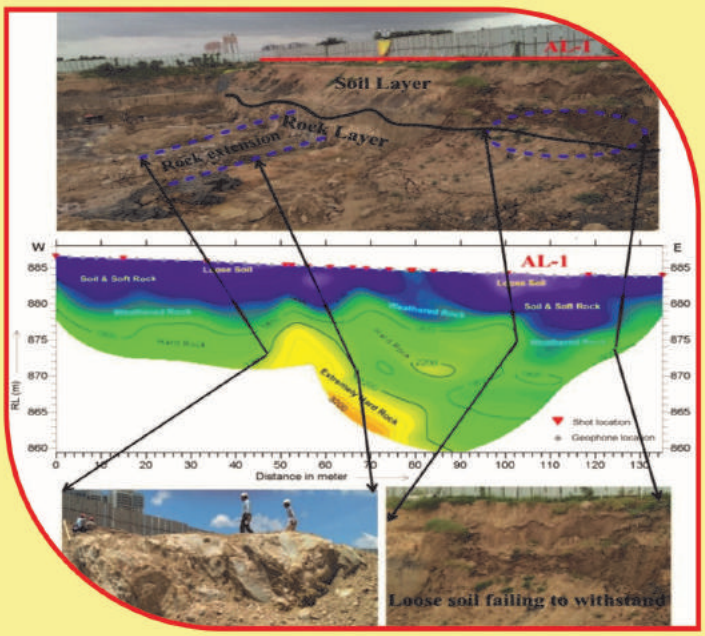
Annual Report 2018 -19



National Institute of Rock Mechanics Annual Report 2018 -19

National Institute of Rock Mechanics
(Ministry of Mines, Government of India)

Head Office
Outer Ring Road, Eshwar Nagar,
Banashankari 2nd Stage, Bengaluru-560070
Karnataka, India

Registered Office
P.O. Champion Reefs,
Kolar Gold Fields-563117
Karnataka, India

Release of technical souvenir of NIRM during "Conference with Industry Partners on Future Stratagies" held on 18 Feb 2019.

Annual Report
2018 - 19

National Institute of Rock Mechanics

(Ministry of Mines, Government of India)

Head Office:
Outer Ring Road, Eshwar Nagar
Banashankari 2nd Stage, Bengaluru – 560070, Karnataka, India
Phone Nos.: +91-80-26934400/02 to 15; Fax: +91-80-26934401

Registered Office:
P.O. Champion Reefs, Kolar Gold Fields – 563117
Karnataka, India
Phone No: +91- 8153-275001; Fax: +91-8153-275002

Web: www.nirm.in **Email:** dto@nirm.in

NATIONAL INSTITUTE OF ROCK MECHANICS

Department Contact Numbers:			
Name	**Designation**	**Phone (off)**	**Phone (Mob.)**
Administrative			
Dr. H S Venkatesh	Director	+91-80-26934400	9845176287
-------	PA to the Director	+91-80-26934402	
Mr. A Rajan Babu	Officer-in-Charge, RO, KGF	+91-8153-275001	9845188807
Dr. Sandeep Nelliat	Controller of Administration	+91-80-26934403	9481826252
Mr. S Ravi	Purchase & Stores Officer	+91-80-26934404	9448141794
Mrs. Uma H R	Finance & Accounts Officer	+91-80-26934405	8861460584
Mr. N Jothiappa	Administrative Officer	+91-80-26934406	9480496164
Dr. Sripad R Naik	Officer-in-Charge, PMC	+91-80-26934413	9449225973

Head of Scientific Departments

Dr. H S Venkatesh	Rock Blasting & Excavation Engineering	+91-80-26934409	9845176287
Mr. Sivakumar Cherukuri	Engineering Seismology & Seismotectonics	+91-80-26934412	9845041866
Mr. A Rajan Babu	Centre for Testing Services	+91-8153-275001	9845188807
	Geomechanics & Ground Control		
Dr. P C Jha	Engineering Geophysics	+91-80-26934407	9448044647
Dr. Sripad R Naik	Numerical Modelling	+91-80-26934408	9449225973
Dr. D S Subrahmanyam	Geotechnical Engineering	+91-80-26934415	9448402572
Dr. A K Naithani	Engineering Geology	+91-80-26934411	9412114842

Editorial committee	Dr. Biju John	Chairman
	Dr. Yogendra Singh	Member
	Dr. Rabi Bhusan	Member
	Mr. Vikram S	Member
	Mr. Bharath Kumar A Y	Member
	Mr. Shashi Nath Verma	Member
Advisor	Dr. P C Jha	
Published by	National Institute of Rock Mechanics	
Printed at	Bengaluru	

Cover photos caption:

Top left *: Delineation of soil & soft rock layers using seismic refraction survey*
Top right *: Excavation of circular pump house*
Bottom left *: Overriding of hanging wall block along a reverse fault near Nellore.*
Bottom right *: Monitoring blast vibration 6m before TB3*

CONTENTS

	Page No.
• DIRECTOR'S REPORT	4
• INTRODUCTION	6
1. MINING SECTOR	7
2. POWER SECTOR	14
3. INFRASTRUCTURE SECTOR	22
4. TESTING SERVICES	27
5. MISCELLANEOUS SECTOR	32
6. OTHER IMPORTANT ACTIVITIES	33
• ANNUAL ACCOUNTS	36
• ANNEXURE (1 to 8)	47
1. ORGANISATION CHART	48
2. MEMBERS OF GENERAL BODY	49
3. MEMBERS OF GOVERNING BODY	50
4. MEMBERS OF PEER REVIEW COMMITTEE	51
5. SUPPORTING ORGANISATIONS & MAJOR CLIENTELE	52
6. LIST OF COMPLETED PROJECTS	54
7. LIST OF PUBLICATION	60
8. NIRM STAFF ON ROLL	62

DIRECTOR'S REPORT

Namaste !

I am delighted to present the Annual Report 2018-19 of National Institute of Rock Mechanics (NIRM), an autonomous organisation of repute under Ministry of Mines, Government of India which summarizes the major activities and achievements of the institute during the last fiscal year. The Institute provided technical and consultancy services to various user organizations in India and abroad. We made significant contributions to knowledge generation as evidenced from research papers. We strive to put our best foot forward every day to serve the industries in the most efficient and effective ways possible. In this year's report, we are highlighting many though certainly not all of the Institute's accomplishments and activities to advance our vision ensuring high quality and standards.

Established as an R&D support and expertise to Mining industry, NIRM deals with field and laboratory investigations, basic & applied research and solving complex problems in almost entire spectrum of Rock Mechanics and Rock Engineering related to Mining and Civil Engineering activities. During this year, NIRM made big strides across the spectrum of energy sector and most of urban infrastructure by providing solutions through applied research. During 2018-19, the Institute was associated with over 153 projects spread across mining, energy and infrastructure sectors. Different investigative techniques are also integrated as per the requirement of various industries. In addition to this, laboratory and in-situ testing services of material and rock samples were also done as required by the industry.

An important event that will have long term impact on R&D activities in NIRM as a whole was the workshop conducted in the month of February 2019 at Bengaluru with industrial partners for understanding their future requirement and expectations from NIRM for timely execution of the projects and the program was chaired by Dr K Rajeswara Rao, Additional Secretary, Ministry of Mines, Government of India. As part of information dissemination and skill development exercise, NIRM conducted two training courses during 2018-19 one each for the Executives of Singareni Collieries Company Limited, Govt. of Telangana and other for executives of Druk Green Power Corporation Ltd., Bhutan. During the financial year there was a surge in number of projects executed in the mining sector and NIRM has made significant contributions to the development of safe and economic practices coal, metal and opencast mines under difficult geomining conditions. Significant projects had been oriented to reduce the risk and hazard by modifying/monitoring the mining methods and adopting best safety practices.

In mining sector NIRM conducted studies viz., design of method of mining, feasibility studies, design of stoping parameters, yield zone & stress distribution determination, review of Ground Control & Management Plan and Strata Control & Monitoring Plan of mines and monitored rock burst that is being continued at KGF, stability studies of pit and dumps, stability analysis through instrumentation and numerical modelling, and monitoring of ground vibration to name a few.

NIRM made a notable contribution in Energy sector. 3dimensional numerical models were created for underground caverns and monitoring of structures using instrumentation. In a significant study, Powerhouse orientation of Devasari HEP hasbeen determined

through in-situ stress analysis. There were issues of crown collapse in the underground cavern of PHEP during excavation, which hindered the progress of the work. NIRM supported and facilitated further excavation through controlled blasting and numerical modelling studies. In-situ stress measurements were also done for the design of Pothead yard and to determine the stress regime in the vicinity of surge gallery.

In Nuclear energy sector NIRM's involvement started from the studies for site selection to foundation clearance through blasting. Seismotectonic evaluation identified suitable sites for siting studies for nuclear installations at east coast of India from three locations. For KKNPP, NIRM is exclusively involved in the blast vibration monitoring. As per BARC's request NIRM also involved in the process of selecting site for nuclear repository through in-situ stress studies. For thermal power plant at Sundargarh, controlled blasting method of operations is adopted for the foundation excavation of various components of installations.

During the period NIRM was involved in five Lift Irrigation Projects (LIP) for various studies. Studies were carried out at Godavari, Palamur and three packages of Kaleshwaram LIPs. In-situ stress studies were conducted for Palamuru and J Chokkarao LIP, whereas the test is conducted for the design of steel liners and delivery mains for B.R. Ambedkar LIP. NIRM was involved in two marine projects for support of extraction, grading and testing of armour rocks for Gopalpur port and a naval base near Vishakhapatnam. In another significant work, geophysical survey was conducted along the pipeline route to identify potential subsidence zones in the Raniganj-Asansol coal fields. NIRM also extended services to housing sector for identifying basement configuration and for optimising blasting activity. With a highly sophisticated DGMS approved testing laboratory & facilities, NIRM has carried out in-situ testing of mining components in the mines viz., SCCL, SAIL, HZL, HCL, HGML, NALCO etc., In addition to this, in-situ testing of various mining components was also done. Laboratory testing of ropes, material and rock samples for determination of various physico-mechanical properties was also done for various industries including ONGC, Varsha project and other mining companies. Many of our Scientists received National and International recognitions, served as expert members on important committees. As part of motivating and encouraging young talent in the field of Mining Engineering, Civil Engineering, Geology, Geophysics etc, the Institute also awarded training and internships to B. Tech and MSc students. This past fiscal year was one of great accomplishments for Vision Forward and the people we serve.

The above mentioned achievements are just illustrative in nature and not exhaustive. These were possible only because of the dedication of Scientists & staffs of NIRM. Team NIRM acknowledges with immense gratitude the enduring support extended by the Chairman & members of General Body, Governing Body and Peer Review Committee. I am indeed thankful to our external experts who guided us in our pursuit for excellence. NIRM has taken enormous strides during the year 2018-19 and we look forward to the institute emerging as the highest performing unit of Ministry of Mines.

Jai Hind !

H. S. Venkatesh

INTRODUCTION

National Institute of Rock Mechanics provides its R&D support and expertise to the mining industry (surface and underground), power industry (hydel, thermal and nuclear) and infrastructure projects (rail, road, metro, irrigation, marine, urban construction etc.) by carrying out varieties of investigations in the area of rock engineering and rock mechanics. Key areas of activities of the Institute include numerical modelling, excavation engineering, controlled blasting, engineering seismology, slope stability, site characterisation (including geological, geophysical and geotechnical investigations), laboratory testing of rock samples, wire ropes and other mining accessories and NDT testing (both in laboratory and in-situ).

During this year, 35 projects were taken up in the mining sector, out of which 3 were from coal mines, 28 from metal mines and 4 others from open cast exploration for granite, limestone, gypsum etc. While investigations were completed and final report submitted for fifteen of them, twenty other are being continued as either data processing or under investigation.

Power sector is the backbone of NIRM and accounts for more than 50% of the revenue earning. Extending our expertise by way of providing consultancy services to the power sector is one of key areas we extend our services in solving the site specific problem and carried out crucial investigations for the design and development. During this year 47 projects were taken up in the power sector, out of which 13 were for nuclear power, 30 for hydroelectric power and 4 for thermal power. Most of the studies were related to the construction stage investigations for safe practice and/or site characterisation for the design implementation. While investigations were completed and final report submitted for twenty two of them, investigation or data processing is being continued for the remaining twenty five.

Apart from key work areas of Mining and Power sector, NIRM extends its R&D support and expertise to the Infrastructure sector which includes Irrigation and Marine projects, Drinking water, Urban housing and Metro and Rail/Road projects. During this year 34 projects were taken up in the infrastructure sector, out of which 18 were related to irrigation projects, three marine projects, seven housing projects and remaining two each from pipeline, underground cavern and metro & road projects. While investigation was completed and final report was submitted for twenty one of them, investigations are being continued for the remaining thirteen projects.

NIRM has DGMS approved testing laboratory for testing of material and rope samples. Both destructive testing at laboratory for wire rope samples and Non-Destructive Testing (NDT) at site for various mining equipment and accessories like winders, wire-rope and shaft components are done. During this year, 22 projects were carried out for these tests. Apart from them, the Institute has well established rock testing facility where both preparation and testing of rock samples for various physico-mechanical properties are done as per ISRM standard. The fracture mechanics set-up at Institute determines both static and dynamic properties of rock joints. During this period seven projects related to rock testing were carried out.

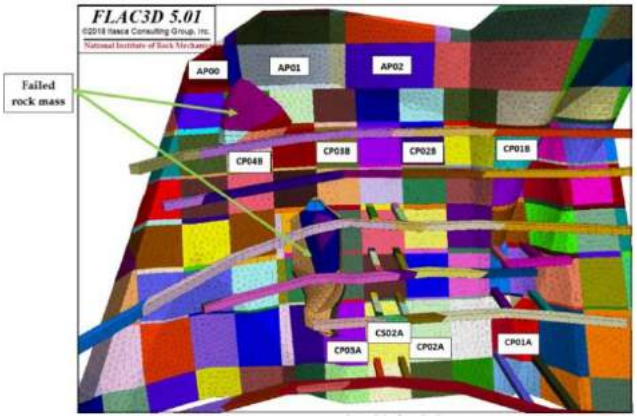
In addition to these projects, six S&T projects including two in-house S&T projects and two projects related to miscellaneous sector carried out during this year.

1. Mining Sector

- To reduce the risk, incidence, severity and damaging effects of possible rock-related hazards, a comprehensive Ground Control and Management Plan (GCMP) has been prepared by the mine management of Zawar Group (Mochia, Balaria, Zawarmala and Baroi). Accordingly M/s Hindustan Zinc Limited (HZL) entrusted NIRM to review and audit GCMP of Zawar Group of Mines for the years 2017-19. NIRM suggested to carry out proper geological mapping and also to install instruments at critical locations.

Rock bolt anchorage testing in the Mine

- The rock mass failure was experienced in India's largest underground mine (Sindesar Khurd Mine) at CP03, resulting in failure of footwall drive at 65 mRL. Geological, geotechnical, empirical and numerical methods of analysis are used for reviewing probable failure characteristics of CP03A stope. The kinematic, Mathew analysis and 3D-FLAC numerical modeling analysis were carried out to know the yield zone and stress distribution patterns. Based on comprehensive studies, suggestion were made to the mine management for safe extraction of ore from further primary and secondary stopes. Thus, it contributed in development of a new mining methodology to extract ore from primary stope, which was selected as a trial stope to implement the recommendations.



FLAC3D model of C block at Sindesar Khurd Mine

- HZL wanted to enhance the production of Rajpura Dariba mine (RDM) by adding new blocks. NIRM reviewed and determined alarming limits for surface subsidence through numerical modelling for the new blocks. A 3D numerical model is being developed in FLAC-3D by incorporating the previously excavated stopes and the planned stopes for excavation in South, East, Main and North lodes of RDM. Numerical modelling is under progress.

- Scientific study has been proposed at Hira Buddini Mine of Hutti Gold Mines Limited (HGML) to determine the impact of ground vibration on surface structures caused due to blasting. Ore is being mined by sub level open stoping. A preliminary site investigation was carried out and field investigation is under progress.

- Blast induced ground vibration and air overpressure studies were conducted near the rock quarry of M/s KNR Constructions. Ground vibration and air overpressure levels were monitored at different locations as per the suggestions from Dept. of Mines and Geology. A safe permissible peak particle velocity limits of 5 mm/s for the recorded frequency

above 18Hz is recommended for Sri Swayambu Pathala Vinayakaswamy temple located at a distance of 175m from the quarry.

- Study was conducted at Valasapalli and Kodur villages of Yerraguntla Mandal, Kadapa District, Andhra Pradesh on ground vibration and air overpressure, caused due to production blasts at Zuari limestone mine. Drilling and blasting practices of the mines were studied and blast induced vibrations were monitored at five different locations for varying blasting parameters. The study found that air overpressure generated by blasting are far below the permissible limit of 133dB. The safe maximum charge per delay for different distances was calculated based on the predictor equation for controlling the ground vibration level within permissible limit.

Monitoring ground vibration and air overpressure near western entrance of Valasapalli village

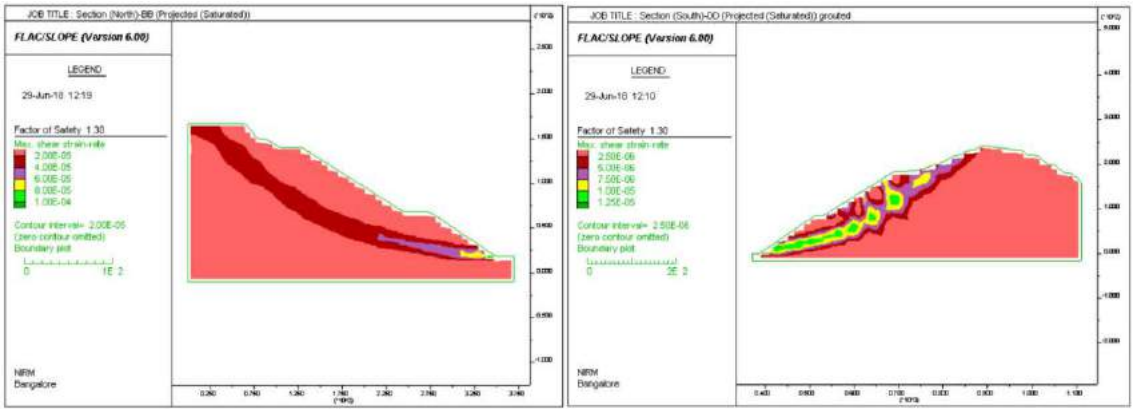
- As per the request from the Department of Mines and Geology, Govt. of Karnataka, blast induced vibration study was carried out for Kumaraswamy Temple, Bellary. The temple is a protected monument, located between the two operating iron ore mines. Ten trial blasts were conducted and ground vibration were measured at different locations around temple. The trial blasts indicated the normal blasting practices being followed at these mines. A peak particle velocity of 2mm/s was recommended as safe limit based on the Director General of Mines Safety (DGMS) standards.

Monitoring of ground vibration near Kumaraswamy temple

- Scientific studies of Pit stability monitoring towards north side of Krishna Limestone mine in Ramayanpatti village, Tirunelveli District, Tamil Nadu were conducted. Geotechnical studies were conducted in this mine and based on field investigations, monitoring using instruments & numerical analysis using the geotechnical parameters, recommendations for optimum design of bench parameters and ultimate slope angle were suggested.

