R & D Highlights 2017

Indian Institute of Technology Bombay

Foreword

I am pleased to share with you that the Institute continues to be ranked as one of the top universities of the country and among the best in the world. IIT Bombay attracts the brightest students from the country for its Bachelor's, Master's and Doctoral programmes, and in the 59 years of its existence, close to 50,000 students have graduated from IIT Bombay.

IIT Bombay is in the midst of rapid and exciting change with three big trends: firstly, there has been very rapid growth in student numbers (from 5,300 students in 2009 to more than 10,000), secondly, the Institute has rapidly grown its postgraduate programmes and R&D activity (funds received have grown from almost 5 fold since 2009) and thirdly, there is a huge student interest in entrepreneurship with a vibrant startup ecosystem developing around the campus. The Institute continues to strive for excellence in its core activities of teaching and research in this milieu of change.

Research and development are an increasing focus of activity at the Institute coupled with strong efforts to see that the fruits of the research are translated into commerce through licensing and startups. The Institute has been able to attract outstanding faculty members from not just India but other parts of the globe. The Institute has set up several large multidisciplinary research centres to address complex problems in a holistic way involving researchers from different academic units. The Institute has also been able to further its links with international and national peer universities, enabling it to enhance its research and educational programmes.

The goal is to promote research that makes a difference - a difference to society, to industry and to the profession itself.

Prof Devang V Khakhar
Director, IIT Bombay

▲ Prof Rajesh Gupta – recepient of India-UK Excellence Award 2016

▲ Release of 'Glimpses of Research' by Mr. Sanjai Kohli, Facebook

▲ TechConnect exhibition of IIT Bombay

▲ IITB wins the National Intellectual Property Award 2015

▲ Prof D B Phatak – recipient of Padma Shri Award 2012

IIT Bombay at a Glance

Research and Development (R&D) at IIT Bombay has evolved and flourished over the decades since the Institute's inception in 1958. The synergy of academics and research has catapulted the Institute into the illustrious circle of world-class institutions. Apart from offering viable solutions to various government sectors, industry and to society, IIT Bombay pursues basic research leading to knowledge generation that lays the foundation for empowering India as a nation to be technologically confident and self-reliant.

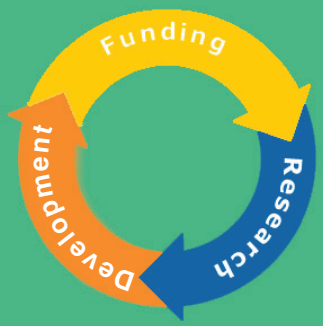
- Academic units: 27
- Research centres: 21
- Faculty: 622 full time,
  ~50 part time (adjunct & visiting)
- Students: ~ 10,000 (2941 PhD)
- Postdoctoral fellows: ~ 130
- Degrees awarded in 2016: 2515
- PhD degrees awarded in 2016: 325
- Research project staff: 1380
- R&D funding for (FY 2016-17; till Dec 2016):
  ₹ 285 crores
- Research publications
  (since inception upto 1.1.17): ~ 22,800
- Research publications (2016): 1785
  - Journal publications: 1274
  - Conference proceedings: 511
- Citations for all publications
  (since inception upto 1.1.17): ~ 2,53,700
- h-index (as on 1.1.17) : 146
- Indian patents filed (2016): 81
- Technology transfers / deployment so far: ~ 150
- Total companies incubated: 99

Patents

Period 1.1.1997 to 1.1.2017

- Indian patent applications: 659
- Foreign patent applications: 123
- PCT applications: 102
- Patents granted (Indian + Foreign): 124 + 54
  - Others under process

R & D Funding



Financial year	Research Funding (₹ in Crores)		
	National Organisations	International Organisations	Total Receipts
2012-13	278	16	294
2013-14	199	15	214
2014-15	227	16	243
2015-16	236	16	252
2016-17	**(as on 31.12.2016)**		**285**

Patent applications filed during 2016

Indian	81
PCT	14
US	11
Trademarks (Indian)	10

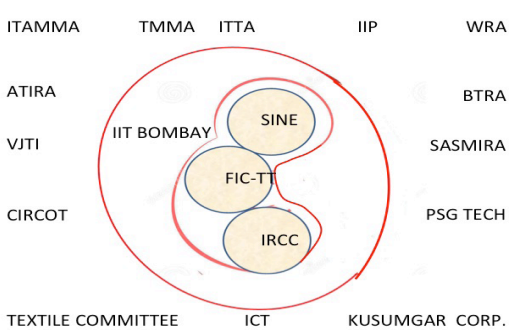
New R&D projects, both short term consulting and longer term sponsored research, are initiated every year in all the areas of science, engineering, management, design and social sciences. Duration of the projects typically ranges from 2 to 5 years. Funding received for R&D activity in FY 2016-17 (till Dec 2016) is ₹ 285 crores. This includes grants received for newly sanctioned as well as ongoing projects.

▲ In-house fabricated solar cells

▲ 1MWe solar thermal power plant at Gurgaon

▼ Cantilever based e-Nose

▼ Organogram for FIC-TT



R&D Overview

IIT Bombay has made concerted efforts to align its R&D focus with the national goal of achieving technological self-reliance. Students and faculty members conduct research projects in all areas of science, engineering, design, management and humanities. The Institute has ongoing academic and research collaborations with many national and international universities, government institutions, PSUs and private industries. These interactions aim to keep pace with expanding frontiers of knowledge and global developments and also continually work towards national needs. Its pre-eminent position at the cutting-edge of research is reflected in its impressive list of research projects and their outcome.

Make in India Activities

Make in India is an initiative of the Govt. of India to encourage multinational and domestic companies to manufacture products in India. IIT Bombay has been working towards developing indigenous technologies and know-how with a focus on economy and efficiency. IIT Bombay has stepped up to impart R&D solutions to various sectors.

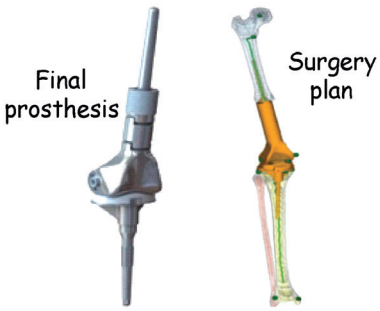
- **Cantilever based e-Nose for explosive detection:** low cost, sensitive device; detects RDX and TNT in parts per billion; has integrated wireless transmission capability

- **National Solar Thermal Power Testing, Research and Simulation Facility:** a grid-connected 1 MWe solar thermal power plant designed, installed and commissioned at Gurgaon, New Delhi; a solar thermal simulator developed that solves energy and mass balance equations for user defined plant configurations. http://www.ese.iitb.ac.in/~NSTPP/

- **Focus Incubation Centre in Technical Textiles (FIC-TT)** and Advanced fiber reinforced polymer development. An initiative funded by the Ministry of Textiles, GoI, to serve as a translational platform between academia, R&D labs and industry, to work towards disruptive innovation in the field of technical textiles.

