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CONSULTING ENGINEERS
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Reputation Resources Results

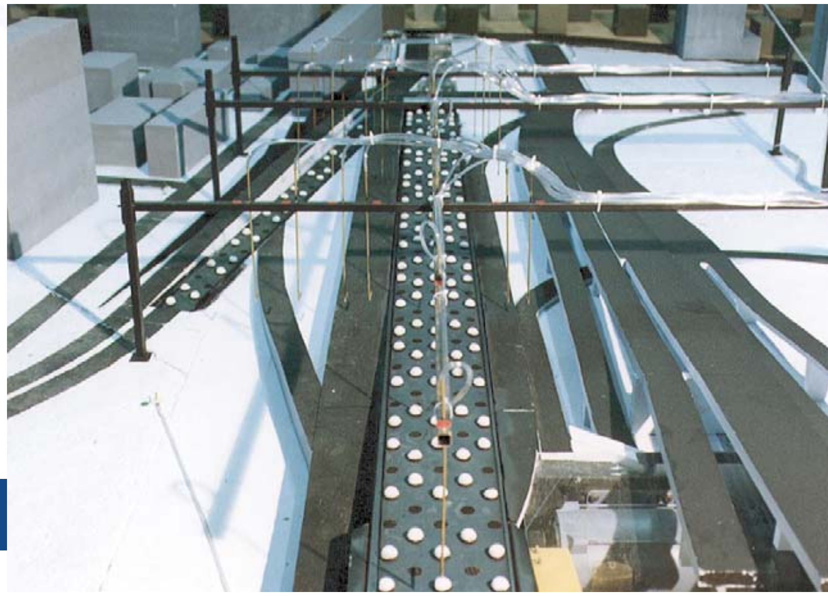
TECHNOTES

ISSUE NO. 3

BOSTON CENTRAL ARTERY/THIRD HARBOR TUNNEL PROJECT

By Mark Vanderheyden, Principal

The proposed Boston Central Artery (I-93)/Third Harbor Tunnel (I-90) Project (CA/T) is a 7.8 billion dollar (US) highway project being funded by the Federal Highway Administration and the Massachusetts Highway Department. A joint venture between Bechtel Corporation and Parsons Brinckerhoff is the project management consultant responsible for the preliminary design, management of the final design, and construction of the tunnel system. The system will include 13.3 miles (21.4 km) of ventilated tunnel and will accommodate upwards of 24,200 vehicles during peak hours. Pollutants emitted by vehicles will be vented through seven ventilation buildings (capable of venting upwards of 14 million cfm) and dozens of minor and major roadway portals proposed or under construction as part of the project. The photograph on page 2 shows a ventilation building being built.



High speed conveyor system

Tunnel ventilation systems are required to both comply with emergency ventilation conditions during accidents and fires, and to ensure adequate tunnel air quality by controlling carbon monoxide (CO) levels. Other regulated criteria pollutants, such as nitrogen dioxide (NO_2) and particulate matter (PM_{10}), are typically not monitored within the tunnel. As part of the Environmental Assessment process it is necessary to demonstrate that there will be no adverse air quality impacts near any of the proposed ventilation buildings and roadway portals.

The assessment of pollutant dispersion from ventilation buildings can be predicted using the US-EPA's Industrial Source Complex (ISCST2) and SCREEN2 computer models. However, computer models are inherently conservative in their predictions which could result in costly over-design, and the complex urban setting around the ventilation buildings and portals may result in erroneous predictions. As well, no acceptable model exists for the prediction of roadway portal impacts.

RWDI applied physical modelling techniques to assess atmospheric dispersion, validate or reduce the required height of ventilation exhaust stacks, and confirm the appropriateness of emitting pollutants via roadway portals. Physical modelling of dispersion from specific and area sources in a boundary layer wind tunnel is an accurate and well-established means of predicting ambient ambient pollutant concentrations.

