सड़क परिवहन
एवं राजमार्ग मंत्रालय
MINISTRY OF
ROAD TRANSPORT
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Resilient India - Disaster Free India

Proceedings

National Workshop and Brainstorming Session on Silkyara Tunnel Case Study: Lessons Learnt from Silkyara Tunnel and other Tunnel Disasters

National Institute of Disaster Management

(Ministry of Home Affairs, Government of India)

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सफ़ी एहसन रिज़वी, भा. पु. से.
कार्यकारी निदेशक

Safi Ahsan Rizvi, IPS
Executive Director

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

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Foreword

It is a pleasure to present the proceedings of the National Workshop and Brainstorming Session on Silkyara Tunnel Case Study: Lessons Learnt from Silkyara Tunnel and other Tunnel Disasters, which brought together experts and practitioners to share knowledge, experiences, and best practices on tunnel resilience.

It was a great honour to commemorate the anniversary of the heroic Silkyara Tunnel Rescue. We gathered to pay tribute to the unwavering bravery, selfless dedication, and unrelenting perseverance of the rescue teams, engineers, and workers who worked tirelessly to save lives.

The Silkyara Tunnel Rescue was a testament to human resilience and the power of collective effort. Against all odds, the rescue teams navigated treacherous terrain, overcame technical challenges, and demonstrated unwavering commitment to saving every life trapped in the tunnel. Let us take a moment to express our deepest gratitude to the heroes of the Silkyara Tunnel Rescue and recommit ourselves to promoting a culture of safety, empathy, and resilience.

The insightful presentations and engaging discussions made by keynote speakers, panelists, and moderators made this conference a truly enriching experience. The workshop highlighted the importance of tunnel resilience in ensuring safety, sustainability, and economic continuity of our transportation systems. We are grateful for the valuable takeaways, which will undoubtedly inform and improve practices in tunnel design, construction, operation, and maintenance. This workshop is a reminder of our responsibility to ensure the safety and well-being of all individuals who work in challenging environments.

These proceedings compile the key findings, insights, and recommendations from the workshop, covering topics such as:

- Advanced materials and technologies for tunnel resilience
- Innovative design and construction methods
- Risk assessment and management strategies
- Emergency preparedness and response planning
- Maintenance and inspection techniques

We hope that these proceedings will serve as a valuable resource for researchers, practitioners, and policymakers working in the field of tunnel engineering and resilience. We look forward to continuing our collaboration and knowledge-sharing in the future.

(Safi Ahsan Rizvi)

Preface

Tunnel resilience is a critical aspect of modern infrastructure, ensuring the safety, sustainability and economic continuity of the transportation system. As the global demand for tunnel infrastructure continues to grow, it is essential that we prioritize resilience in the design, construction, operation and maintenance of tunnels is prioritized.

This proceedings is a culmination of the discussions, presentations, and outcomes of the workshop on tunnel resilience, which brought together renowned experts, researchers and practitioners from tunnelling domain. The workshop provided a unique platform for knowledge/experience sharing, collaboration and innovation, focusing on the latest advances, challenges and best practices in tunnel resilience.

Through this proceedings, it is aimed to provide a comprehensive resource for researchers, practitioners, and policymakers working in the field of tunnel engineering and resilience. It is expected that the knowledge, insights and experiences shared in these pages will contribute to the development of more resilient, sustainable and safe tunnel infrastructure worldwide.

It is a pleasure to extend sincerest gratitude to esteemed experts and delegates for making this workshop on tunnel resilience a success. Their presence, participation and contributions enriched our discussions and debates, providing invaluable insights and expertise to the tunnelling community. Heartfelt appreciations are due for the time and efforts they took to share their knowledge, experiences and best practices with the participant of the programme. Their input has significantly enhanced and improved the understanding of tunnel resilience and its applications.

I owe sincere gratitude to the workshop participants, authors, and reviewers who have contributed to this proceedings. The expertise, enthusiasm and dedication of experts and their organizing team have made this publication possible. It is hoped that this document will serve as a valuable resource and inspiration for the tunnelling community, promoting innovation, collaboration and knowledge sharing in the pursuit of tunnel resilience.

I would like to thank Executive Director (ED), NIDM and Joint Secretary (JS), MoRTH for extending requisite support, cooperation, leadership, guidance and motivation in planning and implementation of this workshop on the anniversary of triumph of zero casualty during Silkyara Tunnel crises that was overcome on 28thNov. 2023.

Prof. Surya Parkash Gupta

Acknowledgement

A *"National Workshop and Brainstorming Session on Silkyara Tunnel Case Study: Lessons Learnt from Silkyara Tunnel and other Tunnel Disasters"*, was organized by NIDM on 28th November 2025 under the Project entitled *"Development of National Highways Climate Adaptation Policy and Guidelines"*, supported by Ministry of Road Transport and Highways, GoI. Our heartfelt thanks are due to Shri Bhaskar Khulbe, IAS (Retd.), OSD (Government of Uttarakhand), for his special address. We are also thankful to Shri Rajendra Ratnoo, IAS, Former Executive Director, NIDM for his constant support and encouragement to organize this workshop. Sincere thanks are due to Shri Rajendra Singh, Hon'ble Member and HOD, NDMA and Lt. Gen. (Retd.) Syed Ata Hasnain, PVSM, UYSM, AVSM, Hon'ble Member, NDMA for their support and guidance in the workshop.

We are thankful to all the collaborators including Delhi Technological University and IIT Delhi. Special thanks are due to Sh. R K Dhiman, ADG (Retd.), BRO & President, Tunneling Association of India for his kind contribution in successful implementation of the workshop. His cooperation and support has always been a great resource and motivation. We are grateful to the participants from NDRF and CDRI (Coalition for Disaster Resilient Infrastructure) for sparing their time to contribute during the deliberations of the workshop. It is indeed a matter of pleasure to express gratitude and sense of respect for all the participants who supported these endeavors by participating in the high level panel discussions and group discussions. Their participation has been very useful and significant in drawing up the key outcomes of this important and strategic workshop.

We also extend thanks to Joint Director, NIDM as well as to Shri S.K. Tiwari, Librarian, NIDM and the entire publication cell of NIDM including Mr. Sanjay Kumar, Consultant (Rajbhasha) and Ms Karanpreet Kaur Sodhi, Jr Consultant, Publication, for their help in printing and publication of this report.

Further, we also express gratitude to the NIDM Administration, Accounts team, Training cell and other staff of NIDM, who helped in this workshop either directly or indirectly.

Prof. Surya Parkash Gupta
(and team)

Contents

Photo 1: Photo taken during rescue operation at Silkyara Tunnel during Nov. 2023.
Source: Pic Credit: Hindustan Times

Abbreviations

ADG	Additional Director General
BRO	Border Roads Organization
CMD	Chairman cum Managing Director
DPR	Detailed Project Report
DRR	Disaster Risk Reduction
DTU	Delhi Technological University
ED	Executive Director
EPC	Engineering, Procurement, and Construction
EWS	Early Warning System
FIDIC	Fédération Internationale des Ingénieurs-Conseils
GBR	Geotechnical Baseline Report
GoI	Government of India
GoUK	Government of Uttarakhand
High CAP Project	Development of National Highways Climate Adaptation Policy & Guidelines Project
IAS	Indian Administrative Service
IRC	Indian Roads Congress
JMI	Jamia Millia Islamia
MECL	Mineral Exploration and Consultancy Limited
MHA	Ministry of Home Affairs
MoRTH	Ministry of Road Transport and Highways
NATM	New Austrian Tunneling Method
NDMA	National Disaster Management Authority

NDRF	National Disaster Response Force
NH	National Highways
NHPC	National Hydroelectric Power Corporation
NIDM	National Institute of Disaster Management
NIRM	National Institute of Rock Mechanics
NTM	Norwegian Method of Tunneling
OSD	Officer on Special Duty
PM	Prime Minister
PMC	Project Monitoring Committee
PMO	Prime Minister's Office
SP	Special Publication
TBM	Tunnel Boring Machine
TEC	Technical Evaluation Committee

Executive Summary

A one-day National Workshop and Brainstorming Session on Silkyara Tunnel Case Study: Lessons Learnt from Silkyara Tunnel and other Tunnel Disasters was held on 28th Nov. 2024 at National Institute of Disaster Management (NIDM), Rohini campus in New Delhi, India to commemorate the victory of zero casualty during Silkyara Tunnel crises with safe rescue of 41 workers on 28th Nov. 2023. This workshop has been a joint initiative of the National Institute of Disaster Management (NIDM), National Disaster Management Authority (NDMA) & Ministry of Road Transport and Highways (MoRTH) , GoI.

The objectives of the workshop were to provide insights on the Silkyara tunnel incident, draw key lessons, and develop strategies to improve disaster preparedness, response, and resilience in tunneling projects. The recommendations drawn from the workshop will also help in the development of actionable strategies for disaster preparedness and response.

National workshop provided an opportunity to gather inputs and feedbacks from various stakeholders and experts from different perspectives including design, construction, physiography, geology, monitoring and response tailored to discuss the unique needs and challenges in each phase of infrastructure.

The inaugural session was followed by one panel session on "Understanding Silkyara Incident & Lessons Learnt" and a group discussion on "Development of Policy and Guidelines Framework on Climate & Disaster Resilient Tunnels", identifying gaps and challenges with a concluding session on the way forward.

The enthusiastic participation of key stakeholders from international, national and state level organisations/institutes and public and private sector facilitated the consultative workshop to successfully achieve its main agenda to develop a policy recommendations for improving safety standards in tunneling projects. The dignitaries and experts emphasised on the urgent need towards capacity building efforts for promoting tunnel expertise and also suggested changes for following best practices in the mind set of developers. Due importance to be given to detailed geological/geotechnical mapping, flexibility in tendering process, updation of monitoring and communication system for the safety of workers and successful completion of any mega infrastructure. All stakeholders appreciated the collaboration of NIDM, NDMA and MoRTH for this workshop for commemorating 1st Memorial Anniversary of Silkyara Tunnel Rescue. It was underscored that standard format for feasibility study and DPR along with strict codal provisions on construction quality check from 3rd party is required. Provision of escape routes should be made mandatory and continuous monitoring using modern techniques, 3D geological mapping should be undertaken. Experiences of hydro - tunnel experts should be used in projects of highway tunnels and these experts should be mapped and attached in different stages of the project. The then ED, NIDM

suggested to take the recommendations forward by understanding how to avert such accidents considering the success story of Silkyara tunnel and the causes for the disaster situation. He suggested to map the risks and vulnerabilities by working on resilient design, strengthening psychosocial support, use of robust technology and effective crisis communication. He ensured that the deliberations on the lessons of Silkyara case study and other case studies of tunnels will help the HighCAP project as a way forward through NIDM.

The workshop was privileged with the presence, guidance and visionary words of distinguished dignitaries and speakers, namely, Shri Bhaskar Khulbe, IAS (Retd.), OSD (Government of Uttarakhand), Sh. R K Dhiman, ADG (Retd.), BRO & President Tunneling Association of India; Lt Gen (Retd.) Syed Ata Hasnain, Member, NDMA; Shri Rajendra Singh, Member & Head of Department, NDMA; Dr. Manoj Verman, Tunneling & rock engineering expert, Rocscience (Representative India & South Asia); Dr. Gopal Dhawan, CMD (Retd.), MECL; Shri B. D. Patni, Chief Geologist (Retd.), NHPC & TEC member, NDMA; Prof. Amit Shrivastav, Dept. of Civil Engineering, DTU and Shri Karamveer Singh Bhandhari, 15th Btn. NDRF among others.

Eighty one (81) participants from organisations like CDRI, IIT, NIRM, JMI etc. comprised tunnelling and construction engineers, geologists, disaster management professionals; policy makers and regulators; academicians and researchers in geotechnical engineering and representatives from construction firms and safety organizations.

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Context

2.1 Background

Road transport, especially highways, plays a pivotal role in the development of a country. The development of highways fosters movement of passengers and freight across the country leading to increased national productivity and socio-economic growth. India has long realized the importance of highways and has been giving the necessary impetus for its development. Interruptions, disruptions and disasters on National Highway services have significant implications in terms of severe impacts on life, economy, environment and infrastructure. Additionally, the sector is also required to build resilience to climate change impacts in order to reduce risks and protect the highway infrastructure such as rising sea-level, extreme weather events, increasing temperature, and other such events.