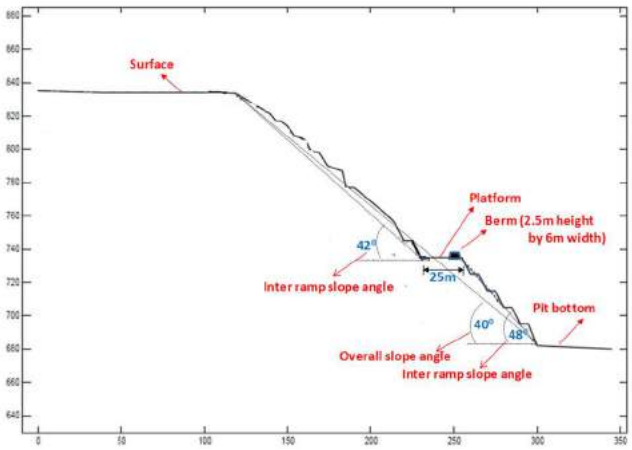
View of Krishna Mine

- Slope Stability Studies for deepening the quarry and enhancing the dump-3 height of Kaliapani Chromite Mine, Kaliapani, Jajpur District, Odisha were conducted. Based on field investigations, laboratory test and numerical analysis, the optimum pit bench parameters (8m width by 8m height) and overall slope angles of the pit footwall and hangingwall are recommended. The results allowed to extract considerable amount of ore more from the area.



Recommended slope design for footwall and hanging wall section, an ultimate pit slope of angle of 31°

- Scientific study to assess the stability of south side (in-corp) highwall benches at MOCP, RG-1 area, of Singareni Collieries Co. Ltd., (SCCL) in Peddapalli District, Telangana State was conducted. On the south side high wall benches, tensile cracks and vertical subsidence (deformations of 1.4m deep at a distance of 26m from crest of the pit) were observed at top surface level of 835 mRL. The rock mass towards highwall section where cracks and subsidence occurred was found to be stable during total station monitoring. The study recommended to maintain a minimum 25m platform at 100m depth of the pit. The suggested bench dimensions were 8 m height by 8 m width with an ultimate pit slope angle of 42° for

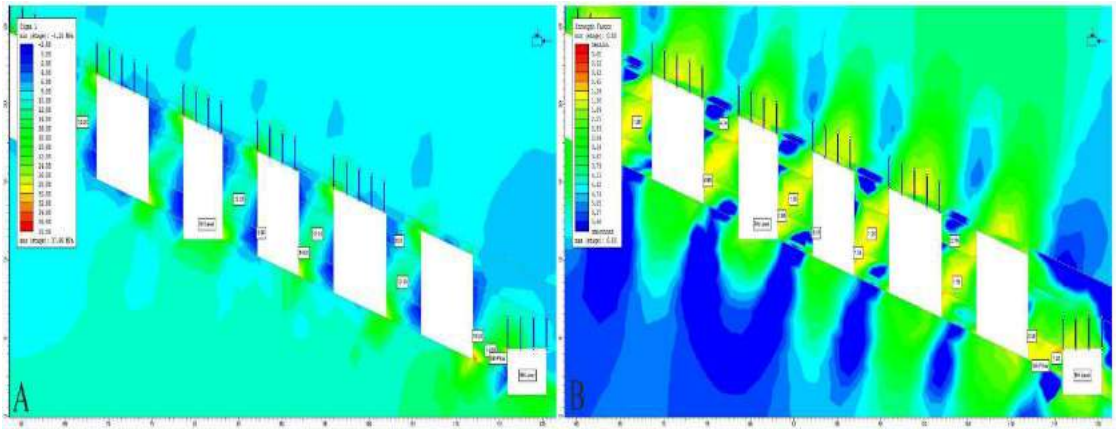


Final recommended highwall benches design in slope disturbed area of the pit

surface level to 100m depth and 48° from 100m to 145m depth in the disturbed slope area of the pit.

- Studies on design of stoping parameters at 11th, 12th & 13.5th level of Balaghat mine and design of sub-level stoping of Chikla & Munsar mine of MOIL with a view to optimize the stoping parameters by both empirical and numerical modelling is continuing. In addition to this at Balaghat, study has been done for (a) feasibility of conversion of in-situ rib pillar to post pillar, (b) deciding dimensions of post pillars and placement of post pillars of varying widths and (c) placing of cable bolts and roof bolts. Data analysis of the instruments installed at Chikla mine is also carried out.

- A study was conducted to evaluate the factor of safety (FoS) of the remnant pillars of the underground Uranium mine operated by the Uranium Corporation of India Limited (UCIL) near Tummalapalle in YSR district, Andhra Pradesh. This study includes the results of numerical modelling to evaluate the FoS for the proposed mining method with long panels. All the pillar dimensions are as per the proposed design of pillar sizes. The strength and the FoS of the remnant pillars formed by the proposed mining method/sequence were examined by numerical modelling for their stability.



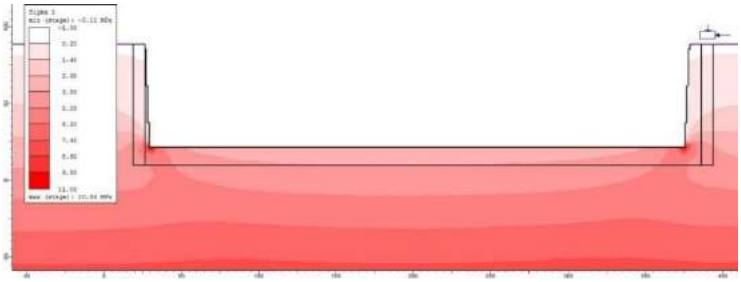
A:*Mining Induced Stresses around the pillars after FW, Parting & HW lode mining without backfilling.* B*: FoS Values around the pillars after FW, Parting & HW lode mining without backfilling*

- Scientific studies were carried on for the design and stability assessment of slopes of Dolomite project of APMDC, Vijayawada. It was proposed to carry out the studies with analysis based on physico-mechanical properties of material and reported deformations. This also includes analysis of monitoring data during the study period. Studies are in progress.

- Scientific Study for slope stabilization and monitoring of ground movement of South Face, Mine I of NLCIL, Neyveli, TN is being carried to suggest some immediate corrective measures to arrest further failure of slide. The study also includes pit slope analysis for determination of optimum slope angle and ultimate depth. Further studies are in progress.

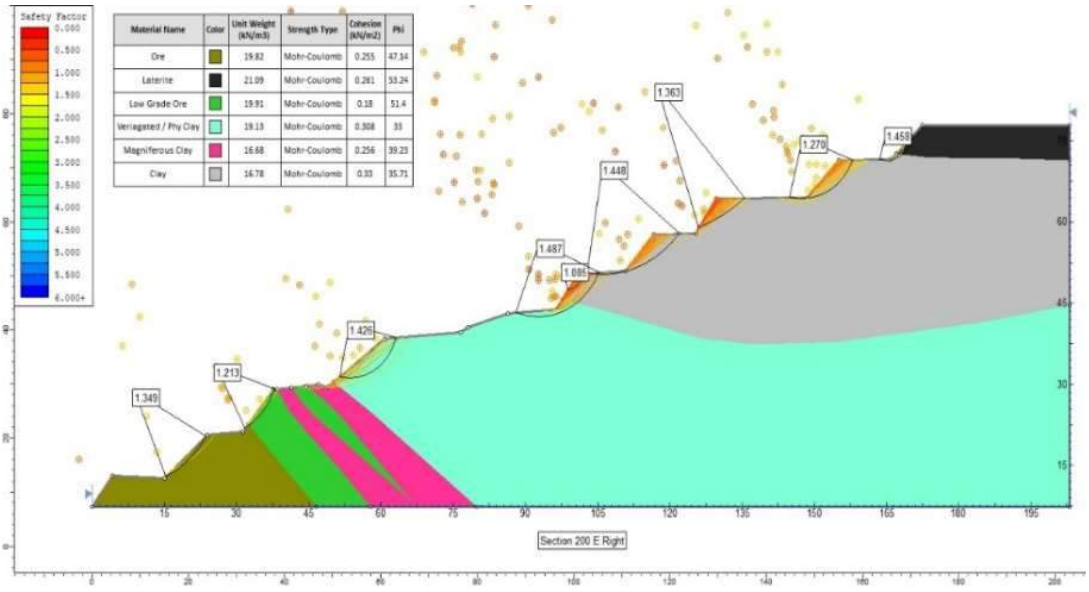
- Scientific studies were conducted at A Narrain iron ore mine, operated by M/s Vedanta Limited, to suggest ultimate dump slope limit and its stability along with suitable dumping parameters. Field investigations and laboratory tests were conducted at the mine and dump samples were collected from the mine. For dump samples, large scale direct shear tests were carried out to generate numerical design of dump. Further studies are in progress.

- Scientific studies to optimize the bench parameters and design of final pit slope stability is being carried out for K Deivendran Granite quarries and other quarries, Tamilnadu. Scientific studies were conducted to assess the stability of high walls and suggested bench parameters for overall final pit stability and to design final pit slope to work up to the maximum allowable depth.



The maximum Stress in this section is 10.54 MPa in the bottom level for one of the sections.

- Scientific study was conducted for design and stability evaluation of proposed deepening of mine workings (from-44 mRL to -66 mRL) including the surface dumps stability at Redi Iron Ore Mine of Gogte Minerals, Maharastra. The analysis is carried out for the existing slope parameters of the mine & the dumps and the corrected slope parameters. From the analysis of the slopes of the mine, the ultimate pit depth can be worked until -85 mRL. The dump with the maximum permissible height of 30m with the FoS at 1.2 has been recommended.



Showing the FoS values of Section 200 East Right

- Geological mapping is done at multiple levels in different segments (from 14th to 4th Level) of the mine for determining geotechnical parameters to evaluate the feasibility of hang wall lode mining of Tumalapalle mine, UCIL, AP. The study also estimates the average Q and RMR values for different locations.

3D Mapping at UCIL

- Studies carried out for the Iron ore operated by M/s M Hanumantha Rao in the forest area in Narayanpur village, Bellary district, Karnataka. The scope of work for the studies related to this project include studying the existing mine layout and method of working, testing of rock samples for determination of physico-mechanical properties, conducting

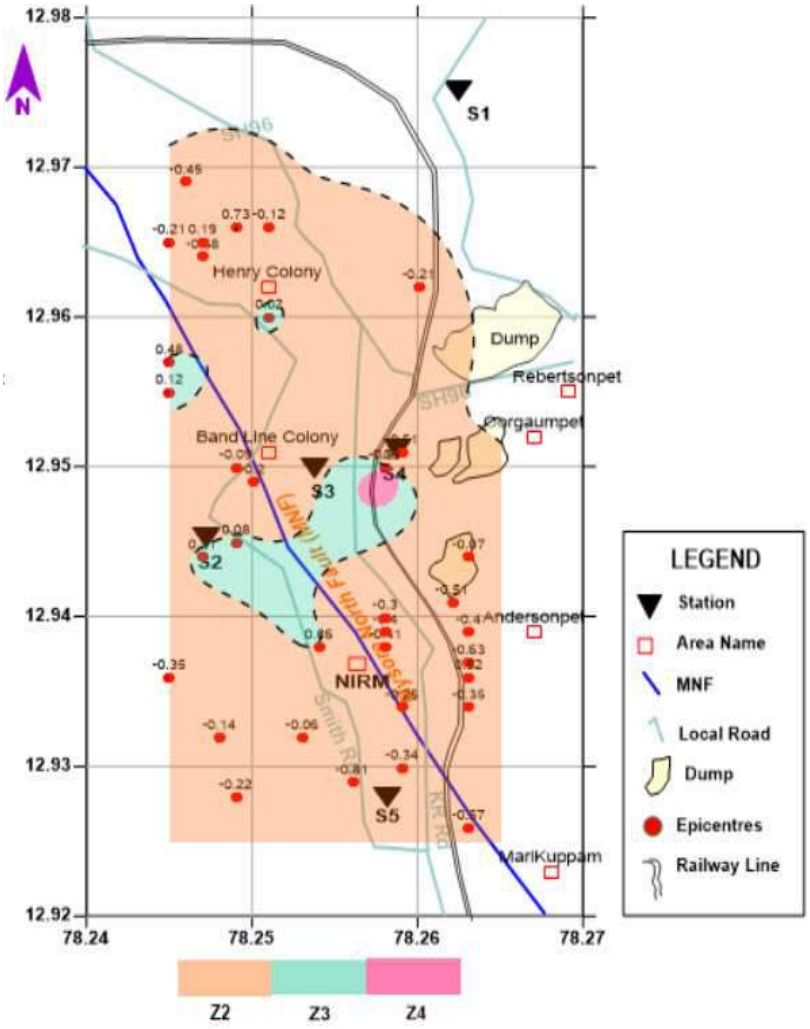
geological-cum-geotechnical studies to assess the stability of present slopes, and suggesting the ultimate pit slope along with recommendations for any remedial measures.

- Presently, seam '7A1' of Rajnagar (R.O.) underground mine of SECL is proposed for development in the panels P1, P2, P3, P4, P5, P6, P7, P8 & P9 with an extraction height of about 2.5 m. The depth of the workings in these panels ranges from 90 m to 150 m, with the seam gradient at 1 in 14. The roof strata consists of coarse grained sandstone. Strata control and monitoring plan (SCAMP) studies were carried out in view to understand the behaviour of the strata. Investigation is under progress.

- Seismic monitoring is continued to estimate seismic hazard at KGF. During this reporting period, five rockbursts have been identified. Monitoring and data processing work is in progress.

- In order to understand the behaviour of the strata while depillaring in the panels 9LS & 4LS of Kurja underground mine of South Eastern Coalfields Limited (SECL), the strata control and monitoring plan (SCAMP) studies were carried out. Further investigation is under progress.

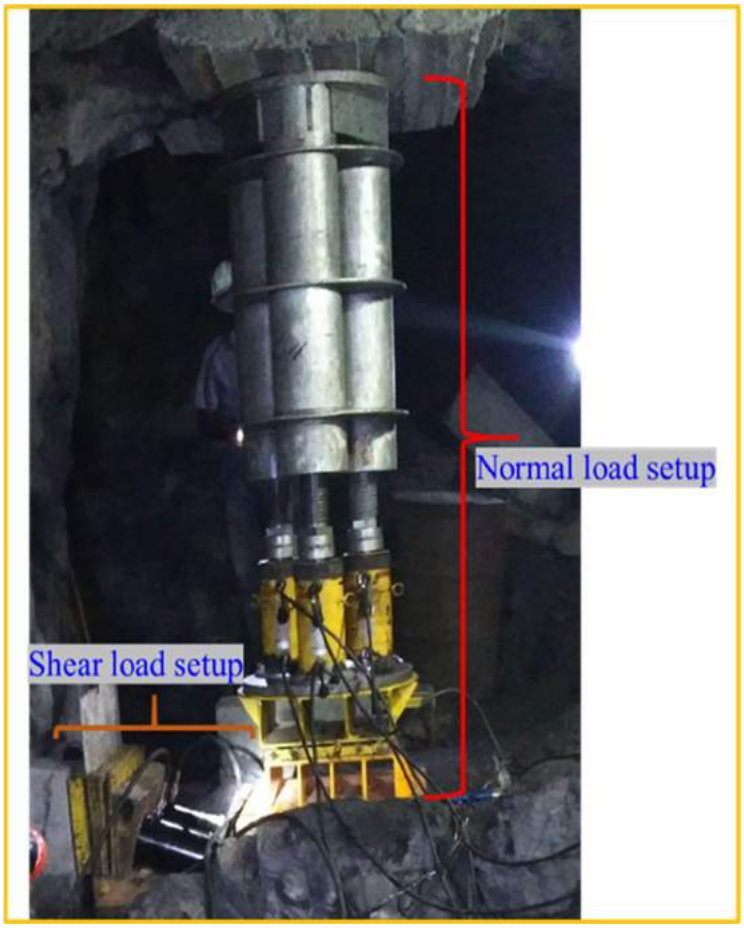
- Seismic activities in and around the mined-out areas of Kolar Gold Fields were monitored to estimate the seismic hazards under an S&T project sponsored by the Ministry of Mines. The study indexed the mining area into five zones, least (Z1) to most hazard (Z5). Most of the surface area is falling in low to moderate hazard. During the monitoring, none of the seismic events were found bothersome enough to inflict a damage to any surface structure. As the stress conditions of the rockmass are transient and could change from one to other location, the hazard zones might migrate, which requires continuous monitoring.



Seismic Hazard Index of the KGF mining area

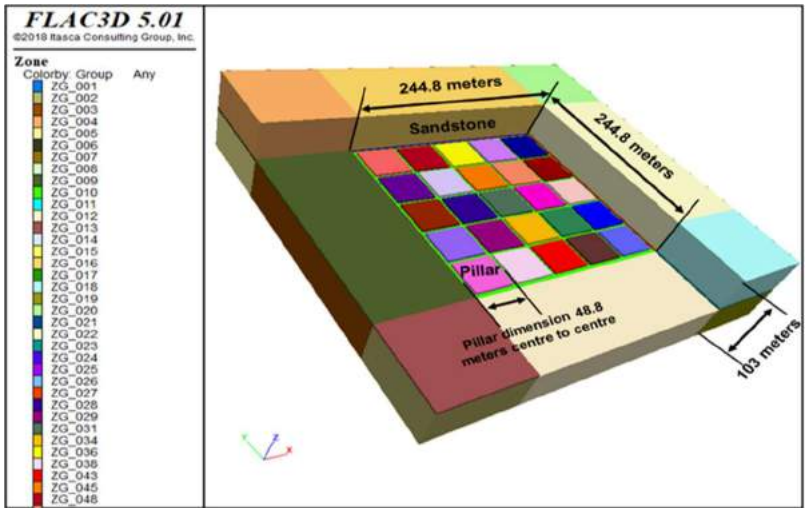
- For optimization of crown and rib pillars as a part of stability evaluation, a 3D numerical model using FLAC-3D, is being developed for Baroi mine, HZL.

- To prevent inrush of water infiltrating from the opencast workings of Chasnalla colliery and Damodar river, there is a proposal to construct water dams at six locations in the underground mine, operated by M/s Steel Authority of India Ltd. In-situ direct shear tests were conducted at the proposed water dam locations which consists of sandstone, coal and shale. The results show that cohesion values between rock to rock contacts are 9.42 kg/cm^2, 5.17 kg/cm^2 and 2.28 kg/cm^2, for coal, shale and sandstone, whereas for contact between concrete to rock 2.34 kg/cm^2, 3.60 kg/cm^2 and 10.63 kg/cm^2 respectively. Foundation rock was found to be competent for constructing the underground water dam.



Direct shear test equipment setup at test location, Chasnalla deep mine

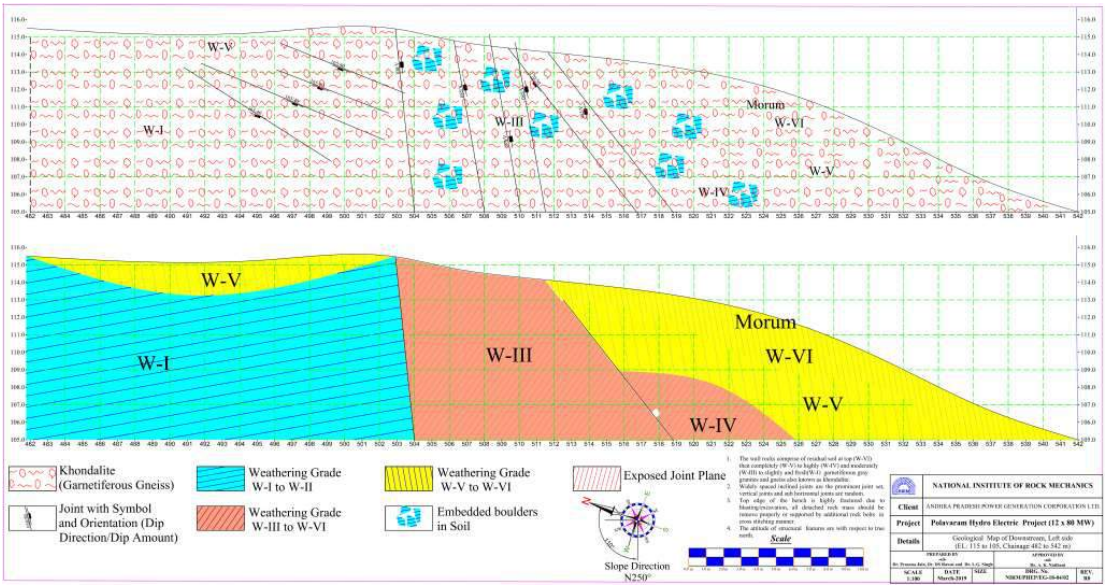
- Studies carried out to assess the horizontal stress field in deeper horizons and to develop roof hazard maps of coal resources in Singareni Collieries Co. Ltd., (SCCL) command area. Hydraulic fracturing technique was used to measure the state of in-situ stress deep below ground. Re-distribution of stresses studied by numerical modelling and analysis on three possible cases for the stability of the mine opening with respect to maximum compression direction. Roof Hazard Maps have been prepared to anticipate the different geological, geotechnical & geo-mechanical parameters that are likely to be negotiated during the development. The study developed a methodology for devising support system and recommended most favourable orientation of the galleries.



