

**N
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**A Premier Research Institute
for Rock Mechanics**

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COMMEMORATIVE TECHNICAL SOUVENIR

*A Historical Journey through last 30 Years of
our dedicated services to the Nation*

April 26, 2019



National Institute of Rock Mechanics
(Ministry of Mines, Govt. of India)

BANGALORE - 560070

Web : <https://www.nirm.in> e-mail : dto@nirm.in

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Glimpses from visitor's gallery

I have spent a little time here with great profit. This institution has made a most promising beginning. I hope it will continue to pick its areas of interest carefully and display state of the art techniques for the benefit of the mining industry.

7.10.92
V. KRISHNAN, Secretary, IITM, N. Delhi.

I was very happy to be shown around this Institute. I am highly impressed by the dedication, enthusiasm and painstaking work of the Scientists. I am sure the Institute will attain even greater heights in years to come

Shameen

11th Nov. 1989
SHRI. DIPAK CHATTERJEE, I.A.S.,
SECRETARY to GOVT. OF INDIA,
MINISTRY OF MINES & MINERALS
DEPARTMENT OF MINES,
NEW DELHI

I am so much happy to see development work done by our own scientists in this institution.

19th August 1996

B. Prasad
SHRI. BIRENDR PRASAD RAISHYA
HON'BLE UNION MINISTER FOR STEEL & MINES
GOVERNMENT OF INDIA

It has been a wonderful experience to visit this Institute which is working under the able guidance & leadership of Prof. Gupta. People abroad should be told about such institutions and their working. Visit to such institutions gives us self confidence and we become firm in our belief that this country has to lead the world.

Jalaluddin

13th August 05

HON'BLE SHRI JUSTICE BILAL NAZKI
CHIEF JUSTICE, HIGH COURT OF A.P.
ANDHRA PRADESH HIGH COURT
HYDERABAD

It has been always a visitor's delight to have come to NIRM and seen around the laboratories and the work done by our Scientists since beginning. Some excerpts from visitor's book from the bygone era tell this all. Our commitment to development is still the same.

Compiled & edited by :

Dr. P C Jha & Dr. D S Subrahmanyam

FOREWORD



I am pleased to release this Technical Souvenir on the eve of this “Inter-ministerial Conference on Future Strategies for NIRM”. This souvenir takes us to the nostalgic days of the formation of NIRM, when myself joined in the first batch of external scientists. The journey from 1988 to 2018 has been a quite arduous one in which we have seen many ups and downs but our spirit never died. We sailed through the rough weather and the industry partners stood behind our dedicated service by sponsoring challenging projects. Thus we have learnt both the art and science of rock mechanics in a hard way in such a manner that we never fear taking the most difficult assignments. Most of the HoDs of scientific departments have the legacy of last 30 years of hard earned experience and they developed their team in such a manner that this Institute today has a prominent place in the national arena and our advice is often the last spoken word in the country for any solution of Rock Mechanics and Rock Engineering problems.

Though the Institute was started with a theme to serve the mining industry, today NIRM has its work spectrum which spans the energy sector (hydel, thermal, nuclear), most of the urban infrastructure sector (rail/ road/metro), Oil & gas and now we ventured into off-shore projects also. On this occasion, I feel proud to release this “Technical Souvenir” which describes the capabilities of various technical departments and highlights the results of investigations of our flagship projects across various diverse areas of Rock Mechanics and Rock Engineering. We now aim to start our academic activities by offering MS and Ph.D. in Rock Mechanics by Research in collaboration with Visvesvaraya Technological University, Bangalore. We have plan to start international collaboration on turn key basis in partnership with existing players in this field.

I am sure the inter-ministerial team present in this conference will take note of this ever-expanding character of the Institute and will support us in all our endeavours by sponsoring high value projects. With this, I solicit support from all the participating ministries and clients in shaping the future of the Institute in years to come. The financial and technical support from our parent ministry in central government, i.e., Ministry of Mines, has been a constant driving force in our quest for excellence. I express my gratitude to Shri Anil Gopishankar Mukim IAS, Secretary, Ministry of Mines, for gracing this event as the Chief Guest. His humble presence reassures the back-end support of the central government in all our future endeavours.

I do hope that deliberations at this conference will provide us both directions and support in chartering our future course of action in our aim to cover greater technical horizon both by expanding our manpower and technical resources to meet the future needs of the industry. It is my earnest desire that in the years to come, NIRM establishes itself as an Institute of both National and International repute.

April 26, 2019

H. S. Venkatesh
DIRECTOR

Our Office (KGF & BLR)



A Panoramic View of the Registered Office of NIRM at Kolar Gold Fields



Entrance view of the Head Office of NIRM at Bangalore

NIRM - LOOKING BACK

Historical Perspective of NIRM

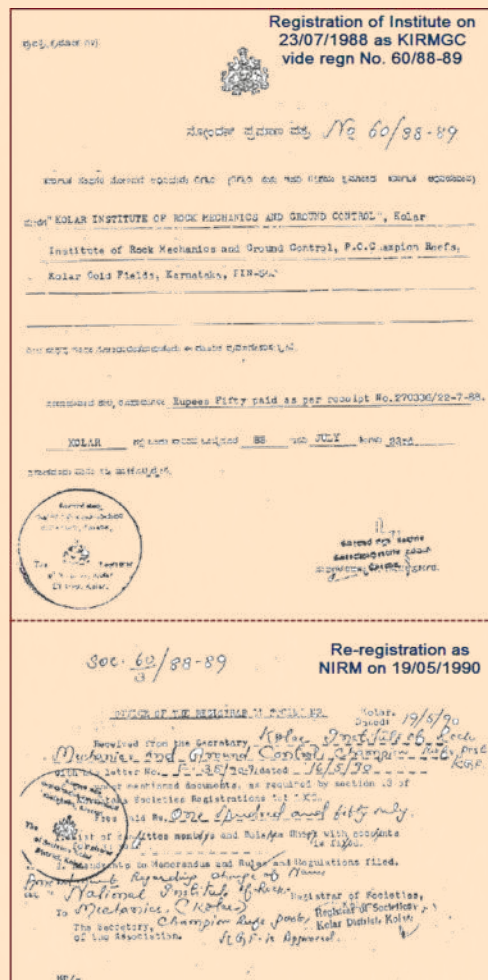


JULY 1988 - THE DAWN OF NIRM

Formation by Presidential Sanction

NIRM was established in 1988 in the R&D unit of erstwhile M/S Bharat Gold Mines Limited at Kolar Gold Fields. The Govt. of India vide their letter No.14/22/87-Met.V dated 27th January, 1988 had conveyed the sanction of the President for establishment of the Institute of Rock Mechanics and Ground Control at Kolar Gold Fields under Science & Technology (Plan) at a total expenditure not exceeding Rs.200 lakhs including a foreign component of Rs.40 lakhs. The then Hon'ble Union Minister of State for Mines, Smt. Ramdulari Sinha announced the approval of

the Government of India for the establishment of the Institute of Rock Mechanics and Ground Control at Kolar Gold Fields while inaugurating the fifth plenary scientific session of the working group on "Rock Bursts" of the International Bureau of Strata Mechanics at the Regional Research Laboratory, Hyderabad on Tuesday, the 2nd February, 1988. Subsequently the Institute was formally



R&D UNIT OF BGML

The Research & Development Unit of M/S Bharat Gold Mines Limited at Kolar Gold Fields was functioning since pre-independence. The Seismic and Micro-seismic Cell was established with the collaboration of Bhabha Atomic Research Centre in 1978 to monitor the seismic activity and to predict rock bursts. As a part of the rock burst research programme, tests on rock specimens for their physico-mechanical properties were carried out in the Materials Testing Laboratory.

The rock mechanics investigations carried out by the R&D unit were acknowledged as to be of very high standard in the opinion of UNDP/ ILO experts who had visited the R&D Unit in 1985. Even the Department of Scientific and Industrial Research of the Ministry of Science & Technology, Govt. of India had recognised the R&D unit of BGML as a prime research centre.

The services of R&D Unit of BGML were also extended to carry out studies on ground control for the mines of Hindustan Zinc Limited and Hutti Gold Mines Limited, on a limited scale.

With the mining activity in KGF mines on a downward trend, the Government of India decided in 1987 that the mines of Kolar Gold Fields be closed in a period of seven years.

However, considering the expertise developed by the R & D Unit of Bharat Gold Mines Limited, it was suggested by an Expert Group constituted by the Secretary, Department of Mines, Ministry of Steel & Mines in 1987 that an Institute of Rock Mechanics and Ground Control be formed at Kolar Gold Fields with the R & D Unit of M/s BGML as its the nucleus. This pragmatic vision paved way for the creation of KIRMGMC, now known as NIRM.

registered in July 1988 under Karnataka Societies Registration Act, 1960, as an autonomous research institute under the administrative control of Ministry of Mines, with the name “Kolar Institute of Rock Mechanics and Ground Control” (KIRMGCC). Subsequently the name of the Institute was changed to “National Institute of Rock Mechanics” (NIRM) by a resolution of the General Body in May 1990.

Initially, the Institute was functioning with the erstwhile staff of the R&D unit of BGML. First Director of the Institute, Dr. N M Raju took charge on 11th July 1989 and first batch of Scientists joined in 1990. NIRM started getting projects from the industry from 1990 when its external cash flow (ECF) was just 3.86 lakhs during 1989-90. During first ten years (1988-98), the Institute was earning around 25-30% of its recurring expenditure and the non-plan grant was covering the remaining expenses. There was all round scientific and financial improvement of the Institute since inception and efforts were made to minimise the expenditure and maximise the internal resources generation so that the dependence upon government budgetary support could be kept at a minimum. From the year 1999-2000, the Institute activity diversified into non-mining sector and a large part of earning came from the hydroelectric sector.

