

AIR FLOW THROUGH A BUS WITH OPEN WINDOWS

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Part support: VREF

Busworld India webinar on air ventilation, air purification and cleaning systems

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Open window bus

- Mainstay of public transport systems
- Vast majority of bus fleet in India and many countries
- Open windows (and doors)
- Hot and/or humid climate
- More eco-friendly than AC bus
- Economical



Studies at TRIPP, IIT Delhi: Bus ventilation

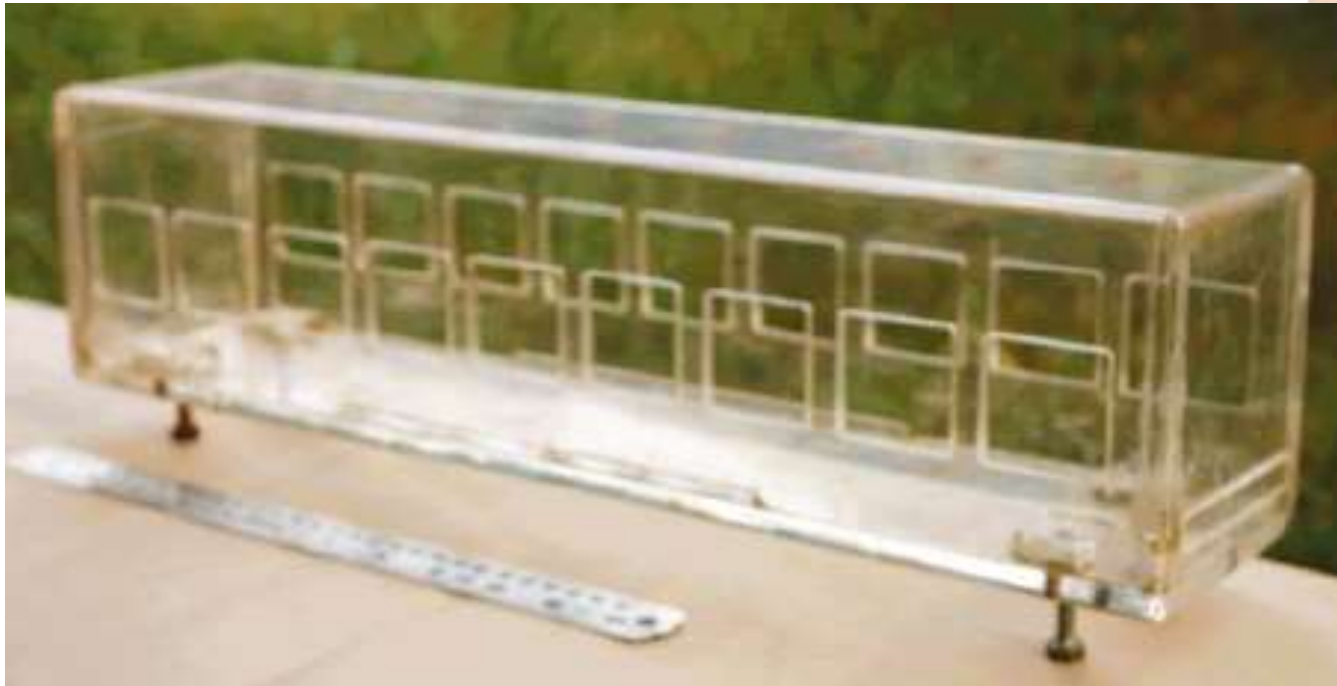
- Experimental studies
 - Scaled model – visualization in water channel
 - Scaled model – measurements in wind tunnel
 - Full-scale bus – visualization in motion
- Computational studies
 - Numerical studies: CFD of full-scale bus
- Innovations
 - Effects of static interventions
slots (front, rear) and/or roof vents



Single floor bus, no interiors

Scaled model – visualization in water channel
Full-scale bus – visualization in motion

Numerical simulation (CFD)



