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Tunnel Safety & Ventilation Graz
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Understanding of critical velocity in Memorial Tunnel Fire Tests using longitudinal ventilation

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Background

- Blockages inside the tunnels influence results
- Jet fans position and starting sequence influence
- Accuracy of measurements
- Documentation of backalyering

Video showing the effects of blockage on backlayering (METRO project 2011)

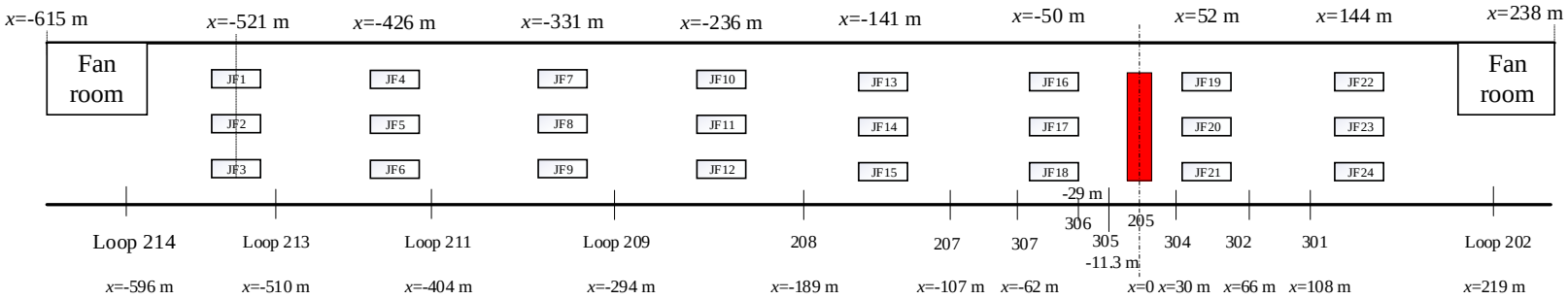
$u_{local}=u_0/(1-A_{blockage}/A_{tot})$

