

# Fire Safety Engineering Workshop Session III B: Case Studies of Fire Safety of Underground Commercial Buildings

Dr. Monideep Dey

 **Deytec, Inc.**

*Quality Fire Safety Management*

Presented at the Fire Safety Engineering Workshop at Sichuan Fire  
Research Institute, May 26, 2015, Chengdu, China

© Deytec, Inc. 2015. All rights reserved.

This document is copyrighted. It is the intellectual property of Deytec, Inc. It may not be reproduced, distributed, published, presented to or used by any other individual or organization other than within the Sichuan Fire Research Institute, for any purpose whatsoever unless written permission is obtained from Deytec, Inc.

Copyright  
Deytec, Inc., 2015

Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China

# Case Studies

- Case Study 1: Underground Pedestrian Street – China University of Mining & Technology
- Case Study 2: Larger-Scale Commercial Spaces in Underground Mass Rapid Transit Stations in Singapore

# Goal

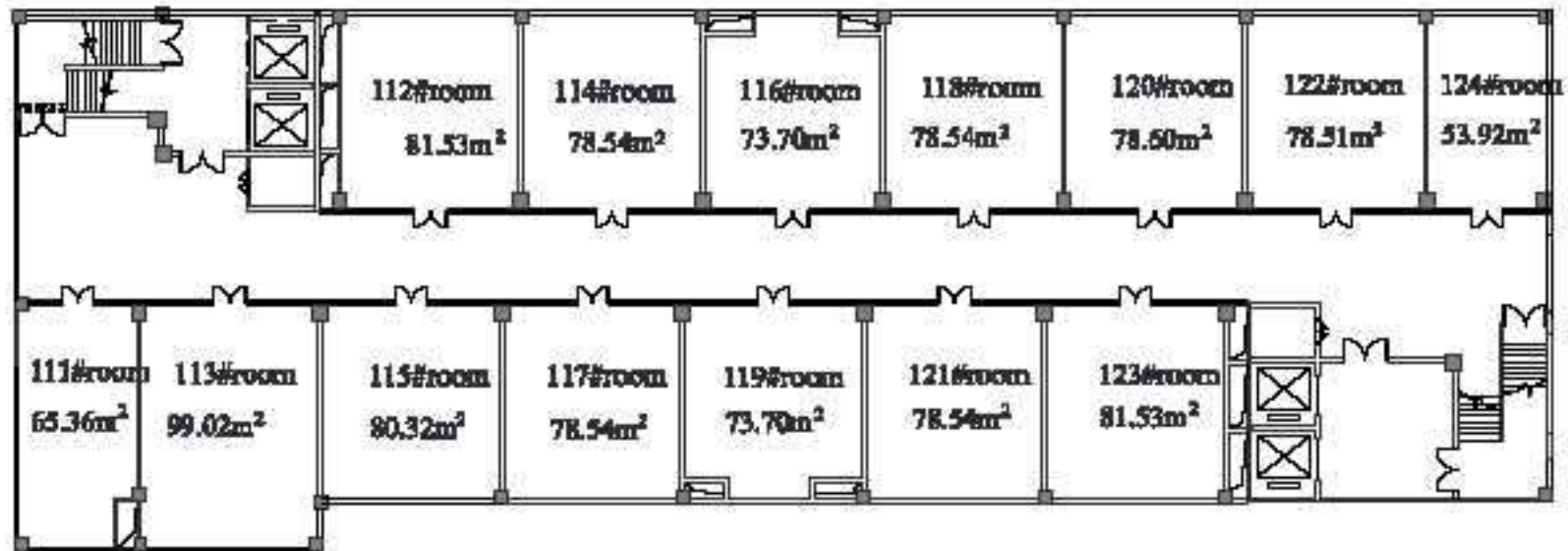
- Present case studies for underground commercial buildings
- Present issues & critique of case studies
- Discuss special considerations for fire safety of underground commercial building
- Recommendations to SCFRI for developing technology base for tall building fire safety

# Case Study 1

## Underground Pedestrian Street

- Need for underground commercial buildings:
  - City & population growth
  - Availability of urban land for development
- Unique aspects of underground buildings
  - Large quantity of combustible materials
  - Fire loading
  - Evacuation population

# Case Study I



Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China

# Project Overview

- 4 evacuation stairways
- Fire detection and alarm systems
- Pedestrian design capacity = 855
- 10 mechanical smoke exhausts in walkway

