ANNUAL REPORT

वार्षिक प्रतिवेदन

2013-14

राष्ट्रीय शिला यांत्रिकी संस्थान
National Institute of Rock Mechanics
(Ministry of Mines, Govt. of India)
Champion Reefs
Kolar Gold Fields - 563 117
Karnataka, India

NIRM Celebrates Silver Jubilee Year

Dr. A K Pujari, IAS, Secretary, Ministry of Mines and Chairman, NIRM Governing Body handing over the Silver Jubilee Memento to Sri P K Lahiri, IAS (retd.), Member of the First Governing Body of NIRM and Present Chairman, Academic Council, ISM, Dhanbad

Dr. N M Raju, Founder Director, NIRM delivering the nostalgic address at the plenary session of the Silver Jubilee Function of NIRM

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An ISO 9001:2008 Certified Research Institute

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NATIONAL INSTITUTE OF ROCK MECHANICS

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Edited & Published by : Technical Coordination & Project Management Department

Printed at : Bangalore – 560 016

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DIRECTOR'S REPORT

The National Institute of Rock Mechanics (NIRM) has been carrying out research and consultancy work in the areas of rock mechanics and rock engineering. The Institute has unique expertise in the key areas of rock mechanics and rock engineering. We are extending our R&D support to whole of the mining industry, civil engineering projects involving underground caverns and tunnels, and to infrastructure projects like underground metros, LPG / crude oil storage caverns, etc. in the country. With a proven track record of 25 years, the Institute celebrated its Silver Jubilee during 2013-14. It is a privilege for me to present the 26th Annual Report of the Institute.

Major Achievements during 2013-14

Our involvement with various projects has continued during 2013-14 with substantial addition in the number of projects and earnings to the Institute. The projects of national importance carried out by the Institute during the year include the geological mapping and design of rock support systems for the underground tunnels and structures for irrigation projects in Andhra Pradesh, geophysical investigations for Haldia-Barauni pipeline section within Ranigaj coal belt area, 3D numerical modelling for mine shafts and underground caverns of hydroelectric projects, rock blasting close to structures for the Chennai Metro Rail, blast design for limestone mines and canal works, and rip-rap blasting for the dam construction works at Indira Sagar Polavaram Project, Andhra Pradesh.

NIRM also carried out proof testing and non-destructive testing (NDT) of wire ropes, mining machinery and their accessories, as per the guidelines of the Directorate General of Mines Safety and as per international standards. In this regard, NIRM signed 5 MoUs with ONGC, UCIL, M/s Shaft Sinkers (Rajasthan) and M/s China Coal (Rajasthan).

Site Characterization

The review of construction stage engineering geological investigations for the crude oil strategic storage projects at Padur and Mangalore were carried out. Construction stage engineering geological mapping of turbine generator buildings foundations of Rajasthan Atomic Power Project Units 7&8 were carried out. Geological investigations were continued for various packages of Pranahita-Chevella irrigation project in AP.

Geophysical investigations were carried out for the 180 km long Haldia - Barauni crude oil pipeline of the Indian Oil Corporation Ltd. Passing through the Raniganj-Asansol coalfield area in West Bengal, the old mining areas were identified to warn about the subsidence prone area in the proximity of the pipeline. For the Nikachhu Hydro Power Project near Trongsa in Bhutan, Seismic Refraction Survey and Electrical Resistivity Imaging were carried out along various pre-identified lines, to map the depth of the overburden and the

hard rock profile, indicate subsurface geological conditions and to identify any major geological pitfalls or anomalies.

In-situ stress and modulus of deformability and shear parameters of the rock mass were determined at Teesta Stage-IV Hydroelectric Project in Sikkim. At Attunli hydroelectric project, the stress tensor around the proposed powerhouse chamber was determined. Based on this study the stable orientation of the underground excavation was suggested to the project authorities.

Design & Monitoring

NIRM carried out numerical modelling for stress analysis, stability evaluation and support design for various hydel, mining and other infrastructure projects. At Tapovan Vishnugad Hydroelectric project, back analysis of modeling parameters based on updated instrumentation data has been taken up. For Mangdechu Hydroelectric Project, Bhutan, the stability of the underground powerhouse complex was evaluated, and modifications in the support system were suggested.

The stability of the shafts at Central Mochia, Balaria, West Mochia and Zawarmala mines of Hindustan Zinc Ltd. was studied using three dimensional numerical models. Feasibility of further deepening of the shaft by another 300 m was also studied. The stability of rock and soil slopes of the south eastern benches at 1 Top pit of Bicholim iron ore mine was evaluated, and recommendations were made to strengthen the slopes. Similar studies were completed for Sonshi Iron ore mine of M/s Cosme Costa & Sons situated in North Goa.

For the pump house and surge shaft under package 23 of Pranahita – Chevella irrigation project in AP, the behaviour of the openings at various stages of excavation was studied using 3D models, and the required supports were recommended.

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.

For Chennai Metro Rail metro rail link, considering the quantity of hard rock to be removed and the proximity of the critical structures on the surface, NIRM provided a tailor-made controlled blasting design for excavation of the underground metro station. Similar studies were also carried out for constructing Mantri Webcity at Bangalore comprising six parcels each containing 17 to 22 storied high raise structures.

At Thangarabalu Hydro Project at Raichur in Karnataka, NIRM Scientists suggested the safe maximum charge per delay for 45 mm and 60 mm hole diameters for box cut (opening of free face) and progressive bench blast. At the Rajasthan Atomic Power Plant (RAPP) 7&8 unit, Rawatbhata. about 14000 cu.m of hard rock was safely excavated by drilling and blasting using the methodology approved by NIRM.

Studies were carried out for Vellathooval small hydroelectric project belonging to Kerala State Electricity Board, the captive limestone mine at Krishnanagar, Kadapa District of Andhra Pradesh, Sangam Kalan limestone mines in Tandur Mandal of Ranga Reddy district, Andhra Pradesh.

For the Sardar Sarovar project, Gujarat, NIRM provided the requisite technical guidance in controlled blasting. Similarly, at Indira Sagar Polavaram Hydro Electric Project, AP, and has been providing solutions to the rock mechanics problems being faced at Tummalapalle mine (Kadapa District, Andhra Pradesh).

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.

National Seminar

As part of its celebrations to commemorate the completion of 25 Years of dedicated services to the Nation, NIRM organized a National Seminar on 'Innovative Practices in Rock Mechanics' (IPRM) at Bengaluru, on 6-7 February, 2014. Over 130 delegates from the industry, research and academic institutes participated in it. Seven Keynote addresses, and 30 technical papers were presented in the Seminar spread over six Sessions.

Performance at a Glance

During 2013-14, NIRM completed 43 research projects, and continued investigations for another 29 projects. NIRM scientists contributed a total of 35 technical papers in various national/international journals and symposia.

NIRM is thankful to various government and private agencies and industries for funding the projects. We also acknowledge the guidance from the Peer Review Committee, and the support from the Governing Body and General Body of the Institute. The assistance from the Ministry of Mines, Govt of India, is gratefully acknowledged. I appreciate the hard work and dedication of all the Scientists and staff of the Institute who toiled to keep up the flag of the Institute flying high. With all these contributions, the Institute could sign off the Silver Jubilee Year with a flourish. I am sure the coming years would see the Institute reach still greater heights.

V Venkateswarlu
Director

1. ENGINEERING GEOLOGICAL INVESTIGATIONS

Engineering geological investigations provide comprehensive geological and geotechnical information for various civil engineering projects during pre-construction, construction and post-construction stages. The inputs of geological and geotechnical investigations are pre-requisite for economic and safe designing of construction projects related to power sector (hydro, thermal, nuclear), transportation sector (metros, rails, tunnels, roads, bridges), mining sector, crude oil storage caverns, irrigation projects as well as 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,
(iii) review of geotechnical reports, and
(iv) preparation of Detailed Project Reports (DPR).

During 2013-14, the Engineering Geology Department had undertaken works related to detailed geological investigations in nine projects, out of which four projects were completed and remaining five are in progress.

- The review of construction stage engineering geological investigations for the crude oil strategic storage projects at Padur and Mangalore were carried out. Three resident geologists (two at Padur and one at Mangalore) were posted for two years at these sites to review the geological and geotechnical investigations on day to day basis with the progress of excavation. As part of the work, rock matrix description, rock discontinuity orientation & description, ground water condition, rock mass quality and permanent support recommendations were reviewed after every drill-blast-mucking-scaling cycle. Based on this, periodic clearances were given for bench excavation and water curtain management. In addition, hydrogeological and geotechnical monitoring review works were also carried out.

- Construction stage engineering geological mapping of turbine generator buildings foundations (TG-7 & TG-8) of Rajasthan Atomic Power Project (RAPP) Units 7&8 were carried out for Larsen & Toubro Limited. The detailed foundation investigations of turbine generator buildings were done. The floors were examined on a grid to grid basis, the size of grid being 1 m x 1 m. All the lithological and structural features were observed and mapped using total station equipment. Classification of rock mass using Rock Mass Rating approach was done and recommendations for the treatment of foundations were made.
- M/s MEIL-MAYTAS-ABB-ANDRITZ (JV) had referred details of tunnels and gravity channels of Pranahita - Chevella Srujala Sravanthi Lift Irrigation Scheme (PCSSLIS)

Package-5 for detailed examination of the underground rock strata for suitability of the twin tunnels in the proposed alignment and adequacy of support design. As a part of this investigation, reports pertaining to geological investigations, laboratory testing of rock specimens, construction methodology for the tunnel & portal excavation, geotechnical monitoring, slope stabilization measures and Computational Fluid Dynamic (CFD) analysis of water flow through the open channel and two parallel tunnels were examined. After review and field investigations, recommendations were made for the construction of portals and tunnels. Alternate alignments were also suggested for sections where safe excavation was not feasible.

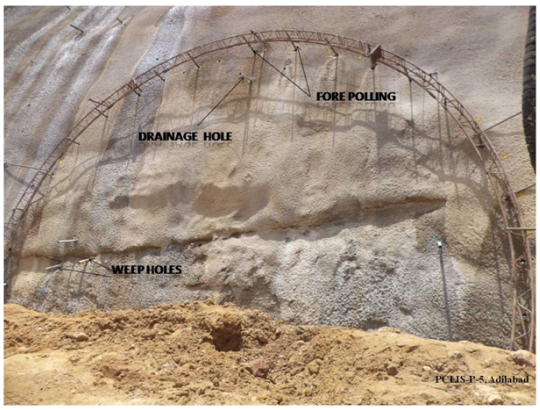


Fig.1.1 Opening of adit portal of tunnel, PCSSLIS-5, Adilabad District, Andhra Pradesh.

- In Package-6 of PCSSLIS (Karimnagar District, AP), geological mapping (3-D and face mapping), rock mass assessment and support system of twin tunnels, namely right main tunnel (RMT) and left main tunnel (LMT), are being carried out by NIRM.


Fig. 1.2 Overbreak and shuttering for backfilling in right main tunnel (downstream side) at right side chainage 8.452 km, PCLIS-P-6, Karimnagar, AP

One resident geologist is posted at the project site. This scheme comprises an underground pump house complex and surge pool. The pump house caverns are located below the hill locally known as 'Jallagutta'. Excavation of these underground caverns will be taken up from access tunnel which joins the caverns from left side (Fig.1.2). The scope of the work includes rock matrix description; rock discontinuity orientation & description, ground water condition, rock mass quality assessment and permanent support recommendations based on rock support categories after every drill & blast-mucking-scaling cycle.

- Construction stage engineering geological investigations of surge pool and pump house (5x30 MW) area of Mahatma Gandhi Kalwakurthi Lift Irrigation Scheme–II, Mahaboobnagar, Andhra Pradesh, is being carried out for the last one year. As part of the work, geological foundation mapping of surge pool (94 m x 40 m), rock ledge

between surge pool and pump house, pump areas (1-5), rock ledge between draft tubes, drain area, sump areas, butterfly valve and service bay of pump house are being carried out for the rock mass assessment, calculation of safe bearing capacity of foundations and support recommendations. Foundation and walls mapping for the surge pool is completed and special treatment plan for shear zones, weathered/sheared dyke and unfavorable major joints are given. Consolidation grouting up to 6.0 m in the foundation of surge pool using primary, secondary and tertiary holes was suggested so that the entire floor area function as single rock mass. For the surge pool Plain Cement Concrete (PCC) of M25 grade lining up to the design foundation level and before 300 mm thick raft foundation was recommended. Pump house area investigations are being carried out for the recommendation of support system of walls and treatment of foundation.

- In Package-12 of PCSSLIS, the feasibility of underground surge pool and pump house is being examined through engineering geological & geotechnical investigations, laboratory testing on rock core samples and support design studies. As a part of these investigation works, engineering geological mapping of surge pool and pump house area on 1:500 scale and geological logging of exploratory drill holes (BH-1, BH-7, BH-9, BH-10 and BH-11) has been completed while geological section along the center line of surge pool and pump house and perpendicular to center line of surge pool and pump house using surface mapping and drill holes data will be prepared. Based on classification of rock masses as per Q /RMR system and analysis of results of all other investigations (engineering geological data, laboratory testing results, in-situ stress parameters and support design), requisite recommendations will be made will be made regarding feasibility of excavation and suitable plan thereof will be submitted.

- The IOT Infrastructure & Energy Services Ltd has assigned the job of assessment of foundation condition and for advising on stability of vertical cuts / excavated surface of Plant Water Pump House area at RAPP Units 7&8. After detailed investigations, the existing design is being modified. In the existing design, six numbers of shear keys are provided in the foundation, which will be eliminated by changing the angle of repose (from 30^{o} to 80^{o}-85^{o}). It is observed that there will be no lateral movement as the rock are very low dipping (up to 5^{o}) and self standing for the last 10 years. Even consolidation grouting in the foundation is not required. M15 grade PCC filling is recommended in the area between PWPH walls and excavated rock face, from the rock bed at the bottom of the raft up to the ground surface. As per IS: 13063 – 1991, an adhesion value of 1-2.5 kg/cm2 between concrete and rock mass is recommended.

- Engineering geological investigations are being carried out for the tail race pool area of Pulichintala hydro electric scheme (4 x 30 MW) in the Guntur District of Andhra Pradesh. The scope of the service includes engineering geological mapping of foundation levels and inclined/vertical surfaces i.e. excavated inclined/vertical walls, identifications of rock defects and recommendations of suitable measures. Existing left bank from tail race pool to end of bell mouth is in unstable condition due to sliding and slippage. The overburden on the left bank comprises weathered rock and fresh phyllite admixed with quartzite. Further investigations are in progress.

2. ENGINEERING GEOPHYSICAL INVESTIGATIONS

Engineering geophysical investigations are essential tools for any civil engineering projects, be it power, infrastructure or mining sector. They provides detailed subsurface information in a non-invasive manner. These form an essential element as design inputs in decision making exercise, in design alteration as well as in various trouble-shooting operations. The Institute carries out routine geophysical investigations for mapping of subsurface strata as part of site characterization studies. Investigations are carried out from surface, underground or across boreholes, using seismic, electrical or GPR tools. During 2013-14, three projects were undertaken including one S&T project sponsored by the Ministry of Mines. Details of the work done in these projects are :

- Indian Oil Corporation Ltd., is operating some 180 km pipeline, mostly buried at 1.0-1.5 m depth, for transportation of crude oil from the port city of Haldia in West Bengal to the refinery at Barauni in Bihar. A section of this pipeline passes through the Raniganj-Asansol coalfield area in West Bengal, wherein there are a number of old mining areas as well as active mining districts. In the past, instances of subsidence over old mined out area have led to damage to the pipeline. Considering the consequential hazard, IOCL identified around 6 km stretch of the pipeline in three sections where some evidence of surface subsidence was visible. It was planned to carry out detailed subsurface mapping (upto a depth of 25 m) using geophysical survey with a view to identify -

  1. voids below the pipeline due to mining (old or new), and
  2. subsidence prone area in the proximity of the pipeline

  Accordingly geophysical survey using electrical resistivity and GPR techniques was carried out close to the pipeline (at 3-5 m distance from it) along the entire 6 km identified stretch. After comprehensive analysis of the processed data, some conspicuous observations were made.

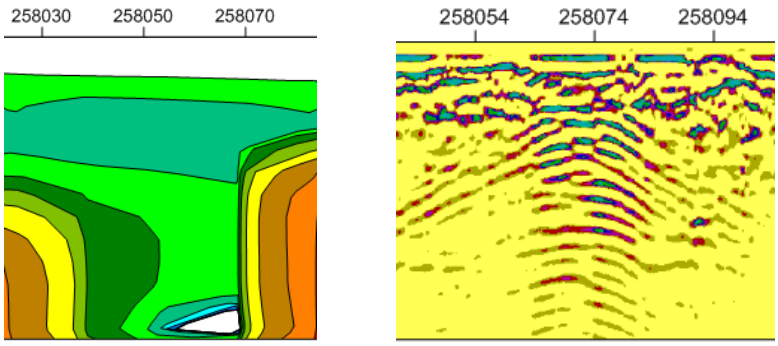


Fig. 2.1 : Signature of a mining gallery in Kajora area

A deep seated cavity was mapped in the Kajora area at around 50 m depth, this is well marked in the resistivity section as a vertical cut in the hard rock and a zero resistivity zone at 50 m depth, indicating that this might be an old mining gallery. The subsidence arch feature indicating strata settlement over this location was mapped continuously up to 5 m depth in the GPR section (Fig. 2.1). Technically, presence of an underground cavity at 50 m depth should not pose any direct threat to the pipeline stability. However, it was suggested that its presence need to be cross-checked with the mine plan available with the ECL authorities.

Another significant feature was the presence of a shallow level old mining activity at chainage 257.730 - 257.930. Its signature was prominent on both resistivity and GPR sections (Fig. 2.2). Considering the location of the shallow old mining gallery, there appears to be a possibility of regional subsidence in this area. Since this entire stretch is close to the location where the pipeline bends at approximately 70^0 angle, the stability of the pipeline is endangered.

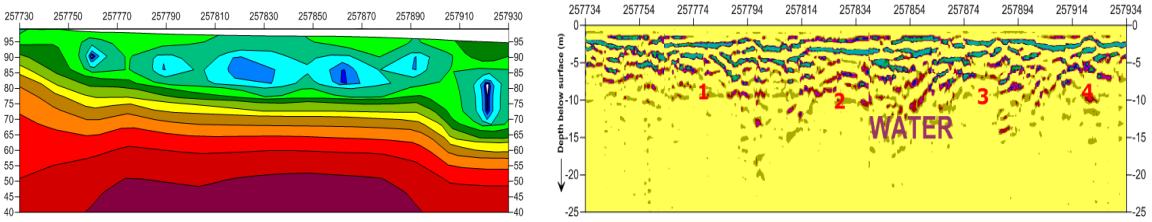


Fig. 2.2 : Part sections from Kajora area

In both the cases, the lateral extent of the mining activity needs to be determined by high-resolution resistivity imaging (up to 25 m depth). To determine the extent of the detailed survey, the mine plan has to be studied. Since ECL authorities indicated that no mine plans were available for the old mining activity, the entire area around this region has to be surveyed again in a grid manner, and the threat quotient to the overall stability of the area has to be assessed. This will provide a likely lead-time before a regional subsidence-like situation arises - if at all the subsurface mining activity is confirmed.

- The Nikachhu Hydro Power Project (NHPP) site at Tashiling near Trongsa in Bhutan is being implemented by M/s Druk Green Power Corporation Limited (DGPCL), Bhutan. As a part of various types of geotechnical investigations for the DPR studies, it was required by M/s DGPCL to carry out Seismic Refraction Survey (SRS) and Electrical Resistivity Imaging (ERI) along various pre-identified lines (Intake, HRT and Desilting Chamber areas). The depth of geophysical investigation was limited to 70 m along the line of survey, with the following objectives :

    1. Map the depth of the overburden and the hard rock profile
    2. Indicate subsurface geological conditions
    3. Identify any major geological pitfalls or anomalies
    4. Depth to the groundwater table (in resistivity section)

  Results of the seismic data processing revealed that the overall strata conditions comprised predominantly overburden material and weathered rock layers; hard rock layer was practically absent (Fig. 2.3). The rock mass conditions around the intake

area were suggestive of weathered rock.

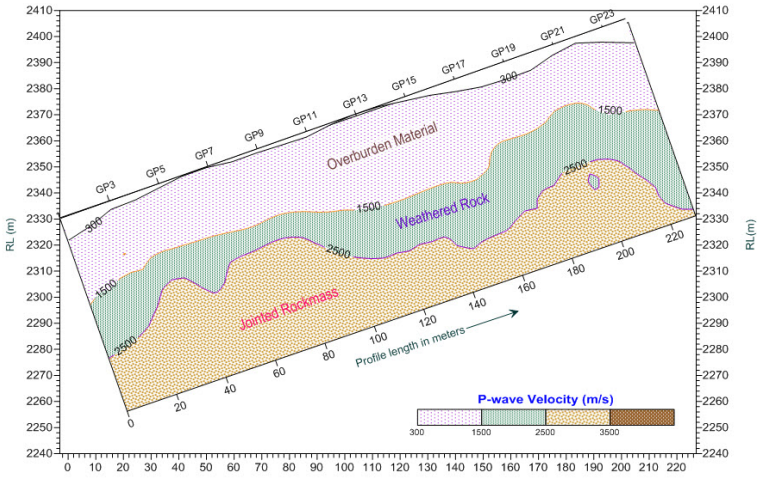


Fig. 2.3 : Typical seismic section showing OB & weathered rock layers

Similarly electric imaging sections revealed the presence of moderately jointed rock mass up to 25 m depth. The rock mass conditions along ER3 line were suggestive of water-saturated and fractured rock mass conditions until RL 2360 m. Along the longitudinal alignment, the rock mass appears to be free from fractured or water-bearing structures. Three prominent water saturated zones (A, B and C) were also mapped. The central bottom part of this section is characterised by moderately jointed rock mass (Fig. 2.4).

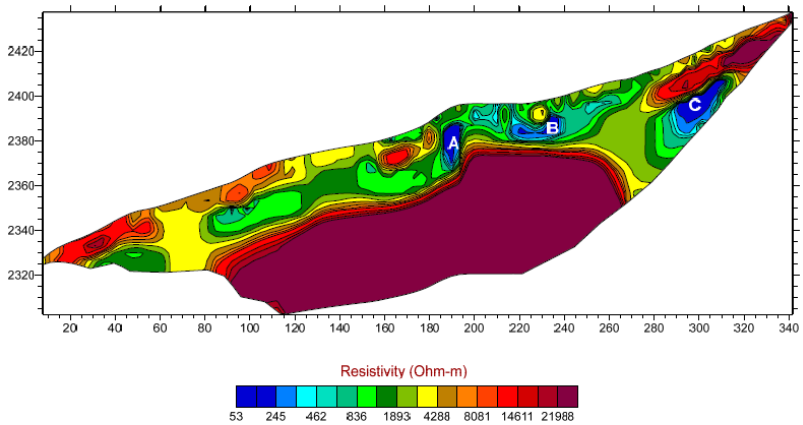


Fig. 2.4 : Typical resistivity section showing jointed rock with water charged OB pockets

A correlation between seismic and resistivity representations indicate that the higher resistivity values might be due to jointed rock mass in dry conditions.

- The S&T project on “Development of a Viable Technique for Assessment of Safety of Structures under Settling Environment” aims at developing an integrated geophysical investigation technique using spectral analysis of surface waves, GPR imaging, NDT testing and laboratory analysis for analysing various types of foundation defects leading to instability of surface structures and for analysis the settlement potential of over old coal mines or reclaimed land for civil structures. This project was sanctioned in the last week of March 2013. NIT has been released and procurement of the required equipment for the project is underway.

3. IN-SITU GEOTECHNICAL INVESTIGATIONS

Determination of the in-situ properties of rock mass is essential for a safe design of any underground structure, and of superstructures like dams. In the design of underground excavations and surface structures the orientation geometry, shape, dimensions, excavation sequence, support system, the acceptable water pressure for the conduits are dependent on the geotechnical properties of the in-situ formations. In underground mining, the mine layout, pillar design, stope design and sequence of mining for safe and economical extraction of the minerals are depend upon the results of geotechnical investigations. Geotechnical Engineering department with its experienced manpower and state of the art equipment is actively involved in different types of in-situ geotechnical investigations (stress, deformability and shear parameters) for numerous projects in India and abroad. During the period 2013-14, this department completed four sponsored projects and continued working on an S&T project sponsored by the Ministry of Mines.

- Teesta Stage-IV Hydroelectric Project in Sikkim envisages construction of 108.5 m high concrete gravity dam, underground powerhouse with 520 MW generation capacity and the desilting chamber. The main litho units exposed in and around the project area include Daling group of meta-volcano-sedimentary rocks, Lingtse granite, gneiss and Central Crystalline Complex (CCC) comprising high grade crystalline rocks, high grade Meta sedimentary units and some calc-silicate gneissic rocks with impure marble.

Fig. 3.1 Measurement of in situ deformability of rock mass at Teesta Stage-IV Hydroelectric project

The scope of the work was to determine the in-situ stress and modulus of deformability and shear parameters of the rock mass in vicinity of the proposed underground powerhouse cavity and in-situ stress at the intake drift of desilting chamber. Results

showed σ_H = 7.28-8.95 MPa (N120^0) at the upstream cross cut drift and σ_h = 3.64-5.97 MPa (N110^0) at the downstream cross cut drift of the powerhouse, whereas it was 7.57 and 5.05 MPa (N20^0) at the intake drift. In-situ deformability at the powerhouse drift E_m was 5.39 ± 0.27 GPa, whereas peak shear parameters were c = 3.66kg/cm^2 and Ø = 55.44^0, the residua being c = 0.734 kg/cm^2 and Ø = 52.71^0.

- At Attunli hydroelectric Project, the scope of the work was to determine stress tensor around the proposed powerhouse chamber. This project is located near Attunli village in the Dibang Valley district of Arunachal Pradesh. The project envisages utilizing the discharges of the NE-SW flowing Dri River and ENE-WSW flowing Tangon River to generate 680 MW of power. The project involves construction of a 204 m long and 85 m high concrete gravity dam. The major rock units exposed in and around the project belong to Etalin formation and Diorite-Granodiorite-Granite Complex or Lohit Granitoid Complex.