Present workshop, on the occasion of anniversary of Silkyara Tunnel Rescue held on 28th Nov. 2024 underscores the significance of disaster resilient infrastructure along highways with focus on resilient tunnels. Highway tunnels are critical components in road transportation networks. They are usually constructed as an important part of modern highway network to shorten the travel time, reduce transportation costs, and improve traffic capacity. Feasibility of tunnel constructions in natural materials, such as rock and soil, causes the geological conditions to play a major role in their stability. The construction and operation of tunnels, particularly in challenging geological and environmental conditions, is a critical area of focus in ensuring both safety and sustainability in infrastructure projects. Disasters related to tunnelling activities such as tunnel collapses, flooding, fires, and gas leaks pose significant risks to workers, communities, and the environment.

On 28th November 2023, 41 workers were rescued from Silkyara tunnel after meticulous efforts of multiple agencies, known as Uttarakhand Silkyara Tunnel Rescue Operation (12th–28th November 2023 for 17 days) a mission that demonstrated the resilience and collective strength of our nation during one of its most challenging moments. Workers were trapped inside tunnel due to collapse of a section of Sikyara tunnel on 12th November 2023 at 05:30 hrs IST. The Silkyara Bend–Barkot tunnel, has been planned to connect National Highway 134 in the Uttarkashi district of Uttarakhand, India. It is part of Char-Dham all-weather road project, located in a seismically active region, faced multiple challenges during its construction, including unexpected geological anomalies, poor water management, and inadequate safety measures. The tunnel's location is in proximity to the Main Central Thrust of the Himalaya which is a major geological sheared fault zone consisting of an extremely weak rock mass constituting meta-siltstone and phyllites.

One of the key lessons learned from the Silkyara tunnel disaster is the importance of proactive risk management and the adoption of advanced technological solutions to enhance disaster resilience in tunnelling projects. The incident not only highlighted the vulnerabilities of tunnels to disasters and

climate hazards but also underscored the need for multi-disciplinary approaches to disaster prevention, mitigation, early warning, preparedness and efficient response. This consultation workshop, taking cue from the past such tunnel incidences aims to bring together industry experts, government agencies, engineers, disaster management professionals, and researchers to explore lessons learned from the Silkyara tunnel disaster and discuss practical strategies for enhancing disaster resilience in tunnelling projects across the region.

2.2 Objective

To understand the Silkyara tunnel incident, draw key lessons, and develop strategies to improve disaster preparedness, response, and resilience in tunnelling projects.

2.3 Need for this Workshop

Taking into account the changing climate and the associated disasters as well as extreme events, National Institute of Disaster Management (NIDM), Ministry of Home Affairs (MHA) has taken up the Project "Development of National Highways Climate Adaptation Policy and Guidelines". The project is aligned to support the Ministry of Road Transport and Highways (MoRTH) on enhancing the climate resilience of National Highways (NHs) in India. To build the resilience of highways, tunnels are an integral part of road sector. On the occasion of the 1st memorial anniversary of Silkyara Tunnel rescue of workers on 28th November 2023, this consultation workshop has been organized by the NIDM, MHA in collaboration with MoRTH and National Disaster Management Authority (NDMA) helped bringing the senior experts, different stakeholders at one platform highlighting the practical issues and challenges from their experiences. Attention to Silkyara tunnel incident reminds us of the need to prioritize safety and preparedness in every project that is being undertaken.

2.4 Target Audience

- Tunnelling and construction engineers
- Disaster management professionals
- Policy makers and regulators
- Academicians and researchers in geotechnical engineering
- Representatives from construction firms and safety organizations

2.5 Expected Outcomes

- Enhanced understanding of disaster risks in tunnelling
- Development of actionable strategies for disaster preparedness and response
- Strengthened collaboration between engineering and disaster management communities
- Policy recommendations for improving safety standards in tunnelling projects for climate and disaster resilience.

2.6 Focus of the workshop

This one day workshop consisted of two technical sessions: panel discussion on *Understanding Silkyara Incident & Lessons Learnt* followed by Group Discussion on *Development of Policy and Guidelines Framework on Climate & Disaster Resilient Tunnels* along with inaugural and valedictory sessions attended by various dignitaries.

The scope for augmenting technology applications, research gaps, data limitations, and knowledge-sharing opportunities have been discussed for future action toward promoting safer, climate and disaster resilient construction practices for reducing disaster risks with respect to tunnels.

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Inaugural Session

3.1 Shri Rajendra Ratnoo, IAS, Former Executive Director, National Institute of Disaster Management (NIDM) presided the inaugural of the National Workshop and Brainstorming session on Silkyara Tunnel case study: Lessons learnt from Silkyara Tunnel and other Tunnel Disasters. Shri Rajendra Ratnoo, welcomed the dignitaries and talked about the commemoration of one year to Silkyara tunnel operation as the success story with its own complexities and challenges. He extended deepest gratitude to the workers, rescuers, government officials and also the private experts who worked tirelessly to rescue those trapped in the tunnel incident, teaching us the importance of implementing strict safety measures at all levels of construction.

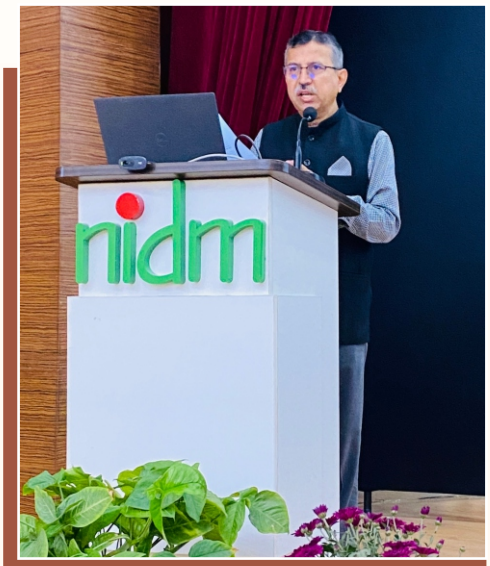

Photo 2: Shri Rajendra Ratnoo, IAS, ED, NIDM welcomed the dignitaries and addressed the delegates.

Shri Ratnoo appreciated the government approach galvanising the success by breaking the silos among different departments. He applauded that Silkyara tunnel event showcased leadership of Hon'ble PM, PMO and other stakeholders in all stages of tunnel rescue operations and the leadership shinning from inside the tunnel during trapped situation which helped in keeping the positive mindset of workers. He said that this event also gave us a lesson on understanding the importance of using global expertise with local skills complimenting the skillset of rat miners in such operations. He pointed to utilize the workshop in understanding how to avert such accidents taking into account the success lessons of Silkyara tunnel.

He suggested mapping the risks and vulnerabilities by working on resilient designs, strengthening psychosocial support, using robust technology and effective crisis communication. He shared the information that NIDM is working on a project with MoRTH for development of policy and guidelines for highways to make them disaster and climate resilient. He ensured that the deliberations on the lessons of Silkyara case study and other case studies of tunnels will help guide the project as a way forward through NIDM.

3.2 Shri Bhaskar Khulbe, IAS (Retd.), OSD to Government of Uttarakhand delivered the inaugural address. He was pleased to deliberate on commemoration of 1st anniversary of Silkyara Tunnel rescue. Shri Khulbe narrated the events of the operations, applauding the collaborated efforts of multiple agencies. He resonated the words of Hon'ble Prime Minister about the operation being a testament of humanity and unwavering commitment of organizations, volunteers, workers and every individual involved in rescue operation becoming an inspiration to everyone. He

complimented the then ED, NIDM and Prof Surya Parkash Gupta, for organizing this timely workshop and giving the experts this platform to share views on how to avoid such disasters, promote resilient infrastructure and lessons learnt. Shri Khulbe said as India is taking many ambitious infra development projects on surface and subsurface, adoption of safe resilient practices has gained importance recently. Therefore, he suggested to give a fresh relook for enhancing safety in the fragile and vulnerable regions in India.

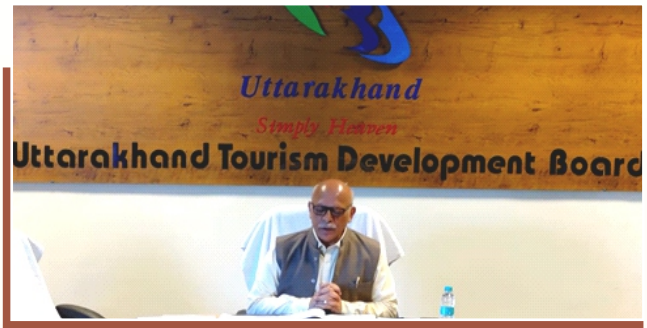

Photo 3: Shri Bhaskar Khulbe, IAS (Retd.) speaking online during the workshop

Shri Khulbe spoke about the various sectoral challenges starting from design phase to monitoring and suggested strict ground rules to be made in tunneling projects especially constructed in fragile regions. He pinpointed the need to review the basics starting from the contracts given in EPC (Engineering, Procurement and Construction) mode with fixed time duration and limited compensation without checking intricate design, ground conditions & construction risks and the risks of unforeseen conditions. He gave example of FIDIC (Fédération Internationale des Ingénieurs-Conseils) Emerald book which requires the projects to undertake detailed investigation through geotechnical baseline report.

Shri Khulbe informed that for Indian tunneling projects, New Austrian Tunneling Method (NATM) and the Norwegian Method of Tunneling (NMT) norms are followed and advised that in future, Indian norms for tunnels may be made. New institute can be set up to undertake the challenges of delicate physiographic conditions of Himalaya using the vast technical expertise India own in this sector. He also expressed the concern of not having much changes in the ground practices even after such tunnel disasters and detailed geotechnical baseline reports are not upto the mark.

Further, he applauded the collaboration on this workshop, and gave the action plan to use the past experiences and experts information by making the repository of the experts. The repository should be updated regularly, consisting of experts who have worked in such tunnel operations, so that in future one can save time and have better coordination and decision making system.

Shri Khulbe suggested the way ahead by promoting regular audit check from third party; following precise standards related to safety such as for escape routes; embrace the technology helping in regular monitor of deformations signs of any failure using modern technology and underground survey techniques and automation of SMS alert can be generated if deformation exceeds threshold. He concluded by stating that all great knowledge need periodic exchange of information like commemorating one year of Silkyara tunnel. Knowledge platforms should be used to gather conviction of everyone towards resilient infrastructure.

3.3 Prof. Surya Parkash Gupta, Project Director and CPI, HighCAP & Head of Geo-Meteorological Risk Management Division, NIDM, welcomed everyone on and off the dais. He set the tone of the workshop by highlighting several tunnel and mining accidents/disasters including 2018 Meghalaya coal mine tragedy where 15 rat hole miners were trapped and killed in the incident.

He also cited the example of rockfall at 5500 above mean sea level on 7th Feb. 2021 which led to debris flow causing damage to Tapovan hydel power project which led to causalities of 204 people. Tunnel disasters may also occur along highways due to collision of vehicles or due to fire when a truck carrying explosives or inflammable material meets with an accident. Incidents happened in the past have shown to be affecting mega infra projects such as dams, mines, hydel power, metro, tunnel, bridges etc. serve as a reminder to focus on the sustainable and resilient practices. In 2011, a cut and cover tunnel was constructed in Meghalaya to avoid the impacts of landslides at Sonapur, thereby serving of a protection structure as well as to maintain traffic continuity.

Prof. Surya Parkash Gupta stated the importance of the workshop towards sharing global best practices and collate the recommendations of experts, as NIDM is undertaking project on developing policy and guideline for climate adaptation national highways. He emphasized that disaster management is a continuous process and the initiation of preparedness activities does not need any disaster event to occur. He also emphasized on taking care of the health conditions and occupational safety standards and establishment of early warning system so that people can take care of themselves.

Photo 4: Prof. Surya Parkash Gupta, PD/CPI, HighCAP & Head of GMR Division, NIDM provided overview of the objectives of workshop

Prof. Surya Parkash Gupta shared from his experiences in public health emergency and disaster management that regular monitoring of health conditions should be made necessary for workers engaged in such field works. The workers should be trained so that in emergency situation, they have the ability to respond effectively. He said the workshop is planned to address the issues and challenges commonly faced in tunnel project. He suggested that ensuring safety and climate risk resilience using a single standard or best practice in other areas may not be effective. Hence, regular consultation meetings can guide us to serve better and utilize the golden hours after any disaster event to save lives, economy, infrastructure and environment.

3.4 Shri RK Dhiman, ADG (Retd.), BRO & President Tunneling Association of India gave the special address. He said that BRO was the first responder team to reach the tunnel site from Rishikesh and resonated the success through effort of the team. He shared his long experience with NHPC and showed the glimpse of the development of different types of tunnel from 90s for different sectors. However, the highway tunnel work started in 2000s. He suggested that construction of highway tunnels should use the knowledge and expertise utilized in hydro tunnels being constructed in difficult terrains. He mentioned that only IRC SP: 91 emphasize on tunnel for highway sector, where Tunnelling Association of India (TAI) did not participate in this codal provision. Construction knowledge and expertise of other projects and their lessons need to be reflected in the codes. He pinpointed the false practices such as not giving enough time for the pre-investigation and preparation of DPR.

