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# ISEG NEWS

Bridging Communication Gap.....Dissipating Information



NHPC Ltd



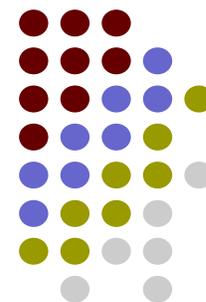
SJVN Ltd



Geological Survey of India  
(Ministry of Mines, Govt. of India)



Mineral Exploration Corporation Limited  
(A Mini Ratna Company of Govt. of India)



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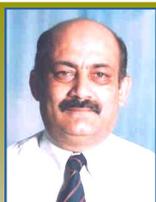
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## MESSAGE FROM SECRETARY

Dear Colleagues;

In the infrastructure development scenario unfolding currently, engineering geology has a greater role to play. Already engineering geologists are having an important role in study of natural hazards and their mitigation. Now, the subject in India has moved truly beyond the territories of river valley projects. As hydropower projects are struggling to make a mark on the country's power map it is the infrastructure activities particularly the railway and road projects in hilly areas that have gained importance.

Many fundamental issues such as study of geological details before finalizing engineering layouts particularly in case of railway alignment and tunnels through the Pir Panjal Range have come to the forefront. Instead of trying out new ventures and then learning from failures it is prudent to consider past experience in this regard. We can save considerable time and costs in projects by making simple changes in the layout in the preliminary stage itself. While giving due regard to basic engineering requirement subtle changes in locations, alignments

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## EDITORIAL

Dear Members,

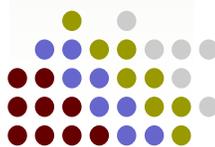
As I present before you the latest issue of ISEG News, words of Shri Aurobindo echoes in my mind. He said "To make the most of the age of regeneration, Indians should strive to be **children of the past, possessors of the present and creators of the future.** The essential enduring past is to be their foundation, the present their material, the future their goal and summit".

This issue carries an article on the engineering geological aspects of Ajanta-Ellora caves highlighting some very important and interesting rock engineering features involved in construction of these ancient monuments. It defies even the present day understanding of underground openings in terms of space, rock cover, shape and

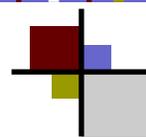
size. It is beyond doubt that today's technology offers great solutions but still professionals may take clue from this ancient marvel in terms of the choice of material utilized and designing of complex underground structure. I sincerely thank Shri U. V. Hegde for his arduous effort.

The dates of the International Conference have been announced. This conference also commemorates Golden Jubilee of the "Journal of Engineering Geology". Besides working professionals, we also seek active participation from various researchers and academicians working in universities and other renowned institutes of the country. The details of the conference are given in the first circular. Timely submission of technical papers/articles by authors is very essential for bringing out ISEG publications within the

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1966-2016  
**JOURNAL OF ENGINEERING GEOLOGY**



**BIANNUAL HIGHLIGHTS****October 2016 to April 2017**

The 3rd Executive Council Meeting of the ISEG was held on 17th December, 2016 at the Expediting Office of SJVN Ltd., IRCON Building, Saket, New Delhi Under the Chairmanship of Shri R.N. Misra, President, ISEG and CMD, SJVN Ltd. The meeting was attended by members of ISEG Executive Council as well as council members of ISEG Delhi-NCR Chapter. Shri Imran Sayeed, Secretary welcomed the Executive Council members and conducted the proceedings. Several important issues including : proposed certification course for practicing Civil/Mining Engineers & Geologists, Geotechnical Orientation Program, organizing International Conference to mark Golden Jubilee of Journal of Engineering Geology, publishing of ISEG Newsletter and Journal of Engineering Geology, permanent office building of ISEG and maintaining ISEG & JoEG websites were discussed. Several important decisions were taken w.r.t. above issues. Sh. Arindom Chakraborty, Joint Secretary, formally proposed the vote of thanks and expressed gratitude to all Council members for sparing their valuable time and participating in the meeting.

**MESSAGE FROM SECRETARY***(Continued From Page 1)*

etc. can be made in a number of cases to make huge gains in terms of early completion of projects. We have to appreciate once again that project development is an activity where diverse but related specializations should come together. Respect for assigned roles is also a requirement for success.

We have been raising the issue of accreditation or licensing of qualified geologists since a long time. In case of engineering geology, mining and natural hazards this is of utmost importance as either financial stakes are very high or it is a matter of safety for all concerned. We do not want unqualified people getting into the profession. This is also important for geologists coming from abroad to practice. They may be well qualified but a process of verification of academic credentials and experience is required. This is religiously followed in all the advanced countries where geology is a regulated profession. Let us at least start thinking in this regard.

The IAEG membership from our country has touched new heights with 131 members for the year 2017. This has been possible due to the sustained efforts by Mr. Y. Deva Vice President (Asia region) IAEG and Mr. R.N. Mishra President, ISEG. The hard work by my team is also reflected in this achievement.

We are going to organize GoP on 15-16<sup>th</sup> June 2017 at Hotel Lalit Vibe Faridabad. All are requested to nominate geologists for this extremely beneficial basic training in engineering geology. The International Conference on "Engineering Geological Solutions for Sustainable Development" is planned on 5-6<sup>th</sup> October 2017 at New Delhi. The first circular has already been issued and abstracts are invited for the same.

This Council has met four times during its tenure and has taken first steps to establish long cherished dream of having permanent office. A bank account has been opened for the purpose of collecting donations. We are trying to get income tax exemption for this purpose. Let us hope that we succeed.

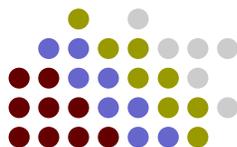
**EDITORIAL***(Continued From Page 1)*

stipulated time. I hope we will see a very successful Conference during October.

The biography section of the newsletter carries the life sketch of Leopold Muller, who had made enormous contribution in establishing the subject of Rock Mechanics and getting it recognized internationally. He formidably integrated and united various groups working in isolation on various problems faced during construction, in the rock massess. I hope his bio-sketch shall enlighten our members, especially geologists and engineers from the younger generation.

In the end, I sincerely thank our President and Secretary for their encouragement and providing constant support to ISEG editorial team.

Kind regards,


**(Rahul Khanna)**

Please remember that ISEG has always stood for the engineering geologists and geotechnical engineers in particular and for all engineering and scientific community in general. One of our objective is to get recognition for engineers and scientists in development of our nation in a sustained manner. ISEG also strives to technically help international community in infrastructural development and environmental safeguards to the extent possible by sharing of knowledge.