▲ RoVer

TV white space installation ▶



◀ Novel design for prosthesis

▲ SüChek

- **National Centre for Photovoltaic Research and Education (NCPRE):** part of the Jawaharlal Nehru National Solar Mission of the Govt. of India and supported by the Ministry of New & Renewable Energy (MNRE) to promote photovoltaics R&D. http://www.ncpre.iitb.ac.in/

- **National Centre for Aerospace Innovation and Research (NCAIR):** a joint initiative of IIT Bombay, Boeing and Department of Science and Technology, Govt. of India; aims to provide economically viable and sustainable solutions to Indian aerospace manufacturers. http://www.ncair.in/

- **RoVer:** a remotely operated vehicle for handling and disposing Improvised Explosive Devices (IEDs).

- **SüChek:** a low cost diabetes testing kit.

- **Centre of Excellence in Steel Technology (CoEST):** sponsored by Ministry of Steel, Govt. of India has a vision to see India as a world leader in steel production and technology. The focus includes R&D in steel technology and creation of high quality manpower for the steel industry.

- **TV White Space test bed:** towards providing broadband access to rural population
  - First test bed set up in 5 villages in Palghar district, Maharashtra
  - Features include several UHF band nodes functioning as client and connected to UHF band node as base-station in a multi-point to point topology. The clients in UHF band are connected to Wi-Fi hotspots to provide Internet access.
  - Work ongoing towards providing cost effective indigenous solution for backhaul.

- **Biomedical Engineering and Technology (incubation) Centre (BETiC):** a centre established by Govt. of Maharashtra and DST; has integrated facilities for design, analysis, prototyping and testing and facilitates clinical trials, IPR and technology transfers in collaboration with medical and industrial partners. http://betic.in/

- **X-ray to 3D / Tabplan 3D:** computationally efficient modeling algorithm developed to convert 2D X-ray images of a bone from a patient into a 3D model; helps surgeons to take accurate decision for obtaining correct implants; won the ‘Gandhian Young Technological Innovation Award in 2014’.

◀ Indigenously developed ECR-1000 ethernet switch router

◀ State-of-the-art nanofabrication facility

TICET – Unlicensed band radio ▶

Night vision - Long range surveillance ▶

Digital India Activities

Work related to communications, network and security, and IT has been one of the major focus. These include R&D towards the Digital India initiative.

- Indigenously developed low cost, power-efficient high speed **ethernet switch routers** deployed at different sites by the Mahanagar Telephone Nigam Ltd, Mumbai, RailTel and National Knowledge Networks.

- **TTSL-IIT Bombay Centre of Excellence in Telecommunication (TICET):** a joint initiative of IIT Bombay, Tata Teleservices Ltd & the Department of Telecommunication, Govt. of India for capacity building, design and fabrication, and offering advisory support to the telecom sector; various technologies developed including cost optimization tool to reduce fuel consumption at telecom towers; supports entrepreneurship.
http://ticet.iitb.ac.in/ticet/home.html

Extensive funding from **Department of Electronics & Information Technology (DeitY)**, Govt. of India allows in various research areas to bring about a transformative impact:

- **Centre of Excellence in Nanoelectronics (CEN):** established in 2006, is a collaborative project with Indian Institute of Science (IISc), Bangalore.
  - State-of-the-art nanofabrication facilities
  - Research projects with social relevance leading to prototype development
  - Indian Nanoelectronics Users Program (INUP): provides hand on training, sharing of expertise in Nanoelectronics to researchers across the country.

http://www.cen.iitb.ac.in/ and http://www.inup.iitb.ac.in/

- **National Centre of Excellence in Technology for Internal Security (NCETIS):** Activities are targeted towards developing indigenous technology and self sufficiency in areas of Electronics System Design and Manufacturing for the strategic sector of internal security. http://www.ncetis.iitb.ac.in/

- R&D in the area of **perception engineering** has enabled the development and improvement of the performance of hearing aids and speech communication devices based on techniques related to noise suppression, distortion-free dynamic range compression and, improvement of consonant-to-vowel ratio.

Ministry of Human Resource Development (MHRD),

Govt. of India has supported a series of programs on knowledge dissemination to various colleges/institutions across India.

National Mission on Education through Information and Communications Technology (NME-ICT)

This project envisions empowerment of teachers, through workshops conducted for thousands of teachers at one go, using a unique blend of technology and an innovative pedagogy. Thousands have experienced the effectiveness of this approach, and of the resulting open source contents.
http://www.it.iitb.ac.in/nmeict/home

- Teach 10,000 Teachers (T10kT) programme
- FOSSEE (Free and Open Source Software for Education)
- Massive Open Online Courses (MOOCs)
- Quality improvement of classroom teaching through Video based Teachers' Training Program

- **Indigenously developed tools for classroom teaching**
  - **Bodhi Tree:** a learning management system developed with video material for regular and flipped classes
  - **SAFE (Smart Authenticated Fast Exams):** permits cheating-free exams to be conducted on a student's own smartphone, via WiFi; supports auto-graded multiple-choice & fill-in-the-blanks type questions.

- **E-Yantra:** initiative to provide hands-on learning to engineering students who have limited access to labs and mentors.

- **Sandhan:** a search engine for Indian languages developed in consortium with many institutions; intended for the tourism domain.

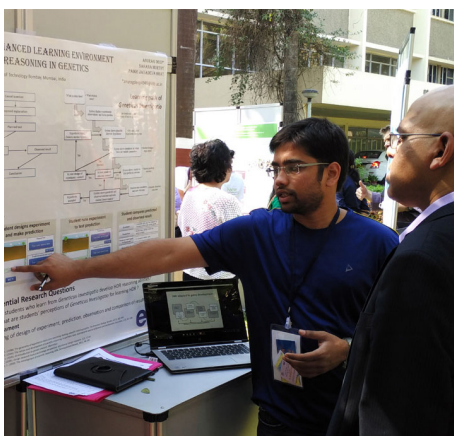
Inter-disciplinary Programme in Educational Technology

This academic unit aims to nurture research, innovation and outreach leadership among in technology-enabled learning and teaching.
www.et.iitb.ac.in

- **Technology-Enhanced Learning of Thinking Skills (TELoTS)**
  - Developing systems, based on the pedagogical strategies of inquiry-based learning, formative assessment and metacognitive reflection.
  - Learning activities in TELoTS systems harness technology affordances such as interactive simulations, adaptive & personalised feedback, and pedagogical agents to provide the required instructional support.
- **Teacher Use of Educational Technology Tools and Strategies (TUET)**
  - Empower teachers to effectively integrate ICT tools effectively in teaching
  - Creating constructively aligned learning designs and assessment through online (MOOC), blended and face-to-face workshops.