Since the inception of this Institute, it was able to restrict the outflow of foreign exchange considerably from our country as the industry’s dependence on foreign consultants for addressing the challenging problems had considerably reduced. In order to keep pace with the latest development, the Institute undertakes S&T projects with an aim to develop new technologies and experiment with the latest investigation tools. With this blend of basic and applied research as well as executing consultancy projects, the Institute maintained its niche position in the industry. The scientific reports of NIRM are being accepted by the various statutory/regulatory authorities such as the Directorate General of Mines Safety, Central Water Commission, Indian Bureau of Mines etc., for awarding permission to the industries to carry out their operations as per the recommendations made by NIRM. The Institute is also recognised as a Scientific & Industrial Research Organisation by the DSIR, Ministry of S&T, Govt. of India.

NIRM - A Pictorial Journey into the Past

Our Past Directors

Dr. N M Raju

June 1989 - Oct. 1998



Dr N. M. Raju was the first Director of the Institute. He added a number of new departments in different areas of research, and made the institute to grow as a national institute of excellence. Under his direction, the institute had made significant strides into coal mining and civil engineering sectors.

Prof. R N Gupta

Oct. 1998 - May 2006



Prof. R. N. Gupta was the second Director. He was the architect of the diversification of NIRM activity from mining to civil engineering projects. Apart from streamlining the administration, his major contribution has been providing the financial stability of the Institute by building up a Corpus Fund.

Dr. P C Nawani

Feb 2008 - July 2011



Dr P. C. Nawani established the Engineering Geology Department. He started the Bangalore Unit of NIRM at the ITI premises in KR Puram. He publicized the activities of the Institute among the hydro-power and infrastructure sectors.

Dr. V Venkateswarlu

Feb 2013 - May 2017



Dr. V Venkateswarlu is credited with establishing the present Head Office of NIRM at Bangalore. It was during his tenure all departments from KGF unit moved to the Head Office and NIRM office at ITI premises was amalgamated into the Head Office.

Honourable Members First General Body

Sri BK Rao, IAS
Secretary, Department of Mines

Sri PK Lahiri, IAS
Addl Secretary, Department of Mines

Sri S Panchapakesan, IAS
FA & AS, Ministry of Steel & Mines

Sri IM Aga, Chairman
Bharat Gold Mines Ltd.

Sri PAK Shettigar, Managing Director
Bharat Gold Mines Ltd.

Sri HV Paliwal, Director (MO)
Hindustan Zinc Limited

Sri MA Khan, Director (T)
Hindustan Copper Ltd

Prof. BB Dhar
Dept of Mining Engineering
IT, BHU

Prof AK Ghose
Dept of Mining Engineering
ISM, DHANBAD

Dr PK Iyengar, Director
BARC, BOMBAY

Sri DN Bhargava, Controller General
Indian Bureau of Mines

Sri VC Varma,
Director General of Mines Safety

Prof GS Marwaha,
Director (Retd), ISM
NAGPUR - 440 025

Sri R Krishnamurthy,
Consultant (Rock Mechanics)
BANGALORE-560 038

NIRM - A Pictorial Journey into the Past



Sri B K Rao, IAS, the then Secretary, Ministry of Steel & Mines, Govt. Of India and Founder Chairman of NIRM with Dr. N M Raju, Founder Director of the Institute during his visit to NIRM in 1990



Sri B K Rao, IAS, the Founder Chairman and Dr. N M Raju, Founder Director of NIRM with the first generation of Scientists of the Institute



Members of First Peer Review Committee on visit to NIRM Labs

Honourable Members First Governing Body

Sri BK Rao, IAS
Secretary, Department of Mines

Sri PK Lahiri, IAS
Addl Secretary, Department of Mines

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Hindustan Copper Ltd

Prof. BB Dhar
Dept of Mining Engineering
IT, BHU

Prof AK Ghose
Dept of Mining Engineering
ISM, DHANBAD

Sri B K Rao, IAS Founder Chairman, NIRM



Sri BK Rao was the Secretary to the Govt of India, Ministry of Mines, from 1985 till his retirement in June 1989. He conceptualised the creation of a national institute

specialized in the field of rock mechanics, to be carved out of the R&D Unit of the Bharat Gold Mines Ltd, to continue the legacy of the ground control research being carried out at the Kolar gold mines. He was thus instrumental in founding the Kolar Institute of Rock Mechanics and Ground Control, later renamed as National Institute of Rock Mechanics, at Kolar Gold Fields.

Vision & Mission of NIRM

The National Institute of Rock Mechanics has been developed as a Centre of Excellence for

- Scientific design of mine workings,
- Design of rock excavations and support systems,
- Site characterisation practices,
- Advanced research in fundamentals of rock mass behaviour, and
- Specialised testing facilities for rock and dimensional stones.

The mandate of NIRM is to provide enabling technology to mining, civil and construction sectors to optimise their resources.

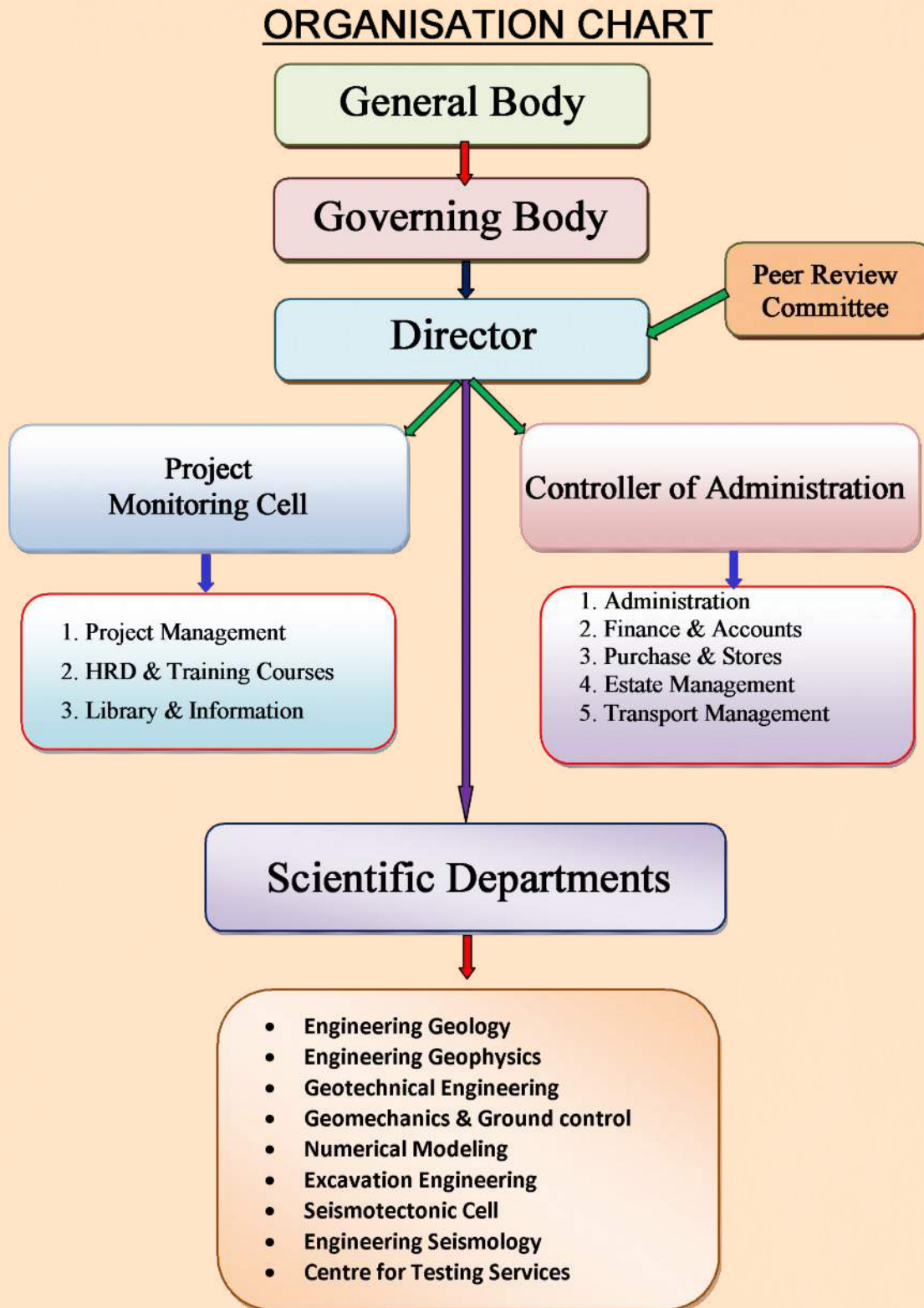
Vision of NIRM

The Institute has a vision to become a self-sustaining Centre of Excellence of International Standard in the areas of rock mechanics, rock engineering and allied fields for the development of mining, construction, petroleum, power and infrastructure sectors. The vision is to lay special emphasis on quality, innovation, professional competency and skill development, so as to serve all the stakeholders in the identified sectors. This vision will be responsive to changing global needs with special emphasis on quality and innovation to serve the industry in the most economical manner.

Mission of NIRM

“To provide scientific and technological inputs to the mining, civil and construction industries to optimize their operations and to perfect their designs with a view to improve production, productivity and product quality for better safety, economy, conservation and environmental management”

Structure of NIRM



NIRM has eight Technical Departments headed by well-experienced Scientists. The Institute is headed by Director and its scientific activities are periodically reviewed by a Peer Review Committee. The Governing Body and General Body of the Institute is the apex body which approves annual accounts, frames rules and regulations and provides administrative directives.