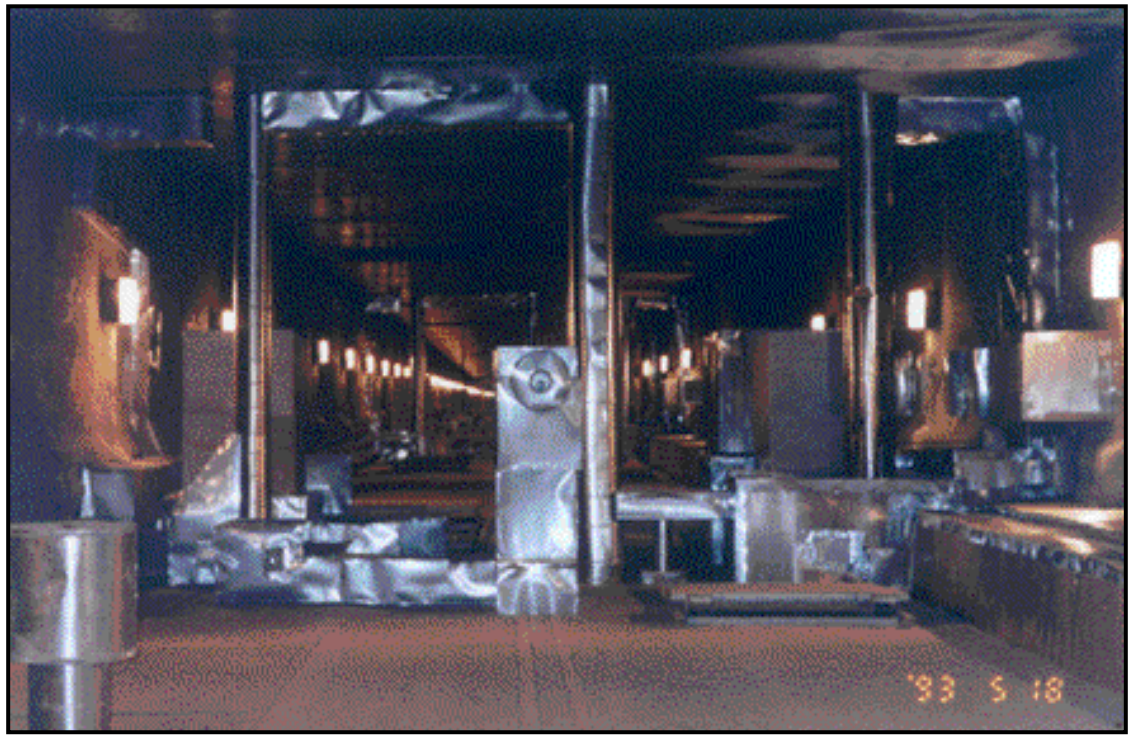
$A_{blockage}$ 10 m^2
A_{total} 42 m^2

24% blockage

u_0=2.5 m/s
u_{local}=3.3 m/s

1. Background





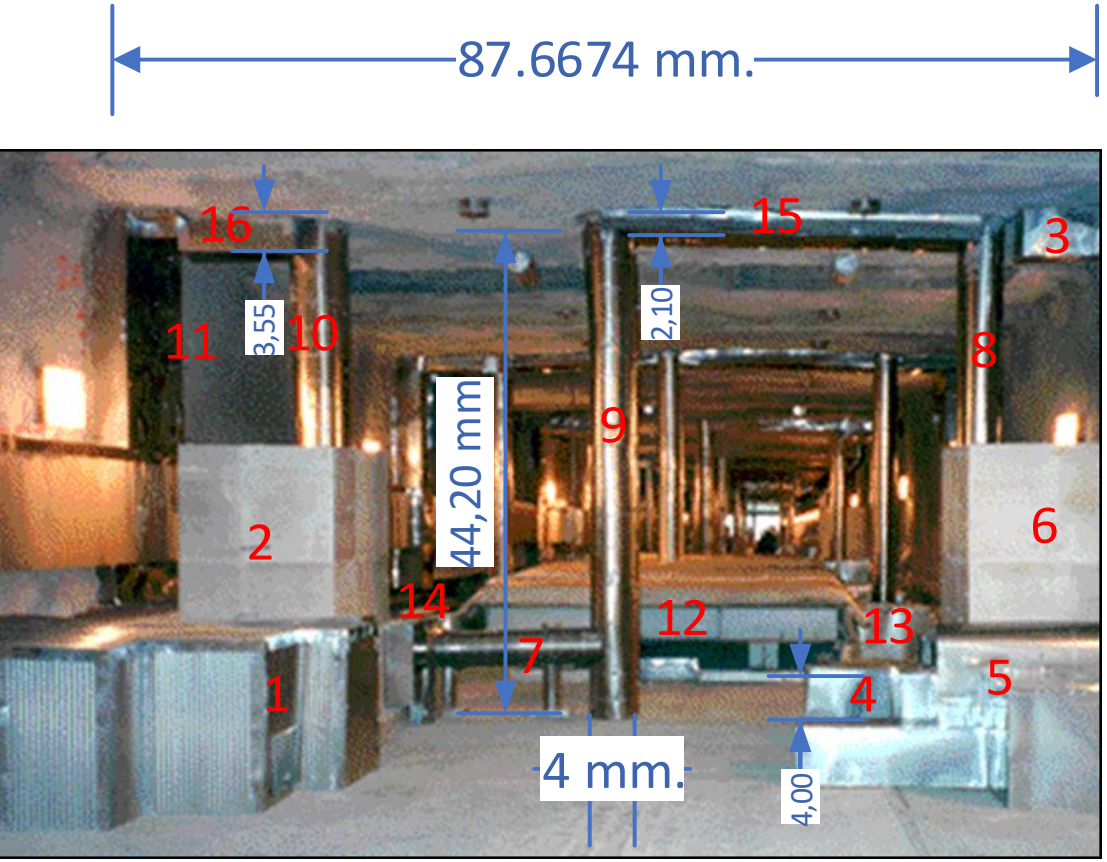
Instrument loop 307 located 62 m north of the fire.

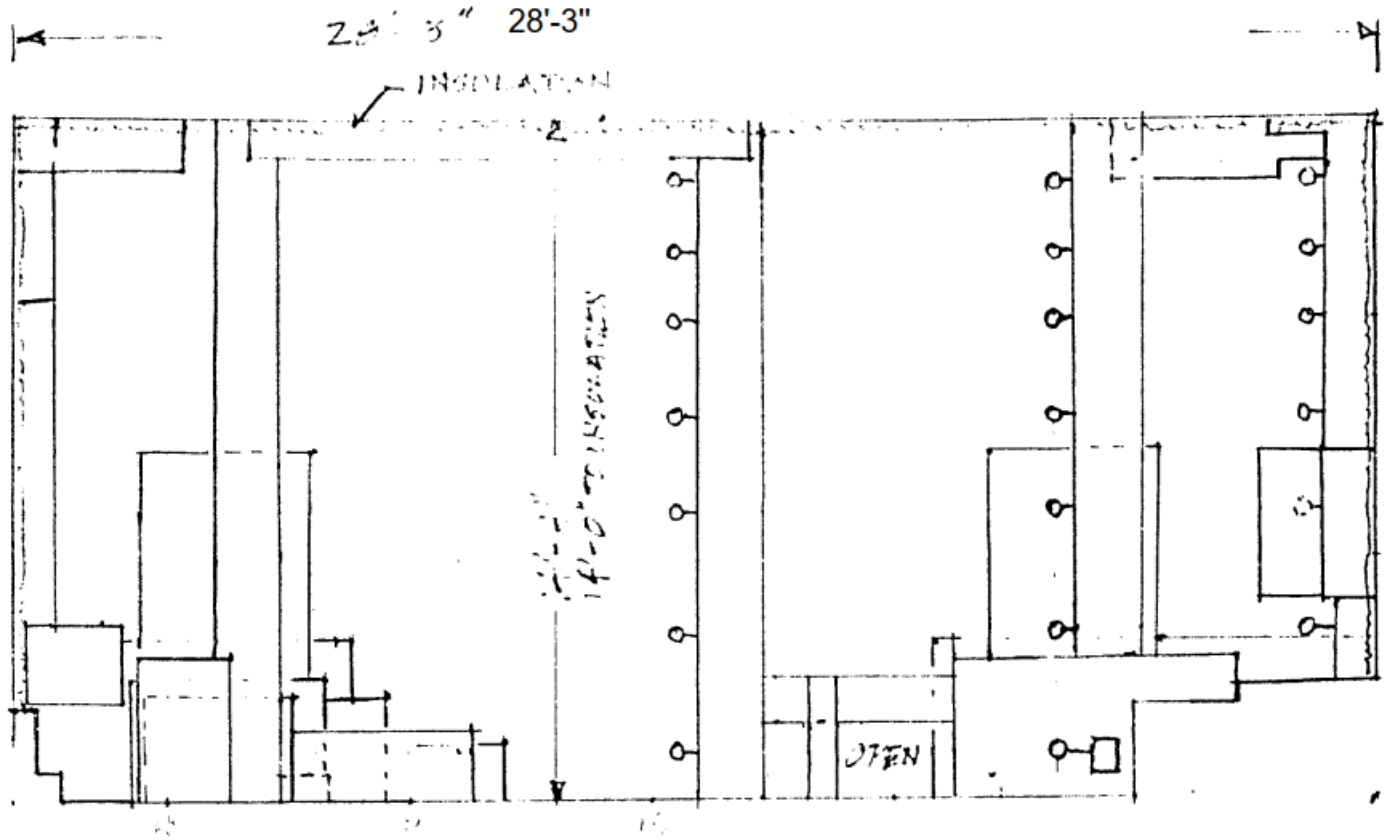
View of jet fan group located south of the fire. Installation typical for all fans (total of 24 fan groups)

