

Experimental Study the Impact of Visibility on Individual Ascent Speed in Stair

Evacuation Case Studies and Evacuation Data

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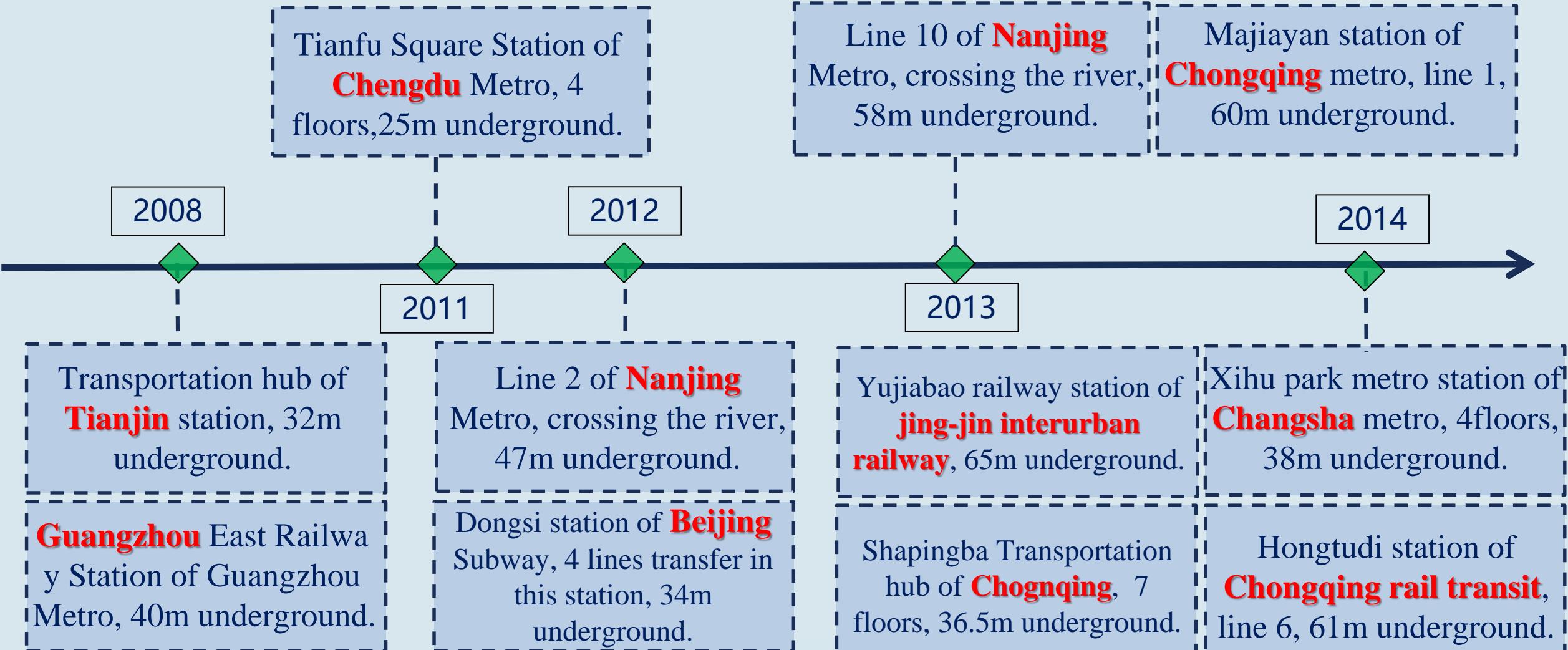


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CONTENT

- Research background and significance
- Experiment and analysis method
- The Results and Discussion
- Conclusion

