

5-Days IAHE's Calendar Training Program on "Disaster Management for Highways"

Background: India's highway network is a vital pillar of the country's economic growth, regional connectivity, and emergency response system. However, highway infrastructure is increasingly exposed to disaster risks due to landslides, floods, earthquakes, cloudbursts, cyclones, forest fires, and other natural hazards, further aggravated by the growing impacts of climate change. In this context, integrating Disaster Risk Reduction (DRR) into the planning, design, construction, operation, and maintenance of highways has become essential to ensure the safety of highway infrastructure, uninterrupted traffic movement, and rapid restoration of connectivity.

Keeping these requirements in view, a five-day training programme on "**Disaster Risk Management for Highways**" has been developed for officials and engineers associated with the highway sector. The programme aims to equip participants with the knowledge and skills required for disaster risk identification and assessment, risk reduction, pre-disaster preparedness, emergency response, rapid damage assessment, and post-disaster resilient reconstruction based on the "**Build Back Better (BBB)**" approach, thereby enabling them to contribute effectively towards the development of safer, more resilient, and disaster-resilient highway infrastructure.

Aim of the Training Programme: To build the capacity of officials and engineers associated with the highway sector in disaster risk management by equipping them with the knowledge and practical skills required to integrate disaster resilience into the planning, design, construction, operation, maintenance, and post-disaster recovery of highway infrastructure.

Objective: To equip the officials of the Ministry of Road Transport and Highways with the knowledge, skills, and competencies to identify, assess, and mitigate disaster risk; design effective disaster management plans and strategies; and mainstream disaster risk reduction in the policies and plans across the sectors of the Ministry aligned with national and global frameworks.

Language of Instruction: The programme will be conducted in English and Hindi to facilitate effective learning and better interaction among the participants.

Training Approach: The training programme will adopt a participatory and practice-oriented approach, combining expert lectures, interactive discussions, case studies, group exercises, GIS-based demonstrations, simulation exercises, and mock drills. Emphasis will be placed on practical learning through real-life case studies, experience sharing, and scenario-based exercises to strengthen participants' understanding of disaster risk management and its application in highway planning, design, operation, maintenance, emergency response, and post-disaster recovery.

Target Audience: The programme is intended for officials and engineers associated with the planning, design, construction, operation, maintenance, and management of highway infrastructure, including:

- Officials of the Ministry of Road Transport and Highways (MoRTH)
- Officials of the National Highways Authority of India (NHAI)
- Officials of the National Highways & Infrastructure Development Corporation Limited (NHIDCL)
- Officials of the Border Roads Organisation (BRO)
- Officials of State Public Works Departments (PWDs) and Road Development Agencies
- Highway consultants, project managers, and professionals involved in highway infrastructure development and maintenance
- Officials associated with disaster management, emergency response, and road safety in the highway sector

Course Content

Module 1: Pre-Disaster Preparedness and Risk Reduction

The "Pre-Disaster" phase is the most critical for engineers. This is the phase where the battle against disaster is planned using drawing boards and maintenance planning. This module covers the following:

1.1 Advanced Hazard Vulnerability and Risk Analysis (HVRA)

Beyond the qualitative risk perception, the emphasis should be on quantitative risk assessment as it provides a better understanding of the ground reality and helps to make informed decisions. Highway corridors are unique because they are linear and traverse multiple hazard boundaries. This section focuses on:

- **Basic concepts:** of Hazard, Vulnerability, Capacity, Exposure, Risk, Disaster Management & Risk Reduction.
- **Corridor-Level Risk Mapping:** Utilizing Geographic Information Systems (GIS) to integrate diverse datasets. Exercises on overlaying highway alignment shapefiles in GIS.
- **Seismic Micro-zonation Maps:** Identifying and mapping segments crossing active faults.
- **Flood Hazard Zonation (FHZ):** Mapping low-lying areas and historical floodplains.
- **Landslide Susceptibility Maps (LSM):** Using Geological Survey of India (GSI) data or any other available data to identify high-risk slopes.
- **Vulnerability Assessment:** Evaluating the physical vulnerability of assets (bridges, culverts, and embankments) based on age, material, and design standards.