Shri Dhiman highlighted the documentation of stepwise experience of BRO during Silkyara tunnel event and also shared about the Sela Tunnel project, which Hon'ble Prime Minister dedicated to the nation. The tunnel has been constructed by the BRO at an altitude of 13,000 feet connecting Tezpur, Assam to Tawang, Arunachal Pradesh the tunnel which will provide all-weather connectivity, boosting the preparedness of the Armed Forces and augmenting the socio-economic development of the border region. He also shared the usefulness of the pocket book available on tunneling for tunnel engineers by Tunnel Association and suggested to integrate interdepartmental association to further help refine the skills of workers of tunnel construction.

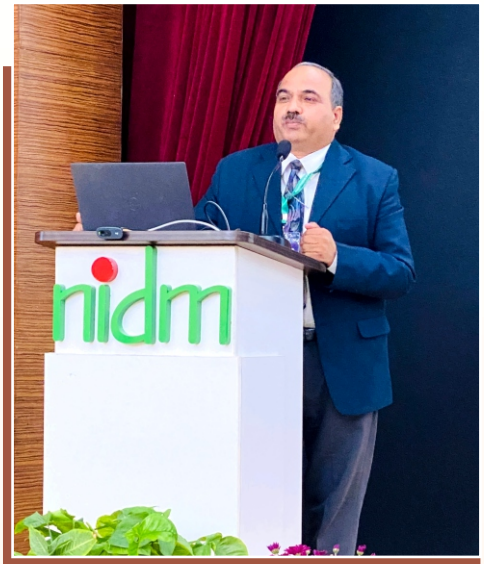

Photo 5: Shri RK Dhiman, ADG (Retd.), BRO & President Tunneling Association of India sharing his experiences from the different parts of the country

He also pinpointed the need of atleast one production factory of TBM in India seeing the high use of TBM in new projects. He ended his speech by sharing the celebration on 4th Dec. as World Tunnel Day.

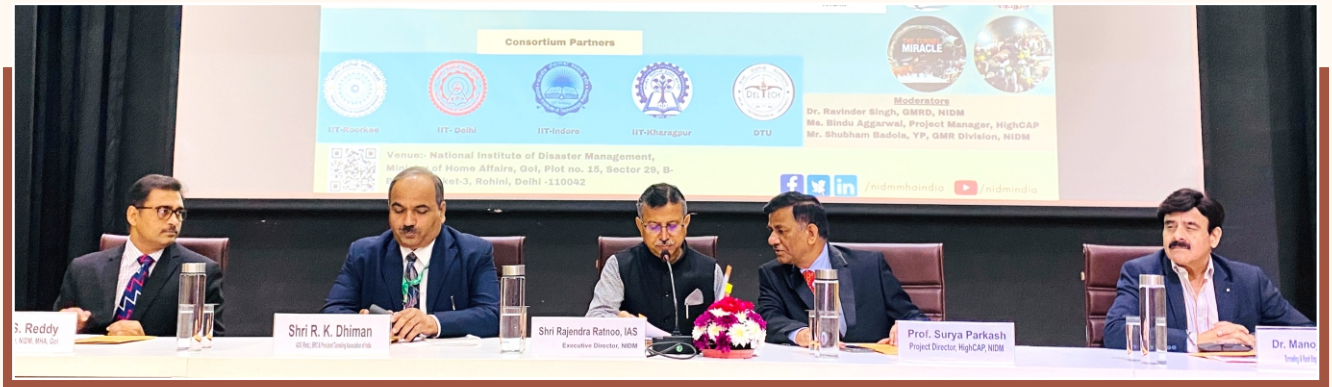

Photo 6: Inaugral session diginatries (Left to right): Col. P. S, Reddy, Joint Director (South), NIDM; Shri RK Dhiman, ADG (Retd.), BRO & President Tunneling Association of India, Shri Rajendra Ratnoo, IAS, Executive Director, NIDM; Prof. Surya Parkash Gupta, PD/CPI, HighCAP & Head GMR Division, NIDM; Dr. Manoj Verman, Tunneling & Rock Engineering expert

3.5 Shri Syed Ata Hasnain, Member NDMA, through his video message, recollected his role, experience and overall day wise activities of Silkyara tunnel operation. He commended the successful rescue effort showcasing whole of Govt approach led by Hon'ble PM, PMO, MHA, MoRTH, GoUK, NDMA, BRO, NDRF, Indian Army etc. leaving no stone unturned. Shri Hasnain emphasized the importance of escape tunnel which was missing in Silkyara case and said safety is paramount. He shared the positive steps taken such as importance given to psychological support to victims and their families, assurance of quality food and communication to maintain a

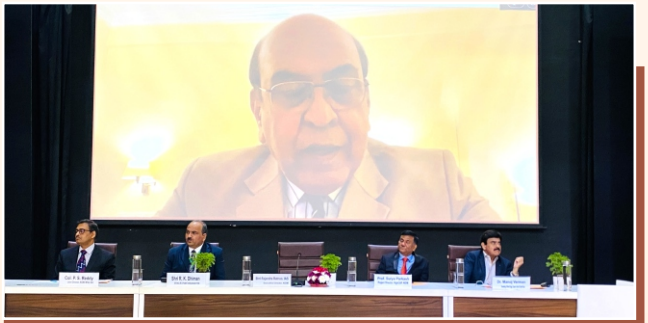

Photo 7: Shri Syed Ata Hasnain, Member NDMA discussed about role of NDMA during Silkyara Tunnel crises

positive mindset. Shri Hasnain suggested taking the lesson from Silkyara, everyone should come together and start by being aware of PM 10 point agenda for DRR (2016) as base of learning.

3.6 Shri Rajendra Singh, HoD NDMA through his special address spoke about the need of keeping a holistic approach in addressing the geological challenges, from preparation of DPR stage to its implementation and undertaking rigorous monitoring during tunnel construction. He suggested the way forward for strengthening safety standards of any infrastructure, keeping stringent checks, more focus on structural stability and required changes/ updation in codal provisions. Shri Singh also proposed development of advance EWS as automated strain detector,swift emergency response plan, better coordination and regular safety training to workers.

3.7 Col. P. S. Reddy, Joint Director (South), NIDM gave the vote of thanks of the inaugural session. The inaugural session of the workshop was followed by two technical sessions. He thanked all the dignitaries of inaugural session, guests, participants, and the organizing team for taking up this workshop on one year of successful Silkyara Tunnel rescue. He emphasized the significance of this platform for providing a crucial opportunity to various think tanks, to share their insights and valuable learning from their practical experiences collaborating to strengthen resilient tunnel policy.

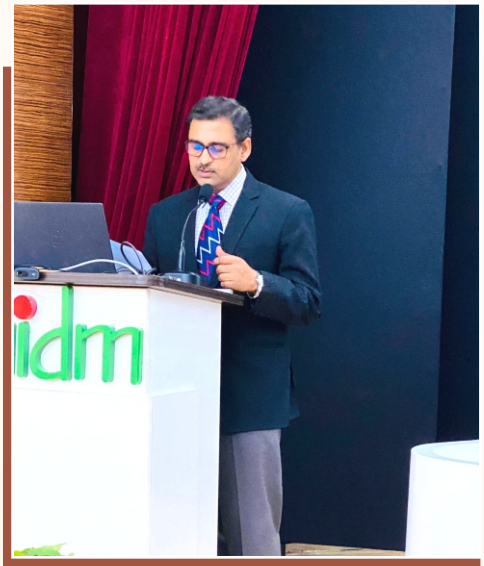

Photo 8: Col. P. S. Reddy, JD (South), NIDM extending thanks to dignitaries & delegates

3.8 Keypoints

- The whole of government approach became the foundation of the success of Silkyara tunnel rescue by cutting the silos among different departments and showcasing great team work and coordination.
- Need to map the risk and vulnerabilities by working on resilient designs, strengthening psychosocial support, use of robust technology and effective crisis communication.
- Adoption of safe resilient practices in India is to be taken as a priority as India is taking many ambitious infra development projects on surface and subsurface.
- Need to create Indian norms for tunnels and set up institutes to undertake the challenges and delicate physiographic conditions of Himalayas using the vast technical expertise, India own in this sector.
- To make the repository of the experts who work in such tunnel operations so that in future one can save time and have better coordination.
- There is a need of atleast one production factory of TBM in India to monitor the high use of TBM in new projects.
- Only IRC SP: 91 emphasize on tunnel for highway sector. Construction knowledge and expertise of other projects and their lessons needs to be reflected in the codes.

- Need to review the process of contracts given in EPC mode with fixed time duration and limited compensation without checking intricate design, ground conditions/construction risk and the risk of unforeseen conditions.
- Need of keeping a holistic approach from preparation of DPR stage to its implementation and undertaking rigorous monitoring during tunnel construction.
- Understanding the importance of using global expertise with local skills is a great example of Silkyara tunnel using the skillset of rat miners in operations.
- Strengthening of safety standards of any infrastructure, keeping stringent checks, focus on structural stability and required changes and updation in codal provisions.

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Technical Session-I

Panel Discussion on Silkyara Tunnel Collapse: Understanding & Lessons Learnt

4.1 Chair: Shri Rajendra Ratnoo, IAS, Executive Director, NIDM

Co-Chair: Dr. Manoj Verman, Tunneling & Rock Engineering Expert

Speakers of the session:

1. Dr. Gopal Dhawan, CMD (Retd.), MECL
2. Shri B. D. Patni, Chief Geologist (Retd.), NHPC & TEC Member, NDMA
3. Prof. Amit Kumar Srivastava, Dept. of Civil Engineering, DTU
4. Shri Karamveer Singh Bhandhari, 15 Btn, NDRF

4.1.1 Dr. Manoj Verman, co-chair of the panel discussion gave brief presentation on 'Understanding Silkyara Incident & lessons learnt'. He shared his experience how things unfolded in 16 days and on 28th November 2023, good news came regarding evacuation of 41 mine workers from Silkyara Tunnel. He shared the biggest lesson learnt was the multiagency coordination for the 17 days mammoth rescue operation. Dr. Verman shared following causes and contributing factors of collapse:

- Area passed through Complex Shear Zone
- Geological challenges leading to poor understanding and errors in designs
- Capture true geological challenges with limited deep drilling and inadequate mapping of the shear zone
- Missed steps in planning and design oversights
- Poor investigation and lack of monitoring
- Reactive versus proactive measures
- Inadequate subsurface mapping

Dr. Verman highlighted major issues that warning signs were ignored as 20 collapses during construction of Silkyara were seen. Thus, he said targeted investigation at different stages is very important. The adaptation of a geotechnical baseline report should be supported by different types of contracts. Integrating advance monitoring techniques should be key to

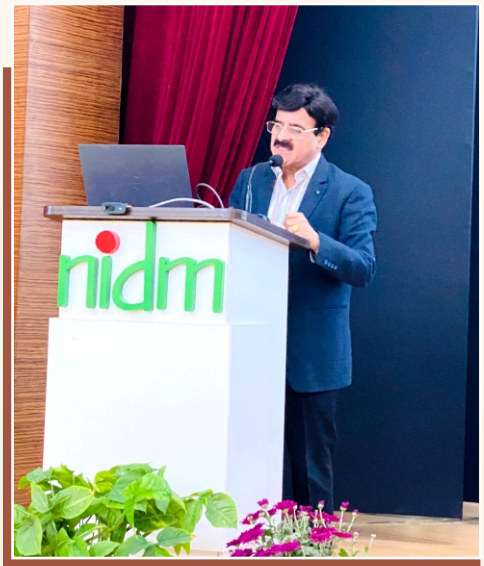

Photo 9: Dr. Manoj Verman, Tunneling & rock engineering expert, shared global experiences and highlighted of major issues related to tunnel collapse

explore the targeted complex sections for comprehensive and targeted geotechnical investigations.

The co-chair, Dr. Manoj Verman also showcased the challenges of current rehabilitation efforts going on at Silkyara tunnel, such as:.