1. Research background and significance



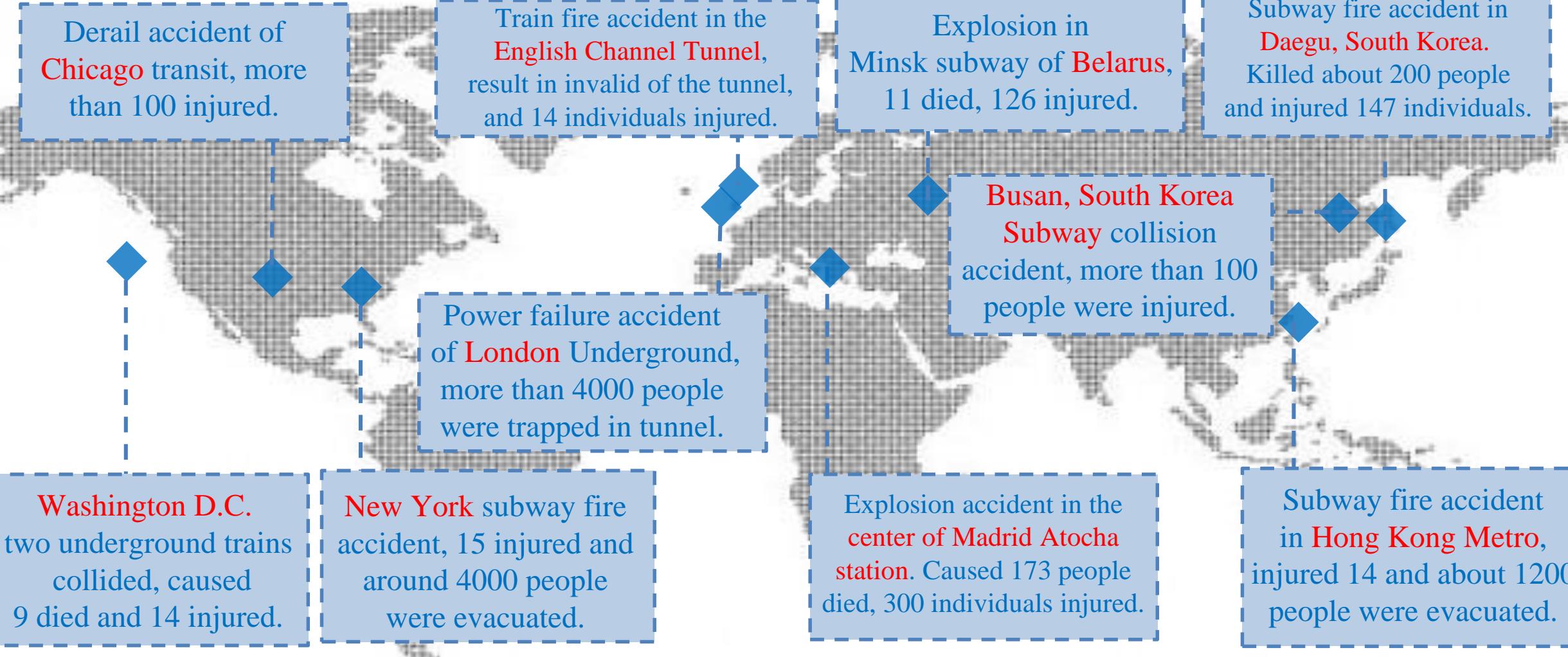
1. Research background and significance

Derail accident of **Chicago** transit, more than 100 injured.

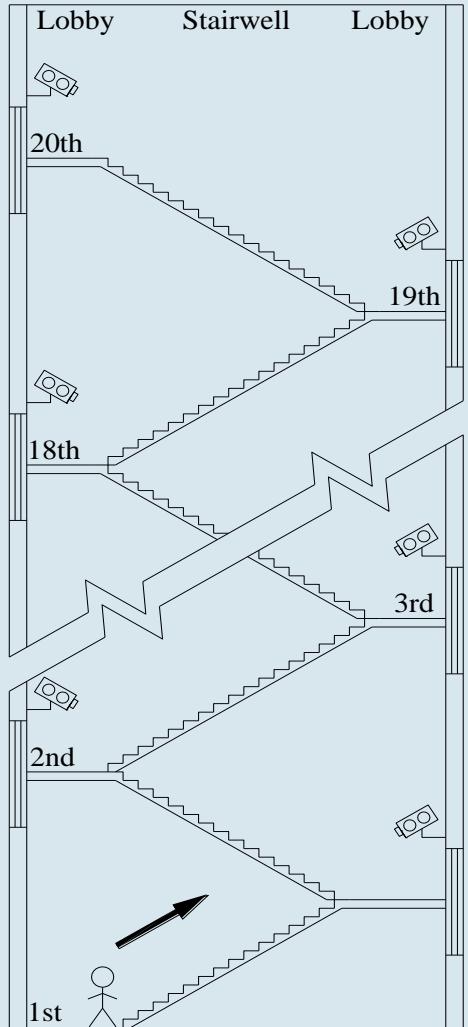
Train fire accident in the **English Channel Tunnel**, result in invalid of the tunnel, and 14 individuals injured.

Explosion in **Minsk** subway of **Belarus**, 11 died, 126 injured.

Subway fire accident in **Daegu**, **South Korea**. Killed about 200 people and injured 147 individuals.

