वार्षिक प्रतिवेदन

ANNUAL REPORT

2012-13

राष्ट्रीय शिला यांत्रिकी संस्थान

NATIONAL INSTITUTE OF ROCK MECHANICS

(Ministry of Mines)

An ISO 9001:2008 Certified Research Institute

Post Office - Champion Reefs
Kolar Gold Fields – 563 117
Karnataka

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कर्नाटक

Twenty five years of NIRM

Starting as an autonomous research institute in 1988 under the Ministry of Mines, Government of India, NIRM has expanded both in stature and competence over the last 25 years to mature as a professional Institute by offering its expertise in rock mechanics to various mining, tunnelling, hydropower and infrastructure projects.

On the occasion of this Silver Jubilee year, we sincerely thank all our peers and clientele for supporting this Institute in its path to progress.

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Front cover : Highlights of various activities of the Institute

Back cover : 3-D modelling for excavation, mine and slope design

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Director's Report

I am pleased to present the 24th Annual Report for the Institute. As you are aware, the National Institute of Rock Mechanics (NIRM) has been extending its R&D support and expertise in advisory role to the mining industry and major civil engineering projects (road / rail / hydroelectric) involving caverns and tunnels. With an excellent track record of over two and a half decades, the Institute has been able to make its presence felt in almost all mining, major hydroelectric and infrastructure projects (like railway tunnels, metro rail tunnels, irrigation tunnels and caverns for strategic storage of fuels). Against this backdrop, we are celebrating our Silver Jubilee year during 2013-14.

Major Achievements during 2012-13

Our involvement with various projects has continued during the 2012-13 with substantial addition in the number of projects ad earnings to the Institute. Compared to 65 research and investigation projects in the previous year, NIRM has carried out investigations for 76 research projects this year, out of which 51 were successfully completed and remaining 25 are continued to next year. NIRM Scientists contributed total 33 technical papers in various national/international journals and symposia. For the year ending March 2013, the Institute registered an internal revenue generation amounting to Rs. 311.25 lakhs and received a Non-Plan grant-in-aid of Rs. 477 lakhs. The external cash flow from the projects was Rs. 738 lakhs. The highlights of major R&D activities during 2012-13 are given below.

Site Characterization

In continuation with ongoing works at the expansion program of the Rajasthan Atomic Power Project (RAPP), construction stage mapping at various surface installations and cut-off drain system has been carried out. The geological mapping and design of rock support systems for the underground crude oil storage cavern at Padur and Mangalore (Karnataka) has been reviewed, and this will be continued till the end of the excavation sequence at the two sites. In addition, geological investigations have been carried out for various packages of Pranahita-Chevella irrigation project in AP.

Geophysical investigations were carried out for Chennai Metro Rail Project , which included strata classification at the prospective excavation site, and in a first-of-its-kind, cross-hole P-wave survey was used at Shenoy Nagar station in Chennai. In the hydroelectric project of KSEB, an alternate route for the HRT through hard rock was suggested in the wake of severe collapse of adit shaft along the existing route. Work on a

new S&T project on dynamic stability evaluation for surface structures in a settling environment has also been taken up.

Investigation work for seismo-tectonic evaluation of the area near Pudimadaka (near Visakhapatnam, Andhra Pradesh) was concluded, while that around Kudankulam Atomic Power Station complex (Tamil Nadu), is being continued. Another work on geothermal study at Manappad around Kudankulam has also been taken up. In addition, field investigations for three S&T projects in the area of seismology and seismo-tectonics have been continuing.

In-situ stress tensor parameters were determined by hydrofrac method for the powerhouse chamber of Etalin Hydro-electric Project, Arunachal Pradesh, and in-situ deformability was measured for the Mullai Periyar Project, Kerala. Different in-situ investigations were conducted at Rajasthan Atomic Power Project and the Mangdechhu Hydero-electric Project, Bhutan.

Design & Monitoring

NIRM has been carrying out numerical modelling for stress analysis, stability evaluation and support design for various hydel, mining and other infrastructure projects. Feasibility of new mining methods in four underground mines (three metal mines – Balasore, IMFA and Facor chromite mines, and one coal mine – Bhatgaon mine of South Eastern Coalfields Ltd) and stability of slopes in two Goan iron ore mines were studied using numerical modelling.

3D modelling for evaluating the stability of the powerhouse complex at Tapovan Vishnugad Hydroelectric Project and stability of slopes of Varunavat Parvat and have been continued.

Instrumentation and analysis of instrumental data is being continued for six major hydel projects both in India and Bhutan. The nano-seismic monitoring station in the powerhouse of Tapovan-Vishnugad hydroelectric project is commissioned and made operational. Recommendations were made to the Druk Green Power Corporation (Bhutan) for procuring a microseismic system to monitor the instability in the powerhouse area.

Excavation Engineering

The Scientists of NIRM provided technical advice and guidance for safe blasting close to existing structures for eight hydel projects including Tala and Mangadechu projects of Bhutan and Tehri project of India. Guidance on controlled blasting was also extended to three mining sites including a sister mine of HGML. Experiments were conducted with controlled blasting for Chennai Metro project and for the switchyard of Rajsthan Atomic Power Project.

Sustainable Mining

The Institute has entered into an MoU with the Uranium Corporation of India Limited, and has been providing solutions to the rock mechanics problems being faced at their Tummalapalle mine (Kadapa District, Andhra Pradesh). instrumentation and monitoring for assessing the stability of sub-level stopes at Hutti Gold Mine has been continued. Investigation for design of support pillar for Kathpal chromite mines and underground opening for Sukinda chromite mines were also taken up.

Strata control investigations are in progress in the underground coal mines of Saoner (Nagpur area), Sarni and Tawa (Pathakhera area) mines of Western Coalfields Ltd. A suitable mining sequence and support system have been designed for Mathani (Pench Area), Mohan (Kanhan Area) collieries of Western Coalfields Ltd, and Kakatiya Project and GDK-10 Incline of Singareni Collieries Co Ltd.

Stability of the slopes of opencast mines of Sateli Iron Ore Mines (Deccan Minerals) and Vibuthigudda iron ore mines, Bellary, Karnataka, were taken up. NIRM is actively involved in implantation of scientific quarrying techniques. Technical guidance has been extended in this field to Pallava Black Galaxy and IMGC quarry in Ongole (Andhra Pradesh), and Evershine Granite Quarry in Ramnagara (Karnataka).

Testing Services

As an accredited test laboratory, NIRM has carried out non-destructive testing of mining components in the mines of Singareni Collieries Co Ltd and Hindustan Zinc Ltd. Long term MoU has been signed with M/s China Coal and Shaft Sinkers (contractors for the shaft sinking project at HZL mines), for various types of testing both at the site and in NIRM material testing laboratory. NIRM has also entered into MoUs with a number of clients including HZL, SCCL, NALCO and other private companies for repetitive testing works both in-situ and in the laboratory.

The diverse projects briefed above reflect the vision of the Institute for a quantum growth, and its resolve for self-sustainability. I am indeed thankful to various sponsoring agencies and industries for reposing faith in our services through sponsored projects and assignments. It is heartening to note that almost 90% of our clients come back to us with repeated work of challenging nature. The inspiration and guidance from the Peer Review Committee has helped us to steer the growth charter during this year. Behind all this is the support from the Governing Body and General Body of the Institute, and the generous assistance from the Ministry of Mines, Govt of India. I cannot but mention the commendable work carried out by the Scientists and staff of the Institute who are at the forefront in executing the projects in time and with strict scientific benchmark. Continuing with this spirit, i am sure the Institute would not only repeat this performance over and over again, but even further excel.

1. ENGINEERING GEOLOGICAL INVESTIGATIONS

Geological and geotechnical inputs are pre-requisite for economic and safe design of constructions in rock related to mining sector, power sector (hydel, thermal, nuclear), communication sector (metro, rail and road tunnels, bridges), crude oil storage caverns, irrigation sector, and for geohazard assessment and mitigation. NIRM carries out detailed geological investigations in various stages of the project development. These investigations include :

(i) detailed engineering geological investigations,
(ii) monitoring of rock mass conditions during construction stage, and
(iii) review / compilation of geotechnical reports, and preparation of Detailed Project Reports.

During 2012-13, the Engineering Geology Department worked on six main projects, out of which four have been completed and two are in progress. They include four projects of reviewing geological conditions and one project of detailed geological mapping.

- During construction of twin tunnels on the Hungund–Hospet Section of NH-13 in Karnataka, engineering geological data recorded by the contractor was reviewed. RMR was calculated after 3-D geological logging of open cut side walls and face of tunnels and measurements of discontinuity data (Fig. 1.1). Based on this, recommendations on adoption of permanent support (a combination of rock bolts, shotcrete and steel ribs) based on 'Q' rock mass classification for two different stages of construction was given for the full length of the tunnels.

- In another review of earlier geotechnical investigations of a lift irrigation project of Pranahitha-Chevella Sujala Sravanthi (Package-8), Andhra Pradesh, it was desired to examine the feasibility of underground surge pool and pump house in place of surface construction. For this purpose, geological traverses were taken and the Rock Mass Rating (RMR) based on the available surface and subsurface borehole data was assessed. On the basis of geological and geotechnical data input from the surge pool and pump house, recommendations were made for the underground construction. It was suggested that the support system for the surge pool and pump house cavities should include rock bolt and shotcrete.

- For Rajasthan Atomic Power Project (RAPP) Units 7&8, the confirmatory sub-soil investigations for various structures and buildings were done by Hindustan Construction Company Ltd through three agencies, namely, M/s Soham's Foundation Engineering Private Limited, Mumbai, Central Water Power & Research Station, Pune,

and NIRM. The data from all the investigations were compiled by NIRM as per the format of the Atomic Energy Regulatory Board (AERB). In another study at RAPP, the cutoff drain area was investigated and 100 mm shotcrete was recommended for the side walls towards the main plant sides.

- Two other projects in respect of review of construction stage engineering geological investigations, namely, for the crude oil strategic storage projects at Padur (Fig. 1.2) and Mangalore, are continuing for the last three years. Three resident geologists have been posted at these sites to review the geological mapping done by the contractor. As part of the work, rock matrix description, rock discontinuity orientation & description, ground water condition, rock mass quality and permanent support recommendations based on rock support categories as mentioned in the basic engineering design, were reviewed after every drill-blast-mucking-scaling cycle. Based on this, periodic clearance was given for bench excavation and water curtain management. The ground water level in the boreholes was monitored to sustain the water pressure in the cavern and the accesses tunnel. Both the projects are being continued over to next year as the excavation work is still in progress.

- A detailed Construction stage engineering geological mapping for foundation of non-nuclear buildings of RAPP Units 7&8 was carried out by NIRM at the request of the Hindustan Construction Company Limited, Mumbai. The non-nuclear buildings include Safety Related Electrical Houses (SREH), Safety Related Pump Houses (SRPH), Fire Water Pump House (FWPH), Diesel Oil Storage Areas (DOSA), Ventilation Stack and Stack Monitoring Room and D2O Upgradation Plant. The investigations included engineering geological mapping on 1:100 scale of strata at foundation levels, identification of geological defects and recommendations of suitable engineering measures. The total geological mapping covered nearly 11,000 sq.m area.

  The project area is occupied by very hard and competent, fine to medium grained sandstones of Kaimur group of upper Vindhyan Super Group. Due to high weathering grade at the foundation of some of the buildings, extra excavation was recommended up to the level of fresh and competent rock mass before the final foundation mapping. Hard, massive and competent rock masses were exposed in the entire foundation surfaces of non-nuclear buildings. Based on the detailed investigations, recommendations were made for remedial measures for the foundations and vertical walls as the excavation progresses, to the satisfaction of AERB.

Fig. 1.1 Center heading method for north RHS portal area of Hungund-Hospet road tunnel showing jointed and moderately weathered metabasic rock

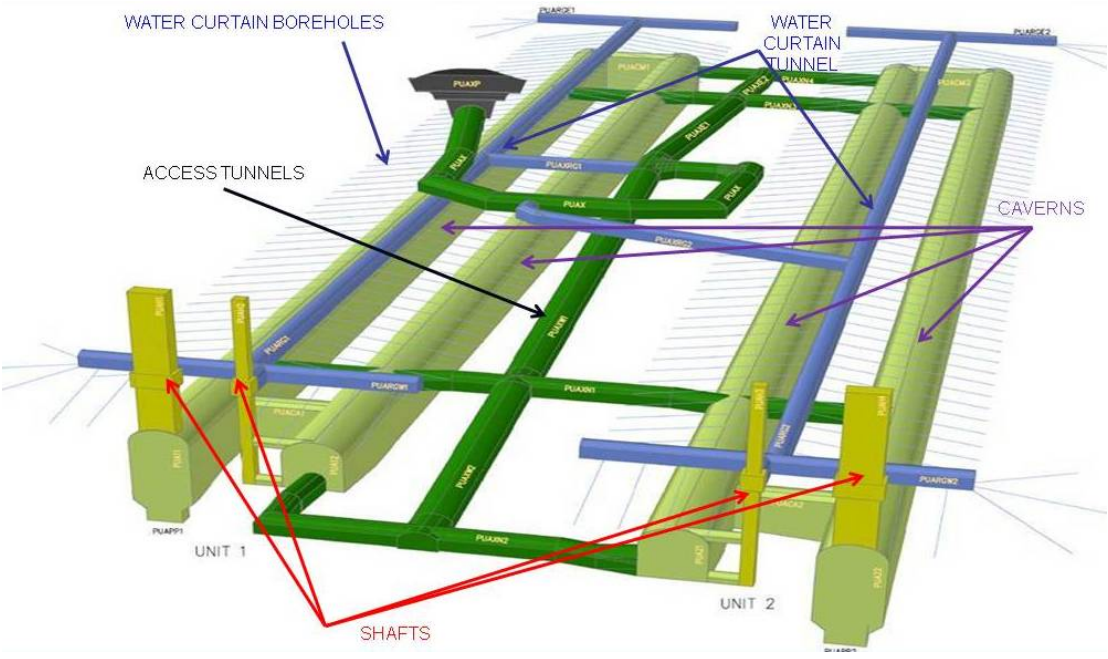

Fig. 1.2 Isometric view of excavation for shafts, tunnels and caverns of the oil storage cavern at Padur, for which review of the geological logging was done by NIRM

2. ENGINEERING GEOPHYSICAL INVESTIGATIONS

Engineering geophysical investigations are carried out by the Institute for various trouble-shooting operations pertaining to mining, civil and other infrastructure projects. In addition, routine geophysical investigations are also done for mapping of subsurface strata as part of site characterization studies. Equipped with state-of-the-art facilities for surface and borehole geophysical investigations, the Institute is carrying out mapping of the subsurface using seismic, electrical and GPR survey techniques. Some of the common studies undertaken by the Institute include seismic refraction, cross-hole survey, resistivity imaging and sounding, GPR mapping and cross-hole tomography techniques using both seismic and GPR techniques. During 2012-13, four projects were undertaken in this field including one S&T project. Out of the three sponsored research projects, two belong to site characterization studies. The S&T project sponsored by the Ministry of Mines envisages development of new investigation techniques and will continue for three years.

- At Pallivasal Hydel Project of KSEB, mapping of subsurface strata was carried out along the proposed HRT alignment. As earlier attempts to drive the HRT through a shaft and adit tunnel suffered setback due to collapse of shaft platform, subsurface strata investigation was done to understand the feasibility of HRT along the proposed alignment or along the alternate alignment. Drilling along the alignment was not possible due to dense tea plantation on the top. Therefore, seismic refraction survey was done to generate subsurface section upt0 70 m depth along the proposed and alternate routes. The geophysical survey results (Fig. 2.1) indicated the presence of thick overburden material extending up to the channel bed level from the entry point to around 500 m length. Thereafter, the formations in the crown portion were mostly boulders for the next 250 m. Except for a few places, the rock cover was very low in the crown of the tunnel along the proposed alignment, but along the alternate alignment, the rock quality was good both at the tunnelling level and in the crown. Hence it was suggested to plan an alternate route with bends.

- Site characterization was carried out for strata classification along a stretch of the Chennai Metro construction close to Chennai Central railway station. As blasting was not permitted on the busy road close to Chennai station, subsurface strata profile up to the excavation depth of 20 m was required to plan the excavation strategy. Seismic refraction survey along the identified lines showed that the jointed rock mass and hard rock layer combine along these lines, which need to be removed by blasting. Around 40% of the subsurface layer had weathered rock and the remaining was compact soil overburden (Fig. 2.2).

- As a troubleshooting application of geophysical investigations, borehole investigations were made around the area of excavation for Chennai Metro Project, where incidences of sinkholes and sinking of building foundation was noticed close to a box-cut excavation in the Shenoy Nagar area. During the excavation for the 220 m x 50 m x 25 m opening, there was excessive leakage of water with silty sand into the excavated area which was eventually pumped out. This excavation was supported by diaphragm walls on both sides and the water had leaked through the joints of the diaphragm walls. Though all visible sinkhole cavities were promptly packed, and water seepage was later arrested, sinking of nearby buildings was observed despite grouting of the subsurface done by the contractor, M/s TT-AFCONS JV.

  As there was not enough free space on the surface on either side of the diaphragm, it was decided to carry out borehole geophysical investigation with P- and S-wave seismic on either side around the length of the diaphragm wall. For this purpose, it was suggested to drill 14 boreholes each for 20 m deep with an inter-separation of 15 m. First a calibration run was done in a nearby intact area, based on whose data a correlation curve was drawn between V_P and SPT. Using this as master curve, V_P from the test holes was converted into equivalent SPT which was then normalized with respect to SPT value determined before the onset of the construction activity. These normalized values were then contoured out in the X-Z plane, and the envelope of the low value contours (< 0.8) was drawn. This was the target area to be strengthened by grouting to arrest further sinking of the nearby buildings. As a testimony to this approach of correlating V_P and SPT, sinking was observed in some new buildings close to the weak zone earmarked by us. It was conclusively inferred that with the withdrawal of water and slush from lower horizon, the top soil layer sustained due to its cohesiveness till the loose ground area became too big. Sudden surface sinking was a tell-tale effect of this wider loose area.

- An S&T project sponsored by the Ministry of Mines has been undertaken for the development of a viable technique for assessment of reclaimed land for safety of structures under settling environment. This project aims at correlating the in-situ and laboratory measurements on rock and soil samples from the subsurface to arrive at a realistic parametric study on the feasibility of construction on a weak ground. It was planned to carry out both surface and borehole investigations using seismic (P- and S-waves), GPR, impact-echo and other deterministic approaches at a number of potential sites. It is expected that these studies would eventually lead to the formulation of a viable geophysical methodology for evaluating integrity of structures and stability of the subsurface. This is a three year R&D work started in March 2013.

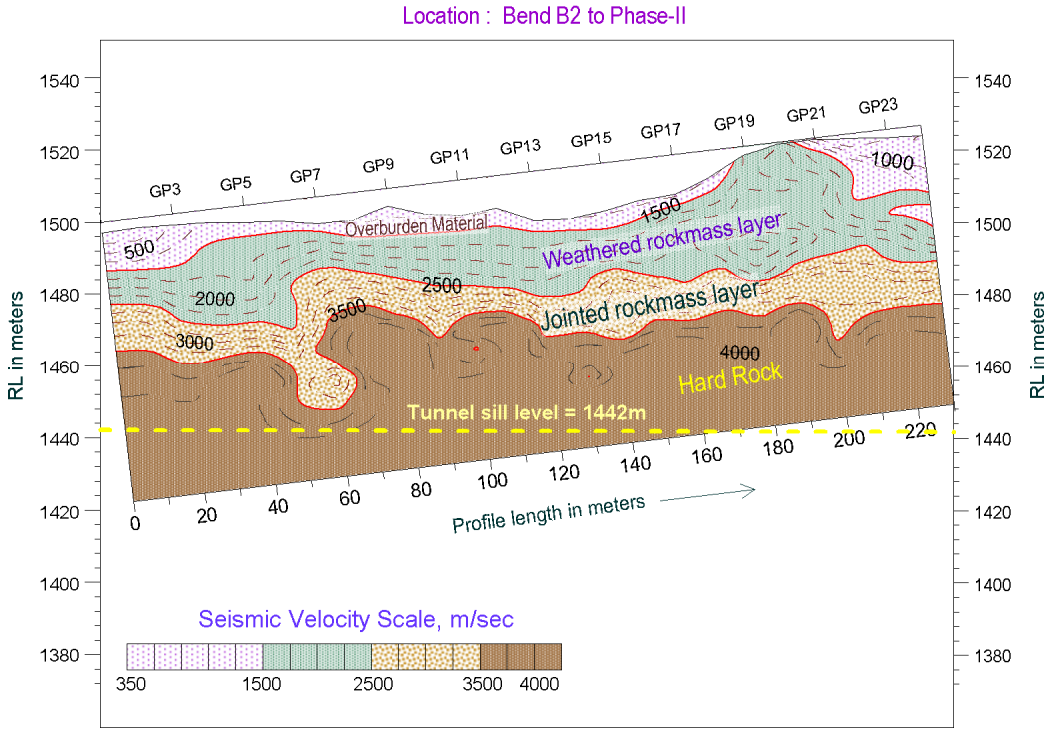

Fig. 2.1 A typical seismic velocity section along the tunnel alignment at Pallivasal HEP

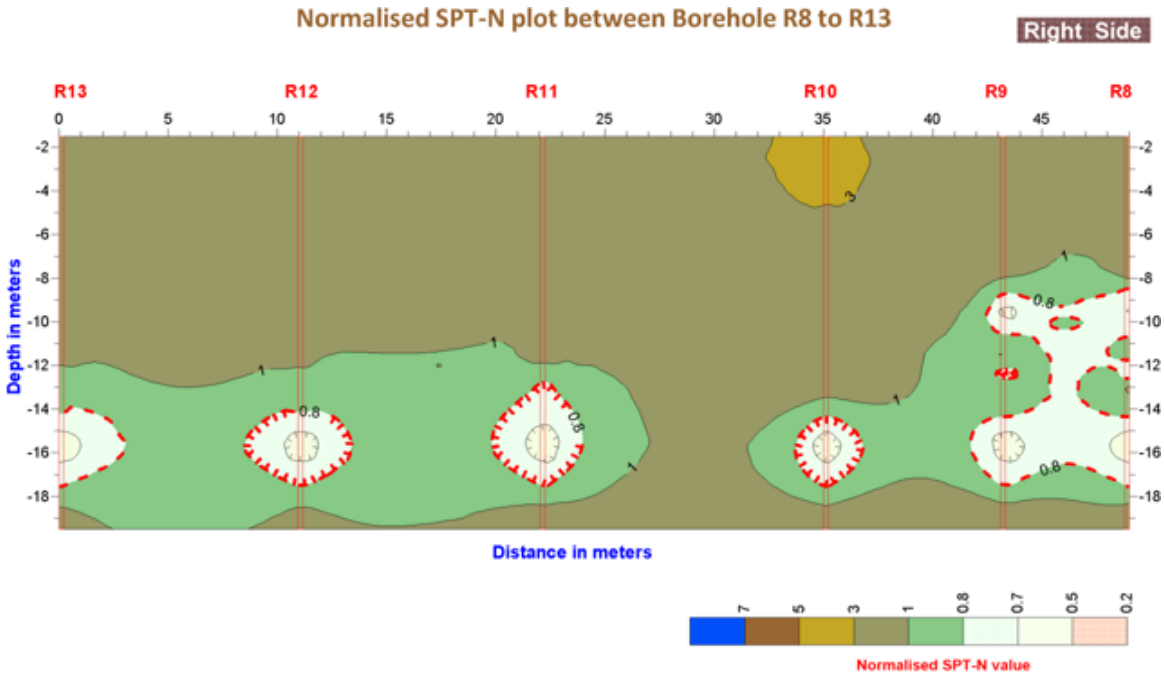

Fig. 2.2 Presence of anomalous zone around excavation area of Shenoy Nagar station of Chennai Metro project

3. GEOTECHNICAL ENGINEERING INVESTIGATIONS

Geotechnical investigations are an integral part for the design of any underground structure, and of superstructures like dams on the surface. In case of civil structures, the geometry, shape, dimensions, excavation sequence, orientation of the support system, acceptable water pressure for the conduits, all depend upon the results of the geotechnical properties of the in-situ rock formations. In mining, geotechnical investigations help in mine layout, pillar design, stope design and sequence of mining for safe and economical extraction of minerals. NIRM is actively involved in carrying out in-situ geotechnical investigations for numerous projects in India and abroad. These investigations are broadly divided into three main groups :

1. Determining in-situ stress parameters
2. Determining in-situ deformability parameters
3. Determining in-situ shear parameters

During 2012-13, the Geotechnical Engineering Department completed four sponsored projects for hydropower sector and work on one S&T project sponsored by the Ministry of Mines is continued. Out of the four completed sponsored projects, one each belonged to measurement of in-situ stress, in-situ deformability (Fig. 3.1) and in-situ shear parameters, while the fourth one involved conducting a combination of various in-situ tests.