# Evacuation Assessment

- Assumed occupant attributes
- Building-Exodus to calculate travel time
  - Complete evacuation in 183 s
- $RSET = T_d + T_{pre} + T_t = 454.6 \text{ s}$



# Smoke Flow Analysis

- Assume water sprinkler in Room # 119 non-functional & room goes to flashover
- Maximum heat release rate = 3367 kW
- Assumed tolerance limits for:
  - Smoke temperature
  - CO
  - Visibility

# Smoke Flow Analysis

- Used FDS to calculate the following conditions in 500 s:
  - Smoke temperature < 60 C
  - CO < 500 ppm
  - Smoke visibility > 10 m

# Smoke Flow Analysis

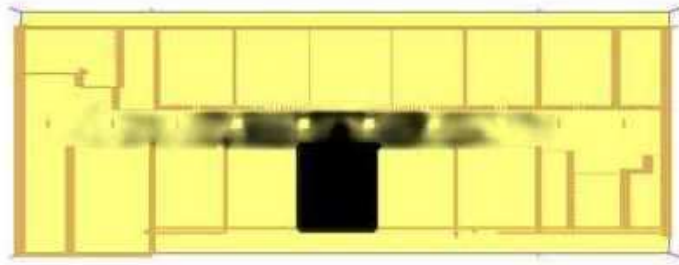


Fig.4 smoke distribution at 400 s

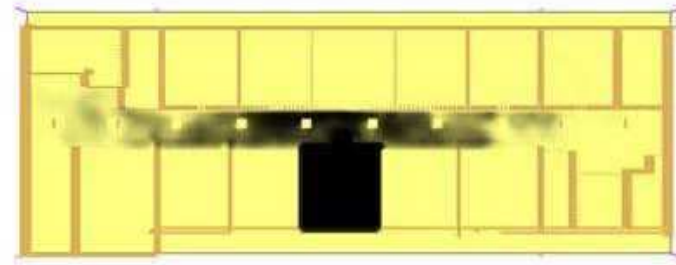


Fig.5 smoke distribution at 500 s

Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China

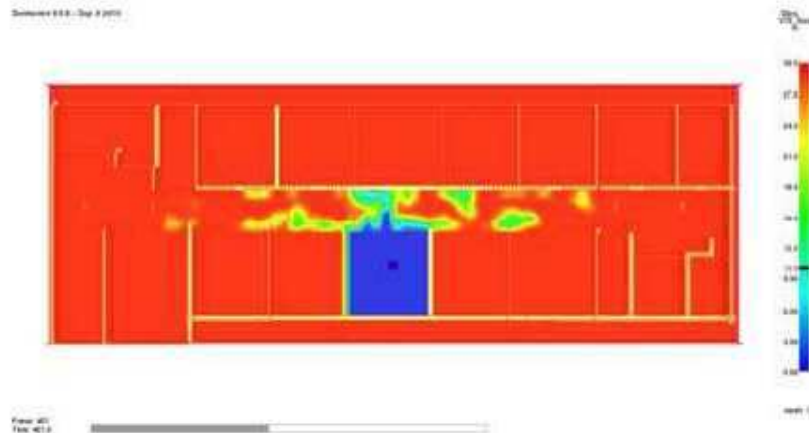


Fig.8 smoke visibility at 400 s

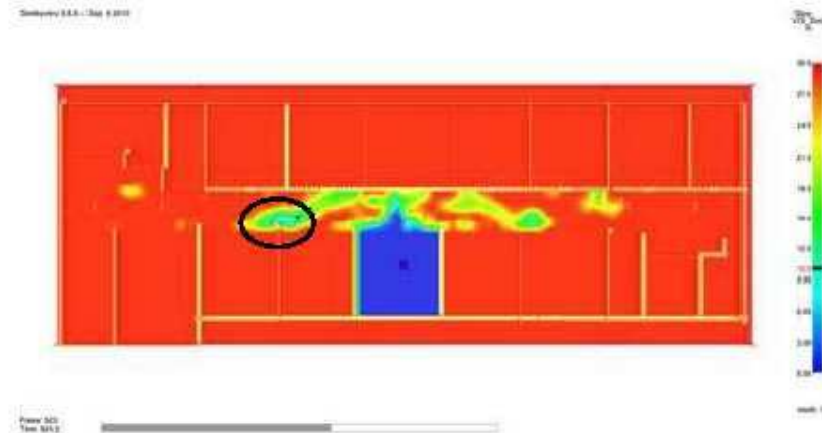


Fig.9 smoke visibility at 500 s

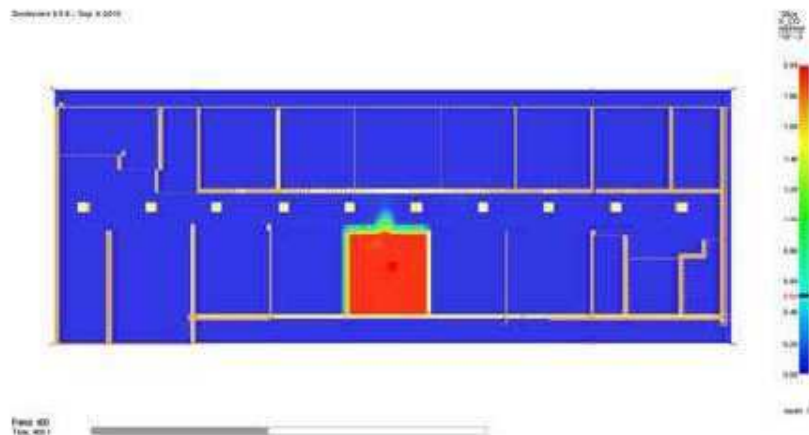


Fig.10 CO volume fraction at 400 s

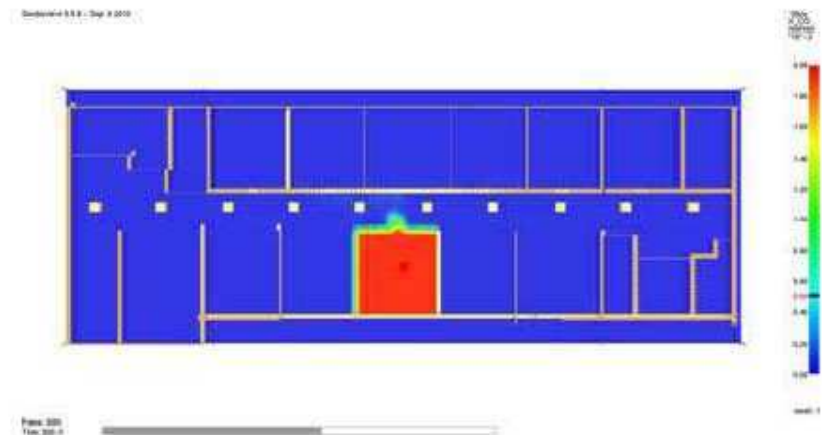


Fig.11 CO volume fraction at 500 s

Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China

# Conclusions of Case Study

- T-aset (500s) > T-rset (454.6 s)
- Accurate prediction of:
  - Smoke movement
  - Evacuation of people
- Level of evacuation safety scientifically defined

# Critique of Case Study

- Models used in study must be validated for all parameters predicted and used in safety analysis