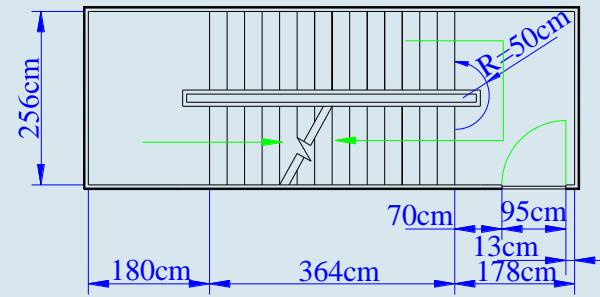


2.Experiment and analysis method

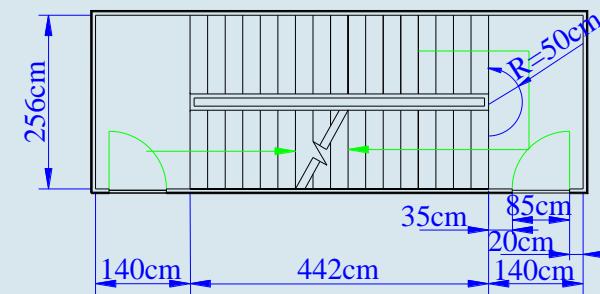


(a) Section diagrammatic of stairwell;

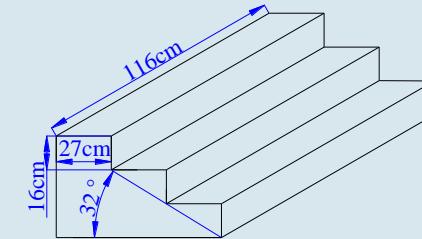
◆ Experiment settings



(b) Plan of stairwell
1-2 (Unit: cm);



(c) Plan of stairwell 1-
2 (Unit: cm);



(d) Size diagrammatic
of step (Unit: cm)

Figure1. The dimension of
the staircase in the study



(a)



(b)

Figure2. The view of the staircase in
lighting-out condition: a on the inside
of the stair; b on the outside of the stair.

2.Experiment and analysis method

◆ Visibility Parameters

◆ Based on lambert-beer law, when the light of wavelength λ go through the smoke:

$$I_\lambda = I_{\lambda 0} \exp(-C_s L)$$

$$T[\%] = \frac{I_\lambda}{I_{\lambda 0}} \times 100 = 100 \times \exp(C_s L)$$



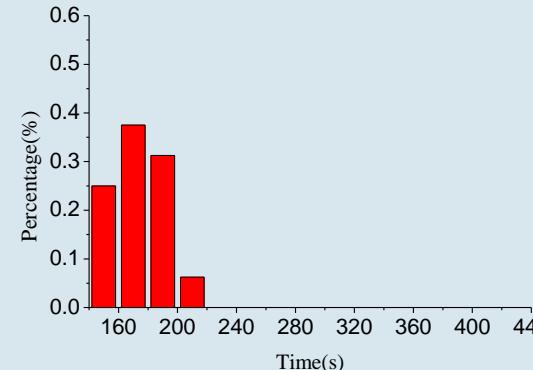
Figure3. People putting on the eye-patch.

Table1. Terms of the evacuation experiment.

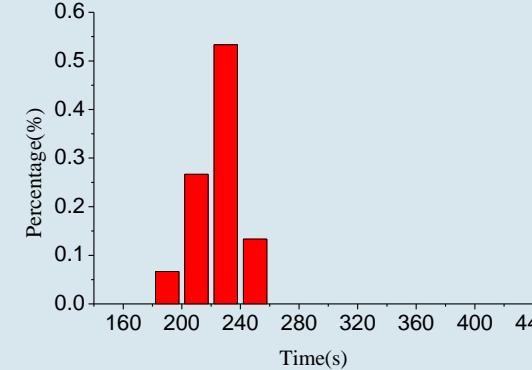
Experiment condition	Condition of lighting system	Condition of eye shield	smoke density	visibility	Male	Female
1	On	-	-	>20m	15	15
2	Off	-	-	—	15	15
3	On	27%	0.13-0.26m ⁻¹	5-10m	15	15
4	On	16%	0.26-0.60m ⁻¹	3-7m	15	15

3.The Results and Discussion

◆ The Probability Distribution of Evacuation Time

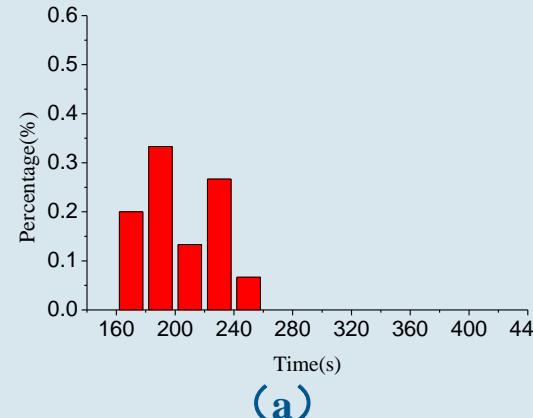


(a)

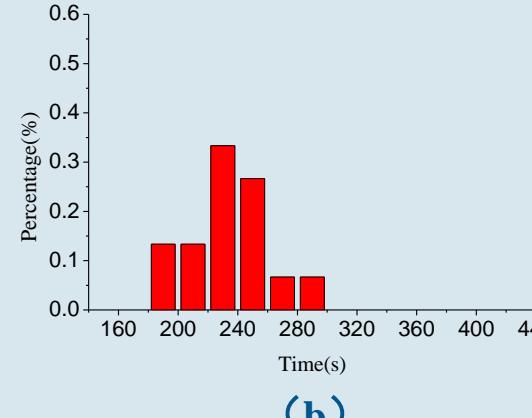


(b)

Figure3. Condition 1:a Male; b female.