Capabilities of NIRM

NIRM has capability to address varieties of problems related to Rock Engineering and Rock Mechanics issues associated with all types of construction be it on surface, underground or in the sea. Its technical departments are equipped with the latest investigation tools and are headed by well -experienced scientists. Core capabilities of the Institute are enumerated hereunder department-wise :

Engineering Geology

- Surface and sub-surface geological mapping on 1:10,000 Scale.
- Detailed mapping on 1:100 to 1:500 Scale for identifying different geological/structural features
- Impact study on the geo-mechanical properties of the rock masses in different geological setting.
- Carrying Rock mass classifications (Q) to understand the rock mass behaviour, failure modes etc
- To suggest suitable support system as per rockmass characterisation

Engineering Geophysics

- Site characterisation for subsurface structures
- Surface wave survey for compaction and subsidence studies
- Mapping bedrock topography, soil stratigraphy, hidden cavities, tunnels (mines), defects, and fractures planes
- Mapping old water-logged workings & barriers in coal mines
- Foundation evaluation of bridge pillars and structures using Cross-hole tomography
- Vibration effect studies and fatigue damage assessment
- Post-failure investigations for forensic analysis
- Active and passive seismic survey for settlement studies

Capabilities of NIRM

Geotechnical Engineering

- Determining in-situ stress parameters by Hydro-fracturing technique (HTPF method) up to 600m depth from the surface
- Determining in-situ deformability parameters by Plate load test method and Plate jacking method
- Determining in-situ deformability parameters by Goodman jack and Pressure meter methods inside the boreholes
- Determining direct shear strength parameters (cohesion and friction angle) for rock-rock and rock-concrete interface both inside the tunnel and from surface
- Measuring Plate bearing capacity and Foot load tests
- Determining Modulus of Subgrade Reaction of Soil
- Scanning boreholes up to the depth of 600 m using Acoustic Borehole Televierer

Engineering Seismology

- On-line monitoring for dynamic stability of excavations
- Continuous monitoring of vibrations and its effects on structural safety
- Estimation of seismic hazard based on micro-earthquake monitoring
- Comprehensive seismotectonic evaluation for nuclear power site based on IAEA and AERB guidelines
- Active fault studies for Nuclear power site evaluation
- Paleoseismic and Paleoliquefaction analysis through trench studies
- Seismotectonic evaluation for major civil engineering structures including nuclear power sites

Capabilities of NIRM

Excavation Engineering

- Optimisation of blast design parameters for surface and underground excavations
- Monitoring & control of fly-rock, ground vibration, air overpressure and rockmass damage
- Blasting for maximising yield of armour rocks
- Controlled blasting design for urban environment
- Development of safe blasting techniques close to strategic structures and integrated approaches
- Proof-checking and vetting of tender documents

Numerical Modelling

- Analysis and design of caverns and tunnels using the latest FEM, Finite Difference and Discontinuum 3D numerical modelling codes
- Predicting anticipated rock mass behaviour around excavations
- Design of supports (rock bolts and SFRS) for tunnels, caverns and large underground multiple excavations
- Dynamic analysis of important surface and underground structures
- Stability analysis of earth and concrete dams and slopes
- Design of stopes, crown pillar and sill pillars for economic and safe extraction in metal mines
- Modelling for safe mining practices under adverse conditions
- Design and implementation of instrumentation of tunnels, caverns and mines during construction and post construction period; and their data analysis
- Structural monitoring of dams using geodetic method

Capabilities of NIRM

Geomechanics & Ground Control

- Coal mine pillar design and strata mechanics studies
- Subsidence prediction and control
- Design of rock reinforcement systems
- Study of parting behaviour in multiple seam extraction
- Design of mining methods for increased safety and productivity
- Optimisation of stoping parameters, barrier/crown pillars
- Stability evaluation of stopes, shafts and other critical structures in the underground.
- Optimisation of bench parameters and pit slope stability for opencast mines
- Designing dump slopes, assess their stability & monitoring of pits

Rock & Materials Testing

- Statutory Materials Testing as per DGMS standard (wire rope, proof load, hydraulic prop)
- NDT using Ultrasonic examination (both in-situ and the laboratory), defectograph and other standard methods
- Preparation of rock samples for standard laboratory tests
- Thermo-mechanical behaviour of rocks using high temperature and pressure triaxial cell
- Acoustic emission studies for fracture development
- Shear testing for rock joints and determining joint properties
- Laboratory testing of rock samples (uniaxial and triaxial) for determining various physico-mechanical properties as per ISRM standards

Sectors We Serve

Our work areas span over Land and sea - from surface to underground, from borehole to laboratory, from modelling to design implementation, and monitoring - both continuous and discrete. We are expanding and diversifying to cover even larger work spectrum. Our work areas cover following major sectors :

- **Mining - Coal, Metal and Opencast**
- **Power - Hydel, Thermal & Nuclear**
- **Infrastructure - Irrigation, Drinking water & others**
- **Transport - Rail, Road, Metro**
- **Oil & Gas - Sample Testing (rock), Storage caverns**
- **Defence - Marine & Underground Space**
- **Natural hazards - Subsidence, Earthquake, Landslide, Slope failure, Hazard mapping**
- **Others - Archaeology, Oil Pipeline**

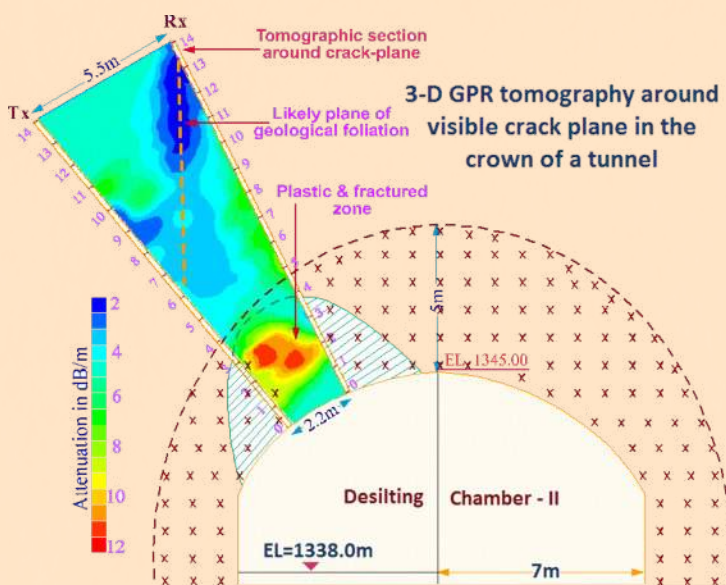
Project activities

Ever since our inception in 1988, the institute has completed over 1020 commercial projects and 15 S&T Projects. Work done in S&T projects help in keeping pace with the latest investigation tool and practices. So far the Institute has published over 800 research papers.

Many of our projects are related to challenging post-failure investigations for problem identification and for planning proper restoration measures. Their successful execution have given NIRM a niche position in the industry and earned us the distinction of being the last word in the rock mechanics investigations in India.

Some of our Flagship Projects

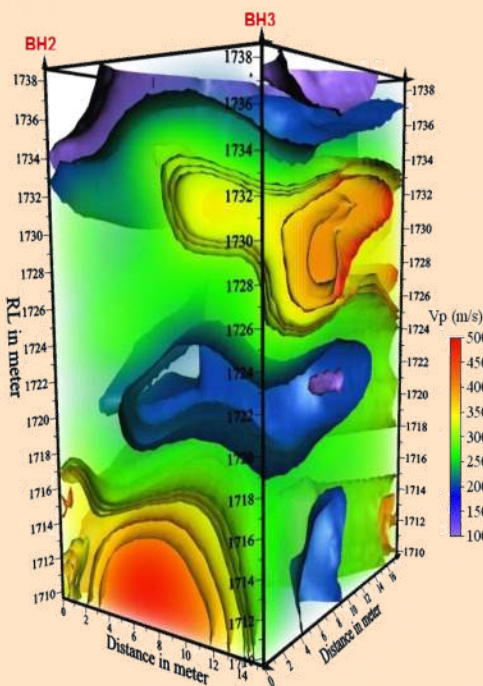
Mapping defects in the crown of tunnel



In Tala hydroelectric projects of Bhutan, a major crack in the crown of the tunnel of desilting chamber was threatening the stability of tunnel. Using Frequency Domain GPR Attenuation Tomography (FDAT), we could locate both the crack profile and the extent of damage, following which the tunnel was stabilised using rib support. This was for the first time, GPR tomography was used in the upward direction in the crown which also established the use of FDAT as a new investigation tool.

