



# TUNNEL TACTICS

Besides tunnel engineering, there are myriad kinds of systems created only for these marvels. Ventilation systems are just one.

BY BINDU GOPAL RAO

**T**unnel ventilation is critical across various verticals. Infrastructure players who build tunnels are required to ensure an adequate air quality, control the spread of smoke in case of fire, or reduce temperatures to acceptable limits. The function of the ventilation relates to the type of tunnel in question. Vehicular tunnels (road, rail and metro) generally require high air quality during normal operation and smoke control in case of fire, while cable tunnels require cooling, smoke control and a certain amount of air exchange. Mine tunnels and station tunnels also require adequate ventilation for physiological, cooling and smoke control requirements.

Tunnels are constructed to ease the transportation of people and materials rapidly, smoothly and in a shorter time than going around via a longer and usually steeper land route. Tunnels have been in existence for centuries. It is

however only in more recent times that comfort, safety and enhanced traveler experience have become aspects of tunnel design, construction and operation.

## THE SPECIFICS

Ventilation systems for tunnels are designed based on the type of tunnel, its application, length and safety aspects. There are broadly three types of tunnel ventilation systems. "Longitudinal systems where a series of cylindrical jet fans draw air into the tunnel and exhaust them on the other side. The system is ductless. This type of ventilation best serves unidirectional and shorter length tunnels within one kilometre. This system offers relatively good ventilation with medium safety and smoke dilution in case of a fire within the tunnel. Semi Transverse where a large civil or mechanical duct and powerful fans are together combined used to draw



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CHANDRASHEKAR HARIHARAN

in fresh air, transport it along the tunnel length and distribute it evenly. This system helps to draw in fresh air and dilute pollutants. In case of a fire, the same system is used to exhaust smoke and heat by immediately reversing the fans and quickly bringing relief to any person trapped inside the tunnel. This system is common in bi directional and longer tunnels. Transverse is the most sophisticated of all Tunnel Ventilation Systems. Transversal ventilation uses separate air ducts to introduce set flow rates of fresh air along the tunnel length and extract the flue air from inside the tunnel. The system ensures comfort safety and efficiency to the tunnel users along its complete length. It is an expensive solution due to the high civil work costs and large mechanical systems installed. Its cost of operation is also high but efficient fans reduce that cost. This ventilation system is normally used in long bi-directional tunnels with high traffic levels and high percentage of heavy goods vehicles transit.



▲ A workman works on a system.



▲ New kinds of blowers keep ventilation going for miles in a tunnel.

The 9 km long Chenani-Nashri tunnel on the Jammu-Srinagar National Highway is a recent example of Transverse Tunnel Ventilation," says Vikram Murthy, National President Elect ISHRAE (Indian Society of Heating Refrigeration and Air Conditioning Engineers).

### GOING GREEN

India has set up very straight forward green guidelines that any architect, builder, or electrical engineer can understand. Despite many setbacks the industry has seen on acceptance in the market place, some environmentalists continue to predict positive ripple effects from technological efficiency. Biodiversity Conservation India Limited (BCIL) headquartered in the fast growing high-tech city of Bangalore, opposes pumping energy into more urban glass towers. During the boom of the early 2000s, he says, "People weren't conscious at all of energy consumption. Dr. Chandrasekhar Hariharan, CEO, BCIL, says, "Zed Collective installed in 2008 a first-of-its-kind earth tunnel ventilation [ETV] system for a residential apartment, and combined ground-heat, evaporation cooling and a network of hot-air release systems in the building that hosts 72 apartments. The ETV system takes advantage of the relatively constant, moderate temperatures and tremendous mass of the deep soil around and below a building. Using thermo-dynamically based mechanisms like those of an air conditioner, these systems transfer heat from the earth into a building or, in summer mode,



▲ A long view of a tunnel in the Himalayas.

move heat out of the building into the earth. In a closed-loop system, heat moves with an anti-freeze solution that is pumped through horizontal or vertical pipes buried in the earth. In an open-loop system, groundwater or surface water is used to deliver or remove heat before being returned to the earth. Because cool soil or water can absorb waste heat more efficiently than can hot air, ground-source systems can slash the amount of energy used for air-conditioning. They have been popular for years in northern and central Europe, where their capacity for efficient heating is more important than their cooling capability." To date, it has the largest fully earth tunnel ventilated air-conditioning system in the world. One room in each residence (the master bedroom,