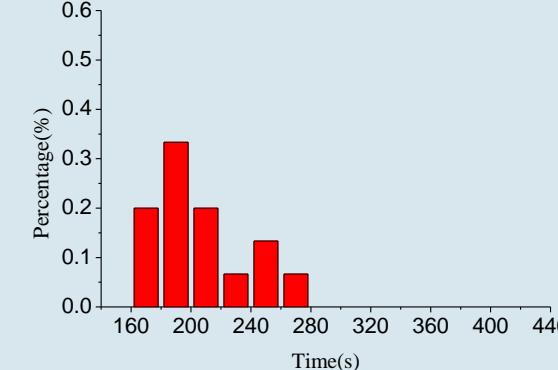


(a)

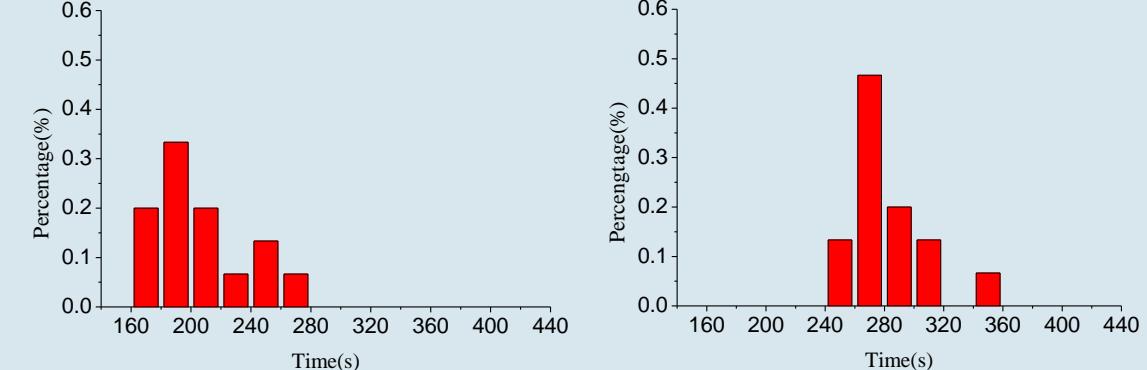


(b)

Figure4. Condition 2:a Male; b female.

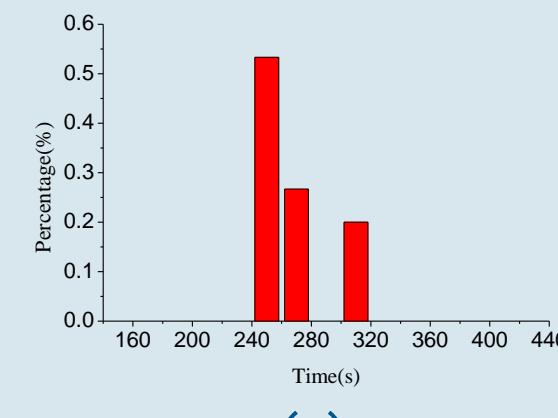


(a)

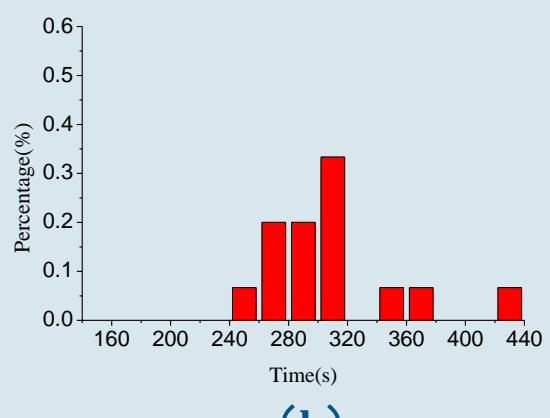


(b)

Figure5. Condition 3:a Male; b female.



(a)



(b)

Figure6. Condition 4:a Male; b female.

3.The Results and Discussion

◆ The Ascent Speed

Table2. Experimental result in Condition 1.

Gender	Max velocity	Min velocity
Male	1.28m/s	0.63m/s
Female	0.97m/s	0.53m/s
Jeon	1.34m/s-1.69m/s	

Table3. Experimental result in Condition 2.

