Designing and Implementing an Energy-Efficient Tunnel Development Ventilation System Meeting the Increased Diesel Traffic Required for the Niagara Tunnel Project, ON, Canada

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Groupe Sorgafra
COGEMACOUSTIC

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Challenge

- Reliable estimate of air flow requirement for using diesel equipment underground
  - ART or SCIENCE?
- Used two recommendations:
  - Swiss standard SIA 196 with a guideline for using 2m3/m per KW of diesel equipment
  - 100 cfm/bhp as practiced in North American Mine and Tunnel ventilation projects

Background

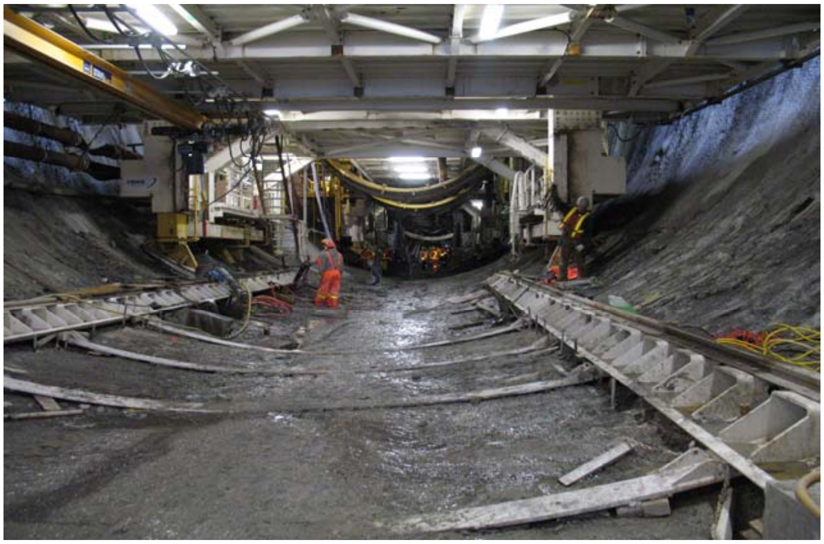
- $600 million dollar hydro tunnel feeding the Sir Adam Beck Power Station (OPG)
- 10.4 km long under the city of the Niagara Falls
- Using the largest hard rock Tunnel Boring Machine in the world – 14.4m (47.23 ft) diameter
- One of the largest tunnel project in North America

TBM views

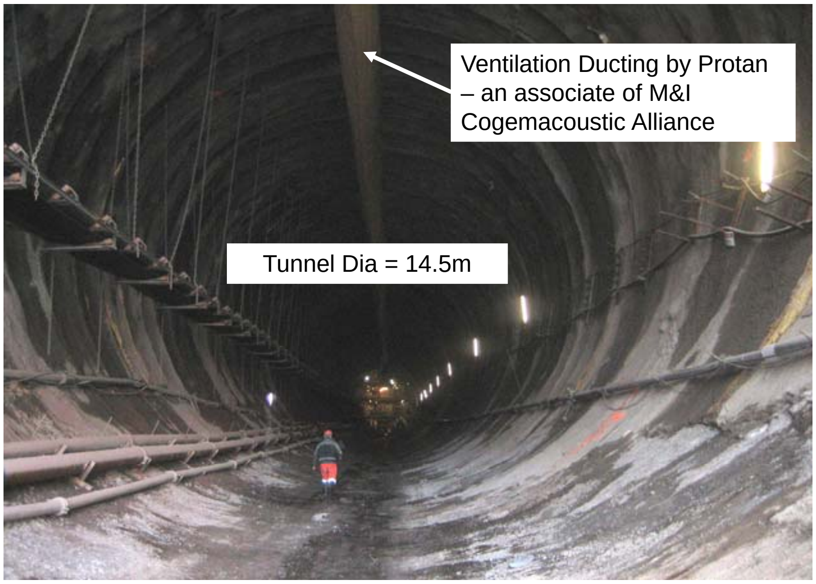
TBM being assembled at the portal

TBM entering the portal

Inside the Tunnel



Scale of work



Ventilation fan and Air supply to the working face

80 m3/s (160,000 cfm) @ 6.0 kPa (24” of w.g.) at the Portal

M&I and Cogemacoustic are currently working on designing ventilation system for meeting additional requirements.

Redesign because additional diesel equipment need

The ventilation principle is shown below.

Figure 1: Ventilation principle

With a duct of 2 600 mm diameter from the portal to CH 10 000: one existing 3 stage fan is installed at the portal (T2.160.3x355.4). **These fans are existing fans and the blade angle does not need to be changed.**

With a duct of 2 600 mm diameter from the portal to CH 6 000: one new 2 stage fan is installed at the portal (T2.160.2x355.4).

Assumptions and Design information

Air Flow Estimate for 700 kW (TBM only) and 1100 kw (Invert & Arch shutter)

This study has been done following the meeting with Strabag the 4th of September:

- airflow at CH 10 000 (TMB) is 50 m^3/s
- airflow at CH 6 000 (Invert concrete + Arch) is 75 m^3/s.

The headlosses of the ventilation layout have been calculated according to the Swiss standards defined on the SIA 196 documents.

The friction and leakage coefficient inside the ventduct are the ones normally considered for brand new duct used for TBM excavation.

Head loss calculation and duct selection

Duct type S according to SIA 196:

- Lambda factor 0.015
- Leakage coefficient 5 mm^2 / m^2

One case has been studied:

- Without booster fans (all the fans are installed at the tunnel portal):
  - With a duct of 2 600 mm diameter from the portal to CH 10 000,
  - With a duct of 2 600 mm diameter from the portal to CH 6 000;

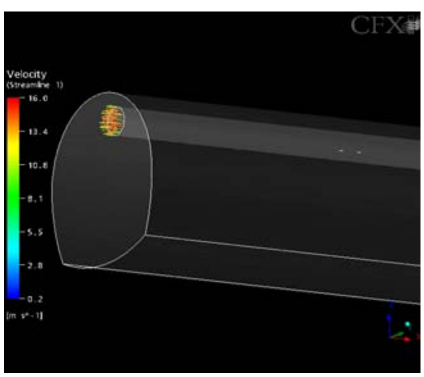
Contribution to Energy Efficiency

- Fan engineering with aerodynamic blades
- Protan ducting with a low friction loss factor

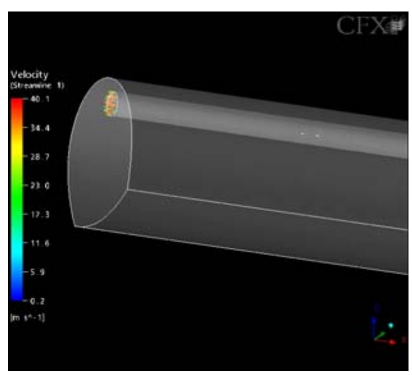
Back to the Challenge

- How to estimate the air flow requirement reliably?
- This estimate has the major contribution to capital and operating costs
- Simulation, is this the ANSWER?
  - Diesel emission dispersion modeling?
  - Should we use this for specific case or it is advisable to do it in most cases?

Simulation example



A tunnel heading with 60,000 cfm (30m3/s)



A tunnel heading with 150,000 cfm (75m3/s)