- The stability of the underground cavern gets enhanced if the long axis of the cavern is oriented along or sub-parallel to the direction of maximum principal stress. For the powerhouse chamber of Etalin Hydroelectric Project, Arunachal Pradesh, executed by M/s Jindal Power Ltd, hydrofracture stress measurement was carried out inside NX boreholes at the vicinity of the proposed powerhouse chamber at RD 225 m. The orientation of maximum horizontal principal stress (8.52 ± 1.8202 MPa) at the measurement site (powerhouse drift) was found to be $N50^{o}E$. Distribution of discontinuities in the powerhouse area, vis–a–vis the principal stress direction, showed that the major principal horizontal stress orientation is the acute bisector of the two principal joint sets S1 and S2 and transverse to the third joint set S3. Hence if the powerhouse has to be located at the present site, the long axis of the powerhouse is required to be oriented along $N50^{0}E$ direction.

- The work on determining in-situ deformability parameters was undertaken for Mullai Periyar Dam in view of stability fears raised by the harvesting states. In this case the deformability parameters of different materials used for the construction of dam were determined through boreholes drilled up to 50 m depth. The deformability parameters determined by pressure meter are :

Depth (ft)	Zone	Deformability modulus (GPa) at the dam
3	RCC capping	12.83
10	RR masonry	4.73
30	Lime Surki	0.38 to 1.42
80	Lime Surki	2.89

Depth (ft)	Zone	Deformability modulus (GPa) at the dam
110	RR masonry	1.43 to 24.39
140	RR masonry	12.69 to 24.76
165	Charnockite	21.13
175	Charnockite	32.28

- For the design of Concrete Gravity Dam, the shear parameters of rock mass and rock mass/concrete interface are two important parameters required. A key requirement in the evaluation of sliding stability of concrete gravity dams is the prediction of shear strength of foundation joints and discontinuities. The shear strength of rock depends upon a number of factors such as strength of rock, rock type, joint pattern, rate of loading, rate of shearing, etc. NIRM carried out investigations at Mangdechhu Hydroelectric Project to determine the in-situ shear characteristics for concrete-rock interface and rock-to-rock interface inside an exploratory drift across the dam axis (Fig. 3.2). The results showed that the cohesion and friction angle at the right bank were 10 to 15% higher compared to those at the left bank. This indicates a better quality rock mass on the right bank.

- Services of NIRM were engaged by M/s Hindustan Construction Company to carryout Deformability Modulus (E_d) and Elasticity Modulus (E_e) of the rock mass at RAPP 7 & 8 Units - Rawatbhata, Rajasthan. E_d and E_e of the rock mass are two important in-situ parameters which provide a basic idea about the impact of the rock mass under loading and unloading conditions, required for the design of foundation. The modulus of deformation, modulus of elasticity, rebound characteristics and coefficient of elastic uniform compression were determined at RAPP, Based on the results, the settlement of the bearing plate, footing and the ultimate bearing capacity of the rock mass were evaluated at the founding level of various structures at RAPP-7&8 Units.

- The work on S&T Project, titled “Development of State-of-the-Art Facilities for In-situ Stress Measurement by Hydrofracture Method in Porous and Fractured Rock Mass”, is being continued. The test sites were identified, and the required equipment was processed through a tender notification. Field investigations would be taken up after receiving the equipment.

Fig. 3.1 Typical set-up for in-situ deformability investigations

Fig. 3.2 In-situ shear investigations inside the drift at left bank of dam site at Mangdechhu HE Project

4. ENGINEERING SEISMOLOGY

Continuous monitoring of seismic activity is essential to understand the seismo-tectonics of the region and assessing the stability of underground and opencast excavations. The Engineering Seismology Department caters to this field of specialization. During 2012-13, this department continued work on two on-going S & T projects, for assessing the seismic hazard potential due to closure of BGML mines at KGF, and it worked on three sponsored projects of Nuclear Power Corporation of India Ltd for assessing the seismic hazard potential to their power plant sites.

- To understand the seismo-tectonics of the Indian shield region, ten Broad Band Stations were installed in the peninsular India, out of which NIRM, KGF, hosts one station. All these stations are connected using V-SAT, and the seismic data from them are downloaded by the Central Seismic Monitoring Station at NGRI, Hyderabad, who are the nodal agent for this study. During 2012-13, the broadband station of NIRM recorded 423 seismic events of local, regional and tele-seismic magnitude. The important local events recorded were from Khozhikode (Kerala), Madhekere (Karnataka), Tiruchchirappalli (Tamilnadu), Guntur & Prakasm (Ongole) (Andhra Pradesh), and Koyna (Maharastra and Gujarat). An earthquake measuring 3.4 on Richter scale was recorded from Mallapuram, Kerala. Amongst the tele-seismic events, the meteoroid strike at Chelyabinsk, Russia, on 15-02-2013 was recorded (Fig. 4.1). All these data were retrieved, archived and sent to the National Seismological Data Center in the Indian Meteorological Department, New Delhi, for detailed analysis.

- In addition, the Strong Motion Accelerograph (SMA) installed at NIRM has picked up 31 seismic events from the mines of Kolar Gold Fields, two events from a long distance and two events from a nearby quarry. One major rockburst recorded by the SMA has a magnitude of 2.6. Seismic data of all events recorded from 2005 -2012 was plotted for the peak ground acceleration versus radial distance to get the attenuation relation of the area and for estimating the seismic hazard. This project is supported by the Ministry of Earth Sciences and will be continued over the next year.

- The NPCIL-sponsored work on seismo-tectonic evaluation and related geological studies in Pudimadaka area in Achutapuram Mandal, Visakhapatnam District, Andhra Pradesh, was concluded during this year. Geomorphic studies identified the abandoned path of the Sharada River in the region between Anakapalli and Tada. Stabilized sand bodies were observed in almost the entire length of the beach. Eighty four lineaments were marked from LISS-IV, Cartosat and Landsat data. Based on the

association and trends, the lineaments were grouped into eight sets. Of these, six were falling in the NW-SE direction, and three in the NE-SW direction. On-shore magnetic data was reinterpreted and integrated with offshore magnetic data. The studies identified the lineament 68 as a continuous feature in on-shore and offshore. Suspected liquefaction features were identified west of Visakhapatnam. As hallow trenches did not yield details of this feature, NIRM suggested deeper trenches to ascertain them. Only one earthquake data of M=3.1 was reported within 30 km of the project site. Based on the studies carried over the last two and half years, a final seismo-tectonic map was prepared (Fig. 4.2), and the final report was submitted to Directorate for Atomic Minerals Exploration and Research. Subsequently field verification for the suspected occurrence of sand dikes was jointly carried out by NIRM-AMD-BARC Scientists during June 2012.

- In earlier seismo-tectonic studies within 30 km radius of Kudankulam plant, it was found that many lineaments had regional affinity. In order to evaluate all the lineaments within 30 to 50 km of the plant, NIRM has taken up further investigations. Thirty two lineaments were identified in this area from the analysis of satellite images, mostly trending in NW-SE and NE-SW directions. These were sympathetic to NW-SE trending Tenmalai fault system which is part of Achankovil shear zone, a major tectonic feature in southern peninsular India. The geomorphic studies and field mapping had identified fault-related features in the plain area east of Western Ghats up to Gulf of Mannar. The surface rupture zone was further studied through trenching which revealed imbricate thrust planes within the laterite cap. Three faults identified in this zone show trapped sediments within laterite due to reverse movement. When OSL dating was carried out on trapped sediment samples to find out the time of deformation, it indicated two different ages for the events. These repeated events indicate that the NW-SE trending Thenmalai fault lineament as active. Due to local problems, further investigation was suspended.

- Following reports of suspected geothermal activity in Manappad area, located about 44 Km North East of the Kudankulam Nuclear Power Project (KKNPP) site, in the form of a hot water spout, NPCIL asked NIRM to investigate its origin. The Scientists of NIRM identified the location based on the morphology of the feature (small circular crater) and interaction with local people. The feature was identified as a depression surrounded by a 3 m diameter circular rim of sand mixed with shells. The location of this incident was falling in a lineament sympathetic to L4, which was not mentioned in earlier reports. In order to ascertain the geothermal activity in the region a series of studies were proposed by NIRM which included remote sensing studies using thermal bands, physical verification of the orifice through trenching and cleaning (during dry season), monitoring the feature for at least one year and chemical analysis of the water samples from nearby wells as well as along the wells along the lineament zone to find out its connection with deep seated source, if any. However, the work could not be initiated due local problem.

- An S&T project was taken up in collaboration with the Indian Institute of Science, Bangalore, to identify paleo-earthquakes from the central and eastern Himalayas through distant liquefaction studies in the Ganga-Brahmaputra basin with a view to estimate the recurrence of earthquakes in the Central-Eastern Himalaya and Upper Assam region. During this period, trench excavations were carried out to identify liquefaction features and surface faulting. Detailed trench logging identified two episodes of deformations. Based on the thickness of individual sedimentary units, a faulting model was generated deciphering the sedimentation and faulting episodes. Stratigraphically controlled samples were collected for dating the time of the individual events. Further, different seismically induced paleo-liquefaction features were identified based on their cross-cutting relations or those related to unconformities. Samples were collected from each of the levels, to obtain the maximum, minimum and contemporaneous ages. Further studies are being continued.

- Another S&T project relates to the neotectonic activity of the Desamangalam Fault which lies in the south western terminus of Palghat gap where microseismic activity was experienced since 1989. The objective of the project is to identify active tectonic elements in this region so as to evaluate the seismic potential of the area. A number of sympathetic (NW-SE) and antithetic (NNE-SSW) lineaments to Desamangalam fault were identified in this area. The faulting seems to be related with fluid activity as evidenced from secondary mineralisation. Field verification identified the sympathetic lineaments dominated with reverse movement and gouge formation and antithetic features dominated with mineral precipitates. A few small-scale normal faults were also identified in this area. In the southern side of the west flowing Bharathapuzha river, which constututes the main drainage system of the area, a number of wide valleys were identified through remote sensing studies. Based on the observations from remote sensing the field checks points were identified for further evaluation of litho units in the channels of these valleys. Trenches were made in these channels to find out the litho units in these paleo-channels. Five samples were collected for OSL dating to correlate the stratigraphic units in the paleo-channels. More trench related studies were planned for the next year to ascertain the dike structures.

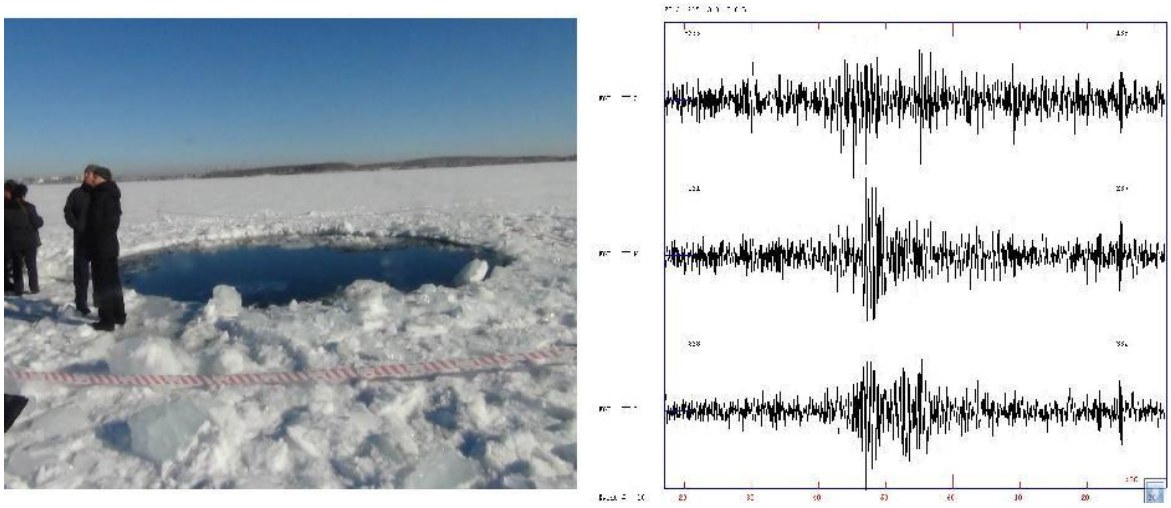

Fig. 4.1 The meteoroid strike in Russia on 15-2-2013; the seismic event which resulted in the wake of meteoroid strike was recorded at NIRM

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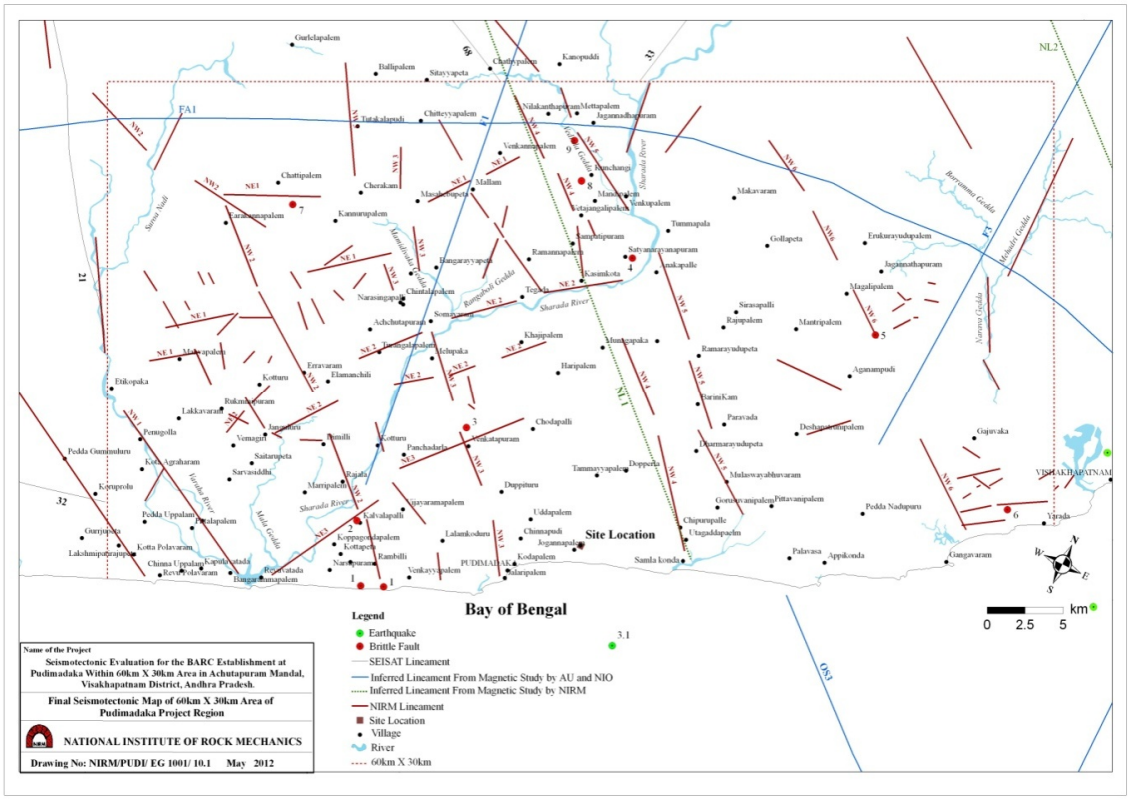


Fig. 4.2 Seismo-tectonic map prepared for Pudimadaka project based on NIRM studies

5. NUMERICAL MODELLING, INSTRUMENTATION AND MONITORING

Numerical Modeling Department at NIRM undertakes analysis of a wide range of rock mechanics problems in the areas of mining and civil engineering using discontinuum and continuum techniques. The department also caters to the stability analysis of concrete structures and underground caverns in rock mass using instrumentation data. During the the year 2012-13, tennew projects were taken up and work on another six was carried over from last year was continued. Out of the 16 ongoing projects, two belonged to stress analysis and modeling for hydel and irrigation projects, four to slope stability analysis, one to embankment stability analysis in mines, three to coal mining and six to the area of instrumentation and monitoring. By the end of 2012-13, five projects were completed and eleven were carried over to next year. The progress made in each category of projects is presented here :

a) Modelling for hydel and irrigation projects :

- For Tapovan Vishnugad Hydroelectric project, NIRM carried out 3D modeling studies based on the geological information given by NTPC prior to the excavation. Subsequent to substantial excavation activities in Tapovan Vishnugad powerhouse complex, the work of “Back Analysis of Powerhouse Complex Behaviour” was taken up based on the instrumentation data provided by NTPC Ltd. There was significant difference in the results obtained from initial model, requiring calibration of the model. According to the calibrated model, 130 m chainage in powerhouse cavern was found to be the most critical section with maximum displacement of 100 mm. In the transformer hall cavern, maximum displacement of 75 mm was found at 50 m chainage after stage 4 of excavation. Of the 55 m rock pillar, nearly 35 m of rock mass at 80 m chainage was found significantly affected due to the excavation process. Hence, it was recommended to stitch the rock mass by cable bolting. The displacement values obtained from the calibrated model (Fig. 5.1) compared well with the measured instrumentation data. The excavation of the caverns was completed at the site. The final calibration of the model will be done after receiving the actual geological details and the instrumentation data from NTPC Ltd.
- Under package – 23 of Pranahita Chevella Sujala Sravanthi Lift Irrigation Project, M/s Patel Engineering, Hyderabad, has undertaken construction of an underground pump house of 94 m (L) x 20 m (B) x 43.5 m (H) size with 18 km long tunnel. The stability of the underground pump house will be evaluated based on stress analysis using 3D numerical modeling, and suitable support system for roof and walls of the cavern will be suggested. This work will commence after receiving the input data from M/s Patel Engineering.

b) Modelling for landslide and slope stability :

- A massive landslide triggered by heavy rainfall during the monsoon season took place in Varunavat Parvat on 23rd September 2004 causing large scale damage to life and property in the town of Uttarkashi lying at its toe. Post landslide, extensive stabilization measures were carried out by THDC India Ltd. based on the inputs from Geological Survey of India (GSI). At the request of THDC, the stability analysis of the treated slope by using three dimensional distinct element code (3DEC) was taken up. The static analysis indicated that the treated and re-profiled slopes were stable. Later certain modifications were made to the static model in order to simulate the seismic conditions. The output in the form of displacements, maximum and minimum principal stress along the slope and at different sections were analysed. The analysis of maximum and minimum principal stress revealed that there were no significant areas of high tensile stress causing failures. The results indicated that the remedial measures undertaken in the rock and soil mass above EL 1530 m in the Varunavat Parvat can be considered to be safe for earthquakes of magnitude similar to that of Uttarkashi Earthquake, 1991.
- In Goa, near Bicholim iron ore mines of M/s Sesa Mining Corporation Ltd., some houses were located at about 90 to 100 m distance from the crest of the top most bench. It was reported that a few cracks appeared in these houses, and in this context, it was required to evaluate the stability of rock and soil slopes of the south eastern benches at 1 Top pit. The stability of the slopes was assessed using 3D Numerical modeling (Fig. 5.2) as well as limit equilibrium analysis. Slope stability analyses at three sections, i.e., 52, 53 and 54 were taken up using the limit equilibrium analysis. The critical factors of safety obtained at these sections were above 1.5 in the extracted profiles (safety circles indicate critical paths within the mine boundary). Further, the stability of the slopes with bench profiles after extraction was analysed using three dimensional numerical models. The safety factors calculated from the models were above 1.5 and compare well with those predicted by limit equilibrium analysis. Both the studies have indicated stable bench profiles with displacements well within the limits. Occurrence of cracks beyond 50 m distance from the edge of the top most bench crest can be ruled out. Thus the modeling studies and limit equilibrium analyses clearly established that cracks formed at the houses located at distances of 80-100 m were not due to the mining activity.
- For the slope stability studies at Pandarathu Limestone Mine of M/s Malabar Cements, Walayar, Kerala, the stability of rock and soil slopes of the benches at the mine was evaluated based on current mining sequence. For this purpose, geological and geotechnical investigations were conducted at the mine, and testing of rock and soil samples were carried out in the laboratory at NIRM. The stability of the overall slopes along with individual benches was evaluated using 3D numerical modelling. Limit equilibrium studies were also conducted to evaluate the stability of the soil slopes. Modelling studies indicated that the existing slopes were stable. The limit equilibrium analysis of the soil slopes indicated that there were localized failures in a few sections, and some other sections have low factor of safety. Recommendations were made on the slope stability parameters to reach the final pit bottom of 320 m

RL. During rainy season proper drainage of runoff water by installing weep holes will help in effective passage of water, improving the stability.

- The stability of Pissurlem waste dump slopes for the Sonshi Iron Ore Mine of M/s Cosme Costa & Sons, Goa, was studied based on detailed numerical modeling and limit equilibrium analysis. The overburden waste of Sonshi mine was being transported and placed in this Pissurlem Dump. In this study, the stability of the dump will be evaluated based on field investigations and slope stability analyses. At present work on laboratory testing of samples collected from the dump is in progress.
- In the Hungund-Hospet section of NH-13 in the state of Karnataka, road widening work between km 265 and 299 involved construction of twin tube D-shaped tunnels (15.5 m diameter and 300 m long). NIRM was proof checking the reports of the consultant for assessment of tunnel design, efficacy of support system and stability of cut slopes near the approaches of the twin tunnels. The design submitted by the EPC contractor was evaluated and proof checked using numerical modeling. Several visits to the project sites were undertaken and discussions were held with the designers, and the contractor at the site. The reports and designs were critically evaluated and suggestions and remedial measures were suggested in the final report to improve the excavation methodology and support measures.

c) Modelling for mining methods and support system :

- M/s South Eastern Coal Fields Ltd. (SECL) intends to experiment with a special depillaring method called "Optimization of Panel Dimension System" at the Mahamaya underground coal mine of Bhatgaon area. The method was proposed by the Society for Mining Research, Sustainable Development and Environment (SMRSDE), and M/s SECL asked NIRM to review it as it is a new technique requiring minimal support at the face. In this study, the support requirement for the proposed depillaring method will be assessed based on the data given by SECL. The associated surface subsidence will also be predicted for the panel under consideration.
- In the Bhupalpalli Area of SCCL, four workable inclined seams (dip of 24^{o} to 14^{o}) are proposed to be extracted by retreating longwall method with powered roof supports (under the name Kakatiya Longwall Project). M/s Indu Projects Ltd., Hyderabad, is the main implementing agency for installation of the longwall equipment and extraction of coal. The trunk and gate roadway development will be by road headers and SDLs will be used while driving the inter connections. Detailed 2D numerical modelling studies were conducted to evaluate the stability of four possible configurations of main gate and tail gates. As per this study, model-1, with both the gateroads above the bottom shaly clay, was found to be an unfavourable configuration from strata control point of view; model-2, with the main gate above the bottom shale and the tail gate below the bottom shale, too was an unfavourable configuration; model-3, with both the gate roads below the bottom shaly clay, was the most unstable as the roof would be under failed state during the development stage itself; model-4, with the same configuration as model-3 but the roof extended up to the overlying sandstone, was found to be the most stable with minor failures in the clay band. Hence it was recommended that model–4 with stone roof and partial stone floor was

the most preferred configuration of Main Gate and Tail Gate, considering only the development of the gate roads. However, if the entire seam is to be worked out, additional safety measures are required.