- Rehab has to be innovative, collapse muck removal without collapse
- Probe Holes and pre support measures to determine how big is the cavity
- Mapping voids
- Agile Excavation Phases (Drift wise excavation with pipe roof grouting, steel arches and face support using fiber glass bolts).
- Continuous monitoring and instrumentation to be carried out

He specified that in rehab techniques, extrusion measures were carried using face extrusometer and drift wise agile evacuation plan. Dr. Verman also extracted the lessons learnt at policy level such as:

- Importance of Robust DPR (Detailed Project Report)– Comprehensive investigation and realistic assessment of geological conditions
- Risk sharing in contracts- Shifting from fixed price models to equitable risk sharing mechanism
- Incorporation of Geotechnical Baseline Reports (GBRs)- Contractor needs to be told about ground condition needing thorough investigation
- Better monitoring systems
- Safety audit technology
- Use of FIDIC Emerald

Dr. Verman while concluding his presentation said, it is important to ensure that we all learn lessons of Silkyara. He requested to think in terms of what appropriate actionable steps can be taken to standardize risk management. Policy makers, Engineering Geologist, contractors etc. should brainstorm and drive innovation with greater focus on worker safety so that in future, tunnel are resilient and safer. Some of the action oriented points raised by Dr. Verman were:

- Adoption of New Technologies Like TBMs
- Shift towards proactive approaches in High stake projects
- Encouragement of International Standards
- Collaboration among stake holders
- Acknowledging the efforts made so far
- Key questions for reflection and discussion
- Drive Innovation widely for varying conditions

4.1.2 Prof. Amit Kumar Srivastava, Department of Civil Engineering, Delhi Technological University told from his experience on Silkyara Tunnel rescue that only pointing the shortcomings on DPR, complex physiography of Himalayan region and lack of Geotechnical Baseline Report will not justify the whole reason behind the tunnel collapse. He added that there are many reasons which

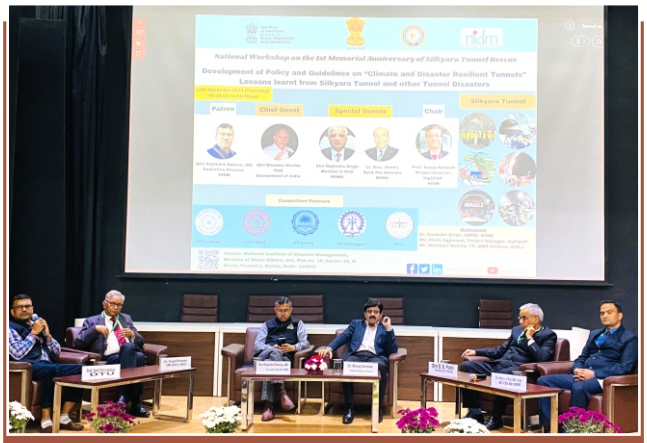

Photo 10: Panel session dignitaries (Left to Right): Dr Amit Kumar Srivastava, Professor, Delhi Technological University; Dr. Gopal Dhawan, MECL; Shri Rajendra Ratnoo, IAS, Executive Director, NIDM; Dr. Manoj Verman, Tunnelling & rock engineering expert, Rocscience, Representative India & South Asia; Shri B. D. Patni, NHPC; Shri. Karamvir Singh, AC, 15 Btn NDRF

needs to be rectified at different steps from design, inspection to policy level. For example construction technology followed and equipment used; need of increased number of borehole studies from currently used 1km spacing. Prof Srivastava also reiterated the issue of third party quality check is not followed in the tunnel. He also shared that monitoring is most important for enhancing safety. Currently real time alarm system is absent and capacity building is also limited. The subject of rock mechanics/ rock engineering is elective in civil engineering, at graduation level/B.Tech level given only a semester knowledge on such important domain.

4.1.3 Dr. Gopal Dhawan (Retd. CMD), MECL shared his long experience of working in Tunnel sector with NHPC and told that accidents like Silkyara are not new and many incidents have occurred in the past. He shared his experience where he and his coworkers were rescued in one incident and pinpointed the importance of using the golden hours efficiently. He applauded the collaborative efforts seen in the Silkyara tunnel rescue, however, raised the question whether without the leadership of Hon'ble PM and PMO such collaboration would have happened in timely manner. He reiterated that High Level Committee of the Silkyara had highlighted the lapses at all level from DPR to execution and casualness related to safety has been a mental block in these situation. He shared the experiences of successful tunnels constructed in early 90s in the Himalaya in complex geology. Dr. Dhawan expressed dissatisfaction towards our current approach and not learning lessons completely from past experiences. He said all technical and scientific community need to come together and work on crossing the issues of DPR, geological/geotechnical/ geophysical mapping and the unknown hidden challenges of the tunnel process. He suggested to enhance our preparedness and be ready with the innovative procedure to respond efficiently in any accident such as commendable rescue by rat hole miners in case of Silkyara tunnel.

Photo 11: Shri B. D. Patni, NHPC shared tunnel experience from hydel sector

4.1.4 Shri B. D. Patni, shared his 40 years of experience in tunnel industry and applauded the rat hole miners work resulting in success of Silkyara tunnel rescue. Shri Patni shared his experience where NHPC also faced collapse of tunnels in the past and how he had been trapped for 20 hrs in past incident. He pinpointed the issue of lack of professional expertise required in carrying any tunneling project and suggested to develop Project Monitoring Committee (PMC).

He highlighted that best global drilling and blasting technology need to be known to the Indian professional. He concluded by sharing that any successful tunnel construction is highly dependent on vision, leadership and team work of the site workers which requires patience, confidence and experience.

Former ED, NIDM added suggestion that geotechnical expert and applied geologist to be made compulsory as a part of any infra projects including the need of innovation on the tendering procedures.

4.1.5 Shri Karamvir Singh, Assistant Commandant, 15 Btn NDRF, shared commendable efforts of the team of NDRF in providing their services, improvisation on the equipment and boosting the morale of all the people present at the Silkyara tunnel rescue site. He shared the incident of 17th Nov. 2023 where a loud cracking sound was heard, which led to panic and halting of construction of escape tunnel operation. It was found that the augur machine was stuck to metal lattice girder. Mr. Singh shared how he along with his team of NDRF went inside in confined space with gas cutter and improvised the equipment as per that situation. NDRF stood at forefront in all the challenges seen in the operation uplifting the morale in any situation. In his concluding remarks, he suggested that the workers should be given regular mock exercises. This will give the workers the idea to have the escape tunnel and supply tunnel in future.

Photo 12: Shri B. D. Patni & Shri Karamvir Singh, Assistant Commandant, 15 Btn NDRF discussed the experiences of Silkyara Tunnel incident

Suggestions shared by participants:

- Instrumentation and compulsory training before working in confined areas
- Brainstorm on issues of supply chain in terms of placements and attracting students in taking as their elective subjects
- Importance of field experience should be reflected in the workers of any new projects.

Photo 13: Suggestions by participant on disaster preparedness by delegates

4.1.6 Shri Rajendra Ratnoo, Chairperson of the panel discussion in his closing remarks said, it is important to detach feasibility from DPR. He further observed that efforts need to come from each stakeholder and from all levels through collaboration, knowledge sharing, continuous communication among stakeholders, leadership, and proactive approach. After listening to the esteemed panel, he reiterated that having a holistic approach is endeavour of NIDM and due importance is being given to sectoral mainstreaming of disaster risk reduction.

4.2 Keypoints

- The workers should be involved in regular mock exercises and compulsory training before working in confined areas. Any past field experience of workers should be given preference.
- To enhance resilience of people and infrastructure, efforts need to come from each stakeholder and from all levels through collaboration, knowledge sharing, effective communication, leadership, and proactive approach.
- There is a need to identify gaps in expertise required for carrying out any tunneling project.
- Every Tunnel project should have third party audit and a project monitoring committee must be constituted.
- Geotechnical engineers and applied geologists to be made compulsorily part of any infra project team.
- Gaps should be identified in the tendering procedures (EPC mode).
- All technical and scientific community should collaborate to address the issues of DPR, geological/geotechnical/geophysical mapping and the unknown challenges of the tunnel process using modern technology and innovation.
- Subsurface investigation using boreholes need to be modified and increased for smaller distance.
- Suggestions were given regarding the need to enhance the capacity building by motivating students in B.Tech to take the subjects like rock mechanics/rock engineering as elective subject or compulsory subject.
- Alarm system should be linked with real time monitoring system.

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Technical Session-II

Group Discussion Session: Development of Policy Framework on Climate and Disaster Resilient Tunnel

A roundtable session was organised to bring out the ideas, suggestions, experiences which may facilitate in the development of robust policy framework on climate and disaster resilient tunnel. The participants were divided in five subgroups focusing on different disaster management aspects as follows:

Group 1: Risk Assessment: Address the existing format/procedures, challenges and gaps needed for risk assessment.

Group 2: Reducing Risk: Discuss the existing codal provisions/ guidelines/ SoPs

Group 3: Monitoring and Early Warning System: Discuss the need for continuous dissemination and detection for monitoring and early warning in tunnel operation

Group 4: Preparedness & Response: Identify the preparedness and response during tunnel incidents

Group 5: Recovery, Redevelopment & Resilience: Discuss on the recovery, rehabilitation, redevelopment, and resilience plan in tunnelling.

The lead discussant of the groups was Dr. Gopal Dhawan, Shri D. S. Rawat, Dr. Manoj Verman, and Shri B.D. Patni. Each group was given opportunity to discuss with the group members and lead discussant shared the views with the audience.

5.1 Key points

Group 1:

- No existing standard format and procedures for risk assessment available for tunnels at present in the industry.
- Possible risks need to be determined at early project stage to apply appropriate compensation of work for effective risk reduction.
- Typical geological uncertainties in Himalaya may include low cover zone, high water discharge, cavity formation etc.
- It is recommended to refer procedures of risk assessment for tunnel in Himalaya presented by Dr. Ian Mc. Feat Smith, Engineer Geologist and Civil Engineer.

Photo 14: Discussion on risk assessment parameters stress zones/unexpected sheared/crushed/fault zone; validation in predicted and actual rock mass conditions; high water discharge under pressure and cavity formation

- Various levels of risks should be defined owing to complex geological conditions and evolve strategy for tackling risk at various levels.
- Consequences and severity of risks and likelihood of its occurrence should be assessed based on previous experience in tunnel construction in similar geological conditions.
- Biggest challenge include mindset of developers/contractors/consultants; at present there is very little emphasis on conducting proper investigations in feasibility report/DPR stage of the project. Global investment on investigations is from 5-6% whereas for Indian projects it seldom exceeds 6%.
- Need for development of geological models through geological mapping and sub-surface exploration of complex geology.
- Poor accessibility for conducting geological mapping, geophysical investigations & exploratory drilling.
- There is non-availability of drilling rigs for deep drilling.
- Application of correct rock mass classification system is need of the hour.

Group 2:

- BIS 4756 (IS: 4756 Safety code for tunneling work) to be adopted.
- Ensuring adequate ventilation system for the removal of polluted gases/dust etc.
- Proper illumination and lighting to be provided during the tunneling activities.
- For lighting and other purposes, electric power be used instead of fossil fuels.
- The accessibility of fire extinguishers, PPE kits is crucial. A record of each worker entering the tunnel should be mandatorily maintained.
- Escape routes at both invert levels of >80 cm dia to be provided in the geologically doubtful tunnel reaches. Probe holes/ geophysical tools need to be applied for further study.
- Geological face and 3D geological mapping to be carried out after every construction cycle.
- Temporary rock support to be provided at the earliest at the problematic tunnel reaches.

Photo 15: Discussion on the existing codal provisions

- Physical rock monitoring to be carried out of the excavated unsupported tunnel areas.
- Drainage holes to be provided in the seepage zone areas.
- Training and awareness to be given time to time and regular mock exercise to be conducted.

Group 3:

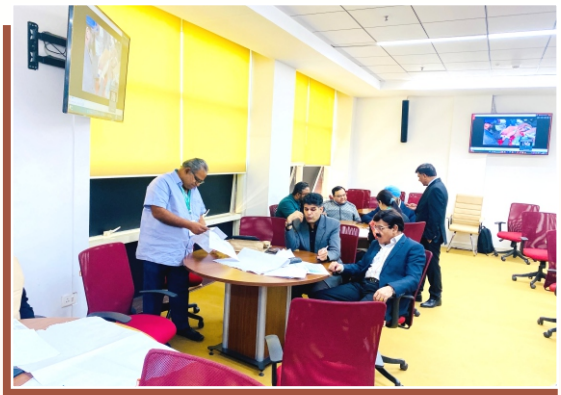

Photo 16: Discussion on the monitoring & early warning system for DRR

- During construction there should be installation of instruments in variety of weak zones or as required. Instrumentation should be able to provide 3D monitoring to identify any pressure cells, rock bursting, squeezing from soft rocks etc.
- Instrumentation for continuous monitoring of gases like methane/SO_2/CO_2/CO should be present.
- Monitoring and check of proper temperature, circulation/ventilation of air.
- Distributed Fibre Optic Sensing (DFOS) may be used as sensors in place of conventional instruments, the readings taken should be properly monitored, evaluated and timely reported.
- It is important to have active participation and discourage any oversight from competent authority/Govt. Engineer/ during audit etc.