Thanks and regards


**(Imran Sayeed)**

*"India is to me the dearest country in the world, not because it is my country but because, I have discovered the goodness in it.... Everything in India attracts me. It has everything that a human being with the highest possible aspirations wants.....Our civilization, our culture, our swaraj depend not upon our wants and indulgence, but upon restricting the wants, self denial."*

-Mohandas K. Gandhi

**NATIONAL GEOSCIENCE AWARDS -2016**



National Geoscience Award (NGA 2016) ceremony was held at the Rashtrapati Bhavan on 12th April 2017. The coveted award was given by the Hon'ble President of India in an august award ceremony held at the Cultural Centre of Rashtrapati Bhavan. Shri Piyush Goyal, Hon'ble Minister of State for Power, Coal, New & Renewable Energy and Mines graced the occasion along with Shri Arun Kumar, Secretary, Ministry of Mines; Prof. Ashutosh Sharma, Secretary, DST and Shri M. Raju, Director General of GSI.

The National Geoscience Awards instituted by the Ministry of Mines in 1966, to honour individuals and teams of scientists for their extraordinary achievements and outstanding contributions in fundamental and applied geosciences, mining and allied fields. The award carries a cash prize and a certificate of citation. This year, twenty-seven geoscientists received the coveted this Awards as individuals or team, for meritorious contributions in twelve fields of geosciences.

In the Applied Geosciences category one team award has been bagged by four members of ISEG from Engineers India Limited (EIL) for their outstanding contribution in the field of Engineering Geology. The team comprised of Dr. Atul Nanda, Dr. Ranjit Rath, Shri Saikat Pal and Shri Gopi Kannan L. The team was awarded for their outstanding contributions in the field of Geosciences and it's innovative applications in the prestigious strategic petroleum reserves project. ISEG family heartily congratulate them on being conferred the highest award for geoscientists in the country.

**ISEG FELICITATED WINNERS OF NGA-2016**



Shri R. N. Misra, President ISEG along with other Executive Council members on behalf of ISEG felicitated Dr. Ranjit Rath, Shri Saikat Pal and Shri Gopi Kannan L. of Engineers India Limited and Executive Council Members of ISEG on 13.05.2017 for winning the prestigious National Geoscience Awards-2016 in the field of Engineering Geology.

**PRESIDENT ISEG RELEASED 1ST CIRCULAR OF INTERNATIONAL CONFERENCE EGCON 2017**



Shri R. N. Misra, President ISEG during Executive Council meeting held on 13.05.2017 released the first circular of "International Conference on Engineering Geological Solutions for Sustainable Development" IGCON-2017 being organised by ISEG to commemorate 50 years of its flagship publication Journal of Engineering Geology on 5th & 6th of October 2017 at New Delhi.

Dr. V. K. Sharma, Vice President, ISEG, Shri Imran Sayeed, Secretary, ISEG, Shri N. K. Mathur, Convener, ISEG Delhi NCR Chapter, Shri Pradeep Singh, Co-Convener, ISEG NCR Chapter, Dr. Ranjit Rath, Council Member, ISEG Delhi NCR Chapter along with Dr. Rajbal Singh, Special Invitee also graced the occasion.

**MECL BAGS SCOPE EXCELLENCE AWARD**



**Dr. Gopal Dhawan (extreme right) receiving the award from Hon'ble President of India, Shri Pranab Mukherjee in presence of Shri Anant G. Geete, Minister (HI & PE) and Shri Babul Supriyo, Minister MOS (HI & PE)**

Mineral Exploration Corporation Ltd. (MECL) has won the "SCOPE Excellence Award", 2014-15 in the Institutional Category II (Mini Ratna I & II PSEs along with ONGC Videsh Ltd., and WAPCOS (Special Commendation). The Award, a Golden Trophy with Citation was received by Dr. Gopal Dhawan, CMD, MECL from Shri Pranab Mukherjee, Hon'ble President of India, during a glittering ceremony at Vigyan Bhawan, New Delhi 11<sup>th</sup> April, 2017.

The Standing Conference of Public Enterprises (SCOPE), the apex body of CPSEs, awards PSEs for Excellence and Outstanding Contribution to the Public Sector Management and recognizes the contribution to encourage outstanding persons for their hard work and leadership qualities. These Awards were instituted in the year 1996-97 and are given in the Institutional & Individual Categories. This year the Jury for conferring the prestigious award was headed by Justice R.C. Lahoti, Former Chief Justice of India.

MECL is a premier agency of Govt. of India for carrying out regional and detailed mineral exploration in the country, providing all exploration services under one roof. Since inception in 1972, it has provided invaluable services for growth of Mineral and Coal Industry.



## LIST OF IAEG MEMBERS FROM INDIA NATIONAL GROUP FOR THE YEAR 2017



(Courtesy: Y. Deva, Vice President (Asia Region) , IAEG)

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### MECL BAGS SCOPE EXCELLENCE AWARD Continued from pg 03

The MoU rating of the company for the year 2014-15 was "Excellent". During the last 5 years, Company has made substantial progress and in the year 2016-17, it has recorded all time high performance. With reference to previous year i.e. 2015-16, drilling production has increased from the level of 4 lakhs metre to more than 5 lakh metre (up by 30%) while the turnover has increased by 15%.

Dr. Gopal Dhawan, CMD who is also former President of ISEG and present Executive Council Member of ISEG has given a strategic vision to the company in which it has planned to increase its drilling production by 7.5 lakhs meters with a CAPEX of Rs.207 crore by 2020. Under the "Strategic Plan", MECL has also taken a number of initiatives for modernization of the company in a holistic manner which includes complete revamping of drilling fleet, application of Drone technology for topographical survey and geological mapping, construction of Ultra Modern Laboratory & Workshop and implementation of Enterprises Resources Planning (ERP).

Dr. Dhawan dedicated the award to all MECL employees and said that this reward should act as a catalyst to achieve goals set for the company by 2020 in the "Strategic Plan".

## AJANTA - ELLORA CAVES : ANCIENT ENGINEERING GEOLOGICAL MARVEL

**Umesh Hegde**

Consulting Engineering Geologist,  
Bengaluru, Karnataka



**Photo 1.** In side view of Cave-26-Ajanta (reproduced from net/websites)



**Photo 2.** Painting of Padmapani reproduced from Wikipedia

Ajanta-Ellora caves are in Aurangabad district of Maharashtra, a UNESCO heritage site famous for the sculptures and ancient paintings, located about 105KM from Aurangabad or 55 Km from Jalgaon. The Ellora caves are on the other hand are nearer to Aurangabad at 29 Km distance.

The author had heard about the Ajanta -Ellora caves but never had an opportunity to see them during all these years. Finally, he visited as a general tourist on 8<sup>th</sup> and 9<sup>th</sup> September 2016. In a way, this location, not only turned out to be very interesting as a tourist destination but also significant from ancient technique of building underground openings. The cave complexes manifest that these are not just the crude openings generally found in many ancient places. Rather they are seen to be carved out within carefully selected suitable geological set up with sound background of architecture and engineering planning along with the use of competent excavation methods. Even in modern days, the word 'underground openings' still raises an eye brows while taking up construction in terms of its geological complexity and difficulties involved. Hence, these caves indicate the competence of people during those ancient times for creating such marvelous and beautiful underground structures.