Gender	Max evacuation speed	Min evacuation speed
Male	0.97m/s	0.60m/s
Female	0.82m/s	0.51m/s
Jeon	1.23m/s-1.61m/s	

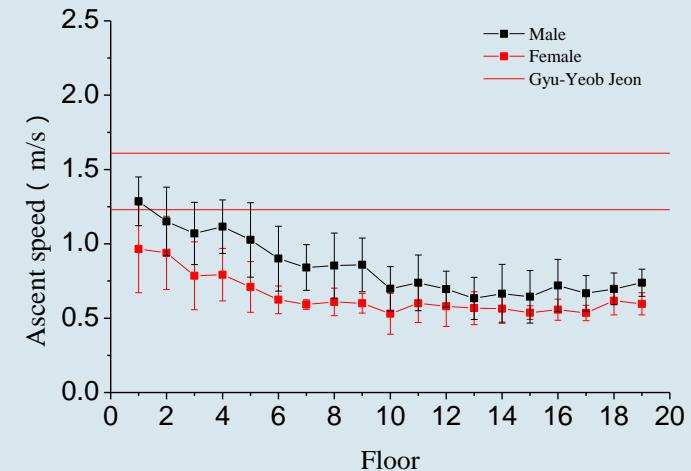


Figure7. Condition 1

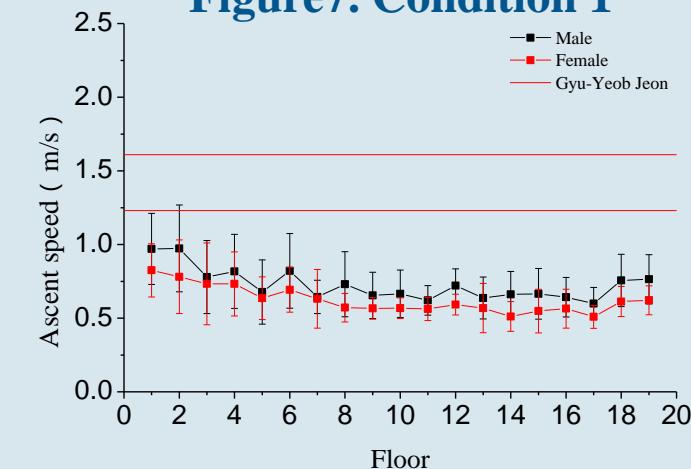


Figure8. Condition 2

3.The Results and Discussion

◆ The Ascent Speed

Table4. Experimental result in Condition 3.

Gender	Max velocity	Min velocity
Male	0.84m/s	0.57m/s
Female	0.55m/s	0.45m/s
Jeon	0.62m/s-0.64m/s	

Table5. Experimental result in Condition 4.

Gender	Max velocity	Min velocity
Male	0.62m/s	0.48m/s
Female	0.55m/s	0.44m/s
Jeon	0.51m/s-0.61m/s	

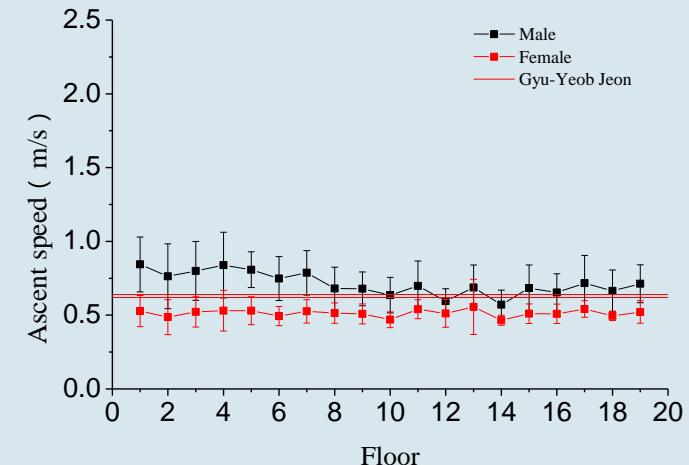


Figure9. Condition 3

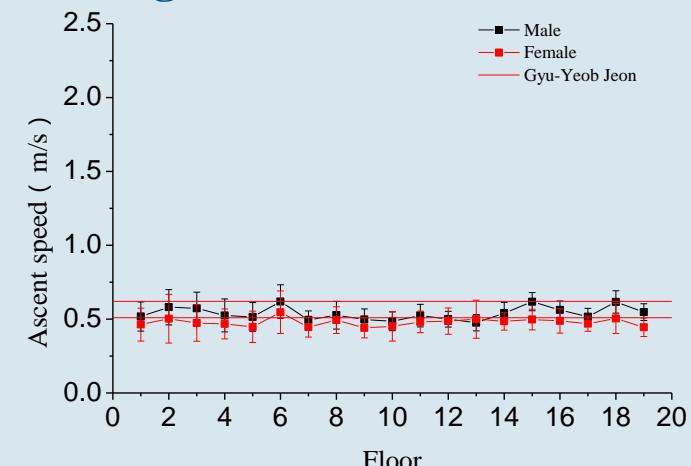


Figure10. Condition 4

3.The Results and Discussion

◆ The Cumulative Average speeds

Table6. Experimental result in Condition 1.