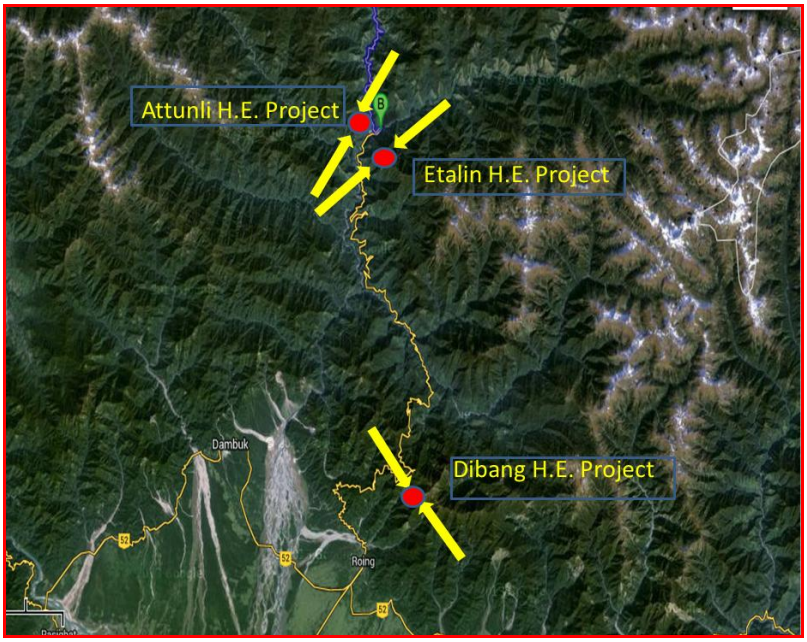


Fig. 3.2 The direction of maximum compression at various projects in Dibang valley

The results of the investigations indicated σ_H = 10.98 ± 0.33 MPa (N30^0) and σ_h = 7.32 ± 0.22 MPa with a K value of 1.68. After a detailed study of the major lineaments and the direction of major compression the recommended orientation of the underground excavation is N30^0 (Fig. 3.2).

- At Mangdechhu Hydroelectric Project in Central Bhutan, the objectives of investigations were (a) to determine of in-situ shear characteristics of the rock-rock interface inside the niches prepared in Class-III area as well as in the shear zone area, and (b) to determine in-situ modulus of deformability of the rock mass at the proposed powerhouse complex. This project envisages construction of a 57 m high concrete gravity dam across river Mangdechhu to generate 720MW of power. An underground power house of width, length and height of 23, 155 and 41m respectively in proposed in granitic gneiss rock. The project area lies in the High Himalayan sequence of rocks.

The project is surrounded by rocks belonging to Thimpu Gneissic Complex (TGC) and meta-sediments of Thimpu-Chekha Group.

Fig. 3.3 Measurement of in-situ deformability of rock mass at Mangdechhu hydroelectric project

Accordingly in-situ shear and deformability parameters of the rockmass at different locations inside the powerhouse complex were determined (Fig. 3.3). The results of the investigations showed c = 3.8267 kg/cm^2 and $\phi = 35.8^0$ for peak shear and c = 2.7918 kg/cm^2 and $\phi = 34.2^0$ for residual shear for Class III rock mass. In the shear zone area, this was c = 3.6111 kg/cm^2 and $\phi = 25.6^0$ for peak shear and c = 2.3538 kg/cm^2 and $\phi = 25.3^0$ for residual shear. In Class III area, the modulus of deformability of rock mass varied from 2.01 to 3.99 GPa, whereas modulus of elasticity varied from 2.31 to 5.24 GPa. In the shear zone area, the modulus of deformability of rock mass rangied from 0.46 to 1.24 GPa, whereas modulus of elasticity ranged from 0.49 to 1.36 GPa.

4. ENGINEERING SEISMOLOGY & SEISMOTECTONICS

Continuous monitoring of seismic activity is essential to understand the seismic risk of the region. Similarly Seismotectonic studies of a region or site decides the feasibility and/or design of any critical civil engineering structure including nuclear establishments, dams underground structures and lifelines crossing active faults. NIRM has been carrying out seismotectonic investigations for nuclear installations, as per IAEA and AERB guidelines. During 2013-14, the Engineering Seismology department continued work on S & T projects for assessing the seismic hazard potential due to closure of BGML mines at KGF. In addition, it worked on three sponsored projects of NPCIL for assessing the seismic hazard potential at their power plant.

- The Broad Band Station (BBS) forming part of the southern shield monitoring network, installed under the World Bank assisted project under the aegis of the Ministry of Earth Sciences, at the Central Seismic Station (KGF Observatory) is working satisfactorily for round the clock monitoring of the seismic activity. Data of BBS station is transmitted to the IMD, Delhi and to NGRI through dedicated VSAT link. This data is scanned daily for seismic events as well as mine-induced-seismicity (rockbursts). Strong Motion Accelerograph (SMA) installed along with BB station is used for recording and studying the effects of rockbursts (Fig. 4.1) and local earthquake activity for seismic risk assessment of the Kolar Gold Fields region.

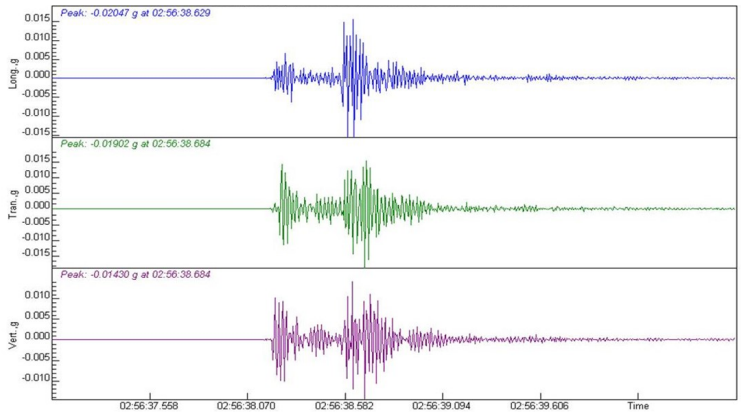


Fig. 4.1 : Seismic signature of rockburst recorded by SMA at KGF Observatory on 30 .01.2014

The strong motion data are used for computing source parameters of rockbursts, such as source radius, seismic moment, stress drop and corner frequency. In addition, power spectral density of strong motion data is regularly analysed. They are useful in characterising rockbursts and for risk assessment to super-structures in the mining

area. DST has approved for further continuation this project for next three years (beyond Jan 2014) but budgetary sanction is still awaited.

- In continuation with the earlier studies by NIRM for evaluating all the lineaments within 30-50 km radius of the Kudankulam Nuclear Power Plant (KNPP), all the 103 lineaments identified by NIRM were grouped in different sets based on their affinity and trend. These lineaments were categorised into three group viz.,

  1) those with no surface expression or seismic activity;
  2) those with no surface expression but associated with seismic activity and
  3) those with both surface expression and seismicity.

  Some of them are falling in hilly terrain and reserve forest. Out of three categories, the first one is not significant to seismotectonic evaluation, the second category may be considered as capable fault and the third category which include lineaments having surface signature of faulting and seismicity may be treated as active faults. NIRM studies identified L4 (Fig. 4.2) and N2 (Fig. 4.3) as active faults.

Fig. 4.2 Faults identified along L4 lineament

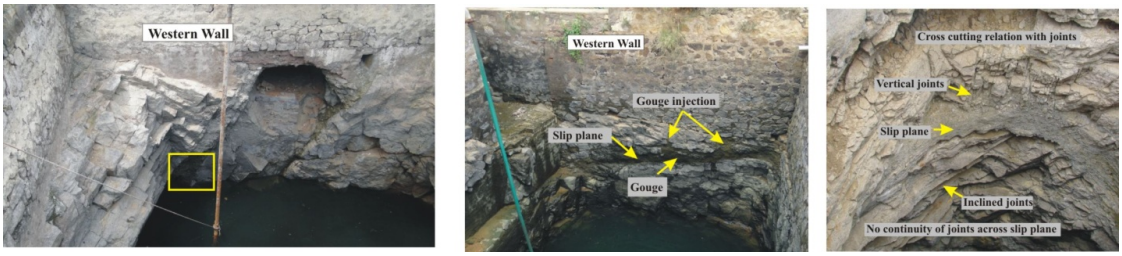


Fig. 4.3 Faults identified along N2 lineament

The L4 represent NW-SE trending Tenmalai fault and N2 a lineament parallel to it. A 700 m long surface rupture was identified along L4 in which two different faulting episodes were identified. Emergence of faulting to the surface was also observed along N2. These two faults are having regional affinity to Achankovil shear system. Two more NW-SE trending lineament sets (M2 and N8) were identified parallel to it. However these lineaments do not show any surface indication of faulting. The N_S lineaments are observed as random and probably formed due to tension. NE-SW lineaments however do not show any evidence of faulting. Further studies are delayed due to site access restriction (forest land) for which permission is awaited from forest authorities.

- In November 2011, Peoples Movement Against Nuclear Energy (PMANE) they reported certain incidence of rock melt and related it with geological phenomena. They raised many questions regarding the safety of the Kudankulam Nuclear power project. Consequently, NPCIL approached NIRM for studying the Rock Melt Extrusions (RME) phenomenon near the Kudankulam Atomic Power Plant Region and evaluate the

issues raised by the PMANE group. For this purpose, areas around the RME site were visited and physical inspection of the features was carried out. It indicated that the suspected RME might be due to the lightning and/or shorting of the high voltage current into the ground through the concrete pole. The RME materials were similar to fulgurite material formed due to lightning effect (Fig. 4.4). It was suspected that the short circuited current (which was of high value) had passed through the pole for a long duration which generated heat resulting in the melting of the reinforced concrete (RCC) material of the pole particularly at the bottom areas.

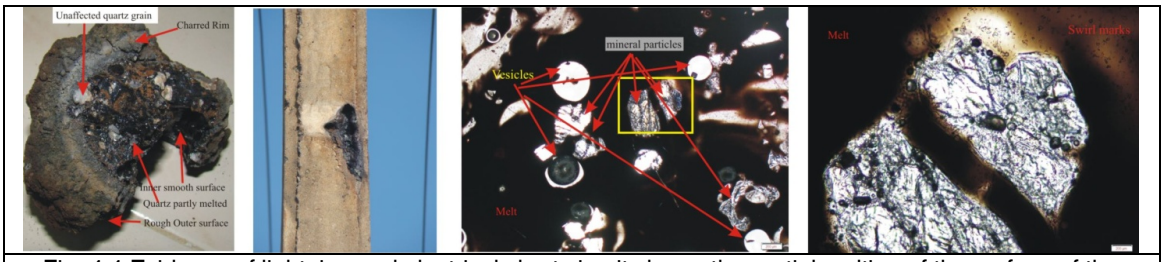


Fig. 4.4 Evidence of lightning and electrical short circuit shown the partial melting of the surface of the concrete electric pole. Photomicrograph of the RME sample showed partially melted mineral grain

A detailed inspection report was submitted giving the observations and evidences stating that these totally related electrical short-circuiting and lightening in the area and is not having any relation with the neotectonic or volcanic activity. Thin section studies indicate no development of neocrystals which are typical of volcanic rocks (Fig. 3 c& d). Geochemical studies also do not show any anomalies suggesting volcanic origin. The referred "rock melts" were the melts of RCC material as well as soil materials in contact with the pole. Both the reports are accepted by the Expert Group constituted by GoI and are included in their report and are available in the web site.

- Following the report of suspected geothermal activity around Kudankulam area, NPCIL approached NIRM to evaluate the incidence. The event occurred in Manappad located 44 km northeast of Kudankulam Nuclear Power Project. Preliminary site visit was done to locate the feature associated with the reported geothermal activity. The water samples were collected from the nearby wells and a pilot study was carried out along the lineament to collect the mineral precipitate from the fracture zones. GSI and AMD was approached for analysis of the collected water and intra-fault materials. At present Tamilnadu Government's permission is awaited to carry out physical verification of the features identified during the preliminary site visit.

- An S&T project was sanctioned by the DST for evaluation of Neotectonic activity of Desamangalam fault in the Western Terminus of Palghat Gap in Kerala. The region around Wadakkancheri, which lies in the south western terminus of Palghat gap is experiencing micro seismic activity since 1989.

  This project is to identify active tectonic elements in this region so as to evaluate the seismic potential of the area. Remote sensing studies identified subtle changes in geomprphology through SRTM data analysis. The study further identified a network of suspected paleochannels south of Bharathapuzha river. Detailed trench investigations were carried out in these paleochannels to understand the shallow stratigraphy (Fig. 4.5). Thick clay observed in trenches close to coast underlain by 3-4 m thick peat bed. In most of the inland area, thin overlying sediments were observed over laterite. Details

study identified that these laterites are derived from the Miocene sediments and are equivalent to Warkalai formations.

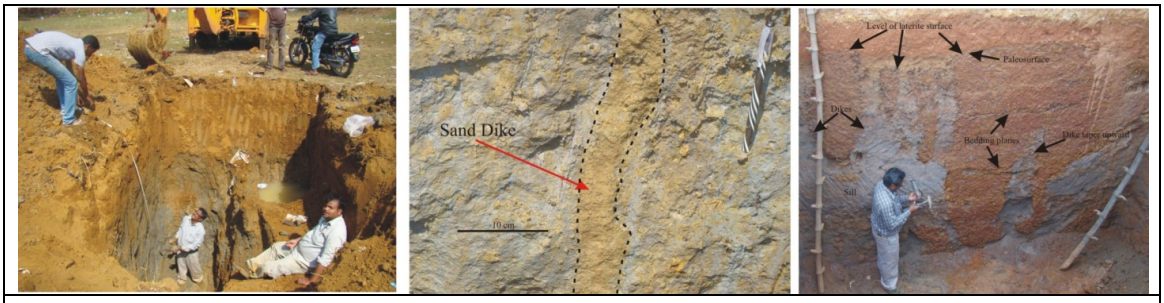


Fig. 4.5 Trench studies in Kerala to identify paleo-liquefaction features

One of the trenches near Edappal shows sand dikes. In that particular trench the excavation was done up to 3 m. The height of the sand dyke was identified up to 1.2 m. Detailed trench studies indicate that similar sand dikes are present in an area of 8-10 km radius. Charnockite rock is the major rock type observed in this area. A number of sympathetic (NW-SE) and antithetic (NNE-SSW) brittle faults to Desamangalam fault (NW-SE) are identified in this area. These are seen to be either parallel or perpendicular to the foliation. The faulting seems to be related with multiple fluid activity as evidence from the secondary mineralisation. Brittle deformation was dominant with reverse movement and gouge formation. For determining the time of the event, stratigraphically controlled samples were collected for OSL dating. Investigations are thus complete under this project.

5. NUMERICAL MODELLING

NIRM undertakes analysis of a wide range of rock mechanics problems in the areas of mining and civil engineering using discontinuum and continuum techniques. During the year 2013-14, the Numerical Modelling Department carried out investigations for ten projects, out of which six belonged to stress analysis and modeling for hydel and mining projects, and four to slope stability and irrigation projects. The progress made in these projects is presented here :

a) Modelling for hydel projects :

- The underground powerhouse complex of Tapovan Vishnugad Hydroelectric project consists of three main types of excavations : i) Powerhouse, ii) Transformer Hall, and iii) Bus Ducts and other tunnels. Based on the geological information given by NTPC, NIRM carried out 3D modelling studies in 2010 using the discontinuum code, 3DEC, by incorporating in-situ conditions like joint sets, weak zones, shear zones and other geological features which were known prior to the excavation.

  After substantial excavation had progressed in Tapovan Vishnugad powerhouse complex, substantial amount of instrumentation data was available to NTPC. Based on this input, NTPC assigned the job of “Back Analysis of Powerhouse Complex Behavior using 3D Numerical Modeling”. An interim report was submitted to NTPC in May 2011. Once again NTPC has submitted instrumentation data for updating this model. Presently, data analysis is in progress. Back analysis of modeling parameters based on these updated set of instrumentation data will be taken up shortly.

- Mangdechu Hydroelectric Project (MHP), under construction in Bhutan, involves construction of 114 m high concrete gravity dam, and an underground powerhouse complex. The stability of the underground powerhouse complex for given excavation sequence and support system was evaluated and modifications in the support system was suggested. Geometrical and geological details were furnished by MHPA. The test results from field and laboratory were also provided by MHPA. 3D discontinuum model was prepared using 3DEC. Shear zones in the powerhouse area based on drill holes in the area were incorporated in the model.

  The model results show that supports in the form of rock bolts in the crown of powerhouse cavern were adequate with the additionally installed 12m long rock bolts for further benching operations. The results also showed that the thickness of SFRS of 250 mm was adequate for control of rock mass movement. The proposed rib sections at different locations were effective in distribution of the movements in the roof, thus improving the stability of the rock mass around the caverns. The studies reveal that due

to the presence of the ribs, the magnitude of displacement reduced by 15 to 20 mm at certain locations. The scooping of 2 m of fractured zone and back filling with concrete significantly increased the stability of rock mass around the caverns. The bus ducts need additional supports as the model studies indicated failure of many bolts.

- A study is commissioned by the MHP authorities to carry out slope stability analysis of the dam abutments slopes in rock as well as in soil mass and to suggest suitable support system. Accordingly a site visit was made by NIR Scientists to study the problem, and then a 3D model was prepared incorporating all the geological and support details at the site. After initial analysis, it was observed that the failure of slopes and benches were not due to displacements, but due to the failure (strength) of rock mass and development of tensile zones at different regions along the slope. As per our observations, we suggested additional supports in the following sections:

Regions	Left Bank	Right Bank	Additional support measures
Section 1	EL 1680 to 1700	EL 1680 to 1690	Pre-stressed cable anchors.
Section 2	Bench at EL1763	EL 1675 to 1685	Pre-stressed cable anchors and rock bolts
Section 3	EL 1675 to 1685	EL 1675 to 1685	Pre-stressed cable anchors (30-50t) of 32mm diameter and 25m long.
Section 4	----	----	----
Section 5	EL 1703 to 1715 Bench at EL 1750	Bench at EL 1747.5 EL 1770 to 1780	Pre-stressed cable anchors and rock bolts
Section 6	Bench at EL 1771	EL 1665 to 1690	Rock bolts, concrete retaining wall, grouting and pre-stressed cable anchors
Section 7	EL 1670-1685 EL 1700-1715 EL 1730-1745	EL1720-1750 EL 1670-1685	Concrete retaining wall and grouting, pre-stressed cable anchors
Section 8	EL 1760-1775	EL1670-1685	Pre-stressed cable anchors, concrete retaining wall and grouting

- Tehri Pumped Storage Project (PSP) comprises four reversible pump turbine units of 250 MW each. This would involve construction of an underground machine hall on the left bank of river Bhagirathi. Hindustan Construction Co. Ltd. is constructing the Tehri PSP underground components. 3D stress analysis using numerical modelling is being carried out by NIRM for the underground caverns of powerhouse complex with downstream surge shaft bus bar tunnels and penstock entry for powerhouse complex, downstream surge shafts, bus ducts and other tunnels at Tehri PSP. Preliminary modelling studies were completed and results were discussed with HCC.

b) Modelling for mining projects :

- Hindustan Zinc Ltd. (HZL) belonging to Vedanta Resources Plc. extracts lead and zinc through underground mines at Zawar group of mines. At the request of HZL, NIRM investigated the stability of the shafts at Central Mochia, Balaria, West Mochia and Zawarmala mines, and studied the feasibility of further deepening of the shaft by another 300 m. For this, NIRM Scientists collected the geological and geotechnical information and conducted three dimensional numerical modeling studies.

In the central Mochia mines, the displacement pattern in a vertical section through the shaft (Fig. 5.1) indicated that the southern wall of the subsidence area had large displacement values (10 -23 mm) near the surface. However, the displacement at the shaft reduced to 8 – 10 mm up to 5th level from shaft top and diminished with depth. The stress distributions were as per the excavations in the surrounding areas and there was no abnormality of stresses surrounding the shaft. Analysis of deepening of the shafts with rectangular section and circular section showed that the circular section was preferable as it offered better distribution of stresses and displacements surrounding the shaft.

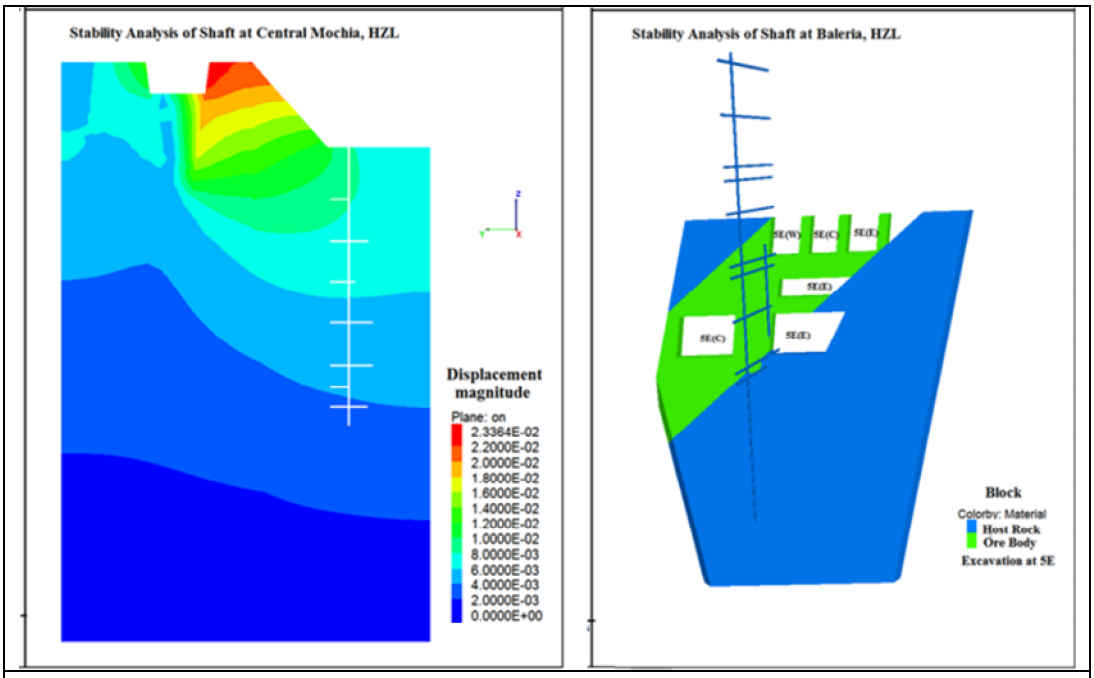


Fig. 5.1 Displacement pattern in a vertical section through the Shaft, Central Mochia 3D model of Balaria Shaft with 5E stopes

Results of 3D stress analysis of the Balaria shaft and the effect of the nearby 3E and 5E stopes indicated that currently the shaft was not affected by the stoping operations. However, the 5E stope between 38 to -25 mRL should be back filled keeping in view the long term stability of the shaft. This warranted design of proper stoping parameters and adoption of controlled blasting in the periphery of the shaft. Analysis of deepening of the shafts with circular section showed that there were no abnormal stresses and displacements surrounding the shaft after deepening. The shaft may be deepened up to -350 mRL with current dimensions.

Results of 3D stress analysis of the West Mochia shaft and the effect of the nearby CW0 stopes indicated that currently the shaft was not affected by the stoping operations. Analysis of deepening of the shafts with circular section showed that there were no abnormal stresses and displacements surrounding the shaft after deepening. The shaft may be deepened up to -275 mRL with current dimensions.

Analysis of the modeling results of Zawarmala mines shaft indicated that since the shaft was located away from the main ore lens and the ore lenses gradually shifted due to plunge, the possibility of stoping operations affecting the shaft were remote. Analysis of

deepening of the shafts with circular section showed that there were no abnormal stresses and displacements surrounding the shaft after deepening. The shaft may be deepened up to -135 mRL with current dimensions.

- The stability of rock and soil slopes of the south eastern benches at 1 Top pit of Bicholim iron ore mine was evaluated. Slope stability analysis at three sections i.e. 52, 53 and 54, were taken up using limit equilibrium analysis. The critical factors of safety obtained at these sections were above 1.5 in the present extracted profiles, which indicated that the benches were stable. However due to the presence of different types of clay materials mixed with sand, there was the likelihood of formation of tension cracks in the benches during the extraction. The factor of safety circles indicated critical paths occurring within the mine boundary. Hence the occurrence of cracks/ground movement due to extraction beyond 50 m from the crest of the top most benches was ruled out.

  Further, the stability of the slopes with bench profiles after extraction was analysed using 3D numerical models. The models predicted the displacements in the range of 0 to 78.6 mm. The safety factors calculated from the models were above 1.5 which compare well with those predicted by limit equilibrium analysis. Based on the field studies, numerical modeling and limit equilibrium analyses, following recommendations were made :

  1. cracks in the locality should be marked and monitored to evaluate further development of the cracks
  2. In the absence of any credible geological input, three to four boreholes may be drilled at different locations to confirm the presence of clay under the top soil.
  3. the present Settling Pond-1 should be back filled, and water should be directly pumped into Settling Pond-2
  4. The top level may be excavated up to 10 m towards north east direction on sections 54 and 55 to maintain better factor of safety.

The study also assessed the ground movement issues at the nearby houses and recommended suitable measures to be undertaken by the M/s Sesa Mining Corporation Ltd., at certain vulnerable areas.

c) Modelling for irrigation projects :

- Pranahitha - Chevella Sujala Sravanthi Lift Irrigation Scheme (PCSSLIS) is being constructed to cater to the irrigation and drinking water needs of the drought prone districts of Telangana. Civil works under this scheme are divided into 245 packages. Under package 23, M/s Patel Engineering Ltd are constructing an underground pump house (122.50 m x 20 m x 38.5 m) and a surge shaft (61.5 m x 21 m x 65.4 m). Currently a 9 m x 9 m construction cum access shaft is excavated to 80 m depth, reaching the crown level of the pump house. The pump house lies in granitic terrain. In this study, the behaviour of the pump house and surge shaft at various stages of excavation and supporting was studied using 3DEC modeling software (Fig. 5.2).