Apart from sculptures/architecture, these caves are more world famous and known for their paintings. But this article with due respects to famous painting works, restricts its descriptions to engineering geological aspects as seen during the short period. This may be of some interest to persons involved in engineering geology and rock engineering.

It is not one or two underground openings but many in numbers. Carved out by hands intrinsically at close intervals under almost low cover zones; defying almost all the general understandings/requirements of underground openings in terms of space, rock

cover, shape and sizes. In view of these aspects, the author felt to share his observations made during two days visit along with some more information gathered from the ISEG publication, ASI tourist brochures, websites, for the benefits of those who have not seen them so far. The list of references is given at the end of this article,

### Geological Aspects of Caves:

Ajanta-Ellora caves are built in Basaltic rocks, popularly known as Deccan traps which consist of series of Volcanic Lava eruptions during Cretaceous period. Broadly these basaltic rocks are categorized in to two groups, viz, (i). **Vesicular** and (ii). **Massive** with or without amygdales-porphyrific/non- porphyritic in hard or soft layers. The massive rocks are either coarse or fine traps. Mineralogically not much variations is reported. The vesicles, a common feature in trap rock are filled with Zeolite and on weathering, fall off or erode, giving pitted appearance on the walls, pillars/ sculptures of many caves. No folding, faulting or tilting in the trap rock is reported in this area. Luckily, the Red bole beds which are weak bands present as intermediate bands within Trap rocks does not appear to be present in this area or might have been avoided carefully. For ease of excavation, the relatively softer bands were reportedly chosen within the basaltic rocks during cave excavations.

Two kind of joints reported in case of Ajanta area, viz, (a) Horizontal having 2m or more spacing, (b). Steeply dipping towards NNW or ENE directions. The individual flows are reportedly varying from 1.5m to 30m. In case of rocks in Ellora area, the thickness of individual flows reportedly varies 0.3m to 4.2m.

On a general observation, probably the freshly cut trap rocks of this area, could be placed as Good to Very Good (RMR) or Very



Most of the joints are horizontal (S-1) and other set of joints are dipping steeper than 45°. Generally, the horizontal joints are filled (photo-03) with cryptocrystalline silica or zeolite minerals in these basaltic rocks.

**Photo 3.** Filling of recrystallized silica along horizontal layers in basaltic rock

good to Extremely good (Q) category of rocks in terms of modern rock mass classification, barring some portions which where inferior through above assessment, say Fair category may be prevailing.

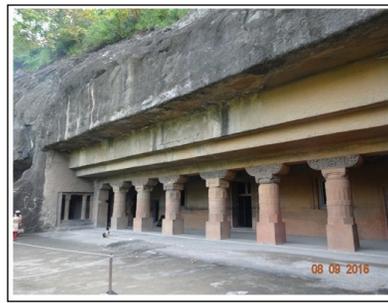
There appears to be some distinct method of excavation followed in these caves, starting with 'lay out marking on the rock face' and further taking up rock excavation from the top to bottom. A narrow tunnel at roof level must have been dug in the initial stage of cave excavation as noted from the some of the incomplete or partially built caves. These top tunnels must have helped in exploring the rock quality for firming up of plans and development of caves. Further expansion of openings must have been made to lower levels and on lateral sides to carve out the central hall, side corridors, various cells/rooms along the outer walls of the caves besides carvings of related sculptures.

The front doors and veranda were reportedly excavated first, followed by central halls and side corridors/adjacent cells/rooms. There are some caves having two or three story openings with narrow rock ceilings separating each floor. In case of Ajanta, cave No-6, is one such example having upper story openings. In Ellora, there are several caves having multiple story caves housing big halls supported with beautifully carved rock pillars, sculptures, statues. The paintings are generally done on walls and ceilings.

**Paintings in the caves:** The paintings (photo 2) have some connotations with geology w.r.t. materials used. Primarily, the ferruginous earth, mixed with rock grit or sand and vegetable fibers, like rice husk, grass, etc. were used for creating initial layer on rough rock cut surface. Second coat of ferruginous earth with fine rock powder and vegetable material were used for fine finishing followed by thin coating of lime washing. The colours used were mainly of red, yellow ochre, reportedly consisted tetta verte, lime, kaolin, gypsum, lamp black and lapis lazuli.

**Excavation method:** The rock excavations are reportedly done using sharp pick-axe to make deep incision inside the rock and further breaking the intervening rock mass till reaching the floors by further use of chisel and hammers. Basically, solid columns left behind top to bottom excavation has been the real supporting elements (photo 4 & 5) in these man-made caves in the absence of conventional steel ribs, rock bolts or anchors which are used in modern day underground openings. Some of the halls, especially in the monasteries are having dimensions of 35m (L) x 22m (W) x 4 to 5m (H).

The ceilings are generally flat suiting to the horizontal layers (photo 6 & 7) of trap rock except for some vaulted/ semi-circular roofs. The columns/pillars are 3m to 6m in height with base width of 0.75 X 0.50m to 1 x 1m. The shape of pillars/columns



**Photo 4.** Front Veranda Pillars in Ajanta caves



**Photo 5.** Square pillars in Ellora caves

are circular, square, octagonal. The spacing varies from 1.5 to 3.5m. There are instances of large halls having only peripheral pillars but centrally unsupported span of 21x15m and galleries/veranda up to 15mx6.5m. The rock cover on top of the caves, especially in case of Ajanta seem to vary from 30m to 50m.

Probably the manual excavation carried out over long periods which is relatively slower in comparison to machinery based excavation, must be the reason to maintain overall stability of underground openings. Systematic provision of columns indicates their knowledge of underground excavations and support requirements. Probably some of the cave excavations must have been carried out over several years. For example, the Kailash Temple cave in Ellora reportedly took



**Photo 6.** Huge unsupported central portion of hall in monastery in having flat roof Ellora caves



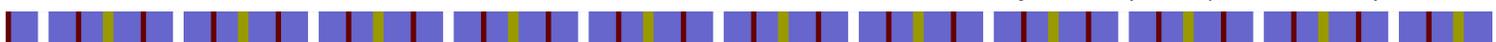
**Photo 7.** View of upper portion of Veranda in Ajanta caves

**Ajanta Caves:**

The Ajanta caves are cut in nearly 200m thick Deccan Trap/ basaltic rock exposed on the left bank of 'Waghora', cascading down in a U-shaped gorge (plate 1 and photo 8 & 9) of a stream in this area. The lush green forest cover with trees and shrubs enhance the panoramic beauty of the area.