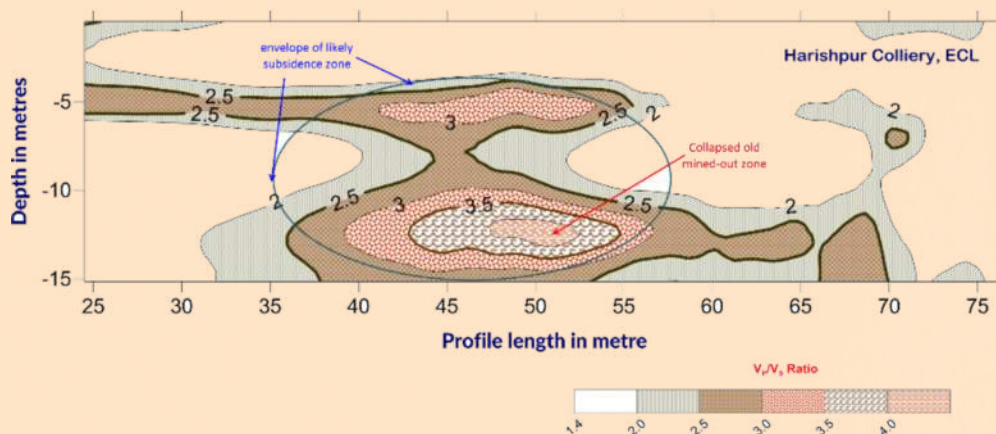
Our Flagship Projects

Defect mapping for strategic structures



NIRM has pioneered the defect mapping capability in the subsurface using 2D and 3D tomography. We carry out both GPR and Seismic tomography in frequency domain and time domain mode. Our specialised data analysis tool makes it possible to highlight any type of defect in the subsurface with maximum possible resolution. In the example shown in the margin, a buried sand lens is detected below the dam axis of Sainj hydroelectric project by 3-D seismic tomography. Construction of dam is not feasible unless porous sand lens is fully treated.

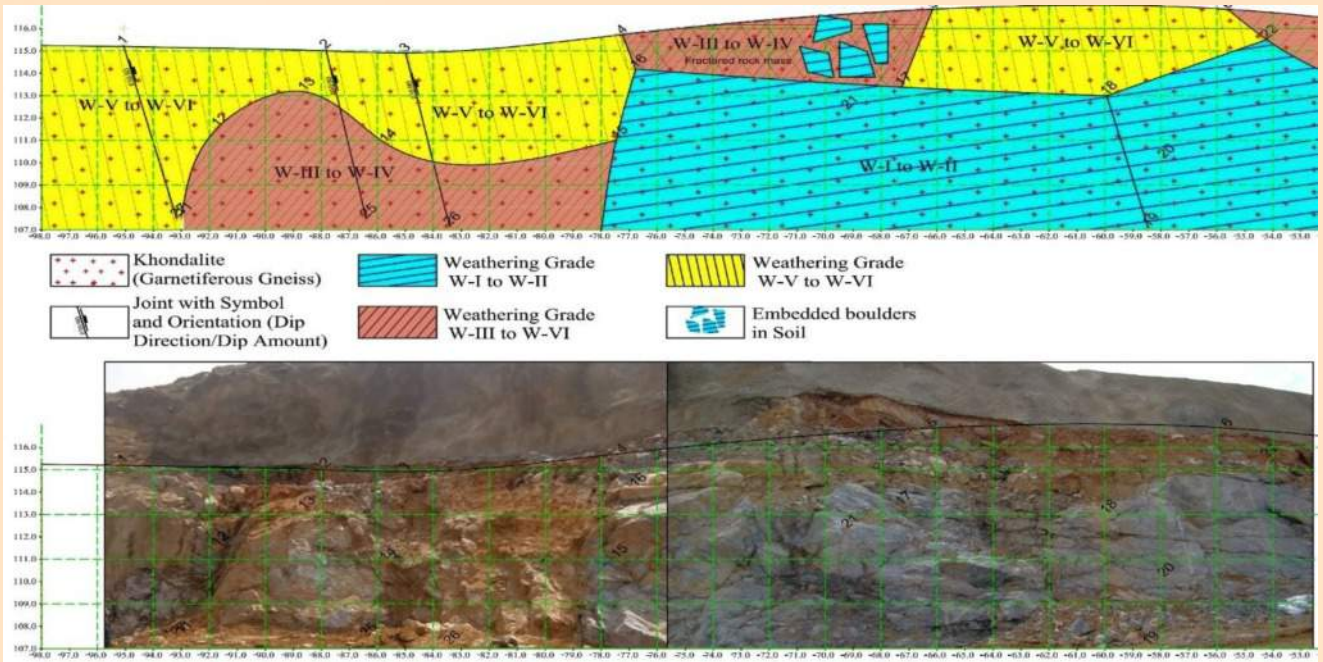
Development of new geophysical technique for settling environment



A new geophysical survey technique is developed for the identification of a potential subsidence zone or settling environment by surface seismic survey using P and S waves. So far there is no credible method to pre-identify such zones and the coal industry was facing perpetual problem of abrupt subsidence or pot hole formation over old mined out area. Following successful trial of this method at five known sites, this survey is being done on commercial scale for unknown regions. This project was supported by the S&T project of the Ministry of Mines, Govt. of India.

Our Flagship Projects

Mapping and characterization of rockmass



Construction stage engineering geological investigations are carried out for the cut slopes pertaining to hydro power, lift irrigations and other civil infrastructure projects on 1:100 and 1:200 scale for mapping and characterization of rockmass. On day-to-day excavation basis engineering geological mapping is done, design support is modified as per site conditions and clearance for benching down is given. This ensures the quality, lifetime, future maintenance and overall safety of structures.

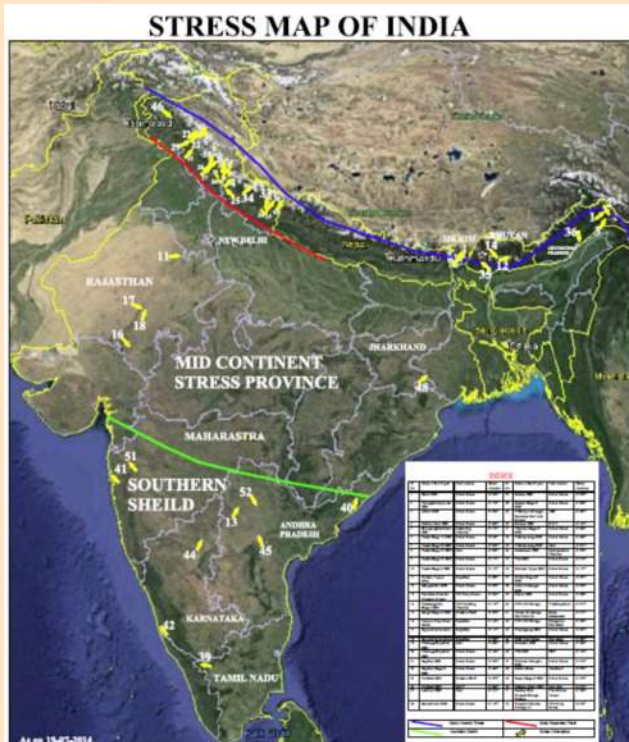
Design modification as per site conditions



Based on detailed engineering geological investigations and taking the safety factor into account, underground surge pool and pump house caverns are converted into circular shafts. Existing excavated construction shaft (10 m diameter) is converted into pump house shaft whereby the excavation time and construction cost is substantially reduced. Total depth of surge shaft is 136.60 m and excavated diameter is 27.00 m. These shafts will be deepest shafts in India for any type of lift irrigation schemes.

Our Flagship Projects

Preparing stress map of India



Based on in-situ stress data measurement over the years at different locations, the Stress Map of India has been prepared. This is periodically updated for quick and reliable information regarding stress directions at various places of India. This is a significant contribution towards World Stress Map. The database of Stress map of India is very helpful both for researchers as well as for commercial and economical investigations. In academic research, this data will contribute to know the possible movement of tectonic plates.

Deep-seated hydro-fracturing

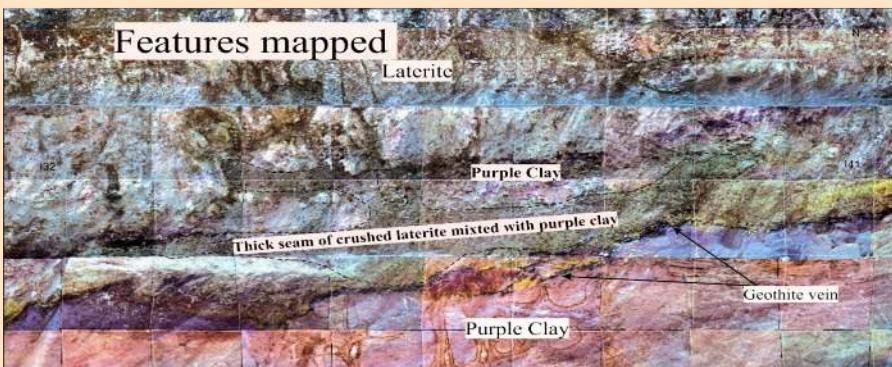
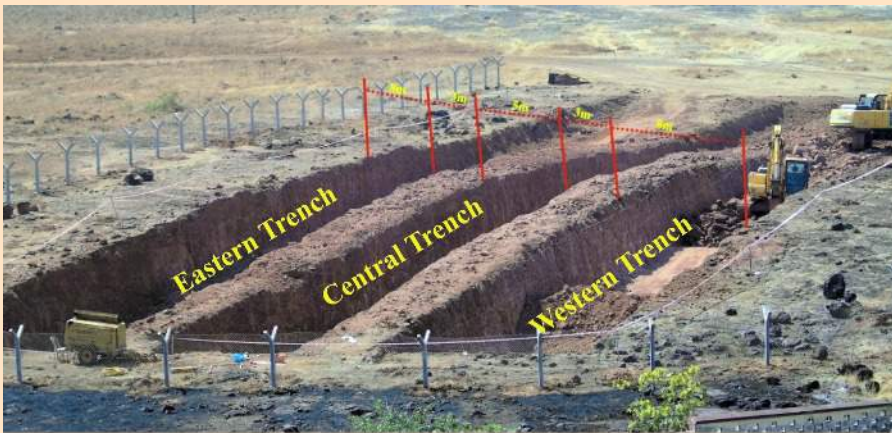


In-situ stress measurements were conducted at the depth of 600 m from the surface at Singareni Collieries area. This is the deepest ever hydro-fracturing experiment done in India. Results of this study will be helpful in gauging the modification of horizontal stresses in the mining area following years of continuous mining.