New information on details from tests

Cross section of Loop 305 – 11.3 m upstream

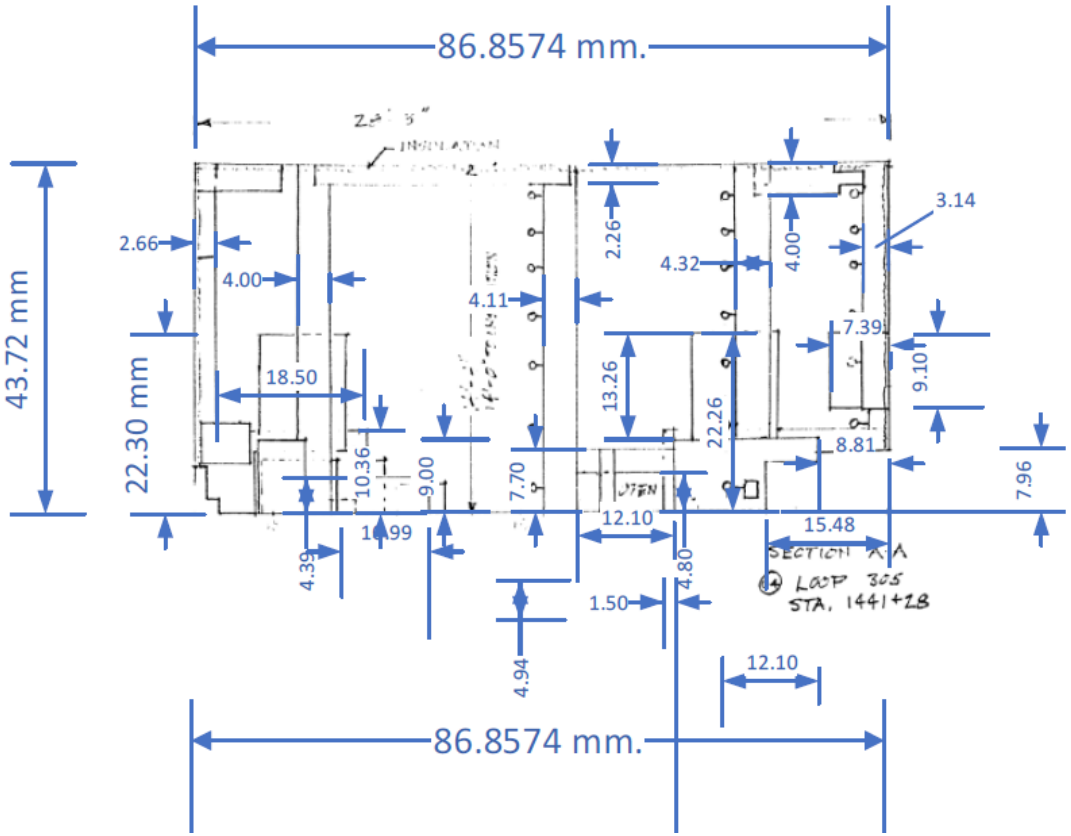
Scale: 1:100



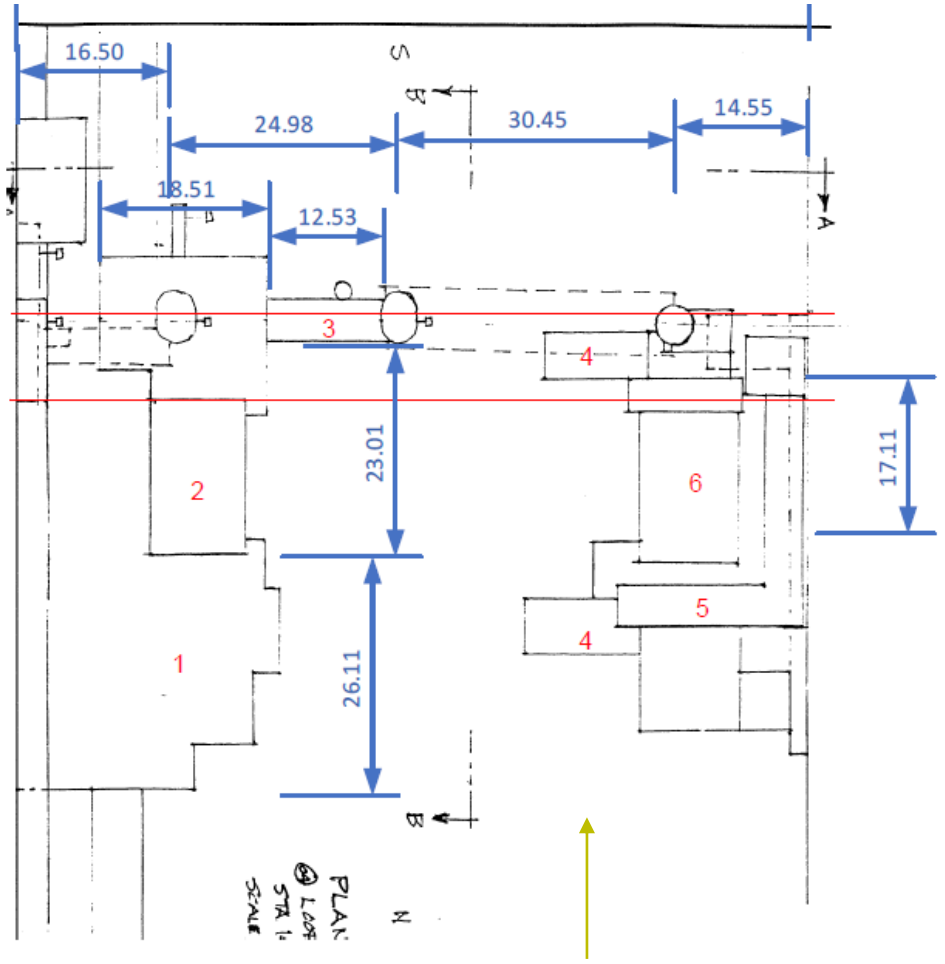


Original sketch from test prep. Ref Joe Gonzales

Mapping details of instrumentation to get correct blockage areas



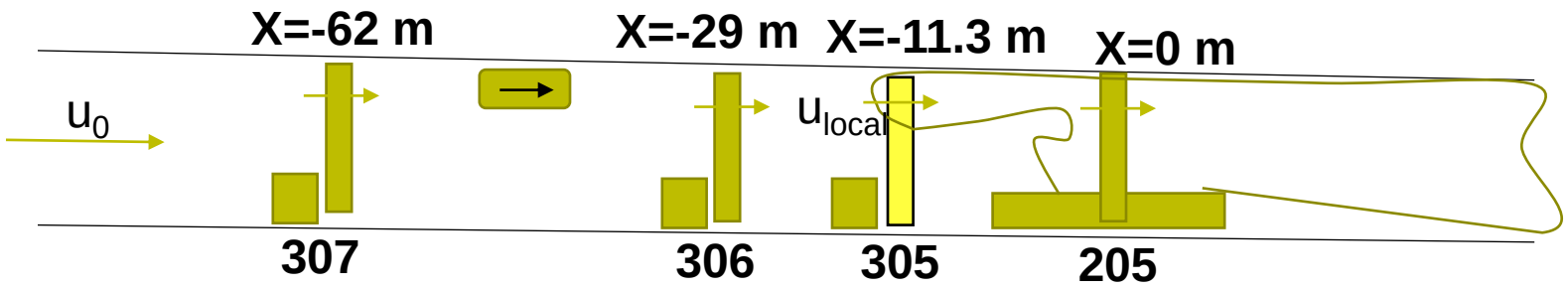
(a) Front view 305, from South to North
Scale 1:100