  The required supports for surge shaft and pump house were estimated using the integrated approach as per IS code 15026-2002. Accordingly, 32 mm diameter and 6 m long bolts (Fe 415) were considered in the crown as well as in the walls, and 40 mm

thick SFRS for the crown and walls of surge shaft and pump house. The modelling results showed that the estimated support system was adequate for most of the places in the surge shaft and pump house. However keeping in view some localised failures and breaking of the bond between SFRS and rock at a few places, the following recommendations were made:

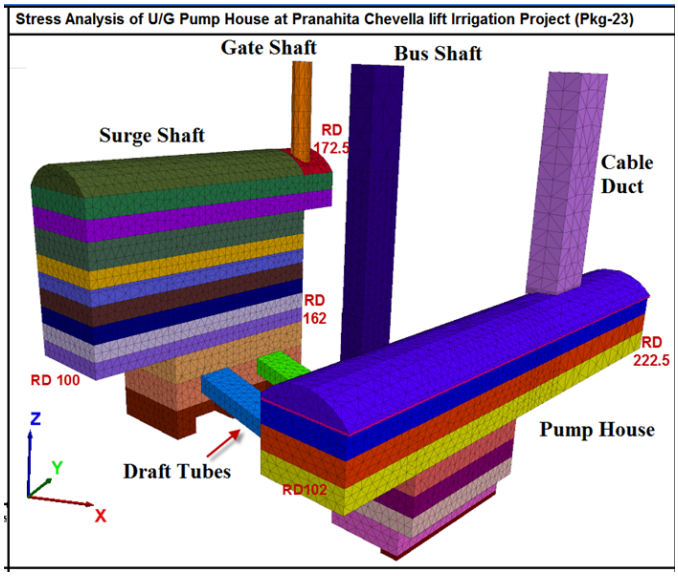


Fig. 5.2 3D view of the model showing pump house, surge shaft and other components

1) SFRS thickness may be increased to 60 mm in the walls of the pump house between EL 485 m and EL 480 m.
2) Controlled blasting techniques may be adopted in order to minimise the damage in the immediate vicinity of the excavation.
3) Rock bolts (6 m long and 32 mm diameter) may be installed all along the floor of the pump house and surge shaft to prevent floor heaving. Provision of an invert can also be considered during construction.

6. ROCK BLASTING & EXCAVATION ENGINEERING

NIRM 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 Rock Blasting & Excavation Engineering Department in the Institute 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 to maximise the fragmentation, monitoring blast vibrations and air overpressure for ensuring safe charge limit and advising on controlled blast design with minimum or no fly rock. During 2013-14, the department worked on eleven industry sponsored projects, out of which five were completed remaining six were in progress.

- Vellathooval small hydroelectric project belonging to Kerala State Electricity Board (KSEB) involves rock blasting to the tune of about 20,750 m^3. As this project lies closer to the existing Panniar powerhouse complex and switch yard, the hard rock needs to be excavated by a site specific controlled blasting method. On request from the project authorities, NIRM submitted a detailed Method Statement to arrange the prerequisites for carrying out the field studies with trial blasts. Subsequently, NIRM guided 20 blasts in powerhouse and tail race area, monitored induced vibrations near critical structures in the vicinity. After regression analyses of 61 data set, a site specific equation was derived based on which safe permissible maximum charge per delay and permissible limit of vibration was suggested. The suggested blast designs and muffling procedures were reviewed in subsequent visit and blasting parameters were further optimized to ensure the restriction of vibration within permissible limits.

- M/s Larsen and Toubro Limited is constructing the 400/220 KV switchyard package at the Rajasthan Atomic Power Plant (RAPP) 7&8 unit, Rawatbhata. As part of this work, about 14000 cubic meter of hard rock had to be excavated by drilling and blasting. The excavation site was located about 20 m from the existing switchyard. Incidentally, NIRM had carried out a study on blast design adjacent to this site for M/s Hindustan Construction Company (HCC). As the location of the new site is nearer to the earlier site, L&T wanted to know the validity of this blast design for their site also.

  In order to examine this, NIRM carried out field investigation at the new site and 10 blasts were monitored for ground vibration and air overpressure. A new predictor equation was derived based on this data. On comparison with the earlier equation, it was found that majority of the data sets were below the 95% confidence line of earlier study but it suggested a lower safe maximum charge per delay.

Based on the DGMS recommendations, a safe peak particle velocity of 20 mm/s was suggested to the industrial structures and 3 mm/s for the structures housing electrical and electronic equipments (as suggested by the project authorities). By using the predictor equations of present case, the safe maximum charge per delay was calculated for a permissible vibration level of 3 mm/s. Further, as the switchyard is located at about 20 m from the blasting site, it was recommended to use non-electric initiation systems which offer full immunity to electrical interference. In-house monitoring of ground vibration at switchyard is being continued.

- Thangarabalu Hydro Project at Raichur in Karnataka belongs to Kare Power Resources Private Limited (KPRPL). Implementation of this project involves around 90,000 m^3 of rock excavation out of which 56,700 m^3 was already excavated. Following complaints of blast vibration induced damages from Yelagundi village located at about 120 m from the excavation site, work on excavating remaining 33,300 m^3 was suspended. On request from the management of KPRPL, NIRM carried out the ground vibration / air over-pressure studies at the site deploying 115 mm diameter holes as practiced there earlier. Subsequently, considering adverse environmental impact due to blasting with 115 mm hole diameter, trials were taken up with the hole diameter of 45 mm and 60 mm. The video observations of the blasts were carried out to know about the efficacy of the muffling material and the extent of flyrock and throw of the blasted material.

  Based on regression analysis of the 33 sets of vibration data generated from different hole diameter, a site specific equation was derived. Considering the type of structures at the Yelagundi village, the permissible level of ground vibration 5 mm/s was arrived as per DGMS norms. The safe maximum charge per delay for this limit was suggested. Blast designs were suggested for 45 mm and 60 mm hole diameters for box cut (opening of free face) and progressive bench blast. It was recommended to discontinue the use of 115 mm diameter holes in the project.

- Zuari Cement Limited is operating a captive limestone mine at Krishnanagar, Kadapa District of Andhra Pradesh. The mine management wanted to conduct a study on ground vibration and air overpressure produced from the production blasts. There were no private structures within the vicinity of mine workings. The mine office, plant, colony belonging to the company is located beyond 1.5km. Valasapalle village was located beyond 1km in NW direction from the present working benches and Yerraguntla town was located beyond 1km in NE direction from the present working benches. During field investigation carried out by NIRM, ground vibration and air overpressure were monitored for six blasts. The predictor equation for ground vibration was derived using 41 sets of data and for air overpressure with 26 sets of data. The frequency of ground vibration was greater than 10Hz. Based on the DGMS guidelines, a peak particle velocity of 10 mm/s was suggested as safe for the structures of Valasapalle village and Yerraguntla town. Based Tthe permissible air overpressure limit was recommended as 133dB. Accordingly, the safe maximum charge per delay was suggested for implementation.

- Mantri Developers Pvt. Ltd., Bangalore, is constructing Mantri Webcity at Bangalore comprising six parcels each containing 17 to 22 storied high raise structures. While removing soil for foundation, hard rock was encountered at parcel 2 and 3 at a depth of

about 4 m. This need to be excavated by blasting but the residences located at a distance of about 35 m from the excavation posed a threat to their stability due to blast vibration (Fig. 6.1). Therefore, Mantri Developers requested NIRM to provide the necessary technical advice for safe excavation of the left over hard rock. Accordingly, field investigation was carried out by NIRM with a set of trial blasts. In total, 13 blasts were carried out during the field investigation period; one in parcel 2 area and 12 in parcel 3 area. The recommended hole diameter was 32 mm. The number of holes was restricted to 30 in a blast while the number of rows to 3. The charge per hole was varied and optimized. Non-electric shock tube initiation system was recommended and used at the site. The muffling was done as per the established field procedure.

Fig. 6.1 Photograph showing proximity of residential structures to blasting location

Blasts were muffled with multi-layer sand bags, link mesh and blasting mats to ensure the control of flyrock and noise. For all the blasts conducted during field investigation, the flyrock was restricted within the source itself and the fragmentation obtained was amenable for direct loading into the tippers.

The recorded ground vibration was greater than 18Hz. Based on the generated vibration data the recommended safe peak particle velocity for the structures around the excavation site was 5 mm/s and safe air overpressure limit was 133dB as per DGMS guidelines. The safe maximum charge per delay for different was suggested within these prescribed limits. During field trials, all the blasts conducted within this limit were safe with respect to ground vibration, air overpressure and flyrock. The same practice was advised to be followed for further excavation at site.

- Sangam Kalan limestone mine belonging to M/s India Cements Limited is located in the Tandur Mandal of Ranga Reddy district of Telangana. In the year 2009, the mine management had awarded NIRM the job of monitoring the blast-induced ground vibration twice a year for a period of two years. Once again the management of Sangamkalan Limestone Mines wanted NIRM to carry out monitoring of vibration due to blasting at their mine for a period of two years. Accordingly two field visit were conducted. During these visits ground vibration and air overpressure were monitored

and a brief technical note was submitted along with the summary of trial blasts. The studies are continuing.

- Sardar Sarovar Narmada Nigam Limited (SSNNL) is constructing 118.6 km Morbi branch Canal which is taking off from Saurashtra Branch canal at chainage 104.4 km near Surendernagar and tails in the Machhu II reservoir. The Morbi canal is passing through industrial area (ceramic industries zone) from chainage 109.3 to 115.6 km. These ceramic industries are very close to the edge of the proposed canal (10 to 75 m). The maximum cutting depth required for canal excavation about 10 m in the rocky strata and therefore rocks are required to be excavated by controlled blasting technique, so that the industrial units are not affected by adverse impacts like flyrock, ground vibration and air overpressure of the blast.

  Therefore, SSNNL approached NIRM to provide the requisite technical guidance for controlled blasting. NIRM carried out a preliminary site investigation and a method statement was submitited to SSNNL incorporating the tentative blast designs, requirements of controlled blasting and suggestion of permissible level of blast vibration.

Fig. 6.2 Controlled blasting adjacent to Shreeji ceramic industry, Morbi

  NIRM team carried out field trial in November 2013 and guided the execution of ten controlled blasts between chainage 109-113km. During this trial, the blast vibration close to the critical industrial structures was monitored (Fig. 6.2). An interim report was submitted incorporating the analysis of the data suggested controlled blasting procedure. Subsequently a visit was made in January 2014 to review the suggested blast designs, cross check the vibrations limits and the efficacy of the muffling arrangements. All of them were found within safe limits.

- Indira Sagar Polavaram Hydro Electric Project (960 MW) is proposed to be constructed by the Govt. of Andhra Prades across river Godavari, 42 km upstream of Rajahmundry. The construction of earth cum rock fill dam, spillway and foundation of this project was awarded to M/s. Transstroy-JSC-EC-UES-JV.

  The main dam is proposed to be constructed with rock fill material of 150 mm to 600 mm and 500 mm to 1000 mm for revetment which shall be obtained from excavation of spill way, power house etc. In order to maximise the output of the graded material from blasting, Transstroy-JSC-EC-UES-JV approached NIRM to provide technical advice on

Rip Rap blasting for the construction of earth cum rock fill dam. NIRM carried out preliminary site investigation during September 2013. Based on the preliminary site investigation, a detailed method statement was submitted to Transstroy-JSC-EC-UES-JV, which incorporated the tentative blast designs for rip rap blasting. Further field investigations using trial blasts shall be carried after receiving intimation from the project authorities.

- Chennai Metro Rail Corporation Limited (CMRL) is constructing a metro rail link in the city of Chennai. One of the construction packages of this project is allotted to TT-AFCONS JV which includes construction of underground metro station at the Chennai city railway station. The construction of underground station involves removal of soil/rock to a depth of about 30 m. The width of the station is 30 m while the length is about 300 m. As part of the construction methodology the station area is isolated by constructing a concrete diaphragm wall (1 m thick) to its full depth. During the mechanical removal of the slot along the perimeter of the station area for the erection of the diaphragm wall, it was found that the top soil is terminated at a depth of about 18 m below which the strata is comprised of hard granite rock (Charnokite).

  Considering the quantity of this hard rock to be removed and the proximity of the critical structures on the surface, the excavation may require tailor-made controlled blasting design. In order to assess the probable vibration intensities due to controlled blasting in near field, experiments were conducted at an alternate site (a quarry near Chennai) during October 2012. From this study it could be established that with controlled blasting vibrations could be restricted to the permissible limit during the actual blasting operations at the proposed metro station near Chennai central.

  As the excavation method happens to be top down, it leads to a situation where in blasting is to be carried out under a RCC roof (partially confined conditions). There were apprehensions with regard to the gas pressure that may be exerted on the concrete roof due to use of explosives. In order to assess this, experiments were planned with open blasting in a prefabricated RCC structures; i) two sides of the structure open and ii) one side closed as illustrated in Fig. 6.3.The objective of the study was to monitor air overpressure, vibrations on the concrete roof and the load exerted on the concrete roof for open blasts conducted with small diameter cartridge explosive within this structure.

Fig. 6.3 RCC concrete experimental structure

A load cell (100 tons capacity, least count 50 kg) was mounted inside the roof of the concrete structure to monitor load exerted by the blasting gas. Experiments were conducted at a quarry site near Kanchipuram in December 2013. First set of experiments of 8 blasts were conducted with both sides of the RCC concrete box open and second set of 8 blasts one side closed with. The analysis of the data revealed that monitoring with high frequency geophone might give better understanding.

- Bagmane Estates Pvt. Ltd., Bangalore is constructing Bagmane Constellation Business Park in Outer Ring Road near Mahadevapura area, Bangalore. The proposed construction area needs to be excavated to a depth of 10 m for basement/ foundation/ column erection. The excavation area (VIRGO) is divided into two blocks, Block A and B of varying dimensions depending upon the requirement. After excavating the soil strata it was observed that the hard rock strata was spread all over the area and its profile was undulating. This hard rock strata needs to be excavated by controlled blasting technique or by application of mechanical means.

  The excavation area is surrounded by private residential structures and multi-storied commercial buildings are located within a radius of about 120 m in different direction (Fig. 6.4). The Fern Paradise residences are located at a distance of about 30 m towards eastern side of the excavation area from its boundary. The residents of the Fern Paradise were concerned about ground vibration and air overpressure levels produced from blasting and its impact on their buildings. Keeping this in view, the project authorities approached NIRM for guiding with the design of controlled blasting to mitigate the adverse impacts of blasting.

Fig. 6.4 Hard rock strata, ORION and residential buildings adjacent to the excavation area in south direction

NIRM team visited the site in October 2013 and carried out reconnaissance survey at the site. Subsequently, a detailed method statement was submitted to Bagmane Estates Pvt. Ltd. On mobilisation of the requisite materials, trial blasts and field investigation were carried out at project VIRGO in December 2013 and January 2014. In total twenty seven blasts were executed under the technical guidance of NIRM. Blasts were muffled to control the flyrock. All the critical structures were regularly

covered for monitoring ground vibration. The blasting crew at the site was trained on controlled blasting procedures.

Based on regression analysis of 137 data points collected during trial blasts, a safe permissible peak particle velocity and maximum charge per delay was suggested to be followed for the remaining rock of excavation. An interim report was submitted for the VIRGO site. The second phase of investigation at project CARINA excavation site will be started upon receiving the intimation from the client.

- Waddera Sangam, Karimnagar District, Telangana, is operating fourteen quarries under Survey No. 493 and 497. At all these quarries rock is being excavated by drilling and blasting method. These quarries are located near some villages. Blasting activities was stopped in these quarries following complaints from villagers. Therefore, quarry owners of Waddera Sangam approached the NIRM to conduct a scientific study on ground vibration, air overpressure and assessment of flyrock due to blasting operations at proposed quarries of Sy. No. 493 & 497.

  Accordingly, a preliminary visit was made during January 2014 at the proposed quarries. During the meeting with the officers of the Directorate General of Mines Safety (DGMS) at the site, the methodology for conducting the study was explained to the DyDG. The quarry owners initiated process for getting the permission from DGMS to conduct the study at the proposed quarries. Further investigation will be taken up after getting the intimation from the client.

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. The Institute is actively involved in rock mass characterization, support design, strata monitoring and design of safe and innovative mining methods. Investigations are undertaken to ensure safe extraction of coal and different minerals occurring under difficult ground. During 2013-14, the Institute has taken up seven projects in this area of research.

- In the baryte mines belonging to the Baryte Mine Owners Association in Pulivendula, YSR District, AP, are small mines with no mechanization or systematic method of work. It was required to design a suitable stoping method and to suggest the support system for the level drivages in the mines located near Velledandla, Vempalli, Velpula and Vemula villages. The roof strata over the ore body are dolerite and the dolomite. The strata have a dip of 50^0 to 90^0 due south (Fig. 7.1), and maximum depth of the baryte ore body in this region is 75 m. The ore body is thin, and the dimensions of the galleries are 2.4 m - 4 m width and 1.8 m to 3 m height.

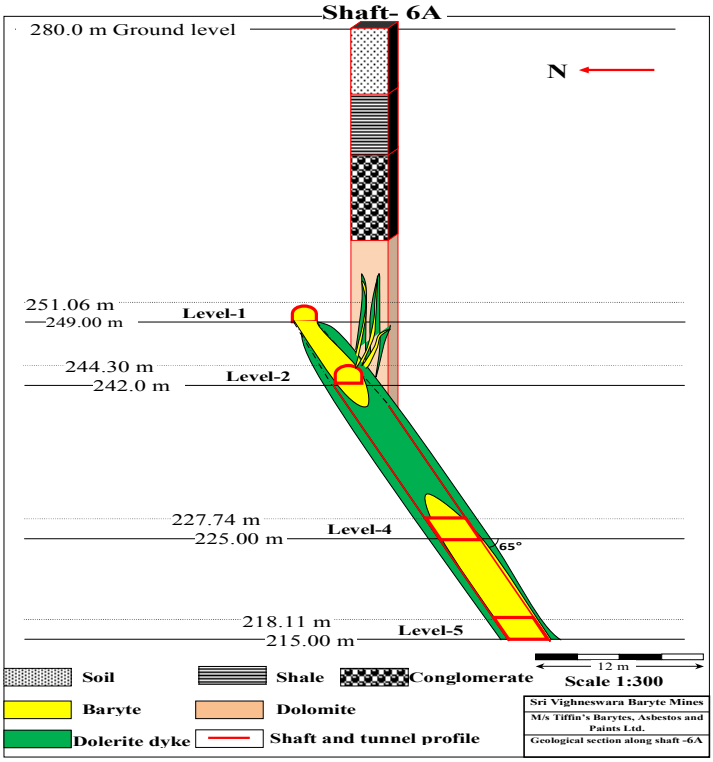


Fig.7.1 : Layout of the baryte mine vis-à-vis the suggested sequence of mining

Based on field and laboratory investigations, the strata have been classified as “Fair” rock mass. Based on the rock mass quality index the maximum safe span of unsupported stopes was estimated as 15 m for the area. The suggested method of working for the ore body is overhand cut and fill mining. The maximum length of the stope recommended is 15 m (center – to - center) and the optimum level interval is 8 m (solid pillar). The stoping sequence is proposed from lower level to upper level.

- In Panel 38 Level East in Seam V at Churcha West Colliery, The depillaring panel is situated under a hill cover of about 465 m; the immediate roof is sandstone having an RMR of 61. The size of the pillars is 35 m x 35 m, size of the galleries 4.8 m x 3.0 m, size of spilts 4.8 m x 3.0 m, and size of slice : 4.8 m x 3.0 m. The main fall generally takes place after an extraction area of 500 to 5100 m^2; and the periodic falls at every 200 to 4900 m^2. At the request of the mine management, the instrumentation and monitoring of this panel is being done to evaluate the ground conditions, for safe extraction during depillaring. Based on the monitoring data, suitable warning limits for stress and deformation will be suggested.

  Accordingly vibrating-wire type stress cells in four pillars, and convergence stations at every junction were installed. The instruments are being continuously monitored in all the three shifts during depillaring of the panel.

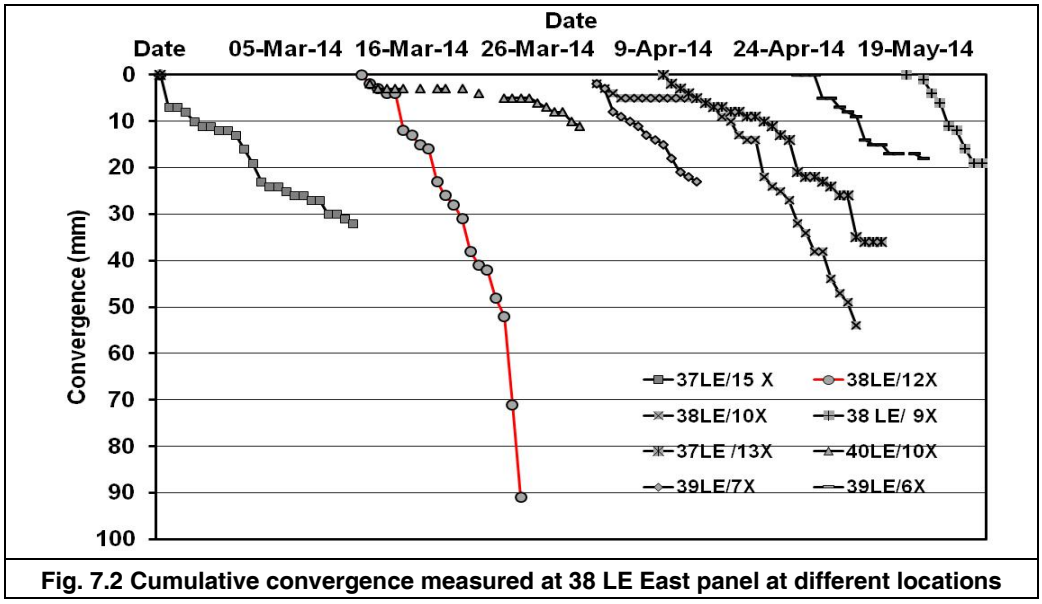


Fig. 7.2 Cumulative convergence measured at 38 LE East panel at different locations

From the strata monitoring observations, it was observed that the maximum convergence recorded in the panel was 91 mm at 37LE/15x, when the point was at goaf edge (Fig. 7.2). In general, the deformations were less in the initial stages, but gradually increased as the extraction line reached the point. From the trend of change in stress recorded in the panel, it was seen that stress values were within normal range of 10 kg/cm2. While the trend of change in stress over the pillars with respect to the line of extraction was as expected, the magnitude of change in stress observed was within safe limits. Further monitoring should be continued and some more stress cells and convergence points should be installed to properly understand the behaviour of the panel during depillaring.

- The Mahamaya underground coal mine of Bhatgaon Area in South Eastern Coalfields Ltd. (SECL) intends to experiment with a special depillaring method called "Optimization of Panel Dimension System" proposed by the 'Society for Mining Research, Sustainable Development and Environment' (SMRSDE). As per the method, the support requirements at the face are very minimum. In order to do so, the mine management commissioned a study with NIRM to undertake investigations for surface subsidence prediction and review the support requirement for the proposed depillaring method for one panel. Accordingly, site visits were made. Further work will be planned after receipt of the requisite input data from the mine management.

- Sonshi Iron ore mine is an open pit mine with fully mechanized mining unit, being the oldest operating mine of M/s Cosme Costa & Sons situated in North Goa. The waste from the mine is being dumped at Pissurlem village. The Pissurlem dump consists of two dumping areas, i.e., the old dumping area which has been stabilised as well as vegetated and new area which is an active dump site. The new dump covered an area of 45 hectares (Fig 7.3). The maximum dump height measured from toe was 83 m, the vertical height being 55 m at the centre. The overall slope angle of the dump was found to be varying from 12^{o} to 20^{o}. The dump profile consisted of 10 m high benches with berm width varying from 4 m to 10 m. The slope constituted nearly 40 percent fines as dump material. The compaction of individual benches was done after every 10m lift with rollers and water. Though the mine management employed a number of slope stabilization measures to improve the stability of the dump, it still had some problems.

Fig 7.3 View of Pissurlem dump

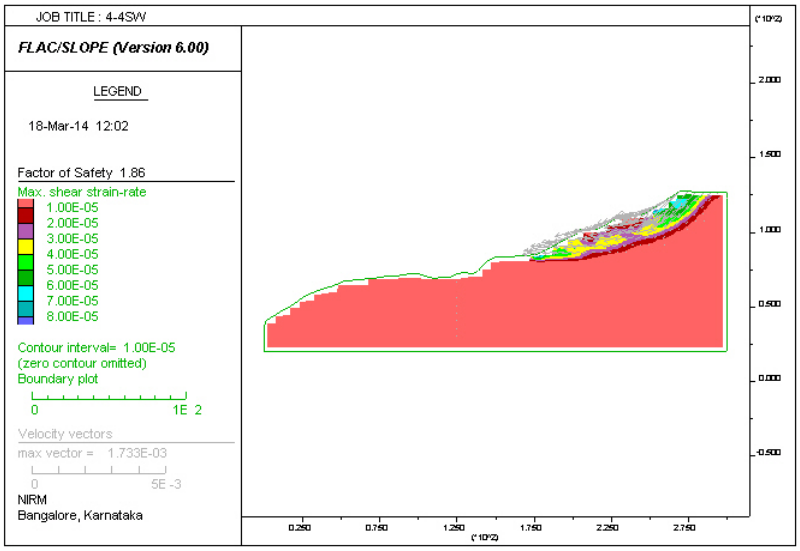


Figure 7.4 Factor of Safety for Section 4-4'SW of the dump slope

On request from the mine management, NIRM carried out detailed geotechnical investigations of the dump and determined the physic-mechanical properties of dump material at the laboratory. In addition, slope stability analysis has been carried out using limit equilibrium analysis and numerical analysis by means of FLAC Slope software. Fig. 7.4 shows the Factor of Safety arrived at using FLAC Slope software at one out of 18 sections that were so analysed. The factor of safety calculated from both the analyses show FOS values above 1.84 and more or less the same at many locations. It was observed that the factor of safety values reduced in most of the sections due to the presence of water table. Hence proper drainage measures needs to be adopted in the field to reduce the build-up of pore water pressure. To further increase the stability of the dump material, a set of additional measures were recommended to the mine management.

- At Tummalapalle mine of the Uranium Corporation of India Limited (UCIL), AP, a suitable mix proportion of the mill tailings and fly ash having better stability properties was required for back filling (stowing). Accordingly, UCIL requested NIRM to carry out laboratory geotechnical investigations on the physico-mechanical properties of various mix proportions of mill tailings and fly ash of Tummalapalle mine (Fig. 7.5).

  The various physico-mechanical properties were determined at NIRM as per BIS / IS codes. It was observed that gravel was absent in the mill tailings, while it is present with a high percentage in the fly ash.