1.2 Resilient Design

A cornerstone of the pre-disaster module must be the detailed study of the five guidelines developed under the "**Capacity Development Project on Highways in Mountainous Regions**" by MoRTH and JICA. These guidelines represent the cutting edge of resilient infrastructure planning in India. The following key guidelines have to be covered:

- (i) **Planning of Hilly Roads:** This guideline revolutionizes route selection. Instead of forcing an alignment through a hazard zone and relying on heavy engineering to hold it, the training must emphasize "avoidance" strategies based on geological surveys.
- (ii) **Slope Protection and Embankment with Advanced Technology:** Moving away from simple gravity retaining walls to advanced solutions like ground anchors, soil nailing, and reinforced earth walls. The training must explain the mechanics of slope failure (rotational vs. translational) and the appropriate selection of countermeasures.
- (iii) **Tunnel in Hilly Area:** Training on the design of tunnel portals to withstand landslides and avalanches, and the waterproofing of tunnels to prevent seepage-induced destabilization.
- (iv) **Mountain Bridge with Advanced Technology:** Designing high-pier bridges and long-span structures to cross deep valleys, thereby avoiding unstable slopes entirely.

1.3 Nature-based Solutions (NbS) and Bio-Engineering

NbS and bio-engineering enhance highway and road network resilience by using vegetation, soil stabilization, and natural drainage to reduce erosion, flooding, and landslides. They provide cost-effective, sustainable infrastructure protection while improving biodiversity, carbon sequestration, and overall environmental performance. The following are the technical applications:

- **Root Reinforcement:** Using specific species like **Vetiver grass** (*Chrysopogon zizanioides*), which have deep, high-tensile strength roots that act like living soil nails, stabilizing slopes up to 3-4 meters deep.
- **Hydrological Control:** Using vegetation to increase evapotranspiration and reduce pore water pressure in slopes, which is a primary trigger for landslides.
- **Hybrid Techniques:** Combining "grey" infrastructure (concrete crib walls, gabions) with "green" infrastructure (brush layering, hydroseeding) to extend the life of the asset and reduce maintenance costs.
- **Case Studies:** Reviewing the successful implementation of bio-engineering in the North East Region and Himachal Pradesh to demonstrate efficacy and cost-effectiveness.

1.4 Early Warning Systems (EWS) Integration

Highways must be integrated into the EWS Network.

Operational Integration:

- **Sensor Networks:** Deployment of rain gauges, slope inclinometers, and wire-line extensometers on critical slopes.
- **Threshold-Based Action:** Establishing protocols where traffic is automatically halted or diverted when rainfall intensity exceeds a specific threshold.
- **Information Dissemination:** Utilizing Variable Message Signs (VMS), highway radio, and mobile apps to warn users of impending hazards (floods, fog, landslides) before they enter the danger zone.
- **Integration:** of highways, roads, and related infrastructure to the CAP-based SACHET system.

Module 2: During-Disaster Response and Operations

The "During Disaster" phase is characterized by panic, chaos, pressure, and devastation all around. This module covers the following:

2.1 Incident Response System (IRS)

The Government of India has adopted the Incident Response System (IRS) as the standard operating framework for disaster response. Highway engineers must understand their specific roles within this hierarchy. IRS Roles for Highway Engineers:

- **Operations Section Chief:** The engineer on-site, responsible for deploying machinery (dozers, excavators) to clear debris.
- **Planning Section:** Responsible for assessing the stability of the remaining infrastructure and planning alternate routes.
- **Logistics Section:** Ensuring fuel, spares, and food for the clearance crews who may be working in isolated conditions for days.
- **Unified Command:** How to interface with the District Magistrate, Police, and NDRF. Who has the final say on reopening a bridge? The training must clarify jurisdictional lines to prevent conflict during emergencies.

2.2 Tunnel Safety and Hazmat Emergencies

Tunnels represent high-risk zones where minor incidents can escalate into catastrophes. The MoRTH circulars mandate strict SOPs. The main SOPs are listed below:

- **Fire Safety:** Ventilation protocols to control smoke (the biggest killer), usage of cross-passages for evacuation, and the role of the Tunnel Control Center (TCC).
- **Hazmat Transport:** Regulation of vehicles carrying dangerous goods (explosives, petroleum). Training on time-window restrictions (e.g., night movement only) and mandatory "manifests" shared with the TCC at least 48 hours in advance.
- **Chemical Spills:** Specific cleanup protocols. For example, knowing that water should not be used on certain chemical fires, and having access to neutralization agents (sand, foam).

2.3 Traffic Management and Evacuation Corridors

In a disaster, the highway becomes the primary evacuation route.

- **Contra-flow Operations:** Techniques for converting a dual carriageway into a one-way outbound evacuation route ("Reversing lanes").
- **Green Corridors:** Establishing dedicated lanes for emergency vehicles (ambulances, NDRF convoys) to move into the disaster zone while civilians move out.
- **Diversion Planning:** Using network theory to identify redundant paths. If a bridge fails, what is the capacity of the detour road? Can it handle heavy relief trucks? These calculations must be done in the pre-disaster phase.

