

DI04006071: Railway, Harbour & Tunnel Engineering

Lecture 6.44: Method of tunnel Ventilation for construction and operation, dust control, lighting, and drainage (Part 2)

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July 23, 2026

Introduction to Tunnel Environmental Control I

Maintaining a safe and comfortable environment within a tunnel is a complex engineering challenge. It requires integrated systems for air quality, visibility, and water management during both construction and permanent operation.

Key Points

- Protects workers during the hazardous construction phase.
- Ensures user safety and comfort during normal traffic operations.
- Provides critical life-safety functions during emergency scenarios (e.g., fires).
- Preserves the structural integrity of the tunnel lining and embedded equipment.

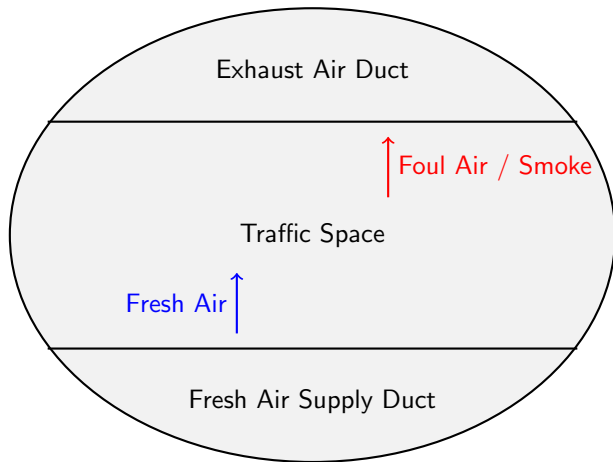
Ventilation During Operation I

Operational ventilation systems are designed to dilute vehicle exhaust emissions, manage thermal loads, and critically, control smoke propagation in the event of a tunnel fire.

Key Points

- Longitudinal Systems: Utilize jet fans mounted on the tunnel crown to push air lengthwise.
- Semi-Transverse Systems: Supply fresh air uniformly via a parallel duct, with exhaust exiting the portals.
- Fully Transverse Systems: Feature dedicated supply and exhaust ducts for precise, localized air management.

Fully Transverse Ventilation Schematic I



Fully Transverse Ventilation Schematic II

Key Points

- Fresh air is supplied from a continuous duct beneath the roadway.
- Foul air and smoke are extracted through a ceiling duct.
- Creates a vertical airflow pattern that is highly effective during fire incidents.

Ventilation During Construction I

Construction ventilation provides breathable air to workers while removing blasting fumes, silica dust, and exhaust from diesel equipment. Temporary ducting and high-pressure fans are utilized.

Key Points

- Blowing Systems: Supply fresh air directly to the tunnel face, displacing dirty air towards the portal.
- Exhausting Systems: Extract contaminated air from the face, drawing fresh air in through the main tunnel.
- Combination Systems: Utilize a main exhaust line with a smaller, secondary blowing fan at the face to eliminate dead zones.

Comparison of Ventilation Methods I

	Feature	Longitudinal	Semi-Transverse	Fully Transverse	
					Air Supply Portal
	Uniform along tunnel	Uniform along tunnel			**Exhaust** Portal
	Portal	Uniform extraction	**Cost** Low	Medium	High
Tunnel Length	Short to Medium	Medium to Long	Very Long		

Key Points

- Selection is driven by cost, length, and strict fire safety codes.
- Fully transverse provides the highest safety margins during emergencies.