NME-ICT ▲

Education technology ▲▼



E-Yantra ▼

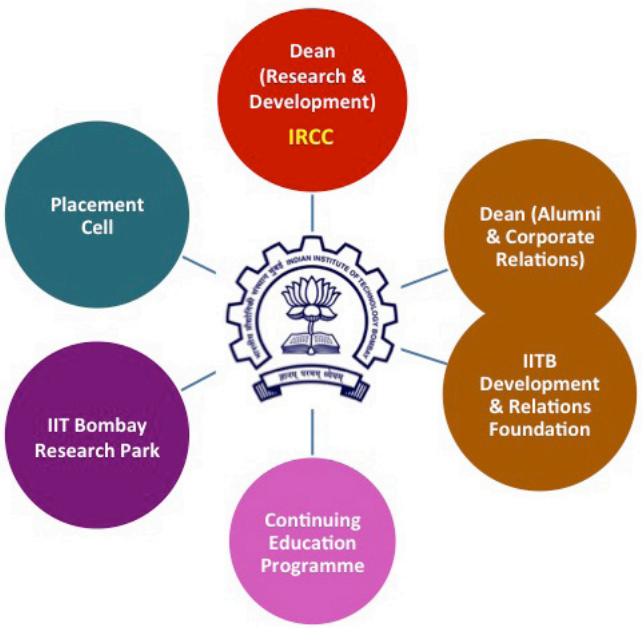
Industry Collaborations

From its inception, IIT Bombay has benefited from being located in one of the most industry-intensive hubs in the country. The overall external R&D orientation of the institute has been very much aligned by this situation. The Institute houses several advanced R&D facilities, including sophisticated state-of-the-art laboratories funded/donated by industry.

▲ MoU with Hindalco under GoI's Uchhatar Avishkar Yojana (UAY)

Benefits

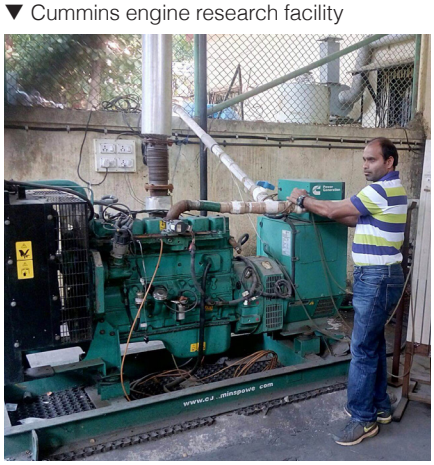
- Access to fresh ideas, innovation and talented student base
- Knowledge creation, technology & HR development
- Access to high-end equipment and other resources
- Facilitating processes and systems for collaboration
- Complementary skills and capabilities upgradation
- Access to qualified personnel for recruitment
- Multidisciplinary research pool
- Access to new technologies
- Leverage public funding



▲ Interfaces for industry interaction

▼ AMAT: Endura equipment for PVD

▼ Cummins engine research facility



- **Applied Materials:** Various modes of interaction to promote research in nanoelectronics, nano-manufacturing and solar photovoltaic technology.

- **PowerAnser Lab:** an IIT Bombay, Tata Consultancy Services (TCS) and Tata Consulting Engineers (TCE) partnership to bring the benefits of IT to the power sector; deployed webSTLF technology and webNETUSE to stakeholders.

- **TCS-IITB Research Cell:** for long term collaboration with TCS in major areas of research like software engineering, machine learning, intelligent infrastructure, scheduling and planning, etc.

- **Cummins Partnership:** integration of new engine and renewable fuels technologies to support sustainable development and to improve lives, especially in rural villages. Successful technology demonstration - Rural electrification of a village in Odisha.

▲ Forbes Marshall lab boiler

- **Forbes Marshall Energy Efficient Lab:** a resource centre to enable implementation of industrial energy efficiency and collaborative research. The lab has a modern steam boiler and steam utilisation equipment with controls and online monitoring.

- **Sentaurus™ TCAD model:** developed in collaboration with **Synopsys** for negative-bias temperature instability (NBTI), a key reliability concern for advanced CMOS devices: a framework for predictive DC and AC NBTI simulation of planar field-effect transistors.

- **Yahoo! Hadoop Cluster Lab:** to help conduct research on search based technologies.

Modes of Interaction

Industry Partners

R & D Projects:

NVIDIA, CAIRN, BG GROUP, SAMSUNG, L&T, BASF, Reliance Industries Limited, IBM, BHEL, TATA, SAP, intel, SIEMENS, NSDL, APPLIED MATERIALS, Micron, hp, Ambuja Cement, Mercedes-Benz, commtel NETWORKS, Google, JOHN DEERE, SRC, Nokia Siemens Networks, GE, Cummins, Castrol, ISPAT, CISCO, BOEING, Pratt & Whitney A United Technologies Company, EATON, Johnson & Johnson

Chair Professorship / Endowment:

TATA, L&T, HAL, praj, WADHWANI FOUNDATION, BAJAJ Distinctly Ahead

Continuing Education Programme:

CEAT, TATA, Godrej, TI, JET AIRWAYS, Reliance Industries Limited, citi, L&T, KVERNER, TVS, TVS SUZUKI LIMITED, Mahindra

Labs & Facilities:

praj, APPLIED MATERIALS, YAHOO!, TATA, Cummins, intel, XILINX, TEXAS INSTRUMENTS, WADHWANI FOUNDATION

Licensing:

intel, LIFE LINK, PXIL Transforming Power Markets, Kalkitech, embio, infineon, TATA POWER Lighting up Lives!, mechworldeco, Stanvac, GREEN VALLEY STEVIA Revealing Nature's secrets... for your health

Consortia:

BOEING, L&T, APPLIED MATERIALS, TATA, LANCO, Strand Life Sciences, MAHAGENCO, HAL, DMG MORI, Chemtrols, SPAN DIAGNOSTICS, XILINX, THERMAX, WAAREE

Student & Post Doc Fellowship Sponsorship:

BASF, MOTOROLA, British Gas, TATA, HAL, LLOYD, KONECRANES, IBM, Schlumberger, ARCI, MERC

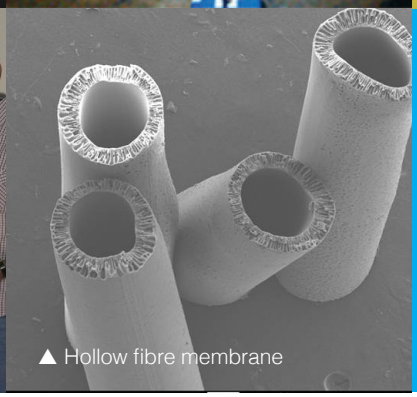
Other Glimpses of R&D

▲ Jaggery making pilot plant

▲ Folic acid enriched cosmetics


▲ Solar Urja Lamps

▲ Team Drishti


▲ Hollow fibre membrane

- **mSanitation:** web and cellular phone applications to track, report and maintain public and communal toilet systems.