Gender	Max velocity	Min velocity	The difference
Male	1.28m/s	0.79m/s	0.39m/s
Female	0.97m/s	0.62m/s	0.36m/s
Choi	0.75m/s for males and 0.53m/s for females		

Table7. Experimental result in Condition 2.

Gender	Max velocity	Min velocity	The difference
Male	0.97m/s	0.70m/s	0.27m/s
Female	0.83m/s	0.60m/s	0.23m/s

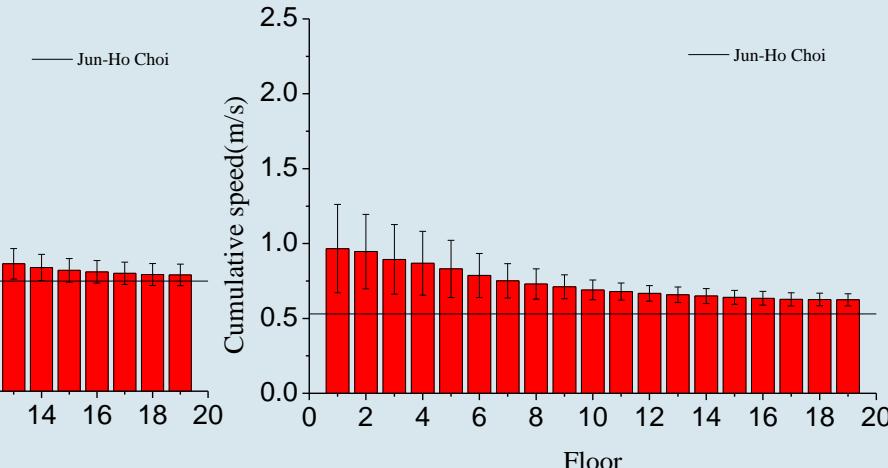
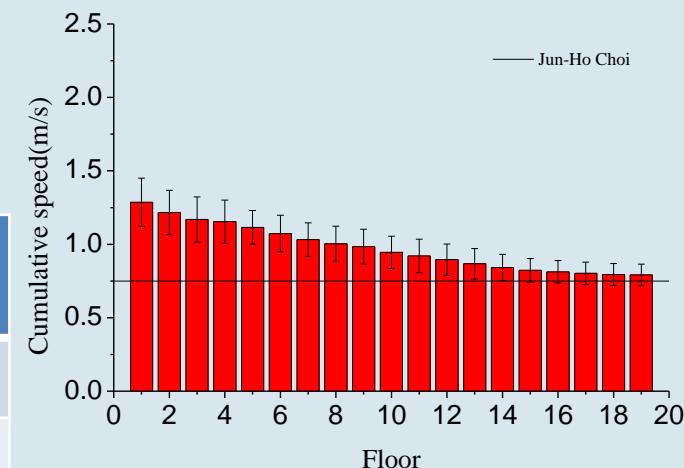


Figure11. Condition 1: a Male; b Female.

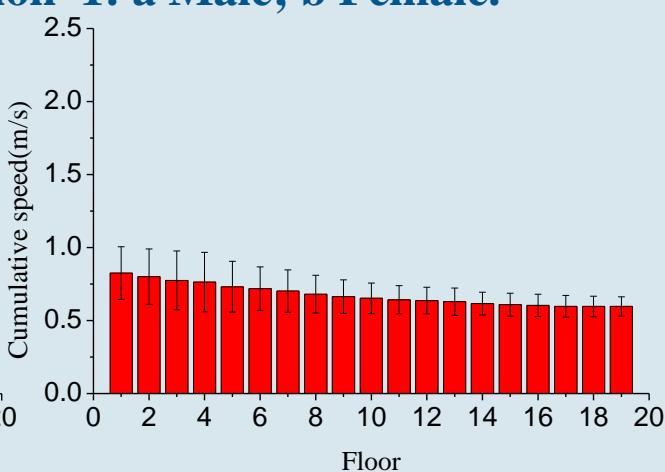
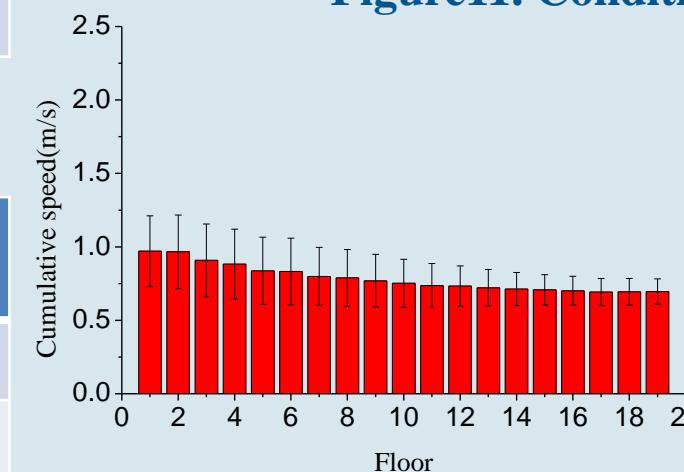


Figure12. Condition 2: a Male; b Female.