Group 4:

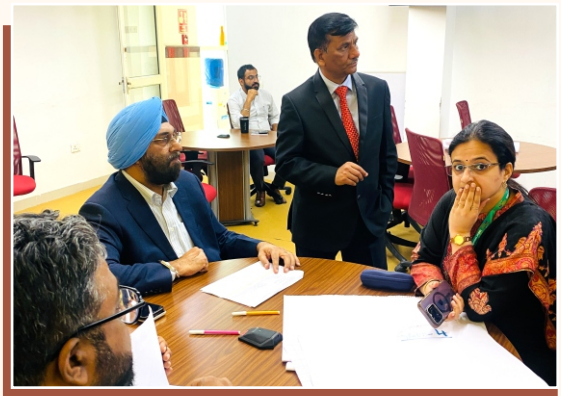

Photo 17: Discussion on the preparedness and response during tunnel incidents

- Identification of problems through diagnosis require both testing and expertise. The expertise should be identified at the start of any project. They should be involved at different required stages.
- Experts should comprise different domains particularly Geotechnical Engineering (rock expert, soil expert) and mining engineering.
- Evacuation tunnel/ Escape route should be made mandatory (with other utilities).
- Integrating monitoring with communication system: Identification of various thresholds of various monitoring/instrumentation and should be communicated timely to concerned authorities for timely action.
- Availability of emergency food rations, oxygen cylinder and first aid during any casualty.
- Safety training to all workers for use of first aid, psychological first aid, rescue and response in absence of experts and health professionals.

Group 5:

- Recovery requires the searching of trapped individuals, arrangements of communication system and efficient clearance of debris removal.
- Redevelopment & reconstruction involve identification of vulnerable zones in tunnel. Design and planning should have phased approval format. Quality control for the stability of tunnel such as quality of shotcrete, strength of rock anchors should be checked. Focus must be given on worker's safety.

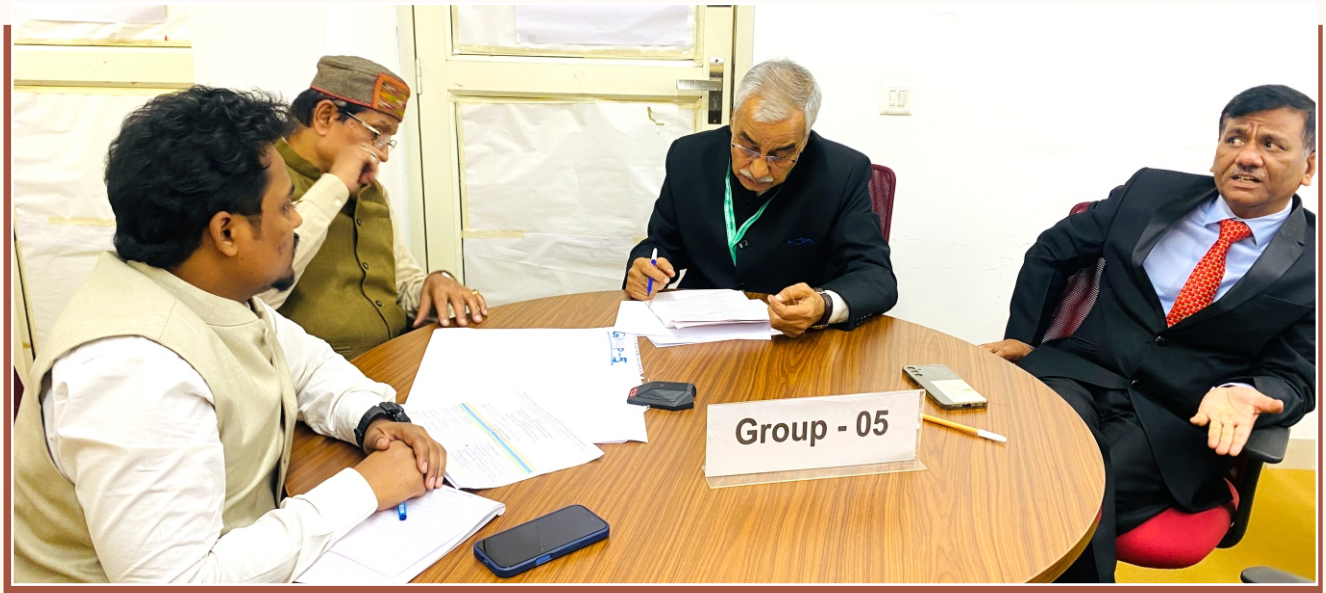

Photo 18: Discussion on the recovery, rehabilitation, redevelopment and resilience plan in tunnelling

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Concluding Session: Way Forward

6.1 Ms. Bindu Aggarwal, Project Manager, HighCAP, NIDM presented the summary of the workshop, reiterating the highlights of inaugural session, panel discussion on Silkyara Tunnel collapse: understanding & lessons learnt and group discussions on development of policy framework on climate and disaster resilient tunnel.

Participants also shared few important points that were collated in the group discussion. Some of the points included were:

- Possible risk factors needs to be determined at an early stage
- Need for standard format for DPR stage
- Need to change the mindset and investigation process must be improved from procurement to analysis, especially for fragile geology, difficult terrain and accessibility.
- Need to cover for geological uncertaintie.
- Need continuous monitoring of stress/ strain through improved monitoring systems
- Preplanning of debris removal and SoP for damage assessment
- Need to develop robust Reconstruction & Rehabilitation design and plan for potentially vulnerable and already collapsed area.
- Need to revisit existing conventional methods and replace with technologically more advanced methods.
- Site specific inspection program must be developed to minimize the probability of any collapse.

6.2 Shri Rajendra Ratnoo, Former Executive Director, NIDM in the valedictory address said that it is the time to act. He commended the group exercise work format where the groups were given tasks systematically to brainstorm on each aspect of disaster risk management. He again emphasised towards the need to observe our actions holistically covering all such accidents/ disasters. Sectors such as Tunnels and underground mining which may need similar expertise and can help each other to understand the problems and challenges holistically. He stated the need of convergence of think tanks and work on policy and SoPs, where good practices should be acknowledged and lessons to be learnt from incidents like Silkyara tunnel.

Shri Ratnoo gave assurance that this workshop will not remain as a one day brainstorming learning activity but further discussions, consultations, capacity building activities of NIDM along with role of

NIDM in project on Development of National Highways Climate Adaptation Policy and Guidelines (HighCAP), will take the actions and recommendations at policy level. This will facilitate country having the proper guidance and support to develop and strategize its own standard plan, DPR, procurement or response recovery Plans in a holistic and sustainable manner with the motive of making a resilient future.

6.3 Prof. Surya Parkash Gupta, Project Director and CPI, HighCAP & Head of Geo-Meteorological Risk Management Division, NIDM, gave the vote of thanks and assured again that he will continue this discussion further using similar platforms and media in future as well. He appreciated the active participation of each participant. He added that to successfully implement policy and guidelines for disaster and climate resilient infrastructure, it is crucial to engage in careful planning, foster collaboration, and consistently evaluate and update our strategies through shared knowledge, expertise and use of technology. He requested that guidance of key experts from organisations such as BIS, NDMA, MoRTH and other key stakeholders for revision of codes and framing of policy guidelines will help in refining the work of project HighCAP, to achieve adequate safety and climate resilience for national highways, thus providing the outcome best suited for the country needs and requirements at par with global standards.

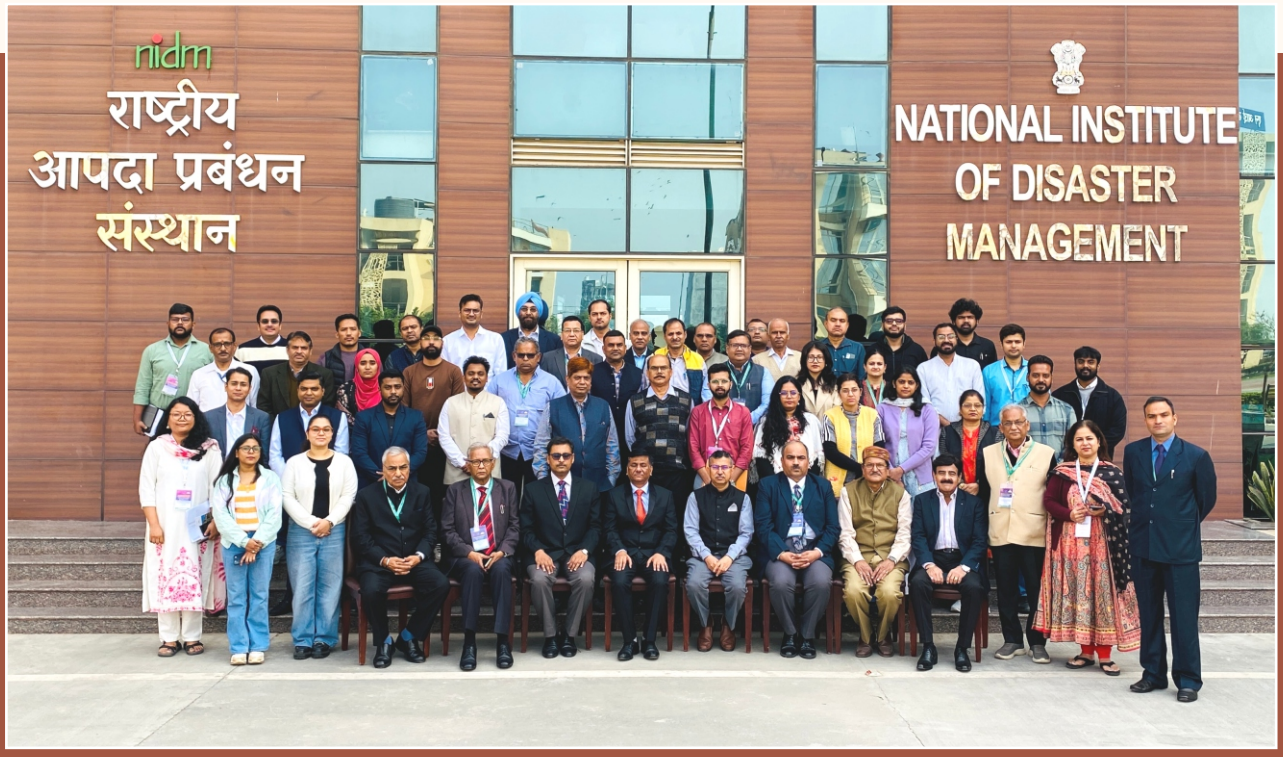

Photo 19: Group Photo of the dignitaries, distinguished experts, delegates, participants and the organizing team for the workshop.

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Profile of Distinguished Speakers

7.1 Shri Bhaskar Khulbe, IAS (Retd.), OSD to Government of Uttarakhand

Shri Bhaskar Khulbe is a 1983 batch IAS officer of the West Bengal Cadre. During his service he held several key positions and contributed to policy making. He was Joint Secretary in the Department of Administrative Reforms, Ministry of Personnel and Grievances at a time of 2nd Administrative Reforms Commission. He was also the Director in Cabinet Secretariat. He has been former advisor to Prime Minister and supervised the rescue of 41 workers from Silkyara Tunnel.

7.2 Shri Rajendra Singh, Member & HOD, NDMA

Shri Rajendra Singh prior his appointments as member NDMA, was at the reins of the Indian Coast Guard from 29 Feb. 2016 to 30 June 2019.

During his service tenure, erstwhile Director General held various important Command and Staff appointments, both afloat and ashore, with unique distinction of commanding all classes of Indian Coast Guard ships. His efforts at apprehending numerous maritime economic offenders whose activities are inimical to national interest were recognized with the award of the Tatrakshak Medal on 15 Aug 1990 and later President's Tatrakshak Medal on 15 Aug 2007.

He was, thus, instrumental in elevating the image of the Coast Guard to a multi-mission service. During his tenure as Director General, he concurrently served as Chairman of the National Maritime Search and Rescue Board, Chairman of the National Oil Spill Disaster Contingency Plan and National Competent Authority to support oil spill response in the waters of Pakistan, Bangladesh, Sri Lanka and Maldives under the South Asia Cooperation Program.

Further with regard to his expertise in disaster management, effective measures and policies were instituted during his tenure which minimized the loss of property and life in the wake of Tsunami, floods and multiple cyclones on the east and west coast of India including Ockhi, Hudhud, Vayu, Fani to name a few.