This data will be helpful in the planning the design as well as excavation sequence of new underground coal mines of SCCL. This project was supported by the Ministry of Coal, Government of India.

Our Flagship Projects

Active fault studies for Jaitapur NPP



One of the largest trench in the world was excavated upto 26m depth for the assessment of a suspected fault at Jaitapur NPP. This trench was excavated in 10 stages with each stage mapped on 1: 20 scale to demarcate the structural features. The study found no normal fault, as suggested by previous study, in the trenched area. This trench is visible even in Google earth.

Seismotectonic evaluation of KKNPP



After the enforcement of AERB guidelines, first comprehensive seismotectonic evaluation for Kudankulam site was assessed for 50 km radius to identify potential seismic source zones. The study identified two active faults outside 20 km radius of the site. These two faults are having regional affinity to a major shear zone of peninsular

India. The seismotectonic studies assigned them to a potential magnitude of 6. The other significant lineaments in the area are considered a magnitude of 5.5. NIRM's reports are the basis for site clearance and seismic design of the reactors.

Our Flagship Projects

Use of Pre-splitting in blasting



Pre-split blast design was executed for the nuclear power project at Rajasthan (RAPP) wherein in 20 m high wall was exposed with excavation of 1.3 million cubic meter of hard rock from 45000 square meter of pre-split area. The post-blast profile reflected a smooth vertical cut which was achieved with due diligence and led to achieving the target safely within the scheduled time.

Controlled blasting technique



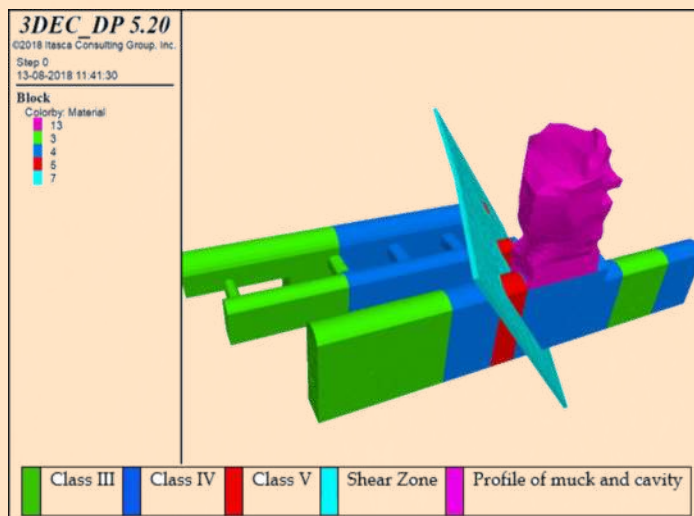
Controlled blast design invokes blasting with no adverse impacts. Problems of over break, fly-rock, noise, adverse ground vibrations, rockmass damage are contained to a minimum level. This was done close to the toe of Tungabhadra dam for excavation of a mini powerhouse.



NIRM has expertise in urban blasting. For the Bangalore Metro project, massive excavation was done close to Vidhan Soudha wherein tonnes of explosive was used for hard rock excavation for the construction of metro station box.

Our Flagship Projects

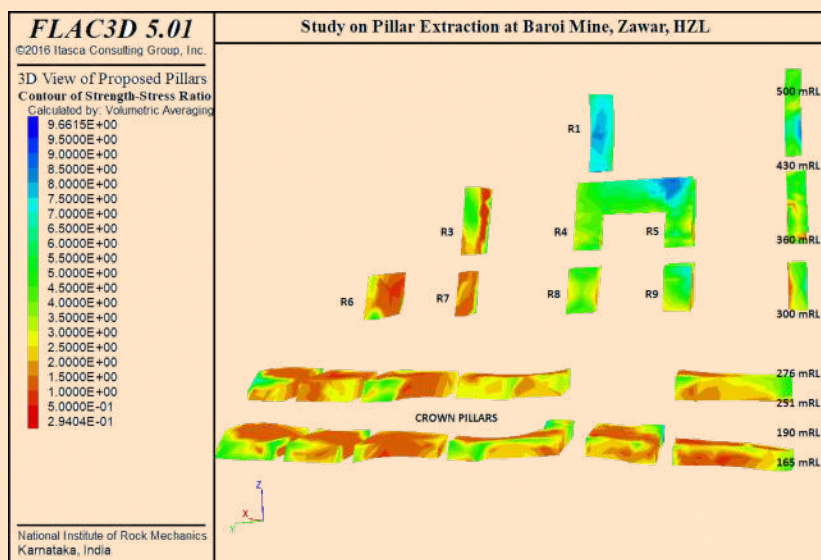
Stability Analysis of underground caverns



NIRM has carried out 3D stress analysis of most of the large caverns in the country and in neighbouring Bhutan to assess their stability. Analysis was carried out using both continuum and discontinuum 3D modelling codes. Incorporation of complex geological features in the 3D model has helped in understanding the interaction of structures with the surrounding rock mass.

NIRM can undertake stability analysis during pre-construction stage with the design of optimum support system, sequence of extraction (particularly in case of multiple caverns), design of the pillars in between the caverns, optimum layout of caverns and other associated tunnels.

Design of optimum stopes in metal mines

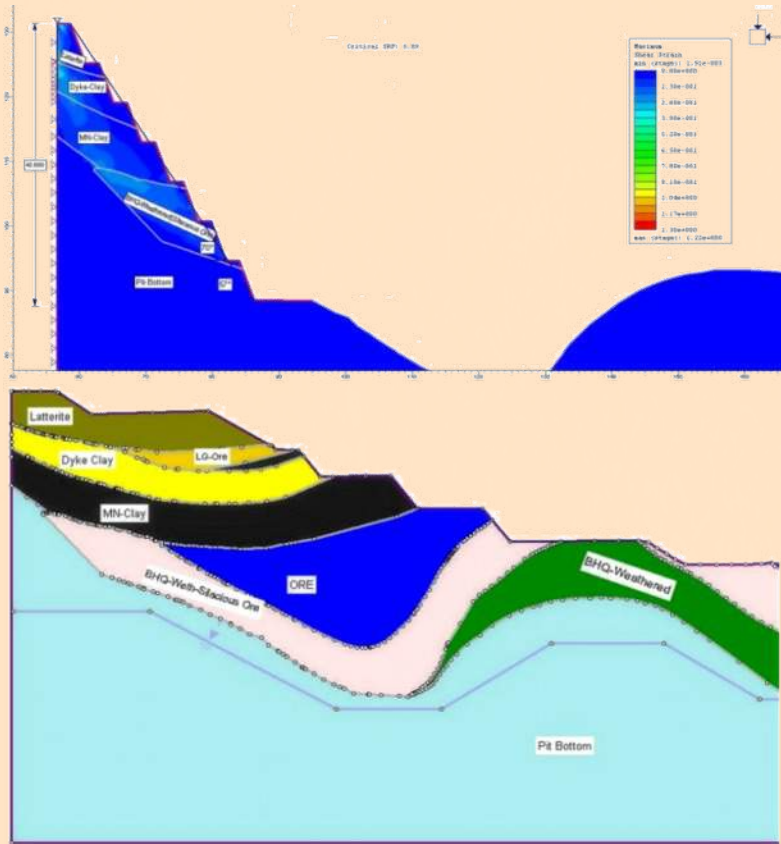


NIRM is scientifically designing the stopes using advanced 3D modelling tools. Optimisation studies with 3D models are done using combination of parameters, which can be practically changed in the field so that maximum recovery of ore without compromising the safety can be achieved.

Feasibility of making tunnels in backfill paste material was also studied with underhand stoping method and the method was successfully applied in RAUG mine of HZL. Dynamic Analysis was carried out to understand the stability of the drives in paste fill and were compared with the field results. Many such works where rock mechanics principals integrated with 3D modelling are being carried out at various mines of Hindustan Zinc Ltd.

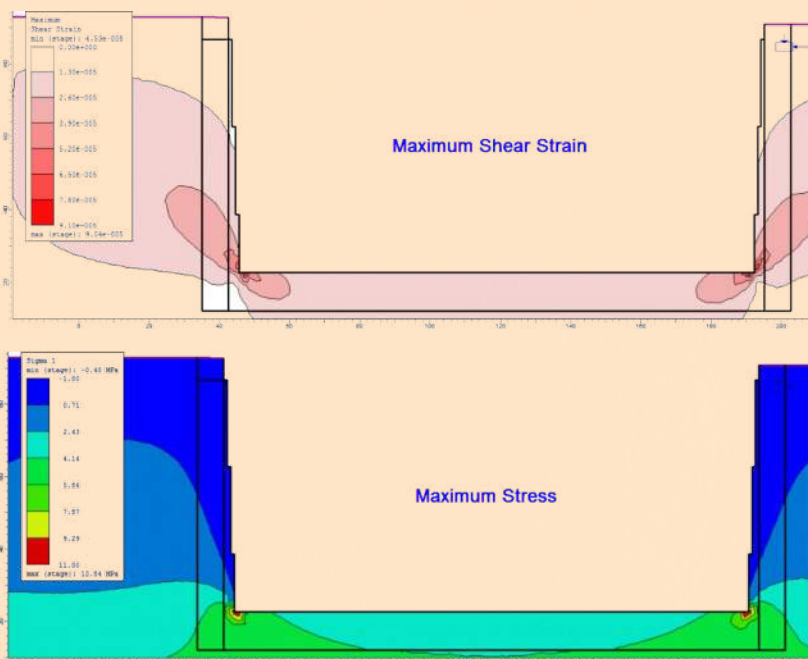
Our Flagship Projects

Analysis of ultimate pit slope



NIRM is actively involved in the design of the Ultimate Pit Slope, dump slope, assess the stability & monitoring of pits for opencast mines. In this case study for the iron ore mines, first the model of site condition is simulated and then numerical analysis is done to suggest the ultimate pit slope for a safe extraction of ore. This helps in optimising the recovery of ore without any failure.