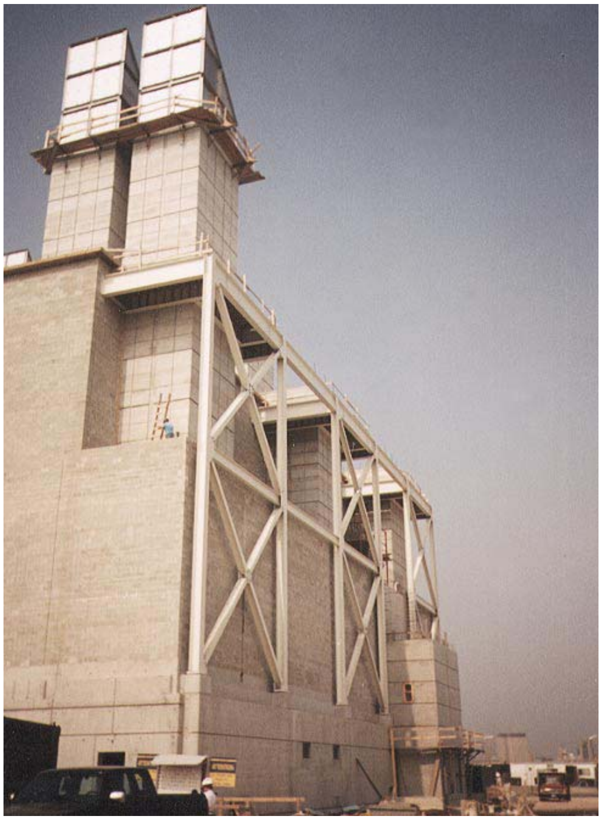
Since local features are accurately replicated in physical models, analysis assumptions are inherently less conservative than those applied during computer modelling.

Emissions from most of the CA/T's ventilation buildings were physically modelled by RWDI, and typically, significant reductions in stack height were recommended. For example, a stack height reduction of 43 1/2 feet was recommended for both of the stacks on ventilation building #8. Each proposed stack has a cross-sectional area of approximately 100 ft^2 and an exhaust flow rate of 104,000 cfm. This reduction translates into a potential cost saving of more than $215,000 (US). The adjacent table summarizes the recommended stack height reductions for the ventilation buildings tested in the wind tunnel by RWDI.

Ventilation Building	Number of Stacks	Analytically Predicted Stack Height (ft)	Wind Tunnel Predicted Stack Height (ft)
1	9	135	**129**
5	12	final design not analyzed	**181 1/2**
6	6	91	**75 1/2**
7	14	107	**94**
8	2	155	**111 1/2**

Critical to the simulation of roadway portal emissions is the physical model's ability to replicate vehicle induced pumping. RWDI developed a high speed conveyor belt system capable of simulating vehicles travelling at speeds of over 40 mph (65 kph) on roadway configurations ranging from one through seven lanes in width. As illustrated on the front cover, hemispheres were used to replicate vehicles travelling along the roadway. Model and full scale vehicular drag forces were accurately scaled to ensure the validity of the simulation. Results showed that portal exhaust "jets" extend significantly farther (greater than 1,000 ft. (300 m)) from the tunnel exit than originally thought. However, the increased length of exhaust "jets" coincidentally results in greater dilution of pollutant concentrations at locations next to the roadway.

Currently, the use of ceiling mounted jet booster fans to exhaust tunnel emissions through some outbound portals is under review. If proven to be a viable solution, booster fans will replace some components of the full transverse ventilation system resulting in potential projectable savings in the tens of millions of dollars.



Ventilation building under construction

DESIGN ISSUES FOR INTERNAL VENTILATION SYSTEMS

By Anton E. Davies, Principal

A properly designed ventilation system will provide suitable air quality for the people using internal spaces, such as train and bus stations, parking facilities, tunnels, and airport terminals. The system must also be able to cope with emergency situations where fire, smoke and heat may create hazardous situations.

A major unknown in designing transportation facilities for normal operations is the emission rate of contaminants from vehicles. The number of operating vehicles, their operating cycle within the facility, level of maintenance and age are just a few of the variables that need to be considered. Typically, this information is sketchy at best. Some emissions data can be gathered from published data such as US-EPA's AP42 and MOBILE series of emission models. However, information on trace substances and odours from internal combustion engines is rarely available.

Apart from the unknowns about emissions from the vehicles, the level of contaminants that can be allowed within the space can be a difficult issue. To design an appropriate ventilation system, criteria must be set for the air quality within the space. Unfortunately, in many cases, there is little guidance in this regard.

Organizations such as Occupational Safety and Health Administration (OSHA) provide workplace standards applicable to "healthy" workers. These standards do not really apply to the general public.

Given that 10% of the general public suffers from respiratory ailments, and a large fraction of the population are elderly, infirm, or children, it is logical that more stringent standards are required where the public is involved. Outdoor criteria and standards are usually designed for the general public, but have no jurisdiction in indoor spaces. The standards for outdoor spaces do not account for the short exposure times typically experienced by users of a transportation facility. This void in jurisdiction can leave the local health authorities responsible for the air quality and they may lack the required expertise to make appropriate decisions.