Velocity vectors: Single floor, no interiors, all windows open

Horizontal plane through window mid-height



W-1



W-4



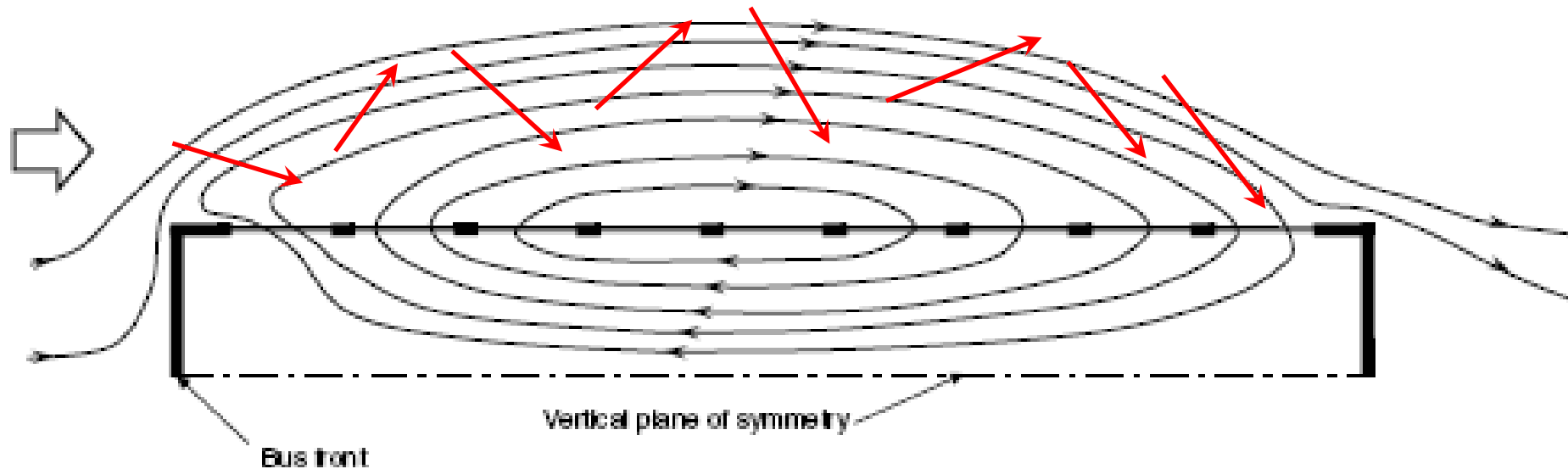
W-9



Vertical plane normal to window, through window mid-span (transverse plane)

Validation. Findings.

- Drag and side forces: Numerical simulations vs. Wind tunnel measurements
- Flow field
 - Inflows and outflows through windows
 - Flow over passengers
 - Effects of modifications
- Air flow through the bus (empty, or seated passengers)