Block configuration for RKNT Dipside block

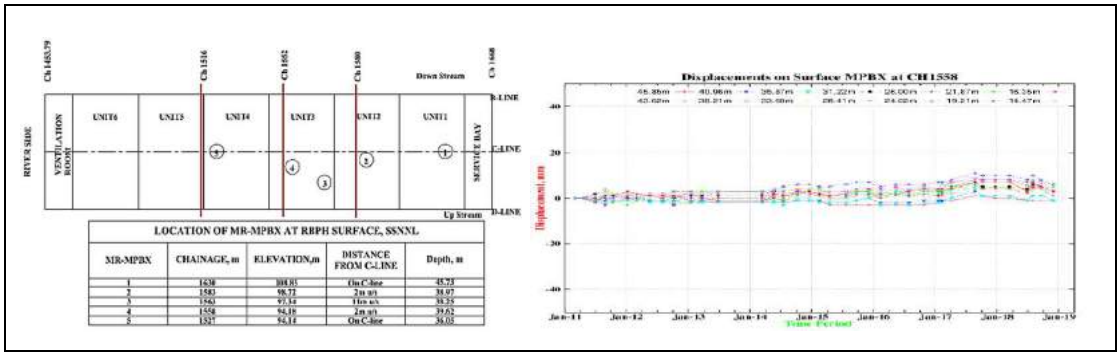
2. Power Sector

- Engineering geological investigations were carried out for the power house of Polavaram multipurpose project being constructed on river Godavari, after reaching the final design excavated profile. In power house area, the rock types exposed are quartzo-felspathic-garnetiferous granite gneisses with intermittent bands of pegmatite. The rock mass is being characterized based on Slope Mass Rating (SMR). Slope protection measures are being recommended. Cement grouting is being done in rock bolting holes before fixing of bolts.



Geological map of the cut slope between 105 and 115m Elevation

- Deformation and stability monitoring of underground powerhouse cavern of Sardar Sarovar project was continued for the year 2018-19, with the existing instruments. It is observed that the trend of displacement in all MRMPBX's (Magnetic Ring Multi-point Borehole Extensometer) are stable during the monitoring period. Geological sections were examined at locations where the displacement exceeded 4mm. It was found that all these anchors are located in agglomerate rock and near to shear zone. Instruments at chainages Ch 1516, Ch 1552 and Ch 1580 are also showing stable trend. Monitoring needs to be continued to ascertain the stability in view of the filling of the reservoir to full level at 136.68m.



Schematic plan of surface MPBX at Powerhouse Cavern and Displacements at RD1558

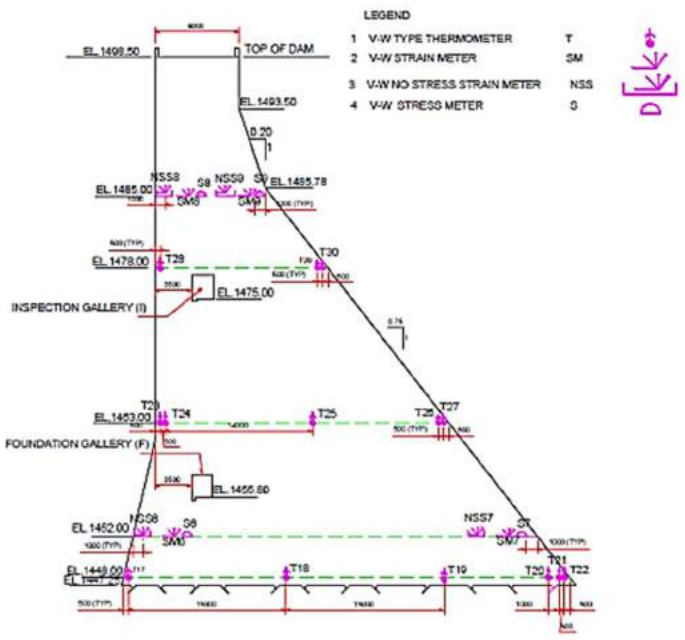
- Analysis of instrumentation data of Desilting Chambers at Tala Hydropower Plant, Bhutan found that the load on ribs seems to be following a cyclic trend for with the water level in the reservoir. The variation of pore water pressure was in accordance with the water level in the reservoir and water levels in the Desilting chambers at most of the places. The variation in load on the ribs appeared to be due to changes in the rock mass

conditions due to hydrological variations and the temperature changes. It will not affect the stability of the chambers. This is confirmed by variations in piezometer observations during the same period.

- The Geodetic monitoring of Sardar Sarovar Dam was continued during this period. The verification of control points was done using DGPS survey. During the period 15 monitoring points were installed. A total of 23 points were monitored in the dam and data has been collected. NIRM has submitted a proposal to SSNNL for real time monitoring of Sardar Sarovar Dam

Control Point Survey at DGPSP1

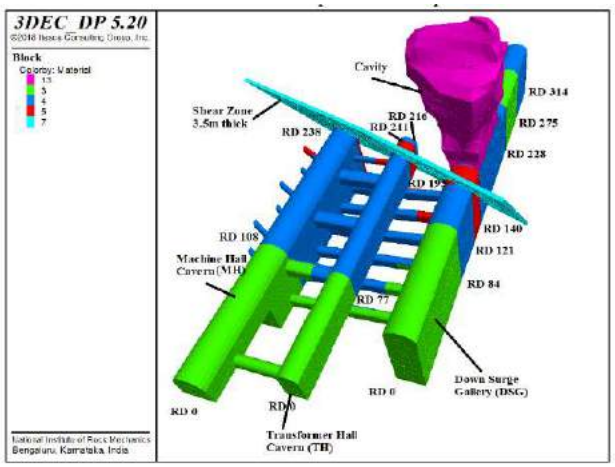
- Analysis of instrumentation data of Desilting Chambers, at Nathpa Jhakri Hydro Power Station, Himachal Pradesh indicated that pore water pressure distribution was normal and varies as per the reservoir levels. There was no significant convergence at desilting chamber access galleries during past 9 years. The displacements measured at Machine Hall Cavern showed stabilizing trend. Analysis of the instrumentation data from dam indicated that the values indicated by most of the instruments were within the design limits. Although a few instruments had shown values very near or in excess of the design values, these values did not indicate any trend.



Location of Instruments in NOF Block -3 of

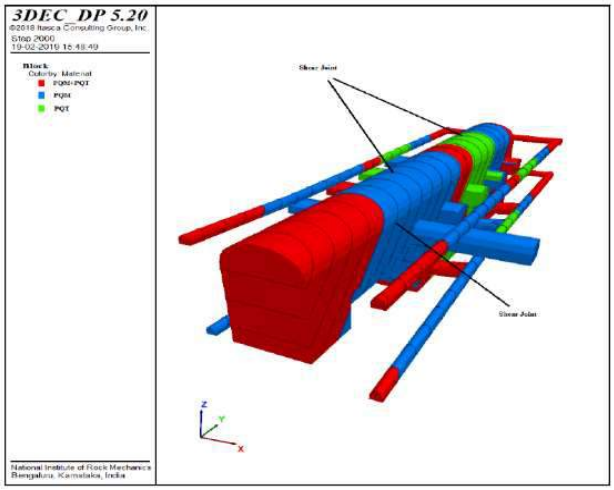
- Following the failure of Rock Mass in downstream surge chamber of Punatsangchhu-II Hydroelectric Project (PHEP-II) geotechnical and geodetic instruments were installed at major caverns of the powerhouse complex. A 3D instrumentation model incorporating the global positions, geological structures, over-break profiles, and actual positions of instruments was developed exclusively for PHEP-II. Detailed direct and derived analysis was carried out for different caverns of the PHEP-II on regular basis. Critical observations and suitable recommendations were made to the project execution team for timely action to prevent any further mishap.

- 3D numerical modelling of Punatsangchhu-II Hydroelectric Project, Bhutan was carried out to study the effect of cavity formation in downstream surge chamber on powerhouse and transformer hall cavern. A 3D discontinuum model was constructed with the actual geometry of the layout. The final cavity shape was also incorporated in the model. It was recommended to install longer bolts to anchor the bolts in competent rock, where the yield zone is extending beyond the rock bolt length. It is recommended to install additional bolts, where the rock bolts have reached the yield load and formed continuous zones of yielded rock bolts.



3DEC model of PHPA-II Powerhouse complex

- In continuation to earlier 3D numerical model of power house cavern of Theri PSP project, HCC requested to rerun the same model with different shear strength parameters. A total of four studies were suggested by HCC for varying support system for modelling by using 3DEC software. The analysis found that—Maximum displacements in crown is within allowable limits (0.8% strain). Displacements are maximum at the elevations 600 to 590 m and also along the zone of weakest rock type of PQT.



Model with shear joints dipping at 500

- A geological repository is being planned at Vishakhapatnam, Andhra Pradesh. As a part of feasibility studies in-situ stress measurements are being done to know the stress regime around the area and other geotechnical parameters of the rock mass. Field investigations are under progress.

- For the installation of pump houses for Units 3 & 4 of Kudankulam Nuclear Power plant, a detailed literature review was carried out to establish the permissible peak particle velocity for different ages of concrete during excavation. Accordingly, 15 trial blasts were carried out as close as 40m from the green concrete. Ground vibrations and air overpressure was monitored by 6 seismographs at different locations. The recorded frequency of the ground vibration was greater than 16 Hz. The

Monitoring blast vibration 6m before TB3

study suggested safe maximum charge per delay for different distances and suitable blast designs for pre-splitting.

- Units 5&6 of KKNPP are in proximity to the existing commissioned structures and also close to green concrete of different ages. Drilling and blasting method will be used for hard rock excavation. 18 trial blasts were carried at the proposed unit 5 & 6 for studying ground vibrations and air overpressure which was monitored at different locations. A site predictor equation for ground vibration and air over pressure was derived based on the data recorded. The recorded frequency of the ground vibration was greater than 10 Hz. Safe maximum charge per delay was suggested for different distances.

- National Thermal Power Corporation is setting up 2×800 MW Super Thermal Power Project in an area of 3000 acres near Darlipalli village in Sundargarh District of Odisha State. Controlled blasting method of operation is adopted to excavate the hard rock to facilitate various components of thermal power project. During Phase III Extension, ground vibration and fly rock mitigation study has been monitored out at two identified locations by deploying two seismographs. Blast vibrations were monitored for 807 blasts. Ground vibrations recorded are in safer limits and fly rock mitigation has been successful.

- During the excavation of Downstream Surge Chamber (DSC) of Punatsangchhu-II hydroelectric project (1020 MW) at Kamichhu, Bhutan a large collapse occurred from the crown area. Suitable blast designs were adopted according to the site requirements to excavate the tunnel connecting cable tunnel and northern wall of the Downstream Surge Chamber, Tail Race Tunnel-1 to meet the downstream wall of the Downstream Surge Chamber, excavation of Head Race Tunnel, ramp connecting Tail Race Tunnel to reach fallen muck from Northern side and benching in DSC northern side, Head Race Tunnel benching for a stretch of 200m in normal zone as well as in the critical zone

Tunnel from cable tunnel made holing through with northern wall of DSC

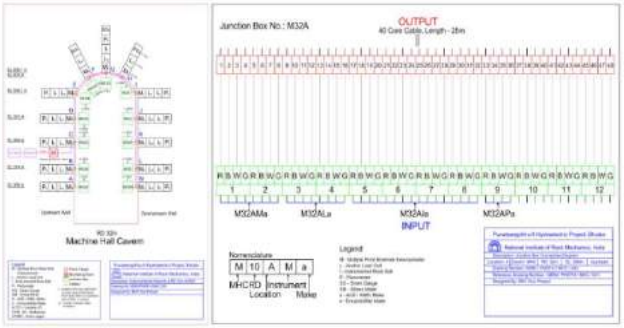
- Controlled blasting method of operation is adopted to excavate the hard rock to facilitate various components of upcoming super thermal power project (2×800 MW) in Sundargarh district, Odisha. During Phase-III, 608 blasts were monitored for ground vibration and air overpressure and found safe with respect to blast vibrations and fly rock mitigation.

Monitoring ground and air overpressure towards Darlipalli village

- For the construction of 3 & 4 units near the existing units 1 & 2 of Kudankulam Nuclear Power Plant, Tamil Nadu, hard rock has to be excavated by drilling and blasting methods in proximity to the structures of unit 1 & 2 and green concrete of different ages. To ensure the ground vibration within statutory limits, trial blasting was carried out by monitoring vibrations at five designated locations.

Monitoring ground and air overpressure near Turbine Pit 3 west corner

- Geotechnical and geodetic instrumentation were designed for the major caverns of the powerhouse complex of Punatsangchhu-II Hydroelectric Project (PHEP-II) as per the request from the project authority. The entire system is planned for remote and automatic data acquisition throughout the life of the project



A typical instrumentation section and network diagram

- The main dam of Indira Sagar Polavaram Hydro Electric Project (960MW) is proposed to be constructed with rock fill material obtained by excavation of spill way, power house etc. NIRM formulated a detailed method statement incorporating the suitable blast design for production of graded rock (for revetment), vibration levels for different ages of concrete, vibration limits of civil structures and presplit blast design for wall rock control.

Showing the sequence of Pre-split blast operation

- The ground vibration and air overpressure monitoring related to blasting at 3&4 units of Kudankulam Nuclear Power Plant, by deploying five seismographs, is continued during this period. The event report of the blast is duly submitted to the client for all the blasts conducted at site.

- The ground vibration and air overpressure monitoring related to blasting at 5&6 units of Kudankulam Nuclear Power Plant, by deploying seismographs at five designated locations, is continued during this period. The event report of the blast is duly submitted to the client for all the blasts conducted at site.

- Punatsangchhu II Hydroelectric Project Authority (PHPA II) is constructing a 1200 MW underground hydroelectric project in Bhutan. NIRM is being associated with WAPCOS for technical guidance of the excavation of HRT bench portion for a stretch of 800m under different geological/rock conditions, deepening of DSC, excavation of draft tube tunnels and other associated tunnels. Considering the various project components which are under excavation, two scientists were deputed for the site as per requirement.

- For constructing Pazhassi Sagar, Small Hydro Electric Projects (SHEP) (7.5 MW) near Kuhiloor village, Kannur district, controlled blasting technique are being used for hard rock excavation. The trial blasts were conducted near intake pool and powerhouse areas. Suitable blast design were suggested to control the fly rock and restrict the ground vibration.

Blast location showing before and after muffling with rubber mat

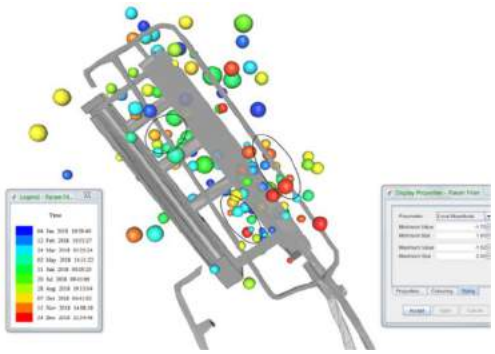
- For constructing a SHEP (6 MW) at Peruvannamuzhi, Kozhikode District, Kerala, controlled blasting technique are being used for hard rock excavation. 12 blasts were carried out near penstock area and eight blasts in the surge shaft area. Suitable blast design was suggested to control the fly rock and restrict the ground vibration.

- Studies for sitting additional units (5&6) of Kaiga NPP site are in progress and NIRM extended intellectual services and support for geological investigations. The borehole logging carried out by the geologist of M/S SOHAM foundation Pvt. Ltd. were reviewed and it was observed that granite / granite gneiss as major basement rock. In some of the bore holes rock was highly fractured and at places shattered. At present the investigation is under progress.

- Bearing capacity of soil is determined for designing the coffer dam and switch yard area of proposed Arun-3 hydroelectric project and for dimensioning the foundation for any structure. The safe bearing capacity is determined by conducting plate load test. Field investigations are under progress.

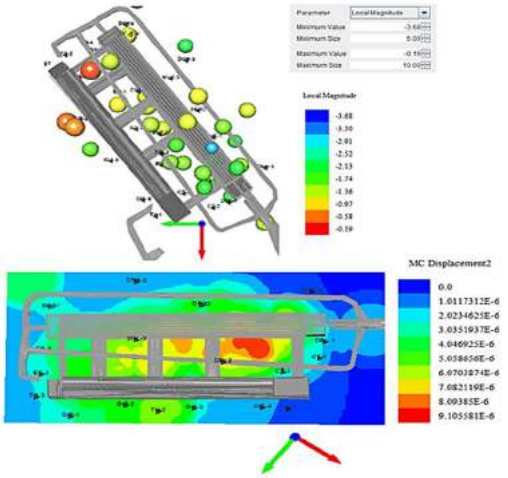
Site before and after blast photographs taken at surge shaft

- Microseismic monitoring system installed at the powerhouse of Tala Hydropower Plant, DGPC Ltd., Bhutan has been functioning since September 2013 for the stability status of the cavern of the powerhouse. Three significant cluster of events were observed. Planar Event Count, Displacement and Log (Apparent Stress) contour have been analysed in detail on the upstream wall of the machine hall. Seismic source parameters acquired indicate that the cavern and its wall are stable.



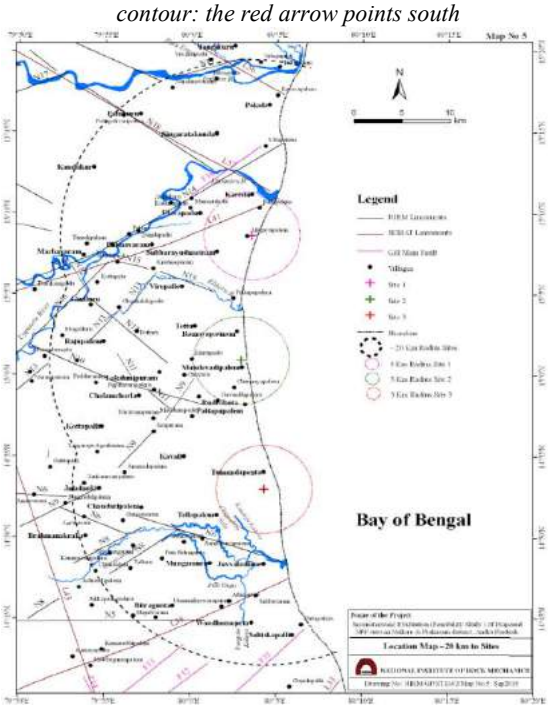
Microseismic events cluster (encircled) during 2018-19

- Thirty stations microseismic monitoring system was installed to analyse the stability of the powerhouse of the Tala Hydropower Plant, DGPC Ltd., Bhutan. The recorded data was processed and analysed in detail and correlated with rock bolt failure. Variation of source parameter of microseismic events with both the rock bolts failure (reported from the project site) was correlated for the precursory signatures but there was no noticeable changes in the characteristics of source parameter. Displacement contour showed no significant change in stress regime nor development of any stress regime with time.



Microseismic event (plan view) and Displacement contour: the red arrow points south

- As a part of identifying a site for nuclear power plants along the east coast in Andhra Pradesh, NPCIL approached NIRM to carryout seismotectonic evaluation for 3 locations. The proposed study area is falling in seismic zone III. The Ongole region which is located in the north east of the proposed site, has witnessed 13 earthquakes in the past 30 years. The present study updated earthquake catalogue for 300 km radius and found three events within 20 km of the study area. The NW-SE trending lineaments are in general associated with abrupt change in river path or river pattern and with signatures of faulting. The studies recommended that, the faults/lineaments extending regionally, required more studies along the strike to understand the fault/lineament behavior in the geological time.