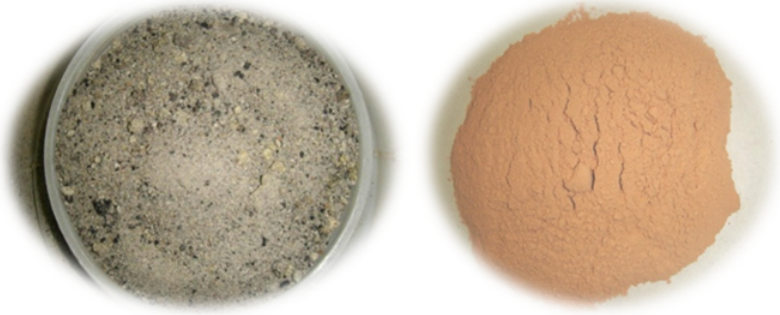


Fig. 7.5 The fly ash and mill tailings samples received from UCIL

The fly ash sample received was cohesionless and did not show any binding properties. As the percentage of fly ash in the mix proportions was decreased from 100% to 0%, it was observed that the failure pattern for uniaxial compression test was predominantly tensile in nature, except for 100 % mill tailings which showed bulging and the failure was in shear. The mill tailings sample the highest cohesive strength of 3.58 kg/cm2. Though the mill tailings showed very good test results it cannot be used as back fill material because of the main drawback of bulking, development shrinkage cracks and its plastic behaviour, it should always be used with combination of other material for improvement of its stability parameters.

The mix proportion of 65% mill tailings and 35% fly ash shows the highest specific gravity of 2.37, highest density – both wet density of 1.87 g/cc and dry density of 1.50 g/cc, highest compressive strength of 2.82 kg/cm^2, highest cohesive strength of 1.55 kg/cm^2, lowest permeability of 2.4 x 10^{-4} cm/sec, lowest void ratio of 0.38 and lowest compression index value of 0.25. Accordingly, it was recommended to use the mix proportion of 65% of mill tailings with 35% of fly ash as the best mix for back filling.

- NIRM was requested by M/s UCIL to suggest the support plan and stoping parameters for the hangwall load, and to formulate the support plans for the crusher chamber of Tummalapalle underground mines in Kadapa district, AP. Accordingly, NIRM made the ground stability assessment and suggested the feasible methods of stoping at the mine, along with suggestions for working of the footwall lode and its support design. The mine authorities are continuing the development of the stopes as per the suggested design.

  Further, the mine management now propose to work the hangwall lode also. Based on field and laboratory investigations, the red shale roof strata over the hangwall orebody (with its Q value 1.9 and RMR 39) had been classified as “Poor Rock Mass”. For these conditions the recommended support system was 1.8 m long, 25 mm diameter, full-column grouted roof bolts, at 1.0 m row spacing, four bolts in a row. In the junctions and in the loading points, additional 3 m long bolts / cables should be installed in between the bolts. The same support system was applicable for the 4.5 m wide strike drives also. It was suggested to extract the hangwall ore body forming 5 m wide rooms and leaving minimum 4.5 m x 4.5 m remnant pillars. The roof in the extracted rooms should also be supported with regular bolting at 1 m x 1 m spacing. With these parameters, the percentage of extraction by the room and pillar method would be more than 75%. Since the workings are shallow, crown pillars may not be necessary. However, rib pillars were required to protect the surface and the extraction areas in the adjacent panels. It was recommended to have rib pillars 7 m in width and 38.5 m in length (dip-rise direction) separating the different stoping panels along the strike.

- In the Sukinda Valley Complex, the Ferro Alloys Corporation Limited (FACOR) is operating Kathpal Chromite Mines in Jajpur district, mining the chromite ore in two mines, at Jungle Pit and Maheshwar Pit. They propose to exploit the chromite ore through underground mining below -92 mRL. In view of this, M/s FACOR wanted NIRM to study the ground conditions at their mines to evaluate the stability of the stopes.

  As part of detailed field investigations, rock samples were collected from the Jungle and Maheshwar Lodes at Kathpal mine, and testing was carried out at NIRM. Based on the studies numerical modelling was carried out for the Maheshwar Lode. In this lode, the orebody is 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. The chromite ore body is extremely fractured (with faults and joints). The serpentinite and the dyke rock are also jointed and disturbed. The modified RMR (MRMR) for the rock mass is obtained by making adjustments for the unfavourable orientation of the joints (70% reduction, and for adverse blasting affect (90% reduction).

  In the present analysis, it was assumed that open stoping method would be adopted at the mine from -77 mRL to -210 mRL. The stopes would be 8 to 10 m in width (orebody width) and about 30 m in length. The stopes would be bounded by rib pillars on either side, and sill pillars above and below. If no persons are likely to be deployed under the hangwall, the allowable factor of safety for rib pillar could be as low as 0.75. For this, the percentage of extraction could be 90, and the rib pillar thickness could be 3.3 m, or say, 4 m (length would be the orebody width). The safety factor required for sill pillars is 1.5. Using the same relation as above, the percentage of extraction under this situation could be 0.8, and the minimum sill pillar thickness works out to be 6.5 m; since there

will be chutes in the sill pillar, the areal extraction ratio (volume extraction) has to be considered; with this the sill pillars could be designed for 8 m.

The three dimensional Hoek and Brown yield criterion proposed by Melkoumian, Priest and Hunt in 2008 was used in the analysis of failure state of the rock mass around the stopes. The three dimensional principal stresses were obtained from the model after the final stage of excavation. These stresses along with strength parameters (mb, s and a) were then incorporated in the form of subroutine into 3DEC to obtain Factor of Safety (FOS) contours. Based on the numerical analysis, it is concluded that the 10 m wide rib pillars would provide a high safety factor of 2. Empirical estimates suggest that the mine management can plan to reduce the rib thickness depending on the required factor of safety. Similarly, the sill pillars and the crown pillar could be maintained at 8 m thickness.

- At the Krishna mines at Ramaiyanpatti, Tirunelveli, Tamilnadu, the mine management requested NIRM to assess the stability of slope and advice for scientific mining methods. Accordingly, it was planned to study the existing mining layout and method of working, test the physico-mechanical properties of rock samples, and to conduct geological-cum-geotechnical studies to assess the stability of present slopes and suggest for ultimate pit slope and remedial measures, required if any. In addition, it was planned to study the environmental impact due to mine operation (ambient air quality and ambient noise levels) and to suggest safe limits. Based on investigations carried out by NIRM, and the data provided by the mine management, detailed study was carried out and following broad recommendations were made.

    1. Benches should be developed along the weathered rock mass of the Charnokite. Systematic rock bolting should be carried out. Suitable retaining wall support has to be made after the development work at appropriate places with proper drainage. Multi Point Borehole Extensometers (MPBX) should be installed inside the weathered rock mass for monitoring the movements within the rock mass.
    2. The top few benches should be protected by geotextiles /geomatting in the slide prone area; alternately, shotcreting with wire mesh should be carried out.
    3. The analysis for the individual benches under dry condition indicated that the maximum safe angle of the individual benches is 50^0-55^0, maximum height and width of benches are 9 m and 12 m, respectively, with a safety factor of 1.3. The overall slope angle should be maintained in the range of 22^0 to 27^0. The safe ultimate slope angle was estimated as 55^0. With the proposed bench parameters of 9 m height and width of 12 m the existing mines can be deepened up to a depth of 70 m from the existing level.

  The monitored ground vibration and air overpressure are within the permissible limits. Hydro geological study showed that there is no effect of the deepening of the pit upto -50 m on the water table. The ambient noise levels monitored for various machineries under operation did not exceed the prescribed norms. The influence zones in all the cases were less than 50 m. The noise dose for the operators was well within prescribed limits of DGMS. The air quality did not show any significant variation in the results of RPM, SPM and gaseous pollutants. All the parameters are well within the norms as per National Ambient Air Quality Standards.

8. MICROSEISMICS AND AUTOMATION

NIRM has developed expertise in real time strata monitoring of underground excavations for their long term stability assessment. Real time strata monitoring helps to predict the time dependent strata instabilities and provide information on support system performance in powerhouse caverns in hydroelectric projects, oil storage caverns transportation tunnels and mining tunnels. This is useful in long term stability assessment as well in evaluating the dynamic strata stability.

- Tapovan-Vishnugad hydroelectric power project at Joshimath is located within the tectonic block bounded by Main central Thrust in the south and Vaikrita thrust in the north with metamorphosed rocks exposed. The area is highly seismic active and falls in zone V. Among other components, this project has an underground power house near Helang for 520 MW (4 x 130 MW) of power generation under the spur between Animath Nala and Alaknanda river. During excavation of powerhouse, incidences of slabbing in roof strata and rockbursts type situation were encountered. In order to assess the stability of the powerhouse cavern and study the dynamic behaviour of the effect of stress re-distribution in the rock mass surrounding this cavern, NIRM had undertaken the real-time microseismic monitoring of the area around excavations.

  As on date 12 channel seismic stations in the APS (access to Pen stocks) tunnel and 48 channel in the crown of the excavation have been done. Preparation works for the installation of remaining stations is in progress as this was hampered earlier due to heavy floods. Full system installation is expected to be completed by September 2014

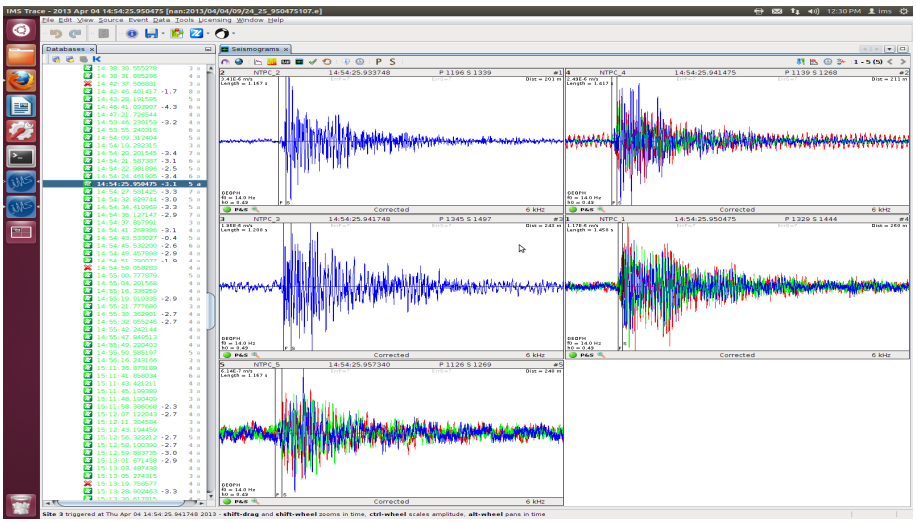


Fig. 8.1 : Microseismic signal due to cracking in the rockmass as recorded by five sensor stations at TVHPP, NTPC

Monitoring of the area surrounding powerhouse cavern is being continued with the existing set-up and all micro-cracking signals are being recorded (Fig. 8.1) and analysed on day-to-day basis.

- The Tala Hydroelectric Project of Bhutan, which was commissioned in 2009 is facing problem of frequent rock bolt failure in the powerhouse cavern. So far more than 800 rock bolts have come out under severe stress conditions. This triggered a major concern to the project authorities on the stability of the powerhouse. In order to analyse the reason behind this phenomenon of expulsion of rock bolts, the NIRM and M/s DGPC, Bhutan entered in to an agreement for round-the-clock-monitoring of the area around powerhouse excavations by 30 station microseismic monitoring network. NIRM agreed to provide logistic support for identifying the proper microseismic system for procurement by DGPC. It was also agreed that upon commissioning of the microseismic network, NIRM shall carry out the monitoring, data analysis work for three years during which DGPC personal will be trained to operate the system in future.

  So far technical support with specification and design layout was provided to the DGPC for procurement of the microseismic system and in carrying out the preparation works for establishment of the 30 station microseismic monitoring system. Accordingly, the monitoring system was commissioned in November 2013. Subsequently, signal triggering levels, individual seismic station performance was checked, electrical parameters were set, data quality check and system operation was standardised. With this the real time operation of the monitoring system started from 1stDecember 2013. The available cavern data was used to draw the sensor locations on the 3D cavern map (Fig. 8.2). Data acquisition, processing and analysis with schematic display of the location of microseismic activity in the backdrop of cavern using the tailor-made software were taken up.

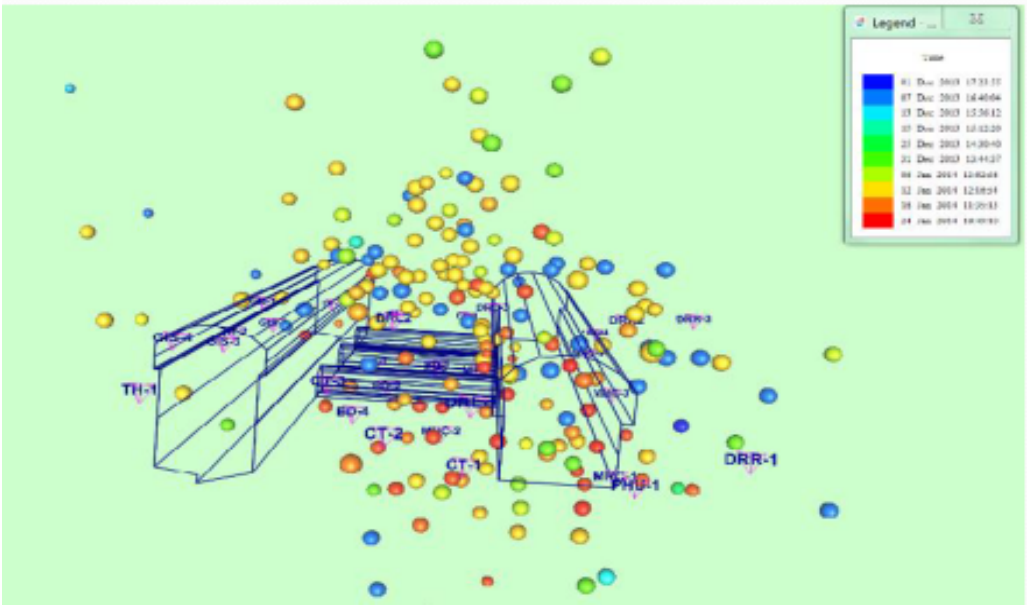


Fig. 8.2 : Mapped microseismic events around power house cavern in 3D view

Right from day one, all the data were downloaded at NIRM Bangalore and processed regularly. Basic data analysis was done for the spatio-temporal distribution of microseismic events prior to the rock bolt failure so as to calibrate the activity rate and

clusters of microseismic activity vis-à-vis impending failure. Training at site for operation and for regular system maintenance was provided to the THPP staff. System is running smoothly and providing the real time data. Monthly and half yearly report was submitted to DGPC with the back analysis of five failure rock bolts correlation with microseismic data. So far, there is no noticeable amount of microseismic data to carry out the intensive data analysis like statistical data analysis and parameter trends (stress changes etc.).

9. TESTING SERVICES

NIRM undertakes all types of rock, soil and material testing as per ISRM and DGMS standards. It is the only DGMS approved laboratory in south India to carry out both destructive tests at laboratory and in-situ NDT tests on various dynamic components. 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 destructive and non-destructive testing for mining machinery parts including winders, suspension gear parts and wire ropes using ultrasonic flaw detector, magnetic particle tester and wire rope defectograph. The destructive tests include reverse bend test, torsion test and tensile test, whereas the non- destructive tests include liquid dye penetration test, ultrasonic testing, magnetic particle testing and in-situ testing of wire rope.

The Institute is also 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. 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, 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.

All these test facilities at NIRM have been brought under the Centre for Testing Services (CTS).

A. Material Testing

- During 2013-14, destructive tests were carried out on 78 rope samples for various clients. Details of Clientele and Types of tests conducted during this period are as under :

No	Clients	Types of test conducted*
1	China Coal No.5 Constructions Pvt Ltd, SK Mines, Rajasthan	UT, MPT and WRD
2	Shaft Sinkers Mauritius Ltd, Rampura Agucha Mines, Rajasthan.	UT and MPT
3	Hindustan Zinc Limited, Zawar Group of Mines, Rajasthan.	UT, MPT and WRD
4	NALCO, Damanjodi, Odisha	WRD

5	Andhra Pradesh Heavy Machinery And Engineering Limited, Andhra Pradesh.	UT, MPT and PLT
6	Singareni Collieries Company Limited, Ramagundam, Andhra Pradesh.	UT and MPT (11 man riding haulers)
7	Hindustan Zinc Limited, Rajpura Dariba Mines, Rajasthan.	UT and MPT
8	Hindustan Zinc Limited, Rajpura Dariba, Mines, Rajasthan.	UT and WRD
9	Hindustan Copper Limited. Rajasthan. Khetri and Kolihan Mines Complex,	WRD
10	Shaft Sinkers Mauritius Ltd, Rampura Agucha Mines, Rajasthan.	UT, MPT, WRD and PLT
11	China Coal No.5 Constructions Pvt Ltd, SK Mines, Rajasthan	UT, MPT and WRD
12	NALCO, Damanjodi, Odisha	WRD and comprehensive tests
13	Shaft Sinkers Mauritius Ltd, Project Camp Office: HZL, Rampura Agucha Mines, Rajasthan.	UT, MPT, WRD and PLT
* UT – Ultrasonic testing, MPT – Magnetic particle testing WRD - Wire rope defectography PLT – Proof load test.		

- For M/s. China Coal No.5 Constructions Pvt Ltd all the vital components of winders and suspension gear parts of 2000 KW (main winder), 1250 KW (auxiliary winder), 15 winches (and their associated components & suspension gear parts) were tested using ultrasonic flaw detector (for detecting internal flaws), electro-magnetic crack detector (for detecting surface and sub-surface flaws), wire rope defectograph (for detecting loss of metallic area, local faults, broken wire, pitting, corrosion, wear etc.). These tests were carried out in July, 2013. After a period of six months, similar tests were conducted in December 2013 as per DGMS guidelines.

- An MoU was signed between M/s. Shaft Sinkers Mauritius Limited (SSML) and NIRM for carrying out Non-Destructive Evaluation (NDE) on vital components such as winders, sheave pulleys, suspension gear parts and its associated attachments at North ventilation shaft of Rampura Agucha mine of Hindustan Zinc Limited. Accordingly, all the vital components of the winders 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, similarly tests were carried out on various components in December 2013 and February 2014 with wire rope defectograph and proof load tests as per DGMS guidelines.

- At Hindustan Zinc Limited, non-destructive evaluation carried out for winders of the Central Mochia, West Mochia, Balaria and Zawarmala mines of the Zawar Group of mines. In addition, non-destructive evaluation was carried out for various winders and other mine machinery of the Rajpura Dariba mines using ultrasonic flaw detector on shaft winder and cage winder, and wire rope defectography on Full Locked Coil (FLC) wire ropes. Results of the NDT indicated the health condition of various components, and the concerned authorities were advised accordingly.

- In Ramagundam area of Singareni Collieries Company Limited (SCCL), at Adriyala Longwall Project, in-situ Non-Destructive Evaluation (NDE) was carried out as per DGMS guidelines for the vital parts of underground and surface haulers of eleven man riding systems.

- Non destructive tests were carried out on the load carrying members and safety chain brackets for M/s APHMEL, Kondapalli (near Vijayawada, AP). They include various tests such as proof load test, break load test, determination of chemical properties, Izod test, micro-examination and hardness tests.

- In Khetri mines of Hindustan Copper Limited (HCL), Non-Destructive Evaluation was carried out on double drum man & material winding hoist ropes, friction hoist for rock winding rope and single drum hoist (Cuba) rope. At Kolihan mines of HCL NDT using wire rope defectograph was conducted on Full Locked Coil (FLC) wire ropes. NDE tests on various components of winders indicated whether or not they were free from flaws, and NDT tests on wire ropes indicated the presence or absence of any significant defects such as LF (local faults) and LMA (loss of metallic area).

- At Damanjodi mines of M/s. National Aluminium Company Ltd. (NALCO), both destructive and Non-Destructive testing was done. While NDT tests were done for wire ropes at site using defectograph equipment and visual inspection, the destructive tests (tensile, torsion and reverse bend tests) were conducted at NIRM on outer layer wires of a failed strand of left hand side rope. The results indicated that 90% of the wires had single digit torsional value which in turn indicates a high degree of deterioration. The mine authorities were warned about this.

B. Rock Sample Testing

- Laboratory geotechnical investigations on core samples from four boreholes of the Adriyala dump area under RG OC – II Extension Block, SCCL were carried out for the purpose of evaluation of the stability of pit slope and Adriyala dump. The scope of work includes determination of various mechanical properties including uniaxial compressive strength, Young's modulus with only loading, Young's modulus with loading and unloading, triaxial compressive strength, and direct shear test on contact plane. Samples were received from different depths from each borehole. Total 68 samples were tested for UCS and other properties. The test results indicated that UCS for the tested samples varied from 2.1 MPa. to 53.2 MPa and the failure pattern for UCS was predominantly tensile.

- Mangdechu Hydroelectric Project Authority (MHPA) in Bhutan wanted laboratory investigations on rock core samples. The scope of work included determination of rock mechanical and physical properties of core samples of Pegmatite and Quartzite from three bore holes, namely DH-1, DH-2 and C-1. A total of 30 samples were tested for physical properties, 35 samples for mechanical and shear properties representing two rock types from three bore holes (DH-1,DH-2 and C-1). A total of seven jointed rock samples were also tested for joint normal and shear stiffness. The received core samples were classified as class-III rock and shear zone rock material by MHPA. All the tests were carried out as per IS Standards except the Triaxial Compression test which was carried out as per ISRM Suggested Method.

The test results for DH-I and DH-2 showed consistency in physical properties in case of pegmatite. The density and P-wave velocity of quartzite was higher than that of pegmatite samples. Pegmatite samples from the shear zone (downstream wall) showed lower values of density and P-wave velocity compared to Class-III rock samples. Average values of UCS for pegmatite, quartzite and the shear zone area were 121 MPa, 237 MPa and 81 MPa, respectively. All the samples in UCS tests failed predominantly in tension. It was observed that the mechanical properties of quartzite were higher than pegmatite, the mechanical properties of the shear zone area were significantly lower than Class-III rocks.

Multi stage triaxial tests were conducted under different confining pressure on 6 samples under dry condition, and 6 samples under saturated condition to determine cohesion and friction angle, both peak and residual. Joint properties such as joint normal stiffness and joint shear stiffness were determined for the selected samples representing Class-III rock and the shear zone area.

- For evaluating the stability of internal dump of PK OC II Extension Block, M/s SCCL requested NIRM to carry out laboratory geotechnical investigations on core samples from three boreholes, BH nos. 1057, 1058 and 1059. Various properties sought to be determined included UCS, Young's modulus with only loading, Young's modulus with loading and unloading, and direct shear test on contact planes. These tests were carried out as per the ISRM methods.

  In total 45 samples were tested for UCS. The samples from each borehole were grouped according to their lithology. Young's modulus was determined on three samples under both conditions, loading alone and loading and unloading sequentially. Direct shear test on contact planes was conducted on 11 samples from three boreholes.

- Laboratory investigations were carried out on rock core samples from pothead yard site of Mangdechhu hydroelectric project. The scope includes determination of mechanical and physical (density only) properties of core samples of quartzitic gneiss and biotite schist from bore hole DH-3. In total, 41 samples were tested.

  Triaxial compression tests were carried out for 10 samples, five each under dry and saturated conditions. It was observed that there was no significant variation in the results obtained under dry and saturated conditions for cohesion and friction angle. A total of 11 samples were tested for physical properties and 30 samples for mechanical properties. All the test results along with observations were communicated to the client.

- The Oil and Natural Gas Commission (ONGC) is in the process of deep drilling for exploration purpose. The Institute of Drilling Technology (IDT), Dehradun- a subsidiary of ONGC, requested NIRM to carry out laboratory geotechnical investigations on core samples from two wellbores. The test results will form input parameters for geomechanical modelling of wellbore stability by IDT. The scope of work includes determination of various physical and mechanical properties such as density, P-wave velocity, UCS - vertical and horizontal, Young's modulus and Poisson's ratio, cohesion and friction angle from triaxial compression test (multiple failure method).

Granite gneiss core samples of 100 mm diameter were received from wellbores of Mumbai high basement field. Re-coring was done in vertical and horizontal directions to obtain the desired test specimens. A total of five samples from 1st wellbore and seven samples from 2nd wellbore were obtained. The tests were carried out as per ISRM Standards.

It was observed that the failure patterns in uniaxial compression test were predominantly tensile in nature, whereas in triaxial compression test they were predominantly shear. Tensile strength could not be determined as proper samples were not available. Though the samples were tested for cohesion and friction angles; it was not possible to obtain values due to insufficient number of failure points.

- In continuation of previous series of tests on wellbore samples from ONGC, core samples of shale from eight more wellbores were received for the same set of physico-mechanical tests. As in the previous case, the 100 mm diameter core samples were re-cored in vertical and horizontal directions to obtain the desired test specimens of BX size (42 mm) for conducting triaxial compression test using Hoek triaxial cell. For uniaxial compression test, both 42 mm and 100 mm diameter samples were used.

  Due to the inherent weakness planes in the received samples, maximum effort was put in to obtain more number of undisturbed cores of required sizes from the received samples. Wherever possible, the vertical and horizontal samples were cored from the same core so as to compare the results. All the test results were systematically analyzed and communicated to the client along with our observations.

C. Inter-disciplinary works

- Under an MoU signed between NIRM & UCIL, physico-mechanical properties of rock samples were to be determined for UCIL mines. Accordingly, shale, dolomite and limestone core samples were received from Tummalapalle mine for the determination of density, compressive strength, Young's modulus, Poisson's ratio and tensile strength. Specimens were prepared and tested as per ISRM standards. Test results were communicated to the concerned department.

- 39 samples of dolerite, baryte & dolomite from the hangwall, the ore body and the footwall of the baryte mines at Pulivendula, AP, were tested for density, tensile strength, compressive strength, Young's modulus and Poissons ratio. The test results were communicated to the concerned department.

- Dimensional stones were tested for stone exporters like Alliance Minerals Pvt. Ltd and M/s Covenant Stones Pvt. Ltd. All the tests were carried out on the prepared test specimens as per ASTM Standards. The test data were compiled and the average values of the samples tested are reported to the client in the form of test reports.

- Rock core samples were also received from Teesta HEP and Vellore Highways Department for the determination of physic-mechanical properties. Tests were carried out for these samples and the test results were reported to the concerned agency.

10. INSTRUMENTATION AND MONITORING

The Institute also deals with stability analysis of concrete structures and underground caverns in rock mass using instrumentation data. Six projects were carried out in the area of instrumentation and monitoring during the reporting year.

- NIRM has been carrying out analysis of instrumentation data of dam and powerhouse area of both Tehri and Koteshwar hydroelectric projects since last five years. Many geotechnical instruments were installed in Tehri and Koteshwar dams. In this study, a data template was prepared using Microsoft Access for analyzing and presenting the instrumentation data for different types of instruments. Template has been tested using the actual instrumentation data from Tehri and Koteshwar projects and handed over to project Authorities. This is user friendly and a graphical output will be given for better understanding of the current trends of different instruments.