- **Nanoparticle ink to films:** simple and economical approach to synthesize size-controlled absorber Cu_2ZnSnS_4 (CZTS) nanoparticles.

- **1 Million Solar Urja Lamps (SoUL):** provided to students in 7903 remote rural villages in Maharashtra, Madhaya Pradesh, Rajasthan and Odisha through support by the National Clean Energy Fund, Ministry New and Renewable Energy (MNRE), Govt. of India. Further activities of deployment across India have been initiated. http://www.millionsoul.iitb.ac.in/

- **Jaggery making plant - Improved process and products:** 1 ton/day jaggery making pilot plant designed, fabricated, tested and commissioned at Tatyasaheb Kore Institute of Engineering and Technology (TKIET), Warnanagar, Kolhapur District.

- **Needle-free vaccine injector:** shock wave driven drug delivery technique for efficient pharmacological effect; reduces pain, bleeding and trauma; can be used to deliver drugs into skin/soft tissues.

- **Drishti:** auto-tunable lens for universal eye glasses; winner in product design category in Samsung Innovation Awards 2012.

- **Nutrient enriched cosmetics:** a cheap drug delivery system developed to deliver nutrient supplements through skin of pregnant women, with an aim to reduce infant mortality.

- **Minimally invasive cartilage regeneration technique:** can be used as a painless, inexpensive, and non-toxic method to cure osteoarthritis.

- **Cryocooler technologies:** having applications in defence, space, surgical techniques, medical imaging and MagLev trains.

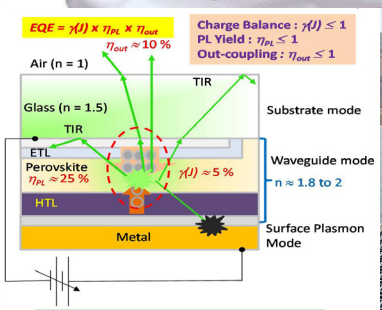
- **Healthcare Research Consortium:** has multiple partners including leading hospitals, cancer research centres, medical technology companies and NGOs.

- **The ISRO - IITB Space Technology Cell:** promotes advanced research related to space technology. http://www.csre.iitb.ac.in/isro_cell/

▲ Transparent UV mask

▲ WAYU

▲ BacKPacK rover



▲ Improving perovskite LED Efficiency

▲ Floating fish cage, Dimbhe dam

- **Wind augmentation and air purifying unit (WAYU):** reduces ambient air pollution levels through active pollutant removal and dilution through wind generation; may be used at traffic intersections, congested roads and places having high pollutant concentrations.

- **SoilSens:** a low cost soil moisture sensor
  - Improves efficiency of water-use
  - Environment friendly
  - Profitable for farmers
  - Sustainability of agriculture

- **Floating fish cage for aquaculture:** designed and developed under the Govt. of India funded Rural Technology Action Group (RuTAG) for protected and controlled rearing of fish species.
  - Safe and robust, can take load of 30 people
  - Simple design, can be assembled in 3-4 days
  - Made of galvanised iron pipes, fiber gratings and PVC drums
  - Easy to maintain and low operational costs

- **Carbogen gas inhaling apparatus:** for stress relief for people working in high-noise environments.

- **Desai Sethi Centre for Entrepreneurship:** The Centre aims to foster entrepreneurship and technology innovation through new programmes for education and research, multi-disciplinary courses, research laboratories and partnerships. Students in the programme will receive instruction and mentorship from internal and external faculty to enable them to become the next generation of business leaders. http://www.iitb.ac.in/dsce/

- **Centre for Urban Science and Engineering (C-USE):** an interdisciplinary centre working to improve the quality of urban life; member of the New York based international consortium, Centre for Urban Science and Progress (CUSP). http://cuse.iitb.ac.in/

- **Management:** R&D in operations; marketing; strategy; and quantitative techniques and applied operations.

- **Rail traffic simulator and optimisation tool:** Development of a commercially viable tool for simulation; visualization and analysis of train operations; and investments on multi-line rail sections.

Technologies Transferred

Direct licensing

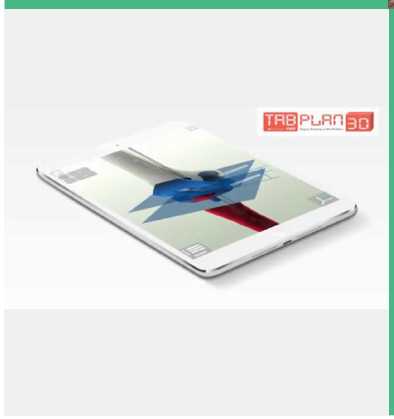
- Board games design
- Design and development of bulk lithography system for novel 3D micro fabrication
- Electro slag refining technology
- Ethernet switch routers
- GRAM++ software
- Hybrid cooling system technology
- Integrated wetland technology
- Multi-utility heat pump technology
- Polymer cantilever based systems
- Portable microscope
- Prediction of body weight and disease risk
- Smart phone based assay reader
- Software for bid matching in day-ahead spot electricity market
- Soil biotechnology for waste management
- Surgical instrument with multiple degrees of freedom
- Tabplan 3D
- Tube-tube heat exchanger technology
- Vestibulator for the CP children
- V-trough concentrated module
- webNetuse
- Wind augmentation and air purifying unit

▲ Integrated wetland technology

▲ Zero Sum: an educational game based on mathematics

▲ Ethernet switch router

▼ Tabplan 3D



▲ Sewage treatment plant set up at BMC, Mumbai

Technologies Licensed

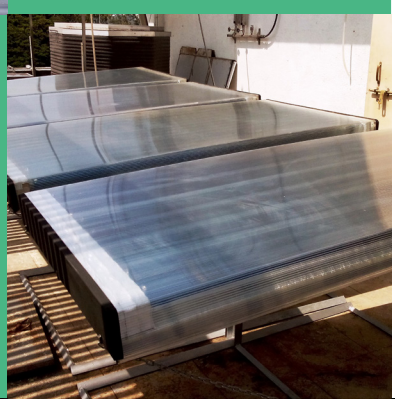
Licensing through collaborative development