**Photo 8:** Panoramic view of Ajanta caves (Photo reproduced from ASI)





**Photo 9.** Close-up view of Ajanta Caves

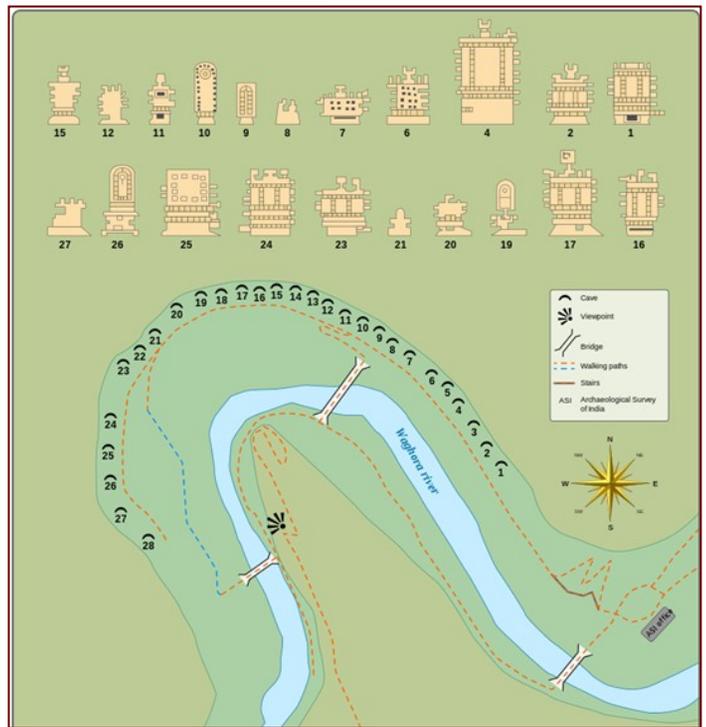
There are 30 rock cut caves, dating back to 2nd Century BC to 5<sup>th</sup> to 7<sup>th</sup> Century AD. The Archaeological Survey of India, who is maintaining these monuments, has numbered these caves from 1 to 30 but chronological order of cave excavation is said to be differing. The Cave no-9,10,12,13 and 15A reportedly built during 2<sup>nd</sup> and 1<sup>st</sup> century BC. Whereas, the remaining caves, viz 1 to 8, 11 and 14 to 29 were excavated during 5<sup>th</sup> to 7<sup>th</sup> century AD that is the work of cave excavation resumed after 400 year.

The place was also said to be used by the travelers, traders for their stay during the travel. These caves were reportedly buried under debris/soils over passage of time for several centuries. They were accidentally discovered on 28<sup>th</sup> April 1819, by a British officer named 'John Smith' during hunting in this area when the existence of these caves came into the knowledge of modern world.

**Worship halls:** These are narrow rectangular halls in plan with high vaulted/ arched roof (photo 1 & 11) called Chaitya-griha meaning "the house of stupa". The halls are longitudinally divided into a central hall and narrow passage/corridor on two sides, separated by a row of pillars, with a stupa in the large recess with domed/arched roof. Space for concentric walking space around the stupa are also provided in these kind of cave openings. The front portion of these caves is provided with carved entrances (photo 10), or with big windows over the door to admit light. Examples are cave no 9, 10 which are the oldest of all caves built during 2<sup>nd</sup>-1<sup>st</sup> century BC. Caves no 19 and 26 are also Chaitya grihas built during 5<sup>th</sup>-6<sup>th</sup> century AD. They are also beautifully planned, vaulted ceilings and decorated pillars. The height of these underground openings must be more than 10m to 12m or so. The roofs are generally provided with rock cut ribs and beams (photo 1 & 11)

It is interesting to note that some of these earlier openings were started with arch/curved roof/ceiling which we follow in modern day's underground openings from stability point of view. Further caves built during later periods mainly for the Monasteries are seen to have flat roofs/ceilings, and noted to be contrary to arched/circular roofs followed in present day underground openings.

**Monasteries:** Most the caves are vihara halls with symmetrical square/rectangular plans. The three sides surrounding wall have been provided with smaller square dormitory rooms hewn in the trap rock from the walls. The central square/rectangular space of the interior of the viharas is surrounded by columns bordering the outside long rectangular corridor on both sides. The roof/ceilings are generally flat both in the lower level or upper level halls in multi-storied caves. As described above, probably looking at the horizontal layers of trap rock and its easy cleavability, facilitating excavation of the flat roof/ceiling, this must have been considered stable and adopted in these caves. Rock cut Insitu columns/pillars and beams (photo 4, 5, 6 & 7) must have been designed with suitable spacing to provide adequate supports. Yet, some of the unsupported flat roof with large span in the central portion of monasteries with sharp edges with walls, can be considered as bold step in creation of big caves.



Architecturally, these caves were built to serve two purposes, viz Chaitya Grihas/Worship halls and Monasteries/Viharas. Primarily these are Buddhist Chaitya Grihas (worship halls) or Viharas/ Monasteries. The Monks who used to stay during rainy days for worshipping, meditation. Large part of their time was also said to be spent on the paintings of Buddhism related spiritual tales on the walls, pillars and the ceilings depicting the natural surroundings of those periods/ habitat.

**Plate 1.** Schematic plan of Ajanta cave area, indicating locations and shapes of individual caves. (Courtesy- Reproduced from Wikipedia)



**Photo 10** Front view of cave no 9



**Photo 11** Cave 10– inside view of vaulted ceiling with side columns

**Ellora Caves:**

There are 34 rock cut caves in Ellora generally visited by the tourists. Otherwise, about 100 caves reportedly exist in that area. Unlike Ajanta, these caves, not only belong to Buddhism but also Hinduism and Jainism. Cave no 1 to 12 belong to Buddhism (photo 12) built during 2.5 century AD to 5<sup>th</sup> and 6<sup>th</sup> century AD. Further caves built during 6<sup>th</sup> and 9<sup>th</sup> century AD mainly belonged to Hinduism, cave no 13 to 29 (photo 13) and Jainism, caves no 30 to 34, (photo 14) temples.

These caves are spread along north to south direction (plate 2) in a length of about 2 Km. Shape and size of Buddhist caves mainly comprising Monasteries /Chaitya Grihas, has general similarity to Ajanta caves.