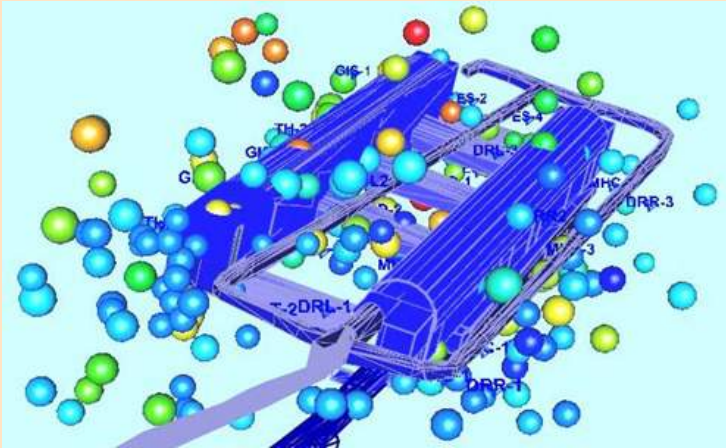
Maximum working depth for granite quarries



In a similar study for granite quarries, studies were conducted to optimise the bench parameters and design of final pit slope to work up to the maximum allowable depth. By carrying out the numerical modelling analysis maximum shear strain and shear stress parameters are determined for the site model to arrive at the safe working depth without any failure.

Our Flagship Projects

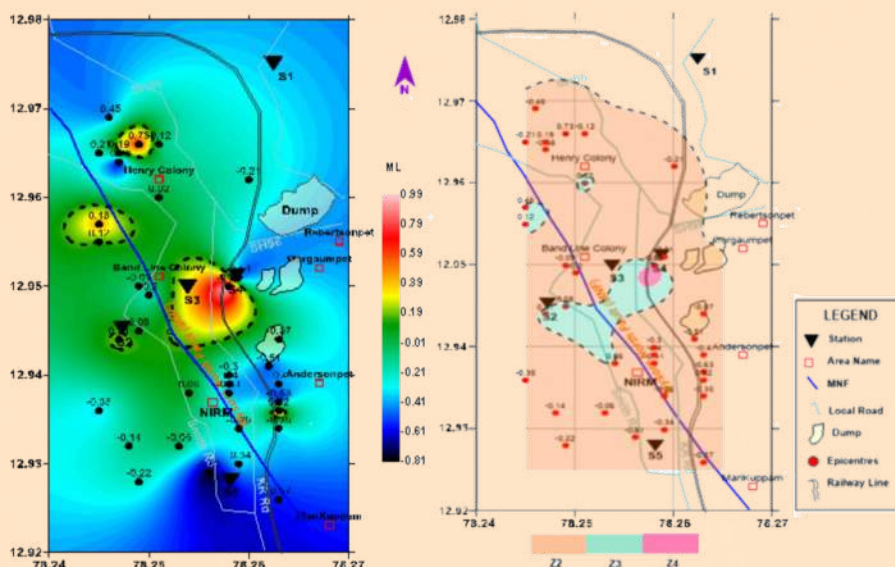
Microseismic monitoring for dynamic stability



In Tala hydroelectric projects of Bhutan, frequent rockbolt failure in the powerhouse was threatening the work environment and had put a question mark on the stability of excavation itself. At this stage, a round-the-clock microseismic monitoring was established by NIRM.

By recording and analysing the background seismicity, the connection between rockbolt failure and seismic events could be traced. All microseismic events are plotted (with indexing as per their size) on the plan of excavation and the resulting seismic risk is evaluated. This network is still under operation and it serves as a safety cum warning network against any impending eventuality.

Assessment of seismic hazard



This project was supported by the Ministry of Mines, Government of India. A micro-seismic network was installed in the old gold mining area of Kolar Gold Fields to record the frequent occurrences of rockbursts even 10 years after the closure of mining activity.

Around 100 events were picked up over one year monitoring period and the data was used to plot the induced hazardous zone on the surface. This study will be helpful for the society in general living at KGF by guiding them against the unsuspected hazard of the remnant mining-induced seismicity at KGF.

Testing facilities at NIRM

Destructive and Non-destructive testing

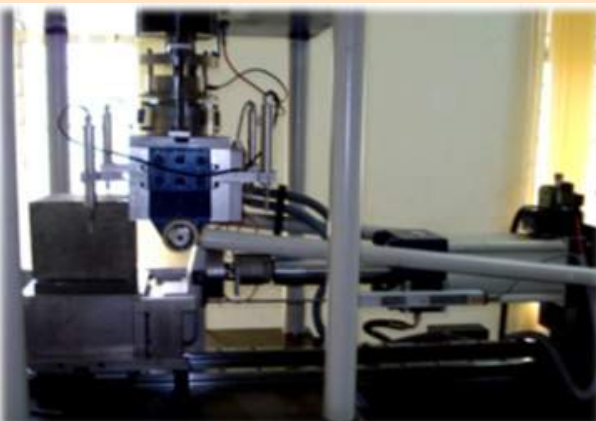


NIRM has got DGMS approved National testing Facility wherein both destructive and non-destructive testing is carried out on wire ropes, mining components and accessories. Apart from them, NDT tests are also done in-situ at the client's place using various NDT equipments and wire rope defectograph. Here NDT tests are being carried out in-situ at SCCL mines on drum shaft, disk brake and thruster breaks is shown. Similarly, wire rope defectograph studies are regularly conducted on ropeways and transport system at various sites (mining & non-mining).

Rock sample testing



The rock sample testing facility at NIRM is equipped with the state-of-the-art facilities for determining various physico-mechanical properties of the intact rock as well as jointed rocks as per ISRM standards. Unique aspect of this testing facility at triaxial cell (Hoek & SBEL) wherein rock sample can be tested both at high temperature and pressure. Post-failure studies and multiple failure triaxial tests are unique to NIRM testing facility.



Fracture mechanics laboratory at NIRM is unique in its character for studying the rock joint properties. Fracture toughness and joint shear strength are the unique parameters of jointed rock which are determined at NIRM. They are essential for design of any subsurface structure.

Heads of Scientific Departments

NIRM has got eight Scientific Departments which are headed by well-qualified and experienced Scientists. Here we briefly introduce Heads of various scientific departments with their bio-data in brief.



Dr. H S Venkatesh
Excavation Engg.

Dr H.S.Venkatesh is a Mining Engineer with M.Tech. from BHU, Varanasi and Ph.D. From NIT, Surathkal. He joined NIRM in the Rock Blasting & Excavation Engineering Department in the year 1990 and took over as HoD in April 2008. He is well versed with opencast and underground blasting operations and has acquired expertise in the area of controlled blasting. He has authored over 65 papers and completed over 180 research and industry sponsored projects. He is the recipient of the prestigious National Mineral Award in the year 2004 in Mining Technology. Dr Venkatesh organized RARE 2016, an International Conference under the aegis of ISRM during November 2016. He is a Fellow of the Institution of Engineers, Member International Society of Explosives Engineers and a

member in several professional bodies like MEAI, ISRM, ITA, ISRMTT, MGMI, ISEG, Visfotak etc. He was member in the expert committees constituted by the State Govt. of Andhra Pradesh, Uttarakhand and Telangana. He represented NIRM as a member in the “Expert Body” as an expert in Blasting & Tunnelling constituted by MoEF&CC, Govt. of India to assess environmental degradation due to Hydroelectric power projects (existing and under construction) in the river basins of Alaknanda, Bhagirathi and their tributaries. Since May 2018, he has taken over as Director of NIRM.



Mr. C Sivakumar
Engg. Seismology

Mr. C Sivakumar is an Electronic Engineer with M. Tech. in Industrial Electronics from NITK, Surathkal. He is continuing in NIRM from erstwhile R&D unit of BGML, and as such working at NIRM since inception. Having been trained at BARC, Bombay, he developed instrumentation for microseismics and strata monitoring. He has secured National Patent for the development of Roof Stability Tester (RST) under the S&T project for detecting hidden flaws in the coal mine roof. He was Principal Investigator of more than three DST projects and two S&T projects in the field of microseismic monitoring

applications to the both coal and hard rock mines. He is recognized as a Mine Induced Seismicity Scientist by Scientific Counsel of CSIR, Australia, European Seismological Society, France and ARMA, USA. He widened application of microseismics technique to the stability monitoring of underground structures for Hydroelectric Projects, Storage caverns, Coal Mines, Hard Rock mines and Slopes in India and Bhutan. He has authored over 60 papers in National / International Seminars/Symposiums/ Conferences/ Technical Workshops.