- Amplified fluorescence polymers as sensors
- Asymmetric device applications in advanced CMOS technologies
- Design of ATM enclosure – ASAN
- Fuel additives for improving efficiency
- Inorganic – organic hybrid coatings
- Laminated object manufacturing - rapid prototyping process
- Modular FRP toilet units for railways
- Short term load forecasting
- Steer-by-wire system for vehicles
- Technology for better packaging of construction materials

▲ Portable microscope

▲ Multi utility heat pump

▲ Fuel additives



▼ Unibody electric 3 wheeler

▲ Non-tracking solar collectors for indoor cooking

◀ Modular Toilet Unit for Indian Railways

Technology Business Incubation

Society for Innovation and Entrepreneurship (SINE) is the technology business incubator at IITB set up in 2004. SINE supports technology startups founded by IITB community or that are based on IITB technologies, and extends the role of the institute by facilitating conversion of R&D into entrepreneurial ventures. Incubated companies cover a diverse spectrum of technology areas including healthcare, big data analysis, mobile apps, fintech, nanotech, biotech, clean-tech, social media, etc. www.sineiitb.org/

IIT Bombay

SINE

Business Incubator

Companies graduated/aquired	35
Companies currently incubated	44
Jobs created through entrepreneurship / start-ups	2550+

Research Park

The IIT Bombay Research Park Foundation is a not-for-profit arm of IIT Bombay registered as a Section 8 company. It was established in 2014 with financial support from the Ministry of Human Resource Development, Govt. of India. This Foundation aims to provide an ecosystem wherein researchers from IIT Bombay and industry work in close collaboration with each other for product innovation, addressing technology challenges and in research areas of mutual interest.

Through this Foundation, IIT Bombay aims to collaborate with large, medium and small enterprises, technology startups and accelerators. This Foundation

IIT BOMBAY
RESEARCH PARK
aspire

provides a mechanism for technology-focused companies to co-locate R&D personnel at IIT Bombay and seamless access to laboratories, research infrastructure and other research services. Industry R&D personnel can have close interaction with IIT Bombay faculty and student researchers.

Social Responsibility

Recognising the importance of contributing to the society in a meaningful way, IIT Bombay focuses on work in both urban and rural communities, providing technology-based solutions and utilizing the power of the internet and communications technology. Tools and technologies for the village industry and craft sector, educational and communication aids, products for alleviating problems of those with disabilities, devices for extending benefits of computer technologies to rural communities, and other useful innovations are some of the areas where IIT Bombay has been actively involved. The Indian Rupee symbol was designed by IIT Bombay which is now the official Indian currency sign used globally.

▲ Retelling stories of indegenous art

Digital India
Power To Empower

GRAM MARG
Enabling Rural India Digitally

Roadmap to rural connectivity ▶

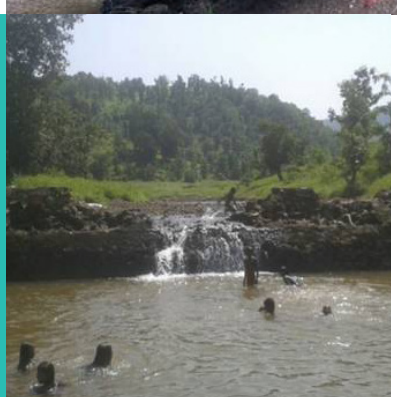
▼ Tricycle for paraplegics

▲ Indian Rupee currency symbol

◀ ByClip:Bicycle parking rack

▲ ASAN: ATM enclosure

▲ Dry sanitation system



▼ Bore recharge system

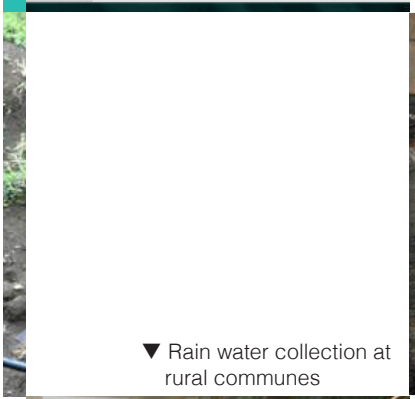
▲ Water supply in Parbhani city

▼ Dhoop stick making machine

▲ Bund at Bhojpada Village, Thane

▼ aAQUA web portal for Indian farmers

▲ Liquid jaggery machine



▼ Rain water collection at rural communes

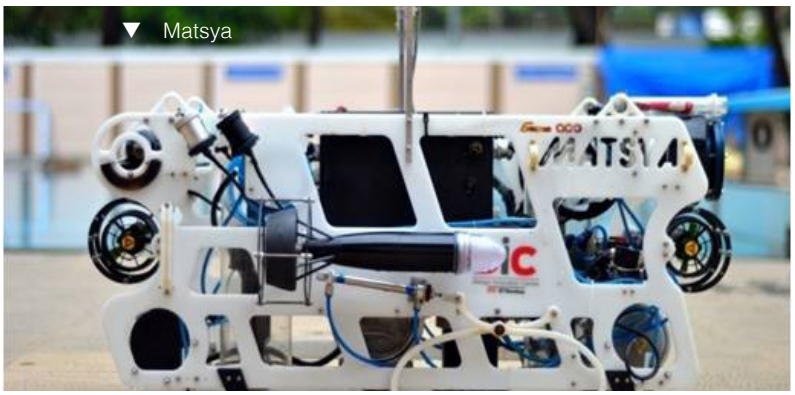
▲ Mumbai Rail Map

▲ Efficient smokeless chulah

▼ Low cost check dams

▲ Water storage tanks constructed using natural fibers ▶

Student Initiatives



▼ Matsya

- **Matsya:** a multidisciplinary platform to pursue research interests in underwater robotics. In the last four years, IITB has developed four vehicles under the series of Autonomous Underwater Vehicles (AUV), each one more advanced and more capable than its predecessor. Matsya 4.0, the newest member of the series, represented IITB at the International RoboSub competition at San Diego, USA in July 2016; secured the second position in the world giving the best performance by any Asian team, beating six-time winner Cornell University and were only marginally behind the winner, Caltech University. The team also won the National Competition for Autonomous Underwater Vehicles (NIOT SAVe) held at Chennai in December 2016. http://www.auv-iitb.org/