- M/s Balasore Alloys Ltd. wanted to extract the ore locked up in the opencast benches of Kaliapani Chromite mine as well as in the underground deposit by using overhand cut & fill method. In this study, feasibility of extraction by underground method as well as underground deposit below 15 mRL up to 160 mRL was evaluated. The overhand cut and fill method was analysed using 3D numerical models to assess its application under the current geomining conditions. The results of 3D model studies indicated that the method can be used successfully if alternate drivages of 4x4 m (or 5 m) were backfilled and supported with pre-cast concrete rings. Other supports required during the mining would be fiber reinforced, shotcrete, forepoling, low pressure grouting and construction of false portal. Modeling studies also indicated that extraction of the ore locked up in slopes by the proposed method would not cause significant instability in the slopes provided all the suggested measures were incorporated during the extraction process. Further, the feasibility of mining below +15 mRL was also studied. The same method of cut and fill with cemented backfill in alternate drives and pre-cast concrete rings may be followed after leaving sufficient crown pillar of 11 m thickness against the opencast workings. It was recommended that overhand cut and fill method was feasible in the present geological condition**.**

d) Instrumentation and monitoring :

- Instrumentation, monitoring and data analysis at the powerhouse complex of Tala Hydro Power Plant, Bhutan, has been continuing since 2002. During April 2012 – March 2013, about 150 instruments were monitored at the power house complex, surge shaft and pressure shaft butterfly valve chamber. Stability of the machine hall cavern was assessed based on convergence observations of the side walls, load on the rock bolts and stress distribution along the length of instrumented bolts and piezometric observations in the side walls. Based on the analysis of the instrumentation data, it was observed that the convergence at the machine hall cavern was continuing although at a lower rate (0.006 to 0.016 mm/day), load on the rock bolts was increasing at some of the locations particularly at 150 u/s at EL506, and some of the instrumented bolts showed marginal increase in compressive stress. It was concluded that the cavern was undergoing time dependent deformation and stress included deformation. The failure of the rock bolts was still continuing (with 8 rock bolts failing in the machine hall and 1 rock bolt in the transformer hall), which can be attributed to the stress redistribution still going on inside the rock mass surrounding the caverns.
- During the construction of the Tala Dam of Bhutan, around 250 geotechnical instruments were embedded in the dam body, which is a concrete gravity dam of 92 m height and 130 m width. Analysis of the dam instrumentation data is regularly being carried out by NIRM. Based on the analysis of the instrumentation data of the dam as provided by DGPCL up to December 2012, it was found that the dam body was working satisfactorily during the operational period. Seasonal cyclic variations in data have been observed in temperature (maximum in August and minimum in

January-February), pore pressure and joint meter readings (separation of 2-5 mm), and stress meters (variation of 3 to 6.5 kg/cm^2). The uplift pressure meters at the foundation indicated maximum uplift pressure of about 33.3 mWC at Block 2 and about 13.5 mWC at Block-5.

- Deformation monitoring of underground powerhouse cavern of Sardar Sarovar Project, Gujarat, has been continuing since the year 2000. In this study, monitoring of MR-MPBX and total station targets in the power house caverns has been continuing. NIRM installed a few surface MPBXs for monitoring the strata between the crown of the powerhouse and surface. Analysis of the instrumentation data during last two years has indicated that the cavern is stable.
- The concrete gravity dam of Sardar Sarovar is 1210 m long with a maximum height of 163 m above the deepest foundation level. Due to the large reservoir capacity and height of the dam, it is necessary to monitor the deformation of the dam, during different levels of reservoir in order to ascertain the dam stability. NIRM proposed to establish a geodetic instrumentation system to monitor the deformation/movement at the crest of the dam based using DGPS instrument. The proposed network consists of monitoring points on different blocks of the dam body on downstream side with four reference (control) points established on both abutments. These control points would be checked twice in a year and regular monitoring would be carried out once in two months. The acquired data would be analysed periodically. Currently, construction of the control points is in progress. The monitoring work will start once the control points and the target points on the dam body are ready.
- Analysis of instrumentation data of the dam, the desilting complex and the power house complex of Nathpa Jhakri Hydro Power Scheme of Satluj Jal Vindyut Nigam Ltd, Shimla, has been continuing for over a decade. The analysis of instrumentation data revealed that the displacements in the powerhouse cavern were in the range of 3 to 20 mm, at RD 92, RD160, RD 123 and RD 41, showing stabilizing trend at EL 1014 on the downstream wall. At RD 184 (EL 1022), the displacements were in the range of 2.0 to 3.0 mm (static since October 2010). The MPBX at RD 248 / EL 1014 in the drainage gallery showed increases in displacements of the order of 1 to 7 mm at 4 m horizon. Relative displacements between the anchors indicated opening up and closing of the cracks. Further monitoring is required to assess the behaviour in detail.
- The Tehri Hydro Power Complex (2400 MW) of THDC India Ltd. comprises the Tehri hydel project, the Koteshwar hydel project and the Tehri Pumped Storage Plant. At present, Tehri and Koteshwar hydel projects are in operation and Tehri Pumped Storage Plant (PSP) (1000 MW) is at construction stage. Many geotechnical instruments were installed in Tehri and Koteshwar dams and monitoring of these instruments is continuing. It was proposed to develop a user friendly data template for analyzing and presenting the instrumentation data for each instrument, with a view to store information and data of all the instruments in a database so as to analyse any particular instrument data at any stage instantaneously. The method of data acquisition was first assessed, and the requirement of data storage, data analysis etc. were understood, and now the data template is being developed.

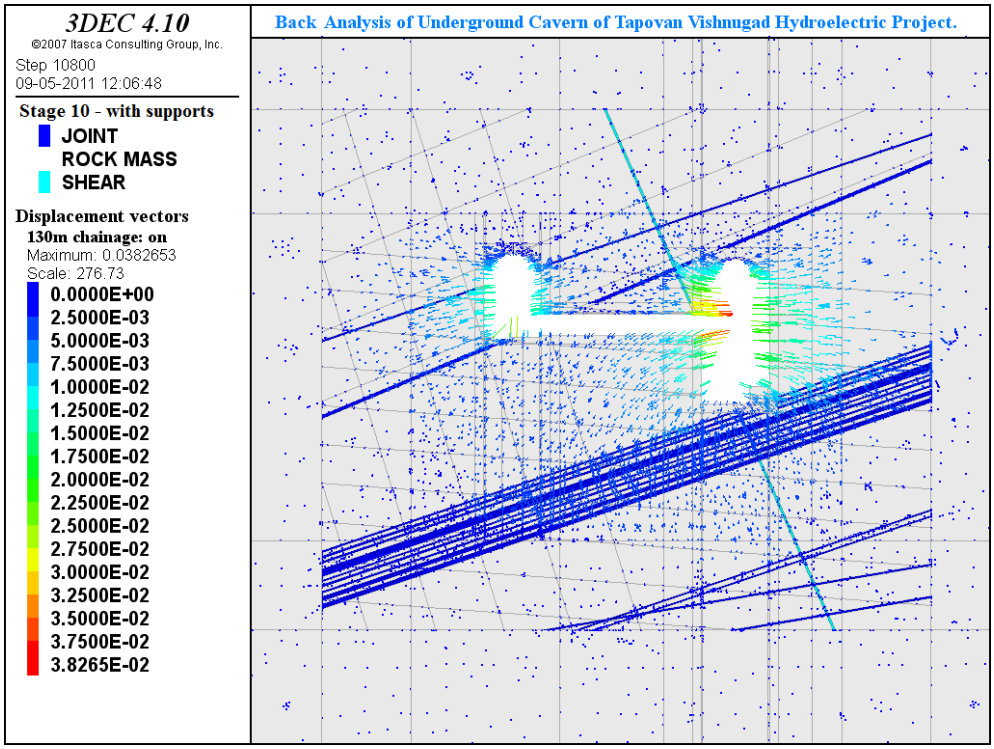


Fig. 5.1 Displacement vectors, obtained from 3D modelling of Tapovan Vishnugad HEP, at RD 130 m chainage after stage 10 of excavation

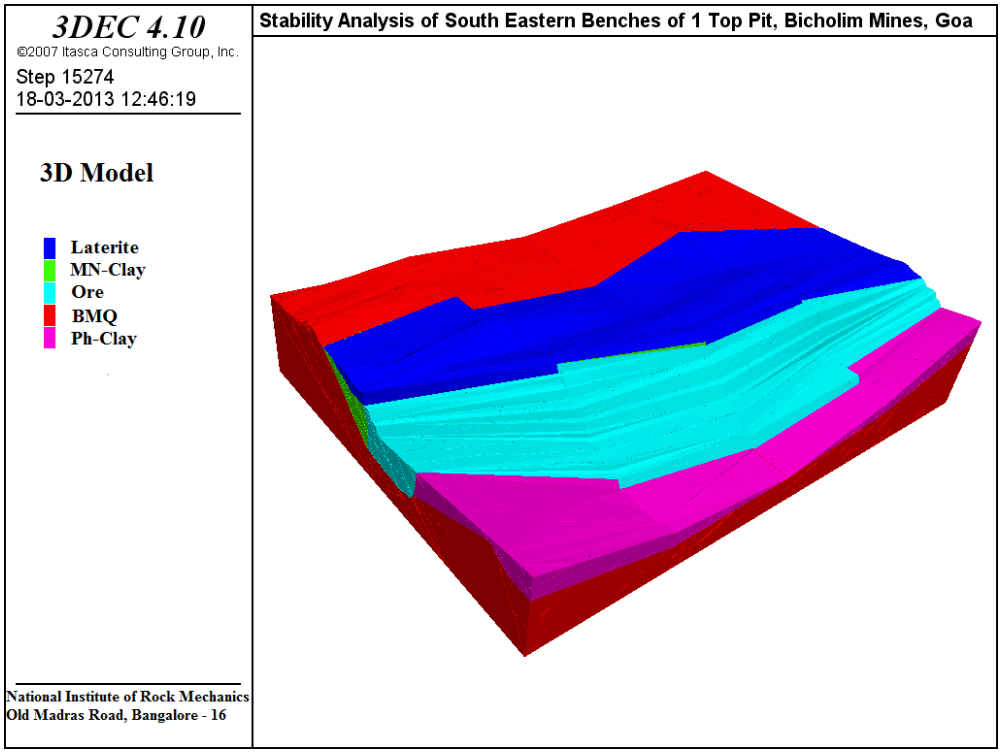


Fig. 5.2 Post-extraction 3D model of south eastern benches at Bicholim mine, Goa

6. ROCK BLASTING & EXCAVATION ENGINEERING

Rock Blasting & Excavation Engineering Department of NIRM has an experienced team of Scientists and is equipped with latest instruments like seismographs, VOD measuring systems, laser based survey systems, digital video camera, fragmentation assessment system, vibration analysis system (signature hole analysis) and state-of-the-art software for blast design. The department has been providing innovative solutions to challenging problems in blasting for various surface and underground excavations in mining, hydroelectric, infrastructure and other civil engineering projects. The projects undertaken pertain to optimization of blast design with vibration monitoring for ensuring safe charge limit and advising on controlled blast design with minimum or no fly rock. During 2012-13, the department worked on fourteen industry sponsored projects, out of which eleven were completed remaining three were in progress. Brief description of work done is presented here.

a) Vibration and air overpressure monitoring :

Out of seven projects undertaken in this category, three pertained to hydel projects, three to mining and quarry projects and one to infrastructure (road) project as detailed below.

- A 100 MW hydroelectric project is being constructed by HPPCL at Sainj in HP. Various components of the projects are located along the right bank of the Sainj river. As the underground excavations were under progress, there were complaints from villagers regarding excess ground vibration. The project authorities (HPPCL) requested NIRM to conduct a scientific study on the impact of vibration. Accordingly, nine blasts were conducted at various project components and vibrations and air overpressure levels were monitored at different locations. The vibration data were regressed and a site specific safe permissible limit of PPV of 5 mm/s was arrived at. The safe maximum charge per delay at various distances was computed and presented in the report for reference during the excavation of the remaining underground components. The air overpressure levels were below the trigger level (105 dB) of the instrument and these levels were not expected to pose any problem to the structures in the villages. Based on these parameters, all the blasts monitored during the field investigation period were found to be within safe limit with respect to ground vibration and air overpressure.

- M/s Jaiprakash Associates Limited (JAL) is constructing dam complex and power house complex of Mangdechhu Hydro Electric Project (720 MW) near Trongsa in Bhutan. The dam complex involves construction of a diversion tunnel, dam and other associated structures. These constructions involve excavation of rock by drilling and

blasting. The nearest private structure from the blasting locations was the Trongsa Dzong and Taa Dzong belonging to the Royal Government of Bhutan and the Raven Crown Resort which were beyond 1,000 m distance from the blasting locations. M/s JAL wanted to carry out ground vibration study to assess the impact of blasting on these surface structures. Based on the DGMS standards, a peak particle velocity of 2 mm/s was suggested as safe for the Dzong and the Taa Dzong whereas for the Rave Crown Resort a peak particle velocity of 5 mm/s was suggested as safe. Based on USBM guidelines and IS Code, the suggested safe air overpressure was 133 dB for all the structures. Nineteen blasts were monitored for ground vibration and air overpressure by deploying six seismographs at different locations. Site specific predictor equations for ground vibration and air overpressure were derived. The monitored ground vibrations and air overpressure for all the blasts during the field investigation were well within the permissible limits and have not even exceeded the threshold limit of the seismographs (<0.5 mm/s) at Dzong, Taa Dzong and Raven Crown Resort. Even the recorded air overpressure levels were less than the permissible limit of 133 dB. The safe maximum charge per delay was restricted to 125 kg for both surface and underground blasts.

- Stage II of Tehri dam project comprises a Pumped Storage Plant (PSP) with an installed capacity of 1000 MW. For this purpose, an underground powerhouse is proposed to be constructed on the left bank. Two headrace tunnels, each of 8.5 m diameter and about 1100 m length, will carry water from the reservoir to this powerhouse. There will be two tailrace tunnels, each of about 10 m diameter and 1000 m lengths, to serve as downstream water conductor system up to the Koteshwar reservoir. As the existing HPP structures and equipment are close to the proposed PSP, the project authorities wanted to take up studies so as to assess the impact of close-in blasting to the HPP structures while excavating the cavern and associated tunnels and shafts for the PSP. A Scientist was deputed to the site for a period of one year for monitoring ground vibrations with four instruments. For monitoring in the near field (distances <30 m), high frequency tri-axial geophones were used, whereas for monitoring in the far field (distances >30 m), conventional geophones were used. Blast vibrations were monitored for seventy seven blasts which were carried out at different faces. In total, 103 sets of data were generated. All the vibrations monitored at HPP structures were well within the accepted limit for the blasts in PSP during November 2011 to February 2013. Considering this, the permissible maximum charge per delay at various distances was recommended.

- In order to assess the impact of ground vibration due to blasting at a depth of 45 m in the sub level open stope of the Heera Buddinni mine on the Buddini village located at about 300 m from the main shaft of the mine, a study was commissioned by the mine authorities, Hutti Gold Mines Ltd. The present sublevel blasting locations are at about 190 m from the Buddini village and are advancing away from the village. Five seismographs were deployed of which two instruments were placed at surface in Buddini village to monitor ground vibration for all the underground blasts. Using the generated data, a site specific predictor equation was derived. The recorded frequency of ground vibration around the mine and village was greater than 16 Hz. Based on the frequency of ground motion, a peak particle velocity of 10 mm/s was

suggested safe for the structures in the Buddini village as per the norms specified by DGMS. It was found that for the blasting carried out during field investigation the peak particle velocity at Buddini village was within this safe limit. Accordingly, the permissible safe maximum charge per delay for different distances was estimated.

- M/s TT-AFCONS JV were implementing the Chennai Metro project. As part of the project, in order to evolve a plausible method of excavation in hard rock close to the busy Chennai station, they approached NIRM for conducting vibration and air overpressure studies. To understand the trend of attenuation of the ground vibration and air overpressure, NIRM carried out experimental studies at an alternate site, a quarry near Chennai. Three sets of experimental blasts were conducted with each set comprising of three blasts. NIRM carried out monitoring of ground vibration and air overpressure at planned distances for the nine blasts. Site specific predictor equations were derived for ground vibration and air overpressure. The recorded frequency range for the ground vibration was >50 Hz. For this range of frequency, the safe peak particle velocity happens to be 15 mm/s as per the guidelines prescribed by DGMS. Considering the surface structures at the vicinity of Chennai Central Metro station area on par with the conventional residential structures (domestic houses / structures / kuchha, brick and cement), a peak particle velocity of 10 mm/s was suggested. The computed maximum charge per delay for different distances was presented.

- In order to monitor ground vibrations and air overpressure at Jambunatheswara temple due to blasting at Jambunathanahalli Iron Ore Mine, a study was commissioned by M/s MML, Karnataka. As a ban was imposed on the mining activities in and around Hospet area, the blasting operation was on hold. Hence field studies will be commenced only after the lifting of ban and receiving intimation thereof from the client. This project is therefore continued over to next year.

- GMR-EPC has undertaken 4/6 laning of NH-13 from Chainage 299 to 265 of Hospet-Hungund project on DBFOT. The project involves the construction of two new bridges across river Tunga Bhadra (TB) and twin tunnels (Fig. 6.1). Part of these tunnels need to be constructed under an operating railway line with a cover of about 15 m by drilling and blasting method. In addition to the railway line a temple is also present at about 68 m from the nearest tunnel face. At the request of GMR-EPC, NIRM reviewed the method statement submitted by the contractor and appropriate suggestions were made. Ground vibrations were monitored and site specific predictor equation was derived. The blast designs were reviewed periodically and appropriate modifications were made. As the tunnels approached the railway zone ground vibrations were monitored vertically above the blasting faces and in the railway zone. Though the permissible level of ground vibration based on the IS code happens to be 70 mm/s, the maximum charge per delay was restricted to 50 mm/s in the design guideline so as to ensure that the vibrations in the vicinity of the railway zone never exceeded the prescribed limit of 70 mm/s. The intensities of vibrations generated from the movement of trains, blasting in the tunnel and a reference point in the proximity to the tracks were measured. It was found that the vibrations from blasting were lower than that from the movement of the trains. In addition the surface

settlement before and after the blasts were measured by monitoring the deformation using auto level. The observations confirmed that there has been no significant impact on the surface movements due to blasting. The extensometer readings inside the tunnel showed that there was no deformation in the tunnel too. Both the tunnels were successfully excavated.

b) Design of controlled blasting operations :

Out of seven projects undertaken in this category, five pertained to hydel projects and one each to mining and atomic power project. Brief description of work done in each of them is detailed below.

- Sengulam Augmentation Scheme (SAS) of Kerala State Electricity Board (KSEB) envisages construction of a diversion weir in the upstream of Kallar bridge on Alwaye – Munnar Road of NH 49. The water from weir is to be diverted through a 6.7 km long D' shaped tunnel to Sengulam reservoir for augmenting the power generation at existing Sengulam power house. Since the rock excavation was to be done by drilling and blasting method, a scientific study on blast design and monitoring of ground vibrations were taken up by the NIRM at the request of the project authorities. Ground vibrations from blasting at tunnel exit end and adit II were monitored by deploying six seismographs. To control flyrock it was suggested to cover the blasts with 2" x 2" SWG 10 link mesh, old rubber trucks tyres and sand. At the tunnel portal blast a muffling method was suggested by utilising the available material at the site like the coconut / arecanut tree stumps, steel plates and old tyres. The vibration data generated for all the 31 blasts were used for regression analysis. In total, 85 sets of readings were used for regression and a site specific predictor equation was derived. For the permissible limit of 25 mm/s for steel bridge, the computed safe maximum charge per delay was found to be 5 kg. Restricting the maximum charge per delay to 5 kg ensured the permissible vibration level to 10 mm/s at the old power house and domestic houses/structures (kuchha, brick and cement). The results from the suggested blast designs were satisfactory. The execution of this augmentation scheme is in progress based on these controlled blasting guidelines.

- The Druk Green Power Corporation Limited (DGPCL), Bhutan, is running a 1020 MW Tala Power House. The project authorities wanted to augment the electricity production by another 30 MW by utlilising the water from a perennial stream flowing downstream of the Tala dam. To divert this stream water into the Tala reservoir, a tunnel of 1.4 km (3.5 m x 3.5 m, D shaped) is to be excavated. For the construction of this tunnel an adit of 59 m long had to be excavated along the dam axis from the dam top (Fig. 6.2). The job of excavation of the tunnel and other associated works was entrusted to M/s Abir Infrastructure Pvt. Ltd, who in turn requested NIRM for a technical guidance on the initial portal excavation by controlled blasting operation. Based on the literature review and our earlier experience, a peak particle of 100 mm/s was suggested as the safe limit for the Tala dam. As the excavation of the adit was to be carried out along the dam axis without disturbing the abutment and concrete dam, it was suggested to excavate the adit for the initial 20 m by heading and benching method of which the heading part (1.6 m x 3.5 m) should be blasted with jack hammer holes with light charge. The bottom bench (2 m) should be

excavated by mechanical means (hydraulic splitter, pavement breaker etc.). Blast design for heading was field tested and suggested to be continued till the initial 20 m of the adit. In order to increase the progress for the section beyond 20 m from the dam, full face blast design (wedge cut) was initially suggested with a hole depth of 1.0 m and later the design was optimized for a depth of 2.0 m. To further accelerate the excavation progress, a burn cut blast design was prepared and field tested with a hole depth of 2.8 m, for which the pull achieved was 2.5 m. Ground vibrations were monitored for fourteen blasts at the critical locations on the dam. All the monitored values were far below the permissible levels. Based on the field requirement and the vibration limit, a maximum limit of 25 kg per delay was suggested.

- Kerala State Electricity Board (KSEB) is implementing two Small Hydro Electric Projects (SHEP) at Peruvannamoozhi and Pazhassi Sagar in Kannur district. These projects envisage the excavation of rock by blasting near Peruvannamoozhi dam and Pazhassi Sagar barrage. As the dam and barrage of these projects are under the control of Irrigation Department, they asked NIRM to submit the pre-construction report incorporating the blasting pattern and specifications to be adopted for the two projects. After a comprehensive review, the possibility of conducting controlled blasting at the two sites was recommended by NIRM. The safe permissible peak particle velocity of 50 mm/s was suggested for Peruvannamoozhi dam, irrigation canal and Pazhassi Sagar barrage. The safe peak particle velocity for the private houses near surge shaft and pressure shaft alignment should be within 10 mm/s as per DGMS standard. The tentative blast designs for the different components of the projects were suggested. It was recommended to use only shock tube initiation system (NONEL) for all the blasts. For the pressure shaft which would pass under the irrigation canal (Ch. 502 – 523 m), the blast design was split up into two rounds / faces as top semi-circle and bottom semi-circle to restrict the maximum charge per delay (kg). This method statement served as a supplement to the tender document under blasting requirement so as to ensure the project completion in time with minimal cost over-run.

- A mini hydel project of 1.4 MW capacity is being commissioned on the Raya Basavanna Canal Khandaleru Power Company Limited (KPCL), Karnataka at the toe of the Tunga Bhadra dam (TB dam) by the Government of Karnataka. As the proposed project is close to the TB dam, before undertaking the construction activity, it is required assess the effect of blasting on the dam, and carry out controlled blasting. NIRM carried out field investigations at the site by conducting 50 blasts at the proposed powerhouse, tail pool and penstock areas of the hydel project. For all the blasts, ground vibration was monitored at toe of the dam and near wall of the Rayabasavanna canal. The monitored ground vibration for all the blasts was within the permissible limit of 20 mm/s. Flyrock was controlled by proper blast design and muffling the blast area with sand bags, link mesh and with blasting rubber mats. The excavation was completed successfully.