3.The Results and Discussion

◆ The Cumulative Average speeds

Table8. Experimental result in Condition 3.

Gender	Max velocity	Min velocity	The difference
Male	0.84m/s	0.69m/s	0.15m/s
Female	0.55m/s	0.46m/s	0.06m/s

Table9. Experimental result in Condition 4.

Gender	Max velocity	Min velocity	The difference
Male	0.55m/s	0.52m/s	0.03m/s
Female	0.47m/s	0.46m/s	0.01m/s

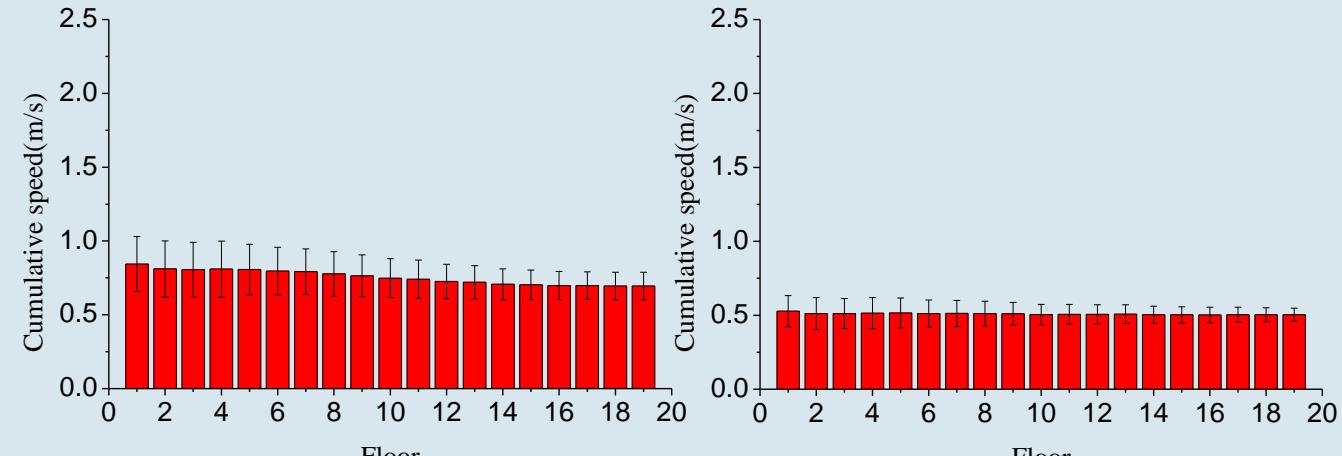


Figure13. Condition 3: a Male; b Female.

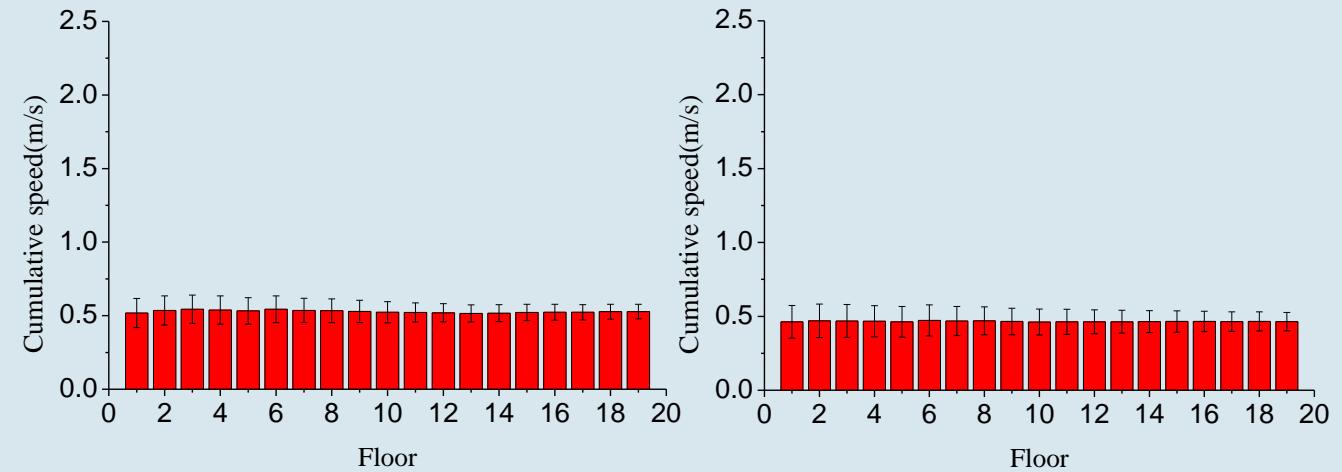


Figure14. Condition 4: a Male; b Female.