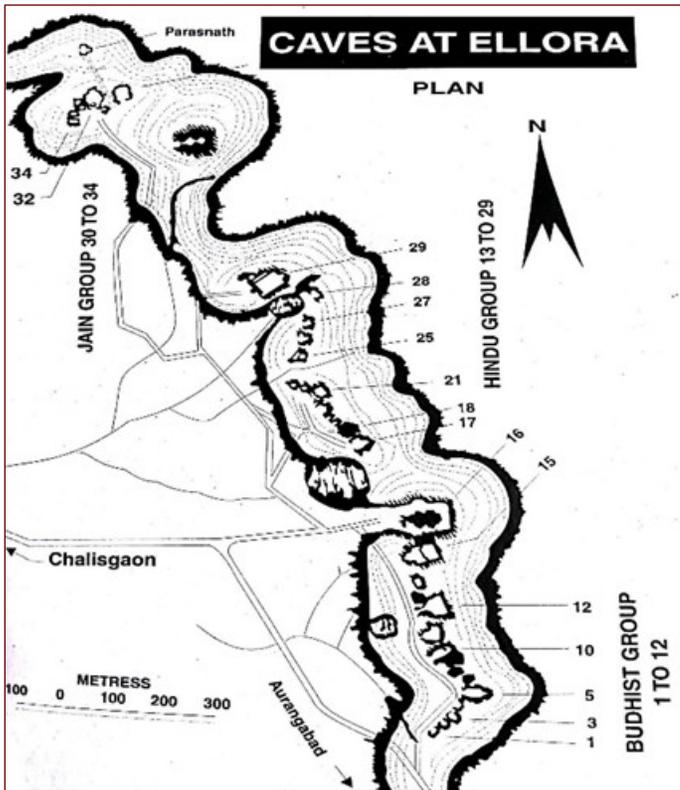


Plate 2. Lay out reproduced from Tourist guide book-Ajanta-Ellora Mittal

**Cave No-16-Kailash Temple:**

Among the Ellora caves, Kailash temple (Kailash meaning an abode of Lord Shiva), is quite popular for its architecture, in-situ rock cut sculptures and various components of temple (photo 13 & 17), all cut from top to bottom of the bed rock. Nearly 85000



Photo 12. Buddhist part of caves in Ellora



Photo 13. Rock cut Kailash temple (from internet)



Photo-14. Cave-32, Jain temple-Indrasabha

The caves comprising Hindu and Jain temples are having two to three stories, carved out within Trap rock and are of great engineering geology interest. Basically, all the intermediate floors are supported with rock pillars/columns carved out or left out systematically



Photo 15. Three Storied Buddhist Monastery in Ellora.

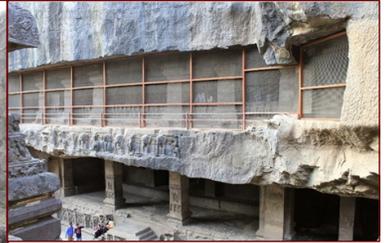


Photo 16. Kailash temple with multi story gallery cut within rock

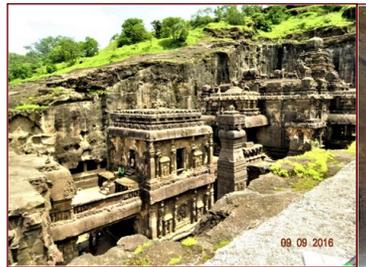


Photo 17. Side view of Kailash temple complex

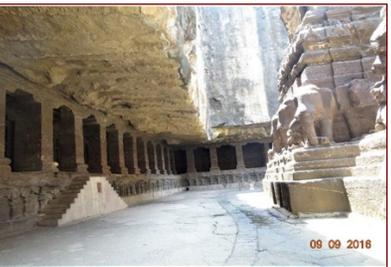


Photo 18. Kailash temple with back view of rock cut corridor with pillar supports

cubic meters of rock excavation was said to be made for building this complex. Thick slab of trap rock has been cut on three sides of the hill in to a deep trench leaving behind vertical wall of rock. The intervening Insitu rock mass was further excavated to create different components of the temple complex, like porch, free standing pillars and other shrines carved out from monolith. Even the side wall from the bottom is carved out in to long corridor/rooms in multi stories (photo 15 & 18) supported with rows of rock columns. The intermediate rock slab is hardly 3m - 4m thick. Probably without very careful and meticulously planned excavation, accomplishing such job would have not been possible.

The remaining Hinduism and Jainism caves carved in multi-level openings with so many big halls and beautifully carved rounded pillars and sculptures are the marvels of rock engineering.

**Conclusion:**

Ajanta-Ellora, manmade caves are indeed a marvelous ancient underground openings. Even though the Deccan trap rocks can be considered as strong and massive rock but its heterogeneity in terms of mineralogy, texture, variation in strength along with jointing and weathering effect could be challenging task to select suitable site and execute such huge complex of caves during ancient times. These caves, manifest great understanding of rock engineering of that period. Use of rock pillars/columns along with beams, etc. are the simpler but natural way of supporting the openings. Certainly, these sites are worth be to seen at least once by engineering geologists and rock engineers during their career which enhances one's confidence in underground openings.



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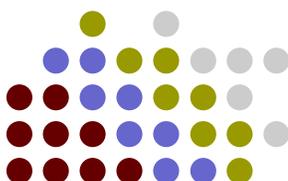
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## EGCON-2017

### International Conference on Engineering Geological Solutions for Sustainable Development



Organized by  
**Indian Society of Engineering Geology**  
5<sup>th</sup> – 6<sup>th</sup> October 2017  
Venue: New Delhi, India

In the present scenario, sustainability of infrastructure projects is of utmost importance, may it be road network projects in coastal/hilly areas, tunnel construction for roadway, railway, hydroelectric & metro projects or large underground caverns. Sustainability of these projects requires multidisciplinary efforts and Engineering Geology can be considered as backbone in successful development of such projects. Keeping these in mind, Indian Society of Engineering Geology (ISEG) proposes to organize a two days International Conference on "Engineering Geological Solutions for Sustainable Development (EGCON-2017)" on 5<sup>th</sup> & 6<sup>th</sup> October, 2017 at New Delhi. Main purpose of this conference is to provide a platform to discuss and ponder upon recent developments in the field of Engineering Geology, advanced technologies in use for development of infra-projects that are economically viable, sustainable and environment friendly.

ISEG introduced Journal of Engineering Geology (JOEG) in 1966, one year after formation of the society in 1965. In 2016 it completed 50 years of publication which itself is a big achievement. Being the only journal devoted to engineering geology in the country, the conference will also mark the Golden Jubilee of JOEG. Apart from regular theme-based presentations and lectures by the speakers from different related fields, EGCON-2017 shall be providing best opportunity to researchers and entrepreneurs in this field to listen and interact with the key-note speakers who will share their vast experiences and give insight on most-relevant technical issues. This international conference will also be a great opportunity for the private developers, consultancy agencies and manufacturers engaged in this field to exhibit their capabilities and develop rapport.

**ABSTRACT SUBMISSION:** Abstracts within 250 words related to above themes are invited, The same may be submitted by 30<sup>th</sup> June, 2017. For details of the themes please refer the 1<sup>st</sup> Circular.