Lineament map for the upcoming sites around Ongole area.

- For the design of dam and powerhouse of proposed Arun-3 hydroelectric project (900 MW), the in-situ deformability, shear parameters and stress tensor of the rock mass are required. Field investigations are under progress.

- 3D numerical modelling of powerhouse complex and surge shaft is being carried out for Arun-3, an upcoming hydroelectric project (900MW) in Nepal. The preliminary model of 3D powerhouse complex is generated with all information except in-situ stress data.

- For Punatsangchhu-II hydroelectric project (1020 MW) Western Bhutan, it is proposed to construct a pothead yard at the right bank of Punatsangcchu River on underlying soil strata consisting of silty, less clayey soil with intermittent boulders. Plate load test was carried out to determine safe bearing capacity for design foundation and the bearing capacity ranges between 32.890 and 41.996 T/m^2

Setup for the Determination of Safe Bearing Capacity

- Hydraulic fracturing test was carried out to determine in-situ stress regime at the vicinity of the downstream surge gallery of Punatsangchhu-II hydroelectric project. The results of the investigations indicate moderate stress regime at test locations, except at transformer hall cavern where it indicated high stress regime and is oriented in 100°. This may be due to excavation influence on the state of stress. The in-situ results obtained at test locations Adit to DSC bottom and cable tunnel can be taken with high confidence as though the measurements were carried out at two distant places apart.

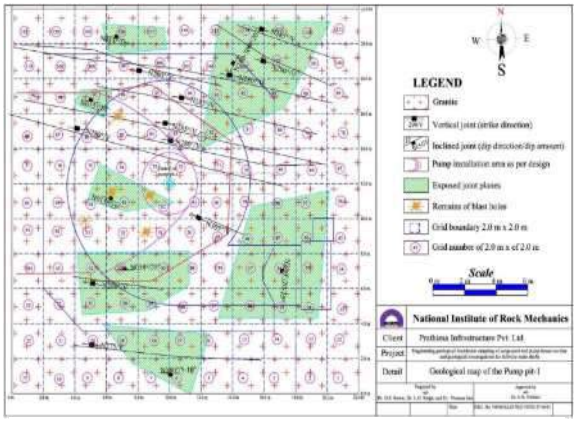
- In-situ stress analysis was carried out to determine power house orientation of Devsari Hydroelectric project (252 MW) Chamoli District Uttarakhand. The results of the investigations at proposed powerhouse site recommend that the long axis of the underground powerhouse may be oriented along N 120°.


Execution of hydraulic fracturing test at borehole no 1

- Studies are being carried out to evaluate the relationship between the characteristics of failure around an opening (cavern) with certain rock type under applied stress conditions. In this regard, a sophisticated system for the study has been developed. This system is used to study exactly the ratio in which the stress is controlled by anisotropy of the rock mass and assessing the rock failure trend under polyaxial loading conditions. It will be helpful to present the necessary data on the site for a site-adapted layout of the final repository and assessment for long-term stability. Field investigations are under progress.

3. Infrastructure Sector

- Geological/geotechnical mapping of the underground caverns and pump pits, for estimation of the rock mass quality (Q) and recommendations for suitable engineering measures based on Q-value and site geological conditions were carried out for Package -10 of Kaleshwaram lift irrigation project. Based on the classification of rock mass rating Bieniawski (1989). Recommendations for the treatment of foundations including the grouting patterns were provided.



Geological plan map of pump pit-1

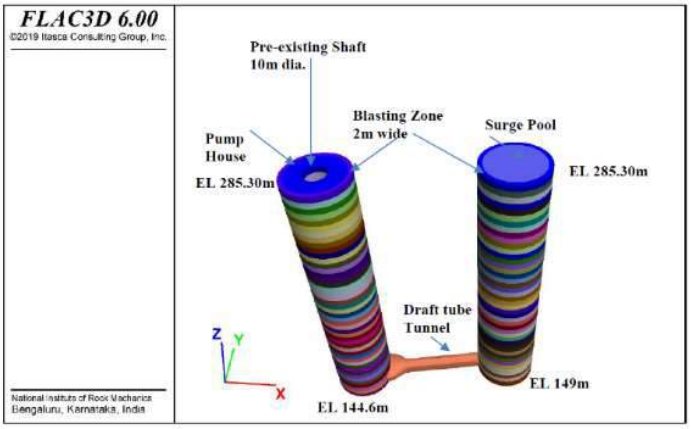
- 3D engineering geological mapping was carried out for the pump house and surge pool cavities of Palamuru Ranga Reddy lift irrigation scheme packages 5 & 8 on 1:100 scale. Rock type exposed after the heading excavation of surge pool and pump house caverns is grey and pink granite belonging to the Peninsular Gneissic Complex of Archaean age and characterized by three number of prominent joint sets. Staining has been recorded along the joint surfaces where the joints are tight and where the opening is up to 20.0 mm, clay coating/filling and rock fragment fillings has been recorded. In general, the rock mass is characterized by the dry condition or minor inflow i.e. < 5.0 l/min. Based on the interpretation of data, appropriated support is recommended.

- Engineering geological investigations of deep underground pump house complex of Kaleshwaram lift irrigation scheme package-12 was carried out. The foundation of pump pits were mapped on 1: 200 scale after the final excavation. Detailed examination of rock types in each grid was carried out which included mineralogical composition, texture, classification and nomenclature and degree of weathering. ISRM (1978) classification for weathering rock mass and rock mass rating by Bieniawski (1989) were applied and bearing capacity of the foundation was evaluated. Based on engineering geological investigations, recommendations for the treatment of foundations were made.

Foundation of Pump Pit-1and 2

- The engineering geological foundation mapping of surge pool, pump house cavities and delivery main shafts and ventilation shafts for Kaleshwaram Lift Irrigation Scheme Package-11, are being carried out to evaluate the design basis foundation parameters. RMR of Bieniawski (1989) has been attempted and based on investigations recommendations for the treatment of foundation were made.

- To determine the support required for the surge pool (dia 26m) and pump house (dia 26.5m), 3D numerical modelling studies were carried out. The rock pillar between the two shafts is 54m. Based on FLAC-3D results, support in the form of rock bolts, steel fibre reinforced shotcrete (SFRS) and steel ribs has been suggested for both shafts. The maximum displacements are observed at the bottom of the shafts, in pump house it is about 7mm and in the surge pool it is 7.5mm.

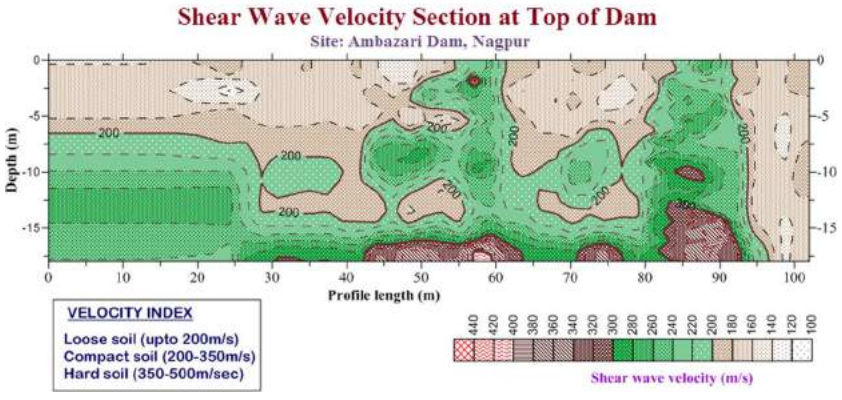


3D model showing pump house, surge pool and draft tube tunnel

- Construction stage engineering geological investigations of pump house complex area of Godavari lift irrigation scheme phase-III, package-III, are being carried out. Underground surge pool and pump house caverns are converted into circular shafts after detailed investigations and taking safety factor in utmost concern. Existing excavated construction shaft (10 m diameter) is converted into pump house shaft. By doing this excavation time and construction cost will be less. Total depth of pump house and surge shaft are 140.60 m and 136.60 m respectively. These shafts will be deepest shafts in India for any type of lift irrigation schemes.

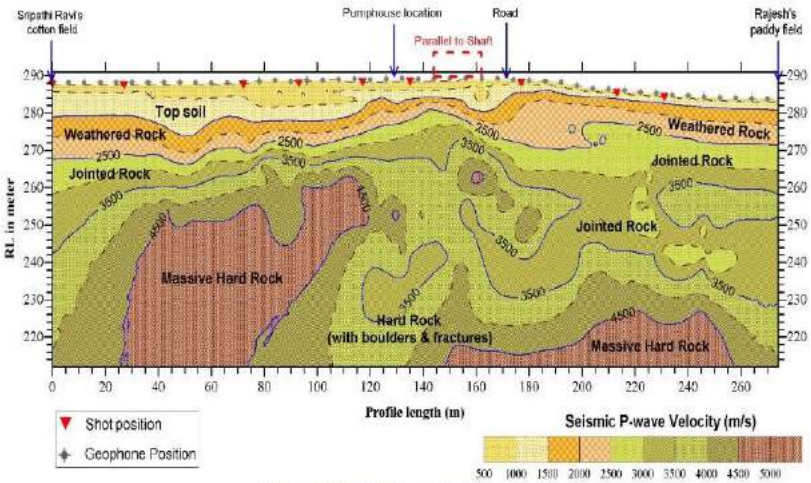
Excavation of Circular Pump-house

- Geophysical survey is carried out over the 146 years old, 15 m high Ambazari dam situated near the southwest border of Nagpur, for parametric evaluation of vibration induced instability for safe construction of MAHA-METRO through its vicinity. Using induced vibrations from a vibratory road compactor, Peak Particle Velocity (PPV) and Peak Ground Acceleration (PGA) at different distances were measured. Multichannel Analysis of Surface Wave (MASW) survey was also done to determine the shear wave velocity profile of the dam body. Based on the spectral (frequency) signature, it was deciphered that vibrations from train would not cause



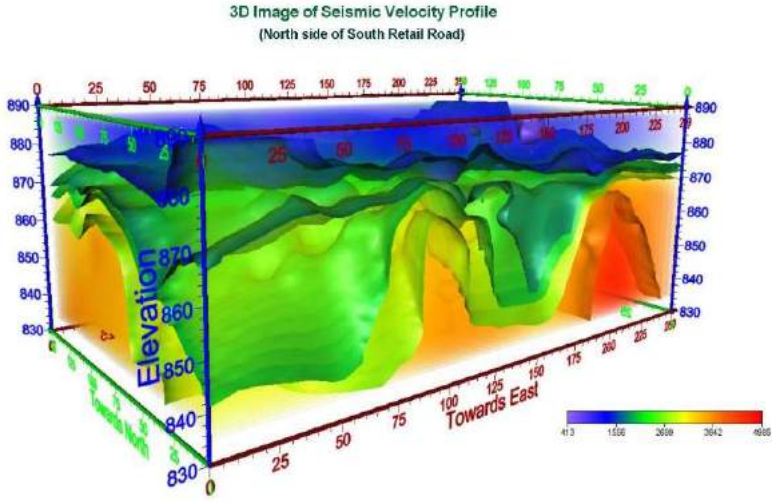
damage to the dam body. The study concluded that the structure of the dam was quite competent to sustain the vibratory impact from the simulation source.

- To evaluate the rock mass and strata condition along the proposed PAT and at the site of appurtenant structures of J.Chokka Rao Devadula Lift Irrigation Scheme (JCR DLIS), seismic refraction survey was used. The study also identified presence of weak zones (low velocity patches) within the hard rock (V_p > 3500 m/s) layer.

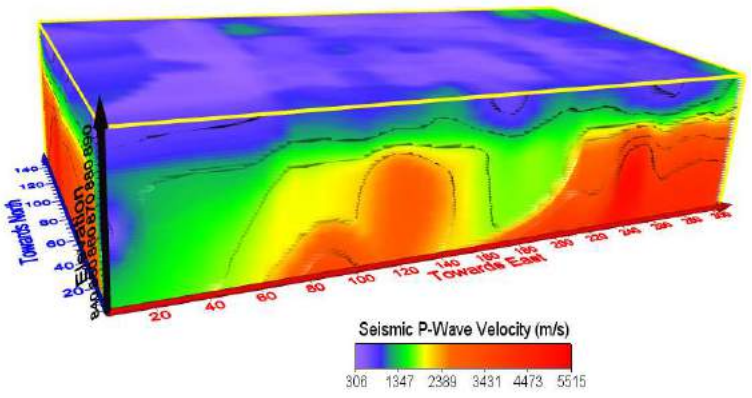


(Site: JCR DLIS Phase-III, Package-3)
(across Surge Pool, Shaft areas)

- For proper planning of rock excavation works and better implementation of construction activities in a piece of land measuring 55,930 m^2 near Nagavara lake, Bengaluru, geophysical survey using seismic refraction was carried out. The results show that that the approximate thickness of soil & soft rock layer is around 3-5 m. The founding level at RL=874 m was generally seen in the hard rock layer.



- For developing a high rise commercial complex, Geophysical studies were conducted to have an accurate information of the subsurface strata at a site adjacent to the Yeswanthpur railway station and the Yeswanthpur flyover on NH 75. Studies using borehole tomography and seismic refraction survey showed that the rocks in the construction site was quite competent.



- Geophysical surveys were carried out along a section of oil pipe line route passing through Raniganj-Asansol Coalfields of West Bengal. The study was aimed at identifying

the potential threat zones with chances of subsidence or sinkhole formation. The study used Multichannel Analysis of Surface Waves (MASW) and Seismic Refraction Survey (SRS) surveys to determine the Vp/Vs ratio of the subsurface rock layers. Electrical Resistivity Imaging (ERI) was also done to correlate and confirm the signature of such weak zones. The data processing is in progress.

- To reconstruct the breakwater at Gopalpur port, 2.8 million tons of eight different graded material from 1 kg to 6000 kg is required. Detailed study was conducted to maximize the yield of armour rock of the specified sizes. Experimental blasts were field tested at one of the quarries and the blast design was optimized.

Photograph showing the fragmented muck

- Varsha project near Vishakhapatnam plans to construct 3 km break water in the sea. For this purpose, 7.8 MT of eight different graded material of 1 kg to 10T and aggregates of about 5.5 MT is required. NIRM conducted trial blast in 6 m bench and recommended to continue the suggested design. During the trial blasts, the armour yield was 37 to 40%.

- Defence Research and Development Organization (DRDO) is planning to construct underground cavern and tunnel in Vizag for utility purpose. As part of this work, rock is to be excavated by drilling and blasting method. The study reviewed controlled blast pattern design for various components and endorsed them for implementation. The maximum charge per delay, void ratio effectiveness and conformity for the obtained profile was included in the reviewed blast pattern.

- For the design of the steel liner at Delivery Mains (DM) of Dr. B.R. Ambedkar Pranahita Chevella Lift Irrigation Scheme, package-11, in-situ deformability test was conducted. The deformability modulus of rock mass (Ed) was ranging between 10.080 and 10.596 GPa and modulus of elasticity (Ee) between 11.535 and 15.929 GPa. The quality of rock mass falls in Good category.

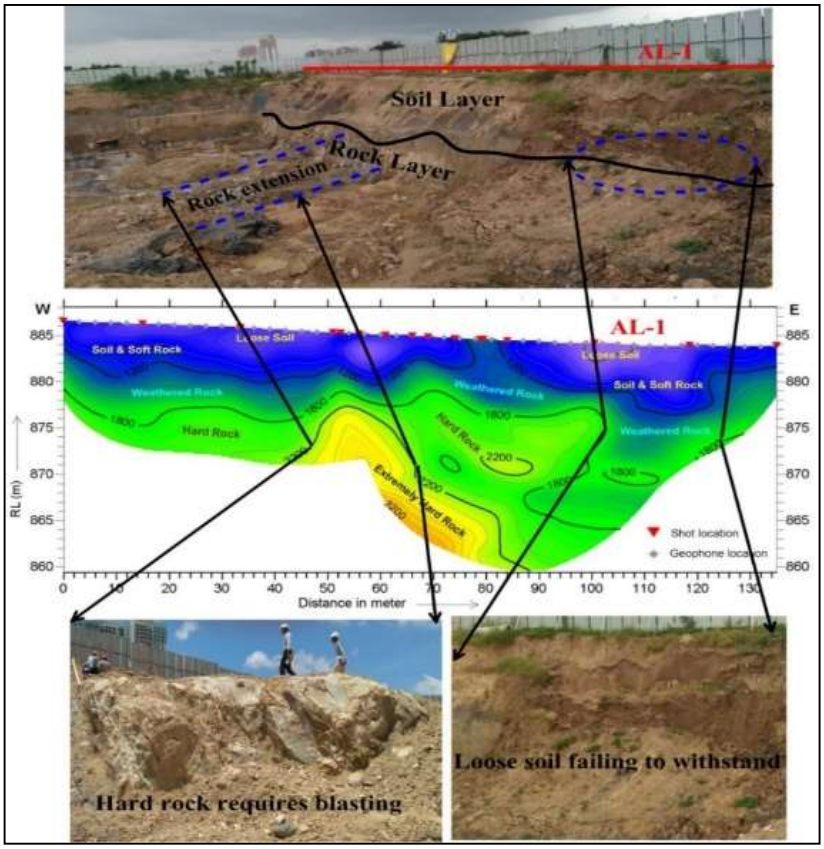
- Hydraulic fracture test was conducted at the proposed pump house / surge pool of J Chokka Rao Devadula Lift Irrigation Scheme (JCRDLIS) to determine in-situ stress. The results of the investigations indicated a medium stress magnitude. The maximum horizontal principal stress direction was N 100°.

- For laying the foundation to construct a high raise commercial building project Kalyani Vista 2, strata have to be excavated to a depth of about 10m through drilling and blasting method. Considering multi-storeyed residential buildings located nearby, the number of holes were restricted to 30 in 3 rows in a blast. Muffling was done with multi-layer sand bags, link mesh and blasting mats to ensure the control of fly rock and sound.

- Hydraulic fracturing test was conducted to determine in-situ stress at the vicinity of the proposed underground pumphouse/ surge pool of Palamuru - Rangareddy Lift Irrigation scheme (PRLIS). The results indicated that a medium stress magnitude is observed along the horizontal principal stress direction of N 50°.

Lowering of hydraulic fracturing equipment with NQ rods

- Seismic survey was conducted to classify the rock mass in a residential area near Nagawara lake, Bengaluru. The survey delineated the subsurface layers accurately with deviation > 5-8% and provided the rock mass classification required for foundation designing. The study also identified the location for additional basement and underground tanks.



Delineation of soil & soft rock layers using seismic refraction survey

- For foundation purpose, strata have to be excavated to a depth of about 10 m from the ground level by drilling and blasting method in the above mentioned land. NIRM carried out field investigation, 15 blasts were monitored with different maximum charge per delays and blast vibrations were monitored at different locations. A site-specific predictor equation for ground vibration at 95% confidence level was derived and presented.

4. Testing Services

- Three wire ropes of BD50-PAT Dozer were received from Bharat Earth Movers Limited, KGF Complex, for determining breaking strength. The Non-Destructive Test (NDT) test conducted includes Visual test, Penetrant test, Magnetic Particle Tests, Ultrasonic Tests, Wire Rope Defectograph, Proof Load Test. Also conducted field tests like Infrared Thermography, Noise dose meter, Vibration Analysis, Self-drop test, Total station survey and major clientele includes HZL, NMDC, NALCO, HCL and SCCL.

Testing of 20mm, RHL wire rope in the presence of M/s Kiswire, M/s BEML & Defence representatives at NIRM, KGF

NDT on winder vital components and on suspension gear parts at Rajpura Dariba Mines, M/s HZL.