(b) Top view 305

Blockage effects

$u_{local}=u_0/(1-A_{blockage}/A_{tot})$

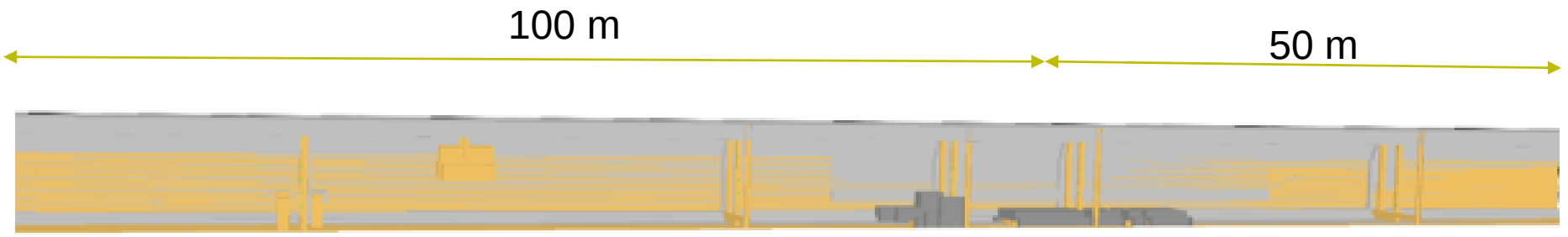


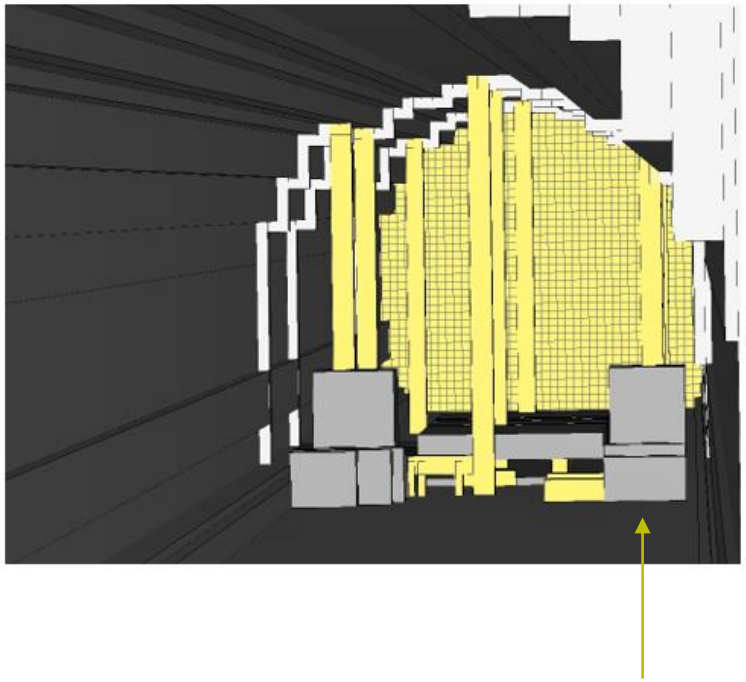
- Blockage ratio at Loop 305: **22 %**. Kile & Gonzalez estimated this to be 17 %.
- The effective blockage ratio around Loop 305 was found to be close to **31 %**. Note that this blockage refers to a region less than 1 m from Loop 305.
- Blockage at fire source center (-0.4 – 0.4 m): Blockage ratio=**31 %**
- **This corresponds to a correction factor of 1.45 for local velocity, both at Loop 305 and at the fire source center (205) instead of 1.2 used originally.**

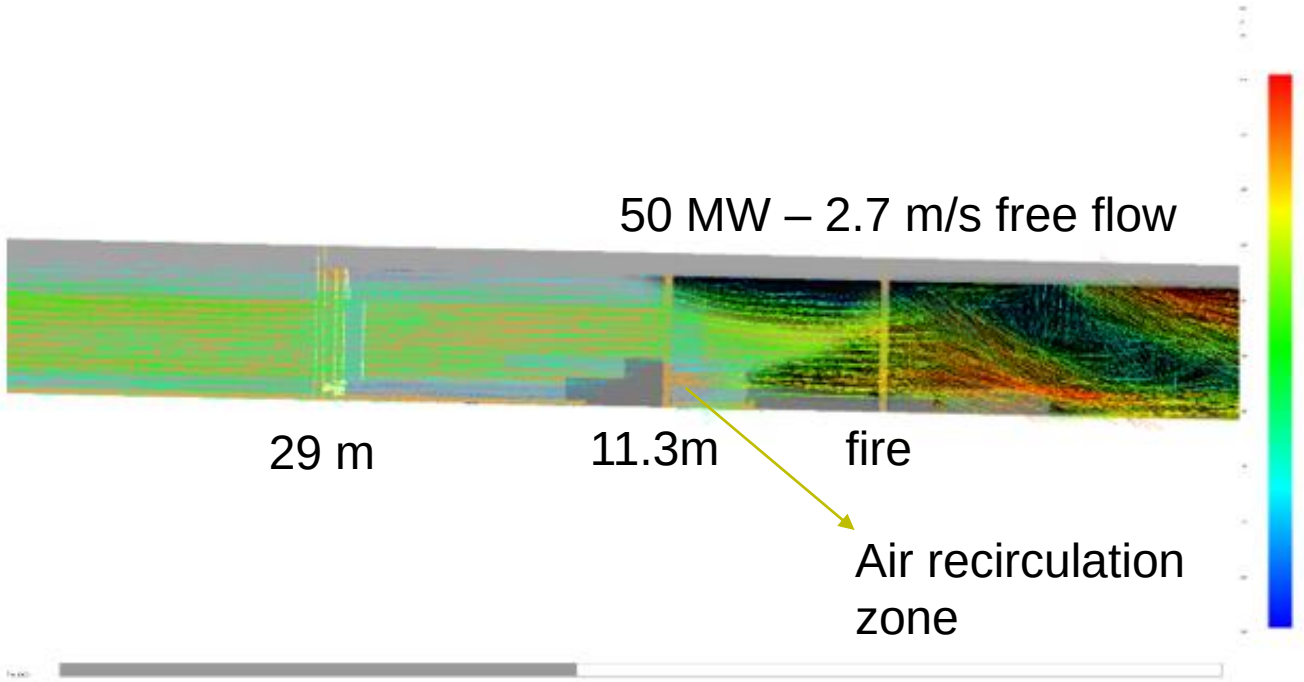
3D simulations using FDS were conducted to investigate these effects

Simulation no.	Fire source	Blockage	Slope	Purpose
M1	Same as in the test	Same as in the test	Same as in the test	Compare to test results
M2	Same as in the test	No	Same as in the test	Influence of blockage on results
M3	On floor	No	Same as in the test	Difference between model and the tests
M4	On floor	No	No	Slope effects