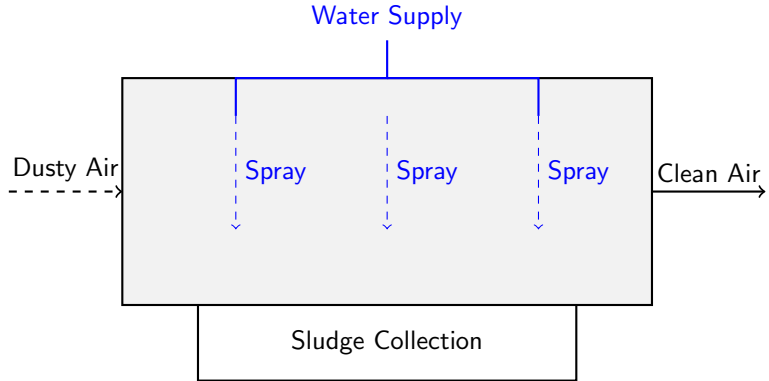
Dust Control Strategies in Tunneling I

Tunnel construction generates significant airborne particulates from drilling, blasting, mucking, and shotcreting. Strict control measures are mandatory to prevent silicosis, protect equipment, and maintain visibility.

Key Points

- Wet drilling techniques suppress dust at the source.
- Water sprays and misting cannons are used during mucking and hauling.
- Dust scrubbers integrated with localized ventilation systems.
- Application of chemical dust-binding agents on temporary haul roads.

Wet Scrubber Dust Suppression Schematic I



Wet Scrubber Dust Suppression Schematic II

Key Points

- Dusty air is drawn into the scrubber chamber.
- High-pressure water sprays capture airborne dust particles.
- The resulting sludge is collected at the bottom for safe disposal.
- Cleaned air is exhausted back into the tunnel or out the portal.

Tunnel Lighting Requirements I

Tunnel lighting must ensure safe entry, passage, and exit of vehicles by minimizing the 'black hole effect' during daylight and allowing sufficient time for visual adaptation.

Key Points

- Threshold Zone: Highest luminance to help eyes adapt from bright daylight.
- Transition Zone: Gradual reduction of luminance into the tunnel interior.
- Interior Zone: Constant, lower baseline luminance for normal driving.
- Exit Zone: Increased luminance to prepare drivers for bright daylight glare.

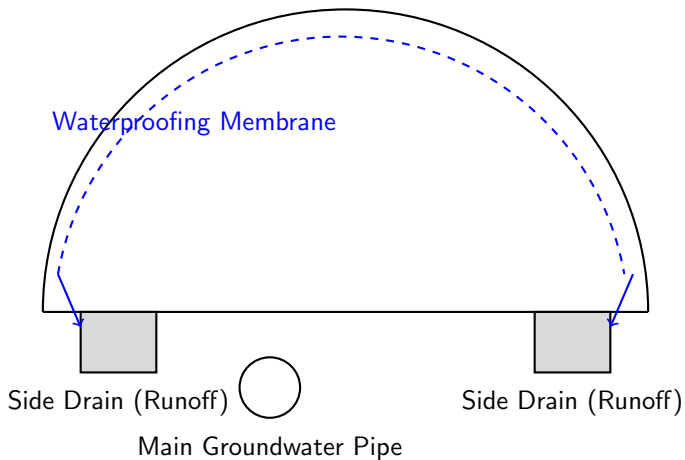
Tunnel Drainage Principles I

Effective drainage prevents water accumulation that can compromise structural integrity, damage electromechanical equipment, and create hydroplaning hazards for users.

Key Points

- Longitudinal slopes (minimum 0.5%) are required to ensure gravity flow.
- Strict separation of groundwater (clean) and roadway runoff (contaminated).
- Sump pits and automated pump stations are necessary in sub-aqueous or dipping tunnels.
- Use of oil/water separators for roadway runoff before environmental discharge.

Drainage System Cross-Section I



Drainage System Cross-Section II

Key Points

- Waterproofing membranes guide groundwater behind the lining to side base drains.
- Roadway runoff is collected in separate continuous surface gutters.
- Both systems prevent hydrostatic pressure buildup against the tunnel lining.

Summary I

The comprehensive management of ventilation, dust, lighting, and drainage is essential for the safe and efficient construction and operation of tunnels.

Key Points

- Ventilation systems must be carefully selected based on length and fire safety needs.
- Dust control requires a combination of source suppression and active filtration.
- Lighting design focuses heavily on facilitating the visual adaptation of drivers.
- Robust drainage systems are critical to handle both infiltration and surface spills.