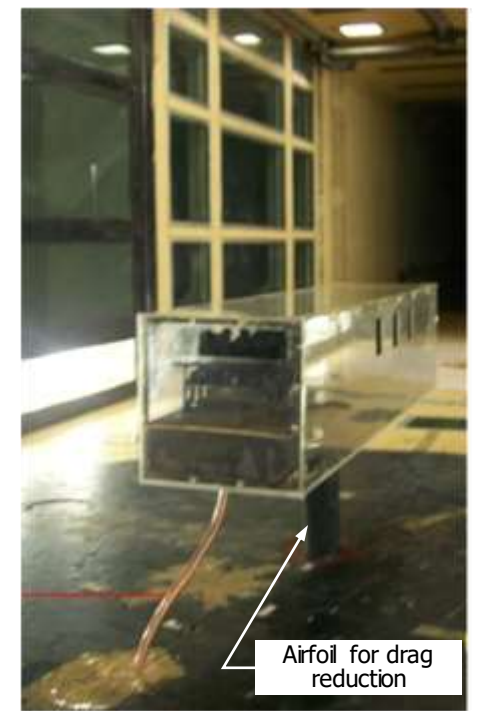
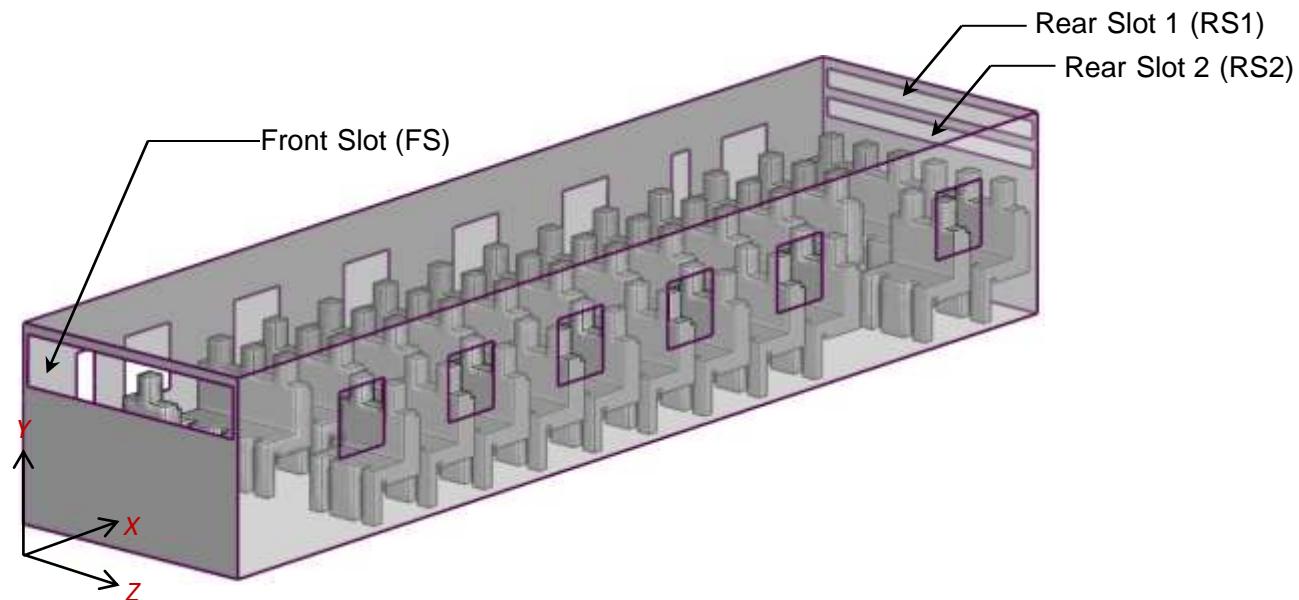
Bus with no passengers, or all seated passengers

- Base design OR Modifications
 - Single floor
 - Low floor
- Modifications
 - Selectively closed windows
 - Slots in front, rear
 - Roof-mounted deflector
 - Roof vents