**SPONSORSHIP:** Government organizations, Public Sector and Private Companies involved in Engineering Geology, Rock Mechanics, Civil Infrastructure Development Projects, Tunnelling, Mining, Mineral Exploration & Geo-hazard Management are welcome to sponsor/co-sponsor the conference. For sponsorship categories please refer the 1<sup>st</sup> Circular.

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|---|--|
| <input type="checkbox"/> Abstract submission deadline   | : June 30 <sup>th</sup> , 2017                 |
| <input type="checkbox"/> Notification of acceptance     | : July 15 <sup>th</sup> , 2017                 |
| <input type="checkbox"/> Full paper submission deadline | : August 31 <sup>st</sup> , 2017               |
| <input type="checkbox"/> Conference                     | : Oct 5 <sup>th</sup> & 6 <sup>th</sup> , 2017 |

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### AJANTA - ELLORA CAVES : ANCIENT ENGINEERING GEOLOGICAL MARVEL

Continued from page 8

The success of building these caves appears to be mainly due to non-destructive method of manual excavation through pick-axe, chisels, hammers in carefully selected strong bed rock. Selection of these caves sites under not so high rock cover zone might have added advantage of having less rock stress regime. There could be many more hidden knowledge of persons, in creating those openings during ancient times. The take away from the studies of these caves openings to modern day works could be as under:

(A) adoption of non-destructive method of excavation- a big factor to have good stability in the underground openings. Probably, most of our stability problems arise in underground works especially in close to moderately jointed rocks due to drill and blast methods which we adopt in majority of the cases for economy and rapid progress. Probably use of non-destructive rock cutting methods like diamond ropes, boring by versatile machines, etc. can be alternatives in the coming years.

(B) Another aspect comes to the mind is giving due importance to rock joints while selection of the shape and size of openings, use of rock pillars/beams as natural supports elements where were the rock mass permit. Probably it may help in reduction of some of the complicated way of underground supports specially in big caverns.

#### References with due Acknowledgement:

1. ISEG Publication – "Indian Monuments through the Ages".
2. Archaeological Survey of India Publications/ tourist brochures on 'Ajanta and Ellora' under World Heritage series.
3. Colorful World Heritage – Ajanta Ellora by ITP Mittal publishing.
4. Wikipedia on Google and a few other web sites on these monuments.

## OBITUARIES



### Shri Ravi Shankar Director General (Retd.), Geological Survey of India

Shri Ravi Shankar started his career in Geological Survey of India as Geologist (Jr.) in April, 1965 after a brief stint in ONGC during 1962-65. He was promoted as Geologist (Sr.) in 1969 and as Director in 1981, became Dy. Director General in 1992 and Sr. Dy. Director General in 1997 and ultimately promoted as Director General, GSI on 1st April, 2001. Shri Ravi Shankar was born on 11 November, 1941, obtained B.Sc (Hons.) in 1961 and M.Sc. degree in Geology in 1962 from University of Lucknow. He was awarded Chancellor's medal for best all round student of the University in 1961.

Shri Ravi Shankar was a unique blend of professional geologist and academic researcher whose contributions have brought about fundamental change in the concepts of contemporary understanding of geology of Indian sub-continent. His contributions in the field of earth science are wide-ranging and multidisciplinary. His work in Lesser Himalayas led to discovery of Ediacaran fauna; presence of marine Permian sequences; high resolution stratigraphic analysis of Terminal Proterozoic; Cambrian rocks. He was also the first Indian Geoscientist to identify and describe the 'Indus Ophiolite belt' as obducted part of subduction zone between Indian and Asian Plates. His work helped in preparation of new geological map of Himalaya on 1:2 million scale and publication of 'Geology and Tectonics of Himalaya'.

Shri Ravi Shanker was pioneer worker in the field of Geothermics and associated energy and mineral resource exploration. He led a multidisciplinary team of earth scientists to Ladakh in 1973. His monumental work in Puga valley, Ladakh in 1973-76 was internationally acclaimed and awarded National Mineral Award in 1975 for the same. His studies led to publication of 'Heat Flow Map of India and adjoining areas' in 1988, which is a fundamental thematic map of the country interrelating thermal regime to basic geological and structural fabric, Tertiary-Quaternary, magmato-tectonic history, prevailing crustal structure and operating intra and infra crustal processes which in turn control neotectonism and recurrent seismicity, natural hazard evaluation and mineral and energy resources. He continued his scientific pursuit and in the field of geothermics and published 'The Geothermal Atlas of India' in 1991, an updated 'Heat Flow Map' in 1999, which attracted high degree of appreciation in National and International fora.

Shri Ravi Shankar, was associated with prestigious multi-disciplinary multi-institutional research project CRUMANSONATA, which helped to identify 1600 km long, 150-200 km wide 'Mid Continental Rift' named as SONATA RIFT, establishment of five layered crustal structure, thermal regimes and their relationship to contemporary tectonics and seismicity. His in-depth thinking and integration of multidisciplinary data brought out the fragmented nature of Indian Shield, comprising a large number of fault-bound tectonic crustal blocks which have been differentially moving relative to each other throughout Tertiary, Quaternary and Recent times. These movements produce stresses responsible for new and contemporary tectonism causing recurrent seismicity in Indian Shield area. His continued research in field of geothermics and deep crustal structures amply established the positive relationship between geothermal systems and hydrothermally mineralized belts. The studies will go long way in search of new mineral deposits.

He authored / co-authored 96 research papers on large spectrum of earth science, published in National and International journals and edited two GSI Special Publications. He was Life Member of Pal. Soc. of India, Geological Soc. of India, Gondwana Geological Society, Association of Exploration Geophysicist and Indian Society of Engineering Geology, where he was also the President of the Society for a term. He was also Member of Research Advisory Councils and Assessment committees of various scientific departments like AMD, BARC, BSIP, WIHG, NGRI, IMD, DST beside several Universities.

Shri Ravi Shankar visited many foreign countries, Japan in 1974 for attending the International Group Training Course in Geothermal Exploration; New Zealand in 1980 to attend the US sponsored conference on Development of Geothermal Resources in ESCAP Region; Thailand and Vietnam in 1982 as Member of High Power Indian Delegation; Philippines in 1997 as Member of Indian Team to attend the first meeting of the Indo-Philippines Joint Committee on Renewable Energy; New Zealand in 1999 to attend 21st New Zealand Geothermal Workshop at Auckland; California in 2000 to attend Geothermal Resource Council.

He was not only a veteran earth scientist but also an affable administrator, became very popular as kind hearted person and earned high regards from all corners of the country. His work brought laurels to the department and to the nation. Shri Ravi Shankar breathed his last in early hours of 3rd February, 2017. He is survived with his wife and one son.