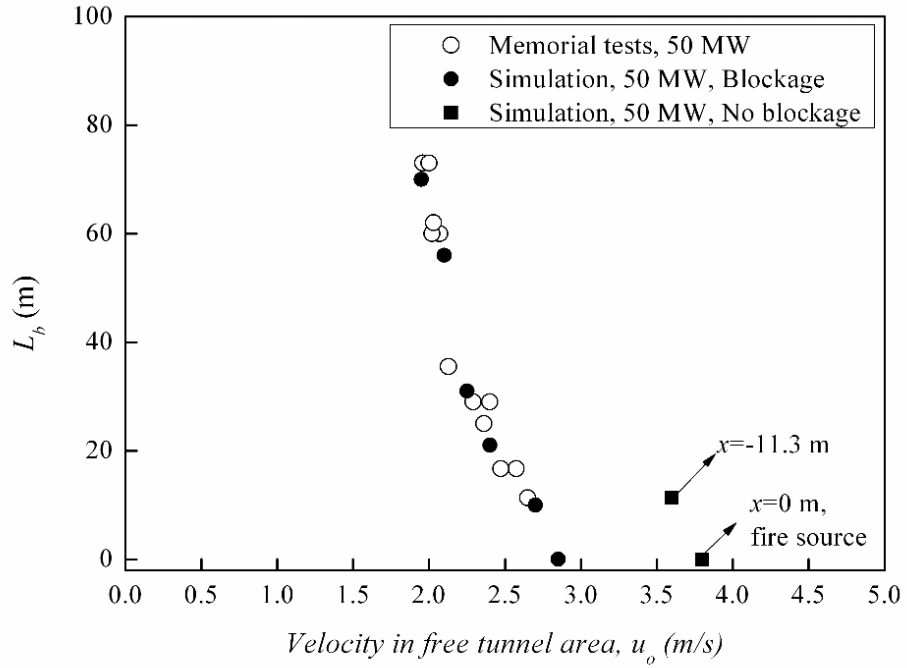
3D simulations using FDS 6.2 – 50 and 100 MW