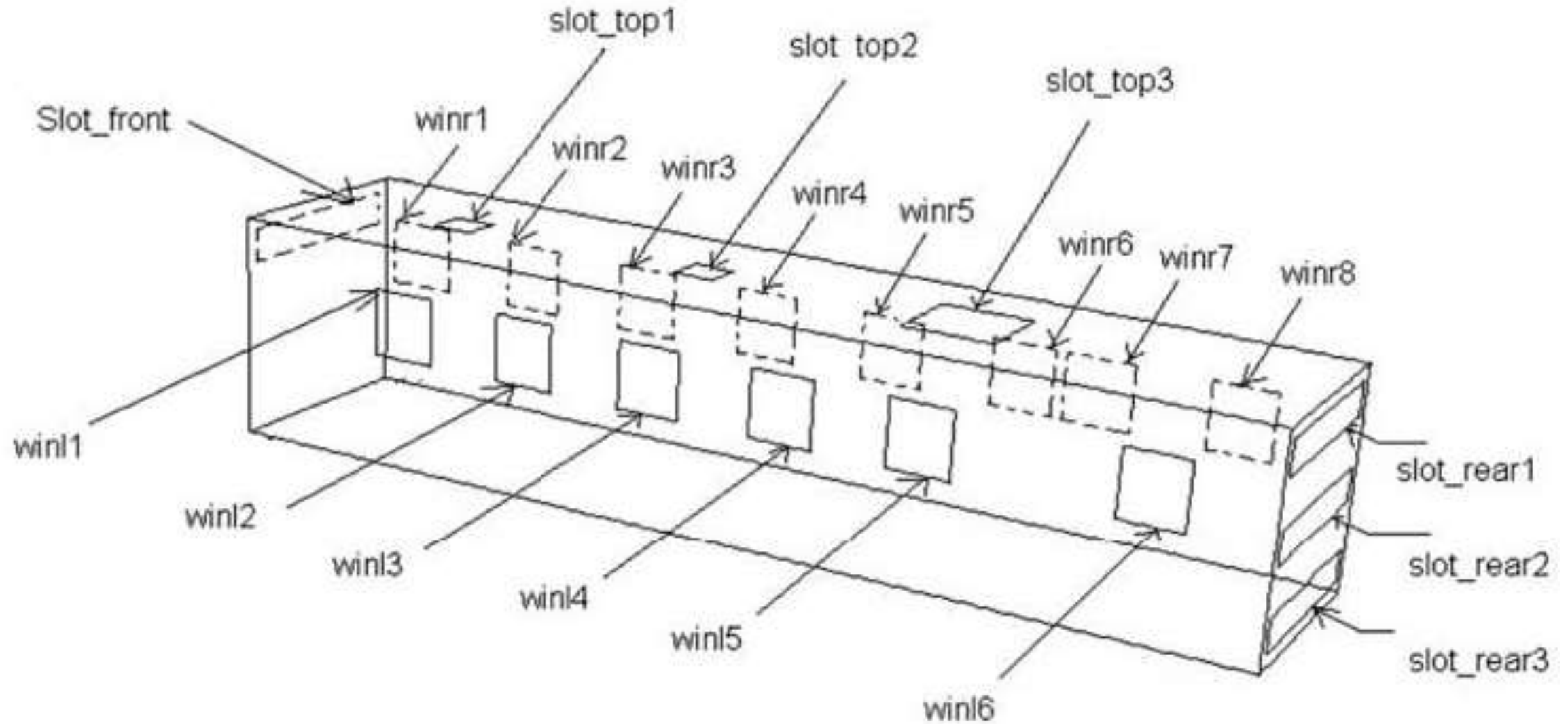
Air velocity : 40 km/h (steady)

