Dr. Harsh K. Gupta stressed the importance of intensifying oceanographic research to gather information on marine resources, ocean-atmospheric interaction studies similar to Global Ocean Observation System (GOOS), tapping the thermal energy resource using ocean thermal energy conversion technique etc. In order to predict environmental changes including monsoon, he strongly advocated the necessity of obtaining information from ocean surface also, in addition to the land surface. Dr. P.C. Pandey emphasized that studies on marine sciences should be given more importance and students as well as research scholars of marine sciences should fully utilise the new XRD facility. In his presidential remarks, Prof. Hanumaiah expressed his satisfaction about the progress of the Cell and suggested to utilize the XRD machine to the maximum extent. He promised that all the necessary facilities including space will be given to the OSTC for its future developmental activities. He also expressed his desire to see that the OSTC becomes a centre of excellence. Prof. K.R. Subrahmanya, Research Coordinator, OSTC and Chairman, Dept. of Marine Geology, Mangalore University welcomed the gathering and explained the purpose of organising the workshop. Dr. K. Pandarinath, Research Scientist, OSTC, Mangalore University proposed a vote of thanks.

The various aspects covered in the workshop included: (1) Elements of X-ray crystallography by Prof. Jayagopal Uchil; (2) Sample preparation and X-ray diffraction techniques for mineralogical studies by Dr. K. Pandarinath; (3) Technical presentation on D8 advanced X-ray diffractometer by Mr. A.K. Choudhary,and (4) Identification and quantification of clay and other minerals by Dr. Pandarinath. The workshop included visit to the XRD laboratory where the salient features of the equipment and its operation were explained by Dr. Pandarinath. The informal valedictory function was held at the fag end of the day when participants gave their appreciative feedback and desire to see more such courses organised by the centre. Dr. S. Rajan, Head - Planning and Evaluation Division, NCAOR and Dr. P.C. Pandey, Director, NCAOR, Vasco-da-Gama distributed certificates to all the participants.

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CONTROLLED BLASTING FOR UNDERGROUND EXCAVATION OF ROCKS*

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EXTENDED ABSTRACT

The National Institute of Rock Mechanics (NIRM) has been providing blasting services to several underground excavation projects, mostly in hydroelectric projects. The objectives were to control overbreak, increase pull and reduce blasting to the surrounding rock mass. The presentation highlighted the practical problems faced at Sardar Sarovar Project and Nathpa Jhakri Project and explained how these problems were solved.

STUDIES AT SARDAR SAROVAR PROJECT (SSP)

The major contributions of NIRM for this project include removal of ramp, removal concrete plugs in draft tube tunnels and excavation of turbine pits.

Removal of Ramp

During excavation of the power house cavern at SSP, distress problem was encountered due to the limited amount of cover and the presence of shear zones. After cracks were observed on the cavern walls, further excavation was suspended and additional treatments to the walls was provided. A construction ramp on the downstream wall was to be excavated by drilling and blasting without causing further damage.

^*Lecture delivered at the monthly meeting of the Geological Society of India at Bangalore on 29 January 2003.*

The excavation of the ramp was critical, as it was providing restraint to the movement of the downstream wall, which was intersected by large openings for six draft tube tunnels below the ramp. Three alternative blast designs were considered for the excavation and the safest method was adopted. The selected method of excavation divided the ramp into two parts, 'main' and 'bark'. The ramp was excavated in 2.0 m layers to minimise the unsupported area and was followed by support/reinforcement. The damage to the downstream wall was assessed by taking multipoint extensometer readings and by observing cracks in the glass plate installed at a critical location, by vibration monitoring and observing drillhole impressions on the wall.

Removal of Concrete Plugs

During construction of the project, an unprecedented flood efitered the power house cavern through draft tube tunnels and caused damage to underground structures. After this incident, these draft tubes were plugged with concrete/ reinforced concrete to prevent future flooding. After heavy gates were erected at the exit end of the draft tube tunnels, these plugs had to be removed by drilling and blasting without causing any damage to the concrete lining and the ribs erected in the tunnels. Controlled blasting was designed and executed successfully for removal of the plugs in the same manner as for tunnel blasting. Details of concrete plugs, the drilling and blasting adopted, and some interesting observations in respect of drilling and blasting in the concrete plugs are dealt with in detail in our report. A seismic method based on the measurement of P-wave velocity in the concrete lining before and after blasting Avas used to quantify the changes/damage to concrete lining.

Excavation of Turbine Pits

These pits were excavated by drilling and blasting method under a complicated condition due to distress problem in the cavern, presence of shear zones and thin rock ledges between the pits. For overall stability of the cavern and pit walls, the vibration due to blasting was minimised by excavating the pit in three stages and by reducing the maximum charge per day to the extent possible. Various drilling, charging and initiation patterns for different stages of the pits were prepared. The overbreak was controlled by adopting modified line drilling/smooth blasting techniques. The deviation of the actual line of excavation from the designed vertical wall of the pits was measured and the percentage of overbreak in terms of the total volume of the pit was calculated.

Overbreak Analysis During Excavation of Draft Tube Tunnels

During excavation of the heading portion of the draft tube tunnels, overbreak was measured after each blast. An illustration of the excavated profiles and the designed profiles at different chainages was presented. In. spite of controlled blasting, the overbreak was more on the riverside of the draft tube tunnel. It was due to shear zones crossing across the side for about 6 m affecting the overbreak for a length of about 5-6 m. The overbreak on the same side and almost the same position of the tunnel indicates that the geology was unfavourable. As the chances of drilling accuracy etc being repeated on the same side, it was inferred that the excessive overbreak was due to unfavourable geology. At 16 m chainage where the shear zone was not prominent, overbreak was least.

STUDIES AT NATHPA JHAKRI POWER PROJECT

A large underground hydroelectric power project (6 x 250 MW) was under construction on the left bank of Satluj river in Himachal Pradesh by Nathpa Jhakri Power Corporation. As a part of this project, four large (525 m long, 16 m wide, 27 m high) underground desilting chambers were being excavated by drilling and blasting. NIRM was involved in blast designs for central top heading, side slashings and horizontal benching [6]. The performance of blast designs was evaluated in terms of pull, overbreak and powder factor and the results achieved. The correlation between the overbreak with rock mass quality in the heading portion of the chamber was not significant.

NIRM was approached again during excavation of the hopper, settling trench and flushing conduit of the desilting chambers. The existing blasting patterns were reviewed and the implementation of these designs was carefully observed. The existing blast design for hopper excavation was modified incorporating smooth wall blasting technique and no changes were made in the blast design for settling trench and flushing conduits. A blast vibration study was also conducted to derive a site-specific predictor equation for peak particle velocity. Based on the literature survey, safe limits of blast vibration for rock, steel fibre reinforced shotcrete, concrete lining and fully grouted bolts were recommended for the conditions of the desilting chambers.

The presentation stressed the need for controlled blasting in various construction projects and informed of the extensive capability available at NIRM to cater to the needs of the industry.