 2009)

Technical Skills

- Languages: Matlab, Fortran, C++.
- FEM tools: Abaqus, Ansys, deal.II.
- Other CAE tools: Simmetrix, AutoCad, Inkscape, Tecplot.

Relevant Courses

Introduction to Finite Element Methods, Nonlinear Finite Element Methods, Composite Materials, Aerospace Structural Analysis, Theory of Vibrations, Theory of Plasticity, Solid Mechanics, Fracture And Fatigue, Functional Analysis for Engineers.

Journal Publications

Jha A. K., Upadhyay C. S., 2022. Geometrically conforming and directionally enriched finite element method for three dimensional slender members. *International Journal for Numerical Methods in Engineering, 123(17)*, 4136–4165.
https://doi.org/10.1002/nme.7003

Jha A. K., Ghosh S., Micromechanical analysis of dynamic fracture in heterogeneous composites using a finite-deformation phase-field model with smeared cohesive interfaces. *(To be submitted to the Journal of Composite Structures)*

Jha A. K., Upadhyay C. S., High-precision directionally enriched finite element analysis of an elasto-plastic slender structure. *(To be submitted to the Journal of Finite Elements in Analysis and Design)*

Jha A. K., Upadhyay C. S., GCFEM based analysis of bending-twisting effect on a plastically deforming slender structure. *(In Preparation)*

Jha A. K., Upadhyay C. S., Directionally enriched finite element analysis of a visco-plastic slender structure under extreme loading conditions. *(In Preparation)*

Jha A. K., Upadhyay C. S., Efficient implementation of higher-order finite element for large scale problems using MATLAB. *(In Preparation)*

Conference Presentations

Saxena P., **Jha A. K.**, Upadhyay C. S., GCFEM using generalized fitting of boundary curves. 8^{th} International Congress on Computational Mechanics and Simulation (ICCMS 2022), IIT Indore, India, 09-11 December 2022.

Jha A. K., Upadhyay C. S., Elastoplastic analysis of thin structures using higher order elements. 6^{th} National Finite Element Developer's / FEAST^{SMT} User's Meet (NAFED-2022), VSSC, ISRO, Thiruvananthapuram, India, 4-5 February 2022.

Jha A. K., Upadhyay C. S., 2021. Thermomechanical analysis of twisted blade. 25^{th} International Congress of Theoretical and Applied Mechanics (ICTAM 2020+1), Milano, Italy,22-27 August 2021.

Upadhyay C. S., **Jha A. K.**, High accuracy computations for classical problems in solid mechanics. 66^{th} International Congress of ISTAM, VIT-AP, Andhra Pradesh, India, 3-5 December, 2021.

Upadhyay C. S., Sharath C., **Jha A. K.**, Towards predictive damage models - some recent experiences. 3rd Structural Integrity Conference and Exhibition (SICE 2020) - "Structural Integrity at Multiple Length Scales", IIT Bombay, India, 18-20 December, 2020.

Jha A. K., Upadhyay C. S., Thermoelastic analysis of rotor blade with temperature dependent material properties. 64^{th} International Congress of ISTAM, Bhubaneswar, India, 9-12 December, 2019.

Jha A. K., and Upadhyay C. S., Solving exotic engineering problems – brute force versus elegant modelling and analysis. Euromech Colloquium 600, New challenges in finite element technology – from the perspective of mechanics and mathematics, Aachen, Germany, 12-14 March, 2019.

Seminar Presentations

Jha A. K., Upadhyay C. S., Adaptive analysis based geometry representation in FEM. Research Scholar Day, Department of Aerospace Engineering, IIT Kanpur, 25th March 2018.

Workshops

IIT Kanpur-University of Heidelberg collaborative workshop on DEAL. II : An open source Finite Element Library, Indian Institute of Technology Kanpur, Kanpur, UP India.

High-Performance Computing for Engineering : organized by IIT Kharagpur and Ansys, Indian Institute of Technology Kharagpur, Kharagpur, WB India.

FEniCS HPC workshop : High-Performance Computing Workshop on Materials and Mechanics, Indian Institute of Technology Madras, Chennai, TN India.

MATLAB and TEQIP Workshops, Indian Institute of Technology Kanpur, Kanpur, UP India.