- Kerala State Electricity Board (KSEB) is constructing a small hydroelectric project (SHEP) of 3.6 MW at Vellathooval in Idukki District. For construction of this new project, about 20,750 m^3 of rock needs to be excavated by drilling and blasting. As

the proposed power house site is closer to the existing Panniar powerhouse complex, it is necessary to evolve a controlled blasting method for rock excavation. KSEB approached NIRM to provide guidance for conducting trial blast at their site and suggest safe blast design parameters for controlled blasting. The first field investigation was carried out in February 2013 wherein twenty blasts were conducted at powerhouse and tail race area. The vibration monitoring stations were identified in consultation with the project authorities. Analyzing the field data, a site specific predictor equation was derived and safe maximum charge per delay was arrived based on the permissible level of ground vibration (12.5 mm/s). A suitable blast design, i.e., box cut to create free face and progressive cut for benching, was recommended. The suggested blast design was reviewed and the vibration levels were checked during the third week of March 2013.

- Power Corporation of Karnataka Limited (PCKL), a public sector undertaking of Energy Department is establishing a 1320 MW thermal power station, whose location is adjacent to the location identified by M/s Gulbarga Cement Ltd for limestone mining activity for their proposed cement plant as approved by the Government of Karnataka. In view of suspected threat due to blasting operations from the mining activities, the Commerce & Industries Department approached NIRM to examine the impact of blast vibrations and offer the technical opinion for the co-existence of cement and thermal power plant. At the planning stage, it was not possible to conduct trial blasts and monitor ground vibrations. Therefore, based on the analysis of ground vibration data generated from thirty limestone quarries (1135 data points) in India (Fig. 6.3), it was found that the plot of PPV against the scaled distance for all limestone quarries clearly showed a range within which all data were confined. NIRM data equation was the most conservative and this equation was used for the estimation of the maximum charge per delay. This paved the way for co-existence of the of the 3.5 MMTPA capacity Cement Plant and 1320 MW Thermal Power Plant. This study showed that in unknown areas, a generalised attenuation relation derived from the analysis of a large number of sites can be used as guidance value to predict ground vibration. However, during the actual mining operation, site predictor equation has to be derived based on actual field measurements for the blasting operations.

- M/s Larsen and Toubro Limited (L&T) is constructing 400/220 kV switchyard at RAPP (7&8), Rajasthan for the Nuclear Power Corporation of India Limited (NPCIL). As part of this work, hard rock had to be excavated by drilling and blasting methods as close as 20 m to the existing substation structures. NIRM had already carried out a study on ground vibration and air overpressure adjacent to this project site and a predictor equation for ground vibration was derived and presented in the final report to M/s Hindustan Construction Company (HCC). As the location of the L&T site is adjacent to HCC site, L&T wanted to know the validity of the predictor equation at their site also. Field investigations were carried out for this purpose, NIRM derived the predictor equation valid for this site.

Fig. 6.1 Controlled blasting activities close to Tunga Bhadra dam and canal

Fig. 6.2 Location of adit portal, and the excavated adit along the axis of Tala dam, Bhutan

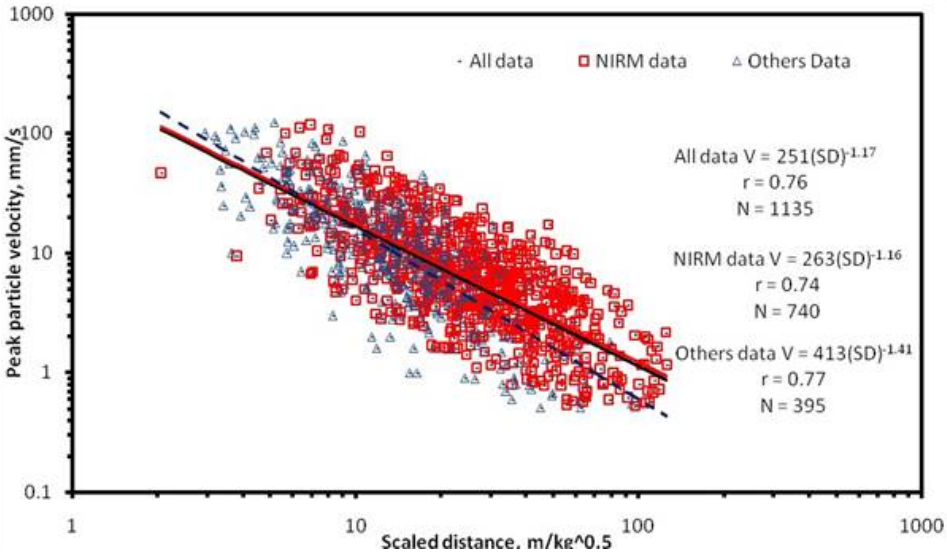


Fig. 6.3 Peak particle velocity versus scaled distance for limestone quarries

7. MINE DESIGN

Ground control investigations, and systematic strata and support monitoring are essential for safe design of underground mining methods and to validate the designs. It is also essential to design safe and economic slope angles in various open pit mines with increasing depth of surface mining excavations. NIRM has been making efforts for extraction of coal and different minerals occurring under difficult ground conditions by designing innovative and modern methods of work. The Mine Design Department of the Institute is actively involved in rock mass characterization, support design, strata monitoring and design of safe and innovative mining methods. During 2012-13, this department has taken up eleven projects in various categories.

a) Stability of workings in hard rock mines :

- NIRM carried out instrumentation at Hutti gold mine in the sub-level stopes in Strike Reef from 2000D/L to 2200 L FE 33 region to study the stability of the barrier pillars, the stability of the hangwall, and the closure of the adjacent galleries. In addition the feasibility of extension of the stoping in R-1 Sub-Block in Strike Reef hangwall up to 8th level (from present position between 9th and 11th levels) was also examined. From the stress cell measurements and the UCS of Middle Reef rock, it was concluded that there was no probability of failure of the pillars. The stiffness ratio of Hutti rock mass had not been found prone to rock burst at shallow depth. Based on empirical estimates, it was concluded that extension of R1 sub-block in Strike Reef hangwall to 8th level can be done without any ground control problems in the area. The hangwall backs of the stopes and the 3 m thick crown pillar would remain stable with the extension of stoping operations up to the 8^{th} level.

- At Kathpal Chromite Mine of M/s FACOR, the Jungle ore body at Jungle Pit dips at an angle of about 40^{o}. The Jungle Pit was developed by a 3 m x 3 m vertical shaft, with horizontal 3 m x 3 m footwall drives connecting the shaft and the ore drives / stopes. The ore body was developed at different depths for sub-level / open stoping method and for Large Diameter Blast Hole (LDBH) stopes with a level interval of 30 m. Based on the numerical analysis, it was concluded that the 10 m wide rib pillars would provide a high safety factor of 2, this can be reduced further depending on the required factor of safety. Empirical estimates suggest that the sill pillars and the crown pillar could be maintained at 8 m thickness.

- NIRM has taken up the study for design of underground openings and support system at Sukinda Mines (Chromite) of the Indian Metals and Ferro Alloys Limited (IMFA) who are in the process of starting underground mining operations. Based on

numerical modelling studies, it was recommended to extract the ore by 'Sub-Level Stoping' or 'Blasthole Stoping' with post filling. For operational efficiency of the blasthole stoping method, a level interval of 50 m was suggested. In view of the "Fair" to "Good" rock mass conditions, two sub-levels were recommended at 15 to 20 m vertical distance. Since the hangwall rocks are strong enough, the stope can also be extended towards the hangwall side without any problem.

- At the request of Uranium Corporation of India Limited (UCIL), NIRM has taken up the rock mechanics investigations for the development galleries and stopes, and for the formulation of the support plans for the proposed underground mine near Tummalapalle (Kadapa district, AP) for mining of pitchblende. Based on comprehensive studies, it was recommended to adopt full-column grouted roof bolts for the support system; additional bolts should be installed in between the regulat bolts in the junctions as well as in the loading points. Breast stoping, room-and-pillar open stoping and step mining method were considered for mining the thin ore body within gently dipping bedded strata. In view of the shallow depth, room and pillar method as a variation of breast stoping method was recommended for the present workings of the mine, up to about 100 m depth cover because of a weak hangwall strata.

b) Strata control in coal mines :

- At Saoner underground mine no. 2 of Nagpur Area, WCL, it was proposed to extract the pillars of the seam V developed by bord & pillar method without disturbance to the surface. NIRM was entrusted with designing a method of extraction of these pillars. Based on the rock mechanics investigations, it was recommended to work the panel no. $E5_c$ by partial extraction methods, either by 'Splitting as a Final Operation' or by 'Wide-Stall Method'. In 'Splitting as the Final Operation', the pillars may be extracted by driving a single level split of maximum 8 m width in the middle of the pillar, with a maximum height of 3.5 m. Alternately, in the 'Wide-Stall method', the existing galleries may be widened to a maximum width of 8 m on two sides of each pillar, and the galleries may be heightened up to 3.5 m. All the heightened galleries should be supported by 3.0 m long full-column grouted cable bolts at 1.0 m x 1.0 m spacing.

- At Sarni underground mines of Pathakhera Area, WCL, two seams – the Upper Workable Seam (UWS) and the Lower Workable Seam (LWS) – are being mined with wide-stall method of working. The mine authorities requested NIRM to carry out studies to find out the methods of extraction which can give maximum production. Caving in the extracted areas was not allowed due to the presence of structures and human habitat on the surface and the danger of subsidence. Stowing (back filling) of the extracted area was also not feasible as stowing material (sand / fly-ash) was not available within immediate vicinity of the mine. Therefore, it was recommended to work the panel no. 5L (W) and other panels in UWS and LWS by one of the partial extraction methods, namely, splitting as a final operation or by wide-stall method. The required design parameters were worked out and the safety factors for each alternative were evaluated.

- At Tawa underground mines of Pathakhera Area, WCL, three seams – the Upper Workable Seam (UWS), the Lower Workable Seam (LWS) and the Bagdona seams – are being extracted partially with wide-stall method. The mine authorities requested NIRM to design alternate methods of extraction which can give maximum production. Based on the investigations carried out at the mine, it was concluded that for the extraction of the developed pillars, the present system of wide-stall is the only alternative, but to increase the production, the galleries could be widened further by 0.5 to 1 m. Accordingly, the required pillar dimensions and their safety factors were evaluated.

c) Design of supports in coal mines :

- The Kakatiya Longwall Project (KLP) of Bhupalpalli Area, SCCL plans to extract coal by longwall method in KTK-8 Incline from all the four steepy dipping seams, namely 1A, 1, 2 & 3 seams. Based on the geological hazard map provided by the SCCL, and the rock mass classification carried out by NIRM using CMRR and RMR approaches, the roof strata in seam nos. 1A, 2 and 3 were classified as “Fair” to “Good” and that of seam no. 1 was classified as “Fair” due to continuous seepage of water from the strata. The suggested support system for all the gate roads is systematic resin-grouted roof bolts of 1.8 m length and 22 mm diameter.

- At Mathani underground mine of Thesgora Sub-Area of Pench Area, WCL, there are four mineable coal seams, i.e, I (B + C), II B, III B and V A, in descending order. Out of them the upper three seams are contiguous. The Deccan Trap basalt rock is difficult to cave, while the strata below it is easily cavable. When a number of panels will be extracted with caving, the massive trap rock may pose the problem of sudden brittle failure (Fig. 7.1), causing massive dynamic loading effect on the support and working seam. Therefore, it was suggested to install a micro-seismic monitoring system in the area, to ascertain the likely failure of the thick deccan trap formations.

- At Maori incline (Mohan colliery) of Kanhan Area, WCL, the 6 m thick I seam is being developed along the floor, with coal-shale intercalations forming the immediate roof. Most of the dip-rise galleries, junctions and some level galleries are facing the problem of roof and side falls (Fig. 7.2). NIRM carried out detailed investigations in the development galleries and in the depillaring panel no. E4C. It was concluded that the roof falls were due to the presence of clay in the roof and due to its swelling effect. Another reason could be the non-settlement of the goaf in the earlier extracted panels due to inter-leaving of two rows of barrier pillars between the panels. It was estimated by NIRM that a single barrier pillar would have enough factor of safety. Hence, it was suggested to experiment with a single row of barrier pillars between the successive panels.

d) Instrumentation and strata monitoring :

Though the design of support system in mines is carried out as per established guidelines, systematic monitoring with strata movement is necessary to verify the design of support system under given geomining conditions. The mine design department undertakes strata and support monitoring investigations on a routine basis.

- At GDK 10 incline, RG-III Area, SCCL, no. 3 seam is being extracted to the full height of 11 m by Blasting Gallery since December, 2011. In order to understand the behaviour of the strata in this panel, a number of instruments were installed in the panel by NIRM. Based on the strata behaviour studies during extraction in BG panel no. 3B, it was observed that the maximum cumulative roof to floor convergence in the advance galleries was about 100 mm to 150 mm at a distance of 5 m from the goaf edge, the deformation was less in the initial stages, but gradually increased with increasing length of the diagonal line of extraction. The deformations were more in between 66AL to 67L galleries. The intensity of abutment loading, change in stress and dilation of pillars were also more in this area. Bed separation within the immediate coal roof was insignificant.

e) Design of slopes in opencast mines :

With increasing depth of surface mining excavations, slope stability is a major concern for the mining engineers. The mine design department has been involved in the design of safe and economic slope angles in various open pit mines.

- Iron ore extraction is being carried out by opencast method in Sateli Iron Ore Mines in Maharashtra of M/s Deccan Minerals Pvt Limited. For ensuring slope stability at footwall side due to clay bands and fissured ground, the mine management requested NIRM to carry out a scientific study of slope stability to suggest a suitable design. In mines with soft strata such as at Sateli, circular failures in the benches are common due to loss of shear strength of the soft strata when it comes in contact with the hydrostatic pressure. In order to analyse the stability of such slopes, limit equilibrium method of slope stability was investigated using the software 'SLIDE', considering a number of circular failure surfaces (Fig. 7.3). Based on a comprehensive study, the safe slope angles for individual benches and for the overall pit were suggested. Accordingly the appropriate bench height and width were also estimated. It was suggested that surface drains should be made to reduce the ground water pressure and all visible or identified tension cracks should be filled up to restrict the rain water from entering into the slopes. While approaching the ultimate pit limits, monitoring of slope movement shall be carried out using instrumentation. Precautions must be taken for improving the drainage system by providing systematic garland drains throughout the periphery of the mine.

Fig. 7.1 Cutter roof conditions at Mathani colliery

Fig. 7.2 Coal shale intercalations causing weak roof conditions at Mohan colliery

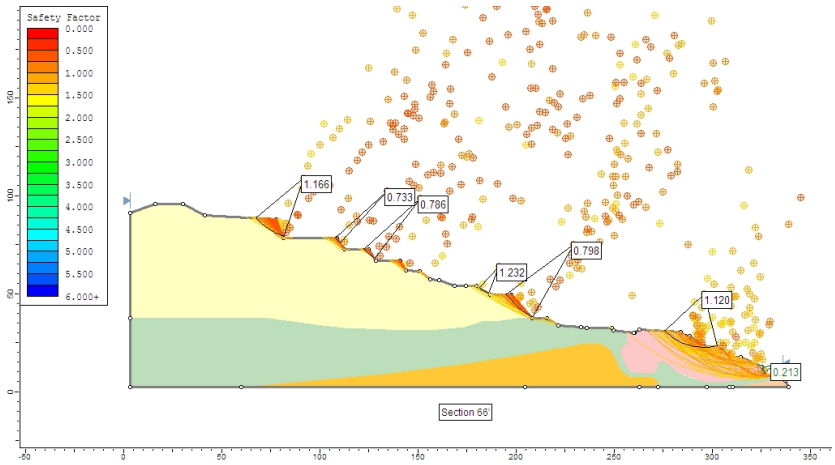


Fig. 7.3 Results of SLIDE analysis for slopes at Sateli mine

8. DIMENSIONAL STONE TECHNOLOGY

Dimensional Stone Technology Department provides technical services for optimum recovery and economic exploitation of granites, marbles and other dimensional stones. This department completed four projects during the year 2012-13.

- The Pallava Granite Industries (India) Pvt. Ltd is extracting granite in the Chimakurthy quarry in Andhra Pradesh. The extraction is being carried out at a depth of about 60 m by multiple benching method with the individual bench height varying from 5 to 6 m. The process of quarrying over many years has lead to vertical high walls causing stability problems and unsafe working conditions (Fig. 8.1). Therefore it was required to carry out scientific studies to assess the stability of high walls and suggest eco-friendly quarrying methods. A detailed geological study of the quarry area was carried out in all the pits. 'Dips' software was used for interpretation of joint patterns and the physico-mechanical properties of the rock samples were tested. The limit equilibrium analysis (using Slide software) was carried out. The individual benches were analysed under dry and fully saturated conditions for slope stability.

  Based on parametric analysis, it was found that the maximum angle of the individual benches should be 85^0, and the maximum height shall be 6 m for stable slopes. An overall pit slope angle of 75^0 with a minimum of 1 m berm width on the final wall for individual benches can be permitted with systematic bolting. A safe slope angle of 65^0 should be maintained for the overburden benches. Fall of loose materials should be protected by clearing and / or with wire meshing and shotcreting. The extraction can be done up to a depth of 150 m with reinforcement. A 3 m x 3 m grid pattern of full column rock bolting on the walls of the individual benches was recommended. While approaching the ultimate pit limits, regular monitoring of slope movement should be carried out.

- M/s Indian Minerals & Granite Company is involved in quarrying black galaxy granite from Chimakurthy quarry in Ongole district of AP. At present, the quarry is operating at a depth of about 70 m below ground level. High walls along the final pit boundary have formed over a period of time due to the quarrying activity. The high walls are neither protected nor stabilised thereby posing a severe threat for continuation of safe mining operations. In view of this, the quarry management approached the NIRM for carrying out scientific studies to assess the stability of high walls at their granite quarry and suggest a scientific and eco-friendly quarrying method. Accordingly, a detailed geological study of the area was carried out, and the joint sets were plotted. Four prominent sets of joints have been identified in the area along with some random joints. Samples of the granite were collected from the quarry area for testing their physico-mechanical properties. The limit equilibrium analysis (using Slide software)

was carried out for six sections. Blast vibrations were recorded with near field monitoring seismograph. The monitored vibrations were found to be within the standard limits.

The analysis for the individual benches under dry as well as fully saturated condition indicated that the maximum angle of the individual benches shall be 85^0, and the maximum height shall be 6 m (Fig. 8.2). The berm width on the final wall for individual benches in the quarry shall be not less than 1 m. The overall safe slope angle for the pit was estimated at 65^0 with a safety factor of 1.3. However, an overall pit slope angle of 75^0 can be permitted with recommended reinforcement. In case of overburden, the safe slope angle of 65^0 has to be maintained. However, for the places where the extraction has already reached up to the boundary and there is no scope for modifying the bench configuration, reinforcement method has to be adopted for stabilising the overall slope. Wire meshing and shotcreting shall be done to protect the loose falls. The barrier between the neighbouring quarries has to be removed for safe operations. While approaching the ultimate pit limits, regular monitoring of slope movement should be carried out. In order to reduce the ground water pressure, surface drains should be made, and all visible or identified tension cracks should be filled up to restrict the rain water from entering into the slopes. Large diameter holes has to be drilled in the quarry face to reduce the ground water pressure Water sprinkling has to be done on the haul roads and in the blasting area before blasting.

- A multi colour granite quarry is being operated by M/s Evershine Monuments, Bangalore at Nellahally in Kanakapura taluk, Karnataka. This quarry is being operated since last 22 years. Quarrying methods using feather and wedges, explosive splitting and blasting for overburden removal were employed. During quarrying operations, concerns regarding the safety of Arkavathy dam located about 200 m from the quarry lease boundary was expressed by the dam management. The quarry owner the approached NIRM to assess the impact of quarry operations on the safety of Arkavathy dam and to suggest safe limits, if any. The main wall of Arkavathy dam located in the eastern part of the study area. The main reservoir is located in the north east direction while the downstream of the dam is located the south east direction. Rest of the area around the study area is covered by the paddy fields (Fig. 8.3).

  The study area is fully covered by sparsely jointed and superficial skin weathered granite boulders of varying sizes. The exposed rock shows fine to coarse granite with few mafic enclaves. The rock also exhibit mesoratic character with wavy foliation in the outcrop. A detailed study of the local geology and the mining method being practiced was carried out. It was noted that at present the production of blocks was underway on the hilltop from massive boulders and on the sheet rock with an overall recovery of 25 to 30%. The waste rock material was dumped along the hill slopes and was observed to be within the quarry lease boundary. The quarry location was at a relatively higher elevation from the dam surface. The quarry was being operated by fully mechanised and state of the art techniques such as diamond wire saw, expansive cement, feather & wedges, rock breakers, excavators etc. The ambient noise levels monitored for various machineries under operation did not exceed the prescribed norms. The air quality did not show any significant variation in the results of RPM, SPM

and gaseous pollutants. With the use of non explosive techniques for extraction of blocks and excavation of waste material, there was no possibility of damage to the Arkavathy dam from the quarry operations.

Thus this study indicated that the present quarry can be safely developed further without any damaging effect on the Arkavathy dam. Stable bench layout was suggested with increased number of working faces for optimum production and easy manoeuvrability of men and machinery. Ramps, preferably with a gradient of 1 in 10 was advised for safe haul roads. The suggested bench configuration of 6 m (height) x 10 m (width) can be adopted with length in multiples of 10 m.

- The Vibuthigudda iron ore mine is operating at a depth of 122 m from the hill top. The present location has thirteen benches 10 m height each. The mine management requested to NIRM to study the existing bench slopes for its stability and to suggest the ultimate pit slope along with recommendations for any remedial measures. Geological data indicate that the deposit occurs at depths greater than 284 m from the existing pit bottom. With the stripping ratio of around 5 tonnes/ 1 ton of ore at this depth, there might be constraints on waste dump and it might not be economical to operate further by opencast method. Therefore, the mine management has also requested to conduct a pre-feasibility study for transition from opencast to underground mining.

  Accordingly a detailed engineering geological study of the area was carried out, and the structural parameters were collected and the physico-mechanical properties of rock sample from the mining area was determined in the laboratory. The calculated average stripping ratio was approximately 1:5. In iron ore mines with soft strata such as at VGM, non-circular failures in the benches are generally experienced. Keeping this in view, the limit equilibrium method with two different conditions (dry and saturated) was used for slope stability analysis due to a number of failure surfaces. In this, the factor of safety of potential failure surface was computed for different sections, and the critical failure surface was identified. At this mine, there was no sign of watery condition. Therefore, only dry condition was considered to estimate the safety factor using Bishop's method (Bishop, 1995). Using different material strength models such as Mohr-Coulomb, Anisotropic and Generalized Hoek-Brown Support types, the required support force for a given safety factor can be determined. Based on our comprehensive study, it was recommended that the extraction can be done up to a depth of 300 m with the available lease area using recommended modified bench configurations and overall pit slope angle of $50^0$from Sections AA' to FF' and from GG' to KK' an additional area of around 10 Ha is required as the ultimate pit limit is crossing the lease boundary. In between sections II' and JJ' an additional area of around 3 Ha is required towards the Northern side and around 7 Ha is required towards Southern side from sections GG' to KK' for the extraction up to a depth of 300 m. During the studies, the ambient noise levels monitored for various machineries under operation did not exceed the prescribed norms. The air quality did not show any significant variation in the results of RPM, SPM and gaseous pollutants. The VGM opencast mine has a limited scope for converting into underground operations. However, a detailed feasibility study may be taken up later for conversion to underground mining while the present open pit mining approaches a limiting depth of around 270 m or so.