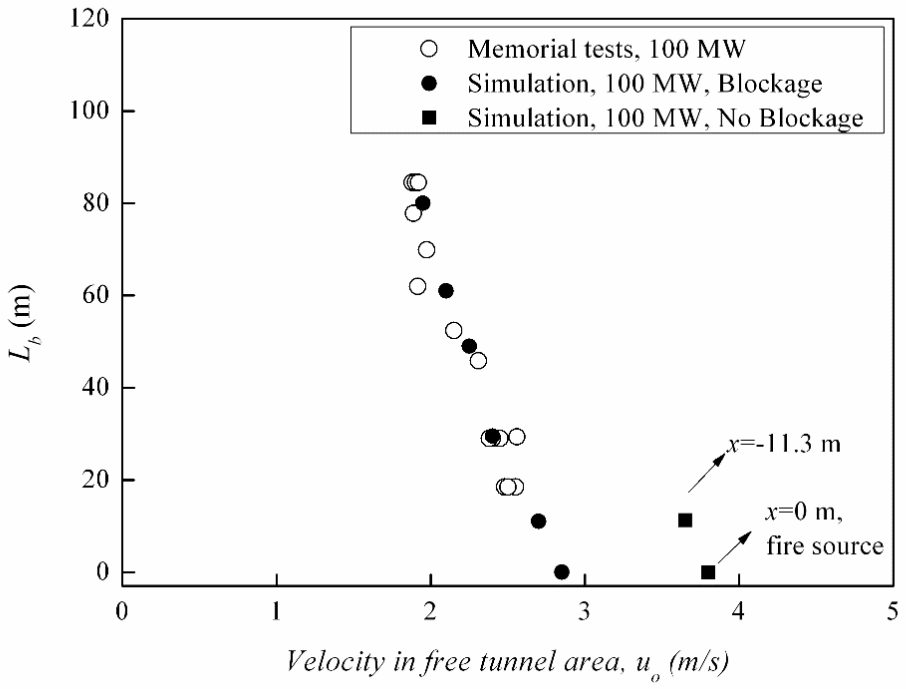






FDS results for 50 and 100 MW

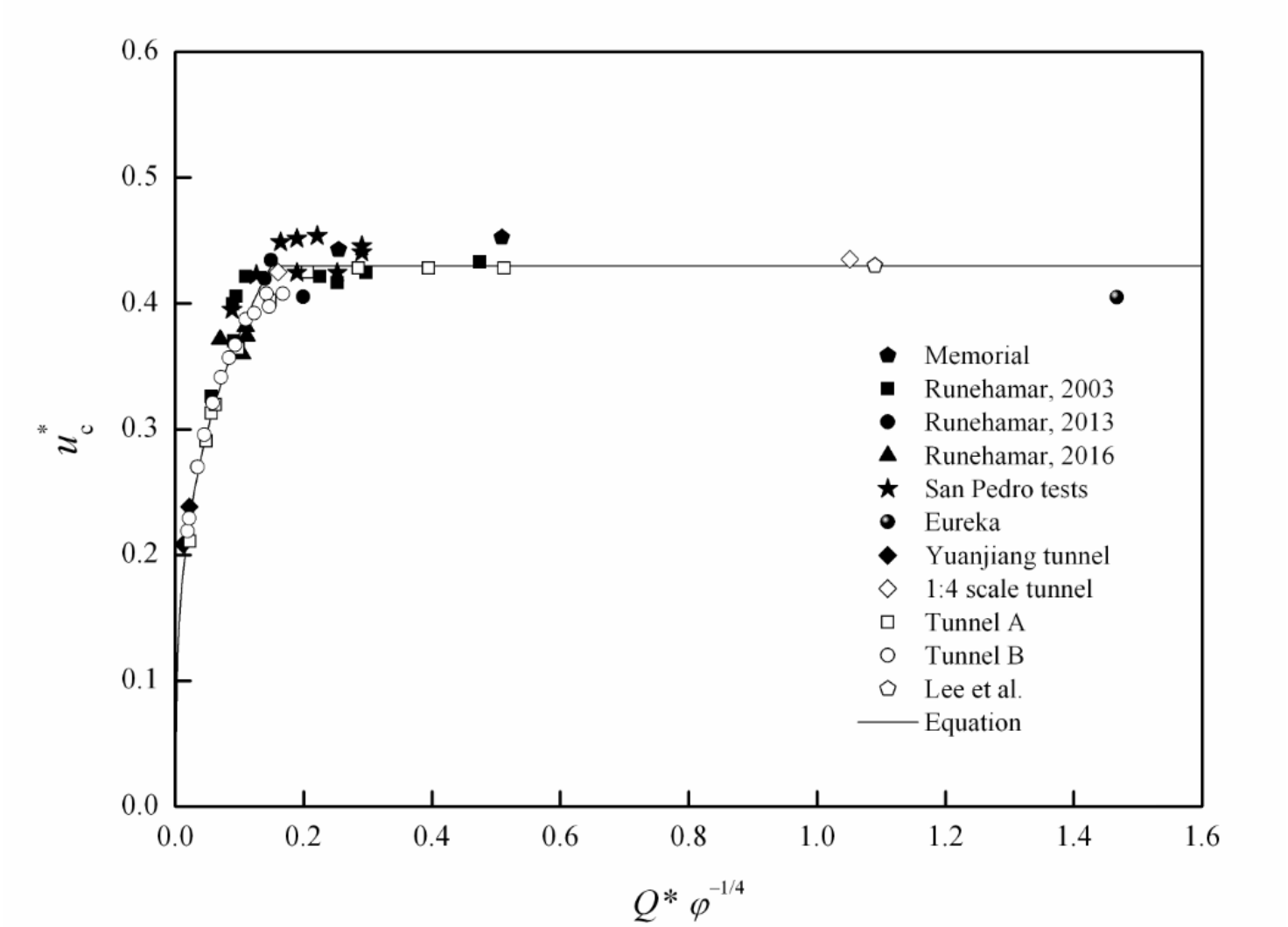




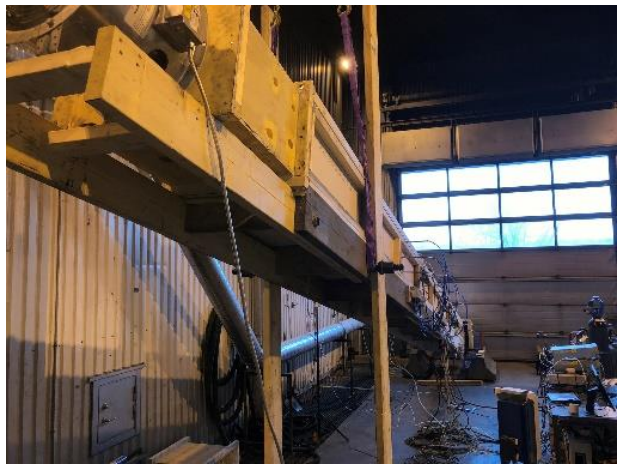
Simulated critical velocities and model prediction for 50 MW

Case no.	notes	Critical velocity
M1	Blockage, slope	2.7-3 m/s