7.3 Lt Gen Syed Ata Hasnain (Retd), Member, NDMA

Through most of his 40 year illustrious career, Lt. Gen. Hasnain has served in turbulent environment and hot spots. From Sri Lanka to Siachen Glacier, from the North East to Jammu & Kashmir (J&K), and in UN operations from Mozambique to Rwanda, he has seen it all in crucial appointments. He served seven tours in J&K, decorated in almost of them and knows the J&K conflict comprehensively. He is associated with the Vivekanand International Foundation and Centre for Joint Warfare Studies, as

Distinguished Fellow and is on the Governing Council of the Indian Council of World Affairs (ICWA) and Institute of Peace & Conflict Studies (IPCS). He speaks on National Security at various military, civil services and corporate institutions with a view to enhance India's strategic culture. He has recently visited Iran and was at the forefront of neutralizing Pakistani influence operations in that country.

Lt. Gen. Hasnain has six decorations awarded by the President for India and two by the Army Chief. He superannuated from the Indian Army in Jul 2013 after 40 years of active service.

7.4 Shri Rajendra Ratnoo, IAS, Former ED, NIDM

Shri Rajendra Ratnoo is an IAS officer of 2001 Batch of Tamil Nadu Cadre. He served as Executive Director, National Institute of Disaster Management (NIDM), Ministry of Home Affairs, Govt. of India till April 2025. Before joining NIDM, he was working as Joint Secretary, Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry, Government of India, where he was looking after International Coordination with European Countries, including India's participation in World Economic Forum (Davos), National Industrial Corridor Programme, India International Convention Centre, Industrial Development Schemes for Jammu & Kashmir, Himalayan and North East states. He was also heading the 'Project Monitoring Group' in DPIIT where he supported the Cabinet Secretariat for monitoring of all the projects of the country above Rs. 500 crores. He was also holding the charge of Controller General of Patents, Designs and Trademarks (CGPDTM).

He has served the state of Tamil Nadu in various capacities in different sectors including, Tsunami Rehabilitation, Rural Development, Fisheries, Shipping, Urban Governance, Technical & Higher Education, Disaster Management, etc. He was also the District Collector in Cuddalore and Kanyakumari Districts. Shri Ratnoo brings with him a wealth of experience in managing a variety of disaster situations including Tsunami, Floods, Cyclones, Oil Spill, Risk mitigation for Chemical Disaster, Fire emergencies as well as health emergencies including swine flu, dengue and COVID-19.

He is a graduate in Economics, Psychology and Philosophy with a post graduate degree in Psychology. A gold medallist from JNU, he has completed his M.Phil. in Community Health from JNU.

7.5 Prof. Surya Parkash Gupta, Project Director/CPI, HighCAP

Professor Surya Parkash Gupta is presently Head of the Geo-Meteorological Risks Management Division and the CBRN, Industrial and Cyber DRR Division at NIDM. He is Chairman IQAC and IAIP, as well as Chief Information Security Officer of the Institute. He is also faculty in-charge of specialized centres on World Centre of Excellence on Landslides Disaster Reduction (conferred by International Consortium on Landslides, Japan under International Programme on Landslides), Early Warning and Communication, Safe Hill Area Development, Coastal DRR&R, EOC and GIS, Flood Monitoring Cell, CBRN, Industrial and Cyber DRR. He has been the Leader of IPL-172 project, IPL-233 project and IPL-275 project under International Programme on Landslide and coordinated the Indo-Japanese Action Plan on Landslides and Disaster Management as part of inter-governmental cooperation

signed by the Prime Ministers of India and Japan. He has been a nodal faculty for coordinating with the Union Ministries of Parliamentary Affairs, Labour & Employment, Petroleum & Natural Gas, Coal, New & Renewable Energy, Communication, Mines, Shipping, and North Eastern States for facilitating formulation of DM plans.

His key areas of interest are landslides, avalanches, earthquakes, floods, cyclones, tsunami, GLOFs, LLOFs, Dam Bursts, mining disasters, public health emergency, CBRN, Industrial and Cyber Risks, DRR for Media, community based disaster risk management, damage and loss assessment, disaster safe hill area development and environmental management. He is presently the Editor of the UGC CARE listed Journal on Disaster & Development. He is National Coordinator of International Association for Promoting Geoethics, Italy and BoR Member at International Consortium on Landslides.

7.6 Shri R K Dhiman AVSM, VSM, Former Additional Director General of BRO

Sh. R K Dhiman AVSM, VSM former Additional Director General of Border Roads Organisation has more than 36 years' experience of executing various infrastructure projects in hilly areas. He has been instrumental in implementation of various innovative proposals in bridges and tunnels He has developed a formula for scour around bridge piers in 'Bouldery Bed" based on data collection of existing bridges. Optimisation of cost of tunnel and time for construction with introduction of new technology is his thrust area, as a president of TAI he is very much concerned about safety during tunnel construction.

7.7 Dr. Manoj Verman, Tunneling & Rock Engineering Expert

Dr. Manoj Verman is a Tunnelling & Rock Engineering Expert. He is a specialist in tunnelling & rock caverns, rock mechanics, mining, field instrumentation and non-destructive testing. He has a career spanning 42 years. In early 1997, he moved to New Delhi to join Advanced Technology & Engineering Services (ATES) and helped strengthen its operations in providing engineering services in niche areas of civil engineering. He rose to the position of Chief Consultant and was heading ATES when he decided to move to Golder Associates, one of the most respected international consulting companies in the areas of ground engineering and environmental services. Soon, recognising his expertise, he was given additional responsibility of being the Vice-Chairman of Global Tunnelling Group at Golder Associates world wide. Later, he had a stint with Halcrow as Director (Tunnelling & Geotechnical) before moving to Geodata, a global design and consultancy company with focus on tunnelling and underground construction.

Dr. Verman has published over 75 papers in refereed journals and conference proceedings. He has served on Technical Committees of RILEM and of Bureau of Indian Standards. He has been on Executive Committee of Indian Geotechnical Society.

He is currently President of Indian National Group of ISRM and has been the Vice President of Indian Society of Engineering Geology. He is President of ISRM Commission on Hard Rock Excavation.

7.8 Dr. Gopal Dhawan CMD, (Retd.) MECL

Dr. Gopal Dhawan has been actively associated with investigation, planning, design and construction of several Hydro Power and Infrastructure projects in Indian Subcontinent in a carrier spanning over 40 years. He superannuated as CMD, MECL. Before joining MECL, Dr Dhawan served NHPC as Executive Director (Geo Tech). Presently, he is Member Panel of Experts with NTPC, Member Project Review Panel Visnugad- Pipalkoti Project of THDC and working as Senior Consulting Engineering Geologist for several companies. He is Life Member of Geological Society of India, Past-President of Indian Geological Congress and Past-President of Indian Society of Engineering Geology (ISEG). He is also member of Dam Safety Review Panel (DSRP) of Damodar Valley Corporation (DVC) for Dam and Barrages, and Member of BIS Sectional Committee, WRD 05.

7.9 Shri B D Patni, Chief Geologist (Retd.), NHPC & TEC member, NDMA

Geotechnical expert with over 38 yrs. experience in geological and geotechnical field. Experience of construction of large dams, stabilization of dam embankment and landslide hill slopes. Extensive work carried out in the field of dam foundation treatment, various types of grouting and ground improvement work. Approximately 600 km tunnelling experience in Himalaya. Successfully completed the two international assignments in Bhutan. Presented more than 25 technical papers in national, international conferences and seminars. Provided consultancy to various public sectors, govt. organisations and private owners for construction of hydro projects and mitigation of natural disaster hazards. TEC member of NDMA and senior consultant disaster management Mizoram and Sikkim.

7.10 Dr. D.S. Rawat, NIRM

Dr. D.S. Rawat did his M.Sc. in Geology in 2000 and Ph.D. in Geology in 2012 from the HNB Garhwal University (A Central University) Srinagar Garhwal. In 2002 he has done Post Graduate Diploma in Water Resources from Indian Institute of Remote Sensing. He joined National Institute of Rock Mechanics as a Scientist-I in October 2008. Prior to join NIRM he worked in various Departments of Uttarakhand Govt. He is having the working experience in engineering geological mapping/logging, collection of field data and their interpretations, rock mass characterization and support design. He has published more than 16 research papers in national, international journals and proceedings.

7.11 Prof. Amit Srivastava, Department of Civil Engineering Delhi Technological University

Prof. Amit Kumar Srivastava has a distinguished academic and professional background. He holds a B.E., M.E. and Ph.D. from IIT Delhi and currently serves as a Professor in the Department of Civil Engineering and as the Dean of the Centre for Extension & Field Outreach at Delhi Technological University, Delhi. With over 30 years of hands-on experience, his expertise includes geotechnical engineering, the strength and deformation behaviour of rocks and rock masses, pavement engineering and modern & sustainable construction practices.

His scholarly contributions include more than 50 research publications at national and international levels. Additionally, he serves as a reviewer for several international journals.

His honors include First Prize in the State Level Technical Paper Competition (1997) organized by Engineers Forum, Chiplun and an appreciation letter from UNESCO for convening an international workshop on Climate Change and Water Resources in South Asia in 2010.

Prof. Srivastava also provides consultancy services for various governmental and private organizations, including PWD Delhi, CPWD, NDMC, DMRC, MCD, DSIDC, and DDA, showcasing his significant contributions to the civil engineering domain.

7.12 Shri Karamvir Singh, Asst. Comm., NDRF

Shri Karamvir Singh Bhandari is serving 15th Battalion NDRF, Gadarpur, Udhamsingh, Uttarakhand as Assistant Commandant. He had joined ITBP in 2007 and served in various ITBP battalions in states like HP, Arunachal Pradesh, Leh and Sikkim. He was part of first successful mountaineering expedition "Bhagirathi 2" of NDRF. He was Operation commander in Silkyara tunnel rescue operation and various flood rescue operations in Uttarakhand.

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Programme Agenda

National Workshop and Brainstorming Session on Silkyara Tunnel Case Study:

Lessons Learnt from Silkyara Tunnel and other Tunnel Disasters

Organized by

National Institute of Disaster Management (NIDM)
Ministry of Home Affairs, Government of India

In collaboration with

National Disaster Management Authority &
Ministry of Road Transport & Highways

Ministry of Road Transport and Highways, GoI 28th November, 2024 (Thursday) • **Time:** 1000 – 1700 Hrs **Venue:** Dronacharya Hall, Ground Floor, NIDM, Sector-29, Rohini, New Delhi		
09:00–10.00	**Registration**	
10:00–11:00	**Inaugural Session**	
10:00–10:01	**National Anthem**	
10:01–10:10	Welcome Address	**Shri Rajendra Ratnoo,** IAS, Former ED, NIDM
10:10–10:15	Context Setting	**Prof. Surya Parkash Gupta,** Project Director/CPI, HighCAP, NIDM
10:15– 10:25	Special Address	**Sh. R K Dhiman,** ADG (Retd.), BRO & President Tunneling Association of India
10:25–10:35	Video Message	**Lt Gen (Retd.) Syed Ata Hasnain** Member, NDMA
10:35–10:40	Special Address	**Shri Rajendra Singh,** Member & Head of Department, NDMA
10:40–10:55	Inaugural Address	**Shri. Bhaskar Khulbe, IAS (Retd.),** OSD (Government of Uttarakhand)
10:55–10:57	Vote of Thanks	**Col. P. S. Reddy,** JD, NIDM
10:57–11:00	**Group Photograph**	

11:00–11:15	**High Tea**	
11:15–13:00	**Technical Session I: Panel Discussion Session**	
	Understanding Silkyara Incident & Lessons Learnt	**Chair: Shri Rajendra Ratnoo,** IAS Former Executive Director, **Co-Chair: Dr. Manoj Verman,** Tunneling & rock engineering expert, Rocscience, Representative India & South Asia
	Silkyara Tunnel Collapse: Understanding & Lessons Learnt	Presentation by **Dr. Manoj Verman** followed by panel discussion 1. Dr. Gopal Dhawan, CMD (Retd.), MECL 2. Shri B. D. Patni, Chief Geologist (Retd.), NHPC & TEC Member NDMA 3. Prof. Amit Shrivastav, Dept. of Civil Engineering, DTU 4. Shri Karamvir Singh Bhandhari, 15 Btn., NDRF
	Question Answers & Discussions	
13:00–14:00	**Lunch Break**	
14:05–15:35	**Roundtable Session**	
	Development of Policy and Guidelines Framework on Climate & Disaster Resilient Tunnels	**Chair: Prof. Surya Parkash Gupta,** Project Director/ CPI, HighCAP
	Sub-Groups: i) Risk Assessment ii) Reducing Risk iii) Monitoring & EWS iv) Preparedness & Response v) Recovery, Redevelopment & Resilience	**Lead Discussant:** i) **Dr. Gopal Dhawan,** CMD (Retd.), MECL ii) **Shri D. S. Rawat,** NIRM iii) **Prof. Amit Shrivastav**, Dept. of Civil Engineering, DTU iv) **Dr. Manoj Verman,** Tunneling & rock engineering expert v) **Shri B.D. Patni,** Chief Geologist (Retd.), NHPC & TEC Member NDMA
	Question Answers & Discussions	
15:35–16:00	**Tea Break**	
16:00–16:40	**Valedictory Session**	
16:00–16:05	Summary of the Workshop	**Ms. Bindu Aggarwal**, NIDM
16:05–16:10	Feedback from participants	Participants
16:10–16:20	Special Address	**Shri Rajendra Ratnoo**, IAS, Former ED, NIDM
16:20–16:30	Way Forward & Vote of Thanks	**Prof. Surya Parkash Gupta,** Project Director/CPI, HighCAP Project, NIDM