Fig. 8.1 A view of the Pallava granite quarry working in benches and high wall at the boundaries of the quarry

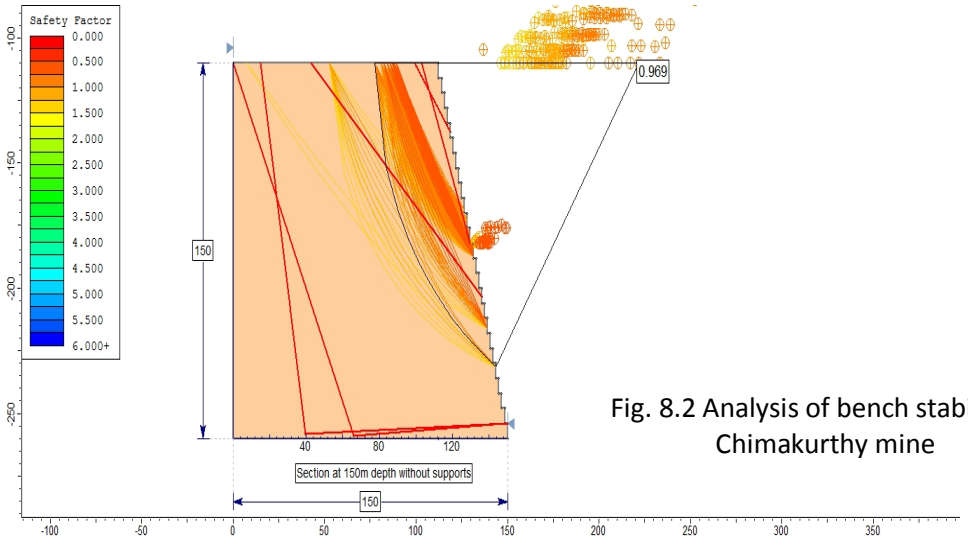


Fig. 8.2 Analysis of bench stability at Chimakurthy mine

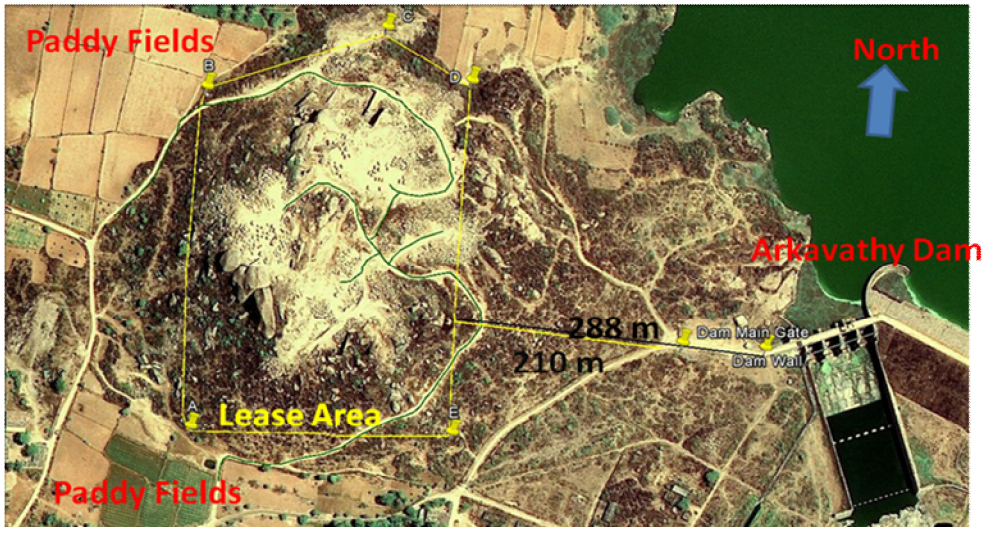


Fig. 8.3 Ariel view of the hillock comprising quarry operations and dam location

9. ROCK & MATERIAL TESTING

Rock and Material Testing laboratory at NIRM has the facilities and expertise to determine the properties of intact and jointed rocks as per ISRM standards, the properties of dimensional stones as per ASTM and European standards, and the destructive and non-destructive testing for mining machinery parts.

The rock testing laboratory is well equipped to carry out research in frontier areas like thermo-mechanical behavior of rocks, geotechnical investigation on rock properties for modeling the underground excavations, and for optimum design of mud fluid for oil exploration. In the area of fracture mechanics, it has the facilities to carry out basic research into thermo-mechanical behaviour of rock, in-situ stress estimation of rock mass from core and application of acoustic emission to understand the fracture mechanism (micro & macro crack growth) and failure of rocks and determination of fracture toughness as per ISRM standards. The major test works done by this department during 2012-13 are :

- For Ramagundam opencast mine (OCP II Extension Block) of SCCL, geotechnical investigations were carried out for core samples from two boreholes for the purpose of slope stability investigations as suggested by CSIRO, Australia. The testing included (a) Uniaxial Compressive Strength, (b) Triaxial Compression Test (multiple failure method), (c) Direct Shear Test on contact planes (parting) as per the ISRM standard methods. The test results indicated that in the case of samples with a visible contact plane, the shear strength was lower than the normal stress; but for samples without any distinct contact plane, the shear strength was higher than the normal stress.

- Similar tests were carried out for samples from PK Opencast mine - II Extension, Manuguru with the same objective (for slope stability investigation). Direct shear test on contact planes was carried out similar to the shear testing of joints with normal stress calculated based on the vertical stress acting on the parting at that particular depth. Sandstone, shale and coal samples were tested from four boreholes. In the case of sandstone, the grain size varied from very coarse to very fine. Two types of shales were tested – shale and sandy shale, and results obtained.

- Laboratory rock mechanics investigations on siliceous sandstone rock samples from different sites of Rajasthan atomic power project were undertaken for HCC, Mumbai. The scope of work included determination of both physical properties (density, specific gravity and water absorption porosity) and mechanical properties (tensile strength, uniaxial compressive strength (dry & saturated), Young's modulus and Poisson's ratio (dry & saturated), cohesion and friction angle (from triaxial

compression test)). All the tests were carried out as per Indian standards except the triaxial compression test which was carried out as per ISRM method. Test results indicated that there was a difference in strength between the dry and saturated sample. In most of the cases saturated samples showed higher strength than the dry ones. Since only one sample was tested, it was not possible to explain the precise reason for this discrepancy. Under uniaxial compression test, the samples showed tensile failure but under triaxial stress conditions, both tensile and shear failures were observed.

- Shear strength of contact plane between two strata for a sedimentary rock (parting) is an important parameter for numerical modelling. As an in-house R&D work, a methodology was developed for shear testing of the contact planes, and the results of two types of sedimentary rocks were analysed. In the drilled cores the contact plane is usually oriented at different angles to the core axis, and its thickness may be about 1 to 2 mm. In order to determine the shear strength of contact plane, the samples were carefully moulded on both ends such that the shearing plane (parting / contact plane) was parallel to the axis of loading. The fixture with moulded sample was placed in the compression testing machine. The normal load was applied considering the depth of the borehole and the experiment was conducted under displacement control (1.5 mm/minute), loading was continued till the sample sheared along the parting plane. Tests were conducted on two types of samples, i.e., (a) sample without any distinct contact plane [coal] and (b) sample with distinct contact plane [shaly sandstone]. It was observed that the shear strength increased with increase of normal stress. The result can be extrapolated for other normal stresses as well.

The material testing laboratory carries out testing of wire ropes, vital components of mine machinery and associated accessories using both Destructive Tests (torsion, reverse bend and tensile tests) and Non Destructive Tests (NDT) for mining and other industries. NIRM has state-of-the-art facilities and infrastructure to carry out tests as per various standards and statutory regulations including DGMS guidelines. During 2012-13, this laboratory has provided services to over twenty mining and allied industries.

- Destructive tests conducted during the year include testing of 94 wire rope samples from 45 companies. Apart from them, various types of Non-destructive tests (involving Ultrasonic, Magnetic Particle, Wire Rope Defectography & Proof Load Tests) were carried out for SCCL (PVK-5, VK-7; Shanthikhani, 21 Incline Yellundu, Adriyala Longwall Project), HZL (Rajpur Dariba mines; Sindeswar Khud mines; Zawar Mines), Palani Temple, APHMEL (Kondapally), NALCO, (Damanjodi mines), Shaft Sinkers Mauritius (RD Mines), China Coal No. 5 Constructions, FACOR (Kathpal Chromite mines) and Technomin Constructions, Bellampally. In addition, destructive and non-destructive tests were conducted for other clients such as M/s Ferro Alloys Corporation Limited, M/s Manganese Ore India Limited, M/s Hutti Gold Mines Limited, M/s Tamil Nadu Electricity Board, M/s Maheswari Enterprises and M/s Hamsa Minerals Limited.
- M /s Singareni Collieries Company Limited have issued a long term work order for in-situ Non-Destructive testing of vital components of winders (double drum), 150 HP

haulers (surface and underground), suspension gear parts, man and material riding cars, and wire ropes. These components were checked using ultrasonic flaw detector (for internal flaws), electromagnetic crack detector (for surface and sub-surface flaws), wire rope defectograph (for loss of metallic area), local faults (LF), pitting , corrosion, wear, etc. During the year, NDT tests were conducted at Shanthikhani, Bellampally, Ramagundam (GDK-1&3, GDK-5, GDK-8, GDK-10, GDK-10A, GDK-11) and Adriyala longwall projects, and destructive tests were conducted on wire ropes of Padmavathi Khani 5 Incline, Venkatesh Khani 7 Incline and Yellandu 21 Inclines (Fig. 9.1). This work is being continued.

- As part of in-situ non-destructive testing for M/s Hindustan Zinc Limited, Rajasthan, all the vital components of the winder and suspension gear parts at Rajpura Dariba Mines, Sindeshwar Khurd Mines and Zawar group of mines were subjected to ultrasonic tests to detect internal flaws. The suspension gear parts were inspected for detecting surface and sub-surface flaws using electro-magnetic crack detector. The tests were carried out on entire mine machinery as per DGMS guidelines (Fig. 9.2). It was recommended to conduct periodic tests to ensure safety.

- At NALCO's Alumina refinery plant, NIRM conducted studies on rope performance of the 30 km long belt conveyor to evaluate its fitness. Non-destructive evaluation studies using defectograph on the left-hand and the right-hand side ropes at the project site were carried out. Destructive evaluation studies on multi-strand wire ropes, including comprehensive tests such as torsion test, reverse bend test and tensile tests, were carried out at NIRM.

- As part of routine in-situ NDT testing for rope of passenger riding car of Palani Temple, Tamilnadu all the vital components of winch and its associated components were inspected during the year (Fig. 9.3). Ultrasonic Testing was conducted to find out internal flaws on the vital components such as drum shaft, motor shaft, brake tie rods, load carrying pins, etc. Magnetic particle testing was conducted on all the attachments of the passenger transportation unit to find out defects such as surface and sub-surface flaws using electro-magnetic crack detector.

- For M/s Andhra Pradesh Heavy Machinery and Engineering Limited, Vijayawada, proof load and NDT tests were conducted on the bracket assembly with white metal rope cappel at one end and 16 bolt ham bone clamp. Except for one sample of the bolt ham bone clamp, they were found to be free from surface / sub-surface cracks and internal flaws.

- M/s Shaft Sinkers Mauritius Limited (SSML) and M/s China Coal No. 5 Construction Limited (CC5CL) are involved in shaft sinking and widening / deepening activities for the mines of Hindustan Zinc Limited. Long term MoUs have been signed with these two companies for Non-Destructive Tests (NDT) on winders, winches, attachments / accessories, and destructive tests on wire rope samples and proof load tests on related components, as per DGMS standards. One set of laboratory and in-situ exercises has been completed for both of them and this will be continued further for next two years as well.

Fig. 9.1 NDT of winder vital components at M/s SCCL

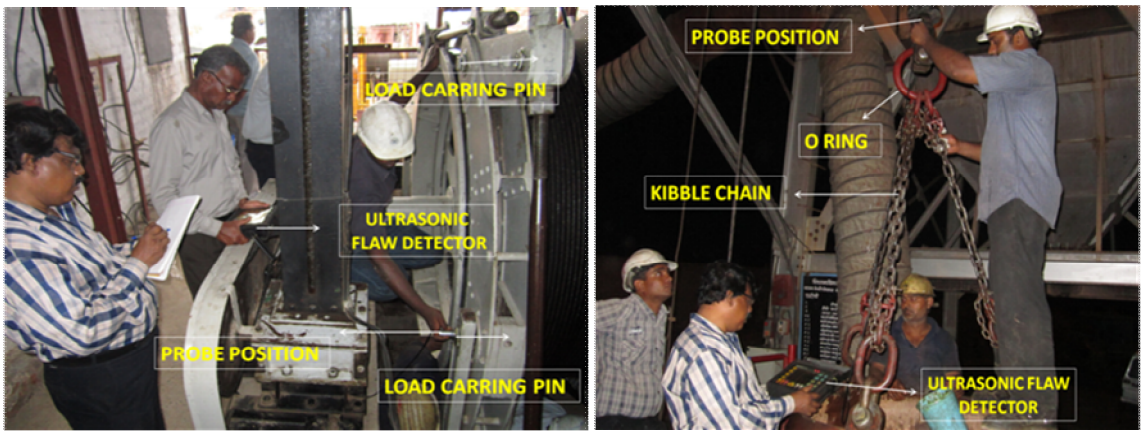


Fig. 9.2 NDT of winder vital components at M/s HZL

Fig. 9.3 NDT of winch and vital components at M/s Palani Temple, Tamil Nadu

ANNUAL ACCOUNTS

KAMALAKAR BHAT & ASSOCIATES

Chartered Accountants

INDEPENDENT AUDITORS' REPORT

To
The Members of National Institute of Rock Mechanics,

Report on Financial Statements.

We have audited the accompanying financial statements of NATIONAL INSTITUTE OF ROCK MECHANICS ("the Institute"), which comprise the Balance Sheet as at 31 March, 2013, and the Income and Expenditure Account for the year then ended, and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

The Institute's Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position, financial performance of the Institute in accordance with auditing standards 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.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to the Company's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

KAMALAKAR BHAT & ASSOCIATES

Chartered Accountants

Opinion:

In our opinion and to the best of our information and according to the explanations given to us, the financial statements give the information required in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India subject to:

i. *Note No.1.F of accounting policies read with notes on accounts no 2.7 regarding non provision for encashment of leave, and provision made for gratuity on the basis of valuation done by LIC and not by actuary, which is inconsistent with Accounting Standard -15 (revised), issued by ICAI. The effect of this on the profitability is yet to be ascertained by the Institute.*
ii. *Note No 2.8 to Notes on Accounts regarding non verification of fixed assets.*
iii. *Note No 2.10 and 2.11 to Notes on Accounts regarding non confirmation and reconciliation of parties accounts and tax deducted at source. The financial effect is not ascertained as the institute is yet to obtain confirmation of balances.*

a. in the case of he Balance Sheet, of the state of affairs of the Institute as at 31 March, 2013 ; and
b. in the Case of Income and Expenditure Account, of the excess of expenditure over income for the year ended on that date.

For Kamalakar Bhat & Associates.,

Chartered Accountants

(FRN 012045S)

Place: Bangalore
Date: September 10, 2013

Sd/-

Kamalakar Bhat
Proprietor
M.No.217751

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, KOLAR GOLD FIELDS – 563 117.

SCHEDULE-14

ACCOUNTING POLICIES AND NOTES ON ACCOUNT FORMING PART OF BALANCE SHEET AND INCOME & EXPENDITURE ACCOUNT FOR THE YEAR ENDING 31ST MARCH 2013.

1. ACCOUNTING POLICIES :-

A. Method of Accounting:

The Institute was maintaining its accounts on cash basis till the year end 31st March, 2012, with effect from April,2012 it has changed its method of accounting from cash to mercantile system.

B. Fixed Assets:

Fixed Assets are capitalised at acquisition costs as and when the asset is put to use by the institute.

C. Foreign Exchange Transactions:

All imports of capital items by the Institute are through advance payments. Thus foreign exchange transactions are entered in the books at the actual conversion rate. Hence, no adjustments are required for fluctuation in exchange rates.

D. Revenue Recognition:

The income from Research & Development projects is recognised on completed contract basis.

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.

The Capital Grant received for 'Plan' is allocated to income over the period in the same proportion as the depreciation is charged on the assets purchased from the Capital Grant. Balance of capital grants appear as Deferred Government Grants in balance sheet under "Other Funds".

F. Retirement Benefits:

The Institute has made arrangement with Life Insurance Corporation of India for payment of gratuity under the Cash Accumulation Group Gratuity Scheme. Provision for the gratuity is accounted as per calculation made under Projected Unit Credit Method.

Regarding Provident Fund accumulation, this Institute has been enrolled with the Employees Provident Fund Organization, Bangalore. The Institute's contribution towards the Provident Fund is charged to "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. This has been followed from 1999-2000 onwards.

2. NOTES ON ACCOUNTS: -

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

2. The land on which the properties transferred during the year 1988-89 by BGML to the Institute has been retained in BGML books, subject to obtaining the direction from the Government of India, on the transfer of land and other formalities. As the Conveyance Deed for transfer of land and building to the Institute could not be executed, the Governing Body has approved the proposal for entering into lease agreement, instead. Necessary adjustments in the accounts if required will be done on execution of lease agreement.

3. The approval of the Central Government that the Institute is a notified association for carrying on Research and Development activities under the section 35(1)(ii) of the Income Tax Act 1961, read with rule 6 of the Income Tax Rules 1962, was up to 31st March 2005. The application for renewal of the same has been submitted to the Income Tax Department and is under active consideration.

4. The Institute has received an amount of Rs.477 Lakhs as 'Grant-in-Aid' under "Non-Plan" for the year 2012-13.

5. It is the normal practice of the Institute to charge off the expenses of manpower component of respective S&T projects and transfer to a pool account of NIRM to meet out shortfall in "Pay & Allowances " and other expenses.

6. During the year institute has changed its method of accounting and it has converted its books of accounts from cash basis to accrual basis with the result whatever expenses relating to previous year paid during the year has been classified as prior period expenses and separately shown as line item in the income and expenditure account. Similarly, income relating to prior period has been classified as prior period incomes and separately shown as line item in the Income and Expenditure Account. The net results of conversion

from cash to mercantile systems resulted in increase in the current year loss to the extent of Rs 43.35 lakhs.

7. Institute has made provision for the gratuity based on the projected unit credit method as per valuation provided by the LIC and during the year institute has made provision of Rs 189.76lakhs. Institute has not made any provision for the leave benefit.

8. Fixed assets register is subject to physical verification and reconciliation.

9. Provision for the income tax has been made based on the calculation made as per income tax provisions.

10. Income Tax Refund receivable as mentioned in the schedule 12(b) to the balance sheet is subject to reconciliation and adjustments, if any.

11. The balances of parties' account are subject to confirmations and adjustments, if any.

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

13. The figures pre-fixed with the (+) or (-) under the column head "Variation during the year" in Balance Sheet as on 31-3-2013 represents the transaction carried out during the year including the value for written off adjustments and corrections.

Sd/-

(A.N.NAGARAJAN)
Registrar &Secretary

Sd/-

(V.VENKATESWARLU)
Director

Sd/-

Member
Governing Body

Refer our report of even date
For KAMALAKAR BHAT & ASSOCIATES
Chartered Accountants

Sd/-

(KAMALAKAR BHAT)
Proprietor
M.No: 217751

Place: Bangalore
Date: 10th September 2013

Consolidated

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS
BALANCE SHEET AS AT 31ST MARCH 2013

LIABILITIES						ASSETS					
Sl. No.	**Particulars**	**Sch No.**	**Balance as on 31-03-2012**	**Variation during the year (+) (-)**	**Balance as on 31-03-2013**	**Sl. No.**	**Particulars**	**Sch No**	**Balance as on 31-03-2012**	**Variation during the year (+) (-)**	**Balance as on 31-03-2013**
			(Amount in Rs)	**(Amount in Rs)**	**(Amount in Rs)**				**(Amount in Rs)**	**(Amount in Rs)**	**(Amount in Rs)**
1	**CAPITAL RESERVE**		3,244,334	-	3,244,334	**1**	**CURRENT ASSETS**	6			
	Internal Capital Reserve		25,042,413	-	25,042,413		a) Cash in Hand		158,905	52,579	211,484
							b) Cash at Bank		8,684,253	10,067,628	18,751,881
2	**OTHER FUNDS**						c) Stock - Stationery Items		-	47,628	47,628
	a) Deferred Government Grant		11,736,594	-	11,736,594	**2**	**INVESTMENTS**				
	b) Income & Expenditure A/c.		(37,325,190)	(19,005,683)	(56,330,874)		a) Short term deposits against project advances received from clients	7	29,000,000	11,500,000	40,500,000
	c) Institute's Development Fund		46,000,000	-	46,000,000		b) Fixed Deposit (IDF)	8	46,000,000	-	46,000,000
						3	**Deposits**	9	397,410	-	397,410
3	**CURRENT LIABILITIES**					**4**	**LOANS AND ADVANCES**				
	a) Advances received against on-going projects	1	150,407,227	28,343,684	178,750,911		a) Advances - Staff	10	1,385,300	111,534	1,496,834
	b) Sundry creditors - pay roll deductions	2	-	19,467	19,467		b) Advances - Suppliers (Including imports)	11	1,635,553	(202,013)	1,433,540
	c) Sundry Creditors - Staff	3	(1,305,092)	1,688,587	383,495						
	d) Sundry Creditors - Others	4	1,776,359	7,690,543	9,466,902	**5**	**Other Current Assets**	12	25,065,989	1,553,640	26,619,629
	e) Provisions	5	-	19,318,073	19,318,073	**6**	**Expenses on Ongoing Projects**		53,979,617	20,215,752	74,195,369
						7	**FIXED ASSETS**	13	33,269,618	(5,292,078)	27,977,540
	TOTAL		**199,576,645**	**38,054,670**	**237,631,315**		**TOTAL**		**199,576,645**	**38,054,670**	**237,631,315**

Notes forming part of the accounts -refer schedule 14

Details of variation during the year 2012-13 (For Block of Fixed Assets)

Purchases Made during the year		46,332
Less: Depreciation for the year 2012-13		5,338,410
Add: Adjustment made during the year		
Variation during the year		**(5,292,078)**

Fixed Assets		**31-03-2012**	**31-03-2013**
Gross Block		115,908,878	115,955,209
Less: Depreciation		82,639,260	87,977,669
Add: Adjustment Made		-	-
Net Block		**33,269,618**	**27,977,540**

For National Institute of Rock Mechanics

Sd/-
(A N Nagarajan)
Registrar & Secretary

Sd/-
(V Venkateswarlu)
Director

Sd/-
Member
(Governing Body)

As per our Report of even date
For Kamalakar Bhat & Associates
Chartered Accountants

Sd/-
Kamalakar Bhat
Proprietor
M.No:2117751

Place : Bangalore
Date: 10th September 2013

Consolidated

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31st MARCH 2013

EXPENDITURE				INCOME			
Sl. No.	**Head of Account**	**2012-13**	**2011-12**	**Sl. No.**	**Head of Account**	**2012-13**	**2011-12**
		(Amount in Rs)	**(Amount in Rs)**			**(Amount in Rs)**	**(Amount in Rs)**
1	Pay & Allowances	77,578,753	54,592,802	**1**	Grant-in-Aid received from Ministry of Mines	47,700,000	1,000,000
2	Expenditure on Completed Project	23,006,665	38,382,763	**2**	Revenue from Completed Projects	47,784,523	87,838,839
3	Other Staff Payment	433,504	922,189	**3**	Miscellaneous Income	6,347,456	9,425,704
4	Administrative Expenses	9,098,752	8,947,902	**4**	Prior Period Income	1,396,616	-
5	Upkeep of Assets	705,628	871,748	**5**	Excess of Expenditure over Income	19,005,683	10,913,675
6	Prior Period Expenses	5,731,227	-				
7	Depreciation on Fixed Assets	5,338,409	5,460,814				
8	Income Tax	341,341					
	Total:-	**122,234,279**	**109,178,218**		**Total:-**	**122,234,279**	**109,178,218**

Notes forming part of the accounts -refer schedule 14

For National Institute of Rock Mechanics

Sd/- (A N Nagarajan) **Registrar & Secretary**

Sd/- (V Venkateswarlu) **Director**

Sd/- Member **(Governing Body)**

Place : Bangalore
Date: 10th September 2013

As per our Report of even date
For Kamalakar Bhat & Associates
Chartered Accountants

Sd/-
Kamalakar Bhat
Proprietor
M.No:2117751

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, KOLAR GOLD FIELDS

Receipt and Payment Account for the year ending on 31st March 2013 — Consolidated

RECEIPT SIDE				PAYMENT SIDE			
Sl. No.	Head of Account	Amount	Amount	Sl. No.	Head of Account	Amount	Amount
		Rs. Ps.	Rs. Ps.			Rs. Ps.	Rs. Ps.
1	2	3	4	5	6	7	8
1	Opening Balance			1	Current Liabilities		32,021,597
	Cash	158,905					
	Bank	8,684,253	8,843,158				
2	Current Liabilities		99,193,066	2	Fixed ssets		46,332
3	Fixed Assets		-				
4	Investments		38,500,000	3	Investments		50,000,000
5	Current Assets		10,314,748	4	Current Assets		42,816,247
6	Direct Expenses		1,987,779	5	Direct Expenses		68,980,382
7	Indirect Incomes		6,208,171	6	Indirect Incomes		
8	Direct Income		47,781,000		Indirect Expenses		
					Closing Balance		
					Cash	211,484	
					Bank	18,751,881	18,963,365
	Total:-		212,827,923		**Total:-**		212,827,923

Date :10th September 2013

NATIONAL INSTITUTE OF ROCK MECHANICS
Champion Reefs Post, Kolar Gold Fields - 563 117.