Fig 10.1: Control point network at SSNNL Dam

- The Sardar Sarovar Project is one of the largest water resources projects of India across river Narmada. Due to the large reservoir capacity and height of the dam, it is necessary to monitor the deformation of dam in order to ascertain the dam stability. NIRM has taken up the geodetic monitoring of the dam for measuring the deflection during different levels of reservoir. NIRM has established geodetic network for monitoring the movement at the crest of the dam. Four control points were established on both abutment of the dam using Differential Global Positioning System (DGPS). Location of the control points are shown in Fig. 10.1. Points on the crest at different blocks were identified in consultation with SSNNL. Installation of the monitoring points on downstream side is in progress. NIRM has started monitoring of some of the points on the dam.

- Continuation of monitoring and analysis of the existing instruments in the Tala powerhouse complex carried out by NIRM from 2002 onwards. Currently about 150 instruments are being monitored at 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. Stability of Machine hall cavern was assessed based on the convergence observations of side walls, load on rock bolts and stress distribution along the length of instrumented bolts and piezometric observations.

  Based on the analysis of the instrumentation data, it was observed that convergence at the machine hall cavern was continuing although at a lower rate (0.006 to 0.014 mm/day), load on the rock bolts increasing at some of the locations particularly at 150 u/s at EL506 (an increase of 8.75T during the operational period, there were no instances of high tensile stress at other instrumented bolts. Currently some of the instrumented bolts show marginal increases in compressive stresses. Thus it was concluded that the cavern was undergoing time-dependent and stress-included deformations due to its close proximity to Main Central Thrust. The failure of the rock bolts was still continuing as the stress redistribution was still going on inside the rock mass surrounding the cavern. Back analysis study done using 3D numerical modeling indicated that more bolts are likely to fail.

- During the construction of the Tala dam about 250 geotechnical instruments are embedded in the dam body. Analysis of the dam instrumentation data is currently being carried out by NIRM regularly based on data provided by the DGPCL. Dam instrumentation was interfaced to Data Acquisition System (DAS).

  Data analysis revealed that the overall change in temperature in block – 2 and block 5 during the monitoring period was upto about 6.42^0 C and 5.14^0 C respectively. Many temperature meters showed cyclic pattern (seasonal variations) in temperature changes which was maximum in the month of August and minimum in the month of January-February. The pore water pressure variation in block 2 was about 0.40 kg/cm^2 and in block 5 it was up to 0.43kg/cm^2. The recordings of joint meter at EL 1292 of 90d/s section in Block-5 indicated cyclic pattern between September-August with peaking in the month of February-March and showed the minimum in the month of August every year. The uplift pressure meters at the foundation indicated maximum uplift pressure of

about 33.5 mWc at Block 2 and about 13.5 mWc at Block 5. However during the last two years there was not much increase in uplift pressures. At block 5 the stress meters at foundation showed stress levels between 3 to 6.5 kg/cm^2. Only one stress meter which was close to downstream wall exhibited cyclic behaviour and recorded a peak of 11.37 kg/cm^2.

- The behavior of underground powerhouse of Sardar Sarovar project is being monitored by NIRM since the year 2000. During construction stages NIRM installed Magnetic Ring Multi Point Borehole Extensometer (MRMPBX), total station targets on power house walls to monitor the deformations inside the cavern. During operational stage five no. of MR-MPBX were installed on surface center line of the powerhouse at a depth varies between 35-45m to assess the roof deformations. The analysis of the instrumentation data for the period October 2012 to November 2013 indicated the following :
  - During Oct 2012 and Nov 2013, the maximum displacements measured were within 2mm. The trend of displacement of almost all the MPBX's at the underground power house showed stable trend during this period.
  - The displacements measured on the columns and beams were negligible and showed stabilizing trend
  - The surface MPBX data confirmed that the area between the crown and surface was stable as no movement was taking place there. Instruments at critical chainages Ch 1516, Ch 1552 and Ch 1580 too showed stable trend.

- The instrumentation data of powerhouse and desilting complex of the Nathpa Jhakri Hydroelectric Project is supplied by SJVNL. This data was analysed to evaluate the stability of the caverns during operational stage. The instrumentation records consisted of data obtained from instruments like MPBX, piezometers, total station targets and crack meter at Desilting chambers, Powerhouse complex and TRT outfall area. The analysis of instrumentation data has been completed and interim report is under preparation.

ANNUAL ACCOUNTS
(2013-14)

GRSM & Associates
Chartered Accountants

No.8/90, 1st Floor, Pampamahakavi Road
Shankarapuram, Bangalore – 560 004
Ph: +91-80-41312149 / + 91-80-2660 2810

e-mail : services@grsmca.com Web : www.grsmca.com

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, 2014, 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 Institute's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances but not for the purpose of expressing an opinion on the effectiveness of the entity's internal control. 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.

Basis for qualified opinion

i. *Non provision of gratuity liability and leave encashment liability for the year ended 31-3-2014 as described in item no.3 of Notes on Accounts to the financial statements, the impact of which is unascertained.*
ii. *Non confirmation of balances by parties as described in item no.7 of Notes on Accounts to the financial statements, the impact of which is unascertained.*
iii. *Non verification, non-reconciliation of fixed assets and non-maintenance of fixed assets register, the impact of which is unascertained.*

Opinion:

In our opinion and to the best of our information and according to the explanations given to us, except for the effects of the matter described in the Basis for Qualified Opinion paragraph, the financial statements give a true and fair view:

a. in the case of he Balance Sheet, of the state of affairs of the Institute as at 31 March, 2014 ; and
b. in the Case of Income and Expenditure Account, of the excess of Income over expenditure for the year ended on that date.

For GRSM & Associates,
Chartered Accountants
(FRN 000863S)

Place: Bangalore
Date: 19/08/2014

Sd/-
Gopalkrishna Hegde
Partner
M. No. 208063

Notes on Accounts

(2013-2014)

Schedule-31

Accounting policies and notes on account forming part of Balance Sheet and Income & Expenditure Account for the year ending 31st March 2014.

1. Accounting Policies :-

A. Background:

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

Basis of Preparation:

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

B. Fixed Assets:

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

C. Foreign Exchange Transactions:

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

D. Revenue Recognition:

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

E. Treatment of Government Grant:

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

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

F. Retirement 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 and intimated by the Insurance Company.

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

G. Depreciation:

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

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

2. Notes on Accounts: -

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

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

3. Institute had made provision in the past for gratuity based on the projected unit credit method as per valuation provided by the LIC as on 31-3-2013. During the year, an amount of Rs.100.20 lakhs was paid against this provision. Due to non-receipt of intimation of liability position as on 31-3-2014, no further provision has been made but an adhoc amount of Rs.7 lakhs was paid and charged to Income & Expenditure Account. Institute has not made any provision for the leave encashment benefit.

4. Fixed Assets are subject to physical verification and reconciliation.

5. Provision for the income tax has been measured at the amount expected to be paid to the tax authorities in accordance with the Income Tax Act, 1961.

6. Tax deducted at Source receivable, as mentioned in the schedule 12(a) to the balance sheet is subject to reconciliation and adjustments, if any.

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

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

Sd/-
(AN Nagarajan)
Registrar & Secretary

Sd/-
(V Venkateswarlu)
Director

Sd/-
Member
Governing Body

Refer our report of even date
For GRSM & Associates
Chartered Accountants

Sd
Gopalkrishna Hegde
Partner
M. No: 208063

Place: Bangalore
Date: 19/08/2014

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

CONSOLIDATED

BALANCE SHEET AS AT 31ST MARCH 2014

(Amount in Rs)

Sl. No.	Liabilities	Sch No.	Balance as on 31-03-2013	Balance as on 31-03-2014	Sl. No.	Assets	Sch No	Balance as on 31-03-2013	Balance as on 31-03-2014
1	**CAPITAL FUND**	1			1	**CURRENT ASSETS**	8		
	a) Capital Reserve		3,244,334	3,244,334		a) Cash in Hand		211,484	225,729
	b) Internal Capital Reserve		25,042,413	25,042,413		b) Cash at Bank		18,751,880	8,849,895
						c) Stock - Stationery Items		47,628	124,005
2	**OTHER CAPITAL FUNDS**	2			2	**INVESTMENTS**	9		
	a) Deferred Government Grant		11,736,594	100,000		a) Fixed Deposits - Instittute Development Fund		46,000,000	46,000,000
	B) Institute's Development Fund		46,000,000	46,000,000		a) Short term deposits against project advances received from clients		40,500,000	45,199,842
	c) Income & Expenditure Account		(56,330,874)	(40,933,586)					
					3	**Deposits**	10	397,410	399,760
					4	**LOANS AND ADVANCES**			
3	**CURRENT LIABILITIES**					a) Advances - Staff	11	1,496,834	1,401,489
	a) Sundry creditors - pay roll deductions	3	19,467	-		b) Advances - Suppliers (Including imports)	12	1,433,540	1,433,540
	b) Sundry Creditors - Staff	4	399,940	1,055,052					
	c) Sundry Creditors - Others	5	9,450,457	4,815,751	5	**Other Current Assets**	13	26,619,630	22,358,570
	d) Project Advacnes Received	6	178,750,911	133,240,158	6	**Expenses on Ongoing Projects**	14	74,195,369	43,310,463
	e) Provisions	7	19,318,073	19,470,662					-
					7	**FIXED ASSETS**	15	27,977,540	22,731,491
	TOTAL		**237,631,315**	**192,034,784**		**TOTAL**		**237,631,315**	**192,034,784**
								-	-

Notes forming part of the accounts -refer schedule 31

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 GRSM & Associates
Chartered Accountants

Sd/-
Gopalkrishna Hegde
Partner
M.No:208063

Place : Bangalore
Date: 19/08/2014

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

CONSOLIDATED

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31st MARCH 2014

(Amount in Rs)

Sl. No.	Expenditure	Sch No	2012-13	2013-14	Sl. No.	Income	Sch No	2012-13	2013-14
1	Administration Expenses	16	9,098,752	9,536,197	1	Grant-in-Aid received from Ministry of Mines	25	47,700,000	23,200,000
2	Pay & Allowances	17	77,578,753	58,957,529	2	Amount received from Completed Sponsored Projects	26	47,784,523	103,800,567
3	Travelling Expenditure	18	433,504.00	548,432	3	Amount received from Completed R & D Projects	27	-	38,425,682
4	Upkeep of Assets	19	705,628	891,797	4	Interest Received	28	6,169,010	6,389,935
5	Expenditure on Completed Sponsored Projects	20	23,006,664	40,110,452	5	Miscellaneous Income	29	178,446	169,707
6	Expenditure on Completed R & D Projects	21	-	30,768,145	6	Withdrawal of Depreciation	30	-	1,058,405
7	Income Tax	23	-	12,003,745	7	Prior Period Income	31	1,396,616	10,678,189
8	Depreciation on Fixed Assets	15	5,338,409	5,328,286	8	Exess of Expenditure of Over Income	-	19,005,683	-
9	Prior Period Expenses	24	5,731,227	8,025					
10	Provision for Income Tax		341,341	10,172,589					
11	Excess of Income over Expenditure	-	-	15,397,288					
	Total:-		**122,234,278**	**183,722,485**		**Total:-**		**122,234,278**	**183,722,485**

Notes forming part of the accounts -refer schedule 31

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 GRSM & Associates
Chartered Accountants

Sd/-
Gopalkrishna Hegde
Partner
M.No:208063

Place : Bangalore
Date: 19/08/2014

NATIONAL INSTITUTE OF ROCK MECHANICS

CHAMPION REEFS POST, KOLAR GOLD FIELDS

Consolidated Receipt and Payment Account for the year ending on 31st March 2014 CONSOLIDATED

(Amount in Rs)

Sl. No.	Receipts	Amount	Amount	Sl. No.	Payments	Amount	Amount
1	2	3	4	5	6	7	8
To	Opening Balance			By	Project Contingency (A)		11,673
	Cash	211,484		"	Project Contingency (B)		213,863
	Bank	18,751,880	18,963,364	"	EMD & Security Deposits		82,889
				"	Staff Welfare		400,000
"	Payroll Deductions Inocme Tax		334,026	"	Service Tax Paid - Projects		1,055,599
"	Advance Against Testing		5,069,194	"	Service Tax Paid - Testing		159,812
"	Advance Received - Sponsored Projects		87,308,075	"	Honorarium/ Incentive (Projects / MTL) Payable		11,613,802
"	Advance Against S&T - DST		360,000	"	Imprest - Anjaneyappa T		5,000
"	Defect Liabities		621	"	Imprest - Sivakumar C		5,000
"	Fixed Deposits		759,530	"	Security Deposit - BESCOM		2,350
"	Material Advance - Staff		136,439	"	Travel Advance		181,133
"	Security Deposits - Employees		170,000	"	TDS & Income Tax		6,685,053
"	Travel Expenditure- Domestic		48,465	"	Material Teasting Expenses		1,200,827
"	Interest Reeceived on IDF		3,256,578	"	Expenditure on R&D Running Projects		516,667

NATIONAL INSTITUTE OF ROCK MECHANICS

CHAMPION REEFS POST, KOLAR GOLD FIELDS

Consolidated Receipt and Payment Account for the year ending on 31st March 2014 CONSOLIDATED

(Amount in Rs)

Sl. No.	Receipts	Amount	Amount	Sl. No.	Payments	Amount	Amount
1	2	3	4	5	6	7	8
"	Interest Reeceived on Savings Bank		326,909	"	Expenditure on Sponsored Running Projects		18,644,841
"	Interest on Term Deposits		1,973,841	"	Security Deposit by IOC Asansol		361,251
"	Surplus from MTL & RFM Test		5,000	"	Stock Stationery Items		363,611
"	Surplus from Sponsored Projects		248,392	"	Institutev-Project Account		3,458,624
"	Terminal/Retirement Benefits		728,819	"	Provision for Gratuity Paid		10,020,000
"	Sundry Creditors - Staff		43,607	"	Sundry Creditors Pay Roll		353,493
"	Medical Advance		30,000	"	Sundry Creditors Others		7,582,599
"	Advacne to Staff		21,603	"	Retention Money - Employees		167,903
"	Grant in Aid (Non- Plan)		23,200,000	"	Purchase of Fixed Assets		40,732
"	Income - Licence Fee		43,518	"	Fixed Deposits - Short Term		5,131,026
"	Income - Others		92,380	"	Advacne to IPRM Seed Money		500,000
				"	Pre Paid Expenses		111,936
				"	Administration Expenses		8,583,865
				"	Salaries & Wages		55,131,604
				"	Travelling Expenses		490,510
				"	Up Keep of Assets		961,049
				"	Prior Period Expenses		8,025
				"	Closing Balance		
					Cash	225,729	
					Bank	8,849,895	9,075,624
	Total:-		143,120,361		**Total:-**		143,120,361

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, Kolar Gold Fields - 563 117. **CONSOLIDATED**

CONSOLIDATED DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2014

Schedule - 15		**Gross Block**						**Depreciation**				**Net Block**	
Name of the Assets	**Rate of Depreciation %**	**Balance as on 01-04-13**	**Assets Written off/Transferred**	**Purcchases up to 30.09.13**	**Purchases between 1.10.13 to 31.12.13**	**Purchases After 01.01.14**	**Total as on 31.03.14**	**Balance as on 01-04-13**	**Depreciation written off**	**Depreciation for the year**	**Total Depreciation as on 31-03-14**	**As on 31-3-14**	**As on 31-03-13**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INSTITUTE:													
Buildings	5	9,108,642	-	-	-	-	9,108,642	8,462,011	-	209,462.00	8,671,473	437,169	646,631
Plant & Machinery	7.5	32,225,642	-	-	-	-	32,225,642	31,589,808	-	76,124.00	31,665,932	559,710	635,834
Water Supply	5	328,926	-	-	-	-	328,926	285,393	-	12,060.00	297,453	31,473	43,533
Power supply	5	503,434	-	-	-	-	503,434	502,764	-	570.00	503,334	100	670
Furniture	5	4,566,256	-	-	-	-	4,566,256	2,153,962	-	193,269.00	2,347,231	2,219,025	2,412,294
Office Equipment	5	2,719,932	-	40,732	-	-	2,760,664	1,346,142	-	115,073.00	1,461,215	1,299,449	1,373,790
Vehicle	7.5	783,835	-	-	-	-	783,835	759,644	-	24,091.00	783,735	100	24,191
Laboratory Equipment	7.5	29,985,087	-	-	-	-	29,985,087	16,721,921	-	1,849,583.00	18,571,504	11,413,583	13,263,166
Technical Books	5	4,693,917	-	-	-	-	4,693,917	2,590,224	-	234,761.00	2,824,985	1,868,932	2,103,693
Computer Software	15	12,719,460	-	-	-	-	12,719,460	9,067,971	-	1,286,265.00	10,354,236	2,365,224	3,651,489
Computer Hardware	20	13,600,322	-	-	-	41,504	13,641,826	12,032,980	-	1,024,470.00	13,057,450	584,376	1,567,342
Conversion of Power line	5	1,799,459	-	-	-	-	1,799,459	1,064,492	-	89,973.00	1,154,465	644,994	734,967
Env Geo Tech Lab		2,113,409	-	-	-	-	2,113,409	1,146,952	-	152,068.00	1,299,020	814,389	966,457
PROJECT:													
Vehicle	7.50	806,889	-	-	-	-	806,889	253,405	-	60,517	313,922	492,967	553,484
Total:-		**115,955,210**	**-**	**40,732**	**-**	**41,504**	**116,037,446**	**87,977,669**	**-**	**5,328,286**	**93,305,955**	**22,731,491**	**27,977,541**
Advance for capital material purchase		-	-	-	-	-	-	-	-	-	-	-	-
(Previous year figures)		***115,908,877***	-	**46,332**	**-**	**-**	**115,955,209**	**82,639,260**	-	**5,338,409**	**87,977,669**	**27,977,540**	**33,269,617**

Note 1. Depreciation has been charged on Straight Line Method.

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS
BALANCE SHEET AS AT 31ST MARCH 2014

Institute

LIABILITIES					ASSETS				
Sl. No.	**Particulars**	**Sch No.**	**Balance as on 31-03-2013**	**Balance as on 31-03-2014**	**Sl. No.**	**Particulars**	**Sch No**	**Balance as on 31-03-2013**	**Balance as on 31-03-2014**
			Rs. Ps.	Rs. Ps.				Rs. Ps.	Rs. Ps.
1	2	3	4	6	7	8	9	10	12
1	**CAPITAL FUNDS**	1							
	a) Capital Reserve		3,244,334	3,244,334	**1**	**CURRENT ASSETS**	7		
	b) Internal Capital Reserve		25,042,413	25,042,413		a) Cash in Hand		108,017	93,988
						b) Cash at Bank		(158,681,754)	(223,430,747)
2	**OTHER CAPITAL FUNDS**	2							
	a) Deferred Government Grant		11,736,594	100,000	**2**	**INVESTMENTS**	8		
	b) Institute's Development Fund		46,000,000	46,000,000		Fixed Deposit (IDF)		46,000,000	46,000,000
	c) Income & Expenditure Account		(163,837,344)	(209,757,125)					
					3	**DEPOSITS**	9	397,410	399,760
3	**CURRENT LIABILITIES**								
					4	**LOANS AND ADVANCES**			
	a) Sundry creditors - Pay Roll Deductions	3	19,467	-		a) Advances - Staff	10	499,127	471,790
	b) Sundry Creditors - Staff	4	382,198	964,842		b) Advances - Suppliers (Including imports)	11	61,605	61,605
	c) Sundry Creditors - Others	5	7,753,144	5,088,551					
	d) Provisions	6	19,318,073	19,470,662	**5**	**Other Current Assets**	12	1,403,832	2,267,585
					6	**Project Account**	13	32,446,586	42,051,172
					7	**FIXED ASSETS**	14	27,424,056	22,238,524
	TOTAL:-		**(50,341,121)**	**(109,846,323)**		**TOTAL:-**		**(50,341,121)**	**(109,846,323)**
								-	-

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

For National Institute of Rock Mechanics

Sd/-
(A N Nagarajan)
Registrar & Secretary

Sd/-
(V Venkateswarlu)
Director

Sd/-
Member
Governing Body

Sd/-
Gopalkrishna Hegde
Partner
M.No:208063

Place : Bangalore
Date: 19/08/2014

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

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31st MARCH 2014

EXPENDITURE				INCOME			
Sch No	Head of Account	2013-14	2012-13	Sch No	Head of Account	2013-14	2012-13
		Rs.	Rs.			Rs.	Rs.
1	2	3	4	5	6	7	8
1	Administation Expenses	9,536,197	9,098,752	6	Grant-in-Aid received from Ministry of Mines	23,200,000	47,700,000
2	Pay & Allowances	58,957,529	77,578,753	7	Miscellaneous Income	169,707	178,446
3	Travel Expenditure	548,432	433,504	8	Prior Period Income	10,678,189	701,929
4	Up Keep of Assets	891,797	705,628	9	Interest Received	4,356,256	4,619,047
5	Prior Period Expenses	8,025	5,731,227	10	Withdrawal of Depreciation	1,058,405	-
		-	-		Excess of Expenditure over Income	45,919,781	45,967,675
14	Depreciation on Fixed Assets	5,267,769	5,277,892				
15	Provisios for Income Tax	10,172,589	341,341				
	Total:-	**85,382,338**	**99,167,097**		**Total:-**	**85,382,338**	**99,167,097**
						-	-

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 GRSM & Associates
Chartered Accountants

Sd/-
Gopalkrishna Hegde
Partner
M.No:208063

Place : Bangalore
Date: 19/08/2014

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, KOLAR GOLD FIELDS

Receipt and Payment Account for the year ending on 31st March 2014

Institute

RECEIPT SIDE				PAYMENT SIDE			
	Head of Account	Amount Rs. Ps.	Amount Rs. Ps.		Head of Account	Amount Rs. Ps.	Amount Rs. Ps.
1	2	3	4	5	6	7	8
To	Opening Balance			By	Provision for Gratuity Paid		10,020,000
"	Cash	108,017		"	Sundry Creditors Pay Roll		353,493
"	Bank	(158,681,754)	(158,573,737)	"	Sundry Creditors Others		7,582,599
"				"	Retention Money - Employees		167,903
"				"	Purchase of Fixed Assets		40,732
"	Terminal/Retirement Benefits		728,819	"	Fixed Deposits - Short Term		5,131,026
"	Sundry Creditors - Staff		43,607	"	Advacne to IPRM Seed Money		500,000
"	Medical Advance		30,000	"	Income Tax		276,634
"	Advacne to Staff		21,603	"	Project Institute Adjustment A/c		3,415,568
"	Grant in Aid (Non- Plan)		23,200,000	"	Pre Paid Expenses		111,936
"	Income - Licence Fee		43,518	"	Administration Expenses		8,583,865
"	Income - Others		92,380	"	Salaries & Wages		55,131,604
"	Interest - IDF		2,994,148	"	Travelling Expenses		490,510
"	Interest - Savings Bank Deposits		98,164	"	Up Keep of Assets		961,049
"	Interest - Term Deposits		759,683	"	Prior Period Expenses		8,025
				"	Closing Balance		
				"	Cash	93,988	
				"	Bank Balance	(223,430,747)	(223,336,759)
	Total:-		**(130,561,815)**		**Total:-**		**(130,561,815)**

-

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

Schedule - 14

Institute

DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2014

		Gross Block						Depreciation					Net Block	
Name of the Assets	Rate of Depreciation %	Balance as on 01-04-13	Assets Written off/Trans-ferred	Purcchases up to 30.09.13	Purchases between 1.10.13 to 31.12.13	Purchases After 01.01.14	Total as on 31.03.14 (Total of Col 3 to Col 7)	Balance as on 01-04-13	Adjustment	Depreciat-ion written off	Depreciation for the year	Total Depreciation as on 31-03-14 (Total of Col 9 to Col 11)	As on 31-3-14 (Col 8 - Col 12)	As on 31-03-13
1	2	3	4	5	6	7	8	9		10	11	12	13	14
Buildings	5	9,108,642	-	-	-	-	9,108,642	8,462,011	-	-	209,462	8,671,473	437,169	646,631
Plant & Machinery	7.5	32,225,642	-	-	-	-	32,225,642	31,589,808	-	-	76,124	31,665,932	559,710	635,834
Water Supply	5	328,926	-	-	-	-	328,926	285,393	-	-	12,060	297,453	31,473	43,533
Power supply	5	503,434	-	-	-	-	503,434	502,764	-	-	570	503,334	100	670
Furniture	5	4,566,256	-	-	-	-	4,566,256	2,153,962	-	-	193,269	2,347,231	2,219,025	2,412,294
Office Equipment	5	2,719,932	-	40,732	-	-	2,760,664	1,346,142	-	-	115,073	1,461,215	1,299,449	1,373,790
Vehicle	7.5	783,835	-	-	-	-	783,835	759,644	-	-	24,091	783,735	100	24,191
Laboratory Equipment	7.5	29,985,087	-	-	-	-	29,985,087	16,721,921	-	-	1,849,583	18,571,504	11,413,583	13,263,166
Technical Books	5	4,693,917	-	-	-	-	4,693,917	2,590,224	-	-	234,761	2,824,985	1,868,932	2,103,693
Computer Software	15	12,719,460	-	-	-	-	12,719,460	9,067,971	-	-	1,286,265	10,354,236	2,365,224	3,651,489
Computer Hardware	20	13,600,322	-	-	-	41,504	13,641,826	12,032,980	-	-	1,024,470	13,057,450	584,376	1,567,342
Conversion of Power line	5	1,799,459	-	-	-	-	1,799,459	1,064,492	-	-	89,973	1,154,465	644,994	734,967
Env Geo Tech Lab		2,113,409	-	-	-	-	2,113,409	1,146,952	-	-	152,068	1,299,020	814,389	966,457
Total:-		**115,148,321**	**-**	**40,732**	**-**	**41,504**	**115,230,557**	**87,724,264**	**-**	**-**	**5,267,769**	**92,992,033**	**22,238,524**	**27,424,057**
Advance for capital material purchase		-	-	-	-	-	-	-		-	-	-	-	-
(Previous year figures)		**115,148,321**	**-**	**46,332**	**-**	**-**	**115,101,988**	**82,446,372**	**-**	**-**	**5,277,892**	**877,242,464**	**27,424,056**	**32,655,616**

Note: 1. Depreciation has been charged on Straight Line Method.