Heads of Scientific Departments



Mr. A Rajan Babu
CTS & GGCD

Mr. A Rajan Babu is a Mining Engineer with B.Tech from KREC, Surathkal. He holds a Bachelor of Law degree from Bangalore University. He is Level - II certificate holder from ASNT in Magnetic particle testing (MPT), Ultrasonic Testing (UT), Visual Testing (VT) and Penetrant Testing (PT). He served as "National Expert" and Consultant for the United Nations Industrial Development Organisation (UNIDO), Member, Governing Board of the Stone Crafts Foundation, Ministry of Textiles, Government of India, Member, Editorial Board, StonEdge, Journal on Indian dimensional stone industry, Jaipur, Member, Stones Sectional Committee, CED 6 and Rock Mechanics Sectional Committee, CED 48, of Bureau of Indian Standards, New Delhi. . He is a Fellow of the Institution of Engineers and Member International Society for Rock Mechanics and Tunneling Technology, India. Presently, he is Officer-in-charge of the Registered Office of NIRM at KGF and serving as Head, Centre for Testing Services - A National Testing Facility at NIRM and Head of Geomechanics & Ground Control Department which caters to Dimensional Stone Mining, Coal Mining and Slope Stability.



Dr. P C Jha
Engg. Geophysics

Dr. Prakash Chandra Jha is a Geophysicist with M.Sc.Tech. and Ph.D. in Applied Geophysics from ISM, Dhanbad. He joined NIRM in April 1990. From 1990-96, he was working in the Seismology department of NIRM. He established the Engineering Geophysics Department at NIRM in 1996, first of its kind in India at that time. Since then, he is heading this division. He has authored over 50 papers, edited and published two conference proceedings (National & International) and completed over 100 research and industry sponsored projects. He has completed three S&T projects including one International Institutional Collaboration Project with NGI, Norway. He has guided for five doctoral thesis (Ph.D.s) awarded by IIT, ISM, BHU, and NIT. *His areas of expertise include all types of GPR survey including guided profiling from single borehole, Frequency Domain Attenuation Tomography (FDAT), 3D-tomography and tomography across non-parallel boreholes; microseismic monitoring for dynamic stability evaluation; defect mapping and characterization; foundation evaluation for building and structures; stability analysis; subsidence studies; vibration data recording and analysis for damage indices - both active and passive (fatigue); and forensic investigations for critical failures; seismic tomography, resistivity imagining; MASW survey for ground stiffness, settlement, liquefaction & compaction analysis, & microzonation for subsidence prone regions.* He is member of several professional bodies and scientific societies in the field of Geophysics, Geology, Seismology, IT, NDT and Rock Mechanics. He was heading the Establishment & Administration of the Institute from July 1999 to April 2008 as Controller of Administration.

Heads of Scientific Departments



Dr. Sripad R Naik
Numerical Modelling

Dr. Sripad R Naik is a Mining Engineer with M.Tech. from IT, BHU and Ph.D from NIT, Surathkal. He joined NIRM in the year 1992. He was working in the Ground Control department during 1992-1996 and in the Numerical Modelling Department during 1996-2001. He was transferred to Bhutan project site during 2001-2006. He is heading Numerical Modelling Department since his return to NIRM in 2006. He has worked on many challenging problems in the area of hydroelectric projects, coal mine method of working, instrumentation and subsidence modelling. He is an expert in planning, design and execution of geotechnical instrumentation work for mining and hydroelectric projects. He has substantial experience in sophisticated research techniques and technologies, particularly in the area of 3D modelling of underground structures, slopes; numerical modelling and instrumentation in the areas of mining and civil engineering. He has published more than 35 technical papers in journals, national and international conferences.



Dr. D S Subrahmanyam
Geotechnical Engg.

Dr. D S Subrahmanyam is a Geologist with M.Sc. from Andhra University, and Ph. D. from Bangalore University. He joined NIRM in 1997 and is heading the Geotechnical Engineering Department since 2014. He is associated mainly with the geological and geotechnical studies of many important engineering projects in the Himalayan region and presently responsible for planning, programming, implementation and monitoring of engineering geological/geotechnical investigations of hydropower projects, communication projects, underground storage projects, underground mines and irrigation projects in India and abroad. He established an innovative technique for conducting stress measurements in fractured and porous rocks for which he has applied for National Patent. He prepared the Stress Map of India as contribution to the World Stress Map. He has authored more than 50 papers published in the National and International journals and proceedings. He is also the Fellow and life member for various National and International societies and associations. He is Editor for seven International journals and also Reviewer for various National and International Magazines. He was Advisor and Interview Board Member for Union Public Service Commission (UPSC). Prior to joining in NIRM, he worked for 7 years in the Granite and Cement industries in various capacities.

Heads of Scientific Departments



Dr. A K Naithani
Engg. Geology

Dr. Ajay Kumar Naithani is a Geologist with M.Sc. and Ph.D. (Engg Geology) from HNB Garhwal Central University. He joined NIRM in 2008 and since then heading of the Department of Engineering Geology. He has been actively involved in the field of engineering geology and landslide hazard assessment for more than 22 years. He has more than 82 scientific papers and 23 popular articles to his credit, published in national and international journals and proceedings. He was conferred with “Young Scientist Fellowship” and “Senior Research Associateship” by Govt. of India. He is the recipient of the prestigious “Young Scientist Award” from Govt. of Uttarakhand for the year of 2007 for his distinguished contributions in the field of Geology, GSI – Sesquicentennial Commemorative Award from Geological Society of India for the year of 2009, for his distinguished contribution in the field of Engineering Geology and Indian Science Congress Association (ISCA) Best Paper Award for the year 2015-16 in the section of Engineering Sciences.



Dr. Biju John
Seismotectonics

Dr. Biju John is a Geologist with M.Sc. and Ph.D. (Earthquake Geology) from Cochin University of Science & Technology. He joined NIRM in 2008 in the Engineering Geology Department. He is specialized in the field of active tectonic structures as well as seismotectonic source evaluation and initiated these studies at NIRM. He is presently leading the Seismotectonics Cell of NIRM attached to the Engineering Seismology Department. His team of scientists carry out active fault and seismotectonic evaluation in different parts of India and has attended to many challenging issues in the field of active fault studies in peninsular India. He has formulated a methodology for seismotectonic evaluation of Nuclear Power Sites and has been involved in some path-breaking findings in paleoseismology. He has more than 50 papers in National and International Publications and a chapter in Elsevier book, to his credit. He is also guiding Doctoral students for PhD through VIT University.

Workshop/ Training/ Conference

NIRM has actively conducted workshops and training programs for the benefits of stakeholders from industry - both mining and construction. Many of such programs are tailor-made for the specific needs of the industry and some of them were exclusively held for executives of the industry. Such programs are conducted both at NIRM as well as the client's place. Training programme on Tunnelling is being conducted for the Railways since last three years in collaboration with NGI, Norway where part training on NMT is imparted at Oslo.

Apart from them, NIRM has organised one National Seminar of Institution of Engineers and two International Conferences, one with NGI and one under the aegis of ISRM, UK. All these training programs and conference were quite popular with wide participation from various industries, institutions and researchers.

These activities are listed here with a pictorial journey.

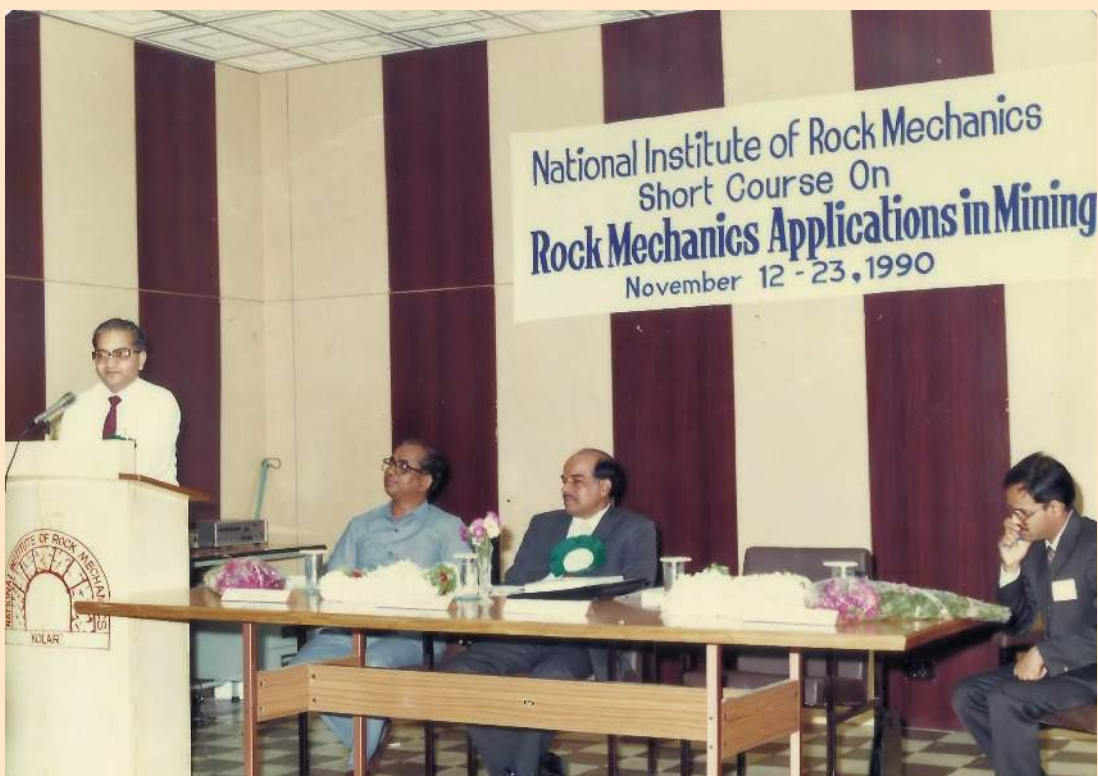
WORKSHOPS

- **Workshop on Safety Measures for Rockburst Control, 19th March 1990 (KGF)**
- **Workshop on Rock Mechanics Applications in Hydro-electric Projects with Special Reference to Srisaïlam Project : 5-7 July, 1994 (SLBHES, Srisaïlam)**
- **Indo-Norwegian Workshop on Recent Trends in Rock Mechanics : 7-9 April, 1997 (KGF)**
- **Workshop on Application of Rock Mechanics in Surface and Underground Excavations, 22-26 August, 2005, (PMI, NTPC, Noida)**
- **Workshop on Rock Mechanics, 05-27th February 2011, (THDC, Rishikesh)**

Workshop/ Training/ Conference



Workshop organised by NIRM under Indo-Norwegian Institutional Cooperation Programme (INICP) in April 1997



First Short Course organised by NIRM in November 1990

SHORT COURSES

Short courses are usually held on concurrent topics to suit the budding requirement of the industry. It is often held at site for client-specific requirement. Courses held at NIRM are open to participants from various industries on nominal fee basis.