- HZL Mines, Rajpura Dariba has an underground mine with two vertical access shafts (Main shaft and Auxiliary shaft). NDT was carried out using MPT and UT on winder vital components and suspension gear parts of the winders. The NDT results on winder vital components and suspension gear parts indicated that they were free from surface, sub-surface and internal flaws. During non-destructive tests conducted on the wire ropes, a fatigue crack was noticed on N1 skip rope of Main shaft which lies at a distance of 350m to 400m from the cappel end. The defect was notified and the unit was replaced immediately. Other skip ropes, cage ropes at Main shaft and cage & counter weight side rope at Auxiliary shaft were free from Local Faults (LF) such as pitting, corrosion and broken wires and also there was no Loss of Metallic cross-sectional Area (LMA).

Magnetic particle & Ultrasonic testing on chain pulley hook

Inspection of wire ropes at Underground Mines of M/s HZL.

- Zawar Group of mines of HZL comprises of four mines namely Balaria mine, Zawar Mala mine, Central Mochia mine and West Mochia mine. NDT was conducted on vital components of the winders and suspension gear parts of 383HP cage winder at Balaria mine, 560HP skip winder and 70HP cage winder parts at Zawar Mala mine, 236HP cage winder at West Mochia mine, 400HP skip winder suspension gear parts and 200HP cage winder and chain pulley blocks at Central Mochia mine. The test results of NDT on cage suspension gear sets and chain pulley blocks indicated that they were free from surface, sub-surface and internal flaws. Defectograph tests were conducted for 17 nos. of wire ropes at Zawar Group of mines used for men and material hoisting. The test results revealed that there were no anomaly and they were free from LF such as pitting, corrosion and broken wires. It was also found that there was no LMA

- The operations at deposit No. 11C & 14 mines, BIOM, NMDC are facilitated by Heavy Earth Moving Equipment (HEMM's). As per the DGMS guidelines, HEMM's equipment was inspected for their fitness and NDT tests were conducted. The NDT test includes Visual test, Penetrant test, Magnetic Particle Tests, Ultrasonic Tests, Wire Rope Defectograph, Proof Load Test, Infrared Thermography etc. Equipment / item like electric rope shovel, water sprinklers, front end loaders, motor graders, electric blast hole drills, EOT cranes and mobile cranes were tested and they were found free from defects.

- NALCO's bauxite mine is located at Panchpatmali hills in Koraput District of Odisha State. Alumina refinery plant of the company is situated at Damanjodi, which is 15km from the Panchpatmali bauxite mines. The mined bauxite is transported to refinery plant by cable belt conveyor. The contour path of the belt conveyor is directed by metallic deflection pulleys through two wire ropes (Left hand side /LHS and Right-hand side RHS). These ropes have to be periodically checked for their fitness. Wire rope Defectography studies were carried out on the cable belt drive ropes and the scanned strip charts were analyzed. Based on the tests carried out on the cable belt drive ropes (Left

Inspection of cable belt drive ropes, M/s NALCO

and Right), it was concluded that the left side rope which was installed during April 2015 had undergone wear and had fatigue cracks along with broken wires on the outer body. The location between Green and Orange splice (approximately 2.38km from Green splice) of Left side rope was found to have undergone severe deterioration characterized by drastic reduction in diameter. The percentage reduction in diameter was 18.92% which was much higher than the safe prescribed limits of 10% as per the discard criteria. Therefore, it was recommended to replace immediately the defective rope region between green to yellow splice (the management may consider for total replacement of rope which is advisable). In general, the right-side rope had undergone excessive wear clubbed with isolated fatigue cracks and few broken wires throughout its length indicating a fast deterioration. It was also recommended that the right-side rope need a careful handling and regular monitoring with caution as it was characterized with excessive wear. The percentage reduction in diameter of left side rope (other than the critical zone between Green and Orange splice) was 7.60% and that of right side rope was 9.20%. As the reduction in diameter of both LHS and RHS rope seemed to be deteriorating fast. By referring the working hours shown in table 1, LHS rope had deteriorated faster than RHS rope w.r.t to the date of installation, it was observed that the LHS rope need to be replaced without taking any risk. Also the RHS side rope was to be considered for replacement as the deterioration appeared to be fast. This suggestion was made by considering the overall health of the rope. Tensile and Comprehensive tests on LHS rope was carried out at NIRM laboratory. Test results revealed that single digit values were noticed in Torsion and Reverse bend test.

Wire rope defectograph studies at Khetri & Kolihan Mines

- HCL has the distinction of being the nation's only vertically integrated copper producing company. The operations at these mines are carried out through shafts run by winders.

Ultrasonic tests on the winder vital components and suspension gear parts and wire rope defectograph studies were carried out. Based on tests conducted on winder vital components and suspension gear parts, it was concluded that all the tested components were free from internal flaws. Defectograph studies conducted on all the wire ropes revealed that the tested wire ropes were free from LF such as pitting, corrosion and broken wires and also there was no LMA.

- The man winding shafts of SCCL are located at different parts of Telangana state. The operations at all the mines are carried out through shafts run by winders. NDT on Winder vital components, suspension gear parts and wire rope using defectograph were carried out at Ramagundam, Yellandu and Kothagudem areas. Using MPT and UT, tests were carried out on the winder vital components and suspension gear parts of 350HP Cage

Inspection of winder vital components at M/s SCCL group of mines

winder at GDK-10 incline, Ramagundam Area, 285kW Cage winder at PVK-5B, Kothagudem Area, 285kW Cage winder at VK-7 incline, Kothagudem Area, 400HP Cage winder at 21 incline, Yellandu Area. The wire ropes used for operating the cages were also inspected. 02 nos. of 32mm FLC ropes each at GDK-10 incline, PVK-5B, VK-7 and 21 incline were tested using wire rope defectograph equipment. All the tests were completed successfully. Based on the tests conducted on winder vital components and cage suspension gear parts, it was concluded that the tested components were free from surface, sub-surface and internal flaws. Defectograph studies were conducted on cage wire ropes and the results revealed that they were free from LF such as pitting, corrosion and broken wires. No LMA was found on the ropes.

- Laboratory geo-technical studies on jointed rock core samples of Punatsangchhu - II Hydroelectric Project, Bhutan were carried out for the determination of Normal Stiffness, Peak Shear Stress &Shear Stiffness, Cohesion & Friction Angle of Joint, & Tensile Strength of intact rock. Sample preparation & testing were carried out as per ISRM suggested methods to determine various properties of rock joints. The data generated from these tests will form input parameters for 3-Dimensional discrete numerical modelling of Powerhouse Complex. Five joint samples from BH-1, BH-3 and BH-4 were tested for determining the Normal stiffness. The stiffness for all the samples were calculated at 5 MPa normal stress. It was observed that the normal stiffness varied from 26.9 MPa/mm to 104.72 MPa/mm. Direct shear tests were carried out on these joint samples to determine the peak shear stress & shear stiffness. Five samples from BH-1, BH-3 and BH-4 were sheared at a constant normal stress of 5 MPa. It was observed that the shear stress varied from 1.83 MPa to 4.86 MPa and the shear stiffness ranged from 1.24 MPa/mm to 4.19 MPa/mm. The Cohesion varied from 0.22 MPa to 3.23 MPa and

the friction angle from 19.86° to 34.94°. The average tensile strength of intact rock was around 6 MPa.

MTS Compression Testing Machine, Extensometer and Data Acquisition System

- Laboratory geotechnical studies were carried out on core samples collected from the wellbores of Gamej field, Khubal field, Sri field and Linch field of CEWELL, ONGC Baroda. A total of 54 core samples were received from four locations for the determination of Uniaxial compressive strength, Static Young's modulus and Poisson's ratio, Cohesion and Friction angle. All the tests were carried out as per ISRM suggested methods on the prepared test specimens. Uniaxial compression tests were done on 36 samples to determine the compressive strength and elastic constants. Average Young's modulus and Poisson's ratio were calculated from the linear portion of the stress-strain curves obtained from uniaxial compression test (20% to 60% of failure stress). Triaxial compression tests (Multiple failure method) were conducted at various confining pressures ranging from 2 MPa to 25 MPa. A total of 18 samples were tested under triaxial stress conditions and Cohesion & Friction angle were determined by computing the data using Roc-data software.

5. Miscellaneous Sector

- The Belum Caves is the largest and longest cave system (1.8 km) open to the public on the Indian subcontinent. These natural caves are formed in the limestone deposit and has significant geological importance. The caves were formed by the solution activity (acid reaction) and erosional activity. NIRM was requested by APTDC to study the safety and stability aspects of the caves. Detailed geological and geotechnical investigation were carried out by NIRM. To know the extent of the caves, geophysical investigations using Seismic Survey as well as the resistivity survey was carried out. The North- Eastern and North -Western area was surrounded by the mining activity. The mining activity around the 2 km^2 area from the cave mouth has the high potential to affect the natural caves. The large sink hole situated in western side of the caves may be used for enlarging the cave area after connecting to main caves towards the Udalmari area. The newly developed area may coin the name of the "BELUM ROCK GARDEN".

Inside View of Belum Cave

- The Broadband station, installed at the Central Seismic Station, Kolar Gold Fields by the Ministry of Earth Sciences, Govt. of India as part of 10 Broadband stations, for monitoring the peninsular India has been working satisfactorily since 2005. This broadband station records the precursors of the earthquake and transfer the data to Indian Meteorological Department, New Delhi and NGRI, Hyderabad. Data is archived continuously and database is being prepared and stored in optical media to be sent to IMD.

6. Other Important Activities

Visit of the Secretary to Govt. of India, Ministry of Mines

Shri.Anil G Mukim, Secretary to Govt. of India, Ministry of Mines discussion with Dr. H. S Venketesh, Director NIRM during the visit

Shri. Anil G Mukim, Secretary to Govt. of India, Ministry of Mines, accompanied by Mr Alok Chandra, Economic Advisor of Ministry of Mines and Ms. Farida M Naik, Director, Ministry of Mines visited our Head Office at Bengaluru on 17th December 2018. He was welcomed by Dr. H S Venkatesh, Director and felicitated by Mr Rajan Babu, Scientist-F and Liaison Officer, SC/ST Cell of NIRM. During this visit Secretary reviewed the activities of NIRM. Mr. Santosh Sharma, CMD, HCL and Dr. Ranjit Rath, CMD, MECL too joined this review meeting in which all HoDs of Scientific departments were present. Secretary (Mines) expressed his appreciation for the work being carried out by this small and well compacted institute.

Conference with Industry Partners on Future Strategies

Dr. H S Venkatesh, Director, NIRM presenting a memento to Dr. K. Rajeswara Rao, IAS, Additional Secretary, Ministry of Mines

NIRM organised a "Conference with Industry Partners on Future Strategies" on 18th Feb 2019 at Taj Yeshwantpur, Bengaluru under the chairmanship of Dr. K. Rajeswara Rao, IAS, Additional Secretary, Ministry of Mines and Controller General, Indian Bureau of Mines, Govt. of India. Shri. Dorji P Phuntshok, Joint Managing Director, Punatsangchhu HEP-II, Bhutan was Guest of Honour during the conference. Shri Alok Chandra, Economic Advisor and Shri Amit Saran, Director of Ministry of Mines graced the occasion. More than 25 industry partners participated and interacted. Industry partners shared their previous experiences with NIRM and also highlighted their future requirements. Additional Secretary, Ministry of Mines expressed satisfaction over feedback from the industry and also assured complete support from Ministry of Mines for NIRM's future endeavours. Organizing Secretary, Dr. Sripad R Naik, HOD, NMD presented the vote of thanks.

Swachhta Pakhwada

On the occasion of the “Swachh Bharat Mission”, National Institute of Rock Mechanics organized Swachhta Pakhwada in and around NIRM Head Office (HO) and

NIRM Registered Office (RO) during 16th-31st October 2018. During the Pakhwada, all employees participated and cleaned the campus area, laboratories, library, rooms, drainage, and also planted trees in the campus.

Cleaning activities carried out at NIRM, HO and RO

A swachhta slogan "स्वच्छता से स्वस्थ समाज" was uploaded on NIRM website and an art work related to the theme of Swachh Bharat Mission was made on the wall of the NIRM HO campus. Swachhta Pakhwada was coordinated by Dr. D. S. Rawat, Scientist, and Mr. A. Rajan Babu, Officer-in-Charge, NIRM RO at Bengaluru and KGF respectively.

Celebration of Hindi Fortnight

Hindi fortnight was successfully organized from 14.09.18 to 28.09.18 at NIRM. On this occasion various competitions such as essay writing, standard noting, word-matching, poetry, were organized to encourage employees and to enhance the use of Hindi language. In the closing ceremony, member of the official language, Ms. Praveena Das Jennifer welcomed all the officers, while explaining the history and importance of the official language said that Hindi is our official language and we should honour and respect it. Due to the development of technical and economic prosperity in the country, Hindi is losing its importance somewhere.

The language and culture of any country plays a very important role in keeping people connected to people in any country. All Heads of Departments also expressed their views. On this occasion, the Director said that every Indian should pay the price of Hindi language and take advantage of economic advancement in the country. It has exposed Indian history since ancient times and is the key to our identity in the future. All officials and employees participated enthusiastically, the prize was awarded to the excitement of all officials and employees in the program.

Celebration of 4th International Day of Yoga

In continuation of the tradition of participating in the worldwide programme on International Day of Yoga, NIRM celebrated IDY-2018 by conducting Yoga session in the NIRM office premises. The yoga session was organised on 21-06-2018. At Bengaluru, Yoga Session was conducted by local Yoga exponent Shri Amit Jaiswal and Mrs. Gitanjali Pande, Yoga teachers from Atma Darshan Ashram, Bengaluru. At KGF office Yoga session was conducted by Guru from Prajapita

Practice of pranayama under the guidance of Yoga Guru

Brahma Kumaris Ishwariya Vishwa Vidyalaya. Yoga Gurus also delivered short speech on the benefits of yoga and urged all the employees to make yoga a daily practice in their lives.

The interactive session comprised of clarifications and explanations by the Yoga Guru. All the employees participated with full enthusiasm to mark the IDY 2018.The session was so well designed considering the age, working and background. The Yoga Guru gave useful practical tips and suggestions to enable the employees practice at home and as well as at places where they travel for their duties. This was advised in daily practice of inner tranquil that will ensure smooth and healthy working atmosphere.

Foreign Visit

- D.S. Rawat attended ITA- AITES WTC 2018 and presented two technical papers in the World Tunnel Congress, during 21st to 26th April 2018 in Dubai.
- G. Gopinath, attended 12th International Symposium in Rock Fragmentation by Blasting, *Fragblast12* at Lulea, Sweden during 11-13 June 2018 to present a paper.
- H.S. Venkatesh and R. Balachander attended 45th Annual conference on Explosives & Blasting Technique, ISEE, Conference at Nashaville, Tennessee, USA during 27 – 30, January 2019 and presented a paper.
- Sripad R Naik, D.S Subrahmanyam, and BNV Siva Prasad attended 10th Asian Rock Mechanics Symposium, 29th October – 3rd November 2018 in Singapore to present technical papers.
- B.H Vijay Sekar presented a paper at Third International Conference on Rock Dynamics and Applications (RocDyn-3), 25th -29th Jun 2018, Trondheim, Norway.
- Bharath Kumar A Y attended 10th Asian Rock Mechanics Symposium, 29th October – 3rd November 2018 in Singapore

Recognition

- Dr. A.K. Naithani was felicitated by Indian Society of Engineering Geology (ISEG) during EGCON-2018 on 3rd December 2018 at Hyderabad for his legendary service and contributions in the fields of Engineering Geology, Infrastructure developmental activities and Natural Hazards.
- Dr. A.K. Naithani is selected as Associate Editor for the Journal of the Geological Society of India.

Training programme conducted

- NIRM conducted five days training course from 11th to 15th June 2018 on Norwegian Method of Tunnelling (NMT) for the Executives of Singareni Collieries Company Limited, Govt. of Telangana at Kothagudem.

- One-week training programme was conducted on Nanoseismics / Microseismic application for underground powerhouse cavern strata monitoring for three DGPC Ltd. executives from 08th Oct-13th Oct at NIRM, Bengaluru.

ANNUAL ACCOUNTS

G. Manjunath & Co.
Chartered Accountants

INDEPENDENT AUDITOR'S REPORT

The Board of Directors of
NATIONAL INSITITUTE OF ROCK MECHANICS
Bangalore

Opinion

We have audited the financial statements of **NATIONAL INSTITUTE OF ROCK MECHANICS**, ("the Institute") which comprise the Balance sheet as at **March 31st 2019**, and the Profit and loss account and Statement of cash flows for the year then ended, and notes to the financial statements, including a summary of significant accounting policies.

In our opinion, the accompanying financial statements give a true and fair view of the financial position of the Institute as at March 31st 2019, and of its financial performance and its cash flows for the year then ended in accordance with the Accounting Standards issued by the Institute of Chartered Accountants of India (ICAI), except for the effects of the matters described in the Basis for Qualified Opinion paragraph.

Basis for Opinion

We conducted our audit in accordance with the Standards on Auditing (SAs) issued by ICAI. Our responsibilities under those standards are further described in the *Auditor's Responsibilities for the Audit of the Financial Statements* section of our report. We are independent of the entity in accordance with the Code of Ethics issued by ICAI and we have fulfilled our other ethical responsibilities in accordance with the Code of Ethics. We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our opinion.

Basis for Qualified Opinion:

The physical verification of assets procured prior to the financial year 2008-2009 are yet to be physically verified and reconciled.

Responsibilities of Management and Those Charged with Governance for the Financial Statements

Management is responsible for the preparation of these financial statements that give a true and fair view of the state of affairs, result of operations and cash flows of the entity in accordance with the accounting principles generally accepted in India. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

No. 300/C, I Floor, 36th Cross, 9th A Main, 5th Block Jayanagar, Bengaluru - 560041
Ph: 080-26534010 Cell: +91 94483 64010 e-mail: ca@gmanjunath.com, gmanjunath.ca@gmail.com

In preparing the financial statements, management is responsible for assessing the entity's ability to continue as a going concern, disclosing, as applicable, matters related to going concern and using the going concern basis of accounting unless management either intends to liquidate the entity or to cease operations, or has no realistic alternative but to do so.

Those charged with governance are responsible for overseeing the entity's financial reporting process.

Auditor's Responsibilities for the Audit of the Financial Statements

Our objectives are to obtain reasonable assurance about whether the financial statements as a whole are free from material misstatement, whether due to fraud or error, and to issue an auditor's report that includes our opinion. Reasonable assurance is a high level of assurance, but is not a guarantee that an audit conducted in accordance with SAs will always detect a material misstatement when it exists. Misstatements can arise from fraud or error and are considered material if, individually or in the aggregate, they could reasonably be expected to influence the economic decisions of users taken on the basis of these financial statements.

As part of an audit in accordance with SAs, we exercise professional judgment and maintain professional scepticism throughout the audit. We also:

Identify and assess the risks of material misstatement of the financial statements, whether due to fraud or error, design and perform audit procedures responsive to those risks, and obtain audit evidence that is sufficient and appropriate to provide a basis for our opinion. The risk of not detecting a material misstatement resulting from fraud is higher than for one resulting from error, as fraud may involve collusion, forgery, intentional omissions, misrepresentations, or the override of internal control.

Obtain an understanding of internal control relevant to the audit in order to design audit procedures that are appropriate in the circumstances, but not for the purpose of expressing an opinion on the effectiveness of the entity's Internal Control.

Evaluate the appropriateness of accounting policies used and the reasonableness of accounting estimates and related disclosures made by Management.

Conclude on the appropriateness of Management's use of the going concern basis of accounting and, based on the audit evidence obtained, whether a material uncertainty exists related to events or conditions that may cast significant doubt of the Institute's ability to continue as a going concern. If we conclude that a material uncertainty exists, we are required to draw attention in our auditor's report to the related disclosures in the financial statements or, if such disclosures are inadequate, to modify our opinion. Our conclusions are based on the audit evidence obtained up to the date of our auditor's report. However future events or conditions may cause the Institute to cease to continue as a going concern.

-+

We communicate with those charged with governance regarding, among other matters, the planned scope and timing of the audit and significant audit findings, including any significant deficiencies in internal control that we identify during our audit.

We also provide those charged with governance with a statement that we have complied with relevant ethical requirements regarding independence, and to communicate with them all relationships and other matters that may reasonably be thought to bear on our independence, and where applicable, related safeguards.

