EVACUATION CONDITIONS IN SUBWAY STATIONS WITH PLATFORM SCREEN DOORS

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INDEX

1.- Introduction.

2.- Subway stations.
   2.1. Cut & Cover stations.
   2.2. Cavern stations.

3.- Modeling of the fire event.
   3.1. HRR curve of the fire.
   3.2. Model for Cut & Cover and Cavern stations with Pyrosim.
   3.3. Ventilation strategy.

4.- Fire and evacuation simulations.
   4.1.- Cut & Cover stations.
   4.2.- Cavern stations.

5.- Conclusions
1.- Introduction

- Fire safety in subway stations → Big concern.

- Arson attacks in subway trains.
  - Firestarr Project → arson stated as the main cause of fire in rail and subway trains.
  - UK data: 2,911 fires in trains (from 1992 to 2000), 77,8% of which involving passenger trains → 56% due to arson attacks.

- Platform Screen Doors (PSD) → Effect on evacuation and safety?
1.- Introduction

- Platform Screen Doors (PSD).
2.- Subway stations

- Two kinds of stations considered in this study:
  
  - Cut & Cover stations.
    
    Their main feature is their big volume Escalators, stairs in the platform.
    Total volume: 135m (long) x 25.5m (wide) x 6.75m (high).
    Platform’s surface: 135m (long) x 9m (wide).

  - Cavern stations.
    
    Less volume than C&C Escalators, stairs in access shaft and connected to the platform through passageways.
    Total volume: 135m (long) x 17m (wide) x 6m (high).
    Platform’s surface: 135m (long) x 4.25m (wide).
2.- Subway stations

2.1.- Cut & Cover

- Cut & Cover station: Crossrail Paddington (London, UK)
2.- Subway stations

2.1.- Cut & Cover

- Cut & Cover station: Crossrail Paddington (London, UK)
2.- Subway stations

2.2.- Cavern

- Cavern station: design concept of Cavern stations in Line 6 subway in Santiago, Chile
2.- Subway stations

2.2.- Cavern

- Cavern station: Chueca station’s platform in Line 5 (Madrid, Spain)
3.- Modeling of the fire event

3.1.- HRR fire curve

- HRR fire curve: Eureka project → Subway car.
3.- Modeling of the fire event

3.2.- Model for C&C and Cavern stations

- Cut & Cover station
3.- Modeling of the fire event

3.2.- Model for C&C and Cavern stations

- Cavern station
3.- Modeling of the fire event
3.3.- Ventilation strategy

- Strategy A: with PSD
  - Exhaust ventilation from the station: 83.3 m3/s (CyC), 61.1 m3/s (Cavern)
  - Exhaust ventilation from the tunnel: 87.5 m3/s
  - It makes compatible exhausting from the station and from the tunnel simultaneously.

- Strategy B: without PSD
  - Exhaust ventilation from the tunnel: 87.5 m3/s.
  - Exhausting from the station and from the tunnel → not a good idea.
3.- Modeling of the fire event

3.3.- Ventilation strategy

- Strategy A: station in M5 subway line in Milan (Italy).
4.- Fire and evacuation simulations

- Fire simulation: reference standard NFPA 130
  - Visibility: 10m (doors, walls).
  - Temperature: threshold time for incapacitation.
  - CO concentration: threshold time for incapacitation.

<table>
<thead>
<tr>
<th>Exposure temperature (°C)</th>
<th>Without incapacitation (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>3.8</td>
</tr>
<tr>
<td>75</td>
<td>4.7</td>
</tr>
<tr>
<td>70</td>
<td>6</td>
</tr>
<tr>
<td>65</td>
<td>7.7</td>
</tr>
<tr>
<td>60</td>
<td>10.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Exposure CO content (ppm)</th>
<th>Without incapacitation (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>A few seconds</td>
</tr>
<tr>
<td>1150</td>
<td>6</td>
</tr>
<tr>
<td>450</td>
<td>15</td>
</tr>
</tbody>
</table>
4. Fire and evacuation simulations

4.1. Cut & Cover stations

- Model created with Pyrosim.

- Means of egress on each platform:
  - Emergency door on the right side.
  - Escalator + stairs on the right side.
  - Escalator + stairs on the left side.
  - Emergency door on the left side.
4.- Fire and evacuation simulations

4.1.- Cut & Cover stations

- Development of the fire.
  - The fire starts on the last carriage on the right.
  - Each carriage is connected to each other.
  - Each carriage has 6 windows, 3 per side, which break out when $T=470^\circ C$. 

![Graph of average temperature in a vandalized carriage](image-url)
4.- Fire and evacuation simulations

4.1.- Cut & Cover stations

- Development of the fire.
  - Buoyancy: the smoke heads toward the upper part of the station (no PSD).
  - Figure: Temperature levels (t=6min, 80ºC in bold).
4.- Fire and evacuation simulations

4.1.- Cut & Cover stations

- Development of the fire.
  - Highest T users face: 80°C in the stairs (no PSD), 80°C close to PSD (with PSD).
  - Visibility: great differences, especially in front of the vandalized carriage.
4.- Fire and evacuation simulations

4.1.- Cut & Cover stations

- Development of the fire.
  - Visibility: great differences all along both platforms during the fire.

![](chart.png)

- % of platform where visibility < 10m

- Time (min)
- Percentage (%)
4.- Fire and evacuation simulations

4.1.- Cut & Cover stations

- Evacuation simulation with Pathfinder.
  - Occupation load: 380 passengers per platform, 60 passengers in the train.
  - Time to react: variable.
  - Smoke makes passengers move slower.
  - Escalator on the right side on the most affected platform: out of service.
  - Similar time needed for evacuation: 140s (with PSD) and 148s (without PSD).

- Passengers react quickly, low occupation load barely affected.
- Harsh conditions: only without PSD, on the stairs.
4.- Fire and evacuation simulations

4.2.- Cavern stations

- Model created with Pyrosim.

- Means of egress on each platform:
  - An emergency door on each side of the platform.
  - Two passageways.
4.- Fire and evacuation simulations

4.2.- Cavern stations

- Development of the fire.
  - The same conditions as in C&C stations.
4.- Fire and evacuation simulations

4.2.- Cavern stations

- Development of the fire.
  - Buoyancy: the smoke heads toward the upper part of the station (no PSD).
  - Figure: Temperature levels (t=6min, 80°C in bold).
4.- Fire and evacuation simulations

4.2.- Cavern stations

- Development of the fire.
  - Highest T users face: 80ºC in the stairs (no PSD), 80ºC close to PSD (with PSD).
  - Visibility: great differences, especially in front of the vandalized carriage.
4.- Fire and evacuation simulations

4.2.- Cavern stations

- Development of the fire.
  - Visibility: great differences all along both platforms during the fire.

![Graph showing visibility percentage over time with and without PSD.](image-url)
4.- Fire and evacuation simulations

4.2.- Cavern stations

- Evacuation process with Pathfinder.
  - Occupation load: 380 passengers per platform, 60 passengers in the train.
  - Time to react: variable.
  - Smoke makes passengers move slower.
  - Escalator on the right side on the most affected platform: out of service.
  - Similar time needed for evacuation: 121s (with PSD) and 116s (without PSD).

- Passengers react quickly, low occupation load barely affected.
- Harsh conditions: only without PSD.
5.- Conclusions

- Occupation load: key factor.
- PSD offer better evacuating conditions.
- PSD make compatible exhaust from tunnel + station.
- Time for detection: great relevancy.