- **Short Course on Rock Mechanics Applications in Mining : November 12-23, 1990**
- **Short Course on Application of Geophysical Investigations to Engineering Projects. July 11-16, 2011 (at Banihal, J&K for IRCON)**
- **Short Course on Drilling and Blasting, 8 - 10 August 8-10, 2011 (Jorethang Project Site, Sikkim)**
- **Short Course on Application of Numerical Modelling to Tunnels, Caverns and Slopes, NIRM, Bangalore, August 1-6, 2011**
- **Short Course on Dimensional Stone Technology, November 23 - 25, 2011 NIRM, KGF**
- **Short Course on Instrumentation for Tunnels, Caverns and Slopes, December 12 - 17, 2011, NIRM, Bangalore**
- **Short Course on Application of Numerical Modelling Techniques, April 1 - 8, 2009, NIRM, Bangalore**
- **Short Course on Application of Rock Mechanics Principles to Tunnelling, August 12-18, 2009, NIRM, Bangalore**
- **Short Course on Application of Rock Mechanics in Tunnelling and Underground Works, November 7 - 10, 2009, Chuzachen, Sikkim (for SEW Infrastructure Ltd)**
- **Short Course on Blasting in Surface Mines with Special Reference to Limestone Mines, April, 2009, Chilamkur, Andhra Pradesh (for India Cements Limited)**

TRAINING PROGRAMS

- Training Programme on "Rock Mechanics", for THDC Engineers, April 05- May 01, 2010 (Rishikesh)
- Training Programme on "Tunnelling Technology" for IRSE (Civil) Engineers, May 15- 30, 2014 (KGF & Oslo)
- Training Programme on Rock Mechanics investigations for Excavation Engineers for L & T Officers, Dec. 8-12 2014
- Training Programme on "Tunnelling Technology" for IRSE (Civil) Engineers, Jan. 05-20 2015 (KGF & Oslo)
- Training Programme on "Controlled Blasting & Excavation Engineering" for BRO personnel, July 25-29, 2016 (KGF)
- Training Programme on "Strata Monitoring" for SECL Official, Jan 30-Feb. 03, 2017 (Bangalore)
- Training Programme on "Strata Monitoring" for SECL Official, Feb. 13-17, 2017 (Bilaspur)
- Training Programme on "Tunnelling Technology" for RVNL and MVRCL Engineers, July 03-20, 2017 (Bangalore & Oslo)



Training Program being conducted for RVNL & MVRCL Officials

CONFERENCES

- Sixth National Symposium on Rock Mechanics, October 15-17, 1992 (IEI Series)
- ROCKSITE-99, International Conference on Rock Engineering Techniques for Site Characterization, December 6-8, 1999, Bangalore (Under Indo-Norwegian Cooperation Programme)
- ICUST-2011, International Conference on 'Underground Space Technology, January 17-19, 2011, Bangalore (with ISEG, Lucknow)
- IPRM-2014, National Conference on Innovative Practices in Rock Mechanics, February 14-16, 2014, Bangalore
- RARE-2016. International Conference on Recent Advances in Rock Engineering, November 16-18, 2016, Bangalore (ISRM, Asia Conference)



First National Symposium organised by NIRM in October 1992

Workshop/ Training/ Conference



ROCKSITE-99 : First International Conference organised by NIRM in December 1999 under NGI-NIRM cooperation programme



RARE-2016 : Conference Proceeding being released on the occasion of last International Conference organised by NIRM in November 2016

Awards/ Honours

NIRM has done exemplary work in the field of Mining Technology. This is evident in the fact that four of its staff have received National Mineral Award in the past, all in the field of Mining Technology. They are listed below in chronological order :

- 1992 : Dr. N M Raju, Director, NIRM
- 1999 : Prof. R. N. Gupta, Director, NIRM
- 2000 : Dr. Singam Jayanthu, Scientist (Ground Control)
- 2004 : Dr. H S Venkatesh, Scientist (Rock Blasting & Excav. Engg)



Dr. H.S. Venkatesh, presently Director, NIRM, receiving the National Mineral Award for Mining Technology in the year 2004

Patents

So far NIRM has secured two patents from the Indian National Patent office out of the research work carried out by the Institute under S&T projects. Two more patents applications are pending for award. They are :

1. **Patent No : 19300 - Granted on 24th May 2005 for Roof Stability Tester for testing the stability of the coal mine roof by automated assessment of impact vibration.**

Inventors : C Sivakumar (Principal Investigator), Dr P C Jha, Y V Sivaram and Dr. N M Raju

Source : Developed under Coal S&T Project

2. **Patent No : 198196 - Granted on 16th January 2006 for Microprocessor Bases Solid State Control (MSBC) system for haulers in coal mines**

Inventors : T Srinivasulu (Principal Investigator) and Dr R N Gupta

Source : Developed under Coal S&T Project

3. **Patent (Applied for) : Application has been filed with with Controller General of Patents, Designs & Trademarks, Govt. of India, for obtaining patents for two more patents for the newly developed methodologies**

(a) In-situ stress measurements in fractured rock mass by using high flow rate technique and

(b) In-situ stress measurements in porous rock mass by using high viscous liquid.

Inventor : Dr. DS Subrahmanyam, Head, Geotechnical Engg Dept

Source : Developed under S&T project of Ministry of Mines

Academic Programme

Various project works carried out by the Institute involves applied research wherein innovative solution has to be provided to the industry for the site specific problem. This is evident from the fact that so far 15 Ph.D.s have been secured by Scientists of NIRM out of the work carried out by them during routine investigations.

Considering these facts in view, the Visvesvaraya Technological University (VTU) at Belgavi has recognised NIRM as an independent 'Advance Research Centre' for the award of M.S. And Ph.D. By research in Rock Mechanics. VTU is one of the leading and largest technical universities in India with authority over engineering education all over the state of Karnataka.

We are awaiting additional space allocation for starting this academic curriculum. It is planned to start this course from the academic year 2019-20. When started, this will be first independent research centre in India providing higher degrees in Rock Mechanics (Mining & Civil Engg).

Apart from this we have plan to develop a 'Skill Development Centre' at our Registered Office at KGF. This centre will impart training to field personnel in Mining and Civil Engineering and bridge the knowledge gap in theory and practice in rock mechanics applications and safety.

New Sectors

Complacency is the last word in research and development. Therefore, our aim is to keep expanding, diversifying and cover broader spectrum of work areas. We have already set our foot in offshore investigations where three large projects are being technically guided/ investigated by us.

- We have plan to cover Oil and Gas sector also. So far we are supporting this industry with specialised rock sample testing, but negotiations are underway to expand our foot-print and cover more sophisticated investigations.
- Port sector and archaeology are another two areas where we want to enter into a big way with our precision investigation tools.

Important Contacts

Dr. H S Venkatesh
Director

Telephone : 080-26934400 (Direct);
080-26934402 (PA)

Fax : 080-26934401

Mobile : 9845176287

email : dto@nirm.in

| Sl. No. | Department | Head of Department | Telephone (Office/ Mobile) | e-mail |
|---------|-------------------------------|----------------------|----------------------------|---------------------|
| 1 | Engineering Geology | Dr. A K Naithani | 080-26934411 9481434153 | egd.nirm@gmail.com |
| 2 | Engineering Geophysics | Dr. P C Jha | 080-26934407 9448044647 | egp.nirm@gmail.com |
| 3 | Geotechnical Engineering | Dr. D S Subrahmanyam | 080-26934415 9448402572 | ged.nirm@gmail.com |
| 4 | Excavation Engineering | Dr. H S Venkatesh | 080-26934409 9845176287 | rbee.nirm@gmail.com |
| 5 | Geomechanics & Ground Control | Mr. A Rajan Babu | 08153-275000 9845188807 | ggcd.nirm@gmail.com |
| 6 | Numerical Modelling | Dr. Sripad R Naik | 080-26934408 9449225973 | nmd.nirm@gmail.com |
| 7 | Engineering Seismology | Mr. C Sivakumar | 080-26934412 9036681157 | csk.nirm@gmail.com |
| 8 | Centre for Testing Services | Mr. A Rajan Babu | 08153-275000 9845188807 | cts.nirm@gmail.com |

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In-situ shear test in progress at Yargol dam site, Karnataka



Complete setup of Direct shear test



National Institute of Rock Mechanics (Ministry of Mines, Govt. of India)

Head Office :
Outer Ring Road, Banashankari II Stage
Bangalore - 560 070

Tel: (+91) 80-2693 4402-4415
Fax: (+91) 80-2693 4402

Registered Office :
Champion Reefs
Kolar Gold Fields - 563 117

Tel : (+91) 8153-275 001
Fax : (+91) 8153-275 002

Web : <https://www.nirm.in>
e-mail : dto@nirm.in

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