Place: Bengaluru

Date: 30.09.2019

for G. **MANJUNATH & Co.**
Chartered Accountants
Firm Regn. No. 001995S

CA G. MANJUNATH
Proprietor

M.R.N.: 027968

UDIN: 19027968AAAAAJ5361

NATIONAL INSTITUTE OF ROCK MECHANICS
BANGALORE.

SCHEDULE-29

ACCOUNTING POLICIES AND NOTES ON ACCOUNT FORMING PART OF BALANCE SHEET AND INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31ST MARCH 2019.

1. ACCOUNTING POLICIES :-

A. Background:

The entity is an autonomous body under the administrative control of Ministry of Mines, Government of India, registered as Society under the Karnataka Societies Registration Act, 1960. It carries on activities of research in the field of Rock Engineering.

Basis of Preparation:

The financial statements have been prepared under the historical cost convention on an accrual basis. The accounting policies have been consistently applied by the Society and are consistent with those used in the previous year.

B. Fixed Assets:

Fixed Assets are initially recorded at acquisition cost, as and when the asset is put to use by the Institute and carried at such cost less accumulated depreciation and impairment loss, if any.

C. Foreign Exchange Transactions:

Foreign currency transactions are recorded in the reporting currency by applying to the foreign currency amount the exchange rate between the reporting currency and the foreign currency at the date of the transaction. Monetary items, if any, are reported using the exchange rate prevailing at the closing rate. Exchange differences, if any are recognized as income or expense in the income and expenditure statement.

D. Revenue Recognition:

Revenue from services as well as from research and consultancy projects are recognized under Completed Service Contract Method. Revenue in respect of Interest is recognized on time proportion basis taking into account the amount outstanding and the rate applicable.

E. Treatment of Government Grant:

Grant received from Ministry of Mines under "Non plan is utilised to meet "Pay & Allowances". Grants received under " Plan" is utilised to meet capital expenditure.

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

1

The Capital Grant for 'Plan' received as per sanction order from Ministry of Mines, is credited to Deferred Government Grants Account and is allocated to income over the period in the same proportion as the depreciation is charged on the depreciable assets purchased out of these Capital Grant. Balance of capital grants appear as Deferred Government Grants in balance sheet under "Other Funds". Non Plan grants, being revenue in nature, when received are directly taken as Revenue in Income and Expenditure Account.

F. Retirement / Long Term Employee Benefits:

The Institute has made arrangement with Life Insurance Corporation of India for payment of gratuity and leave encashment under the Group Gratuity Scheme and group leave encashment scheme. Expenses for the gratuity and leave encashment is accounted as per calculation made under Projected Unit Credit Method and intimated by the Insurance Company and is charged as expense in the Income and Expenditure Statement under "Pay & Allowances".

Regarding Provident Fund accumulation, this Institute has been enrolled with the Employees Provident Fund Organization. The Institute's contribution towards the Provident Fund is charged as expense in the Income and Expenditure Statement under "Pay & Allowances".

G. Depreciation:

Depreciation is charged on straight-line basis as per the method specified by the Government of India, Department of Economic Affairs vide their letter No.4/24/63-GS dated 27th September 1968.

As per this letter, depreciation on additions to Fixed Assets during the year has to be charged at full rate if they are put into use before 30th September, at half of the rate, if they are put into use between 1st October and 31st December and at one fourth of rate, if assets are put to use after 31st December of the relevant financial year. Upto 1998-99, the one-fourth rate of depreciation for assets put to use for less than three months was not implemented.

2. NOTES ON ACCOUNTS: -

1. Capital Reserve represents value of assets transferred free of cost by BGML during 1988-89.

2. The land and building transferred during the year 1988-89 by BGML to the Institute is subject to receipt of direction from the Government of India. Registration of the transfer of land with sub-registrar and other related formalities are pending. The title of these land and buildings in the name of the Institute is thus subject to the foregoing.

3. Accounting for expenses and liability towards group leave encashment and group gratuity is based on contributions sought by LIC of India, with whom the Institute has entered into an arrangement for payment of gratuity and leave encashment.

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

2

4. Physical verification of Fixed Assets, procured during the period of last 10 financial years from 2008-09 to 2018-19 completed. The assets procured prior to the year 2008-09 are subject to physical verification and reconciliation.

5. Provision for the income tax has been measured at the amount expected to be paid to the tax authorities in accordance with the Income Tax Act, 1961. Tax Expenses debited to the income & expenditure account comprises of provision of current tax for the year & the differences between tax deducted at source claimed by the Institute and that allowed by the department for the past years.

6. The accumulated interest earned on the Fixed deposits of Institute Development fund for Rs.33.65 lakhs transferred to corpus fund i.e. Institute Development Fund during the year 2018-19.

7. The Institute has filed audited accounts & relevant returns up to 31/03/2015 with District Registrar of Societies, Kolar, as required under the Societies Registration Act, for renewal without the requisite fee. The Institute has made an adhoc provision in the books of accounts for Rs.2,00,000/- towards society registration renewal fees as the intimation of amount of fee to be remitted is not received from the said authority.

8. The previous year figures have been re-grouped, re-classified or renamed wherever necessary to confirm with the current year presentation.

Uma.H.R
Finance & Accounts Officer

H.S.Venkatesh
30/09/2019
Director

Member
Governing Body

Refer our report of even date
For **G.MANJUNATH & CO**
Chartered Accountants
(FRN : 001995S)

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

Place: Bangalore
Date: 30-9-2019

G.MANJUNATH & CO
Proprietor
(MRN 027968)

3

NATIONAL INSTITUTE OF ROCK MECHANICS

BANGALORE

CONSOLIDATED BALANCE SHEET AS AT 31ST MARCH 2019

(Amount in Rs)

Sl. No.	Liabilities	Sch No.	Balance as on 31-03-2019	Balance as on 31-03-2018	Sl. No.	Assets	Sch No	Balance as on 31-03-2019	Balance as on 31-03-2018
1	**CAPITAL FUND**	1							
	a) Capital Reserve		32,44,334	32,44,334	1	**FIXED ASSETS**	7	7,79,17,098	5,01,89,985
	b) Internal Capital Reserve		2,50,42,413	2,50,42,413					
					2	**INVESTMENTS**	8		
2	**OTHER CAPITAL FUNDS**	2				a) Fixed Deposits - Institute Development Fund		5,64,45,024	5,30,80,024
	a) Deferred Government Grant		8,15,78,557	8,21,03,201		b) Short term deposits against project advances received from clients		16,24,42,023	13,95,88,665
	b) Institute's Development Fund		5,64,45,024	5,30,80,024					
					3	**CURRENT ASSETS, LOANS & ADVANCES**			
3	**CURRENT LIABILITIES**					Deposits	9	5,35,628	5,35,628
					4	**Loans and advances**			
	a) Sundry Creditors - Staff	3	5,78,425	24,49,488		a) Advances - Staff	10	9,90,106	17,54,890
	b) Sundry Creditors - Others	4	1,03,80,462	2,12,06,063		b) Advances - Suppliers	11	78,59,233	1,49,68,046
	c) Project Advaces Received	5	25,14,61,636	20,50,39,519		**Other Current Assets**	12	4,39,55,470	3,01,32,681
	d) Provisions	6	3,18,99,155	1,78,75,318		a) Expenditure on Ongoing Projects	13	6,93,08,574	6,22,97,218
						b) Sundry Debtors	14	4,97,36,617	3,95,18,987
	Income & Expenditure A/c.	16	2,06,63,786		5	**Current Assets**	15		
						a) Cash in Hand		-	-
4	Significant accounting policies & Notes on Accounts	29				b) Cash at Bank		1,21,04,019	1,11,39,594
						c) closing Stock		-	-
					6	**Income & Expenditure A/c. (Dr)**	16		68,34,642
	TOTAL		**48,12,93,792**	**41,00,40,360**		**TOTAL**		**48,12,93,792**	**41,00,40,360**

The Schedules referred to above form an integral part of the Balance Sheet

For National Institute of Rock Mechanics

(Uma.H.R)
Finance & Accounts Officer

(H.S.Venkatesh) 30/09/2019
Director

Member
Governing Body

As per our Report of even date
For G Manjunath & Co
Chartered Accountants
FRN :001995S

(CA G.Manjunath)
MRN : 027968

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

Place : Bangalore
Date :30-9-2019

NATIONAL INSTITUTE OF ROCK MECHANICS
BANGALORE
CONSOLIDATED INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31st MARCH 2019

(Amount in Rs)

Sl. No	Expenditure	Sch No	2018-19	2017-18	Sl. No.	Income	Sch No	2018-19	2017-18
1	Administrative Expenses	17	1,02,57,798	1,11,13,254	1	Grant-in-Aid received from Ministry of Mines	24	7,02,00,000	6,36,00,000
2	Pay & Allowances	18	11,07,55,321	9,86,32,860	2	Amount Received Against Completed Projects	25	13,95,63,405	12,05,01,436
3	Travelling Expenditure	19	18,22,960	7,39,107	3	Interest Received	26	1,31,20,370	1,11,58,273
4	Upkeep of Assets	20	9,49,470	5,82,502	4	Miscellaneous Income	27	16,36,942	13,03,508
5	Expenditure on Completed Projects	21	4,10,47,567	5,55,94,761	5	Withdrawal of Depreciation	28	5,24,644	5,24,644
5	Depreciation on Fixed Assets	7	1,11,98,578	90,62,174					
6	Prior Period Expenses	22	-	-					
7	Tax Expenses	23	1,81,50,239	82,27,270					
8	Excess of Income over Expenditure		3,08,63,428	1,31,35,933					
	Total:-		**22,50,45,361**	**19,70,87,861**		**Total:-**		**22,50,45,361**	**19,70,87,861**

The Schedules referred to above form an integral part of the Income and Expenditure Account

For National Institute of Rock Mechanics

(Uma.H.R)
Finance & Accounts Officer

(H.S.Venkatesh)
Director
30/09/2019

Member
Governing Body

As per our Report of even date
For G Manjunath & Co
Chartered Accountants
FRN :001995S

(CA G.Manjunath)
MRN:027968

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

Place : Bangalore
Date : 30-9-2019

NATIONAL INSTITUTE OF ROCK MECHANICS
BANGALORE
Consolidated Receipts and Payments Account for the year ending on 31st March 2019

(Amount in Rs)

	Receipts	Amount		Payments	Amount
To	**Opening Balance**		By	TDS on Fixed Deposits	94,272
"	**Cash**		"	TDS on Project Receipts	1,20,03,562
"	**Bank**	1,11,39,595	"	Refund of EMD	2,77,500
			"	Purchase of fixed assets	2,46,95,961
"	Grant - in - aid	7,02,00,000	"	Transfer to Fixed Deposits	10,35,65,000
"	Licence Fee Received	1,410	"	Advances to Others	57,90,076
"	Other Income Received	1,86,248	"	Administrative Expenses	1,05,99,228
"	Security Deposits/EMD received	2,97,500	"	Salaries & Wages	12,65,60,919
"	Interest Received on Savings Bank Deposits	15,85,103	"	payment of terminal benefits(net)	9,14,789
"	Interest Received on Term Deposits	48,62,006	"	Advance to Staff	97,83,820
"	Fixed Deposits Matured	7,82,37,071	"	Travelling Expenses	10,58,606
"	Advance Received - S& T Projects	2,22,93,000	"	Up Keep of Assets	7,92,575
"	Advance Received - Sponsored Projects	17,61,84,944	"	Project Contingency (B)	23,208
"	Advance Received - Centre for Testing service	21,55,620	"	staff welfare	4,03,192
"	Other Advances Recovered	13,78,462	"	Honorarium/ Incentive (Projects / MTL)	73,21,417
"	Income tax refund received with Interest	24,65,444	"	Expenditure on Running Projects	2,54,92,392
"	Input credit of GST received	16,52,208	"	Expenditure on Sponsored Projects	72,67,076
			"	Contigency - Centre for Testing Servcies	71,586
			"	Expenditure on Completed Sponsored Projects	1,45,892
			"	**Closing Balance**	
				Cash	
				Bank	**1,21,04,020**
	Total	**37,26,38,611**		**Total**	**37,26,38,611**

For National Institute of Rock Mechanics

(Uma.H.R)
Finance & Accounts Officer

30/9/2019
(H.S.Venkatesh)
Director

Member
Governing Body

As per our Report of even date
For G Manjunath & Co
Chartered Accountants
FRN :001995S

(CA G.Manjunath)
MRN : 027968

G. MANJUNATH & CO. FRN 001995S Chartered Accountants

Place : Bangalore
Date :30-9-2019

NATIONAL INSTITUTE OF ROCK MECHANICS
Bangalore

Schedule - 7

CONSOLIDATED DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2019

(Amount in Rs)

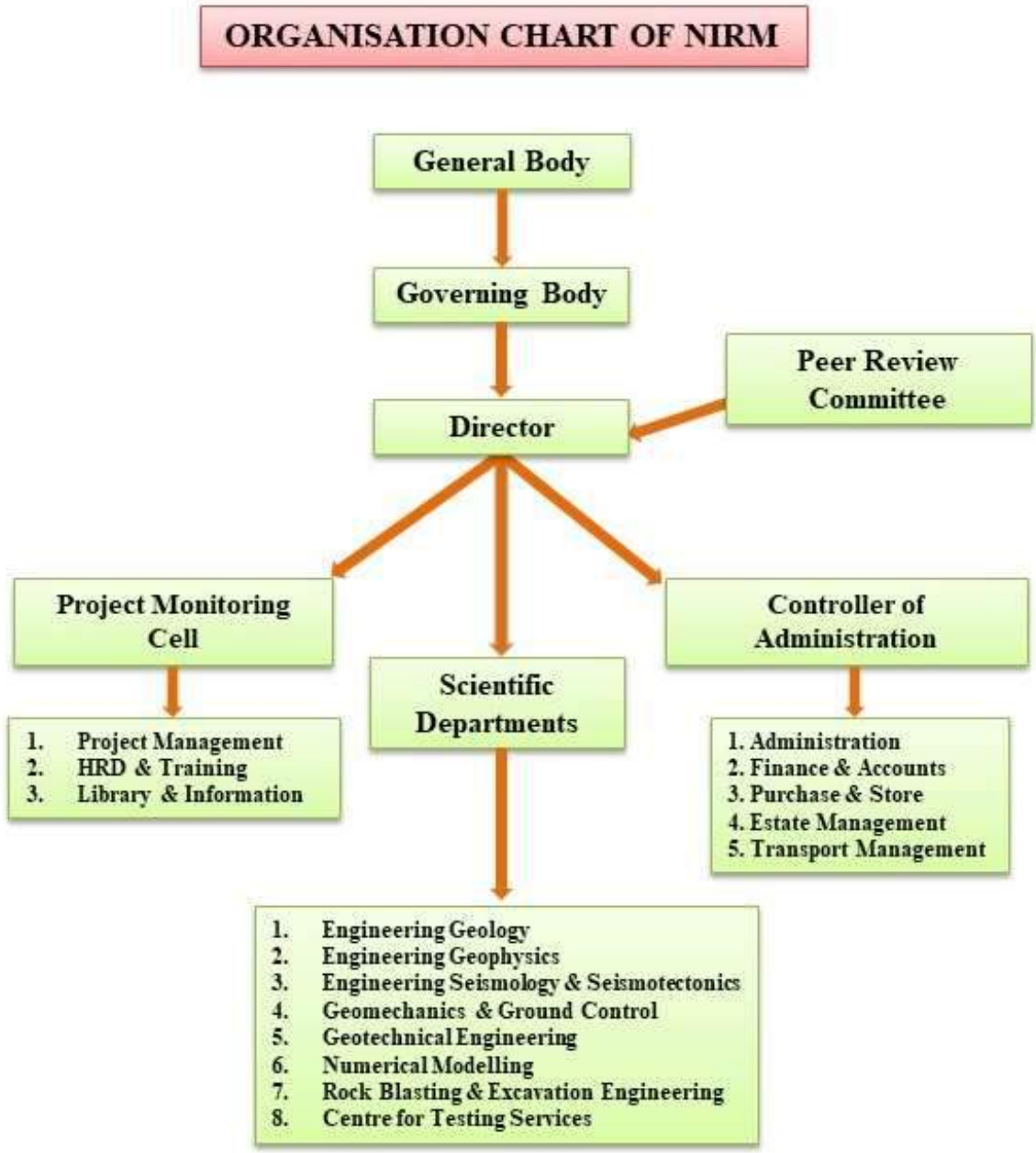
		Gross Block						Depreciation				Net Block	
Name of the Assets	Rate of Depreciation %	Balance as on 01-04-2018	Assets Written off/Transferred	Purchases up to 30.09.2018	Purchases between 1.10.2018 to 31.12.2018	Purchases After 01.01.2019	Total as on 31.03.2019 (Total of Col 3 to Col 7)	Balance as on 01-04-2018	Depn-written off	Depreciation for the year	Total Depreciation as on 31-03-2019 (Total of Col 9 to Col 11)	As on 31-3-2019 (Col 8 - Col 12)	As on 31-3-2018
1	2	3	4	5	6	7	8	9	10	11	12	13	13
Buildings	5	2,17,32,967	-				2,17,32,967	1,06,99,372	-	10,86,648.35	1,17,86,020	99,46,947	1,10,33,595
Plant & Machinery	7.5	3,32,40,834	-				3,32,40,834	3,32,40,734	-	-	3,32,40,734	100	100
Water Supply	5	3,28,926	-	-	-	-	3,28,926	3,28,826	-	-	3,28,826	100	100
Power supply	5	5,03,434	-	-	-	-	5,03,434	5,03,334	-	-	5,03,334	100	100
Furniture	5	45,83,988	-	76,759		-	46,60,747	31,90,838	-	2,33,037.35	34,23,875	12,36,872	13,93,150
Office Equipment	5	33,61,868	-		1,66,427	3,08,846	38,37,141	19,93,450	-	1,76,114.65	21,69,565	16,67,576	13,68,418
Vehicle	7.5	7,83,835	-	-	-	-	7,83,835	7,83,735	-	-	7,83,735	100	100
Laboratory Equipment	7.5	6,31,16,097	-	49,30,582	6,06,022	1,70,89,449	8,57,42,150	2,93,46,826	-	54,46,653.92	3,47,93,479	5,09,48,671	3,37,69,271
Technical Books	5	46,93,917	-	-	-	-	46,93,917	37,63,899	-	2,34,695.85	39,98,595	6,95,322	9,30,018
Computer Software	15	1,83,58,034	-	12,19,223	12,68,775	92,64,099	3,01,10,131	1,83,57,934	-	33,79,150.39	2,17,37,084	83,73,047	100
Computer Hardware	20	1,46,33,368	-	8,43,115	-	5,89,514	1,60,65,997	1,46,33,268	-	1,98,098.70	1,48,31,367	12,34,630	100
Conversion of Power line	5	17,99,459	-	-	-	-	17,99,459	15,14,357	-	89,972.95	16,04,330	1,95,129	2,85,102
Env Geo Tech Lab	7.5	21,13,409	-	-	-	-	21,13,409	19,20,168	-	1,58,505.68	20,78,673	34,736	1,93,241
PROJECT:										-			
Vehicle	7.5	19,68,620	-	-	-	25,62,881	45,31,501	7,52,032	-	1,95,701	9,47,733	35,83,768	12,16,588
Total:-		**17,12,18,756**	**-**	**70,69,679**	**20,41,224**	**2,98,14,789**	**21,01,44,448**	**12,10,28,772**	**-**	**1,11,98,578**	**13,22,27,351**	**7,79,17,098**	**5,01,89,985**
(Previous year figures)		*14,06,15,543*	-	2,34,76,285	10,71,542	60,55,386	17,12,18,756	11,19,66,598	-	90,62,174	12,10,28,772	5,01,89,984	2,86,48,945

Note: 1. Items not put into use : NIL
2. Depreciation has been charged on Straight Line Method.