▲ Ventilation systems take up plenty of space place in terms of coolers and blowers.

naturally) is maintained at or below 75 with air cooled by circulation through "earth tunnels". No compressor-driven air-conditioning is used; the only operating energy used is for fans. At night, the system is aided by a mechanism that cools water by radiating heat to the night sky, then stores the water and circulates it through the geothermal conduits the next day ahead of the cooled air. During execution of the project, workers dug over a 12 ft.-deep and 5 ft.-wide set of channels around and under the apartment building. They excavated nearly 1200 cubic meter of earth and buried a network of five kilometres of pipes inside the earth! That was before they started construction on the cluster of 72 flats that are distinctly defined to be sustainable and green.

### SAFETY MATTERS

The system safety of a tunnel ventilation system is a func-

tion of the detailed engineering specification of the mechanical and civil system design, the components robustness, reliability and installed redundancy in control systems. There are reputed internationally experienced tunnel design consultants and manufacturers who provide such fail safe systems across the world and in India. Codes and Standards developed internationally are adopted in India. Testing, commissioning and continuous maintenance ensure compliance and safety. As far as safety is concerned the ventilation systems come into play as they are essential to maintaining clean air, ensure carbon dioxide levels are under control and vehicular emissions are absorbed. For instance on the Chenani-Nashri tunnel on Jammu-Srinagar National Highway, ABB has designed, engineered and supplied low harmonics variable speed drive (VSD) system for tunnel ventilation.

### NEW VISTAS

Transverse tunnel ventilation is not common in India because tunnel lengths are typically within a kilometer. The advent of long tunnels has brought transverse tunnel ventilation applications to India this year as described earlier in the particular example of the J & K Tunnel. BCIL's unique low-cost, low-maintenance, low-energy-use air-conditioning system is quietly making history in a picturesque setting of a low-rise apartment block in Yelahanka, to the north of Bangalore. This set of apartments has no 'sick building syndrome' that comes from regular AC's that circulate stale air through the hours of use with only 8% fresh air intake. The ETV system works on 100% fresh air



▲ There are several vendors who offer innovation tunnel ventilation systems in India alone.

24x7 with energy costs that are 30% of a regular AC. The 4-floor apartment block looks like any other, but the rooms are warm in winter, and cool in summer; the system uses the night air to cool your rooms, and the hot afternoon air for heat exchange. "This blend of 3 natural low-energy systems is the very first of its kind in the world," says Anup Naik, a senior architect at BCIL. "Besides, this is the largest earth tunnel ventilation system reported so far." The benefit for the resident families is obvious: at a fraction of the cost of regular air-conditioning, you get the comfort of cooled and warmed rooms, depending on the time and season of year. This natural AC system is ozone-friendly and 100% CFC- and HCFC-free.

#### TECH TALK

As far as technology is concerned almost all international technologies are available in India. "Specifically, advance EC Fans for energy efficiency, reliable and fast acting dampers, actuator systems, digitally programmed and controlled operating systems, giant tunnel boring systems, civil and mechanical strengthening techniques applied to tunnels being



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#### VIKRAM MURTHY

constructed in India. All these ensure high reliability and easy monitoring of the system on a continuous cycle," says Murthy. The design of BCIL Collective also helped significantly with passive design elements that helped heat escape, and created a double skin for the building that prevented heat ingress. "Not a single brick, clay tile or block was used because such blocks use precious food-giving topsoil, and consumes high energy in manufacture. The building used an energy-efficient variant of concrete blocks that offered 'coolth' [as against warmth] to a house. In regular homes, every summer has the inside of your home than it is outside. That's because of the heat that conventional concrete blocks trap in your rooms," says Hariharan.

Tunnels are a fascinating aspect of civil and mechanical design that have delighted users through the ages. They save costly fossil fuel and offer quick access to remote and distant locations. Safe and reliable ventilation combined with innovative and brilliant lighting systems offer an enhanced experience for users of modern tunnels, India's tunnel design and execution capability is on par with the world's best. **cw**