M2	No blockage, slope	3.95 m/s
M3	No blockage, slope, floor	3.88 m/s
M4	No blockage, no slope , floor	3.8 m/s

Comparison with new data



Effects of slope and critical velocity



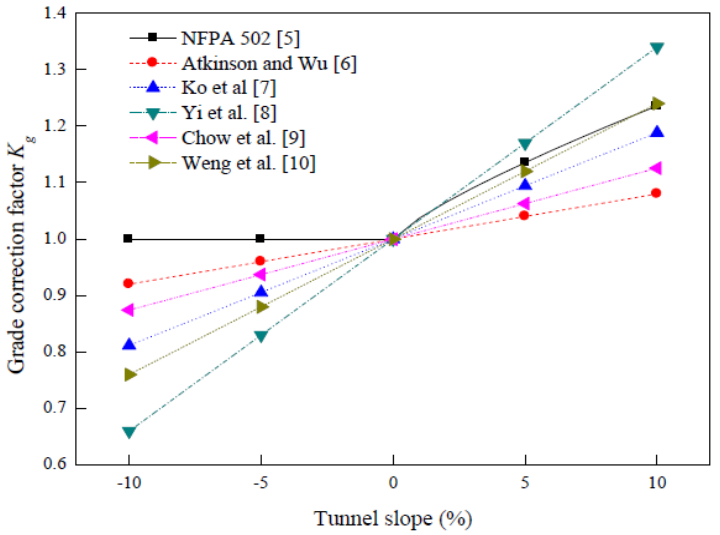
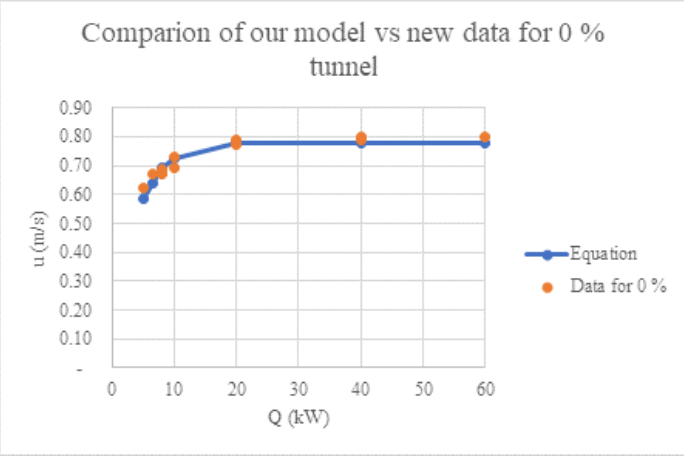
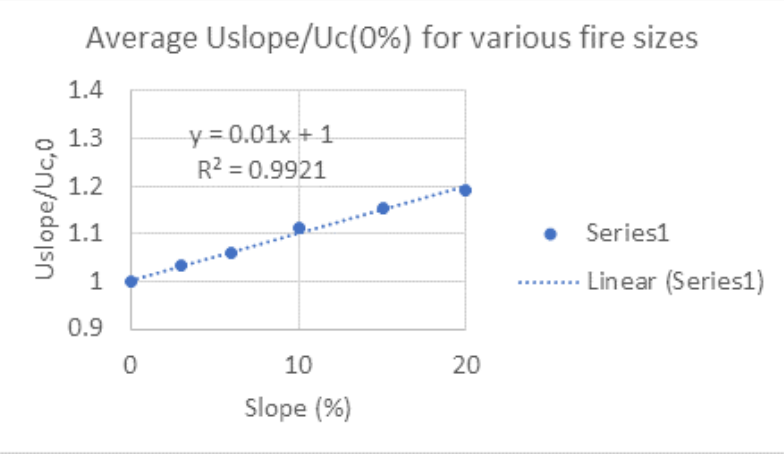