- Blind validation pursuant to ISO 16730-1 highly recommended
- Movement of smoke and temperature generally accurate
- Prediction of CO and visibility difficult for under ventilated fires

# Special Considerations for Commercial Underground Buildings

- Advanced sprinkler systems
- Advanced detection & alarm system
- Fire fighter access
- Life cycle management
- Inspection, testing, & maintenance

# Special Considerations for Commercial Underground Buildings

- Integration of Systems
- Systems reliability
- Defense in depth
- Eliminate single point failures
- Information system



# Recommendations to SCFRI

- Use ISO 23932 to develop safety requirements for underground buildings
  - Specific safety objectives, functional requirements & performance criteria for underground buildings
  - Special designs scenarios & design fires with ISO 16733-1
  - Special engineering analysis & assessment with performance criteria

# Recommendations to SCFRI

- Benefit of ISO FSE standards is to address special features & requirements
- Need to validate calculation methods
- Special considerations must be overlaid over fire safety engineering analysis
- Fire safety engineering provides process to identify key hazards and engineering understanding

# Case Study II – Underground Commercial Buildings

- Large scale commercial spaces in underground mass rapid transit stations
- Prescriptive requirements limit commercial spaces in stations
  - 100 m<sup>2</sup> for shop
  - 15 m<sup>2</sup> for kiosk