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS
BALANCE SHEET AS AT 31ST MARCH 2014

PROJECT

(Amount in Rs)

Sl. No.	Liabilities	Sch No.	Balance as on 31-03-2013	Balance as on 31-03-2014	Sl. No.	Assets	Sch No	Balance as on 31-03-2013	Balance as on 31-03-2014
1	**OTHER CAPITAL FUNDS**				1	**CURRENT ASSETS**			
	Income & Expenditure Account	1	107,506,470	168,823,539		a) Cash in Hand	6	103,467	131,741
						b) Cash at Bank	7	177,433,634	232,280,640
2	**CURRENT LIABILITIES**					c) Stock - Stationery Items	8	47,628	124,005
	a) Advance received against on-going projects	2	178,750,911	133,240,158					
	b) Sundry Creditors - Others	3	1,697,313	(273,423)	2	**INVESTMENTS**			
	c) Sundry Creditors - Suppliers & Employees	4	17,742	90,831		a) Short Term Deposits against Project Advances received from clients	9	40,500,000	45,199,842
	d) Institute Account	5	32,446,586	42,051,172					
					3	**LOANS AND ADVANCES**			
						a) Advances - Staff	10	997,707	929,699
						b) Advances - Suppliers	11	1,371,935	1,371,935
					4	**Other Current Assets**	12	25,215,798	20,090,985
					5	**Expenses on Ongoing Projects**	13	74,195,369	43,310,463
					6	**Fixed Assets**	14	553,484	492,967
	TOTAL		**320,419,022**	**343,932,277**		**TOTAL**		**320,419,022**	**343,932,277**
								-	-

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 GRSM & Associates
Chartered Accountants

Sd/-
Gopalkrishna Hegde
Partner
M.No:208063

Place : Bangalore
Date: 19/08/2014

NATIONAL INSTITUTE OF ROCK MECHANICS
CHAMPION REEFS POST, KOLAR GOLD FIELDS
INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDING ON 31ST MARCH 2014

PROJECT
(Amount in Rs)

Sl. No.	Expenditure	Sch No	2012-13	2013-14	Sl. No.	Income	Sch No	2012-13	2013-14
1	Expenditure on Completed Sponsored Projects:	**15**	23,006,664	40,110,452	1	Amount received against Completed Sponsored Projects	**18**	47,784,523	103,800,567
2	Expenditure on Completed R & D Projects:	**16**	-	30,768,145	2	Amount received against Completed R & D Projects	**19**	-	38,425,682
3	Income Tax	**17**	-	12,003,745	3	Interest Received	**20**	1,549,963	2,033,679
4	Depreciation on Fixed Assets - Vehicle	**14**	60,517	60,517	4	Prior Period Income	**21**	694,687	-
	Excess of Income over Expenditure		26,961,992	61,317,069					
	Total:-		**50,029,173**	**144,259,928**		**Total:-**		**50,029,173**	**144,259,928**
								-	-

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 GRSM & Associates
Chartered Accountants

Sd/-
Gopalkrishna Hegde
Partner
M.No:208063

Place : Bangalore
Date: 19/08/2014

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, KOLAR GOLD FIELDS

Receipt and Payment Account for the year ending on 31st March 2014

PROJECT

(Amount in Rs)

	Receipts	Amount	Amount		Payments	Amount	Amount
TO	Opening Balance			By	Project Contingency (A)		11,673
	Cash	103,467		"	Project Contingency (B)		213,863
	Bank	177,433,634		"	EMD & Security Deposits		82,889
			177,537,101	"	Staff Welfare		400,000
"	Payroll Deductions Inocme Tax		334,026	"	Service Tax Paid - Projects		1,055,599
"	Advance Against Testing		5,069,194	"	Service Tax Paid - Testing		159,812
"	Advance Received - Sponsored Projects		87,308,074	"	Honorarium/ Incentive (Projects / MTL) Payable		11,613,802
"	Advance Against S&T - DST		360,000	"	Imprest - Anjaneyappa T		5,000
"	Defect Liabities		621	"	Imprest - Sivakumar C		5,000
"	Fixed Deposits		759,530	"	Security Deposit - BESCOM		2,350
"	Material Advance - Staff		136,439	"	Travel Advance		181,133
"	Security Deposits - Employees		170,000	"	TDS & Income Tax		6,408,419
"	Travel Expenditure- Domestic		48,465	"	Material Teasting Expenses		1,200,827
"	Interest Reeceived on IDF		262,430	"	Expenditure on R&D Running Projects		516,667
"	Interest Reeceived on Savings Bank		228,745	"	Expenditure on Sponsored Running Projects		18,644,841
"	Interest on Term Deposits		1,214,158	"	Security Deposit by IOC Asansol		361,251
"	Surplus from MTL & RFM Test		5,000	"	Stock Stationery Items		363,611
"	Surplus from Sponsored Projects		248,392	"	Institutev-Project Account		43,056
				"	Closing Balance		
					Cash	131,741	
					Bank	232,280,641	
							232,412,382
	Total:-		**273,682,175**		**Total:-**		**273,682,175**

NATIONAL INSTITUTE OF ROCK MECHANICS

Champion Reefs Post, Kolar Gold Fields - 563 117.

Schedule - 14

PROJECT

DEPRECIATION SCHEDULE FOR THE YEAR ENDING 31ST MARCH 2014

		Gross Block						Depreciation				Net Block	
Name of the Assets	**Rate of Depreciation %**	**Balance as on 01.04.13**	**Assets Written off/Transferred**	**Purcchases up to 30.09.13**	**Purchases between 1.10.13 to 31.12.13**	**Purchases After 01.01.14**	**Total as on 31.03.14**	**Balance as on 01.04.13**	**Depreciation written off**	**Depreciation for the year**	**Total Depreciation as on 31.03.14**	**As on 31.3.14**	**As on 31.03.13**
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Vehicle	7.5	806,889	-	-	-	-	806,889	253,405	-	60,517	313,922	492,967	553,484
Total:-		**806,889**	**-**	**-**	**-**	**-**	**806,889**	**253,405**	**-**	**60,517**	**313,922**	**492,967**	**553,484**
Advance for capital material purcha		-	-	-	-	-	-	-	-	-	-	-	
(Previous year figures)		**806,889**					**806,889**	**192,888**	**-**	**60,517**	**253,405**	**553,484**	**614,015**

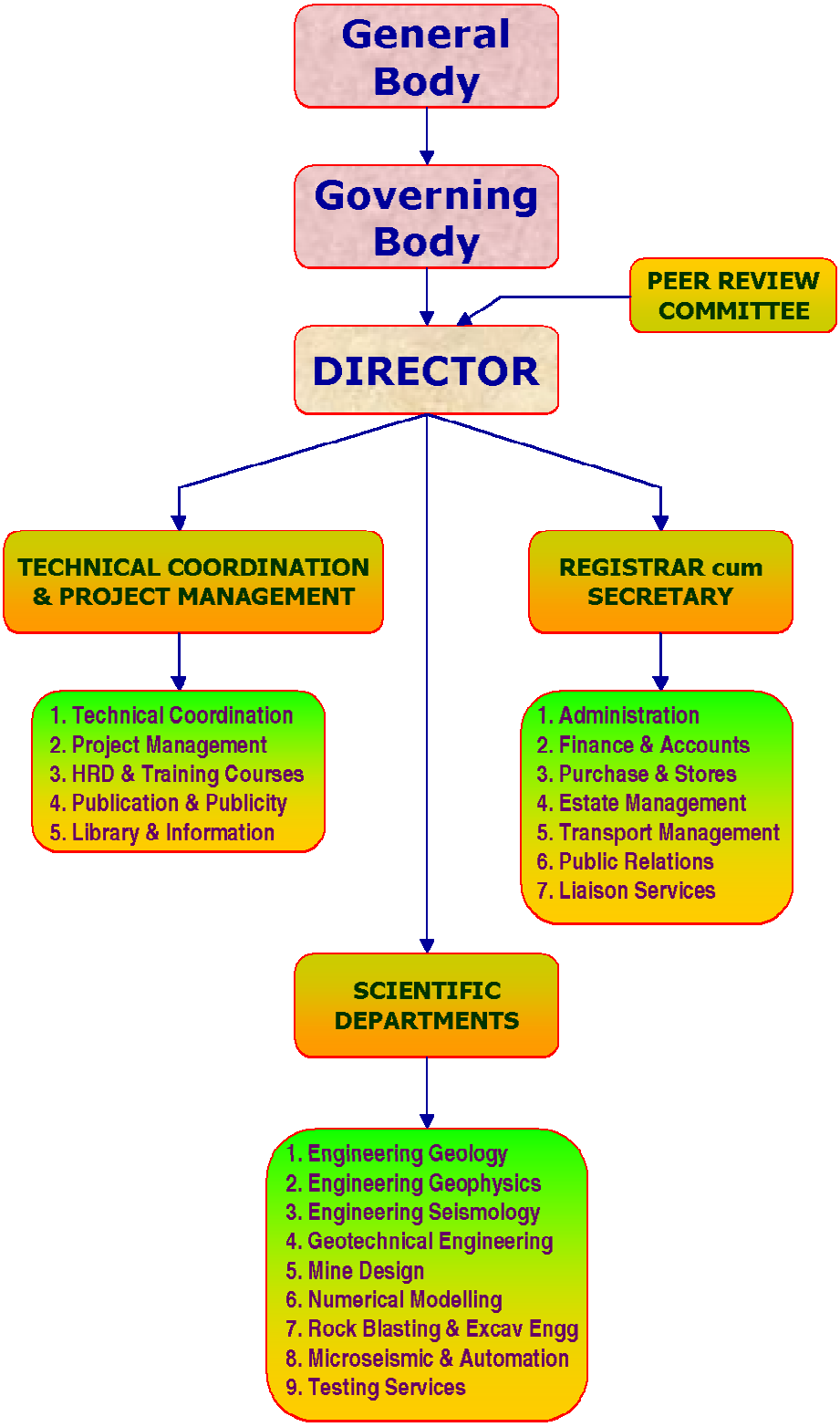
Note: 1. Items not put into use : NIL

2. Depreciation has been charged on Straight Line Method.

A N N E X U R E

Annexure - 1

ORGANISATION CHART



Annexure - 2

MEMBERS OF THE GENERAL BODY
(2014-16)

Chairman

Dr Anup K Pujari, 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

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

Ms Sujata Prasad, IAS
Jt. Secretary & Financial Advisor
Ministry of Mines, R.No.321A
III Floor, A Wing, Shastri Bhawan
New Delhi – 110 115

Ms Sunanda Sharma
Economic Advisor
Ministry of Mines, R.No.305
III Floor, D Wing, Shastri Bhawan
New Delhi – 110 115

Dr Joyesh Bagchi
Dy Secretary (Technical)
Ministry of Mines, R.No.306
III Floor, D Wing, Shastri Bhawan
New Delhi – 110 115

Dr SK Wadhawan
Director General
Geological Survey of India (GSI)
KOLKATA - 700 016

Sri Rahul Guha
Director General
Directorate General of Mines Safety
Dhanbad 826 001
Jharkhand

Dr Amalendu Sinha
Director, CSIR-
Central Institute of Mining & Fuel Research
DHANBAD – 826 015

Prof DC Panigrahi
Director
Indian School of Mines
DHANBAD – 826 003

Sri AS Walvekar
Executive Director (Geology / R&D Divn.)
National Hydro-Power Corporation Ltd
NHPC Office Complex, Sector-33
Faridabad – 121 003
Uttar Pradesh

Sri B Ramesh Kumar
Director (Operations)
Singareni Collieries Company Limited
KOTHAGUDEM COLLIERIES – 507 101

Prof BB Dhar
Formerly : Director, CIMFR
Director (Research), AIU
Director (R&IC), Amity Univ.
Advisor, HESRT&SD
NEW DELHI – 110 048

Sri AK Rudra
Retd. Director General of Mines Safety
KOLKATA – 700 002

Sri A Sundaramoorthy
Director General (Retd.), GSI
CHENNAI – 600 099

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

Secretary (Non-member)

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

Annexure - 3

MEMBERS OF THE GOVERNING BODY
(2014-16)

Chairman

Dr Anup K Pujari, 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

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

Ms Sujata Prasad, IAS
Jt. Secretary & Financial Advisor
Ministry of Mines, R.No.321A
III Floor, A Wing, Shastri Bhawan
New Delhi – 110 115

Ms Sunanda Sharma
Economic Advisor
Ministry of Mines, R.No.305
III Floor, D Wing, Shastri Bhawan
New Delhi – 110 115

Dr Joyesh Bagchi
Dy Secretary (Technical)
Ministry of Mines, R.No.306
III Floor, D Wing, Shastri Bhawan
New Delhi – 110 115

Dr SK Wadhawan
Director General
Geological Survey of India (GSI)
KOLKATA - 700 016

Sri Rahul Guha
Director General
Directorate General of Mines Safety
Dhanbad 826 001
Jharkhand

Dr Amalendu Sinha
Director, CSIR-
Central Institute of Mining & Fuel Research
DHANBAD – 826 015

Prof DC Panigrahi
Director
Indian School of Mines
DHANBAD – 826 003

Sri AS Walvekar
Executive Director (Geology / R&D Divn.)
National Hydro-Power Corporation Ltd
NHPC Office Complex, Sector-33
Faridabad – 121 003
Uttar Pradesh

Sri B Ramesh Kumar
Director (Operations)
Singareni Collieries Company Limited
KOTHAGUDEM COLLIERIES – 507 101

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Kolar Gold Fields - 563 117

Secretary (Non-member)

Mr AN Nagarajan
Registrar-cum-Secretary
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Champion Reefs
Kolar Gold Fields - 563 117

Annexure - 4

MEMBERS OF THE PEER REVIEW COMMITTEE
(2014-16)

Chairman
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Director General of Mines Safety (Retd)
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Members

Alt. Chairman
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Director General (Retd.), GSI
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Prof VR Sastry
Mining Engineering Department
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Professor, AcSIR-CIMFR
Central Institute of Mining & Fuel Research
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Dr Asim Kumar Sinha
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Annexure - 5

SUPPORTING ORGANISATIONS & MAJOR CLIENTELE

Central Government Ministries & Departments

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

Public Sector Organisations/ State Government

Oil and Natural Gas Commission (ONGC)
Indian Oil Corporation Limited (IOCL)
Atomic Minerals Directorate (AMD)
Nuclear Power Corporation of India Limited (NPCIL)
Engineers India Limited (EIL)
Manganese Ore India Limited (MOIL)
Uranium Corporation of India Limited (UCIL)
Hutti Gold Mines Limited (HGML)
South Eastern Coalfields Limited (SECL)
Western Coalfields Limited (WCL)
Hindustan Copper Limited. (HCL)
Hindustan Zinc Limited (HZL)
National Aluminium Company Ltd. (NALCO)
National Thermal Power Corporation (NTPC Limited)
Tehri Hydroelectric Development Corporation (THDC Limited)
National Hydroelectric Power Corporation (NHPC Limited)
Satluj Jal Vidyut Nigam Limited (SJVNL)
Sardar Sarovar Narmada Nigam Limited (SSNNL)

Andhra Pradesh Heavy Machinery and Engineering Limited (APHMEL)
Andhra Pradesh Power Generation Corporation (APGENCO)
Karnataka Power Corporation Limited (KPCL)
Singareni Collieries Company Limited.
Kerala State Electricity Board (KSEB)
Kerala State Electricity Board (KSEB)

Private Companies

Transstroy-AFCONS JV, Chennai
Transstroy-JSC-EC-UES, AP
Hindustan Construction Company Limited (HCC), Mumbai
Jindal Power Limited, Gurgaon
IOT Infrastructure & Energy Services Ltd , AP
Megha Engineering & Infrastructures Ltd, AP
Navyuga Kommu Venkateshwara Metal Miners, AP
Navayuga Engineering Company Limited, AP
Larsen & Toubro (L&T) Construction, AP
Ferro-Alloys Corporation Limited (FACOR)
M/s Sesa Mining Corporation Ltd., Goa
M/s Patel Engineering Ltd, Hyderabad
M/s Cosme Costa & Sons, Goa
The India Cements Limited (ICL), AP
Kare Power Resources Private Limited (KPRPL)
Zuari Cement Limited, AP
Mantri Developers Pvt. Ltd., Bangalore
M/s India Cements Limited, Chennai
Bagmane Estates Pvt. Ltd., Bangalore
Waddera Sangam, AP
Shaft Sinkers Mauritius Ltd, Rajasthan
China Coal No.5 Constructions Pvt Ltd, Rajasthan
India Resources Limited, AP
Alliance Minerals Pvt. Ltd , AP
Covenant Stones Pvt. Ltd., TN

International Organisations

Druk Green Power Corporation Limited (DGPCL), Bhutan
(Formerly Tala Hydrolectric Project, Bhutan)
Mangdechhu Hydroelectric Project Authority (MHPA), Bhutan

Annexure – 6

LIST OF PROJECTS

Sl. No	Title of Project	Persons involved	Status
1	Construction stage engineering geological investigations at crude oil strategic storage project (2.50 MMT), Padur, Karnataka	*AK Naithani, Manoj Kumar, Prasnna Jain & LG Singh*	Completed
2	Construction stage engineering geological and geotechnical investigations of crude oil strategic storage project (1.5 MMT), Mangalore, Karnataka	*AK Naithani and DS Rawat*	Completed
3	Construction stage engineering geological mapping of Turbine Generator Buildings foundation of Rajasthan Atomic Power Project (RAPP) Units 7&8, Rawatbhata in Chittorgarh, Rajasthan	*AK Naithani, Prasnna Jain & LG Singh*	Completed
4	Review of preliminary / preconstruction reports on geotechnical investigations of Pranahita - Chevella Sujala Sravanthi Lift Irrigation Scheme Package-5, Adilabad District, Andhra Pradesh	*A.K. Naithani*	Completed
5	Engineering geological investigations of Pranahitha – Chevella Sujala Sravanthi Lift Irrigation Scheme (Package-6), Karimnagar District, Andhra Pradesh	*AK Naithani, Devendra Singh Rawat, LG Singh, Prasnna Jain & Manoj Kumar*	On-going
6	Construction stage engineering geological investigations of surge pool and pump house (5X30 MW) area of Mahatma Gandhi Kalwakurthi Lift Irrigation Scheme–II, Mahaboobnagar District, Andhra Pradesh	*AK Naithani, LG Singh & Prasnna Jain*	On-going
7	Engineering geological, geotechnical, laboratory testing and support design for the underground surge pool and pump house project of Pranahitha – Chevella Sujala Sravanthi Lift Irrigation Scheme (Package-12), Siddipet, Andhra Pradesh	*AK Naithani, LG Singh & Prasnna Jain*	On-going
8	Geotechnical assessment of the plant water pump house (PWPH) of Rajasthan Atomic Power Project (RAPP) Units 7&8, Rawatbhata, Rajasthan	*AK Naithani*	On-going
9	Engineering geological investigation of Pulichintala Hydroelectric Scheme (4 x 30 MW), Guntur District, Andhra Pradesh	*A.K. Naithani, Prasnna Jain and Manoj Kumar*	On-going
10	Geophysical surveys along HMRB oil pipe line and Andal RCP in the Raniganj-Asansol Coal Belt Area	*P. C. Jha, V. R. Balasubramanaim, N. Sandeep, Y. V. Sivaram, D. Joseph & B. Butchi Babu*	Completed

Sl. No	Title of Project	Persons involved	Status
11	Geophysical Investigations in the Intake and Desilting Chamber areas of Nikachhu Hydro Power Project in Bhutan	*P. C. Jha, V. R. Balasubramanaim, N. Sandeep, Y. V. Sivaram, D. Joseph & B. Butchi Babu*	Completed
12*	Development of a viable technique for assessment of safety of structures under settling environment, **S&T Project**	*P. C. Jha* Project Leader	On-going
13*	Monitoring Indian Shield Seismicity with 10 BBS to understand seismotectonics of the region using V-SAT Connectivity, **S&T Project**	*C. Srinivasan and Y A Willy*	On-going
14*	Monitoring Indian Shield Seismicity with 10 BBS to understand seismotectonics of the region using V-SAT Connectivity, **S&T Project**	*C. Srinivasan Project Leader*	On-going
15	Seismotectonic Evaluation of Kudankulam Atomic Power within 30-50 Km Radius area, Tamil Nadu	*Biju John, D.T. Rao, Yogendra Singh, K.S Divyalakshmi and C. Srinivasan*	completed
16	Geological Studies for evaluating the Rock Melt Extrusions (RME) in the Kudankulam Atomic Power Plant region, Tamil Nadu	*Biju John, D.T.Rao, and Yogendra Singh*	completed
17	Geothermal study at Manappad around Kudankulam Area, Tamil Nadu	*Biju John, Yogendra Singh, and C. Srinivasan*	On-going
18*	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, and KS Divyalakshmi*	Completed
19	Determination of in-situ stress, shear and deformability parameters at the proposed power house and intake drift of Teesta Stage-IV hydroelectric project, Sikkim	*S. Sengupta, D.S. Subrahmanyam, R.K. Sinha and G. Shyam*	Completed
20	Determination of in-situ stress parameters at the proposed powerhouse chamber of Attunli hydroelectric project, Arunachal Pradesh	*S Sengupta, D. S. Subrahmanyam, R. K. Sinha, and G. Shyam*	Completed
21	Determination of in-situ shear and deformability parameters of the rock mass encountered inside the powerhouse and transformer cavern of Mangdechhu hydroelectric project, Bhutan	*S. Sengupta, D.S. Subrahmanyam, R.K. Sinha and G. Shyam*	Completed
22	Determination of in-situ shear and deformability parameters of the rock mass encountered at Shear zone area at proposed powerhouse cavern of Mangdechhu hydroelectric project, Bhutan	*S. Sengupta, D. S. Subrahmanyam, R. K. Sinha, and G. Shyam*	Completed

Sl. No	Title of Project	Persons involved	Status
23*	Development of state of the art facilities for in-situ stress measurement by hydrofracture method in porous and fractured rock mass, **S&T Project**	*S. Sengupta, Project Leader*	On-going
24	Suggesting controlled blasting method and monitoring ground vibration and air overpressure at Vellathooval SHEP, Vellathooval, KSEB, Kerala	*A. I. Theresraj, R. Balachander, G. Gopinath, K. Vamshidhar and H. S. Venkatesh*	Completed
25	Study on providing safe charges for blasting near 400/220KV switchyard, RAPP (7&8), L&T, Rawatbhata, Rajasthan	*G. Gopinath, R. Balachander, A. I. Theresraj, K. Vamshidhar and H. S. Venkatesh*	Completed
26	Advice on blast design parameters based on the ground vibration and air overpressure studies at Thangarabalu Hydro Project, Raichur, Karnataka	*A. I. Theresraj, K. Vamshidhar G. Gopinath, R. Balachander and H. S. Venkatesh*	Completed
27	Ground vibration and air overpressure studies at Zuari limestone mine, Zuari Cement Limited, Yerraguntla, Kadapa District, AP	*R. Balachander, G. Gopinath, A. I. Theresraj, and H. S. Venkatesh*	Completed
28	Technical guidance on controlled blasting and monitoring blast vibration at Mantri Web City, Hennur, Mantri Developers Pvt. Ltd., Bangalore	*R. Balachander, G. Gopinath, A. I. Theresraj, and H. S. Venkatesh*	Completed
29	Monitoring of Ground Vibration and Air Overpressure at Sangam Kalan limestone Mine, Phase IV, ICL, Tandur Mandal, Andhra Pradesh	*G. Gopinath, G. C. Naveen, A. I. Theresraj,R. Balachander, and H. S. Venkatesh*	On-going
30	Technical Guidance on Controlled Blasting and Monitoring of Blast Vibration at Morbi Branch Canal Project, Morbi, SSNNL, Gujarat	*G. Gopinath, A. I. Theresraj, R. Balachander, G. C. Naveen and H. S. Venkatesh*	On-going
31	Technical Advice on Rip Rap Blasting for the Construction of Earth Cum Rock Filled Dam, Indira Sagar Polavaram Project, East Godhavari District, Andhra Pradesh	*G. Gopinath, A. I. Theresraj, R. Balachander, G. C. Naveen and H. S. Venkatesh*	On-going
32	Study on feasibility of blasting for hard rock excavation in Top Down method, TT-AFCONS Jv., CMRL Site, Chennai	*G. Gopinath, A. I. Theresraj, R. Balachander, G.C. Naveen and H. S. Venkatesh*	On-going
33	Technical guidance on controlled blasting and monitoring blast vibration at Bagmane Constellation Business Park, Outer Ring Road, Bangalore	*R. Balachander, G. C. Naveen, A. I. Theresraj, G. Gopinath, and H. S. Venkatesh*	On-going
34	Study on ground vibration and assessment of flyrock at quarries of Sy. No. 493 & 497, Waddera Sangam, Karimnagar District, AP	*A. I. Theresraj, G. Gopinath, R. Balachander, G. C. Naveen and H. S. Venkatesh*	On-going
35	Back Analysis of Powerhouse Complex Behaviour using 3D Numerical Modeling at Tapovan Vishnugad Hydroelectric Project, NTPC Ltd., Noida	*Sripad R Naik, Roshan Nair and K. Sudhakar*	Completed