▼ Rakshak

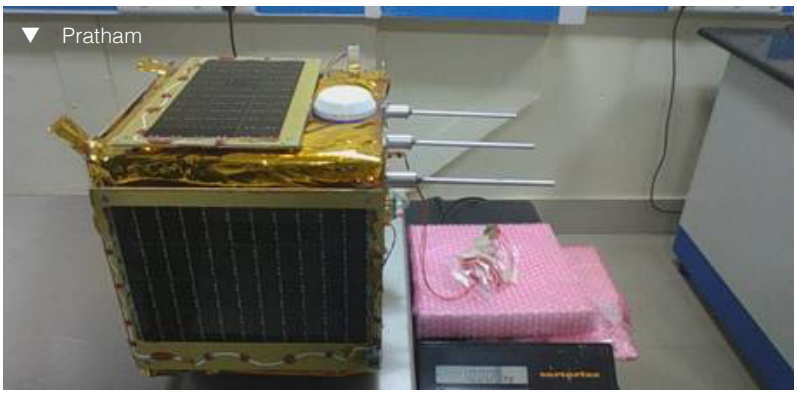
- **Solar Decathlon:** Students of IITB and the Rachna Academy of Architecture, Mumbai designed and constructed a 700 sq.m house powered entirely by solar energy and participated in the Solar Decathlon competetion held at Versailles, France, July 2014. http://teamshunya.in/

- **Mars Rover:** a six wheel mobility system on which various subsystems are integrated; consists of rocker-bogie suspension system and four wheel steering system. The steering system allows for sharper and easier turns on tough terrains and also enables on the spot rotation for the rover. The team participated in the Arkaroola Mars Robot Challenge 2014, and was one amongst the 23 student teams that made it to the finals of the University Rover Challenge 2015 held at the Mars Desert Research Station in southern Utah, USA. http://urc.marssociety.org/home

- **Rakshak:** robust Unmanned Aerial Vehicles (UAV) - a fixed wing aircraft developed for civilian applications, to counter problems like search and rescue missions and military surveillance; participated in the event 'SAE Aero Design Collegiate 2015 (Advanced class)'; stood 7th out of 15 international teams; achieved an overall rank of 12 in the competition.


▼ Solar powered house

- **Pratham:** design of a satellite to orbit at an altitude of 500-600 km with four months mission life; two downlinks and weight of 9.8 kgs; successfully launched by ISRO on September 26, 2016 from the Satish Dhawan Space Centre (SHAR) at Andhra Pradesh; more than 40 students from various departments involved. http://www.aero.iitb.ac.in/pratham/



▼ Pratham

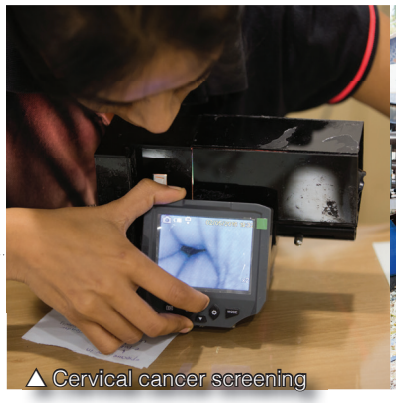
- **Intelligent Ground Vehicle Competition:** The student team competed in the 24th edition of Intelligent Ground Vehicle competition at Oakland University, Michigan, USA in June 2016; stood fourth in the 'Basic Auto-Nav Challenge' category; and qualified as one of the five teams to appear in Advance Auto-Nav Challenge. The team also geared up for Mahindra RISE Driverless Car Challenge and has cleared three out of five stages of the challenge.

- **IIT Bombay Racing:** The team competed in three international competitions in design and engineering of amateur high performance race cars; endurance run completed at Formula Student Silverstone Circuit, UK'16; achieved overall rank of 67 in Formula Student 2016 and ranked 45 in Cost Event of the competition; has presented in 10 reputed conferences. http://www.iitbracing.org

▼ ORCA: Latest edition of car with team

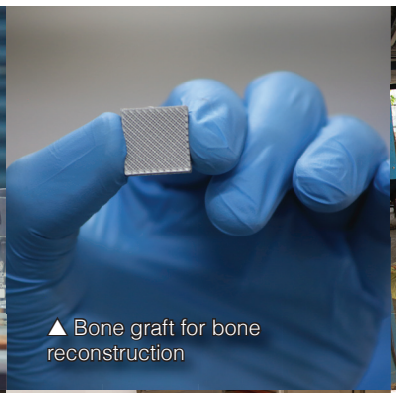
Tata Centre for Technology and Design

The centre aims to develop solutions to challenges faced by resource-constrained communities using an end-to-end innovation approach.