Model : LES

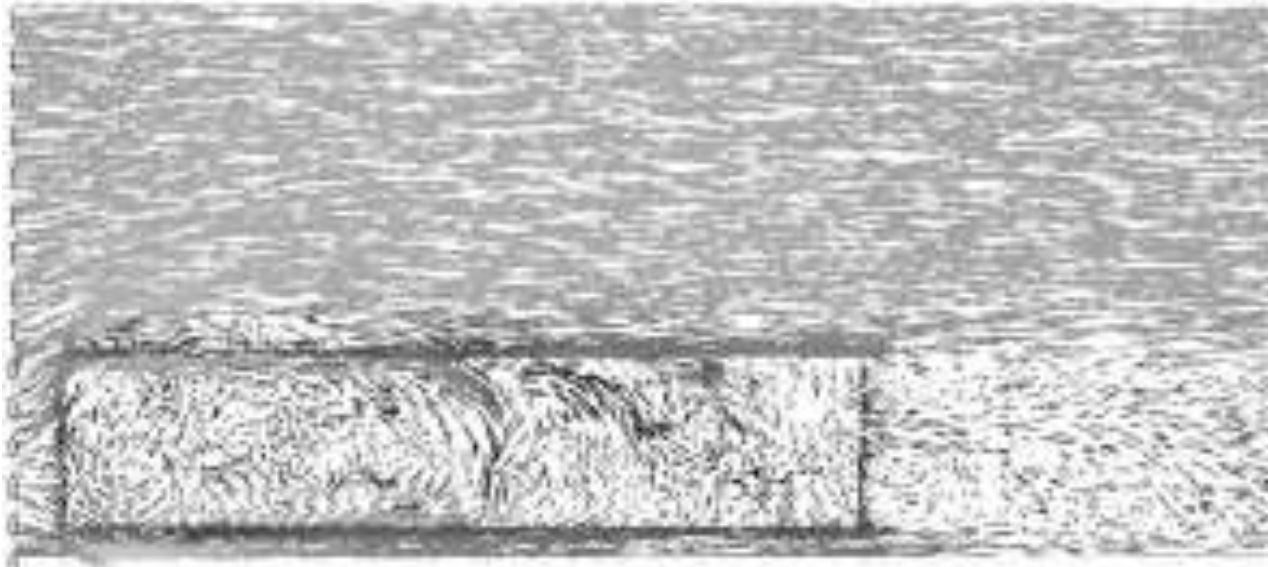
Ground effect



Windows, Roof vents, and Front & rear slots



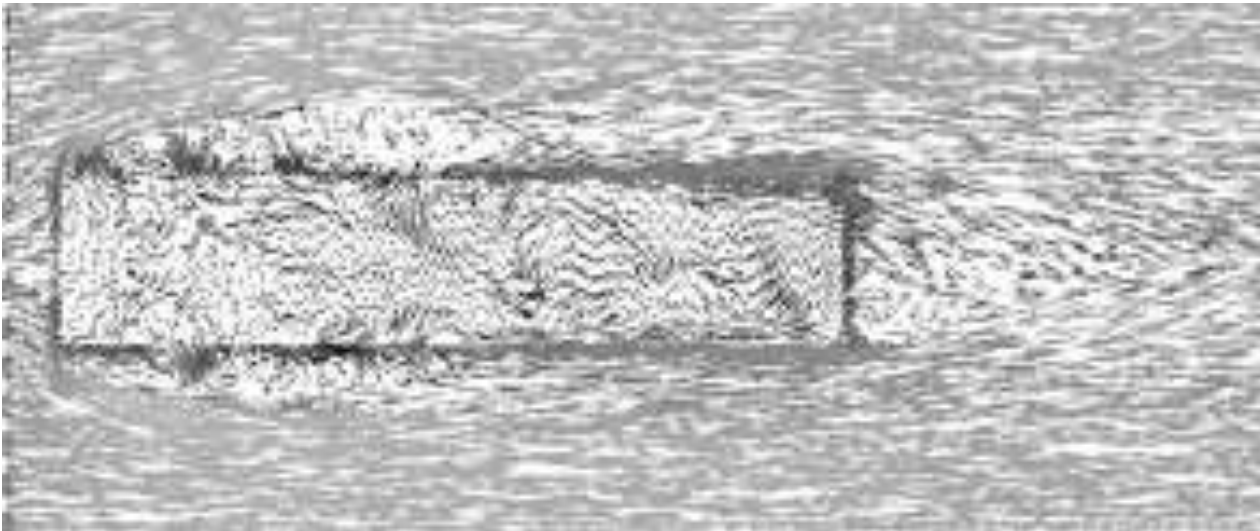
Velocity vectors: Open all windows, two top slots, two rear slots



Vertical center plane.

Through flow : 8 to 17 kg/s
400 - 800 Nm³/min

Aerodynamic drag force :
Up to 28 % less



Horizontal plane at mid-plane of windows.

- ★ More studies in progress
- ★ Low-floor bus
- ★ Enhanced thermal comfort; convection only, no radiation
- ★ Extendable to particle (dust) and virus dispersion.

Concluding remarks

- ◇ Considerable experience in bus ventilation with open windows.
- ◇ Potential for enhanced thermal comfort, and drag reduction.
- ◇ Considerably enhanced ventilation:
 - ◇ can disperse virus
 - ◇ can develop seating plan that minimizes exposure to virus
- ◇ No major changes to bus body structure.
- ◇ Further studies are needed.
- ◇ Extendable to railway coaches.

Public Transport
for Sustainability

Thank you.