Sl. No	Title of Project	Persons involved	Status
36	Geodetic Monitoring of Sardar Sarovar Dam, SSNNL, Kevedia, Gujarat	*Sripad R Naik, K. Sudhakar, Rabi Bhushan, and B H Vijay Sekar*	Completed
37	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, and K. Sudhakar,*	Completed
38	Stress Analysis of Underground Pump house at Pranahita – Chevella SS package – 23, M/s Patel Engineering, Hyderabad, A P	*Sripad R Naik, Roshan Nair, and K. Sudhakar*	Completed
39	Instrumentation, Monitoring and Data Analysis at Powerhouse complex Tala Hydro Power Plant, Bhutan	*Sripad R Naik, K. Sudhakar, Roshan Nair, Rabi Bhusan, and BH Vijay Sekar*	Part Completed
40	Analysis of Instrumentation data of Dam at Tala HE Project, Bhutan	*Sripad R Naik*	Part Completed
41	Surface Subsidence Prediction and Review of support system at Mahamaya U/G mine, Bhatgaon area, SECL, Chattisgarh	*Sripad R Naik, Dr. Ritesh Lokhande, and K. Sudhakar*	Part Completed
42	Deformation Monitoring of Underground Powerhouse Cavern of Sardar Sarovar Project, Gujarat	*Sripad R Naik, K. Sudhakar, Rabi Bhusan, and B H Vijay Seka*	Part Completed
43	Investigation into Stability of Pirsurlem Waste dump slopes at Sonshi Iron Ore Mine, M/s Cosme Costa & Sons, Goa	*Sripad R Naik, Amrith Renaldy, B H Vijay Sekar, and K. Sudhakar*	On-going
44	Stability Analysis of Shafts at Central Mochia. Baleria, West Mochia and Zawarmala mines if Hindusthan Zinc Ltd.	*Sripad R Naik, Roshan Nair, Rabi Bhusan, Amrith Renaldy and K. Sudhakar*	Completed
45	Analysis of Instrumentation Data of Dam, Desilting complex, Power house Complex, of NJHPS, SJVNL, Shimla	*B. H. Vijay Sekar, K. Sudhakar, Rabi Bhusan*	Completed
46	Assessment and Proof checking of support system at surge pool and pump house in Pranahita Cheevella Sujala Sravanthi Package 8	*Sripad R Naik, Roshan Nair and K. Sudhakar*	On-going
47	Slope Stability Analysis of Abutment Cut Slopes for Concrete Gravity Dam at Mangdechu Hydroelectric Project, Bhutan	*Sripad R Naik, BH Bijay Sekar, Rabi Bhusan, and K. Sudhakar*	On-going
48	3D Stress analysis of Underground caverns of Powerhouse complex with D/S Surge shaft bus bar tunnels and penstock entry for at Tehri PSP	*Sripad R Naik, Rabi Bhusan, BH Bijay Sekar, and K. Sudhakar*	On-going
49	Design of Supports and Suitable Stoping Method for the Baryte Mines at Pulivendula, YSR District, Andhra Pradesh	*SK Reddy, Prasnna Jain, and V Venkateswarlu*	Completed
50	Strata Control Investigations in Panel 38 Level East in Seam V at Churcha West, SECL	*C Nagaraj, Amrith T Renaldy, K Vamshidhar and V Venkateswarlu*	On-going

Sl. No	Title of Project	Persons involved	Status
51	Testing of Fly Ash and Mill Tailings for the Purpose of Stowing at UCIL	*Praveena D Jennifer, Amrith T Renaldy, V Venkateswarlu*	Completed
52	Design of Support Systems for Crusher Chamber and for Hangwall Lode, UCIL	*V Venkateswarlu, C Nagaraj & Amrith T Renaldy*	On-going
53	Rock Mechanics Investigations to Evaluate the Requirement of Support Pillars in LDBH Stopes at Kathpal Chromite Mine, FACOR	*Sripad R Naik, Roshan Nair, Rabi Bhusan, and V Venkateswarlu*	On-going
54	Advice for scientific mining methods and studies to assess the stability of slope at the Krishna mines at Ramaiyanpatti, Tirunelveli, Tamilnadu.	*G. C. Naveen, A. Rajan Babu, S.S. Meena, V. Venkateswarlu, Amrith Renaldy, Rabi Bhusan, Lakshmipathy, S. Thobias*	Completed
55	Stability monitoring of powerhouse cavern of Tapovan-Vishnugad Hydroelectric power project (TVHPP) using the Nanoseismic monitoring system in real time, Joshimath	***C. Sivakumar and Vikalp Kumar***	On-going
56	Installation and commissioning of microseismics monitoring unit at Tala Power House Cavern, Bhutan	***C. Sivakumarr***	Completed
57	Microseismic monitoring for stability evaluation of Powerhouse of Tala Hydel Project, Bhutan	***C. Sivakumar and Vikalp Kumar***	On-going
58	In-situ Non-Destructive testing for M/s. China Coal No.5 Constructions Pvt Ltd.	***M. Victor, A. Rajan Babu, Sagaya Benady, Syed Asghar, M. Lakshmipathy and Royston Angelo Victor***	Completed
59	In-Situ Non-Destructive testing for M/s. Shaft Sinkers Mauritius Ltd.	***M. Victor, A. Rajan Babu, Sagaya Benady, and Royston Angelo Victor***	Completed
60	In-situ Non-Destructive tests for M/s. Hindustan Zinc Limited, Zawar (Part A) and Rajpura Dariba Mines.	***M. Victor, A. Rajan Babu, Sagaya Benady, and Royston Angelo Victor***	Completed
61	In-situ Non-destructive Tests for M/s. Singareni Collieries Company Limited.	***M. Victor, A. Rajan Babu, Sagaya Benady, Syed Asghar, M. Lakshmipathy, and Royston Angelo Victor***	Completed
62	Non-Destructive Testing for Andhra Pradesh Heavy Machinery and Engineering Limited, Vijayawada.	***M. Victor, A. Rajan Babu, Sagaya Benady, Syed Asghar, and Royston Angelo Victor,***	Completed
63	In-situ Non-Destructive Tests for M/s. Hindustan Zinc Limited, Rajpura Dariba Mines – Part B	***M. Victor, A. Rajan Babu, Sagaya Benady, Syed Asghar, M. Lakshmipathy, and Royston Angelo Victor***	On-going
64	In-Situ Non-Destructive Testing for Hindustan Copper Limited. Khetri and Kolihan Mines, Rajasthan	***M. Victor, A. Rajan Babu, Sagaya Benady, Syed Asghar, M. Lakshmipathy, and Royston Angelo Victor***	On-going
65	Destructive and Non-Destructive testing for M/s. National Aluminium Company Ltd. (NALCO) Damanjodi, Odisha	***M. Victor, A. Rajan Babu, Sagaya Benady, Syed Asghar, and Royston Angelo Victor***	On-going

Sl. No	Title of Project	Persons involved	Status
66	Laboratory Geo-technical Investigations on Rocks for Evaluating the Stability of Pit Slope and the Adriyala Dump under the formation of RG OC – II Extension Block	***A. Rajan Babu; S. Udayakumar; Praveena Das Jennifer; G. D. Raju & D. Joseph***	Completed
67	Laboratory Geo-technical Investigations on rock samples -Mangdechhu HEP, Bhutan	***A. Rajan Babu; S. Udayakumar; Praveena Das Jennifer; G. D. Raju & D. Joseph***	Completed
68	Laboratory Geo-technical Investigations on Rocks for Evaluating the Stability of Internal Dump of PK OC – II Extension Block, SCCL	***A. Rajan Babu; S. Udayakumar; Praveena Das Jennifer; G. D. Raju & D. Joseph***	Completed
69	Laboratory Geo-Technical Investigations – Pothead Yard Mangdechhu HEP, Bhutan	***A. Rajan Babu; S. Udayakumar; Praveena Das Jennifer; G. D. Raju & D. Joseph***	Completed
70	Laboratory Geotechnical Investigations on Rock Core Samples from Mumbai High (BH-64 & B-36), ONGC	***A. Rajan Babu; S. Udayakumar; Praveena Das Jennifer; G. D. Raju & D. Joseph***	Completed
71	Laboratory Geotechnical Investigations on rock core samples from Wellbores B-12-1, B-12-4, C-2-2, 519, 578, BT-1, KK-5 and KK-12, ONGC	***A. Rajan Babu; S. Udayakumar; Praveena Das Jennifer; G. D. Raju & D. Joseph***	Completed
72	Strain energy analysis during UCS test and Effect of strain rate on strength of rock during UCS test	***In-house R&D***	On-going

Annexure – 7

LIST OF PUBLICATIONS

1. AK Naithani, DS Rawat, LG Singh and PC Nawani, 2014: Engineering geological and geotechnical evaluation of the water conducting system and powerhouse area of Bunakha Hydroelectric Project, Bhutan Himalaya. Indian Journal of Power & River Valley Development, vol. 64, nos. 1-2, pp. 1-12.
2. AK Naithani, PC Nawani, LG Singh and DS Rawat, 2013: Engineering geological evaluation of the spillway of dam II-B of Bunakha Hydroelectric Project, Chukha Dzong, Bhutan. Journal of Geological Society of India, vol. 81, no. 6, pp. 835-843.
3. AK Naithani and LG Singh, 2013: 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, vol. 2, no. 2, pp. 9-18.
4. Biju John and DT Rao, 2014: Seismo-tectonic evaluation of critical civil engineering facilities: The standard practice, Proc. National Seminar on Innovative Practices in Rock Mechanics, Bengaluru, pp. 133-138.
5. Biju John, E Praseeda, Yogendra Singh, KS Divyalakshmi, Pijush Samui and C Srinivasan, 2014: Thenmala fault, south India: some new observations International seminar on Environmental Earth Sciences: Accomplishments, Plans and Challenges 19-22 March 2014.
6. Biju John, KS Divyalakshmi, Yogendra Singh and C Srinivasan, 2013: Use of SRTM data for a quick recognition of the active tectonic signatures. International Seminar GEOMORPH 2013, held at Nanjing, China, during 16-20.10.2013.
7. Biju John, Sandeep Nelliat and Yogendra Singh, 2014: A note on the brittle fault zones observed in the southwestern terminus of Palghat–Cauvery Shear Zone. Seminar or Precambrian Shear Zones of South India. March 29, 2014, pp. 14-24.
8. KS Divyalakshmi, J Sriganesh, V Ram Mohan, and RS Kankara, 2014: Sensitivity analysis for fault direction in tsunami propagation model for Kovalam–Mamallapuram coast, Tamil Nadu. International Conference on Environmental Earth Sciences: Accomplishments, Plans and Challenges, 19-22 March 2014.
9. DS Rawat, AK Naithani, LG Singh, Prasnna Jain and G Srinivasa Rao, 2014: Construction stage engineering geological assessment of a lift irrigation tunnel – A case study. Proc. National Seminar on Innovative Practices in Rock Mechanics, Bengaluru, pp. 60-64.
10. DS Rawat and GS Rawat, 2013: Problem of landslides in Bachangad catchment of Garhwal Himalaya in Uttarakhand, Journal of Indian Landslides, vol. 6, no. 2, pp. 13-24.

11. GD Raju, 2014: Dynamic Rock Supports for burst prone ground – A review, Proc. National Seminar on Innovative Practices in Rock Mechanics, Bengaluru.

12. G Shyam, DS Subrahmanyam, RK Sinha, 2014: Evaluation of deformability characteristics of rock mass at Pare Hydroelectric Project for the design of dam foundation. Proc. Innovative Practices in Rock Mechanics, Bengaluru.

13. HS Venkatesh, R Balachander and G Gopinath, 2013: Approach to urban excavation with special reference to Metro Rail. Visfotak – Journal of Explosives Safety & Technology Safety, Vol. No. 7, March 2013, pp. 35-40.

14. HS Venkatesh, Al Theresraj, G Gopinath and R Balachander, 2013: Is blasting the real issue ? Proc. National Seminar on Explosives & Blasting Techniques for Mining, Quarry and Infrastructure Industry (EBTMQI), NITK, Surathkal, pp. 49-57.

15. HS Venkatesh, Al Theresraj and R Balachander, 2014: Blast vibration impact studies at an operating power house complex due to nearby underground blasting, Proc. Innovative Practices in Rock Mechanics, Bengaluru, pp. 179-183.

16. S Kumar Reddy and VR Sastry, 2013: Strata monitoring studies in Blasting Gallery panel during depillaring based on field instrumentation, Journal of Indian National Group of International Society for Rock Mechanics, 2013.

17. S Kumar Reddy and VR Sastry, 2013: Gallery monitoring in Blasting Gallery panel during depillaring - A case study, Journal of Mines, Metals & Fuels, Volume 61, No. 7 & 8, pp. 257-260.

18. S Kumar Reddy, VR Sastry and K Ram Chandar, 2013: Induced blasting practice for hard roof management in Blasting Gallery method - A Case study, Proc. National Seminar on Explosives & Blasting Techniques for Mining, Quarrying & Infrastructure Industry (EBTMQI), 27-28 September, 2013, Surathkal.

19. S Kumar Reddy, VR Sastry and Roshan Nair, 2014: Assessment of mining induced stress with numerical modelling during depillaring of underground coal pillars with Blasting Gallery method, Proc. National Seminar on Innovative Practices in Rock Mechanics, Bengaluru.

20. LG Singh, AK Naithani, DS Rawat and PC Nawani, 2013: Geological, lineament and landslide studies of the reservoir and its vicinity of Bunakha hydroelectric project, Bhutan Himalaya. Journal of Engineering Geology, vol. 38, no. 1, pp. 90-111.

21. RD Lokhande and V Venkateswarlu, 2013. Strata behavior investigations in continuous miner panels at Venkatesh Khani No. 7 Incline. MineTech, Volume 34, no. 2, pp. 39-44.

22. Manoj Kumar, Manav Mittal and Pijush Samui, 2013: Performance assessment of genetic programming (GP) and minimax probability machine regression (MPMR) for prediction of seismic ultrasonic attenuation, Earthquake Science, vol. 26, no. 2, pp. 147-150.

23. Manoj Kumar, Pijush Samui and AK Naithani, 2013: Determination of uniaxial compressive strength and modulus of elasticity of travertine using machine

learning techniques, International Journal of Advance Soft Computing Application, vol. 5, no. 3, pp. 1-13.

24. Manoj Kumar, Pijush Samui and AK Naithani, 2014: Determination of stability of epimetamorphic rock slope using minimax probability machine, Geomatics, Natural Hazards and Risk, DOI:10.1080/19475705.2014.883440, pp. 1-8.

25. Manoj Kumar, Prasnna Jain, LG Singh and AK Naithani, 2014: Rock support assessment for unit-1 of unlined underground strategic crude oil storage cavern project, Padur, India. Proc. National Seminar on Innovative Practices in Rock Mechanics, pp. 94-102.

26. Manoj Kumar, Pijush Samui and Bhairevi G Ayer, 2014: Machine learning techniques applied to uniaxial compressive strength of oporto granite, International Journal of Performability Engineering, vol. 10, no. 2, pp. 189-195.

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Chapter contributed in book

S Sengupta, DS Subrahmanyam and RK Sinha, 2013: Estimation of the impact of mining on stresses by actual measurements in pre and post mining stages by hydrofracture method - A case study in a copper mine. Effective and Sustainable Hydraulic Fracturing, published by INTECH Open Science. pp. 915–925.

Annexure-8

SILVER JUBILEE CELEBRATIONS

1. National Seminar

A two-day National Seminar on "**Innovative Practices in Rock Mechanics**" (IPRM) was organized by the National Institute of Rock Mechanics (NIRM) as part of its Silver Jubilee celebrations, on 6th and 7th February, 2014 at Capitol Hotel, Bangalore.

Over 130 delegates from India and abroad participated in the Seminar. The Indian delegates included Scientists from various research and academic institutes, practicing engineers from different mining, hydro-electric, nuclear power sector and infrastructure companies, instrument manufacturers and suppliers, and distinguished invitees. Foreign delegates were from the companies NFC and CC5C (China), AMEC (USA) and Golder Associates (UK).

Sri A. K. Monnappa, IAS, Managing Director, HGML delivering the inaugural address of IPRM as Chief Guest

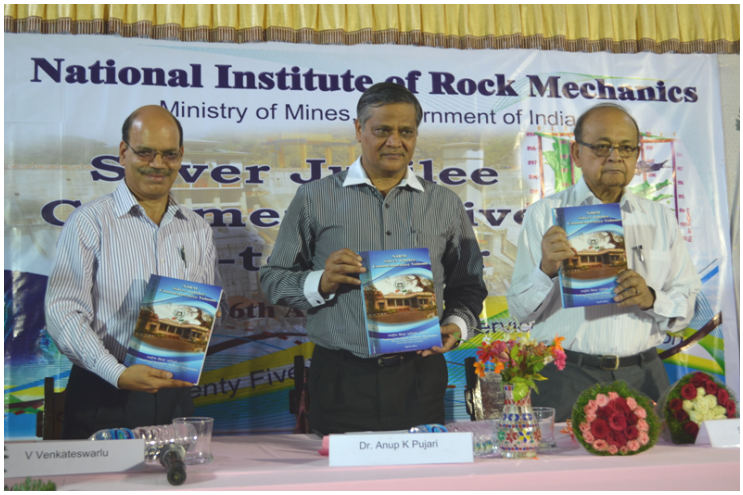
The inaugural address of the Seminar was delivered by Sri AK Monnappa, IAS (Managing Director, HGML) as the Chief Guest. Prof T Ramamurthy (formerly with IIT, Delhi), Sri R Gupta (formerly CMD, UCIL and BGML) and Sri BC Pathak (Project Director, NPCIL) also addressed the gathering as Guests of Honour. The Seminar had six Technical Sessions in which over 30 technical papers were deliberated on topics related to emerging trends, innovative developments and modern practices in the areas of geotechnical problems, geophysical investigations, rock blasting, rock support, back filling, numerical modelling, hard rock mining and slope stability, rock stress and rock strength measurements. In addition, there were ten technical papers presented in the Poster Session. The Papers in the Seminar were published in a bound Volume.

The Seminar recommendations were finalized in the Open Forum, and were circulated to all concerned individuals and agencies.

2. Silver Jubilee Function :

NIRM celebrated its completion of 25 years in the service to the nation, by organizing a Silver Jubilee Commemorative Get-together at Kolar Gold Fields on 26th April, 2014. Dr Aunp K Pujari, Secretary, Ministry of Mines and P K Lahiri, Chairman, Indian School of Mines attended the function as Chief Guest and Guest of Honour.

The Silver Jubilee Get-together was attended by the members of its first Governing Body, past directors, scientists and former staff. Among those attended were Sri PK Lahiri, IAS (retd.), Chairman, ISM, Dhanbad; Dr Anup K Pujari, IAS, Secretary to the Govt of India, Ministry of Mines; Prof BB Dhar, Director (retd.), CIMFER, Dhanbad; Prof AK Ghose, Director (retd.), ISM, Dhanbad; Prof DP Singh, VC (retd.) of various Universities, Prof T Ramamurthy, Professor (retd.), IIT-Delhi; Dr NM Raju, Founder Director (retd.), NIRM; Dr P C Nawani, Director retd.), NIRM; and Sri R Gupta, (retd.) MD, BGML & MD, UCIL. Both past (retired or left) and present employees of NIRM with their families and some local invitees attended this function.



Dr Anup K Pujari, IAS, Secretary, Ministry of Mines, Govt. of India (centre), **along with Mr AK Lahiri, IAS, Chairman, ISM, Dhanbad** (right), **releasing the NIRM Silver Jubilee Commemorative Volume**

During the function, a Commemorative Volume (with details of the history of the Institute, its achievements, memorabilia, and highlights of the present work) was released. A presentation on the formation of the Institute was made. In his speech, the Secretary, MoM, Dr Pujari, who is also the Chairman for NIRM Governing Body, assured full support for further development of the Institute. He advised that wide publicity should be given to the activities of the Institute so that it is well-recognised. Other speakers too highlighted that the Institute should increase its manpower and develop an archive to preserve the legacy of rock mechanics research carried out since 1980s. Some of the dignitaries shared their memories of the past and gave suggestions for future growth of the Institute

Mementos were presented to the NIRM past associates by Sri PK Lahiri, and to the present staff by Dr Anup K Pujari. All the participants were taken around the laboratories of NIRM at KGF.

Annexure-9

VISIT OF PARLIAMENTARY STANDING COMMITTEE

The Study Group of the Parliamentary Standing Committee (PSC) on Coal & Steel, headed by Mr Kalyan Banerjee, MP, had a meeting with the officers of NIRM at Bangalore on 24.10.2013. This was the first ever visit by the PSC to NIRM. During this meeting Director, NIRM, presented the overall activities of the Institute.

Dr V Venkateswarlu, Director, NIRM, presenting the activities of the Institute before the Parliamentary Standing Committee

During this meeting, the PSC asked NIRM to list out its best performances so far. NIRM identified the investigations for the Katra-Qazigund Railway Line, and the excavation design given for Bangalore Metro, as two of its several significant achievements in the recent years. PSC expressed their happiness over the Institute's activities. The PSC suggested that NIRM should take up an R&D work for mining at great depth. Members of PSC suggested that people of the country must know about the Institute. For this, NIRM should publicise its activities through brochures and publicity material.

The PSC wanted to know whether NIRM was involved in evaluation of the Kedarnath disaster. NIRM replied that it is a member of the Committee formed to evaluate the role of dams in causing disasters in the state of Uttarakhand, including the floods in Kedarnath. Based on the suggestions of the PSC, NIRM is now proposing an S&T project for problems related to the stability of pillars in mining at great depth.

The PSC desired that since NIRM has a number of projects in the north and north-eastern states, it should have offices in the northern region also. NIRM is ready to open offices elsewhere in the country, provided sufficient space (minimum 10 acres of land), and funds for construction of the building, are made available to it.

Annexure-10

NEWS LETTER

- Mrs KS Divyalakshmi visited to China in the month of October 2013 for presenting the paper entitled "Use of SRTM Data for a Quick Recognition of Active Tectonic Signatures" from 16-10-2013 to 20-10-2013. Funds for this travel had received from DST and CSIR. And the detailed report of visit had submitted to DST and CSIR
- Dr Biju John, and Mr Yogendra Singh had visited NPCIL, Mumbai during December 2013 to attend the expert committee meeting for Kudankulam Nuclear Power site.
- Mrs KS Divyalakshmi presented a paper on International Conference on Environmental Earth Sciences: Accomplishments, Plans and Challenges which is held at Chennai 19th March 2014-22nd March 2014
- Dr Biju John, and Mr Yogendra Singh had visited the proposed Jaithapur Nuclear power site for understanding the light house lineament.
- Dr AK Naithani is a member of the High Power Committee for Pranahita – Chevella Sujala Sravanthi Scheme, Packages-5, 7, 10, 12, 13 and 14 for resolving technical, commercial, designs or any other issues during the execution of PCSLIS projects.
- Dr AK Naithani attended 1st & 2nd Programme Advisory Committee (PAC) Meeting of MoES on Koyna deep borehole investigations project held at NGRI, Hyderabad on 22nd April 2013 and 20th January 2014.
- Dr AK Naithani attended Doctoral Committee Meetings at Centre for Disaster Mitigation and Management, VIT University, Vellore, Tamil Nadu.
- Dr AK Naithani delivered a invited lecture on "Engineering geological and geotechnical investigations of dam of the Bunakha hydroelectric project (180 MW), Chukha Dzong, Bhutan Himalaya" in a National Workshop on 'Contemporary Practices in Engineering Geology and Geohazards' organized by Indian Society of Engineering Geology and GSI at Hyderabad on 14 June 2013.
- Dr DS Rawat, Dr LG Singh, Mr Prasnna Jain and Mr Manoj Kumar presented a technical papers in a National Workshop on 'Contemporary Practices in Engineering Geology and Geohazards' organized by Indian Society of Engineering Geology and GSI at Hyderabad on 14 June 2013.
- Dr AK Naithani attended Annual General Meeting (AGM) of the Geological Society of India organized by Department of Applied Geology, Indian School of Mines at Dhanbad on 16th November 2013.
- Dr AK Naithani presented a research paper in International Conference on "Future Challenges in Earth Sciences for Energy & Mineral Resources ESEMR 2013" organized by Department of Applied Geology, Indian School of Mines at Dhanbad from 14th -16th November 2013.
- Dr DS Subrahmanyam has delivered a Guest Lecture for the members of Geological Society of India, Bangalore, and for Staff Engineers at Jindal Power, New Delhi

- Mr Amrith T Renaldy attended the National Seminar on "Policies, Statutes & Legislation in Mines – Recent Reforms & their Impacts on Indian Mining Industry" during 30th November to 1st December 2013 at CIMFR, Dhanbad.
- Mr S Kumar Reddy attended seminar on 'Explosives & Blasting Techniques for Mining, Quarrying & Infrastructure Industry' (EBTMQI) organized by NITK- Surathkal, during 27-28 September, 2013
- Dr Rabi Bhusan attended the Regional workshop on Landslide Disaster Management, Nilgiris, Tamilnadu conducted by Geological Survey of India
- Dr HS Venkatesh and Mr A Rajan Babu along with Director, NIRM visited SCCL Corporate Office and held discussion with C & MD and Chief R&D at Hyderabad during 06–08 August 2013 regarding projects (business development).
- Dr. H. S. Venkatesh delivered invited lecture on Drilling & Blasting Technologies and its Application at ESCI, Hyderabad during 20 – 21st August 2013
- Mr GC Naveen, attended two days workshop on Tunnel Design and Construction –Issues and Challenges organised by Central Board of Irrigation and Power, New Delhi during 24-25 September, 2013.
- Dr HS Venkatesh and Dr PC Jha attended a meeting on 30.08.2013 with Chief Engineer and Superintendent Engineer, Erode, TNEB with regard to 500MW (PSP) near Emerald. Tamilnadu.
- Dr HS Venkatesh and Mr G Gopinath attended conference and presented paper on "Is Blasting the Real Issue" Nat. Sem. on Explosives & Blasting Techniques for Mining, Quarry and Infrastructure Industry (EBTMQI), Dept. Mining Engineering, NITK, Surathkal during 27-28 Sept. 2013. Dr Venkatesh Chaired a Technical Session on 28.9.2013.
- Dr HS Venkatesh was nominated as a member representing NIRM in the Expert Body on "Environmental degradation due to Hydroelectric power projects (existing and under construction)" as an expert in Blasting & Tunnelling constituted by MoEF, Govt. of India formed as per the order of the Hon'ble Supreme Court
- Dr HS Venkatesh was nominated as a member of the Governing Council 2012- 2014, Journal of Tunnelling Association of India (TAI).

Degree awarded :

- Mr Ritesh D Lokhande was awarded Ph D (Doctor of Philosophy) degree in Mining Engineering from Indian School of Mines, Dhanbad.
- Mr VR Balasubramaniam was awarded Ph D (Doctor of Philosophy) degree from the Department of Earth Sciences, IIT, Mumbai.
- Mr G Doraswamy Raju was awarded Ph D (Doctor of Philosophy) degree in Mining Engineering from McGill University, Canada.