# Case Study II

- Whole commercial floors allowed:
  - On floor above station floor
  - Fire separated from station floor
- Larger spaces in station studied using PB approach
- 3 stations evaluated by Task Force
- Planned to develop guide for similar commercial spaces in future

# Case Study II

- Stakeholders involved:
  - Land Transport Authority (LTA)
  - Fire Safety Department (authority)
  - Private corporations in charge of spaces
- Fire safety objectives:
  - Safeguard people from injury or death due to fire in station
  - Safeguard occupants during evacuation

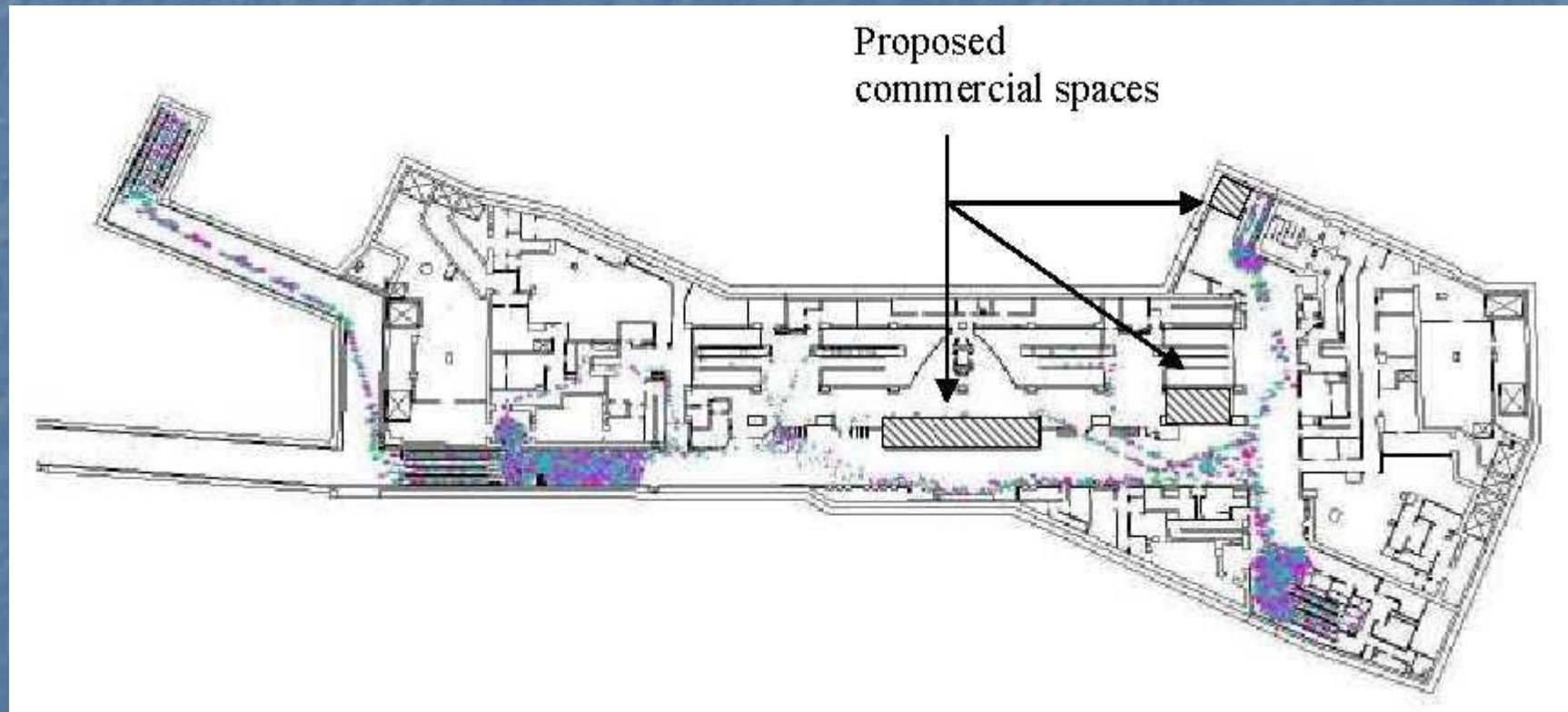
# Case Study II

- Fire safety objectives:
  - Facilitate activities of emergency personnel
  - Prevent spread of fire to adjacent buildings
- Root & sub-objectives:
  - Occupants must reach safe place before untenable conditions
  - Provisions for adequate time for occupant escape