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Glimpses of the workshop

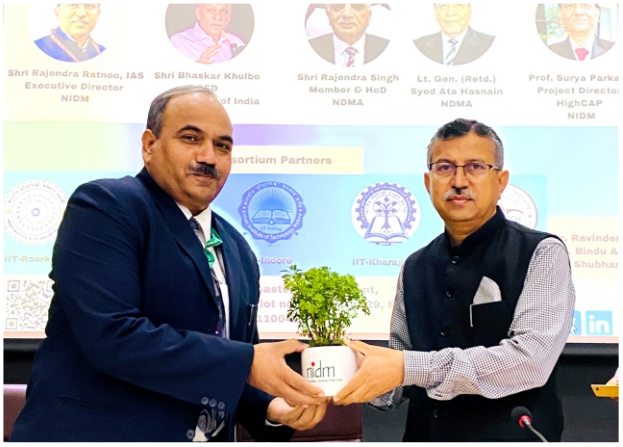

Photo 20: Shri Rajendra Ratnoo, IAS, ED, NIDM felicitated Shri RK Dhiman, ADG (Retd.), BRO & President Tunneling Association of India during inaugural session

Photo 21: Shri Rajendra Ratnoo, IAS, ED, NIDM felicitated Dr. Manoj Verman, Tunneling & rock engineering expert, Rocscience, Representative India & South Asia during inaugural session

Photo 22: Prof. Surya Parkash Gupta, Project Director/CPI, HighCAP, NIDM felicitated Shri Rajendra Ratnoo, IAS, Former ED, NIDM during inaugural session

Photo 23: Welcome address by Shri Rajendra Ratnoo, IAS, Former ED, NIDM during inaugural session

Photo 24: Participants attending the workshop

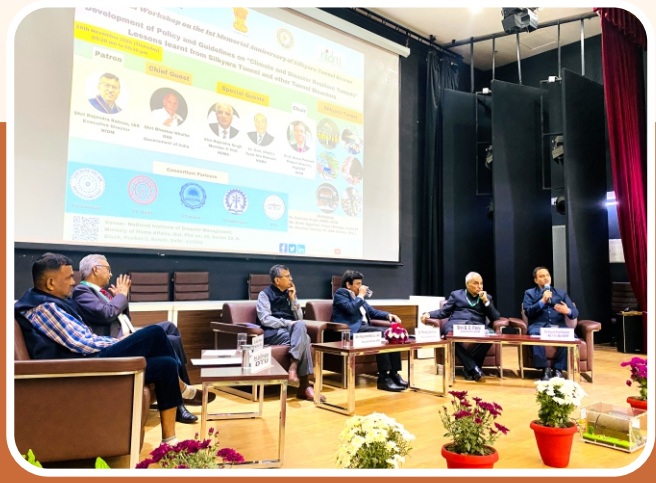

Photo 25: Deliberation during panel discussion on understanding Silkyara incident and lessons learnt

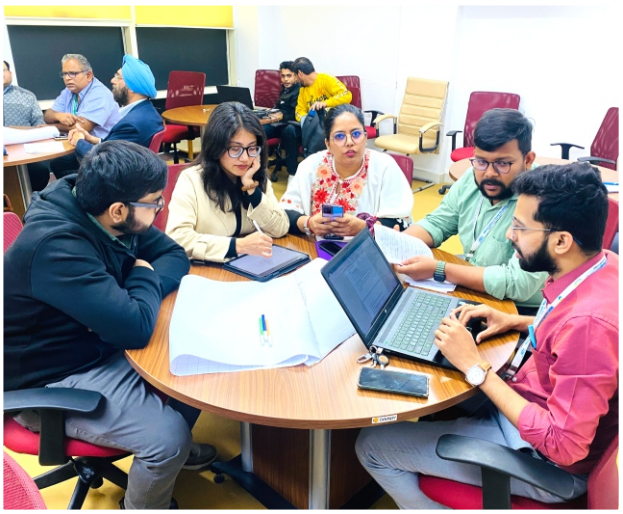

Photo 26: Discussion on the development of policy and guidelines framework on climate & disaster resilient Tunnels during roundtable session

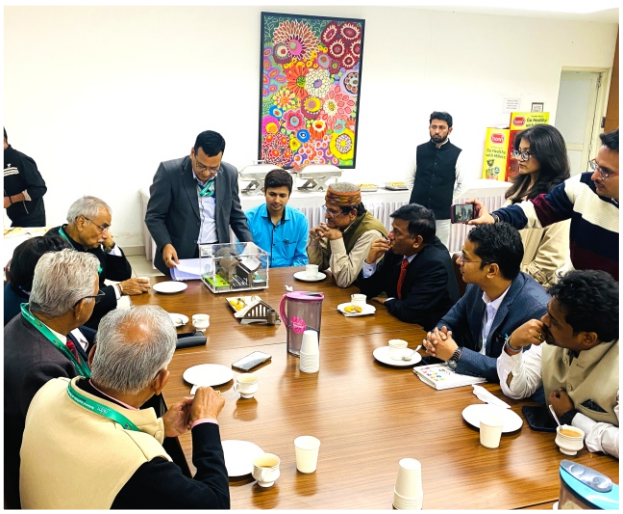

Photo 27: Tunnel expert presenting his model during tea break discussion

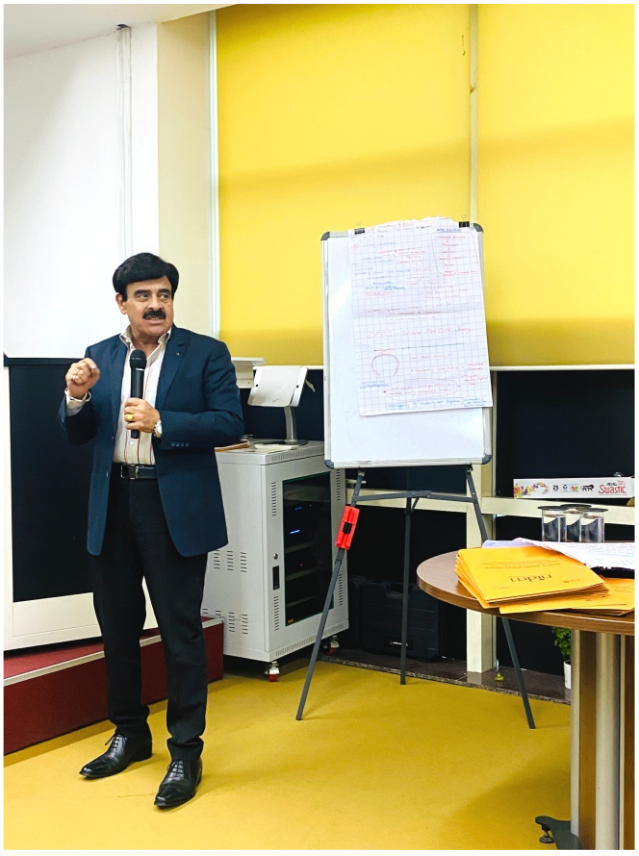

Photo 28: Dr. Manoj Verman, Tunnelling & rock engineering expert presented group exercise on tunnel preparedness & response

Photo 29: Shri B. D. Patni, NHPC discussed sub-group outcomes on the recovery, redevelopment & disaster resilient tunnels

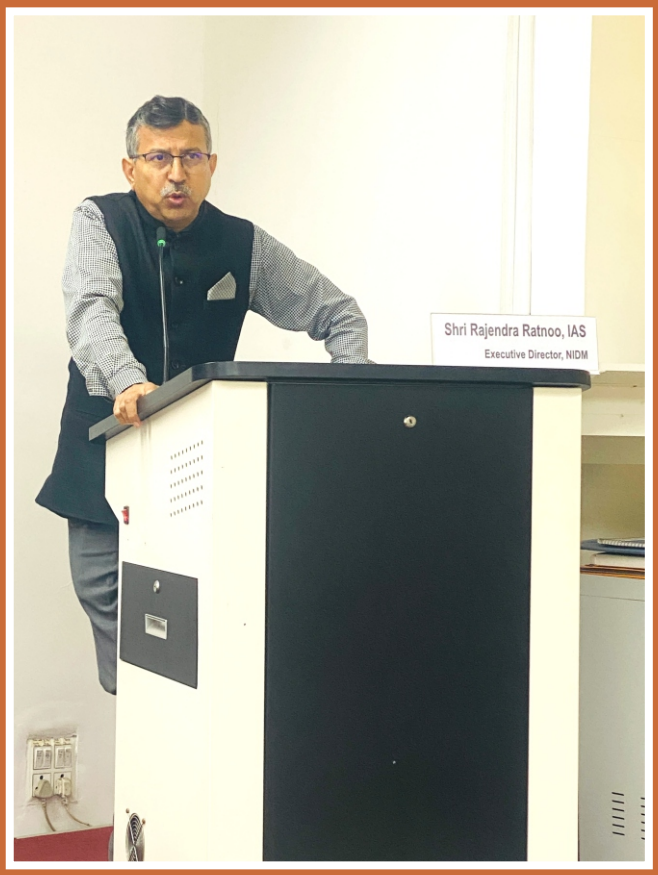

Photo 30: Shri Rajendra Ratnoo, IAS, ED, NIDM give a special address during valedictory session

Photo 31: Shri Rajendra Ratnoo, IAS, ED, NIDM gave a memento to Mr. Karamvir Singh, Asst. Comm. NDRF

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सड़क परिवहन एवं राजमार्ग मंत्रालय
MINISTRY OF ROAD TRANSPORT AND HIGHWAYS
सत्यमेव जयते
nidm
Resilient India : Disaster Free India
National Workshop on the 1st Memorial Anniversary of Silkyara Tunnel Rescue
Development of Policy and Guidelines on "Climate and Disaster Resilient Tunnels"
Lessons learnt from Silkyara Tunnel and other Tunnel Disasters
28th November 2024 (Thursday)
09:30 am to 05:30 pm
Patron
Chief Guest
Special Guests
Chair
Shri Rajendra Ratnoo, IAS
Executive Director
NIDM
Shri Bhaskar Khulbe
OSD
Government of India
Shri Rajendra Singh
Member & HoD
NDMA
Lt. Gen. (Retd.)
Syed Ata Hasnain
NDMA
Prof. Surya Parkash
Project Director,
HighCAP
NIDM
Silkyara Tunnel
THE TUNNEL MIRACLE
Consortium Partners
IIT-Roorkee
IIT- Delhi
IIT-Indore
IIT-Kharagpur
DTU
Moderators
Dr. Ravinder Singh, GMRD, NIDM
Ms. Bindu Aggarwal, Project Manager, HighCAP
Mr. Shubham Badola, YP, GMR Division, NIDM
Venue:- National Institute of Disaster Management,
Ministry of Home Affairs, GoI, Plot no. 15, Sector 29, B-
Block, Pocket-3, Rohini, Delhi -110042
/nidmmhaindia
/nidmindia

List of Participants

S No.	Name	Designation	Organisation/Institute
1.	Mr. Karamvir Singh	Assistant Commandant	NDRF
2.	Mr.Arighna Mitra	Analyst (Advocacy)	CDRI
3.	Mr. Empati Uday Kumar	Analyst (Technical Studies)	CDRI
4.	Dr. Manoj Verman	Tunnel Expert	National Highways and Infrastructure Development Corporation Limited
5.	Mr. Kunal Bhutani	Assistant Manager	IL&FS Gurgaon
6.	Mr. Manish Lamba,	Engineer	IL&FS Gurgaon
7.	Mr. R K Dhiman	ADG (Retd.), BRO	
8.	Mr. K. Jayavel	Managing Director	Dharani Geotech Engineers India Pvt
9.	Mr. P. K. Gupta	Advisor (Geo)	Feedback Infra.
10.	Dr. Rajshree Dasgupta	Assistant Professor	IIT-Delhi
11.	Dr. Gopal Dhawan	Former CMD MECC, Former ED	NHPC
12.	Ms. Shweta Dua	Technical Adviser	GIZ
13.	Mr. Arpan Mazumdar	Technical Advisor	GIZ
14.	Ms. Tora Saika	Technical Advisor	GIZ
15.	Mr. Sultan Singh Meena	Scientist-III	NIRM, Bengalore
16.	Dr. D. S. Rawat	Scientist-III	NIRM, Bengalore
17.	Mr. Jagmohan	Assistant Engineer	MCD North
18.	Mr. Priyank Jindal	Sr. Consultant	NDMA
19.	Mr. Ankit Verma	Deputy Manager	Spar Geo Infra Pvt. Ltd.
20.	Mr. Nitin Goyal	Director (Business Development)	Spar Geo Infra Pvt. Ltd.
21.	Dr. S. K. Jha	Delhi University	
22.	Mr. B.D. Patni	Geo Techno. Consultant	
23.	Dr. Akansha Tyagi	Assistant Professor	IIT Roorkee
24.	Prof. P. K. Goyal	Professor	DTU