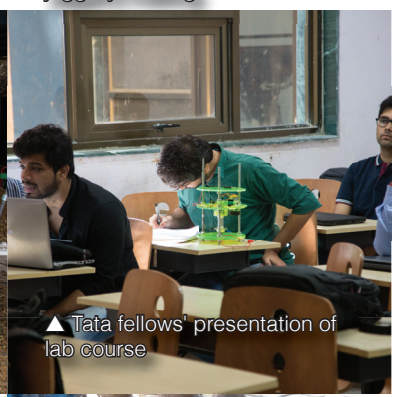

△ Cervical cancer screening

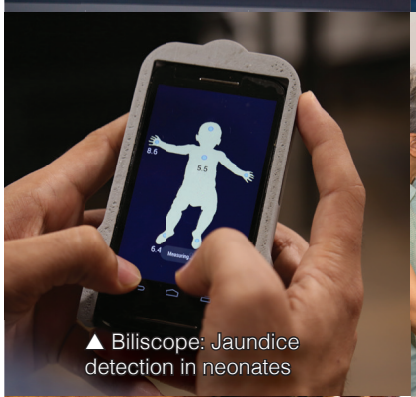

△ Removing drudgery in jaggery-making


△ Clay-based water purifier


△ Bone graft for bone reconstruction

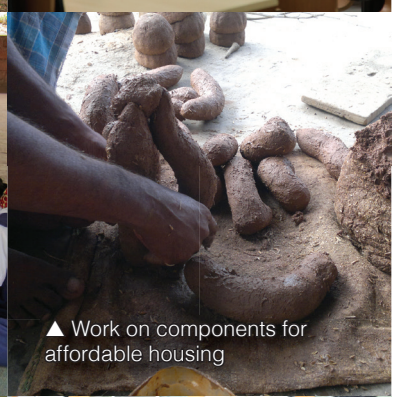

△ Gasifier based cook-stoves for garden waste

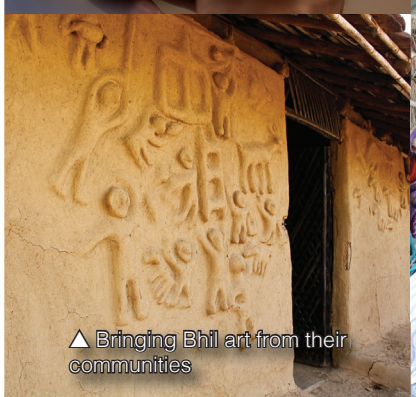

△ Tata fellows' presentation of lab course


△ Biliscope: Jaundice detection in neonates


△ Lab workshop for students from Vigyan Ashram


△ Learning English through stories

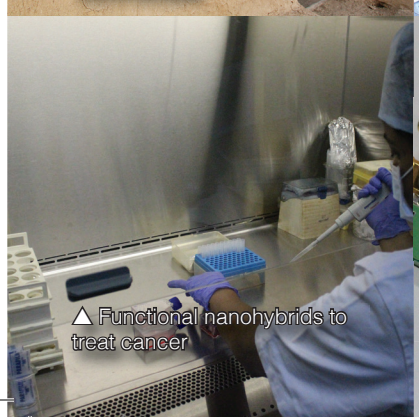

△ Work on components for affordable housing

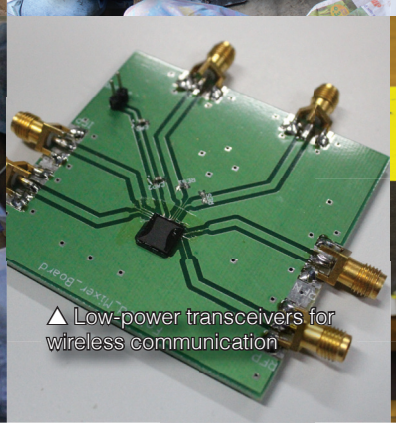

△ Bringing Bhil art from their communities


△ Mechanised de-shelling process for the marking nut

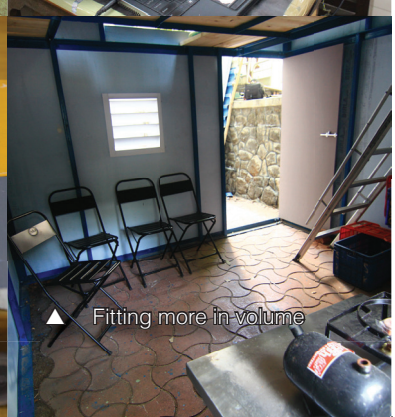

△ Pro-seminar filed trip


△ Low cost, rugged solar PV microinverter


△ Functional nanohybrids to treat cancer


△ Low-power transceivers for wireless communication


△ Coloured cool roof coatings


△ Fitting more in volume

Centres of Excellence/Consortia

- Biomedical Engineering and Technology Incubation Centre
- Centre for Aerospace System Design & Engineering
- Centre for Computational Engineering and Science
- Centre for Formal Design and Verification of Software
- Centre of Excellence in Nanoelectronics
- Centre of Excellence in Steel Technology
- Centre of Propulsion Technology
- Focus Incubation Centre in Technical Textiles
- Forbes Marshall Energy Efficient Lab
- Geospatial Information Science and Engineering
- Healthcare Research Consortium
- National Centre for Aerospace Innovation and Research
- National Centre for Mathematics
- National Centre for Photovoltaic Research and Education
- National Centre of Excellence in Technology for Internal Security
- National Mission on Education through ICT
- National Solar Thermal Research, Testing and Simulation Facility
- PowerAnser Laboratory
- Solar Energy Research Institute for India and the United States
- Tata Centre for Technology Development
- Tata Teleservices - IIT Bombay Centre of Excellence in Telecommunication
- Wadhwani Research Centre for Bioengineering

Important Awards and Fellowships

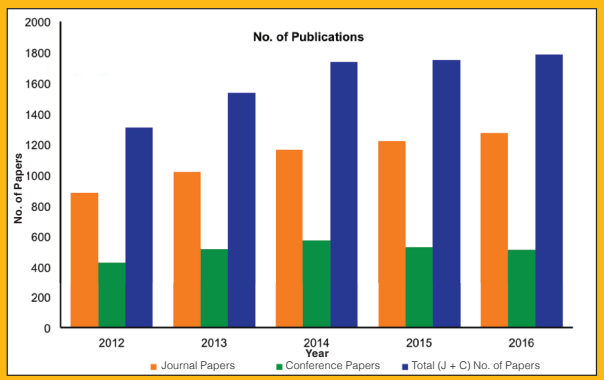
Awards

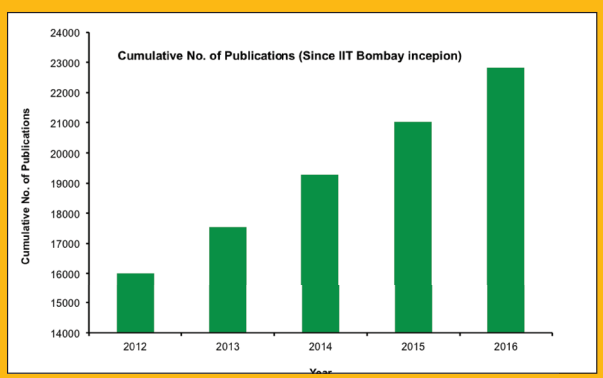
- Padma Shri: 2
- Shanti Swarup Bhatnagar Prize for Science and Technology: 13
- Infosys prize: 1
- Swarnajayanti Fellowship: 12
- J C Bose National Fellowship: 12
- DAE-SRC Outstanding Research Investigator: 4
- C N R Rao National Prize for Chemical Research: 2
- Chemical Research Society of India medals: Silver: 3; Bronze: 13

Fellowships

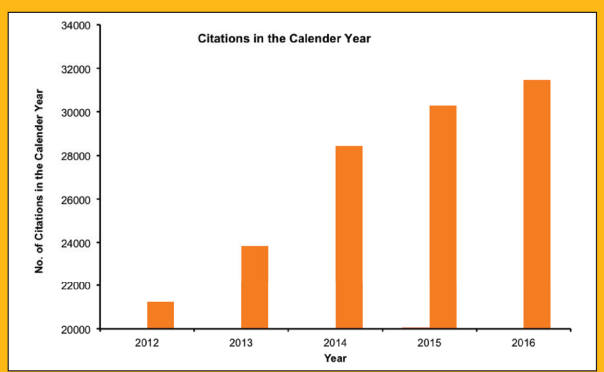
- Fellow, Indian National Science Academy, New Delhi: 13
- Fellow, Indian Academy of Sciences, Bangalore: 21
- Fellow, Indian National Academy of Engineering, New Delhi: 29
- Fellow, The National Academy of Sciences, India (Allahabad): 28
- Fellow, Institute of Electrical and Electronics Engineers: 5

