

DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 6.43: Method of Tunnel Ventilation, Dust Control, Lighting, and Drainage

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Civil Engineering

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Introduction to Tunnel Environment I

A tunnel is a confined underground space where environmental control is critical for the safety of workers during construction and passengers during operation. Effective management of air quality, visibility, and water ingress determines the success and safety of the tunneling project.

Key Points

- Provides safe breathing environment by removing harmful gases and dust
- Maintains adequate visibility to prevent accidents
- Prevents flooding and structural damage through effective drainage
- Controls temperature and humidity levels inside the tunnel

Tunnel Ventilation During Construction I

During construction, ventilation is required to supply fresh air and remove noxious gases produced by blasting, mucking, and internal combustion engines. Natural ventilation is rarely sufficient, necessitating mechanical systems such as blowing, exhausting, or a combination of both.

Key Points

- Blowing System: Forces fresh air to the working face through ducts
- Exhausting System: Extracts foul air and dust from the face
- Combination System: Utilizes blowing for fresh air and exhausting for foul air
- Air requirements depend on the number of workers and equipment used

Mechanics of Construction Ventilation I

Blowing System



Exhausting System



Key Points

- Blowing systems provide immediate fresh air to workers at the face.
- Exhausting systems quickly remove smoke and dust after blasting.
- Ducts must be durable, flexible, and leak-proof.

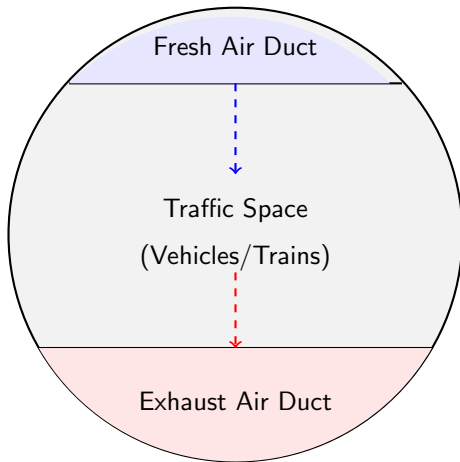
Tunnel Ventilation During Operation I

Operational ventilation ensures a safe environment for vehicular or rail traffic by diluting exhaust emissions, particularly carbon monoxide and diesel particulates. It also plays a vital role in fire life safety by controlling smoke movement during an emergency.

Key Points

- Longitudinal Ventilation: Air flows from one portal to another using jet fans
- Semi-Transverse Ventilation: Fresh air is supplied uniformly, exhaust exits via portals
- Transverse Ventilation: Both supply and exhaust are uniformly distributed along the tunnel
- Choice depends on tunnel length, traffic volume, and fire safety requirements

Transverse Ventilation System Profile I



Transverse Ventilation System Profile II

Key Points

- Fresh air is supplied from a dedicated upper or side duct.
- Exhaust air is collected in a separate duct, usually at the invert or crown.
- Provides the highest level of safety and air quality control.

Dust Control in Tunneling I

Dust generation is a major hazard in tunneling, causing respiratory diseases such as silicosis and reducing visibility. It primarily originates from drilling, blasting, mucking, and shotcreting. Strict control measures are mandatory to protect worker health.

Key Points

- Wet Drilling: Using water flushed through the drill steel to suppress dust at the source
- Water Sprays and Atomizers: Deployed during and after blasting to settle airborne particles
- Dust Collectors: Mechanical extraction systems integrated into tunnel boring machines (TBMs)
- Proper use of Personal Protective Equipment (PPE) like respirators

Comparison of Construction Ventilation Methods I

Different mechanical ventilation systems offer unique advantages and limitations depending on the tunneling phase.

Comparison of Construction Ventilation Methods II

Key Points

- | Feature | Blowing System | Exhausting System | Combination System |
- | :— | :— | :— | :— |
- | ****Air Flow**** | Fresh air to face | Foul air from face | Fresh to face, Foul away |
- | ****Setup Time**** | Fast clearance at face | Slow clearance at face | Rapid overall clearance |
- | ****Tunnel Atmosphere**** | Foul air travels through tunnel | Fresh air drawn through tunnel | Keeps both face and tunnel clean |
- | ****Best For**** | General mucking, drilling | Post-blasting clearance | Long tunnels, high-gas areas |

Tunnel Lighting Requirements I

Adequate lighting is essential to prevent accidents, guide traffic, and facilitate construction work. In operational highway tunnels, lighting must adapt to the external ambient light to prevent the 'black hole effect' at the entrance and the 'glare effect' at the exit.

Key Points

- Threshold Zone: High-intensity lighting to match bright external conditions
- Transition Zone: Gradual reduction in lighting intensity
- Interior Zone: Constant, lower-intensity lighting for regular driving
- Emergency Lighting: Uninterruptible power supply (UPS) backed systems for evacuation

Tunnel Drainage During Construction I

Groundwater ingress is a frequent challenge during tunnel excavation. Uncontrolled water can destabilize the tunnel face, flood the invert, and damage equipment. Temporary drainage systems are installed to manage this water safely.

Key Points

- Sumps and Pumps: Water is collected in low-point sumps and pumped out to the portal
- Gravity Drainage: Usable if the tunnel is excavated on an upgrade
- Wellpoints and Deep Wells: Pre-drainage of the ground ahead of the excavation face
- Grouting and Freezing: Ground treatment methods to seal off water inflows

Permanent Tunnel Drainage I

Once the tunnel is completed, a permanent drainage system must be in place to handle groundwater seepage, roadway runoff, and potential wash water or spillages. This prevents hydrostatic pressure buildup behind the final lining.

Key Points

- Waterproofing Membranes: Installed between primary and secondary linings to direct water downward
- Longitudinal Side Drains: Collect seepage water at the base of the tunnel walls
- Central Invert Drain: Collects surface runoff and roadway wash water
- Oil Interceptors: Installed at portals to treat polluted runoff before discharge

Summary I

Effective environmental control in tunnels is a multifaceted engineering challenge. Robust ventilation systems, proactive dust suppression, adaptive lighting, and reliable drainage are not merely accessories, but integral components that ensure structural integrity, operational efficiency, and human safety.

Key Points

- Construction ventilation requires careful selection of blowing or exhausting methods.
- Operational ventilation must handle routine emissions and emergency fire scenarios.
- Dust control protects worker health, while proper lighting prevents visual hazards.
- Drainage systems manage water ingress to protect the tunnel lining and interior operations.