G. MANJUNATH & CO. ★ Chartered Accountants ★ FRN 001995S

ANNEXURE
(1-8)

ANNEXURE-1


ORGANISATION CHART OF NIRM
General Body
Governing Body
Peer Review Committee
Director
Project Monitoring Cell
Scientific Departments
Controller of Administration
1. Project Management
2. HRD & Training
3. Library & Information
1. Administration
2. Finance & Accounts
3. Purchase & Store
4. Estate Management
5. Transport Management
1. Engineering Geology
2. Engineering Geophysics
3. Engineering Seismology & Seismotectonics
4. Geomechanics & Ground Control
5. Geotechnical Engineering
6. Numerical Modelling
7. Rock Blasting & Excavation Engineering
8. Centre for Testing Services

ANNEXURE-2

MEMBERS OF THE GENERAL BODY	
Chairman	
Secretary, Ministry of Mines Government of India 3rd Floor, A Wing, Room No. 320, Shastri Bhavan, Dr.Rajendra Prasad Road, New Delhi – 110 001.	
Members	
Additional Secretary, Ministry of Mines, 3rd Floor, A Wing, Room No.327, Shastri Bhavan, Dr.Rajendra Prasad Road, New Delhi-110 001	Director Indian Institute of Technology (ISM), Dhanbad-826 003. Jharkhand
Joint Secretary & Financial Advisor, Ministry of Mines, 3rd Floor, A Wing, Room No.321, Shastri Bhavan, Dr.Rajendra Prasad Road, New Delhi–110 001	Member (D & R), Central Water Commission, Room No.401 (S), Sewa Bhavan, R.K.Puram, New Delhi-110 066
Joint Secretary / Economic Advisor, (In-charge NIRM) Ministry of Mines, Shastri Bhavan, Dr.Rajendra Prasad Road, New Delhi–110 001	The Advisor (Projects), Ministry of Coal, 3rd Floor, A Wing, Shastri Bhavan, Dr.Rajendraprasad Road, New Delhi–110 001
Director General, Geological Survey of India, (GSI) No.27, Jawaharlal Nehru Road, Kolkata-700 016	Director (Operations), Singareni Collieries Company Ltd., Kothagudem Collieries , Khammam Dist, Telangana–507 101
Controller General, Indian Bureau of Mines, Indira Bhavan, 22/1, Civil Lines, Nagpur-440 001	Prof. Bharat B Dhar, Former Director, CIMFR Director (Research), AIU; Director (R&IC), Amity University, Advisor, HESRT&SD, D-20, Pamposh Enclave, New Delhi-110048
Director General of Mines Safety, Hirapur, Dhanbad-826 001 Jharkhand	Prof. V.R.Sastry, Department of Mining Engineering, National Institute of Technology Karnataka, Surathkal-575 025
Director, Central Institute of Mining & Fuel Research, Barwa Road, Dhanbad-826 015	Director, National Institute of Rock Mechanics, Banashankari 2nd Stage, Bengaluru-560 070
Executive Director (Mining) National Thermal Power Corporation, NTPC Bhawan, SCOPE Complex, Institutional Area, Lodhi road, New Delhi-110003	

ANNEXURE-3

<table>
<tr><th colspan="2">MEMBERS OF THE GOVERNING BODY</th></tr>
<tr><td colspan="2"><u>Chairman</u></td></tr>
<tr><td colspan="2">Secretary, Ministry of Mines
Government of India
3rd Floor, A Wing, Room No. 320, Shastri Bhavan, Dr. Rajendra Prasad Road,
New Delhi – 110 001.</td></tr>
<tr><td colspan="2">Members</td></tr>
<tr><td>Additional Secretary, Ministry of Mines,
3rd Floor, A Wing, Room No.327,
Shastri Bhavan,
Dr.Rajendra Prasad Road,
New Delhi-110 001</td><td>Director
Indian Institute of Technology (ISM),
Dhanbad-826 003
Jharkhand</td></tr>
<tr><td>Joint Secretary & Financial Advisor,
Ministry of Mines,
3rd Floor, A Wing, Room No.321,
Shastri Bhavan,
Dr.Rajendra Prasad Road,
New Delhi–110 001</td><td>Director (Operations),
Singareni Collieries Company Ltd.,
Kothagudem Collieries ,
Khammam Dist,
Telangana –507 101</td></tr>
<tr><td>Joint Secretary / Economic Advisor,
(In-charge NIRM)
Ministry of Mines,
Shastri Bhavan,
Dr.Rajendra Prasad Road,
New Delhi–110 001</td><td>Prof. Bharat B Dhar,
Former Director CIMFR,
Director (Research), AIU,
Director (R&IC), Amity University,
Advisor, HESRT&SD,
D-20, Pamposh Enclave,
New Delhi-110 048</td></tr>
<tr><td>Director General,
Geological Survey of India, (GSI)
No.27, Jawaharlal Nehru Road,
Kolkata-700 016</td><td>Prof. V.R.Sastry,
Department of Mining Engineering,
National Institute of Technology Karnataka,
Surathkal-575 025</td></tr>
<tr><td>Controller General,
Indian Bureau of Mines,
Indira Bhavan,
22/1, Civil Lines, Nagpur-440 001</td><td>Shri. A. Sundaramoorthy,
Director General (Retd), GSI
No.44, VV Nagar, 6th Street,
Kolathur (PO), Chennai-600 099</td></tr>
<tr><td>Director General of Mines Safety,
Hirapur,
Dhanbad-826 001
Jharkhand</td><td>Director,
National Institute of Rock Mechanics,
Banashankari 2nd Stage,
Bengaluru-560 070</td></tr>
<tr><td>Director, CIMFR,
Central Institute of Mining & Fuel Research,
Barwa Road,
Dhanbad-826 015</td><td></td></tr>
</table>

ANNEXURE-4

MEMBERS OF THE PEER REVIEW COMMITTEE **(1st January 2017 - 31st December 2019)**		
Chairman		
Prof. Bharat B Dhar Former Director, CIMFR; Director (Research), AIU Director (R&IC),Amity University; Advisor, HESRT&SD NEW DELHI – 110 048		
Alternate Chairman		
Prof. V R Sastry Department of Mining Engineering National Institute of Technology Karnatala (NITK), Surathkal Srinivas Nagar PO Mangalore – 575 025		
Members		
Shri A Sundaramoorthy, (Retd. Director General , GSI), Chennai-600 099		Mr. T.K. Sivarajan CE, (Designs(N&W)), Central Water Commission, 8th Floor, Seva Bhavan, RK Puram, New Delhi-110 066
Dy. Director General Directorate General of Mines Safety, South Zone, Koramangala, Bengaluru-560 034		Prof. T G Sitharam, Department of Civil Engineering, IISc, Bengaluru-560 001
Executive Director, (Mines), Neyveli Lignite Corporation Ltd., Mine I & IA, Administrative Office, Block 26 Neyveli-607 803 (Tamil Nadu)		Director National Institute of Rock Mechanics, Banashankari 2nd Stage, Bengaluru-560 070
Director (Operations), Singareni Collieries Company Ltd., Kothagudem Collieries, Khammam Dist, Telangana–507 101.		Shri S Ravi Secretary National Institute of Rock Mechanics Banashankari 2nd Stage, Bengaluru-560 070
Prof. VMSR Murthy, Professor and Head, Department of Mining Engineering IIT (ISM), Dhanbad-826 004		

ANNEXURE-5

SUPPORTING ORGANISATIONS & MAJOR CLIENTELE

Central Government Ministries & Departments

Ministry of Mines
Ministry of Coal
Ministry of Earth Sciences
Department of Science & Technology
Department of Atomic Energy
Indian Railways
Atomic Minerals Directorate for Exploration and Research (AMD)

State Government Ministries & Departments

Andhra Pradesh Heavy Machinery and Engineering Limited (APHMEL)
Andhra Pradesh Power Generation Corporation (APGENCO)
Karnataka Power Corporation Limited (KPCL)
Kerala State Electricity Board (KSEB)
Shri Mata Vaishno Devi Shrine Board (SMVDSB), J&K
Singareni Collieries Company Limited
Telangana State Power Generation Corporation (TSGENCO)
Irrigation & CAD Department, Government of Telangana
TANGEDCO, Tamil Nadu

Public Sector Organisations

Coal India Limited (CIL)
Hindustan Copper Limited (HCL)
Hindustan Petroleum Corporation Limited (HPCL)
Hindustan Zinc Limited (HZL)
Hutti Gold Mines Limited (HGML)
Indian Oil Corporation Limited (IOCL)
Manganese Ore India Limited (MOIL)
National Aluminium Company Ltd. (NALCO)
National Hydroelectric Power Corporation (NHPC Limited)
NTPC India Limited
Nuclear Power Corporation of India Limited (NPCIL)
Oil and Natural Gas Corporation (ONGC)
Sardar Sarovar Narmada Nigam Limited (SSNNL)
Satluj Jal Vidyut Nigam Limited (SJVNL)
South Eastern Coalfields Limited (SECL)
THDC India Limited
Uranium Corporation of India Limited (UCIL)
Western Coalfields Limited (WCL)
Neyveli Lignite Corporation India Ltd. (NLCIL)

Private Companies

Balasore Alloys Limited Ltd.
China Coal No.5 Constructions Pvt Ltd.
Ferro-Alloys Corporation Limited (FACOR)
Technology House (India) Pvt. Ltd.
Chennakeshava stone crusher.
RS DCI Pvt. Ltd.
Secon Pvt.ltd.
MSRDC, Mumbai
Prathima Infr.Ltd.
Kalyani developers, Bengaluru
SDFI Pvt. Ltd.
Gammon India Ltd.
HES Infra Private Ltd
Hindustan Construction Company Limited (HCC)
India Resources Limited.
IOT Infrastructure & Energy Services Ltd.
Jindal Power Limited
Kare Power Resources Private Limited (KPRPL)
Larsen & Toubro (L&T) Construction
Megha Engineering & Infrastructures Ltd.
Navayuga Engineering Company Limited
Navyuga Kommu Venkateshwara Metal Miners
Patel Engineering Ltd.
Prathima Infrastructures Ltd.
Ramco cements Ltd.
Sesa Mining Corporation Ltd.
Shaft Sinkers Mauritius Ltd.
Shriram EPC Limited
SNC-Lavalin Infrastructure Private Ltd.
Soham Renewable Energy Private Limited (SREPL)
The India Cements Limited (ICL)
Transstroy-AFCONS JV, Chennai
Transstroy-JSC-EC-UES, AP
Zeenath Transport Company (ZTC)
Zuari Cement Limited
RIL,Yargol

International Organisations

Druk Green Power Corporation Limited (DGPCL), Bhutan
Mangdechhu Hydroelectric Project Authority (MHPA), Bhutan
Punatsangchhu II (1020 MW) HEP, Bhutan
SJNV Arun-3 Power Development Company (SAPDC), Pvt.Ltd., Nepal

ANNEXURE-6

LIST OF COMPLETED PROJECTS

Sl No.	Project No.	Title	Person Involved
1	ND 15-15	NDE of vital components at RA mines, HZL	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
2	ND 16-02	Rope testing (proof load test and NDT) of OCSL plant equipment at BIOM, Bacheli complex, NMDC	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
3	ND 16-04	In-situ NDT testing of winders and wire ropes of Khetri & Kolihan Copper mines, HCL	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
4	ND 16-10	NDT on winch vital components and wire rope tests	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
5	ND 16-9B	NDT on vital components of winders at Zawar group of mines, HZL	*A Rajan Babu, G D Raju, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
6	ND 17-01	NDT on vital components of winders at Rampura Agucha mines, HZL	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
7	ND 17-02	NDT on vital parts of the winders at Khetri & Kolihan mines, HCL	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
8	ND 17-03B	NDT on winder suspension gear parts and wire ropes at Zawar group of mines, HZL	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
9	ND 17-04	NDT on cable belt drive wire ropes at NALCO, Damonjodi, Odisha	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
10	ND 17-05	Prototype / Proof load tests on hoist attachments, SSML	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
11	ND 17-07	NDT on winch vital components and wire rope tests, of ADST, Palani, Tamil Nadu	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*

12	ND 17-3A	NDT on vital components of winders of RD Mines ,HZL	*A Rajan Babu, Sagaya Benady, Royston A Victor, Prashanth Kumar, Syed Asghar, Babu S*
13	RF 15-02	Testing of core samples for Hutti, UTI and Hirabuddinni Gold Mines	*A Rajan Babu, S Udaya Kumar, D Joseph, G D Raju, R Prabhu*
14	RF 16-02	Laboratory geotechnical investigations on core samples of Dr.B.R.A.Pranahita-Chevella LIS, Package-11, MEIL	*A Rajan Babu, S Udaya Kumar, D Joseph, G D Raju, R Prabhu*
15	RF 17-01	Laboratory geotechnical investigations on rock core samples from well bores of Geleki area of Assam Asset, Sivasagar, ONGC	*A Rajan Babu, S Udaya Kumar, D Joseph, G D Raju, R Prabhu*
16	RF 17-02	Laboratory geotechnical investigations on rock core samples from well bores of Mumbai offshore area, A&AA Basin (Jorhat) and Cauvery Basin (Karaikal), ONGC	*A Rajan Babu, S Udaya Kumar, D Joseph, G D Raju, R Prabhu*
17	RF 17-03	Laboratory geotechnical investigations on rock core samples from Borehole NBH 6A/1, 13, 14, 15, 31, 39, 40 & 45, L&T Construction, P1 Project, Vizag, Andhra Pradesh	*A Rajan Babu, S Udaya Kumar, D Joseph, G D Raju, R Prabhu*
18	RF 18-01	Determination of rock joint properties for input to 3D numerical modelling of power house complex, PHPA II, Bhutan	*A Rajan Babu, S Udaya Kumar, D Joseph, R Prabhu*
19	EG 15-02	Construction stage engineering geological mapping of pond floors of natural draft cooling towers (NDCT) and two pump house foundation of Rajasthan atomic power project (RAPP) units 7&8, Rawatbhata in Chittorgarh District of Rajasthan	*A K Naithani, Prasnna Jain, L G Singh, D S Rawat*
20	EG 17-01	Construction stage engineering geological foundation mapping of Yargol gravity type concrete dam in Bangarapet, Karnataka	*L G Singh, A K Naithani, Prasnna Jain, D S Rawat*
21	EG 17-02	Engineering geological investigations of Kaleshwaram DBRAPCSS-II Lift irrigation Scheme Package-6, Karimnagar District, Telangana	*A K Naithani, D S Rawat, L G Singh, Prasnna Jain*
22	EG 17-03	Engineering geological investigations of Kaleshwaram DBRAPCSS-II Lift irrigation Scheme Package-6, Karimnagar District, Telangana	*A K Naithani, D S Rawat, L G Singh, Prasnna Jain*
23	EG 17-06	Engineering geological foundation mapping of surge pool and pump house and geological investigations for draft tubes of Kaleshwaram lift Irrigation projects package-10 Siddipet District, Telangana	*D S Rawat, A K Naithani, L G Singh, Prasnna Jain*

24	EG 18-02	Engineering geological investigations of Palamuru Ranga Reddy Lift irrigation Scheme Package-5&8, Nagarkurnool District, Telangana	*A K Naithani, D S Rawat, L G Singh, Prasnna Jain*
25	EG-PV 18-01	Preliminary visit of cavity area formed in the tunnel at CH.5.105 km of Kaleshwaram Lift Irrigation Project, Package-10, Telangana	*Prasnna Jain, A K Naithani, D S Rawat, L G Singh*
26	GP 16-01	Geophysical survey to ascertain the risk of subsidence around HMRB oil pipe line (Ch 257.700 to 257.800)	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
27	GP 16-02	Seismic refraction survey at the proposed Silahalla dam site Kundah, Nilgiri, Tamil Nadu	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
28	GP 17-01	Geophysical survey at Vadnagar site of ASI, Gujarat	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
29	GP 17-02	Geophysical survey for assessing the cause of subsidence of access road to the Tata Promont Housing Society, Bengaluru.	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
30	GP 17-04	Geophysical investigation for vibration induced instability to evaluate safety at Ambazari dam toe due to construction of metro via duct for reach-3	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
31	GP 18-01	Geophysical survey for mapping sub-surface strata at JCRDLIS Phase-III, Package-3,Telangana	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
32	GP 18-02	Geophysical survey for mapping hard rock profile at the Construction site of Karle Infra Pvt. Ltd., Bengaluru	*P C Jha, S Nellait, B Butchi Babu, Y V Sivaram, S N Verma*
33	GC 17-02	Supply of equipment for installation at 5E HW Panel, Tummalapalle mine, UCIL, AP	*A Rajan Babu, G D Raju, A Y Bharath Kumar*
34	GC 18-01	Evaluation of pillar factor of safety for the proposed mining method with long panels at Tummalapalle Uranium Mine, UCIL, Andhra Pradesh	*A Rajan Babu, G D Raju, A Y Bharath Kumar*
35	SS 16-02	Slope stability studies of Copila Gaichem Paul Iron Ore Mine Siagao and Collem village, Dharbandora Taluka, South Goa, Goa	*A Rajan Babu, G D Raju, T Amrith Renaldy, S S Meena, S Kumar Reddy, S Udaya Kumar, A Y Bharath Kumar*
36	SS 17-02	Scientific studies for pit stability monitoring towards North side of final pit slope stability up to 120m depth working of Krishna lime stone mine in Ramayanpatti village, Tirunelveli District, Tamil Nadu	*A Rajan Babu, G D Raju T Amrith Renaldy, S S Meena, S Kumar Reddy, A Y Bharath Kumar*
37	SS 17-03	Slope stability studies to deepen the quarry and enhancing the dump-3 height of Kaliapani chromite mine, Kaliapani, Jajpur Dist., Odisha	*A Rajan Babu, S Kumar Reddy*

38	SS 18-03	Scientific studies to optimize the bench parameters and design of final pit slope stability of K. Deivendran Granites quarry in Veeriyampalayam Village, Tamil Nadu	*A Rajan Babu, T Amrith Renaldy, S S Meena, S Kumar Reddy, S Udaya Kumar, A Y Bharath Kumar*
39	GE 15-03	Determination of in-situ stress parameters at Hutti Gold Mine for the design of stopes below 20th level	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
40	GE 16-05	Determination of in-situ Shear parameters at the proposed dam across Markendaya river at Yargol near Kolar for design of the dam	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
41	GE 17-01	Determination of in-situ modulus of deformation of rock mass at the delivery main tunnels of Dr.B.R.Ambedkar Pranahita-Chevella Lift Irrigation scheme (P-11), Karimnagar District, Telangana	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
42	GE 17-02	Determination of in-situ stress tensor at the proposed underground power house of Naitwar-Mori H. E. Project.	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
43	GE 17-03	Determination of various in-situ rock mass parameters at the proposed desilting chamber and power house site of Goriganga-IIIA, H. E. Project.	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
44	GE 17-04	Determination of in-situ stress parameters at the proposed underground surge pool / pump house of Palamuru Rangareddy Lift-III pumping station	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
45	GE 17-05	Determination of in-situ stress parameters at the proposed underground surge pool / Pump house of Palamuru Rangareddy Lift-II pumping station	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
46	GE 17-07	Determination of safe bearing capacity by plate load & foot load tests at Pothead yard of Punatsangchhu-II HE Project	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
47	GE 17-08	Determination of in-situ Stress tensor at the proposed underground pump house of PRLIS, Pkg.16.	*D S Subrahmanyam, G Shyam, K Vamshidhar, S Vikram, K N Shashidhara*
48	MS 11-01B	Microseismic monitoring for 2nd year at TVHPP HEPP, NTPC	*C Sivakumar, Vikalp Kumar*
49	MS 16-01	Stability monitoring of power house cavern of Tala hydro power plant, DGPC, Bhutan	*C Sivakumar, Vikalp Kumar*
50	NM 12-01	Geodetic monitoring of Sardar Sarovar dam, SSNNL, Gujarat	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, K Sudhakar*
51	NM 13-03	3D stress analysis of underground powerhouse complex at Mangdechu Hydroelectric Project, Bhutan.	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, K Sudhakar*
52	NM 15-05	Deformation monitoring of U/G power house cavern of Sardar Sarovar project	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, K Sudhakar*