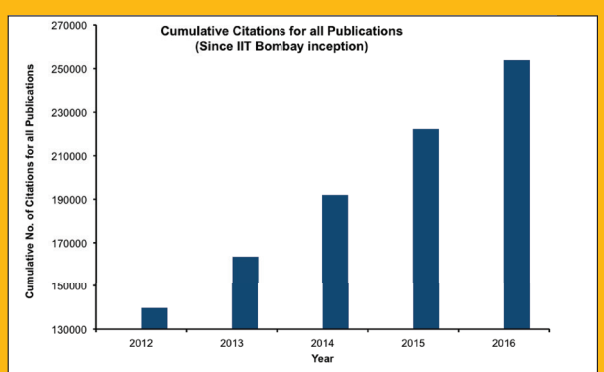
Publications





Citations





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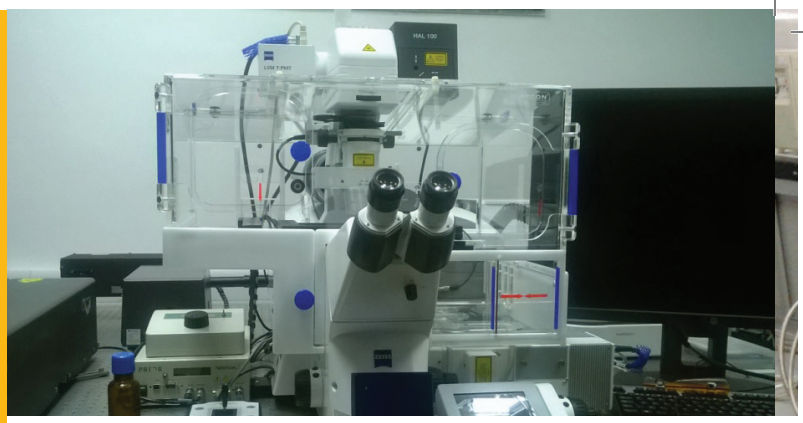
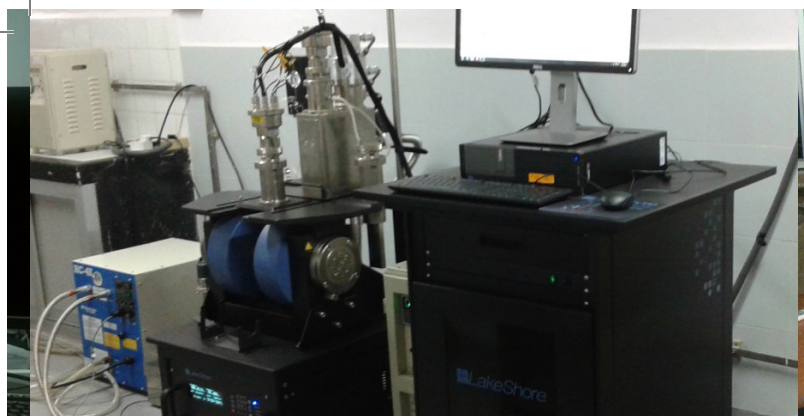


▲ Laser Scanner Microscope Facility

▲ Protein Crystallography Facility

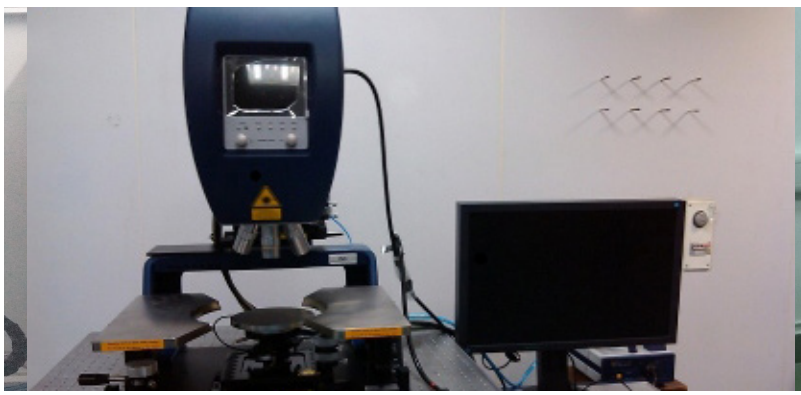
▼ High Resolution Mass Spectrometer

▼ 750 MHz NMR Spectrometer



▲ Hall Measurement System

▲ Image based Spray Diagnostic Systems



▲ Laser Doppler Vibrometer

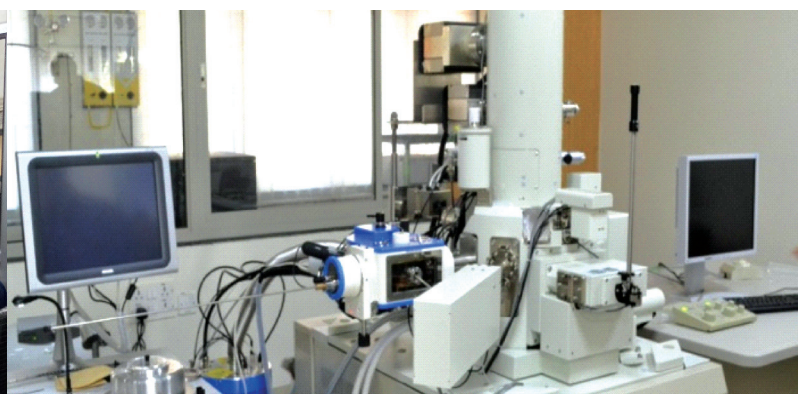
▲ Spinning Disc Confocal Facility

Research Facilities

The Institute provides high end infrastructure facilities and laboratories to support research activities. Facilities are augmented and upgraded regularly.

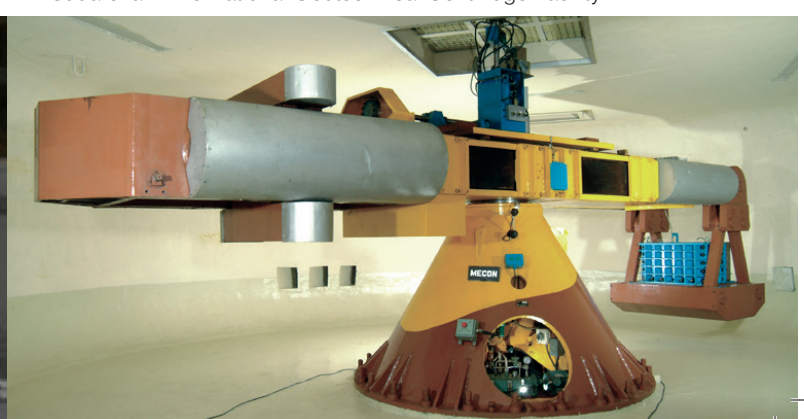
▼ High Resolution X-Ray Diffractometer

▼ Cryo FEG Scanning Electron Microscope



▼ Orientation Imaging Microscope Facility

▼ Sudarshan: The National Geotechnical Centrifuge Facility



The Industrial Research and Consultancy Centre (IRCC)

IRCC was established in 1975 as the nodal unit responsible for managing and coordinating all activities related to research and development at the Institute, including facilitating interactions with external agencies, setting up simplified processes for financial, manpower and intellectual property management, licensing activities and schemes for incentivising and supporting researchers.

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