May his soul rest in peace.

### Dr. N.D. Mitra Senior Deputy Director General (Retd.), Geological Survey of India



Dr. N.D. Mitra, Senior Deputy Director General, Geological Survey of India superannuated from service on 31st August, 1994, after a distinguished service of about 32 years in the department. Born on 22nd August, 1936, Dr. Mitra graduated Honours in Geology from Presidency College, Kolkata in 1956; post graduation from the same College in 1958 and later Ph.D from Calcutta University in 1973.

Dr. Mitra worked as Asst. Geologist in the Atomic Minerals Division, later joined GSI as Geologist (Jr.) in 1962, gradually promoted to the post of Dy. Director General in 1989 and finally to the post of Sr. Dy. Director General in the year 1993. During tenure in GSI, Dr. Mitra made significant contributions in mineral resources, especially in coal exploration. He was associated in Gondwana and Tertiary coalfields of the country in course of which sizeable deposits of coal have been located in almost all coal belts, many of which are now under active exploitation.

He contributed immensely for locating coking coal in Madhya Pradesh which was earlier known to contain non-coking coal only.

Dr. Mitra's monumental work in coal geology of India received both national and international acclaim. He was honoured with National Mineral Award in 1975 for discovery of many new coal deposits in the country. He was also awarded with the Coggin Brown Gold Medal of MGMI in 1970. He was editor of publications of Mining, Geological & Metallurgical Institute. He visited Australia, Thailand, USSR, Brazil and Japan as delegate from GSI. He was the Chief delegate of GSI in the International Gondwana symposium, Sao Paulo, Brazil in 1988. He was nominated as the Convener of the 9th International Gondwana Symposium held at Hyderabad in 1994. He has more than 50 scientific papers to his credit published in national and international journals.

Dr. Mitra breathed his last in the midnight of 2-3 February, 2017. Dr. Mitra is affectionately remembered for his invaluable contributions.

May his soul rest in peace.

Courtesy : Shri M. Raju , D.G. GSI, Kolkata



# LEOPOLD MULLER

FATHER OF ROCK MECHANICS

BIOGRAPHY

**Leopold Muller** was born in Salzburg, Austria on 7<sup>th</sup> August 1908. He graduated in Civil Engineering from the Technical University of Vienna. His doctoral thesis submitted in 1933 on the topic "Statistical Collation of Joint Measurements" became a foundation stone in rock and discontinuity mechanics. Beside engineering, he had also studied music at the Conservatory to keep up his interest in the arts. Interestingly, his lectures and articles on Johann Wolfgang von Goethe were highly esteemed in academic circles. He was also recognized as authority on the scholarly works of Paracelsus.

As a young graduate engineer at a time of world economic crises, Leopold Muller was obliged to take a job as an unskilled labourer, although he quickly moved up to become contractor's supervisor for construction of Grossglockner high-alpine road. In 1948, after his return from captivity as a prisoner of war (world war II), he co-operated as senior construction engineer in the Kaprun hydroelectric power project. Subsequently he started his own office for geology and civil engineering, having engaged in all aspects of construction in rock, tunneling, cavern and dam construction and other hydropower installations. He also got involved in the construction of underground railways, landslide and rock anchoring, as well as in mining.

In 1965 he was appointed as Director of the Department of Rock Mechanics at University of Karlsruhe. He held this post until 1976. His activities were dedicated to building a holistic understanding of nature, to the aesthetic integration of structures in the landscape, and to appreciating the ecological impact of engineering works. In this, he was ahead of time. Later as a consultant, his experience was much in demand for all aspects of rock construction, for dams, tunnels and hydroelectric caverns, for the investigation and stabilization of landslides, and for mining projects. Because of his jovial and balanced way of communicating with people, not only was he accorded widespread professional recognition, but he made friends all over the world. His initiative led to the formation of the "*International Arbeitsgemeinschaft fur Geomechanik*" based in Salzburg in 1951, which ten years later was renamed as International Society for Rock Mechanics (ISRM). Leopold Muller served as its founding President between 1962 to 1966. Despite professional demand well into old age, Leopold Muller always behaved courteously and showed interest and respect to his students.

Between 1957 and 1984 Prof. Müller published the Journal "*Geologie und Bauwesen*" later entitled "*Felsmechanik und Ingenieurgeologie*" and "*Rock Mechanics*". He authored over 250 publications with particular concentration on the areas of Engineering Geology and Geomechanics, as well as two volumes of his textbook "*Der Felsbau*" (Construction in rock) which could not be completed due to his sudden death on 7<sup>th</sup> August 1988 at the age of 80 years. With this textbook he aimed at setting down his wide-ranging experience and comprehensive expertise for coming generations.

The early 1960's gathered the attention of the engineering community towards the rock mass and its behaviour because a number of catastrophic failure had occurred worldwide viz., Malpasset dam failure in France, Coalbrook coal mine failure in South Africa and over topping of Vaiont Dam in Italy etc. Consequently, Rock Mechanics was born as a new discipline in 1962 in Salzburg, Austria, mainly by the efforts of Prof. Müller and he officially endorsed it during the first ISRM Congress in 1966. In later part of his life he aggregated various researchers and scientists from all over the world interested in the



**Leopold Muller**

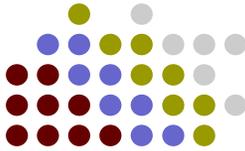
(7 January 1908 - 1 August 1988)



new-born branch of science, "**rock mechanics**", with the purpose to integrate and unite the scattered knowledge obtained by different groups working more or less in isolation on problems posed by rock masses. With all his forte and contribution to this science, he very well deserves the title of "Father of Rock Mechanics".

In 1989, ISRM honoured its much respected founding President by constituting *Muller Award* to be given every four year to a world renowned professional for distinguished contribution to rock mechanics and rock engineering. The award is a work of art, in stone, symbolic of the country hosting the ISRM congress, accompanied by a silver medal with a portrait of Leopold Muller and engraved name of the recipient along with date and title of the award.

**Compiled By : Rahul Khanna, Editor, ISEG**



## GEOTECHNICAL ORIENTATION PROGRAMME-2017

Organized by  
**Indian Society of Engineering Geology (ISEG) in association with ISEG Delhi-NCR Chapter**  
 Dates: 15<sup>th</sup> – 16<sup>th</sup> June 2017

### THEME: ROLE OF ENGINEERING GEOLOGY IN INFRASTRUCTURE PROJECTS

Venue: **Hotel Vibe, Lalit**  
 12/7 Mathura Road, Near Badarpur Toll Plaza,  
 Faridabad-121003

ISEG has been conducting the Geotechnical Orientation Program (GOP) every year. The programme provides an insight to the budding technocrats about the best industry practices being adopted to mitigate geotechnical challenges. Keeping in view the present industry requirements, the programme are designed in such a way that the participants can have a direct interaction with the experienced professionals, which will help them in shaping up their professional career in future.