53	NM 16-05	Geotechnical instrumentation installation and monitoring at Kaleshwaram project (P-11), MEIL	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Aditya Mishra, BNV Sivaprasad*
54	NM 16-08	Analysis of instrumentation data of dam, desilting chamber ,surge shaft, powerhouse complex and TRT out fall area at NJHPS	*Sripad R Naik, B H Vijay Sekar, K Sudhakar, Rabi Bhusan, Aditya Mishra*
55	NM 17-01	Analysis of instrumentation data assistance in installation & monitoring of instruments at C#3 package of Punatsangchhu-II hydroelectric project, Bhutan	*Sripad R Naik, BNV Sivaprasad, K Sudhakar, Rabi Bhusan, B H Vijay Sekar, Aditya Mishra*
56	NM 17-02	3D numerical model studies for stress analysis of underground power house complex & Underground surge shaft of Naitwar-Mori Hydroelectric project, Uttarakhand	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Aditya Mishra*
57	NM 17-04	Stability analysis of Butterfly Valve Chamber(BVC), using 3D numerical model at Mangdechhu H.E. Project, Bhutan	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, Aditya Mishra, K Sudhakar*
58	NM 17-05	Stability analysis of BUS duct Shaft above draft tube tunnels using 3D numerical modelling at PCLIS-11	*Sripad R Naik, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Aditya Mishra*
59	NM 17-06	Scientific Studies to assess the feasibility of underhand mining method at Rampura Agucha U/G mines, HZL	*Aditya Mishra, Aman Soni, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Sripad R Naik*
60	NM 17-07	Technical assessment of Underground Mining Method at Rampura Agucha U/G mines, HZL	*Aditya Mishra, Aman Soni, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Sripad R Naik*
61	NM 17-08	Design of ground supports below -233 mRL up to-533 mRL at Rampura Agucha U/G mines, HZL	*Aditya Mishra, Aman Soni, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Sripad R Naik*
62	NM 17-09	Scientific studies to design geotechnical instrumentation plan at Rampura Agucha U/G mines, HZL	*Aditya Mishra, Aman Soni, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Sripad R Naik*
63	NM 17-10	Audit of ground control Management plan of Rampura Agucha U/G mines, HZL	*Aditya Mishra, Aman Soni, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Sripad R Naik*
64	NM 17-11	Assessment of global stability and feasibility on account of mining the crown and rib pillars of mined out stopes in Zawar group of mines, HZL	*Aditya Mishra, Aman Soni, B H Vijay Sekar, Rabi Bhusan, K Sudhakar, Sripad R Naik*
65	NM 17-12	Analysis of instrumentation data of power house complex and desilting chamber (April 1, 2017 to March 31, 2018) at Tala Hydroelectric project , Bhutan	*Sripad R Naik, K Sudhakar, Rabi Bhusan, B H Vijay Sekar, Aditya Mishra*
66	RB 17-04	Monitoring of blast induced vibration at two identified locations (Phase-III, Darlipalli super thermal power project (DSTPP), stage-1(2 x 800 MW), NTPC Ltd. Odisha, Extension-II	*G C Naveen, R Balachander, G Gopinath, H S Venkatesh*

67	RB 17-06	Blast design for armour rock to construct break water for Gopalpur port - Orissa, Afcons Infrastructure ltd	*G Gopinath, R Balachander, G C Naveen, H S Venkatesh*
68	RB 17-07	Controlled blast design for excavation of Hydro-technical structure and ground vibration measurement near operating units 1&2 of Kudankulam Nuclear Power Plant, Kudankulam, Tamil Nadu	*G Gopinath, R Balachander, G C Naveen, H S Venkatesh*
69	RB 17-08	Technical guidance for construction of tunnel from cable tunnel to reach downstream surge chamber and remaining excavations in tail race tunnels, Punatsangchhu II(1200 MW) hydroelectric project	*R Balachander, G C Naveen, G Gopinath, H S Venkatesh*
70	RB 17-09	Monitoring of blast induced vibration at two identified locations (phase-III), Darlipalli super thermal power project (DSTPP), Stage-I (2x800 MW), NTPC Ltd, Odisha - Extension-III	*G C Naveen, R Balchander, G Gopinath, H S Venkatesh*
71	RB 17-11	Ground vibration and air overpressure studies at Zuari limestone mine, Zuari cement ltd, Yerraguntla, YSR Dist., Andhra Pradesh	*G C Naveen, R Balchander, G Gopinath, H S Venkatesh*
72	RB 18-03	Technical guidance for rock excavation by controlled blasting at Karle Town center Project, Bengaluru	*G Gopinath, R Balachander, G C Naveen, H S Venkatesh*
73	RB 18-04	Technical guidance for rock excavation by controlled blasting at Kalyani Vista 2 Project, JP Nagar, Kalyani Developers, Bengaluru.	*G Gopinath, R Balachander, G C Naveen, H S Venkatesh*
74	RB 18-08	Controlled blast design for the excavation of structures of Unit 5 & 6 and ground vibration measurement near operating Units 1 & 2 of KKNPP, Kudankulam, SRC Projects Private Limited, Tamil Nadu	*G Gopinath, R Balachander, G C Naveen, H S Venkatesh*
75	RB 18-10	Ground vibration and air overpressure studies at M/s.KNR constructions Ltd., quarry, Modigolam Village, Irala Mandal, Chittoor Dist., Andhra Pradesh	*R Balachander, G C Naveen, G Gopinath, H S Venkatesh*
76	ES 12-01	Geothermal study at Manappad and around Kudankulam Area , Tamil Nadu	*Biju John, Yogendra Singh, K S Divyalakshmi*
77	ST 16-01	Seismotectonic evaluation (Feasibility study) of proposed Gugulapalli NPP site , Nellore, Andhra Pradesh	*Biju John, Yogendra Singh, K S Divyalakshmi*

ANNEXURE-7

LIST OF PUBLICATION

1. Balasubramaniam V R, Goverdhan K, Jennifer P D, 2018. Evaluation and visualization of seismic hazard using continuous seismic monitoring above old mined out area, National Conference on Prospects and Retrospect in Engineering Geology, Geophysics & Instrumentation (EGCON-2018) 3-5 December 2018. Hyderabad.
2. Butchibabu B, Khan P K, and Jha P C, 2019. Foundation Evaluation of a Repeater Installation Building using Electrical Resistivity Tomography and Seismic Refraction Tomography, Journal Environmental and Engineering Geophysics, March 2019, v. 24, no. 1, pp. 27–38.
3. Butchibabu B, Khan P K, and Jha P C, 2019. Foundation evaluation of underground metro rail station using geophysical and geotechnical investigations, Engineering Geology, v. 248, pp. 140–154.
4. Sivakumar C and Kumar V, 2018. Hydroelectric caverns stability evaluation and rock bolts failure investigation using induced seismicity, in National Conference on Prospects & Retrospect in Engineering Geology, Geophysics & Instrumentation held from 03-05 Dec 2018, Hyderabad, India.
5. Gopinath G, Venkatesh H S and Balachander R, 2018. Optimisation of Blast Design for An Armour Stone Quarry- A Case Study, 12th International Symposium in Rock Fragmentation by Blasting, Fragblast12, 11-13 June 2018, Lulea, Sweden.
6. Goverdhan K, Balasubramaniam V R, Jennifer P D and Sivakumar C, 2018. Preliminary assessment of seismic hazard in old mining area using surface mounted seismic sensors, published in Journal of Indian Geophysical Union, v. 22, no.6, pp. 598-606.
7. Jennifer P D and Porchelvan P, 2018. Seismic Hazard Assessment based on induced seismicity in underground mines: a comparative review of approach to hazard quantification, National Conference on Prospects and Retrospect in Engineering Geology, Geophysics & Instrumentation (EGCON-2018), 3-5 December, 2018. Hyderabad.
8. Jha P C and Venkatesh H S, 2018. Geophysical survey for addressing geo-environmental problem due to unplanned rapid urbanisation, National Conference on Prospects & Retrospects in Engineering Geology, Geophysics and Instrumentation, (EGCON2018), Hyderabad, 3-5 December 2018.
9. John B, 2018. Importance of Geological Studies in Earthquake Hazard Assessment. In Integrating Disaster Science and Management: Global Case Studies in Mitigation and Recovery. Elsevier Book Chapter 2, pp. 27-40.
10. Sudhakar K, Naik S R and Sinha R K, 2018. Developments in Geotechnical Instrumentation and Long-term Monitoring of Large Underground Caverns, All India Seminar on Technological Advancements and Emerging Mining Methods, (TAEMM-2018), 24-25 August 2018, Dhanbad.
11. Reddy K S and Babu A R, 2018. Slope stability studies in open pit mines. A case study, Indian National Group of International Society for Rock Mechanics (ISRM India) Journal, v. 07, no.2, 36-40.
12. Naik S R, Sastry V R and Mishra A, 2018. Effect of Orientation on Stability of Caverns – A Numerical Modelling Study, 10th Asian Rock Mechanics Symposium, (ARMS-10), 29- October – 03 November 2018, Singapore.
13. Naithani A K, 2018. Engineering geological investigations of power house area of Polavaram hydroelectric project (12 x 80 MW), Andhra Pradesh, ISEG News, v. 14. no. 2, pp. 6-7.

14. Naithani A K, Rawat D S, Singh L G and Jain P, 2018. Assessment of the excavatability of rock based on rock mass quality - a case study from India. Int. J. Geotechnical and Geological Engineering, Springer Publ., v. 36(6), pp. 4015-4027.
15. Naithani A K, Singh L G, Jain P and Rawat D S, 2018. Engineering geological assessment of cut slopes – a case study from hydroelectric project. Indian Landslides, vol. 11 no. 1&2, pp 1-6.
16. Naithani A K, Singh L G, Jain P and Rawat D S, 2018. Geotechnical assessment of the foundation of housing chamber of Yaragol Gravity dam, Karnataka State, India. Nanoscience and Nanotechnology, Whoice Publ. Pvt. Ltd., v. 1, no. 1, pp. 1-7.
17. Naveen G C, Balachander R, Gopinath G and Venkatesh H S, 2018. Controlled blasting and ground vibration analysis. National conference on Future trends in mining., 25-26th May, 2018, Bengaluru.
18. Naveen G C, Meena S S and Babu A R, 2018. A case study of blast design in M-Sand producing quarry, National seminar on, M-Sand: Future perspective and its sustainability.
19. Naveen G C, Sastry V R and Chander K R, 2018, Review on application of digital image processing technique in analysis of structural damage due to blast induced ground vibration, International Conference on Paradigms in Engineering and Technology (ICPET 2018), 28-29th December 2018, Hyderabad, Telangana.
20. Rajendran C P, Sanwal J, John B, Anandasabari K, Rajendran K, Kumar P, Jaiswal M and Chopra S, 2018. Footprints of an elusive mid-14th century earthquake in the central Himalaya: Consilience of evidence from Nepal and India. Geological Journal, https://doi.org/10.1002/gj.3385.
21. Rawat D S, Babu R N S, Rao G S, Naithani A K, Reddy P, Ravindra N K, Singh L G and Jain P, 2018. Excavation of large underground surge pool benching and delivery mains (vertical shafts) with the Alimak Raise Climber method-A case study, Proceeding volume, World Tunnel Congress 2018, Dubai.
22. Rawat D S, Naithani A K, Rao G S, Singh K and Babu R N S, 2018. Engineering geological evaluation of rock mass of the transformer cavern – a case study from lift irrigation project, India. Tunnelling Association of India (TAI) Journal, v. 7, no. 2, pp. 84 – 91.
23. Sekar B H V and Naik S R, 2018. Dynamic rock slope stability analysis using UDEC software, The Third International Conference on Rock Dynamics and Applications (RocDyn3), 25-29 June 2018, Trondheim, Norway.
24. Singh Y and John B, 2018. Identification of subtle signature of active deformation: Example from Indian Peninsula, In 19th General Assembly of WEGENER, Grenoble, France, 10-13 Sep 2018. Sciences conf.org:Wegener2018:218738.
25. Singh Y and John B, 2018. Nature of Young Deformations in the part of Eastern Ghat Mobile Belt, Peninsular India. XV Congreso Geologico Chileno.
26. Prasad S B N V and Naik S R, 2018. Planning for Geotechnical and Geodetic Instrumentation in underground Caverns, 10th Asian Rock Mechanics Symposium, (ARMS-10), 29- October – 03 November 2018, Singapore
27. Prasad S B N V, Thapliyal AP, Bhusan R and Naik S R, 2018. Delineation of Cavity in Downstream Surge Chamber at Punatsangchhu-II Hydroelectric Project, Bhutan, Journal of Geological Research, v. 1 no. 1, pp. 1-7.
28. Subrahmanyam D S, Shyam G, Vamshidhar K and Vikram S, 2018. Hydraulic fracturing stress measurements in porous rock mass, Asian Rock Mechanics Symposium, Singapore, 29th - 3rd November 2018.
29. Venkatesh H S, Balachander R, Gopinath G and Naveen G C, 2019. Excavation of a Tunnel to reach a Large Underground Cavern roof fall, 45th Annual conference on Explosives & Blasting Technique, ISEE, Conference 27 – 30, January 2019, Nashaville, Tennessee, USA.

ANNEXURE-8

NIRM STAFF

(as on 31.03.2019)

Director: ***Dr H S Venkatesh***

Centre for Testing Services
- Mr A Rajan Babu
- Mr S Udaya Kumar
- Mr J Raja
- Mr Royston Angelo Victor
- Mr D Prashanth Kumar
- Mr R Prabhu
- Mr S Babu

Engineering Geology
- Dr A K Naithani
- Dr Devendra Singh Rawat
- Dr L Gopeshwor Singh
- Dr Prasnna Jain

Engineering Geophysics
- Dr P C Jha
- Dr Sandeep Nelliat
- Dr Butchi Babu Bongu
- Mr Y V Sivaram
- Mr Shashi Nath Verma

Geotechnical Engineering
- Dr D S Subrahmanyam
- Mr G Shyam
- Mr K Vamshidhar
- Mr Vikram S
- Mr Shashidhara K N

Geomechanics & Ground Control
- Mr A Rajan Babu
- Mr T Amrith Renaldy
- Mr Sultan Singh Meena
- Dr Sandi Kumar Reddy
- Mr Bharath Kumar A Y

Numerical Modelling
- Dr Sripad R Naik
- Mr B H Vijay Sekhar
- Dr Rabi Bhushan
- Mrs Praveena Das Jennifer
- Mr B N V Siva Prasad
- Mr K Sudhakar

Engineering Seismology & Seismotectonics
- Mr Sivakumar Cherukuri
- Dr V R Balasubramaniam
- Dr Biju John
- Dr K S Divyalakshmi
- Dr Yogendra Singh
- Mr Vikalp Kumar
- Mr Goverdhan Kantepudi

Rock Blasting & Excavation Engineering
- Dr H S Venkatesh
- Mr G Gopinath
- Mr G C Naveen
- Mr R Balachander

Project Monitoring Cell
- Dr Sripad R Naik (OIC)
- Mr Sultan Singh Meena (Sci-IC)

Administration
- Dr Sandeep Nelliat
- Mr S Ravi
- Mrs Uma H R
- Mr N Jothiappa
- Mr M P Adithya
- Mrs B S Shruthi
- Mrs Janaki Bhavani P
- Mr P Venkata Reddy
- Mr K Manjunath

Resigned
- Mr Aditya Mishra
- Mr Aman Soni
- Dr G D Raju

Diseased
- Mr Sagaya Benady

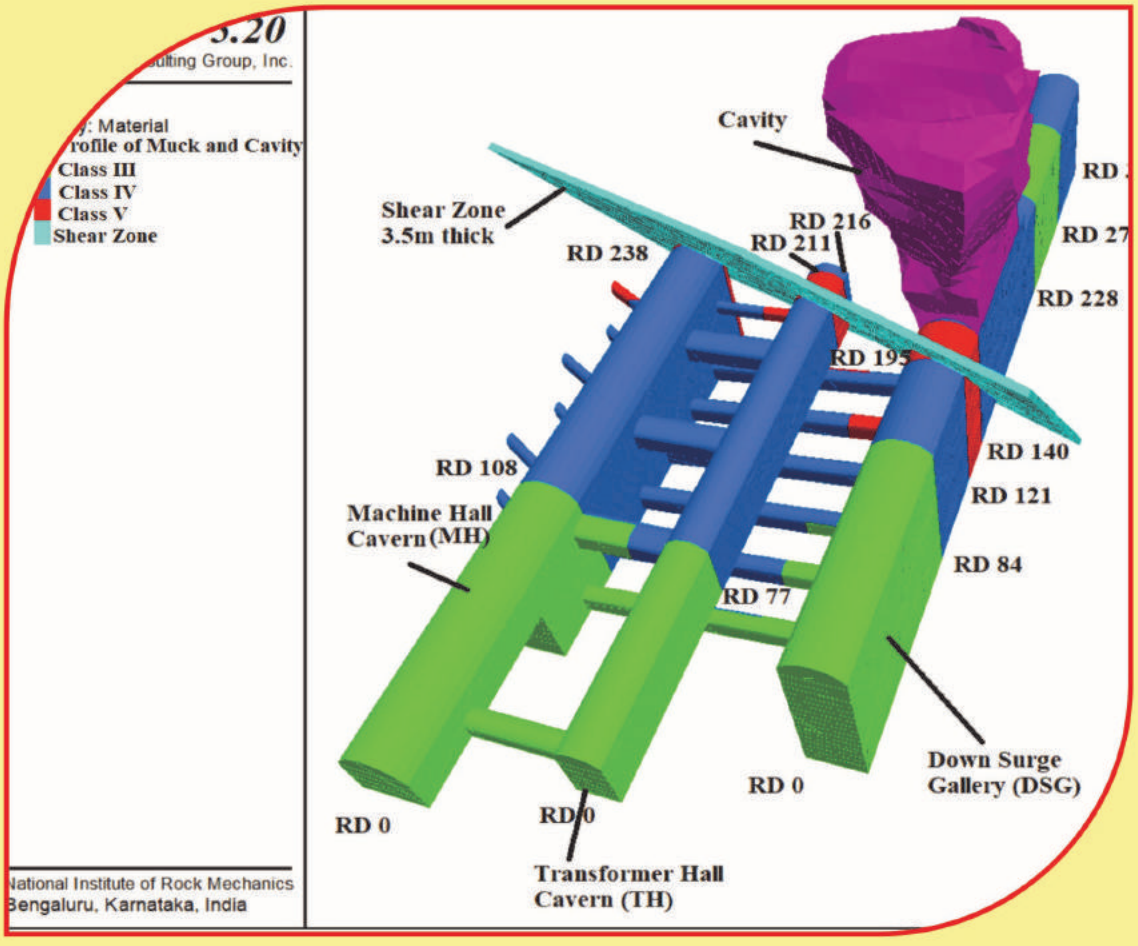
Retired
- Mr D. Joseph
- Mr J V Sastry
- Mr Syed Asghar
- Mr N Selvaraj

Group photo with the Executives of Singareni Collieries Company Limited, Govt. of Telangana, participated in the training program orgainised by NIRM at Kothagudem.

Republic Day celebration at
NIRM HO, Bengaluru and NIRM RO KGF

Independence Day celebration at
NIRM HO, Bengaluru and NIRM RO KGF

Caption of Photos at back cover:
Top: *View of Kaliapani Chromite mines, Balasore, Odisha*
Bottom*: 3D discontinum model of cavity at power house complex of PHEP-II, Bhutan.*


3.20
ulting Group, Inc.
: Material
rofile of Muck and Cavity
Class III
Class IV
Class V
Shear Zone
Cavity
Shear Zone
3.5m thick
RD 238
RD 216
RD 211
RD 228
RD 195
RD 140
RD 108
RD 121
Machine Hall
Cavern (MH)
RD 84
RD 77
RD 0
RD 0
RD 0
Down Surge
Gallery (DSG)
Transformer Hall
Cavern (TH)
National Institute of Rock Mechanics
Bengaluru, Karnataka, India