Figure 2. Existing correlations for grade factor K_g vs. tunnel slope in percentage.





Conclusions

- The effective blockage at control loop 305 is about 31 % instead of 17%.
- The numerical results show similiar effects of blockage on smoke control.
- Effects of slope overestimated in present version of NFPA502.
- The critical velocities from the Memorial tests previously used needs to be revised.
- The uncertainty in the Memorial tests needs to be fully analysed.
- New tests needs to be carried out. Plan to perform 1:3 in May-June 2021 (1:3) using Memorial blockages.

Thanks!

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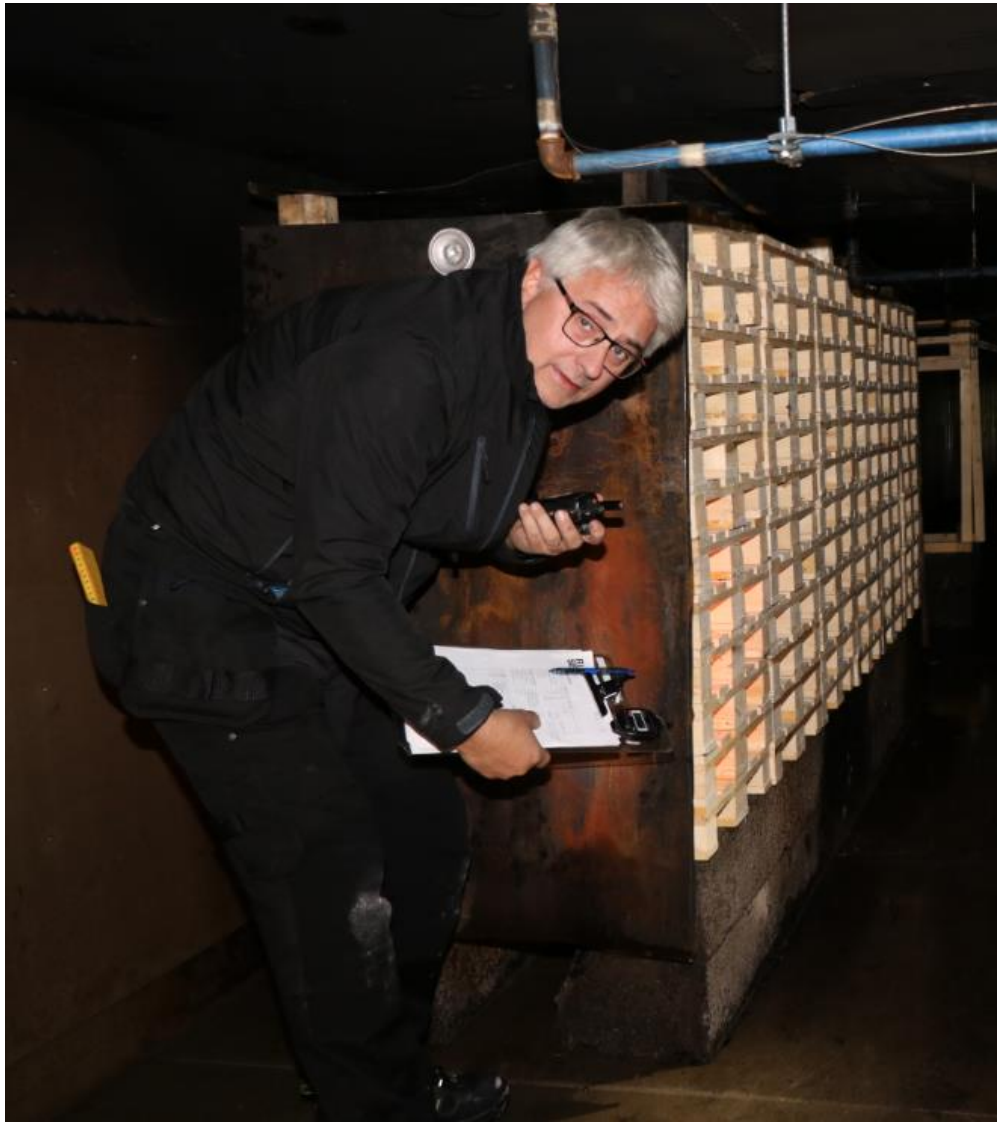

1:3