#### SUB-THEMES

- **Challenges and remedies in surface & subsurface excavations.**
- **Slope stability issues in infrastructure projects.**
- **Field work & geological & geotechnical data collection**
- **Geological data processing and interpretation for use in design.**

#### TARGET PARTICIPANTS

Professionals from Geology, Geophysics, Civil, Mining and Geotechnical background engaged in infrastructure projects having ≤10 years of experience. Students may also apply.

#### COURSE FEES

Rs 10,000/- per participant (including programme kit and refreshments).

#### CONTACT DETAILS

|   |  |
|---|--|
| Convener : <b>N.K. Mathur</b><br>Mobile No. : 9717288891<br>E-mail : nkmathur55@rediffmail.com, india.seg@gmail.com | Treasurer : <b>Vivek Sharma</b><br>Mobile No. : 8826688578<br>E-mail : bastariya4u@gmail.com |
|---|--|

Website : www.isegindia.org, www.joegindia.com  
 C/O Engineering Geology & Geotechnical Division, NHPC Office Complex , Sector 33, Faridabad, Haryana.

## ISEG NEWS

( A Biannual Newsletter of ISEG)

**Imran Sayeed**, Secretary,  
 Indian Society of Engineering Geology  
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**Rahul Khanna**, Editor, ISEG  
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 isegpapers@gmail.com

### Indian Society of Engineering Geology

C/O Director Monitoring, GSI, CHQ, 27 J.L. Nehru Road, Kolkata, West Bengal-700016

#### INCOME & EXPENDITURE ACCOUNT

(For the year ended on 31<sup>st</sup> March 2016)

| INCOME                                   | Amount (Rs.) | Amount (Rs.)        |
|--|--------------|---------------------|
| Sponsorship Fees                         | 3,233,972.00 |                     |
| Registration Fees received (EGNM)        | 2,607,263.00 |                     |
| Advertisement Fees                       | 328,289.24   |                     |
| Exhibition Fees received                 | 326,904.00   |                     |
| Membership fees (IAEG& ISEG)             | 192,299.00   |                     |
| Interest received / accrued on FDR's     | 164,160.00   |                     |
| Interest received on Saving account      | 64,989.00    | 6,917,876.24        |
| <b>Total</b>                             |              | <b>6,917,876.24</b> |
| EXPENSES                                 | Amount (Rs.) | Amount (Rs.)        |
| Activity Expenses                        |              |                     |
| National Seminar Expenses                | 50,000.00    |                     |
| EGNM 2015 Expenses                       | 5,861,013.00 |                     |
| IAEG Expenses                            | 79,205.00    | 5,990,218.00        |
| Administrative Expenses                  |              |                     |
| Accounting Charges                       | 3,000.00     |                     |
| Audit Fees                               | 3,000.00     |                     |
| Bank Charges                             | 2,389.00     |                     |
| Legal Expenses                           | 6,750.00     |                     |
| Interest & Penalty                       | 4,390.00     |                     |
| Meeting Expenses                         | 2,430.00     |                     |
| Postage Courier & Internet Expenses      | 26,713.00    |                     |
| Web Updation & Server Rental             | 23,503.00    | 72,175.00           |
| Depreciation                             |              | 86.00               |
| <b>Total</b>                             |              | <b>6,062,479.00</b> |
| <b>Excess of Income over Expenditure</b> |              | <b>855,397.24</b>   |

#### Auditor's Report

As per our separate report of even date attach

**FOR INDIAN SOCIETY OF ENGG. GEOLOGY**

**FOR RAKESH K SRIVASTAVA & CO.**

Chartered Accountants

Sd/-  
**(Alok Kumar)**  
 Treasurer  
 Place: Lucknow  
 Date: 17.10.2016

Sd/-  
**(Imran Sayeed)**  
 Secretary

Sd/-  
**Stamp of firm (Pooja Mittal)**  
 Partner

### Indian Society of Engineering Geology

C/O Director Monitoring, GSI, CHQ, 27 J.L. Nehru Road, Kolkata, West Bengal-700016

#### BALANCE SHEET AS ON 31.03.2016

| Source of Funds                                     | SCH | AMOUNT(Rs.)  | AMOUNT(Rs.)         |
|---|-----|--------------|---------------------|
| <b>General Fund</b>                                 |     |              |                     |
| Opening Balance                                     |     | 3,697,504.04 |                     |
| Add: Excess of Income Over Expenditure              |     | 855,397.24   | 3,697,504.04        |
|   |     | 4,552,901.28 |                     |
| Less: Income tax written off                        |     | 50,784.00    | 4,502,117.28        |
| <b>Total</b>  |     |              | <b>4,502,117.28</b> |
| Application of Funds                                | SCH | AMOUNT(Rs.)  | AMOUNT (Rs.)        |
| <b>Fixed Assets</b>                                 |     |              |                     |
| Opening Balance                                     |     | 856.00       |                     |
| Less: Depreciation @ 10%                            |     | 86.00        | 770.00              |
| <b>Investments</b>                                  | A   |              | <b>2,469,904.00</b> |
| <b>Current Assets, Loans &amp; Advances</b>         |     |              |                     |
| Stock of Publication                                |     | 103,870.00   |                     |
| <b>Advances recoverable in cash or kind</b>         |     |              |                     |
| TDS (A.Y. :2015-16)                                 |     | 94,449.00    |                     |
| EGNM-2015   |     | 48,5428.24   | 579,877.24          |
| <b>Cash and Bank Balances</b>                       |     |              |                     |
| Cash in Hand  |     | 57.00        |                     |
| <b>Cash at Bank:</b>                                |     |              |                     |
| SBI Kolkata   |     | 2,400.28     |                     |
| SBI Lucknow   |     | 322,630.91   |                     |
| UCO Bank Lucknow                                    |     | 1,022,607.85 |                     |
|   |     | 1,022,607.85 |                     |
| <b>Less: Current Liabilities</b>                    |     |              | 2,031,443.28        |
| <b>Total:</b>                                       |     |              | <b>4,502,117.28</b> |
| Significant Accounting Policies & Notes on Accounts | B   |              |                     |

#### Auditor's Report

As per our separate report of even date attach

**FOR INDIAN SOCIETY OF ENGG. GEOLOGY**

**FOR RAKESH K SRIVASTAVA & CO.**

Chartered Accountants

Sd/-  
**(Alok Kumar)**  
 Treasurer  
 Place: Lucknow  
 Date: 17.10.2016

Sd/-  
**(Imran Sayeed)**  
 Secretary

Sd/-  
**Stamp of firm (Pooja Mittal)**  
 Partner