Annexure - 11

STAFF ON ROLL

(as on 31.03.2013)

Director

Dr V Venkateswarlu

Departments & Regular Staff

Engineering Geology (5)
- Dr AK Naithani
- Dr L Gopeshwor Singh
- Mr Devendra Singh Rawat
- Mr Prasnna Jain
- Mr Manoj Kumar

Engineering Geophysics (4)
- Dr PC Jha
- Mr Sandeep Nelliat
- Mr Butchi Babu
- Mr YV Sivaram

Geotechnical Engineering (3)
- Dr DS Subrahmanyam
- Mr RK Sinha
- Mr G Shyam

Environmental & Exploration Geophysics & Seismotectonics (4)
- Mr VR Balasubramaniam
- Dr Biju John
- Mr Yogendra Singh
- Mrs KS Divyalakshmi

Engineering Seismology (2)
- Mr C Sivakumar (*addl Charge*)
- Mr Y Ahnoch Willy
- Mr N Maruthi P Naik

Microseismics and Automation (2)
- Mr C Sivakumar
- Mr Vikalp Kumar

Mine Design (4)
- Mr C Nagaraj
- Mr Amrith T Renaldy
- Mr S Kumar Reddy
- Mr K Vamshidhar

Rock Blasting & Excavation Engg (5)
- Dr HS Venkatesh
- Mr G Gopinath
- Mr GC Naveen
- Mr AI Theresraj
- Mr R Balachander

Numerical Modelling (4)
- Mr Sripad R Naik
- Dr Rabi Bhusan
- Mr BH Vijay Sekhar
- Mr K Sudhakar

Centre for Testing Sercices (12)
- Mr A Rajan Babu
- Dr GD Raju
- Mrs Praveena D Jennifer
- Mr S Udayakumar
- Mr M Victor
- Mr D Joseph
- Mr Sagaya Benady
- Mr Royston A Victor
- Mr D Prashanth Kumar
- Mr Syed Asgar
- Mr R Prabhu
- Mr N Selvaraj

Technical Coordination & Project Management (2)

Dr PC Jha *(addl. charge)*
Mr Sultan Singh Meena
Mr A Vijaya Kumar

Administration (9)

Mr AN Nagarajan
Mr Pankaj Kumar
Mr S Ravi
Mr JV Sastry
Mrs S Lourdu Mary
Mr N Jothiappa
Mrs CV Lalitha
Mr J Raja
Mr N Sounderrajan

Drivers (2)

Mr P Venkata Reddy
Mr K Manjunath

Staff Resigned (2)

Dr Ritesh D Lokhande
Dr Roshan Nair

Staff Died in Harness

Mr M Lakshmipathy

Staff Retired during the Year (5)

Mr S Satyanarayana
Mr G Mohandoss
Dr GM Nagaraja Rao
Dr S Sengupta
Dr C Srinivasan

Total staff on roll : 59 *(including Director)*

Twenty five years of NIRM

A Silver Jubilee Supplement

NIRM : In retrospect

(a silver Jubilee Supplement)

1. INTRODUCTION

The National Institute of Rock Mechanics (NIRM) was registered under the Karnataka Societies Act on 23rd July, 1988, as an autonomous research Institute under the Ministry of Steel & Mines, Govt of India, and has celebrated its Silver Jubilee during 2013-14.

The las 25 years had been quite fulfilling for the Institute, during which it has grown from strength to strength in the service to the Nation. It has earned a good name, recognition and credibility based on the work of the Scientists and the staff. We have a number of scientific and technical achievements. The credibility is reflected in the number of projects coming to it from all over the country and abroad, its good financial standing, its multitudinous clientele list and the support coming forth from our Administrative Ministry, and the industry.

We are extremely thankful to all those who made this possible before us. On this occasion, i would like to congratulate the Scientists, Scientific & Technical Staff, Supporting Staff and Administrative Officers. Excellent, dedicated people, committed to the growth of the Institute. We have the best work force, and the best work ethos.

Founder Chairman Sri BK Rao, and the first Director Dr NM Raju

As part of the Silver Jubilee celebrations, we have brought out a Commemorative Volume, detailing a historical account on the formation of the Institute, the technical achievements and R&D developments made by the Institute, and the contributions made by the Scientists in these areas during the last 25 years. We have also organized a National Seminar on “Innovative Practices in Rock Mechanics”, in which Scientists, academicians and practicing engineers from all over the country participated. Following is a brief account on the developmental history of NIRM during the last 25 years.

2 ESTABLISHMENT OF THE INSTITUTE

Stability of underground excavations is a major problem facing the mining industry. Especially with the mine workings reaching greater depths in the country, the available planning and designing methods are inadequate. In view of this, a need was felt for trained and competent rock mechanics engineers to tackle problems of rock mechanics and ground control in mines.

There was no institute to look after the problems of hard rock mining and other civil engineering projects. Consequently, many project authorities in India were taking the help of foreign consultants to solve their rock mechanics problems. In view of above, there was an urgent need for establishing a rock mechanics research centre, exclusively to tackle the problems of stability of underground excavations in mines, particularly at deeper levels, and in civil engineering projects.

2.1 BGML R&D Unit

The Kolar Gold Fields was unique in that it had one of the deepest underground mines in the world. The mining activities at the Kolar Gold Fields (KGF) had a history of over a century. The holding company, the Bharat Gold Mines Limited (BGML), had a Research & Development Unit, which had gained over the years unique expertise in solving hard rock deep mining problems pertaining to rock mechanics and ground control. It had three cells, namely the Rock Mechanics Cell, Seismic & Micro-seismic Monitoring Cell and Material Testing Laboratory. The pioneering work by the Unit in the field of rock mechanics in non-coal mines was recognized internationally.

The contribution of Sri R Krishnamurthy, the Manager (Mine Planning & Technical Services), BGML till 1986, and later Consultant (Rock Mechanics) for BGML, was vital in creating the facilities for strata monitoring at BGML and in establishing in collaboration with BARC. Truly, he can be named as the father of rock mechanics research in India.

The expertise developed by the Research & Development Unit of Bharat Gold Mines Limited and its rock mechanics investigations were acknowledged as to be of very high standard in the opinion of UNDP/ILO experts who visited the R&D Unit. In view of this, Dr Yung Sam Kim, UNDP Consultant on Rock Mechanics, in his final report to BGML in December 1986, suggested that an “International Rock Mechanics & Mining Research Centre – IRMMC” can be established at KGF keeping the R&D Unit of BGML as the nucleus.

2.2 Proposal for a Research Institute

The mining activity in KGF mines was on the downward trend and the Government of India have, vide their letter dated 17th December, 1987, directed that the mines of Kolar Gold Fields be closed in a period of 7 years.

The Ministry of Mines, under the Chairmanship of Sri BK Rao, Secretary (Mines), called for a meeting with respect of establishment of a Rock Mechanics Institute at KGF on 29th April 1987, and another meeting on 8th May 1987. The Expert Group constituted by the Secretary, Department of Mines, Ministry of Steel & Mines in 1987 proposed that this Institute of Rock Mechanics and Ground Control be formed at Kolar Gold Fields with the Research & Development Unit of M/s Bharat Gold Mines Limited, as its nucleus. Sri R Krishnamurthy facilitated BGML in the preparation of S&T Scheme (of BGML) for this. Sri BK Rao held a meeting with the Polish Delegation, along with Sri IM Aga and Sri R Krishnamurthy of BGML, on 11th Feb 1988 to firm up the proposal. Prof A Kidybinski of International Bureau of Strata Mechanics, Dr E Puszczewicz, Dy Director General of Polish Coal Industry & R&D Division and Dr A Goszcz, Central Mining Institute of Poland, recommended in writing for the establishment of a research institute at KGF.

2.3 Formation of NIRM

The Government of India, vide their letter No.14/22/87-Met.V dated 27th January, 1988, conveyed the sanction of the President for establishment of the Institute of Rock Mechanics and Ground Control at Kolar Gold Fields under Science & Technology (Plan) at a total expenditure not exceeding Rs. 200 lacs including a foreign component of Rs.40 lacs.

The Memorandum of Association was framed by a societal Body of technical people (the General Body and the Governing Body of the Institute), with the name “Kolar Institute of Rock Mechanics and Ground Control” and registered on 23rd July 1988, under Karnataka Societies Registration Act, 1960 & Karnataka Societies Registration Rules 1961, as an autonomous research institute under the administrative control of Ministry of Mines, Government of India. The Rules and Regulations of the Institute were also adopted.

Subsequently the name of the Institute was changed to “National Institute of Rock Mechanics (Kolar)” by a resolution of the General Body in 1990, and later as “National Institute of Rock Mechanics”. In 2008, NIRM opened a Unit at Bangalore within the campus of the Indian Telephone Industries in Krishnaraja Puram.

2.4 Initial Years in the Development of NIRM

Sri PAK Shettigar, Managing Director, BGML, was given the responsibility of acting Director for the Institute, and Sri VN Murthy, Secretary, BGML, was to act as Secretary of the Institute. Sri R Krishnamurthy, who was earlier the head of the erstwhile R&D Unit, and Sri Shrikant B Shingarputale, Manager (Mine Planning & Technical Services), BGML, took care of the activities of the Institute and did all the background

work required for the formation of the Institute and for transfer of manpower and assets from BGML to NIRM.

Subsequently, Dr NM Raju took charge as the Director of the Institute in June, 1989. Technical Framework and the Organizational Structure of the Institute were drafted and adopted. Similarly, the Terms & Conditions of Service of Employees were also made and approved by the Governing Body. Eight Scientists and 25 scientific, technical and supporting staff of the R&D Unit of BGML were formally absorbed into NIRM with effect from 1.1.1990. The infrastructure available with the BGML R&D Unit became the property of the new Institute. This included the land, office buildings and residential buildings within and around the Institute, the rock and material testing equipment, and the rock mechanics and micro-seismic monitoring facilities.

During 1990-91, 17 more Scientists were appointed. The technical manpower of the Institute was organized into ten disciplines, namely,

1. Numerical Modelling and Mine Design.
2. Rock Mechanics Instrumentation
3. Geotechnical Studies
4. Ground Control
5. Slope Stability
6. Rock Blasting
7. Seismology
8. Electronics Instrumentation
9. Materials Testing and Rock Fracture Mechanics
10. Technical Services

Augmenting the already available rock and materials testing equipment in the earlier R&D Unit, additional state-of-the-art equipment and modern computing hardware & software were procured to enable the Scientists to carry out the investigations and the research in different areas of rock mechanics.

3. OBJECTIVES & THE ORGANISATIONAL STRUCTURE

The mandate of NIRM is to provide enabling technology to mining, civil engineering sectors and construction industries to achieve improved production, productivity and quality, with enhanced safety and economy. The major areas of research include rock mechanics, rock engineering and geotechnical engineering.

Based on the expertise developed over the years, the objectives and areas of work have been redefined time and again to meet continuously changing needs of the industry. In the year 2005, NIRM charted its Roadmap, and also formulated its Vision and Mission in its Vision 2020 document.

3.1 Objectives of NIRM

- To assist the mining, civil and construction engineering projects including hydro-electric projects/railway tunnels/underground storage caverns in solving ground control problems for the safety and stability of the structures in rock;
- To optimize the design of mine workings for improved safety, conservation & productivity;
- To mitigate the environmental impacts in rock excavation engineering, and to undertake EIA and EMP of mega projects;
- To develop excellence in rock engineering and provide consultancy services to mining, civil and construction engineering projects in the design of rock excavation; and
- To organize training courses in rock mechanics/engineering and develop facilities for research leading to doctorate degree.

3.2 Vision

NIRM has a vision to provide scientific and technological expertise with the state-of-the art techniques to mining, civil and infrastructure industries in the field of rock mechanics; to serve as a valuable resource in rock mechanics, to be identified as benchmark and statutory body for all types of investigations in rock mechanics; and to be a national pride by remaining as a Centre of Excellence of global standards.

3.3 Mission

The Mission of NIRM is to continue to support the mining and construction industries in safety and resource optimization by way of providing consultancy in the fields of scientific design of mine workings, design of rock excavations and support systems, optimized site characterization and evaluation and testing of rock and material samples for understanding rock mass and material behavior relevant to design requirement.

3.4 Organizational Structure

According to the Rules and Regulations of the Institute, the Secretary, Department of Mines / Ministry of Mines, is the Chairman of both the General Body and the Governing Body. The General Body would appoint the members of the Governing Body. The General Body will have a Chairman, conventionally up to 12 ex-officio members (senior officers of MoM, and Director-level officers from the industry), and maximum 3 non-official members (experts in the area of rock mechanics); many of the members are common to the Governing Body as well. The Members would have a term of three years.

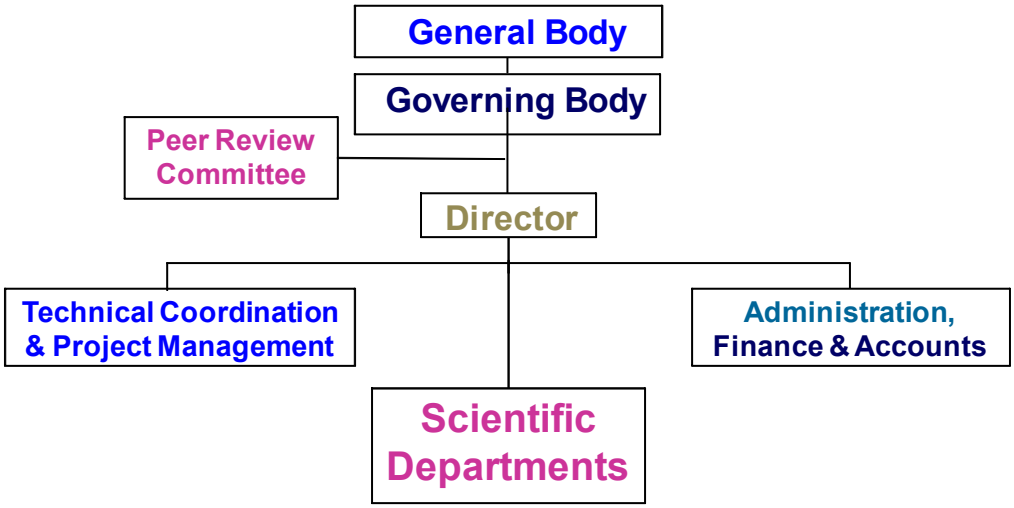
Director, NIRM, is vested with executive and administrative powers of the Society. Director is responsible for the proper administration of the affairs and funds of the Society under the direction and guidance of the GB.

To help the Director in the day-to-day affairs of the Institute, there is an Administration Department, with an Administrative Officer and a Finance & Accounts Officer. During

1999 to 2010, a functional post of Controller of Administration (CoA) was operated to look after the administrative affairs of the Institute. A senior Scientist was given the additional assignment. The posts of Purchase & Stores Officer and Registrar were created in 2009 and 2010, respectively.

For technical support to the Director in managing the project works of the different departments, and for liaison with the funding agencies, a Technical Services Department was formed by the Director, with a senior Scientist as its Head. Later, in 2008, this department was renamed as Technical Coordination & Project Management Department (TCPMD).

Earlier, the Director, NIRM, was reviewing the research activities of the Institute periodically and was reporting to the Governing Body. In the year 2000, a research advisory committee for the Institute, named as the Peer Review Committee (PRC), was constituted by the GB for this purpose. This Committee has a Chairman and minimum seven Members, all experts from academic / research institutes and the industry, with a term of three years. Accordingly, the present overall organizational structure of the Institute is :



When the Institute was formed, a Sub-Committee recommended the Technical Framework for the Institute with the areas of research as : Geomechanics & Ground Control, Numerical Modelling & Mine Design, Seismic / Micro-seismic Lab & Instrumentation, Rock Blasting and Testing Services. The Director organized them into ten disciplines :

1) Numerical Modelling & Mine Design
2) Rock Mechanics Instrumentation
3) Geotechnical Studies
4) Ground Control
5) Slope Stability
6) Rock Blasting
7) Seismology
8) Electronics Instrumentation
9) Materials Testing & Rock Fracture Mechanics
10) Technical Services.

Later, Ground Control and Slope Stability were clubbed together, and Rock Mechanics Instrumentation was also brought under the same department. The department of Engineering Geophysics was established in 1996. In 1997, the Granite Mining Cell

was formed. In 2002, a department of Environmental Geotechnology was started, and Mine Design was separated out. A separate department of Engineering Geology was started in 2008. While attrition was taken in stride, many of the young Scientists were rotated from one department to the other to broaden their areas of work. The scientific departments were re-named and redesigned depending on the areas of work, expertise developed at the Institute and as per the needs of the industry.

4. SIGNIFICANT R&D ACHIEVEMENTS

NIRM has been developed with a vision to make it a Centre of Excellence for scientific design of mine workings, design of rock excavations and support systems, site characterization practices, and advanced research in rock mechanics and ground control. The Institute has undertaken several S&T projects funded by Central Govt Ministries and Departments. A large number of projects were sponsored by the industry (mining, civil engineering, hydel and infrastructure development) for problem solving and trouble shooting, making use of the expertise developed by the Scientists. Significant contributions were made in the following sectors :

Metal Mines
Coal Mines
Hydro-power Sector
Nuclear Power Sector
Underground Storage Caverns
Railways / Metro
Other infrastructure industries (Oil Pipelines, storage caverns, etc.)

The projects investigated encompass a large number of subject areas, including :

1) Design of mining methods and optimization of pillars, for maximising the recovery of extraction and for improved safety in hard rock mines
2) Ground control and mine design in coal mines
3) Comprehensive package to hydro-electric projects covering a) Geotechnical Investigations, b) Numerical Modelling using 2D & 3D models, c) blast design for smooth blast, d) design of support systems, and strata & support performance monitoring
4) Design of optimum drilling & blasting patterns for safety of the nearby structures, optimisation of blast design, blast vibration and air over-pressure studies
5) Engineering geological investigations during various stages of the project developments, i.e., feasibility report (FR), detailed project report (DPR), construction and post construction stages.
6) Optimum design of rock slopes under wide range of ground conditions
7) Basic research in the field of Rock Fracture Mechanics

From 1990 to 2013, the Institute had executed nearly 800 projects (765 sponsored projects, and 35 long term S&T Projects) covering most of the rock mechanics topics. So far, the Scientists have published about 620 research papers in various renowned Journals / periodicals / conference / seminar / symposium etc (nearly 200 papers in International fora, and the remaining in National fora).

4.1 Scientific Works

The table below indicates the performance of the Institute in terms of projects executed and research papers published since inception.

Performance of the Institute in terms of technical output

Year	Number of Projects Completed	Number of Research Papers Published
1990-1991	04	12
1991-1992	07	11
1992-1993	21	29
1993-1994	20	14
1994-1995	28	22
1995-1996	17	18
1996-1997	29	19
1997-1998	35	11
1998-1999	30	26
1999-2000	46	48
2000-2001	59	34
2001-2002	47	24
2002-2003	53	26
2003-2004	36	26
2004-2005	46	46
2005-2006	37	27
2006-2007	35	13
2007-2008	24	28
2008-2009	26	31
2009-2010	45	25
2010-2011	37	51
2011-2012	29	26
2012-2013	46	28
2013-2014	43	25
Total	**800**	**620**

4.2 Training Programmes Organised

NIRM conducted Workshops and training programs in different areas of rock mechanics and rock engineering for the benefit of practicing civil and mining engineers, geologists and geophysicists. They included :

Event	Date
Workshop on Safety Measures for Rockburst Control	19 March, 1990
Short Course on Rock Mechanics Applications in Mining	12 - 23 November, 1990
Workshop on Numerical Methods in Rock Excavation Design	29 - 30 November, 1991
Workshop on Rock Mechanics Applications in Hydro-electric Projects with Special Reference to Srisailam Project	5 - 7 July, 1994
Indo-Norwegian Workshop on Recent Trends in Rock Mechanics	7 - 9 April, 1997
Workshop on Application of Rock Mechanics in Surface and Underground Excavations, for the Executives of NTPC	22 - 26 August, 2005
Application of Geophysical Investigations to Engineering Projects.	11 - 16, July 2011
Drilling and Blasting.	8 - 10 August 2011
Application of Numerical Modeling to Tunnels, Caverns and Slopes	1 - 6 August 2011
Dimensional Stone Technology.	23 - 25 November 2011
Instrumentation for Tunnels, Caverns and Slopes.	12 - 17 December 2011
Training Programme on "Rock Mechanics".	5th April to 1st May 2010; and for 75 days till end of March, 2011
Application of Numerical Modelling Techniques.	1 - 8 April 2009
Application of Rock Mechanics Principles to Tunnelling.	12 - 18 August 2009
Application of Rock Mechanics in Tunnelling	7 - 10 November 2009
Blasting in Surface Mines with Special Reference to Limestone Mines	April, 2009

4.3 Seminars / Symposia Organized by NIRM

The Institute supported several Seminars and Symposium organized by other Institutes. In addition, three of the major events organized by the Institute were :

1. The 6th National Symposium on Rock Mechanics, Bangalore, 15-17 October, 1992.
2. ROCKSITE-99, International Conference on Rock Engineering Techniques for Site Characterization, Bangalore, 6-8 December, 1999.
3. ICUST-2011, International Conference on ‘Underground Space Technology, Bangalore, 17-19 January, 2011.
4. IPRM-2014. National Seminar on “Innovative Pratises in Rock Mechanics”,

4.4 Awards & Patents

All the previous Directors of the Institute are National Mineral Awardees. The NIRM Scientists, Dr S Jayanthu and Dr HS Venkatesh, have also received the National Mineral Award.

The Institute received the patent rights from the Indian National Patent office for its innovations, namely the “Roof Stability Tester”, and for an improvised haulage motor output monitoring tool for optimizing productivity in coal mines. The technology developed for “Microprocessor based solid state controller for improving Hauler’s efficiency in coal mine” has been transferred for commercialization through NRDC.

The Institute has received an ISO 9001:2008 certification from RINA, a certification authority of IQ NET.

5. FINANCIAL PERFORMANCE

NIRM was established in 1988 with a capital grant of Rs. 200 lakhs. It started getting projects from the industry from 1990. Over the years, NIRM has gradually increased its income from projects and other sources. Using the amounts excess of income over expenditure, the Institute was able to build-up a Corpus.

As an autonomous research institute under the Ministry of Mines, NIRM is required to get financial support from the Ministry. Such a support, to meet about 80% of the expenditure towards salaries and wages, was extended by the MoM to NIRM from 1988 to 1994-95. From 1995-96 to 2007-08, the support from the Ministry remained at about Rs. 100 lakhs per year, which was 30 to 50% of the total recurring budget of the Institute. The balance amount during this period was being met from the income generated from the scientific projects.

However, from the financial year 2008-09, the expenditure towards salaries and wages went up to Rs. 400 lakhs in 2008-09 and to Rs. 500 lakhs in 2009-10. On the other hand, there was almost no non-plan grant from the Ministry to NIRM during this period. Due to this, the Institute had incurred a net loss of Rs. 140 lakhs in 2008-09 and Rs. 308 lakhs in 2009-10. Even during the years 2010-11 and 2011-12, the shortfall between income generated from projects and the expenditure remained around Rs. 300 lakhs. With this, the Institute had depleted the Corpus. The following table summarises the financial position of the Institute during the last 25 years.

Recurring Grants-in-aid as a % of recurring expenditure

(₹ in Lakhs)

Year	Govt. Grant		Revenue Earned from Projects (IEBR)	Expenditure (including depreciation)
	Capital	Recurring		
Initial Grant for establishment of NIRM	**200**	-	**-**	**-**
1990-1991	33.70	26.30	10.83	41.60
1991-1992	18.00	72.00	13.18	63.10
1992-1993	15.00	60.00	22.62	78.72
1993-1994	20.00	80.00	40.59	85.83
1994-1995	23.00	92.00	33.00	107.08
1995-1996	18.00	72.00	37.40	116.79
1996-1997	17.00	68.00	40.89	130.26
1997-1998	21.00	84.00	75.22	202.64
1998-1999	19.00	76.00	120.43	210.40
1999-2000	17.20	68.80	72.69	163.55

Year	Govt. Grant		Revenue Earned from Projects (IEBR)	Expenditure (including depreciation)
2000-2001	50.00	100.20	199.40	221.40
2001-2002	90.00	93.60	196.45	217.66
2002-2003	75.00	105.00	169.73	269.37
2003-2004	62.00	104.00	172.53	259.69
2004-2005	0	115.00	364.60	246.43
2005-2006	30.00	115.00	257.99	284.84
2006-2007	26.00	105.00	324.50	257.22
2007-2008	0	0	304.46	248.05
2008-2009	47.00	0	255.99	436.66
2009-2010	0	0	306.21	701.94
2010-2011	0	50.00	276.98	701.61
2011-2012	0	10	589.64	656.37
2012-2013	0	477	324.6	749.89
2013-2014	1	232	400	800

6. FUTURE AHEAD

The Institute's research work is of utmost importance to the nation, particularly to the mining, civil and hydroelectric power, nuclear power sectors, railways, rail-metro projects, highways, oil sector. The Institute is also recognized as a Scientific & Industrial Research Organization by the Dept. of Scientific & Industrial Research, Ministry of S&T, Govt. of India. This kind of research work is specialized in nature and needs to be continued in future. Some grey areas in these sectors are to be identified and solved by developing indigenous technology instead of importing technology from abroad.

The high quality services provided by NIRM have found wide acceptance with the industry. With modern equipment and a coherent team of experienced and dedicated Scientists, NIRM combines research activities and consulting services to provide solutions for a wide range of rock engineering problems.

During last twenty-five years, NIRM has carved out a niche in the national arena in the field of rock mechanics and rock engineering by providing solutions to the civil and mining engineering sectors. This is reflected in our exponential growth of external cash flow (ECF) through sponsored R&D and industrial projects.

The Institute has made big strides towards attaining self-sufficiency, which is a key element of our vision. This phenomenal growth reflects the faith shown in our work by the sponsoring industry. Having been encouraged by this response from industry, we have now decided to adopt International Standards in all our works. We have defined our quality policy and objectives to meet the International Standards, and we have obtained the ISO 9001 : 2008 certification.

During the next few years, NIRM proposes to further develop its infrastructure facilities, augment skilled manpower in core areas, and encourage skill development through training. We shall try for collaborative research work with other institutes. We shall strive for the all round development of the Institute, with quality improvement in the overall research output, and to realize the vision of the Institute for a quantum growth as laid out in its Vision document.

Keeping the Roadmap in the sights, and Vision as our target, the Institute has a resolve to achieve still greater heights.

7. ACKNOWLEDGEMENTS

The Institute is immensely grateful to all those who made it possible for it to reach the Silver Jubilee, and for the wonderful legacy.

The Scientists and Staff of NIRM are thankful to all the Chairmen and Members of the previous and present Governing Bodies, General Bodies, Peer Review and various other Committees, for the guidance provided all through these years.

The achievements made by the Scientists could not have been possible but for the help and support by the various funding organizations, the user industries and the sponsoring clients. We are deeply indebted to them all.

It would be our endeavour to come up to the expectations of all the above and be worthy of them, by achieving greater research output in the coming years.

Delegates at the IPRM-2014 Conference organised by NIRM at Bangalore in commemoration of the Silver Jubilee Year of the Institute

Starting from a humble beginning of just 34 staff and six departments in 1988, NIRM has matured today with over 64 staff and ten departments.

With this doubling of staff strength, we have multiplied our earnings over 20 times and expanded our client base to over 15 times in the last 25 Years.

On this occasion, we salute our Peers and Clients who reposed their faith in our services and guided us to this eventual path to progress !

1988 25 2013

NIRM