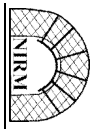
Consolidated

DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2013

		Gross Block						Depreciation					Net Block	
Name of the Assets	Rate of Depreciation %	Balance as on 01-04-12	Assets Written off/Trans-ferred	Purcchases up to 30.09.12	Purchases between 1.10.12 to 31.12.12	Purchases After 01.01.13	Total as on 31.03.13 (Total of Col 3 to Col 7)	Balance as on 01-04-12	Adjustment	Depreciation written off	Depreciation for the year	Total Depreciation as on 31-03-13 (Total of Col 9 to Col 11)	As on 31-3-13 (Col 8 - Col 12)	As on 31-03-12
1	2	3	4	5	6	7	8	9		10	11	12	13	14
INSTITUTE:														
Buildings	5	9108642	0	0	0	0	9108642	8252549	0	0	209462	8462011	646631.00	856,093.00
Plant & Machinery	7.5	32225642	0	0	0	0	32225642	31513684	0	0	76124	31589808	635834.00	711,958.00
Water Supply	5	328926	0	0	0	0	328926	273333	0	0	12060	285393	43533.00	55,593.00
Power supply	5	503434	0	0	0	0	503434	499510	0	0	3254	502764	670.00	3,924.00
Furniture	5	4566256	0	0	0	0	4566256	1960693	0	0	193269	2153962	2412294.00	2,605,563.00
Office Equipment	5	2673600	0	46332	0	0	2719932	1233106	0	0	113036	1346142	1373790.00	1,440,494.00
Vehicle	7.5	783835	0	0	0	0	783835	724002	0	0	35642	759644	24191.00	59,833.00
Laboratory Equipment	7.5	29985087	0	0	0	0	29985087	14872338	0	0	1849583	16721921	13263166.00	15,112,749.00
Technical Books	5	4693916	0	0	0	0	4693916	2355463	0	0	234761	2590224	2103692.00	2,338,453.00
Computer Software	15	12719460	0	0	0	0	12719460	8346026	-564320	0	1286265	9067971	3651489.00	4,373,434.00
Computer Hardware	20	13600322	0	0	0	0	13600322	10446265	564320	0	1022395	12032980	1567342.00	3,154,057.00
Conversion of Power line	5	1799459	0	0	0	0	1799459	974519	0	0	89973	1064492	734967.00	824,940.00
Env Geo Tech Lab		2113409	0	0	0	0	2113409	994884	0	0	152068	1146952	966457.00	1,118,525.00
PROJECT:														
Vehicle	7.50	806,889	-	-	-	-	806,889	192,888		-	60,517	253,405	553,484	614,001
Total:-		**115908877**	**0**	**46332**	**0**	**0**	**115955209**	**82639260**	**0**	**0**	**5338408.68**	**87977668.68**	**27977540.33**	**33269617**
(Previous year figures)		***113516202***	*0*	**2301095**	**70110**	**21470**	**115908877**	**86610288**	***-9431842***	*0*	**5460814**	**82639260**	**33269618.00**	**26905928**

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

Date:10th September 2013



NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS
BALANCE SHEET AS AT 31ST MARCH 2013

LIABILITIES						ASSETS					
Sl. No.	Particulars	Sch No.	Balance as on 31-03-2012	Variation during the year (+) (-)	Balance as on 31-03-2013	Sl. No.	Particulars	Sch No	Balance as on 31-03-2012	Variation during the year (+) (-)	Balance as on 31-03-2013
			Rs. Ps.	Rs. Ps.	Rs. Ps.				Rs. Ps.	Rs. Ps.	Rs. Ps.
1	2	3	4	5	6	7	8	9	10	11	12
1	**CAPITAL RESERVE**		3,244,334	-	3,244,334	1	**CURRENT ASSETS**	6			
	Internal Capital Reserve		25,042,413	-	25,042,413		a) Cash in Hand		73,832	34.185	108,017
							b) Cash at Bank		(162,759,038)	4,077,284	(158,681,754)
2	**OTHER FUNDS**										
	a) Deferred Government Grant		11,736,594	-	11,736,594						
	b) Income & Expenditure A/c.	1	(117,869,669)	(45,967,675)	(163,837,344)	2	**INVESTMENTS**	7			
	c) Institute's Development Fund		46,000,000	-	46,000,000		a) Fixed Deposit (IDF)		46,000,000	-	46,000,000
3	**CURRENT LIABILITIES**					3	**DEPOSITS**	8	397,410	-	397,410
	b) Sundry creditors - pay roll deductions	2	-	19,467	19,467	4	**LOANS AND ADVANCES**				
	c) Sundry Creditors - Staff	3	238,715	143,483	382,198		a) Advances - Staff	9	400,458	98.669	499,127
	d) Sundry Creditors - Others	4	221,204	7,531,940	7,753,144		b) Advances - Suppliers (Including imports)	10	61,605	-	61,605
	e) Provisions	5	-	19,318,073	19,318,073						
						5	**Other Current Assets**	11	193,860	1,209,971	1,403,831
						6	**Project Account**	12	51,589,846	(19,143,260)	32,446,586
						7	**FIXED ASSETS**	13	32,655,617	(5,231.561)	27,424,056
	TOTAL		**(31,386,409)**	**(18,954,712)**	**(50,341,121)**		**TOTAL**		**(31,386,409)**	**(18,954,712)**	**(50,341,121)**

Details of variation during the year 2012-13 (For Block of Fixed Assets)

Purchases Made during the year		46,332
Less: Depreciation for the year 2012-13		5,277,892
Add: Adjustment made during the year		-
Variation during the year		**(5,231,560)**

Fixed Assets		**31-03-2012**	**31-03-2013**
Gross Block		115,101,988	115,148,320
Less: Depreciation		82,446,372	87,724,264
Add: Adjustment Made		-	-
Net Block		**32,655,616**	**27,424,056**

For National Institute of Rock Mechanics

Sd/-
(A N Nagarajan)
Registrar & Secretary

Sd/-
(V Venkateswarlu)
Director

Sd/-
Member
Governing Body

Place : Bangalore
Date: 10th September 2013

As per our Report of even date
For Kamalakar Bhat & Associates
Chartered Accountants

Sd/-
Kamalakar Bhat
Proprietor
M.No:2117751

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31st MARCH 2013

EXPENDITURE				INCOME			
Sl. No.	Head of Account	2012-13 Rs. Ps.	2011-12 Rs. Ps.	Sl. No.	Head of Account	2012-13 Rs. Ps.	2011-12 Rs. Ps.
1	2	3	4	5	6	7	8
1	Pay & Allowances	77,578,753	54,592,802	1	Grant-in-Aid received from Ministry of Mines	47,700,000	1,000,000
2	Expenditure on Inhouse Projects	-	143,321	2	Miscellaneous Income	4,797,493	1,958,233
3	Other Staff Payment	433,504	922,189	3	Prior Period Income	701,929	-
4	Administrative Expenses	9,098,752	8,947,902				
5	Upkeep of Assets	705,628	871,748				
6	Prior Period Expenses	5,731,227	-				
7	Depreciation on Fixed Assets	5,277,892	5,400,297	3	Excess of Expenditure over Income	45,967,675	67,920,026
8	Income Tax	341,341					
	Total:-	**99,167,097**	**70,878,259**		**Total:-**	**99,167,097**	**70,878,259**

For National Institute of Rock Mechanics

Sd/- (A N Nagarajan) **Registrar & Secretary**

Sd/- (V Venkateswarlu) **Director**

Sd/- Member **(Governing Body)**

Place : Bangalore
Date: 10th September 2013

As per our Report of even date
For Kamalakar Bhat & Associates
Chartered Accountants

Sd/-
Kamalakar Bhat
Proprietor
M.No:2117751

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, KOLAR GOLD FIELDS

Receipt and Payment Account for the year ending on 31st March 2013

Institute A/c

RECEIPT SIDE				PAYMENT SIDE			
Sl. No.	**Head of Account**	**Amount** Rs. Ps.	**Amount** Rs. Ps.	**Sl. No.**	**Head of Account**	**Amount** Rs. Ps.	**Amount** Rs. Ps.
1	2	3	4	5	6	7	8
1	Opening Balance			1	Current Liabilities		20,209,357.00
	Cash	73,832.00					
	Bank	(162,759,037.55)	(162,685,205.55)				
2	Current Liabilities		19,731,648.00	2	Fixed ssets		46,332.00
3	Investments		38,500,000.00	3	Investments		16,000,000.00
4	Current Assets		1,448,614.00	4	Current Assets		3,950,633.00
5	Direct Income		47,700,000.00	5	Direct Expenses		68,978,322.00
6	Direct Expenses		1,952,330.00	6	Closing Balance		
					Cash	108,017.00	
7	Indirect Incomes		3,963,521.00		Bank	(158,681,753.55)	(158,573,736.55)
	Total:-		**(49,389,092.55)**		**Total:-**		**(49,389,092.55)**

Date : 10th September 2013

NATIONAL INSTITUTE OF ROCK MECHANICS
Champion Reefs Post, Kolar Gold Fields - 563 117.

Institute

DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2013

		Gross Block						Depreciation					Net Block	
Name of the Assets	Rate of Depreciation %	Balance as on 01-04-12	Assets Written off/Trans-ferred	Purcchases up to 30.09.12	Purchases between 1.10.12 to 31.12.12	Purchases After 01.01.13	Total as on 31.03.13 (Total of Col 3 to Col 7)	Balance as on 01-04-12	Adjustment	Depreciation written off	Depreciation for the year	Total Depreciation as on 31-03-13 (Total of Col 9 to Col 12)	As on 31-3-13 (Col 8 - Col 12)	As on 31-03-12
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Buildings	5	9108642	0	0	0	0	9108642	8252549	0	0	209462	8462011	646631.00	856,093.00
Plant & Machinery	7.5	32225642	0	0	0	0	32225642	31513684	0	0	76124	31589808	635834.00	711,958.00
Water Supply	5	328926	0	0	0	0	328926	273333	0	0	12060	285393	43533.00	55,593.00
Power supply	5	503434	0	0	0	0	503434	499510	0	0	3254	502764	670.00	3,924.00
Furniture	5	4566256	0	0	0	0	4566256	1960693	0	0	193269	2153962	2412294.00	2,605,563.00
Office Equipment	5	2673600	0	46332	0	0	2719932	1233106	0	0	113036	1346142	1373790.00	1,440,494.00
Vehicle	7.5	783835	0	0	0	0	783835	724002	0	0	35642	759644	24191.00	59,833.00
Laboratory Equipment	7.5	29985087	0	0	0	0	29985087	14872338	0	0	1849583	16721921	13263166.00	15,112,749.00
Technical Books	5	4693916	0	0	0	0	4693916	2355463	0	0	234761	2590224	2103692.00	2,338,453.00
Computer Software	15	12719460	0	0	0	0	12719460	8346026	-564320	0	1286265	9067971	3651489.00	4,373,434.00
Computer Hardware	20	13600322	0	0	0	0	13600322	10446265	564320	0	1022395	12032980	1567342.00	3,154,057.00
Conversion of Power line	5	1799459	0	0	0	0	1799459	974519	0	0	89973	1064492	734967.00	824,940.00
Env Geo Tech Lab		2113409	0	0	0	0	2113409	994884	0	0	152068	1146952	966457.00	1,118,525.00
Total:-		**115101988**	**0**	**46332**	**0**	**0**	**115148320**	**82446372**	**0**	**0**	**5277892**	**87724264**	**27424056.00**	**32,655,616.00**
Advance for capital material purchase		0	0	0	0	0	0	0		0	0	0	0.00	0.00
(Previous year figures)		***112709313***	*0*	**2301095**	**70110**	**21470**	**115101988**	**86486558**	*-9440483*	*0*	**5400297**	**82446372**	**32655616.00**	**26222769**

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

Date : 10th September 2013

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS
BALANCE SHEET AS AT 31ST MARCH 2013

LIABILITIES						ASSETS					
Sl. No.	**Particulars**	**Sch No.**	**Balance as on 01-04-2012**	**Variation during the year (+) (-)**	**Balance as on 31-03-2013**	**Sl. No.**	**Particulars**	**Sch No**	**Balance as on 01-04-2012**	**Variation during the year (+) (-)**	**Balance as on 31-03-2013**
			(Amount in Rs)	**(Amount in Rs)**	**(Amount in Rs)**				**(Amount in Rs)**	**(Amount in Rs)**	**(Amount in Rs)**
1	**CAPITAL RESERVE**					**1**	**CURRENT ASSETS**				
2	**OTHER FUNDS**						a) Cash in Hand		85,073	18,394	103,467
	Income From Completed Projects		80,544,479	26,961,992	107,506,470		b) Cash at Bank		171,443,291	5,990,344	177,433,634
							c) Stock - Stationery Items		-	47,628	47,628
3	**CURRENT LIABILITIES**										
	a) Advance received against on-going projects	**1**	150,407,227	28,343,684	178,750,911	**2**	**INVESTMENTS**				
	b) Sundry Creditors - Others	**2**	(196,394)	1,893,707	1,697,313		a) NIRM Institute Development Fund			-	-
							b) Short Term Deposits against Project Advances received from clients	**5**	29,000,000	11,500,000	40,500,000
	c) Sundry Creditors - Suppliers	**3**	17,742	-	17,742						
						3	**LOANS AND ADVANCES**				
	d) Institute Account	**4**	51,589,846	(19,143,260)	32,446,586		a) Advances - Staff	**6**	984,842	12,855	997,707
							b) Advances - Suppliers	**7**	1,573,948	(202,013)	1,371,935
						4	**Other Current Assets**	**8**	24,682,129	533,669	25,215,798
						5	**Expenses on Ongoing Projects**	**9**	53,979,617	20,215,752	74,195,369
						6	**Fixed Assets**	**10**	614,001	(60,517)	553,484
	TOTAL		**282,362,901**	**38,056,122**	**320,419,023**		**TOTAL**		**282,362,901**	**38,056,122**	**320,419,023**

Details of variation during the year 2012-13 (For Block of Fixed Assets)

Purchases Made during the year		-
Depreciation for the year 2012-13		60,517
Add: Adjustment made during the year		-
Variation during the year		**60,517**

Fixed Assets		**31-03-2012**	**31-03-2013**
Gross Block		806,889	806,889
Less: Depreciation		123,730	184,247
Less: Adjustment Made		-	-
Net Block		**683,159**	**622,642**

For National Institute of Rock Mechanics

Sd/- Sd/- Sd/-
(A N Nagarajan) (V Venkateswarlu) Member
Registrar & Secretary **Director** **(Governing Body)**

Place : Bangalore
Date: 10th September 2013

As per our Report of even date
For Kamalakar Bhat & Associates
Chartered Accountants

Sd/-
Kamalakar Bhat
Proprietor
M.No:2117751

NATIONAL INSTITUTE OF ROCK MECHANICS

CHAMPION REEFS POST, KOLAR GOLD FIELDS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2013

EXPENDITURE				INCOME			
Sl. No.	**Head of Account**	**2012-13**	**2011-12**	**Sl. No.**	**Head of Account**	**2012-13**	**2011-12**
		(Amount in Rs)	**(Amount in Rs)**			**(Amount in Rs)**	**(Amount in Rs)**
1	**Expenditure on completed projects:**			**1**	Amount received against completed projects	47,784,523	41,166,878
a)	Contingency Expenditure	1,726,467	2,568,954				
b)	Other Expenditure	5,357,183	3,499,961	**2**	Salary Charges against S & T Projects	-	537,382
c)	Equipment Expenditure	2,443,191	1,842,009				
d)	Overhead Expenditure	5,814,028	6,269,271	**3**	Interest received on Short Term Deposits (Projects)	1,549,963	1,819,096
e)	Travelling Expenditure	3,484,049	2,408,949				
f)	Service Tax	4,181,747	3,335,566	**4**	Prior period Income	694,687	-
g)	Depreciation on Fixed Assets - Vehicle	60,517	60,517				
2	Excess of Income over Expenditure	26,961,992	23,538,128				
	Total:-	**50,029,173**	**43,523,356**		**Total:-**	**50,029,173**	**43,523,356**

For National Institute of Rock Mechanics

Sd/-	Sd/-	Sd/-
(A N Nagarajan)	(V Venkateswarlu)	Member
Registrar & Secretary	**Director**	**(Governing Body)**

Place : Bangalore

Date: 10th September 2013

As per our Report of even date

For Kamalakar Bhat & Associates

Chartered Accountants

Sd/-

Kamalakar Bhat

Proprietor

M.No:2117751

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, KOLAR GOLD FIELDS

Receipt and Payment Account for the year ending on 31st March 2012

Project

RECEIPT SIDE				PAYMENT SIDE			
Sl. No.	**Head of Account**	**Amount**	**Amount**	**Sl. No.**	**Head of Account**	**Amount**	**Amount**
1	Opening Balance			1	Current Liabilities		11,812,240
	Cash	85,073					
	Bank	171,443,291	171,528,364				
2	Current Liabilities		79,461,418	2	Fixed ssets		-
3	Fixed Assets		-				
4	Investments		-	3	Investments		34,000,000
5	Current Assets		8,866,134	4	Current Assets		38,865,614
7	Direct Expenses		35,449	5	Direct Expenses		2,060
8	Indirect Incomes		2,244,650	6	Indirect Expenses		-
9	Direct Income		81,000		Indirect Expenses		-
10	Institute A/c		-		Closing Balance		
					Cash	103,467	
					Bank	177,433,634	177,537,101
	Total:-		**262,217,015**		**Total:-**		**262,217,015**

Date : 10th September 2013

NATIONAL INSTITUTE OF ROCK MECHANICS
Champion Reefs Post, Kolar Gold Fields - 563 117.

Project

DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2013

		Gross Block						Depreciation					Net Block	
Name of the Assets	**Rate of Depreciation %**	**Balance as on 01-04-12**	**Assets Written off/Transferred**	**Purcchases up to 30.09.12**	**Purchases between 1.10.12 to 31.12.12**	**Purchases After 01.01.13**	**Total as on 31.03.13 (Total of Col 3 to Col 7)**	**Balance as on 01-04-12**		**Depreciation written off**	**Depreciation for the year**	**Total Depreciation as on 31-03-13 (Total of Col 9 to Col 12)**	**As on 31-3-13 (Col 8 - Col 13)**	**As on 31-03-12**
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Vehicle	7.5	806889	0	0	0	0	806889	192888		0	60517	253405	553484	614001
Total:-		**806889**	**0**	**0**	**0**	**0**	**806889**	**192888**		**0**	**60517**	**253405**	**553484**	**614016**
Advance for capital material purchase		0	0	0	0	0	0	0		0	0	0	0	
(Previous year figures)														

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

Date : 10th September 2013

Annexure

Annexure - 1

ORGANISATION CHART

Annexure - 2

MEMBERS OF THE GENERAL BODY

Chairman

Shri RH Khwaja, IAS
Secretary to the Government of India
Ministry of Mines
III Floor, A Wing, R. No. 320
Shastri Bhawan, Dr. Rajendra Prasad Road
New Delhi – 110 115

Members

Addl. Secretary to the Govt. of India
Ministry of Mines, R.No. 308-A
III Floor, A Wing, Shastri Bhawan
Dr Rajendra Prasad Road
New Delhi – 110 115

Ms. Anjali Anand Srivastava, IAS
Jt. Secretary & Financial Advisor
Ministry of Mines
III Floor, A Wing, R.No. 321A
Shastri Bhawan, Dr Rajendra Prasad
Road, New Delhi – 110 115

Shri Gurpit Singh Jaggi
Director (Technical)
Ministry of Mines
III Floor, D Wing, R.No. 306
Shastri Bhawan
Dr Rajendra Prasad Road
New Delhi – 110 115

Director General
Directorate General of Mines Safety
Dhanbad 826 001
Jharkhand

Shri A Sundaramoorthy
Director General
Geological Survey of India
Kolkata

Shri DV Singh
THDC India Ltd
Ganga Bhawan
Pragatipuram, Byepass Road
Rishikesh – 249 201
Uttarakhand

Shri JK Sharma
Director (Projects)
National Hydro-Power Corporation Ltd
NHPC Office Complex, Sector-33
Faridabad – 121 003
Uttar Pradesh

Director (Projects)
NTPC Ltd
SCOPE Complex, Core-7, 5th Floor
7, Institutional Area, Lodhi Road
New Delhi – 110 003

Project Director
National Geotechnical Facility
Dehradun

Shri Ravi Shanker
Director General (Retd), GSI
B-5, Sector K, Aliganj
Lucknow - 226 024

Shri BKP Sinha
Director (MO) (Retd), HZL
1/15, H I G,
Rajasthan Housing Board Colony
Goverdhan Vilas
Udaipur – 313 001

Prof AK Ghose
Apartment No. 3B,
104, Regent Estate
Kolkata – 700 092

Director
National Institute of Rock Mechanics
Champion Reefs
Kolar Gold Fields - 563 117

Secretary (Non-member)

Shri AN Nagarajan
Registrar-cum-Secretary
National Institute of Rock Mechanics
Champion Reefs
Kolar Gold Fields - 563 117

Annexure - 3

MEMBERS OF THE GOVERNING BODY

Chairman

Shri RH Khwaja, IAS
Secretary to the Government of India
Ministry of Mines
III Floor, A Wing, R.No.320
Shastri Bhawan, Dr. Rajendra Prasad Road
New Delhi – 110 115

Members

Addl. Secretary to the Govt. of India
Ministry of Mines, R.No.308-A
III Floor, A Wing, Shastri Bhawan
Dr Rajendra Prasad Road
New Delhi - 110 115

Ms. Anjali Anand Srivastava, IAS
Jt. Secretary & Financial Advisor
Ministry of Mines
III Floor, A Wing, R.No.321A
Shastri Bhawan
Dr Rajendra Prasad Road
New Delhi – 110 115

Shri Gurpit Singh Jaggi
Director (Technical)
Ministry of Mines
III Floor, D Wing, R.No.306
Shastri Bhawan
Dr Rajendra Prasad Road
New Delhi – 110 115