The dearth of information, both in terms of emissions and criteria, leaves the engineer with a difficult design problem. The cost of over-design does not allow the user of conservatism as a method of ignoring these unknowns. In these circumstances, it is most prudent to rely on specialized measurement programs designed specifically for the project. These programs can include the use of odour panels, sampling, and continuous monitoring of toxic exhaust gases.

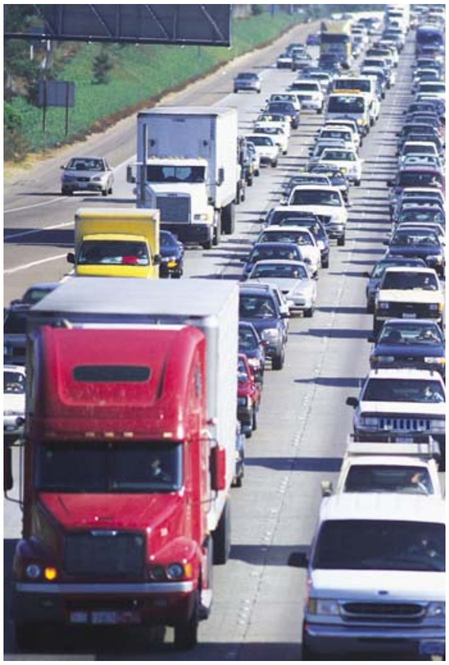
As far as the specifics of the design are concerned, fresh air needs to be supplied in areas occupied by the public. For example, in bus stations, air should be supplied over the platform areas. Therefore, the building exhaust should be located so the bus emissions are drawn away from the platform. Using this method, the public exposure can be be limited to the ambient air quality standards, while the remainder of the space which is large and unoccupied can be designed to less stringent criteria.

Measurement programs allow the designer to tailor the ventilation system to the type and number of vehicles that will use the facility, thus optimizing the amount and cost of ventilation air. These methods, used with specialized design tools such as computational fluid dynamics (CFD) and physical modelling can save a great deal in initial and operating costs, while providing safe and comfortable conditions for the public and employees.

Continuous indoor air quality monitoring system in a bus terminal

NOVEL METHODS FOR ESTIMATING THE IMPACT OF ROADWAY EMISSIONS

by David S. Chadder, Principal



Emissions from North American roadways are typically assessed using numerical emission and dispersion models. Emission models, like the MOBILE series, account for different mixes of cars and trucks, traffic speeds, and the fractions of vehicles that are in either hot or cold start operating modes, among other factors. Most US jurisdictions assess the impact from mobile sources in terms of levels of carbon monoxide. Dispersion models like CAL3QHC or HIWAY2 allow the user to numerically model roadway emissions from each lane while idling or moving. These models do a reasonable job of estimating ambient contaminant (e.g., NO_x, CO, and PM-10) levels, although, like most predictive models, the results tend to be conservative.

When the results of a roadway assessment are presented to the public, the selection of the contaminants for study is often questioned and more exotic compounds such as poly-cyclic aromatic hydrocarbons (PAHs), and diesel odours are suggested.

A Case Study

At issue, in a recent RWDI study, was a proposed truck processing facility near the Canada/US border. Residents were concerned because up to one hundred trucks could be left idling in the toll/weighing yard. Similarly, concerns were raised over the inhalable fraction of particulate matter because some constituents of diesel exhaust are known cancer-causing agents.

The lack of available data from published literature and the inability to measure odours through ambient means, required that RWDI take source samples, using tedlar bags, from diesel trucks while idling, accelerating, cruising, and under various load conditions. These samples were submitted to an odour panel to decide the detection and annoyance threshold levels for diesel odour. From the dilution response curves, emission rated were determined and used with the CAL3QHC model to estimate the odour impact under a variety of local traffic scenarios and meteorological conditions. Odour contours were plotted over a base map area. With respect to the PAHs, both ambient and source samples were also taken.

A video camera was used to record traffic movements that were responsible for high pollutant levels. A data logger system monitored both ambient levels of NO_x and wind direction, and if the exhaust plume from the highway traffic impinged on the monitoring station, a video record was taken. The recorded tape was later observed and the conditions under which high pollution events occurred were documented. Large diesel trucks were found to be the causes of these events, particularly at night under poor dispersion conditions.

As a result of the assessment, RWDI recommended that the following measures be implemented in the design of the facility: build a canopy with a diesel exhaust collection hood; reduce the number of parking places for trucks; redesign the facility to provide a maximum buffer zone distance between the facility and nearby residences; lower traffic speed entering the facility; re-route truck traffic through the parking lot away from residences; post signs to inform truckers to shut off their idling trucks; and ban overnight parking.

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