S No.	Name	Designation	Organisation/Institute
25.	Mr. Sourabh Gokhale	JEEMS/ MCD	
26.	H. Kumar	GM/RNNL	
27.	Mr. Mohammad Hardur Ali	Research Scholar	Jamia Millia Islamia
28.	Ms. Sidra	Research Scholar	Jamia Millia Islamia
29.	Mr. Bhaskar Khulbe, OSD (Govt. of Uttrakhand)	(Online)	Govt. of Uttarakhand
30.	DDMO SWKA, Meghalaya	(Online)	
31.	Shri Kuldeep Razdan	(Online)	
32.	Mr. Mahendra		(Online)
33.	Mr. Pratik	(Online)	
34.	Ms. Nazia Khan	IPRO	NIDM
35.	Dr. Preeti Soni	SPC-IUINDRR	NIDM
36.	Dr. Ajinder Walia	Assoc. Professor	NIDM
37.	Dr Pankaj Kumar	Assistant Professor	NIDM
38.	Mr. S. N. Sidh	Assistant Professor	NIDM
39.	Dr. Arkaprabha Sarkar	Assistant Professor	NIDM
40.	Dr. Prerna Joshi	Assistant Professor	NIDM
41.	Dr. Gagandeep Singh	Assistant Professor	NIDM
42.	Mr. S.K. Tiwari	Librarian	NIDM
43.	Mr. Amandeep Singh	Consultant E-learning	NIDM
44.	Ms. Priyanka Sharma	Jr. Consultant (SMO)	NIDM
45.	Ms. Santosh Mishra	Training Assistant	NIDM
46.	Ms. Megha Kohli	Training Assistant	NIDM
47.	Ms. Vidhi Awasthi	Stenographer	NIDM
48.	Ms. Amrita Gupta	Personal Assistant to ED	NIDM
49.	Ms. Ritu	Jr. Consultant	NIDM
50.	Mr. Arshad Azmi	Young Professional	NIDM
51.	Mr. Arun Verma	Young Professional	NIDM
52.	Ms. Gulshan Hira	Young Professional	NIDM
53.	Ms. Stanzin Tsela	Young Professional	NIDM
54.	Ms. Atisha Sood	Consultant (PH)	NIDM
55.	Mr. Rajiv Kumar	Training Assistant	NIDM

S No.	Name	Designation	Organisation/Institute
56.	Mr. Udayanatha Mishra	Consultant	NIDM
57.	Ms. Karishma, YP, NIDM	Young Professional	NIDM
58.	Ms. Sakshi Goswami	PA GMRD	NIDM
59.	Mr.Vimal Tiwari	Young Professional	NIDM
60.	Mr. Sandeep Kumar	DEO	NIDM
61.	Mr.Vishesh Kanojia	Project Associate	NIDM
62.	Mr. Ajay Negi	Jr. Consultant, IT	NIDM
63.	Mr. Jatin Kumar	IT Engineer	NIDM
64.	Mr Santosh Kumar	IT Engineer	NIDM
65.	Mr. Abhinav Walia	Sr. Consultant	NDMA
66.	Dr. Aditya K. Anand	Project Scientist-II	NIDM
67.	Ms. Yogita Garbyal	Project Scientist-II	NIDM
68.	Mr. Gautam Pathare	Sr. Project Associate	NIDM
69.	Mr. Numan	Jr. Consultant	NIDM
70.	Dr. Ravinder	Sr. Consultant	NIDM
71.	Mr. G. S. Gurjar	JC Campus Mgt	NIDM
72.	Mr. Shubham Bodola	Young Professional	NIDM
73.	Mr. Ishwar Singh	JC Admin	NIDM
74.	Mr. A.K. Pandey	PS	NIDM
75.	Mr. C. S. Anand	Consultant (Accounts)	NIDM
76.	Ms. Kratika Pandey	Young Professional	NIDM
77.	Ms. Srishti Sinha	Project Assistant	NIDM
78.	Dr. Ganesh	Consultant	NIDM
79.	Ms. Koyal Sindhu	JC- IUINDRR	NIDM
80.	Ms. Annyesha Purkrait	Young Professional	NIDM
81.	Mr. B. B. Sharma	Consultant Maintenance	NIDM

*****

Workshop Programme Team

Patron

Shri Rajendra Ratnoo, Former Executive Director, NIDM

Programme Chair

Prof. Surya Parkash Gupta, Project Director/CPI, HighCAP & Head GMR Division

Programme Coordinators/Moderators

Ms. Bindu Aggarwal, Project Manager, HighCAP

Dr. Ravinder Singh, Sr. Consultant, NIDM

Supporting Team

Ms. Yogita Garbyal, Project Scientist-II, HighCAP, NIDM

Dr. Aditya Kumar Anand, Project Scientist-II, HighCAP, NIDM

Mr. Gautam Pathare, Sr. Project Associate, HighCAP, NIDM

Mr. Shubham Badola, YP, NIDM

Mr. Vishesh Kanojia, Project Associate, HighCAP, NIDM

*****

Development of National Highways Climate Adaptation Policy and Guidelines Project

Road transport, especially highways, plays a pivotal role in the development of a country. The development of highways fosters movement of passenger and freight across the country leading to increased national productivity and socio-economic growth. India has long realized the importance of highways and has been giving the necessary impetus for its development.

Interruptions, disruptions and disasters on National Highway services have significant implications in terms of severe impacts on life, economy, environment and infrastructure. Additionally, the sector is also required to build resilience to climate change impacts in order to reduce risks and protect the highway infrastructure from sea-level rise, extreme weather events, rising temperature, and other such events.

Taking into account the changing climate and the associated disasters as well as extreme events, there is need for a comprehensive policy and guidelines that foresees the long-term challenges of the increasing intensity of climate risks and provides a direction for building resilience of existing and new highways in the country.

On request of Ministry of Road Transport and Highways (MoRTH), National Institute of Disaster Management (NIDM) has taken up the present Project "Development of National Highways Climate Adaptation Policy and Guidelines". The current study is aligned to support the Ministry of Road Transport and Highways, Government of India on enhancing the climate resilience of National Highways (NHs) in India. Project encompasses determination of 2000 km of National Highway segments corresponding to four climate zones: extremely hot/cold temperatures, locations susceptible to flooding, coastal areas and hilly regions that frequently witness landslides, floods and earthquakes. Project involves climate impact projections, multihazard risk modelling and identification of suitable adaptation strategies for drafting climate adaptation policy.

The objectives of project are:

(i) To study the potential vulnerability and risks of highways to climate related disaster and extreme events.

(ii) To identify suitable & cost-effective adaptation options, and delineate resilience framework.

(iii) To study existing codes, manuals and practices and recommend adaptation strategy integration.

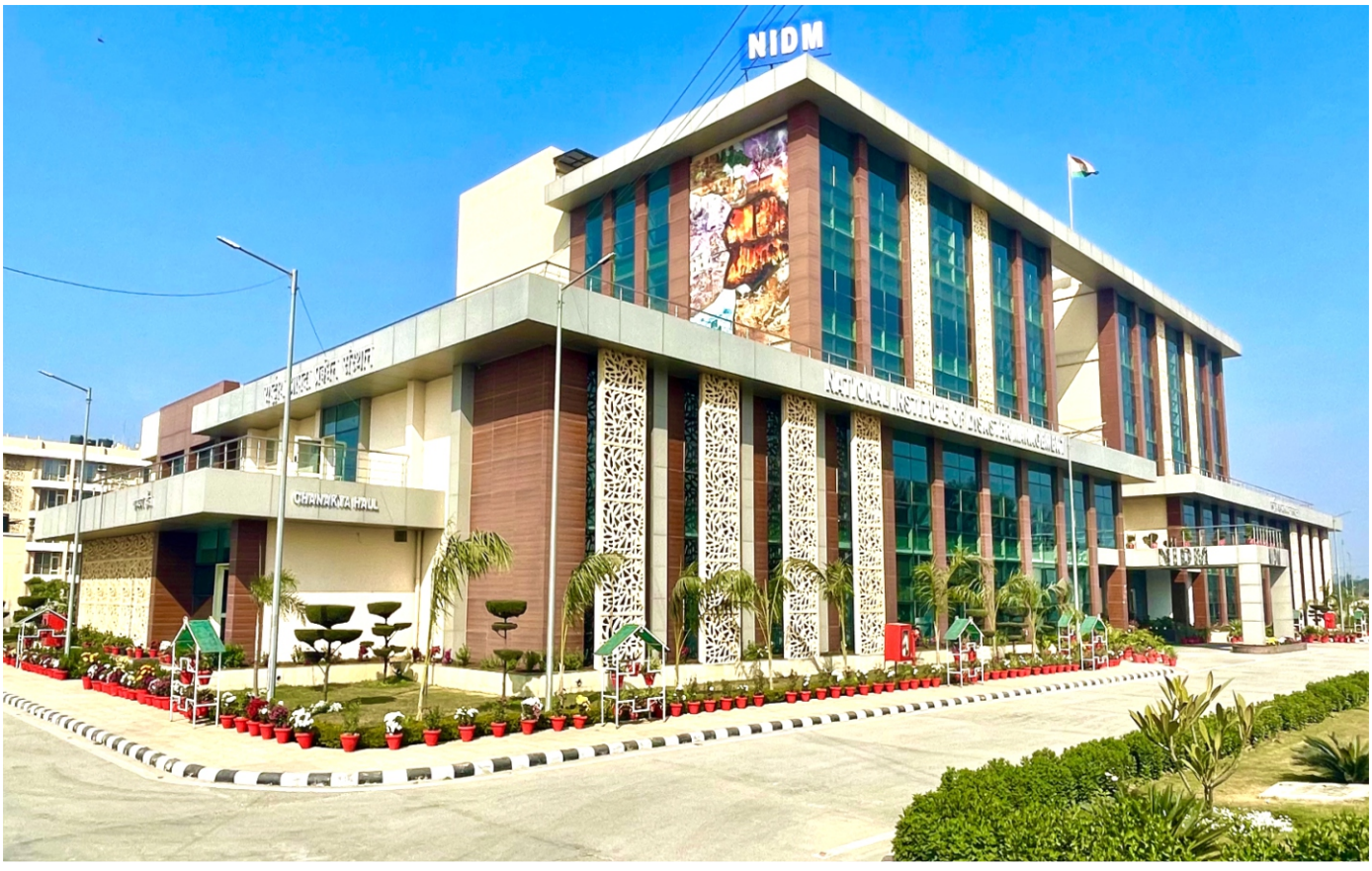
(iv) To develop climate adaptation policy and guidelines including DRR for national highways in India.

(v) To develop Transport Emergency Management Plan (TEMP) and Traffic Evacuation Plan (TEP)

(vi) To prepare capacity toolkit and execute pilot training programme on adaptation policy & guidelines.

About NIDM

The National Institute of Disaster Management (NIDM) was constituted under an Act of Parliament with a vision to play the role of a premier institute for capacity development in India and the region. The efforts in this direction that began with the formation of the National Centre for Disaster Management (NCDM) in 1995 gained impetus with its re-designation as the National Institute of Disaster Management (NIDM) for training and capacity development. Under the Disaster Management Act 2005, NIDM has been assigned nodal responsibilities for human resource development, capacity building, training, research, documentation and policy advocacy in the field of disaster management. Both as a national Centre and then as the national Institute, NIDM has performed a crucial role in bringing disaster risk reduction to the forefront of the national agenda. The Institute believes that disaster risk reduction is possible only through promotion of a "Culture of Prevention" involving all stakeholders. The Institute works through strategic partnerships with various ministries and departments of the central, state and local governments, academic, research and technical organizations in India and abroad and other bi-lateral and multi-lateral international agencies.



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