Shri A Sundaramoorthy
Director General
Geological Survey of India
27, Jawaharlal Nehru Road
Kolkata – 700 016

Project Director
National Geotechnical Facility
Dehradun

Director General
Directorate General of Mines Safety
Dhanbad 826 001
Jharkhand

Shri DV Singh
THDC India Ltd
Ganga Bhawan
Pragatipuram, Byepass Road
Rishikesh – 249 201
Uttarakhand

Shri JK Sharma
Director (Projects)
National Hydro-Power Corporation Ltd
NHPC Office Complex, Sector-33
Faridabad – 121 003
Uttar Pradesh

Shri AK Ganju
Member (D&R)
Central Water Commission
Room No. 401(S) Sewa Bhawan
R.K. Puram
New Delhi – 110 066

Advisor (Projects)
Ministry of Coal
III Floor, R.No.309-A
Shastri Bhawan
New Delhi – 110 115

Shri Ravi Shanker
Director General (Retd), GSI
B-5, Sector K, Aliganj
Lucknow - 226 024

Shri BKP Sinha
Director (MO) (Retd), HZL
1/15, H I G
Rajasthan Housing Board Colony
Goverdhan Vilas
Udaipur – 313 001

Prof. A. K. Ghose
Apartment No. 3B,
104, Regent Estate
Kolkata – 700 092
West Bengal

Director
National Institute of Rock Mechanics
Champion Reefs
Kolar Gold Fields-563 117

Secretary (Non-member)

Shri A.N. Nagarajan
Registrar-cum-Secretary
National Institute of Rock Mechanics
Champion Reefs
Kolar Gold Fields - 563 117

Annexure - 4

MEMBERS OF THE PEER REVIEW COMMITTEE

Chairman
Shri Ravi Shanker
Director General (Retd), GSI
B-5, Sector-K, Aliganj
Lucknow - 226 024

Members

Prof. A. K. Ghose
Apartment No. 3B
104, Regent Estate
Kolkata - 700 092
West Bengal

Director General
CSIR, 2 Rafi Marg
New Delhi

Project Director,
National Geotechnical Facility
Dept of Science & Technology

Shri B. K. P. Sinha
Director (MO) (Retd), HZL
1/15, H I G
Rajasthan Housing Board Colony
Goverdhan Vilas
Udaipur - 313 001
Rajasthan

Director
Centre for Techno-Economic Mineral
Policy Options (C-TEMPO)
CGO Complex, Block 11 (Eleven)
5th Floor, Lodhi Road
New Delhi - 110 003

Shri A.K. Ganju
Member (D&R)
Central Water Commission
Room No. 401 (S), Sewa Bhawan
R. K. Puram
New Delhi - 110 066

Director
National Institute of Rock Mechanics
Champion Reefs
Kolar Gold Fields - 563 117

Director (S & T)
Directorate General of Mines Safety
Dhanbad - 826 001
Jharkhand

Secretary (Non-member)

Shri A.N. Nagarajan
Registrar-cum-Secretary
National Institute of Rock Mechanics
Champion Reefs
Kolar Gold Fields - 563 117

Annexure - 5

SUPPORTING ORGANISATIONS & MAJOR CLIENTELE

Central Government Ministries & Departments

Ministry of Mines, Government of India
Ministry of Coal, Government of India
Ministry of Earth Sciences, Government of India
Dept of Science & Technology, Ministry of Science & Technology, Govt. of India

Public Sector Organisations/ State Government

Airport Authority of India, Chennai (AAI)
Andhra Pradesh Mineral Development Corporation Ltd. (APMDC)
Atomic Minerals Directorate (AMD)
Central Mine Planning & Design Institute Limited (CMPDI)
Department of Mines and Geology, AP
Engineers India Limited (EIL)
Himachal Pradesh Power Corporation Ltd. (HPPCL)
Hindustan Copper Ltd. (HCL)
Hutti Gold Mines Limited (HGML)
IRCON International Limited
Kerala State Electricity Board (KSEB)
Malabar Cements
Manganese Ore India Limited (MOIL)
Mysore Minerals Ltd (MML)
National Aluminium Company Limited (NALCO)
NHPC Ltd.
North Eastern Electric Power Corporation Limited (NEEPCO)
NTPC Ltd.
Nuclear Power Corporation of India Ltd (NPCIL)
Sardar Sarovar Narmada Nigam Limited (SSNNL)
Satluj Jal Vidyut Nigam Limited (SJVNL)
Singareni Collieries Company Limited (SCCL)
Tamilnadu Electricity Board (TNEB)
THDC India Limited
Uranium Corporation of India Limited (UCIL)
Western Coalfields Limited

Private Companies

TT-AFCONS Jv
Aiswarya Granites
Andhra Pradesh Heavy Machinery and Engineering Limited
Faiveley Transport India Ltd
Ferro-Alloys Corporation Limited (FACOR)
Gammon India Ltd

GMR Infrastructure Ltd
Hindustan Construction Company Limited (HCC)
Hindustan Zinc Limited (HZL)
Indian Metals and Ferro Alloys Limited
Jindal Power Limited
Navayauga Engineering Company
POABS Rock Products Pvt. Ltd
SEW Infrastructure Ltd.
Soma Enterprises Ltd
The India Cements Limited (ICL)

International Organisations

Druk Green Power Corporation Limited (DGPCL), Bhutan
(Formerly Tala Hydrolectric Project, Bhutan

Annexure – 6

LIST OF PROJECTS

Sl No	Title of Project	Persons involved	Status
1	Review of construction stage engineering geological investigations of twin tunnels on the Hungund – Hospet Section of NH-13, near Hospet, Karnataka	*AK Naithani & LG Singh*	Completed
2	Construction stage engineering geological mapping of SREH, SRPH, FWPH, DOSA, V STACK and D_2O buildings floors and walls of Rajasthan Atomic Power Project Units 7 & 8, Rawatbhata, Rajasthan	*AK Naithani, Rabi Bhusan & LG Singh*	Completed
3	Review of preliminary geotechnical investigations of Pranahitha-Chevella Sujala Sravanthi project (Package-8), Karimnagar District, Andhra Pradesh	*AK Naithani & LG Singh*	Completed
4	Geotechnical assessment of the cut-off drain of Rajasthan Atomic Power Project (RAPP) Units 7&8, Rawatbhata, Rajasthan	*AK Naithani & LG Singh*	Completed
5	Compilation report on sub-soil investigation-field investigation, laboratory investigation and evaluation of bearing capacity for V Stack, SREH, SRPH, FWPH, DOSA and D_2O buildings of Rajasthan Atomic Power Project (RAPP) Units 7&8 Rawatbhata, Rajasthan	*Rabi Bhusan, Divyalakshmi KS ,AK Naithani & V Venkateswarlu*	Completed
6	Review of construction stage engineering geological excavation investigations at crude oil strategic storage project, Padur, Karnataka	*AK Naithani, Manoj Kumar, Prasnna Jain & LG Singh*	On-going
7	Review of construction stage engineering geological mapping at crude oil storage project, Mangalore, Karnataka	*AK Naithani, Devendra Singh Rawat & LG Singh*	On-going
8	Seismic refraction survey along the power tunnel alignment at the intake area of Pallivasal Hydroelectric Project, Munnar, Kerala	*PC Jha, V R Balasubramaniam, N S&eep, YV Sivaram, D Joseph & B Butchi Babu*	Completed
9	Seismic refraction survey at the CMRL project site at the Chennai Central Station, TT-AFCONS JV, Chennai	*PC Jha, VR Balasubramanaim, N Sandeep, Y V Sivaram, D Joseph & B Butchi Babu*	Completed
10	Mapping of weak zones around diaphragm wall of the proposed Shenoy Nagar station of Chennai Metro Project	*PC Jha, V R Balasubramanaim, N Sandeep, YV Sivaram, D Joseph & B Butchi Babu*	Completed
11*	Monitoring Indian Shield Seismicity with 10 BBS to Understand Seismo-Tectonics of the Region using V-SAT Connectivity, **S&T Project**	*C Srinivasan & Y A Willy*	On-going

Sl No	Title of Project	Persons involved	Status
12	Seismo-tectonic evaluation and related geological studies in Pudimadaka area in Achutapuram Mandal, Visakhapatnam, Andhra Pradesh	*DT Rao, Biju John, Yogendra Singh, GH Kotnise, K Kanna Babu, KS Divyalakshmi, C Srinivasan & PC Nawani*	completed
13	Seismo-tectonic evaluation of Kudankulam Atomic Power within 30-50 km radius area, Tamil Nadu	*Biju John, DT Rao, Yogendra Singh, KS Divyalakshmi & C Srinivasan*	On-going
14	Geothermal study at Manappad around Kudankulam Area, Tamil Nadu	*Biju John, Yogendra Singh, & C Srinivasan*	On-going
15*	Estimating the Recurrence of Earthquakes in the Central-Eastern Himalaya and Upper Assam from the Distant Liquefaction Features of the River Plains, **S&T Project**	*Biju John & Faculty from IISc, B'lore*	Completed
16*	Evaluation of Neotectonic Activity of Desamangalam Fault, in the Western Terminus of Palghat Gap, Peninsular India, **S&T Project**	*Biju John, Sandeep Nelliat, & Yogendra Singh*	On-going
17	Determination of in–situ stress parameters by hydrofrac method near the proposed Powerhouse chamber of Etalin H E Project, Arunachal Pradesh	*S Sengupta, DS Subrahmanyam, RK Sinha, & G Shyam*	Completed
18	Determination of In-situ Deformability parameters of dam construction materials by pressure meter test at Mullaiperiyar, Kerala	*S Sengupta, DS Subrahmanyam, RK Sinha, & G Shyam*	Completed
19	Different Rock Mechanics investigations conducted for the design of Dam at proposed Mangdechhu H E Project, Bhutan	*S Sengupta, DS Subrahmanyam, RK Sinha, & G Shyam*	Completed
20	Different Rock Mechanics investigations conducted at Rajasthan Atomic Power Project	*S Sengupta, DS Subrahmanyam, RK Sinha, & G Shyam*	Completed
21*	Development of State-of-the-Art Facilities for In-situ Stress Measurement by Hydrofracture Method in Porous and Fractured Rock Mass, **S&T Project**	*RK Sinha, S Sengupta, DS Subrahmanyam & G Shyam*	On-going
22	Study on ground vibration and air overpressure due to blasting adjacent to powerhouse complex, head race tunnel etc, Sainj HEP, HPPCL, Kullu, HP	*AI Theresraj, G Gopinath, R Balachander & HS Venkatesh*	Completed
23	Suggestion on controlled blast design for diversion weir & tunnel and monitoring of ground vibration to study the blast effects on Kallar bridge, Sengulam Augmentation Scheme, Kerala State Electricity Board	*AI Theresraj, G Gopinath, R Balachander & HS Venkatesh*	Completed
24	Study on the impact of ground vibration due to blasting at Sub-Level Open Stope Method on surface structures, Heera Buddini Gold Mine, HGML, Karnataka	*R Balachander, AI Theresraj, G Gopinath, & HS Venkatesh*	Completed
25	Ascertain the feasibility of co-existence of a proposed limestone mine adjacent to the proposed 1320 MW thermal power plant	*HS Venkatesh, AI Theresraj, G Gopinath & R Balachander*	Completed

Sl No	Title of Project	Persons involved	Status
	belonging to PCKL, Gulbarga		
26	Technical advice on blast design for tunnel portal at Tala Dam Left Bank, Bhutan, Bhutan (Phase I and II)	*R Balachander, G Gopinath, AI Theresraj & HS Venkatesh*	Completed
27	Technical guidance on blast design for twin tunnels and monitoring of vibration near railway track, Hungund–Hospet section of NH-13, GMR-EPC, Bangalore	*R Balachander, G Gopinath, AI Theresraj, & HS Venkatesh*	Completed
28	Monitoring the intensity levels of ground vibration and air overpressure at different distances for experimental rock blasting at a quarry site near Chennai	*AI Theresraj, R Balachander, G Gopinath, & HS Venkatesh*	Completed
29	Pre-construction report on the application of controlled blasting techniques for the excavations of Peruvannamuzhi and Pazhassi Sagar SHEP, Kozhikode, KSEB	*AI Theresraj, R Balachander, G Gopinath & HS Venkatesh*	Completed
30	Ground vibration study to assess the impact of blasting at dam complex of Mangdechhu hydroelectric project on surface structures, Bhutan	*G Gopinath, R Balachander, AI Theresraj, & HS Venkatesh*	Completed
31	Methodology for controlled blasting techniques and monitoring ground vibration for 1 4 MW mini hydel project on Raya Basavanna Canal, Khandaleru Power Company Limited, Karnataka	*G Gopinath, R Balachander, AI Theresraj, K Vamshidhar & HS Venkatesh*	Completed
32	To study the impact of PSP blasting on underground structures at HPP, Tehri, Uttarakhand	*K Vamshidhar, AI Theresraj, R Balachander, G Gopinath & HS Venkatesh*	Completed
33	Suggesting controlled blasting method and monitoring ground vibration and air overpressure at Vellathooval SHEP, Vellathooval, KSEB	*AI Theresraj, R Balachander, G Gopinath, K Vamshidhar & HS Venkatesh*	On-going
34	Study on providing safe charges for blasting near 400/220KV switchyard, RAPP (7&8), L&T, Rawatbhata, Rajasthan	*G Gopinath, R Balachander, AI Theresraj, K Vamshidhar & HS Venkatesh*	On-going
35	Monitoring ground vibrations and air overpressure at Jambunatheswara temple due to blasting at Jambunathanahalli Iron Ore Mines, MML, Hospet, Karnataka	*HS Venkatesh, AI Theresraj, R Balachander & G Gopinath*	On-going
36	Slope Stability Studies at Pandarathu Limestone Mine of M/s Malabar Cements, Walayar, Palakkad Dist , Kerala	*Sripad R Naik, Roshan Nair, & K Sudhakar*	Completed
37	Analysis of Instrumentation Data of Dam, Desilting complex, Power house Complex, of NJHPS, SJVNL, Shimla	*Sripad R Naik, K Sudhakar, & Roshan Nair*	Completed
38	Design of Longwall gateroads in 1A Seam, Kakatiya	*Sripad R Naik, V*	Completed

Sl No	Title of Project	Persons involved	Status
	Longwall Project, SCCL, M/s Indu projects Ltd, Hyderabad, Andhra Pradesh	*Venkateswarlu & K Sudhakar*	
39	Feasibility of proposed overhand cut & fill method for excavation of locked-up weathered Chromite ore from opencast pit as well as in underground deposit at Kaliapani Chromite Mines	*Sripad R Naik, Roshan Nair, V Venkateswarlu & K Sudhakar*	Completed
40	Assessment of tunnel design, efficacy of support system and stability of cut slopes near approaches of twin tunnels, Hungund-Hospet section of NH-13, Boyance Infrastructure Private Ltd , Bangalore	*Sripad R Naik, Roshan Nair & K Sudhakar*	Completed
41	Back Analysis of Powerhouse Complex Behaviour using 3D numerical modeling at Tapovan Vishnugad Hydroelectric Project, NTPC Ltd , Noida	*Sripad R Naik, Roshan Nair & K Sudhakar*	On-going
42	Stress analysis of underground pump house at Pranhita–Chevella Sujala Sravanthi Package–23, M/s Patel Engineering, Hyderabad, Andhra Pradesh	*Sripad R Naik, Roshan Nair & K Sudhakar*	On-going
43	Stability analysis of landslide area of Varunavat Parvat, THDC, Rishikesh	*Sripad R Naik, Roshan Nair & K Sudhakar*	On-going
44	Stability analysis of South-eastern benches of 1 top pit of Bicholim Mines, M/s Sesa Mining Corporation Ltd , Goa	*Sripad R Naik, Roshan Nair & K Sudhakar*	On-going
45	Investigation into stability of Pirsurlem waste dump slopes at Sonshi Iron Ore Mine, M/s Cosme Costa & Sons, Goa	*Sripad R Naik, Amrith Renaldy & K Sudhakar*	On-going
46	Instrumentation, monitoring and data analysis at powerhouse complex Tala Hydro Power Plant, Bhutan	*Sripad R Naik, K Sudhakar & Roshan Nair*	On-going
47	Deformation monitoring of underground power house cavern of Sardar Sarovar Project, Gujarat	*Sripad R Naik, K Sudhakar & Roshan Nair*	On-going
48	Analysis of Instrumentation data of dam at Tala Hydro-electric Project, Bhutan	*Sripad R Naik, K Sudhakar & Roshan Nair*	On-going
49	Geodetic monitoring of Sardar Sarovar dam, SSNNL, Kevadia, Gujarat	*Sripad R Naik, K Sudhakar & Rabi Bhusan*	On-going
50	Surface subsidence prediction and review of support system at Mahamaya U/G mine, Bhatgaon area, SECL, Chattisgarh	*Sripad R Naik, Ritesh Lokhande & K Sudhakar*	On-going
51	Development of instrumentation data template for Koteshwar and Tehri dams	*Sripad R Naik, K Sudhakar & Roshan Nair*	On-going
52	Monitoring of sub-level stopes in strike reef at Hutti Gold Mine, HGML	*C Nagaraj & V Venkateswarlu*	Completed
53	Design of underground openings at Sukinda Chromite Mines	*Sripad R Naik, K Sudhakar & Roshan Nair*	Completed
54	Methods of extraction of coal seams at underground mines of Saoner no. 2 (Nagpur Area),	*RD Lokhande & V Venkateswarlu*	Completed

Sl No	Title of Project	Persons involved	Status
	and Sarni and Tawa (Pathakhera Area), WCL		
55	Design of supports of gateroads at Kakatiya Longwall Project	*V Venkateswarlu*	Completed
56	Strata control investigations at Mathani Colliery, Pench Area, WCL	*RD Lokhande & V Venkateswarlu*	Completed
57	Strata control investigations at Mohan Colliery, Kanhan Area, WCL	*RD Lokhande & V Venkateswarlu*	Completed
58	Strata behaviour analysis in BG Panel 3B in 3 Seam at GDK-10 incline, RG-III Area, SCCL	*S Kumar Reddy*	Completed
59	Slope design at Sateli Iron Ore Mines of M/s Deccan Minerals	*Amrit Renaldy & V Venkateswarlu*	Completed
60	Evaluation of the requirement of support pillars in LDBH stopes at Kathpal Chromite Mine, FACOR	*Sripad R Naik, K Sudhakar, Roshan Nair & V Venkateswarlu*	On-going
61	Determination of the stoping parameters at Tummalapalle Mine, UCIL	*C Nagaraj & V Venkateswarlu*	On-going
62	Studies for scientific quarrying and for assessing the stability of high walls at Pallava black galaxy quarry, Ongole, Andhra Pradesh	*A Rajan Babu, SS Meena, GC Naveen, Piyush Gupta, Amrith Renaldy, Rabi Bhusan & M Lakshmipathy*	Completed
63	Studies for scientific & eco-friendly quarrying methods and for assessing the stability of high walls at the Indian Minerals & Granite Company, Chimakurthy, Ongole, Andhra Pradesh	*A Rajan Babu, SS Meena, GC Naveen, Piyush Gupta, Dr V Venkateswarlu, Amrith Renaldy, Rabi Bhusan & M Lakshmipathy*	Completed
64	A study on the impact of evershine multi colour granite quarry operations on nearby Arkavathy dam and other structures and recommendation for scientific quarrying, Nellahalli village, Karnataka	*A Rajan Babu, SS Meena, G C Naveen, Piyush Gupta, Yogendra Singh, Amrit Renaldy & M Lakshmipathy*	Completed
65	Advice for scientific mining methods and studies for assessing the stability of slope at Vibuthigadda iron ore mine located in Belagal village, Bellary, Karnataka	*GC Naveen, A Rajan Babu, SS Meena, V Venkateswarlu , Amrith Renaldy, Rabi Bhusan & M Lakshmipathy*	Completed
66	In-Situ Non-Destructive Testing for M/s Hindustan Zinc Limited, Rajasthan	*M Victor, A Rajan Babu, S Sathyanarayana, GC Naveen, Syed Asghar & M Lakshmipathy*	Completed
67	Destructive and in-situ non-destructive tests for M/s National Aluminum Company Limited (NALCO)	*M Victor, A Rajan Babu, S Sathyanarayana, GC Naveen & Syed Asghar*	Completed
68	In-situ non-destructive testing for Palani Temple, Palani, Tamilnadu	*M Victor, A Rajan Babu, S Sathyanarayana & Syed Asghar*	Completed
69	Non-destructive tests for M/s Andhra Pradesh Heavy Machinery and Engineering Limited, Vijayawada	*M Victor, A Rajan Babu, S Sathyanarayana & Syed Asghar*	Completed
70	In-situ non-destructive testing of vital components	*M Victor, A Rajan Babu,*	On-going

Sl No	Title of Project	Persons involved	Status
	of M/s Singareni Collieries Company Limited	*S Sathyanarayana, SS Meena & Syed Asghar*	
71	Destructive and non-destructive tests for M/s Shaft Sinkers Mauritius Limited, Delhi	*M Victor, A Rajan Babu, S Sathyanarayana, G C Naveen & Syed Asghar*	On-going
72	Destructive and non-destructive tests for M/s China Coal No-5 Construction India Pvt Limited, Rajasthan	*M Victor, A Rajan Babu, S Sathyanarayana, G C Naveen & Syed Asghar*	On-going
73	Laboratory geo-technical investigations on rock samples from Ramagundam Opencast Mine - II Extension Block (BH No. 1278 & 1279), SCCL	*GM Nagaraja Rao, S Udayakumar & Praveena Das Jennifer*	Completed
74	Laboratory geo-technical investigations on rock samples from RAPP Project, Rajasthan, HCC Ltd	*GM Nagaraja Rao, S Udayakumar, GD Raju & Praveena Das Jennifer*	Completed
75	Laboratory geo-technical investigations on rock samples from PKOC - II Extension Block (BH no. 1038, 1039, 1040 & 1041), SCCL	*GM Nagaraja Rao, S Udayakumar, GD Raju & Praveena Das Jennifer*	Completed
76*	Development of Methodology for Shear Testing of Contact Plane (Parting Plane) of Sedimentary Rocks, In-house **R&D project**	*GM Nagaraja Rao, S Udayakumar, GD Raju & Praveena Das Jennifer*	Completed
	**** S&T / R&D project***		

Summary of project activities :

No of completed projects during 2012-13 : 51

No of on-going projects by the end of 2012-13 : 25

Total no of projects taken-up during 2012-13 : 76
(Including 5 S&T/R&D projects)

Annexure – 7

LIST OF PUBLICATIONS

1. Balasubramaniam VR., Jha PC and Chandrasekhar E, 2013. Imaging near surface defects using step-frequency ground-penetrating radar, Near Surface Geophysics, vol. 11, pp. 19-27, doi : 10.3997/1873-0604. 2012044.

2. Balasubramaniam VR, Jha PC, Chandrasekhar E, Butchi Babu B, Sivaram YV and Sandeep N, 2013. Imaging weak zones in the foundation using frequency domain attenuation tomography, Journal of Applied Geophysics.

3. Biju John and Yogendra Singh 2013. Precambrian Geology as background information to active tectonics in shield areas. In XII MSI National Seminar on "Current trends of Research in Precambrian Geology and Vision 2020" at Mysore University, Karnataka, India. pp. 149-150.

4. Biju John, Yogendra Singh, Sandeep Nelliat and Ganapathy GP, 2013. Morphotectonic evidence of active deformation - an example from Peninsular India. In Abstract Volume of International Symposium on Advances in Earthquake Science, Gandhinagar. pp. 32-33.

5. Gopinath G, HS Venkatesh, R Balachander & AI Theresraj, 2012. Pre-split blasting for final wall control in a nuclear power project , 10th International Symposium on Rock Fragmentation by Blasting, Fragblast10, November 24 - 29, New Delhi.