Module 3: Post-Disaster Recovery and "Build Back Better"

This is often the most neglected phase in traditional training, which typically tends to stop at road clearance. The following segments will address the aftermath of disaster operations aimed at bringing normalcy and strengthening the infrastructure better than pre-disaster conditions. This module covers the following:

3.1 Rapid Damage Assessment (RDA)

Immediate decision-making requires accurate data. Therefore,

- **Technology-Aided RDA:** The use of **Drones (UAVs)** for photogrammetry of landslides and bridge inspections in inaccessible areas. This allows for safe, remote assessment of crown cracks in slopes or scour in riverbeds.
- **Standardized Coding:** Adopting a "Red/Yellow/Green" tagging system for structures.
 - **Green:** Safe for all traffic.
 - **Yellow:** Restricted use (light vehicles only, speed limits).
 - **Red:** Closed/Unsafe.
- **Mobile GIS:** Using apps to geotag damage, upload photos, and sync with a central command dashboard in real-time.

3.2 The "Build Back Better" (BBB) Framework

Reconstruction is an opportunity to correct the flaws that led to the disaster.

- **Forensic Engineering:** Before rebuilding, engineers must conduct a "Root Cause Analysis". Did the culvert fail because of blockage (maintenance issue) or insufficient capacity (design issue)? If it were designed, rebuilding it to the same specification ensures it will fail again.
- **Resilient Upgrades:**
 - **Upsizing Hydraulic Capacity:** Replacing pipe culverts with box culverts or bridges to handle increased flash flood volumes (Cloudburst resilience).
 - **Flexible Structures:** In seismic zones, replacing rigid masonry walls with flexible gabion or reinforced earth walls that can deform without collapse.
 - **Betterment Policies:** Understanding the administrative and financial rules that allow for "betterment" (upgrades) during reconstruction, rather than just "replacement in kind".

3.3 Post-Disaster Needs Assessment (PDNA) and Financing

Engineers need to speak the language of finance to secure reconstruction funds.

- **PDNA Methodology:** Introduction to the internationally accepted PDNA framework (supported by NIDM) to quantify "Damages" (physical asset destruction) and "Losses" (economic impact of road closure).
- **Funding Sources:** Understanding the eligibility criteria for the **National Disaster Response Fund (NDRF)** and **State Disaster Response Fund (SDRF)**. How to structure proposals for World Bank/ADB resilience funding.

Detailed Schedule

Time Period	Description of Topic
Day 1: Strategic Framework & Pre-Disaster Risk Assessment	
<i>Focus: Understanding the threat and mapping the risk.</i>	
09:45 - 10:15	➤ Introduction & Preparedness ➤ Shift from Relief to Resilience: Sendai Framework & PM's 10 Point Agenda. ➤ Mission Karmayogi: The "Resilient Engineer" Competency Framework.
10:15 - 13:00	➤ Overview of Disaster Management concepts ➤ Types of disasters affecting highways (Landslides, Earthquakes, Floods, Cloudbursts, Fires) ➤ Climate Change Impacts: Extreme precipitation (Cloudbursts), GLOFs, and Heat Stress on pavements. ➤ Case studies of past highway disaster events ➤ Insight: Why historical data is no longer a reliable predictor for design. ➤ Highway vulnerability and risk assessment (HVRA) ○ Technique: Corridor Risk Mapping using GIS. ○ Overlaying Highway Alignments with Seismic, Flood, and Landslide Hazard Maps. ○ Exercise: Identifying "Critical Assets" on a sample highway map. ○ Identification of high-risk highway sections
13:00 - 14:00	Lunch Break
14:00 - 17:15	➤ Geotechnical Investigations & Planning: ○ JICA Guideline 1: Planning of Hilly Roads (Avoidance Strategy). ○ Site Investigation: Geophysical surveys, identifying paleo-landslides. ○ Exercise: Reviewing a DPR for geotechnical adequacy. ➤ Early Warning Systems (EWS): ○ Integrating Weather Data (IMD) with Highway Operations. ○ Instrumentation: Slope Inclinometers, Rain Gauges, River Level Sensors. ○ Protocol: Automated road closure thresholds. ➤ Disaster preparedness planning for highways ➤ Mitigation measures to reduce disaster impact