# Case Study II

- Safety measures in original design:
  - Automatic sprinkler system in commercial spaces
  - Automatic fire detection in public areas
  - Smoke purging for public areas & corridors
  - Dry riser systems for fire brigade
- Design fire in one of added commercial spaces

# Evacuation Modeling



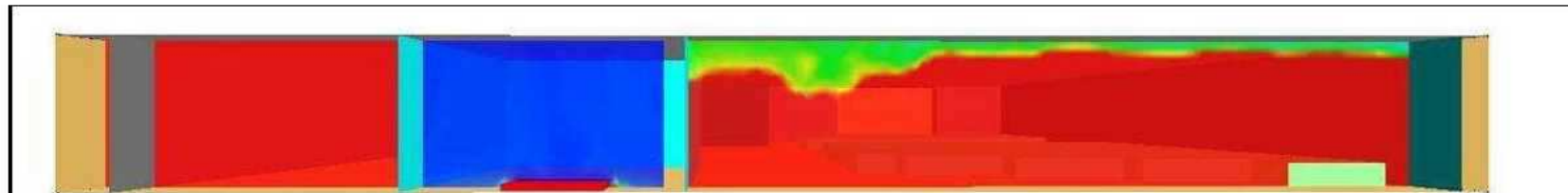
Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China



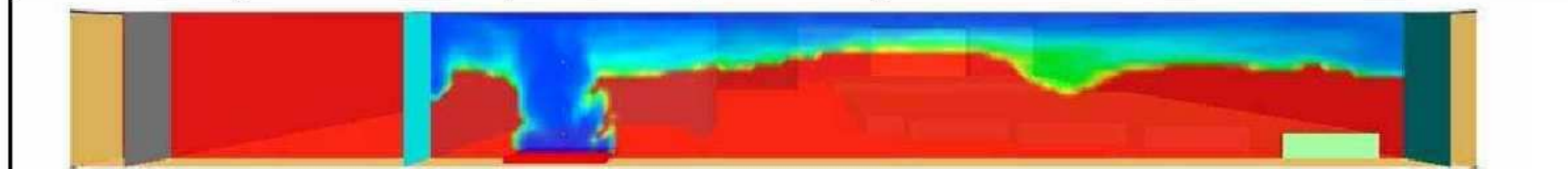
# Case Study II

- STEPS evacuation model used for base & proposed design
  - Some change in flow pattern
  - Modeling showed evacuation times unaffected
- FDS used to study smoke flow
  - Low ceilings heights
  - Enclosed limited space
  - Difficult to maintain visibility for evacuation

# Smoke Movement



Active fire separation activating successfully – Visibility slice taken at 3 minutes



Failure of active fire separation system – Visibility slice taken at 2.3 minutes when visibility required for way-finding is exceeded



Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China

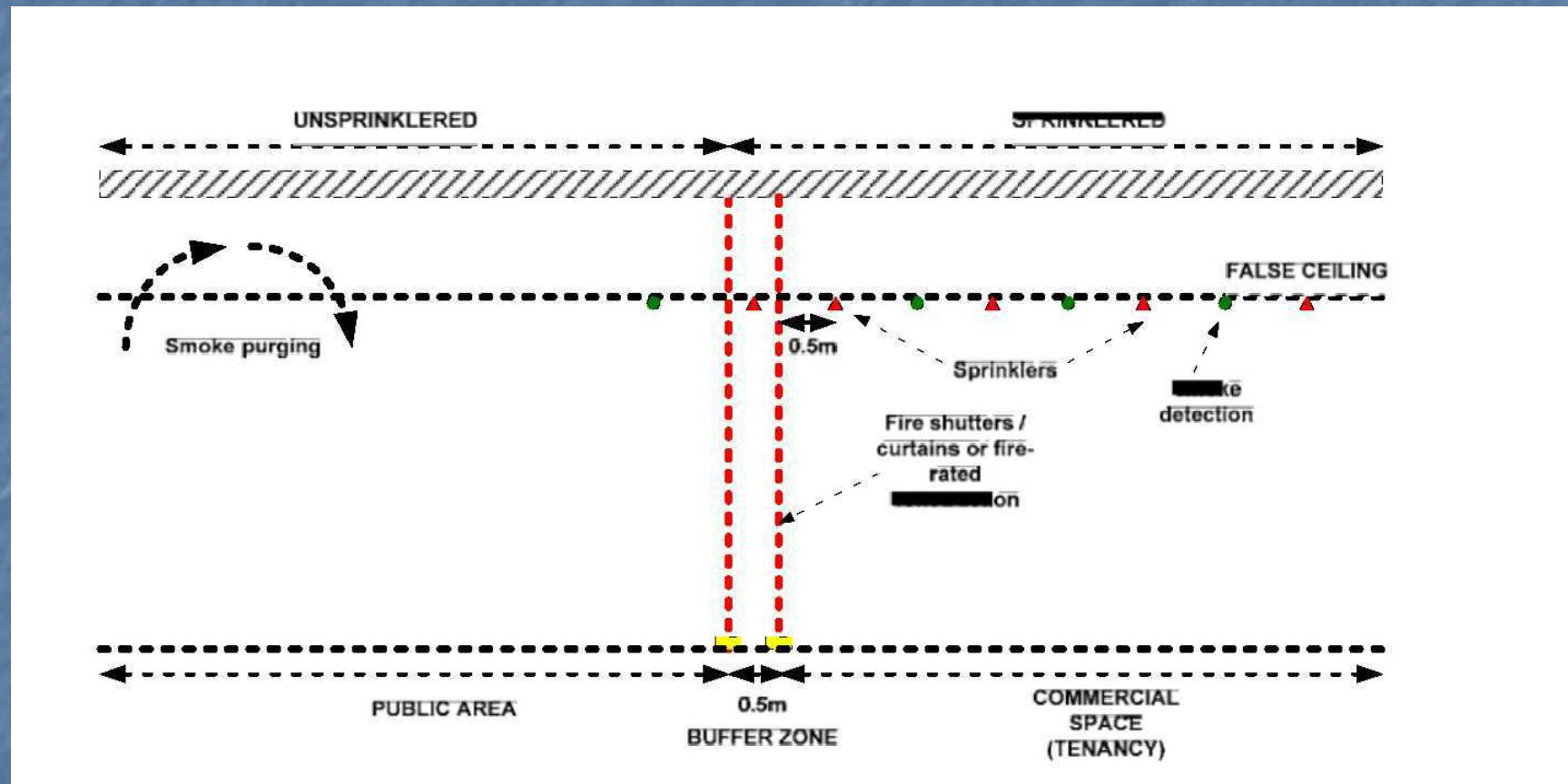
# Design Features Implemented

- Implementation of smoke control difficult in already built stations
- Fire separation between commercial & public areas examined
- Failure scenarios examined to determine important features
  - Fire separation
  - Fire detection

# Design Features Implemented

- 50 % of shop open to outer space
- Stacking of goods outside shop was concern
- Design decisions
  - 2<sup>nd</sup> layer of fire separation
  - Increase maintenance & inspection
  - Prevent single failure of component that can have major impact

# Final Design Concept



Presented at the Fire Safety  
Engineering Workshop at  
Sichuan Fire Research Institute  
May 26-27, 2015, Chengdu, China

# Fire Safety Management

- No merchandise permitted beyond line of tenancy
- Line of tenancy clearly marked
- All trades & services limited to those in approved list
- 3-monthly testing & maintenance schedule
- Fire safety management procedure documented in O&M manual

# For Future Stations

- Use engineered smoke control system
- Guideline developed for PB design
  - Size of commercial space
  - Location within station/impact on evacuation
  - Occupant load for evacuation analysis
  - Use of alternative systems to fire separation

# Recommendations to SCFRI

- Use ISO 23932 to develop safety requirements for underground buildings
  - Specific safety objectives, functional requirements & performance criteria for underground buildings
  - Special designs scenarios & design fires with ISO 16733-1
  - Special engineering analysis & assessment with performance criteria



# Recommendations to SCFRI

- Benefit of ISO FSE standards is to address special features & requirements
- Need to validate calculation methods
- Special considerations must be overlaid over fire safety engineering analysis
- Fire safety engineering provides process to identify key hazards and engineering understanding

# Questions

- Comments and discussion
- Thank you
- Contact Information:
  - [deytec@frontiernet.net](mailto:deytec@frontiernet.net)
  - [www.deytecinc.com](http://www.deytecinc.com) or [www.linkedin.com/pub/dr-monideep-dey/1b/94/a13](https://www.linkedin.com/pub/dr-monideep-dey/1b/94/a13)