6. Gupta P, Roy S and Rajan Babu A, 2012. Study on noise levels generated due to jack hammer drills in granite quarries, Frontiers in Science, vol. 2, no. 3, pp. 47-52.

7. Kumar Reddy S and Nagaraj C, 2012. Longwall goaf monitoring using deep hole extensometer. International J of Earth Sciences & Engineering, vol. 5, no. 1, pp. 1402 – 1405

8. Kumar Reddy S and Sastry VR, 2012. Induced stresses in blasting gallery panel during depillaring based on field instrumentation – A case study, International Journal of Earth Sciences and Engineering, vol. 5, no. 6 (01), pp. 1820 - 1827.

9. Kumar Reddy S and Sastry VR, 2012. Strata monitoring studies during extraction of thick seams by Blasting Gallery Method - A case study, World Conference on Applied Science and Engineering Technology, 17-19 August 2012, Vijayawada.

10. Kumar Reddy S and Sastry VR, 2012. Strata monitoring studies with convergence stations in galleries of Blasting Gallery panel during depillaring – A case study. Seminar on Ground Control and Improvement, Central Board of Irrigation and Power, 20-21 September, 2012, New Delhi.

11. Kumar Reddy S and Sastry VR, 2013. Gallery supporting and monitoring in Blasting Gallery panel during depillaring - A case study, International Conference on Developments in Best Practices in Surface and Underground Mining and Innovative Developments in Mining Machinery, 28-30 January 2013, Kolkata.

12. Kumar Reddy S, 2013. Mass production technology in underground coal mines of SCCL – An emerging trend, 2nd World Conference on Applied Science and Engineering Technology, 8-9 March 2013, Hyderabad.

13. Kumar Reddy S, 2012. Coal as energy - Problems and issues related to mining industry, International Conference on Energy and Environment, 1-4 December 2012, Hyderabad.

14. Lokhande RD, 2013. Pot hole subsidence in underground coal mining – Some Indian experiences. International J of Geotechnical and Geological Engineering. Vol. 31, no. 2, pp. 793 – 799.

15. Lokhande RD, 2013. Pot hole subsidence in underground coal mining – A case study. Indian Conference on Mine Surveying (ICMS-2012), Indian School of Mines, Dhanbad. pp. 255 – 262.

16. Naithani AK, 2012. Underground rock caverns for strategic crude oil storage in India-nature of studies, design and construction. Current Science. vol. 103, no. 5, pp. 490-496.

17. Naithani AK, Singh LG, Devendra Singh Rawat and Nawani PC, 2012. Engineering geological and geotechnical evaluation of Dam Spillway (II-C) of Bunakha Hydroelectric Project, Bhutan Himalaya. ISRM (India) Journal. vol. 1, no. 2, pp. 16-22.

18. Rajan Babu A, Adhikari GR and Pitchumani PK, 2011. Excavations by controlled blasting for the construction of an Underground LPG Storage Cavern at Vizag, Indian Society of Engineering Geology, vol. XXXVII (1-4), 413-427.

19. Rajendran CP, Rajendran K, Biju John and Sanwal J, 2013. Earthquake recurrence in the central Himalaya: Some outstanding issues. In EGU General Assembly. vol. 15, EGU2013-2688-1.

20. Roshan Nair and Sripad R Naik, 2012. Numerical analysis of an underground powerhouse in adverse geological conditions of Upper Himalayas, International Conference on Tunneling and Underground Space for Global SOCIETY – WTC2012 (TUTG and ITA-ALTIS), Bangkok, 8- 23 May 2012

21. Sandeep N, PC Jha, YV Sivaram, VR Balasubramaniam and B Butchi Babu, 2012. Integrated geophysical surveys for site characterisation along hydro tunnel under low overburden conditions Journal of engineering geology. vol. XXXVII, 1-4, pp. 161-168.

22. Sengupta S, Subrahmanyam DS, Sinha RK and Shyam G, 2012. “Estimation of the Impact of Mining on Stresses by actual Measurements in Pre and Post Mining Stages by Hydrofractue Method- A Case Study in a Copper Mine” - Chapter in

book titled "Effective and Sustainable Hydraulic Fracturing", ISBN 980-953-307-651-0

23. Singh LG and Vallinayagam G, 2012. Petrological and geochemical constraints in the origin and associated mineralization of A-Type granite suite of the Dhiran area, Northwestern Peninsular India. Geosciences. vol. 2, no. 4, pp. 66-80.

24. Srinivasan C, Harbindu A, Sharma ML and Willy YA, 2012. Strong ground motion predictive equation for low magnitude and near-field earthquake data for shield region in India, Proc. 15th World Conference on Earthquake Engineering, Lisbon, September, 2012

25. Srinivasan C, Willy YA and Carter RM, 2013. Strong motion rockburst study in the flooded mines of Kolar Gold Fields. Proc. Symposium on Advances in Earthquake Sciences, Institute of Seismological Research, Gujarat, February, 2013.

26. Subrahmanyam DS, Sengupta S, Sinha RK and Shyam G, 2012. Determination of in-situ stress at Desilting Chamber of Punatsangchhu hydroelectric project (Bhutan), to reconfirm its orientation influenced by topography - A case study, 7th International Conference on Case Histories in Geotechnical Engineering, Chicago, USA.

27. Venkatesh HS, AI Theresraj, R Balachander, G Gopinath and K Vamshidhar, 2012. Ground vibration studies in Indian limestone mines vis-à-vis the mines of India Cements Limited, The Indian Mining & Engineering Journal. vol. 51 No. 09, September 2012, pp 25-29.

28. Venkatesh HS, K Vamshidhar, G Gopinath, AI Theresraj ans R Balachander,2012. Optimisation of blast design for an iron ore mine and assessment of fragmentation through image processing, 10th International Symposium on Rock Fragmentation by Blasting, Fragblast10, November 24 - 29, New Delhi.

29. Venkatesh HS, R Balachander, G Gopinath and AI Theresraj, 2012. Controlled blasting for underground hydroelectric projects – NIRM experience, 10th International Symposium on Rock Fragmentation by Blasting, Fragblast10, November 24 - 29, New Delhi.

30. Venkatesh HS, G Gopinath, R Balachander AI, Theresraj and K Vamshidhar, 2012. Controlled blasting for a Metro Rail project in an urban environment, 10th International Symposium on Rock Fragmentation by Blasting, Fragblast10, November 24 - 29, New Delhi.

Paper accepted for publication :

1. Jain Prasnna, Naithani AK and Singh TN : Performance characteristics of a tunnel boring machine in basalt and pyroclastic rocks of Deccan traps – A case study from Mumbai, India. Journal of Rock Mechanic and Geotechnical Engineering.

2. Naithani AK, Singh LG and Devendra Singh Rawat : Construction stage engineering geological investigations of surge pool area of Mahatma Gandhi Kalwakurthi Lift

Irrigation Scheme-II (5x30 MW), Mahaboobnagar District, Andhra Pradesh. Journal of the Geological Society of India.

3. Naithani AK, Devendra Singh Rawat, Singh LG and Nawani PC : Engineering geological and geotechnical evaluation of the water conducting system and power house area of Bunakha Hydroelectric Project, Bhutan. Journal of the Geological Society of India.

4. Naithani AK, Nawani PC, Singh LG and Devendra Singh Rawat : Engineering geological evaluation of the spillway of Dam (II-B) of Bunakha Hydroelectric Project, Chukha Dzong, Bhutan. Journal of the Geological Society of India.

5. Naithani AK, Singh LG : Engineering geological investigations of surge pool and pump house (5 x 130 MW) area of Pranahitha - Chevella Sujala Sravanthi Lift Irrigation Scheme- 08, Karimnagar District, Andhra Pradesh. ISRM (India) Journal.

6. Sandeep N, PC Jha and PR, Mohanty : Imaging of sand lens at a barrage site in the Indian Himalaya – A case study using cross-hole seismic tomography. Journal of the Geological Society of India.

7. Srinivasan C, Willy YA and Carter RM : Characteristics of rockbursts in the flooded mines of Kolar Gold Fields. 8th International Conference of Rockbursts and Seismicity in Mines, to be held in Moscow, Russia during September, 2013.

Annexure-8

NEWS LETTER

1. The 5th foundation day of the Society of Earth Scientists (SES) was celebrated at NIRM, KGF on 17th April 2013. As part of this, Dr PC Jha delivered a lecture on "Investigating structural stability by engineering geophysical techniques".

2. Dr AK Naithani delivered two invited lectures on "Case Studies of Landslide Causes and Consequences" and on "Landslide Hazard Zonation Mapping Techniques", in a training programme on 'Landslide Risk Mitigation and Management' organized by Centre for Disaster Management, Administrative Training Institute, Mysore on 26 July 2012.

3. Dr AK Naithani delivered an invited lecture on "Geotechnical Site Investigations for Underground Excavations" in the 3rd Annual Conference on "Tunnel Construction in India: Market Opportunities, Best Practices & New Technologies" organized by India Infrastructure Publishing Pvt. Ltd. at New Delhi on 08 May 2012.

4. Dr AK Naithani attended the Workshop on "Optimizing Geotechnical Investigations for Hydropower Projects" and the 35th Annual General Meeting of the Indian Society of Engineering Geology at New Delhi on 08 December 2012 and presented a research paper.

5. Dr AK Naithani attended the 3rd Annual Conference on "Tunnel Construction in India: Market Opportunities, Best Practices & New Technologies" organized by India Infrastructure Publishing Pvt. Ltd. at New Delhi during 08-09 May 2012.

6. Dr C Srinivasan attended the training programme on "Managing Technology Value Chains for Directors and Division Heads, from 7th to 11th January,2013, at Administrative Staff College of India, Hyderabad.

7. Shri Yogendra Singh attended the Symposium on Advances in Earthquake Sciences held at Institute of Seismological Research, Gujarat during February, 2013, and presented the paper titled Morphotectonic Evidence of Active Deformation - an Example from Peninsular India.

8. Dr DS Subrahmanyam has been nominated as Reviewer for International Journal of Mining Engineering and Mineral Processing and International Journal of Geoscience (Scientific & Academic Publishing, USA).

9. Dr HS Venkatesh gave a presentation on "Blasting for Tunnels & Caverns" attended by senior officers and Executive Trainees of THDC at R & D Unit, THDC, Rishikesh, on 19th October 2012.

10. Dr HS Venkatesh, Mr AI Theresraj, Mr G Gopinath, Mr R Balachander and Mr K Vamshidhar, attended the 10th International Symposium on Rock Fragmentation by blasting, Fragblast10, during November 24 – 29 at Vigyan Bhawan, New Delhi.

11. Dr HS Venkatesh and Mr AI Theresraj delivered invited lectures on Drilling & Blasting Technologies and their Applications, at Engineering Staff College of India, Hyderabad ,on 19th and 20th June 2012.

12. NIRM conducted a Training Course on "Application of FLAC to Mining Problems" for the engineers from CMPDIL at NIRM, Bangalore, during 22nd August to 29th August 2012.

13. Mr Sripad R Naik and Dr Roshan Nair attended the event "Trimble Express – 2012" organized by M/s AIMIL Ltd. at Bangalore, on June 25, 2012.

14. Mr K Sudhakar attended the Seminar of "Emerging Technologies in Surveying", organised by Topcon Sokkia India (P) Ltd and Toshni-Tek International, at Chennai on June 25, 2012.

15. Mr Sripad R Naik attended the SPSS Seminar on "Application of SPSS tool for Researchers / Faculty" organised by JSS Academy of Technical Education, Bangalore, on 13th and 14th March 2013.

16. Mr Sripad R Naik attended the International Conference on Tunneling and Underground Space for Global Society – WTC2012, jointly organized by TUTG and ITA-ALTIS, during18th to 23rd May 2012, at Bangkok, Thailand.

17. Mr Sripad R Naik delivered a lecture on "Monitoring and Warning Technologies for Landslide & Demonstration", at Administrative Training Institute at Mysore on 26th July, 2012.

18. Mr K Sudhakar attended the meet on "Tunneling Mechanics & Underground Excavation" jointly organized by East West Institute of Technology, Bangalore, Karnataka Geotechnical Centre (KGC) & Karnataka Environmental Research Foundation (KERF), during 27th to 29th April 2012, and gave a lecture on "Installation of Geotechnical Instruments and its importance".

19. Mr S Kumar Reddy guided four BTech Mining Engineering students of Dr T Thimmaiah Institute of Technology (Dr TTIT), KGF (Mr Mirza Baig Yasin, Mr Shankar Rao Reddy, mr S Md Alim & Mr Reddy Rajesh) for their project work on "Mass production technology with continuous miner in underground coal mines".

20. Mr Amrith Renaldy guided four 8th Semester, BE Mining Engineering students of Dr TTIT, KGF (Anand Vijay Sattayam, Rudraiaha M, Vikash Kumar & Soma Shekar Goud H) BTech for their project on "A study on design parameters of haul road to reduce accidents in opencast mines".

21. Mr Amrith Renaldy guided four 8th Semester, BE Mining Engineering students of Dr TTIT, KGF (Prabhu, Syed Anwar Pasha, Shiva Kumar & Vijaya

Kumar) for their project on “A study of occupational health hazards associated with dumper operators in opencast mines”.

22. Mr Amrith Renaldy attended the conference on “Surface Miners – An Innovative Technology for Minerals Sector” during 17-18 August, 2012, at Kolkata.

23. Mr Amrith Renaldy attended the training program “Application of FLAC to mining Problems” at NIRM, Bangalore during 22-29 august, 2012.

24. Mr Amrith Renaldy had given lectures and hands on training to the MTech Geoinformatics students at Indian School of Mines, Dhanbad, on the subject “Remote Sensing with GIS and its Applications in Mining Industry”.

25. Mr A Rajan Babu and Mr M Victor participated in the one day programme on Career Guidance in NDT, on 10 August 2012, organized by ASNT Southern Inspection Services, Chennai, Tamilnadu.

26. Mr A Rajan Babu attended the BIS meeting held at Jaipur on 10th January 2012 and presented the Grading Methodology for inclusion in the Standard.

27. Mr A Rajan Babu attended the Granite Development Council (GDC) meeting held at Bangalore on 2nd February, 2012 under the chairmanship of Secretary, MoM.

28. Rajbhasha Hindi Pakhwara was celebrated at NIRM from September 14 to 28, 2012.

Higher Qualifications Obtained :

1. Mr A Rajan Babu obtained level – II certificates from ASNT in Magnetic particle testing (MPT), Ultrasonic Testing (UT), Visual Testing (VT) and Penetrant Testing (PT).

2. Mr RD Lokhande was awarded the degree of Doctor of Philosophy by Indian School of Mines, Dhanbad, for his research work on “An investigation into the causes of pot-hole subsidence, and its prediction in underground coal mining”, in the area of Mining Engineering.

3. Mr Devendra Singh Rawat was awarded the degree of Doctor of Philosophy in Geology from HNB Garhwal University, in February , 2013

4. Mr LG Singh was awarded the degree of Doctor of Philosophy in Applied Geology from Kurukshetra University in May, 2012.

5. Mr Rabi Bhusan was awarded the degree of Doctor of Philosophy in Earth and Planetary Sciences from University of Allahabad in June, 2012.

Annexure - 9

STAFF ON ROLL as on 31.03.2013

Director
Dr V Venkateswarlu

Departments & Regular Staff
(as on 31.03.2013)

Engineering Geology
- Dr AK Naithani
- Dr Rabi Bhusan
- Dr L Gopeshwor Singh
- Mr Devendra Singh Rawat
- Mr Prasnna Jain
- Mr Manoj Kumar

Engineering Geophysics
- Dr PC Jha
- Mr VR Balasubramaniam
- Mr Sandeep Nelliat
- Mr D Joseph
- Mr Butchi Babu
- Mr Y V Sivaram

Geotechnical Engineering
- Dr S Sengupta
- Dr DS Subrahmanyam
- Mr RK Sinha
- Mr G Shyam

Rock Fracture Mechanics
- Dr GM Nagaraja Rao
- Mr S Udayakumar
- Mr GD Raju
- Mrs Praveena D Jennifer
- Mr Abdul Majeed

Engineering Seismology & Seismotectonics
- Dr C Srinivasan
- Mr Y Ahnoch Willy
- Dr Biju John
- Mr Yogendra Singh
- Mrs KS Divyalakshmi

Microseismics and Automation
- Mr C Sivakumar
- Mr Vikalp Kumar

Mine Design
- Mr C Nagaraj
- Mr Sagaya Benady
- Mr S Kumar Reddy
- Mr Ritesh D Lokhande
- Mr N Selvaraj

Rock Blasting & Excavation Engg
- Dr HS Venkatesh
- Mr AI Theresraj
- Mr G Gopinath
- Mr K Vamshidhar
- Mr R Balachander

Numerical Modelling
- Mr Sripad
- Mr K Sudhakar

Dimensional Stone Technology & Material Testing
- Mr A Rajan Babu
- Mr S Sathyanarayana
- Mr M Victor
- Mr Sultan Singh Meena
- Mr GC Naveen
- Mr MS Nagaraj
- Mr G Mohandoss
- Mr Syed Asgar

Environmental Engineering
- Mr T Amrith Renaldy
- Mr Piyush Gupta
- Mr M Lakshmipathy

Technical Coordination & Project Management
- Dr PC Jha *(addl. charge)*
- Mr GS Govinda Setty
- Mr A Vijaya Kumar
- Mr N Sounderrajan

Administration
- Mr AN Nagarajan
- Mr Pankaj Kumar
- Mr S Ravi
- Mr J V Sastry
- Mrs S Lourdu Mary
- Mr N Jothiappa
- Mrs CV Lalitha
- Mr J Raja
- Mr P Venkata Reddy

Resignation
- Dr Roshan Nair
- Dr Surendra Roy
- Mr Piyush Gupta

Retirement
- Dr G R Adhikari
- Mr DT Rao
- Mr Abdul Majeed
- Mr MS Nagaraj
- Mr G Mohandoss

Quality Objective

NIRM works to :

Excel as an R&D organisation by providing high quality, need based, value added services in the emerging areas of rock mechanics and rock engineering for surface and underground excavations.

Disseminate the knowledge and expertise through publication of papers in national and international journals and seminars.

Facilitate skill enhancement through training and workshops.

Conduct training courses and workshops for professionals, and provide research facilities for higher education in rock mechanics and rock engineering.

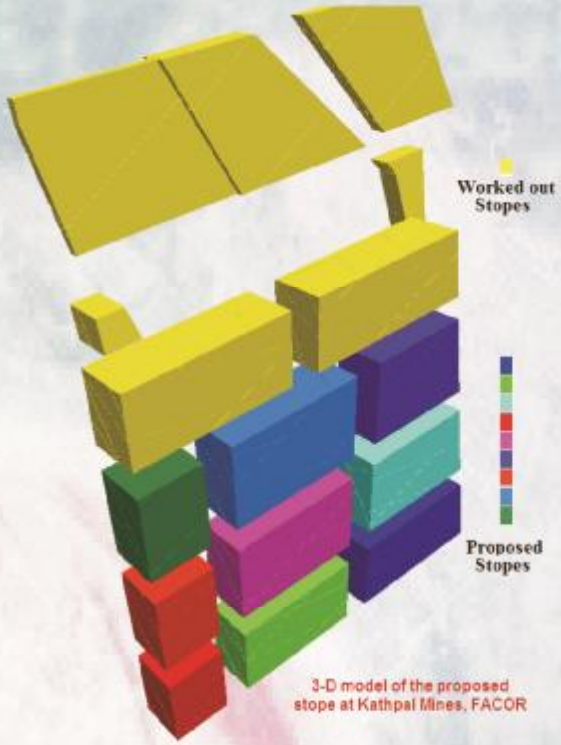
Quality Policy

NIRM is dedicated to :

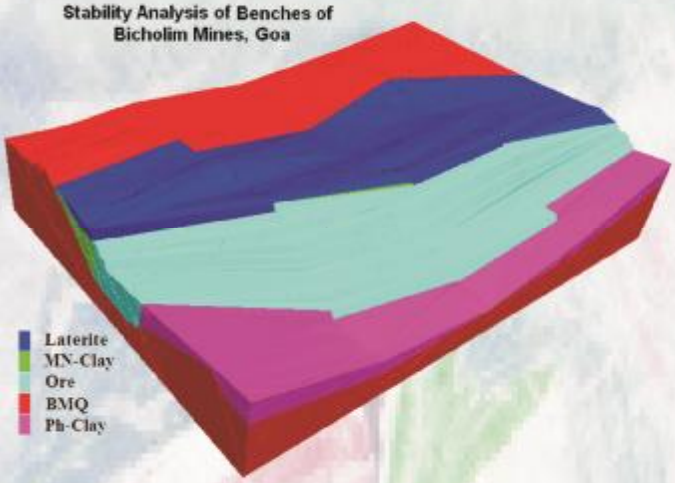
Carry out advanced research in the areas of Rock Mechanics and Rock Engineering to remain a centre of excellence.

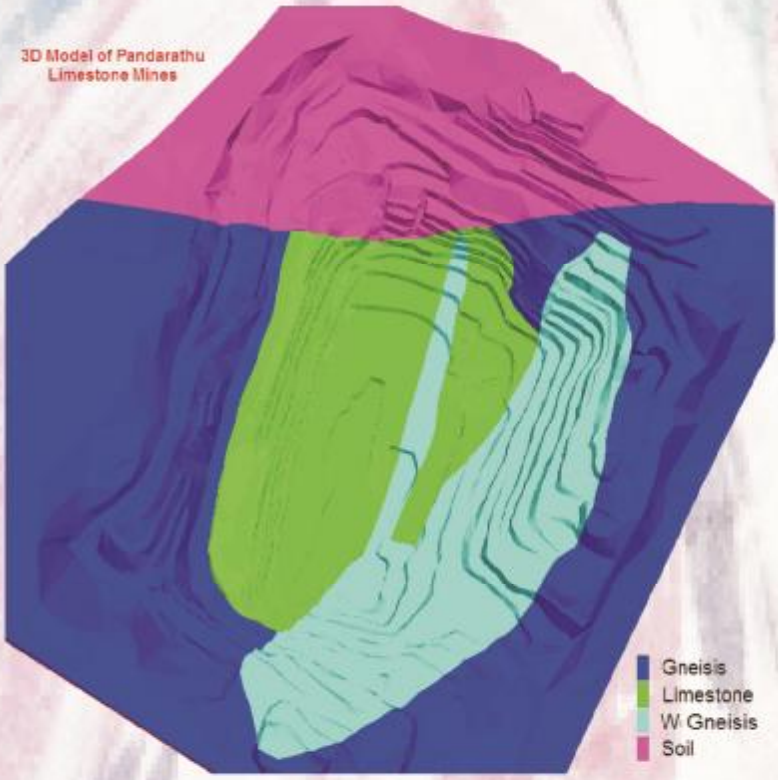
Provide quality services to the total satisfaction of customers with strict adherence to contractual specifications.

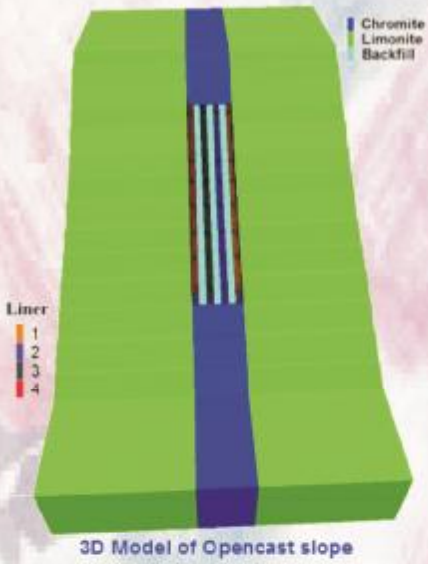
Enhance knowledge and skill of the employees through self development on continuous basis.



3-D model of the proposed stope at Kathpal Mines, FACOR







3D Model of Opencast slope

Spectrum of 3-D modelling studies being carried out at the Institute

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