	➤ Roles and responsibilities of highway personnel ➤ Safety procedures during emergency situations ➤ Use and importance of Personal Protective Equipment (PPE)
Day 2: Resilient Design & Engineering Mitigation	
<i>Focus: The "Hard Skills" of engineering resilience.</i>	
09:45 - 13:00	➤ Causes of landslides in hilly and mountainous highways ➤ Identification of landslide-prone zones ➤ Early warning signs of slope failure ➤ Immediate response actions during landslides ➤ Traffic regulation, diversion planning and public safety ➤ Safe debris clearance practices ➤ Slope Stabilization & Protection: ○ JICA Guideline 2: Slope Protection with Advanced Technology. ○ Solutions: Soil Nailing, Ground Anchors, Rockfall Barriers, Reinforced Earth. ○ Comparative Analysis: Rigid vs. Flexible Retaining Structures. ➤ Nature-based Solutions (NbS): ○ Bio-engineering: Vetiver System, Hydroseeding, Coir Geotextiles. ○ Eco-DRR: Managing drainage using natural swales. ○ Case Study: Successful bio-engineering practices
14:00 - 17:15	➤ Tunnel Resilience & Safety: ○ JICA Guideline 3: Tunnel Design in Hilly Areas. ○ Seismic considerations for tunnels. ○ Portal protection against landslides/avalanches. ➤ Hydraulic Design for Resilience: ○ Designing for Cloudbursts: Revising Return Periods. ○ Bridge Scour Protection. ○ Case Study: Failure analysis of bridges during floods (Cause vs. Effect).
Day 3: During-Disaster Response Operations	
<i>Focus: Command, Control, and Coordination.</i>	
09:45 - 13:00	➤ Incident Response System (IRS): ○ IRS Structure: Incident Commander, Operations, Planning, Logistics. ○ Highway Engineer's Role in the Unified Command.

	○ Tabletop Exercise: Assigning roles for a hypothetical major landslide scenario. ➤ Tunnel Emergencies & Hazmat: ○ SOPs: Fire Safety, Ventilation, Evacuation Galleries. ○ Hazmat Management: Manifests, Time Windows, Chemical Spill Response. ○ Simulated Video Analysis: Reviewing tunnel fire incidents and response errors. ○ Rescue and evacuation techniques ➤ Traffic Management & Logistics: ○ Diversion Planning: Establishing redundant routes. ○ Green Corridors for Relief Supplies. ○ Communication: VMS, Social Media role, etc.
14:00 - 17:15	➤ Fire Safety & Forest Fires: ○ Types of fires on highways (Vehicle fires, tanker fires, forest fires, tunnel fires) ○ Causes and risk assessment of highway fires ○ Fire prevention and safety measures ○ Crowd control and safe evacuation distances ○ Highway Fire Risk: Vehicle fires, Tankers. ○ Coordination with Fire Services. ○ Use of Fire Extinguishers and Hydrants ➤ Cloudburst ○ Concept and characteristics of cloudburst events ○ Impact of sudden flash floods on highways ○ Emergency response during cloudburst situations ○ Communication systems and information dissemination ○ Traffic diversion and temporary route management ○ Relief measures and rapid restoration of highways ➤ Earthquakes ○ Basics of earthquakes and seismic zoning ○ Impact of earthquakes on roads, bridges and tunnels ○ Do's and Don'ts during earthquake events ○ Emergency evacuation procedures ○ Post-earthquake inspection of highway structures ○ Temporary restoration and reopening of traffic
Day 4: Post-Disaster Recovery & Build Back Better	
<i>Focus: Assessment, Reconstruction, and Betterment.</i>	
09:45 - 13:00	➤ Rapid Damage Assessment (RDA): ○ Tools: Drones (UAVs), Mobile Apps for Geotagging.

	○ Assessment Protocol: Red/Yellow/Green Tagging of Bridges/Slopes. ○ Exercise: Analyzing drone footage of a disaster site to estimate damage. ➤ Build Back Better (BBB): ○ Concept: Moving beyond restoration to resilience. ○ Root Cause Analysis (Forensic Engineering). ○ "Betterment" principles in design and contracting. ○ Group Work: Developing a BBB proposal for a washed-out bridge.
14:00 - 17:15	➤ Financing & PDNA: ○ Post-Disaster Needs Assessment (PDNA): Damages vs. Losses. ○ Accessing SDRF/NDRF funds. ○ Preparing bankable proposals for resilient reconstruction. ➤ Case Studies (Global & National) & Lessons Learned
Day 5: Integrated Mock Drill/Simulation & Conclusion	
<i>Focus: Synthesis and Evaluation.</i>	
09:45-10:15	➤ Briefing: ○ Scenario Introduction: "Cyclone Impact on Coastal Corridor" or "Himalayan Seismic Event." ○ Team Assignments (Command, Ops, Planning)
10:15 - 16:00	➤ Integrated Mock Drill (Simulation): ○ Planning and briefing for mock drills ○ Integrated mock drill covering multiple disaster scenarios ○ Emergency communication and coordination practice ○ Traffic management during disaster situations
16:00 - 17:00	➤ Debriefing (Hot Wash): ○ Review and analysis of mock drill performance. ○ Identifying gaps in SOPs vs. Actual Response. ○ Identification of improvement measures ○ Best practices in highway disaster management
17:00 - 17:30	➤ Feedback and concluding session