3.The Results and Discussion

◆ The Ratio of Handrail Utilization

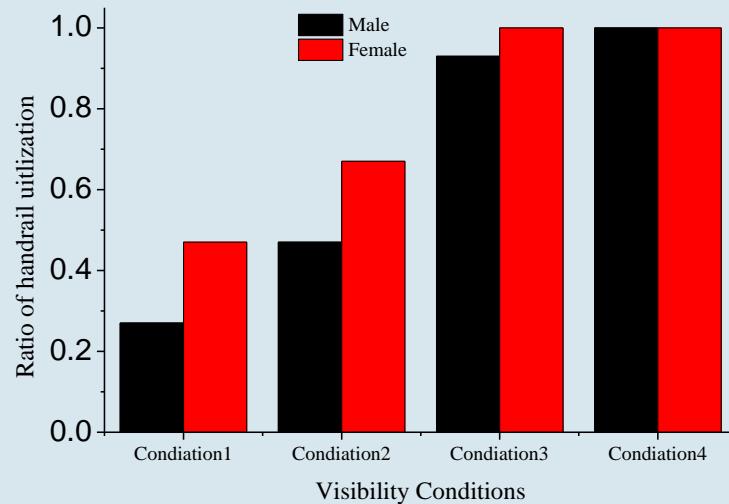


Figure15. The ration of handrail utilization

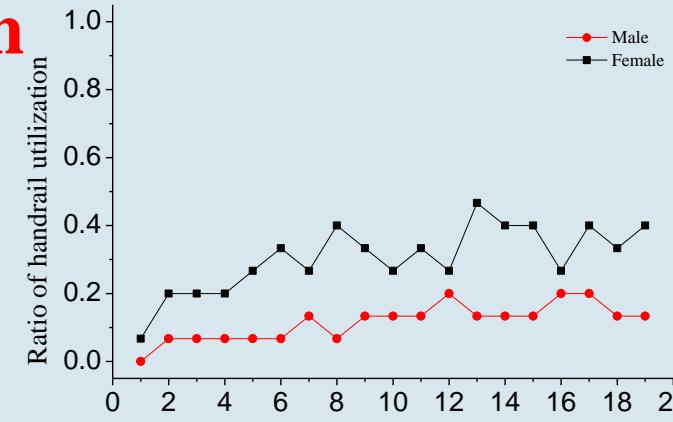


Figure16. Condition 1

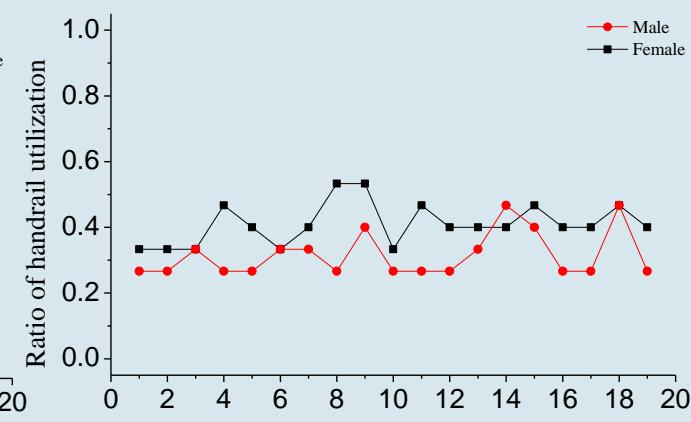


Figure17. Condition 2

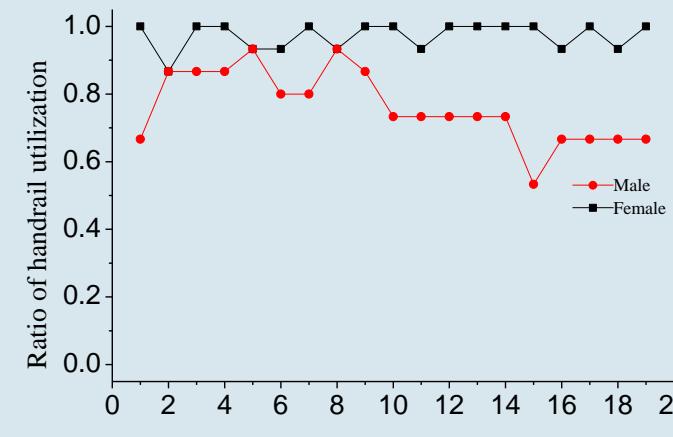


Figure18. Condition 3

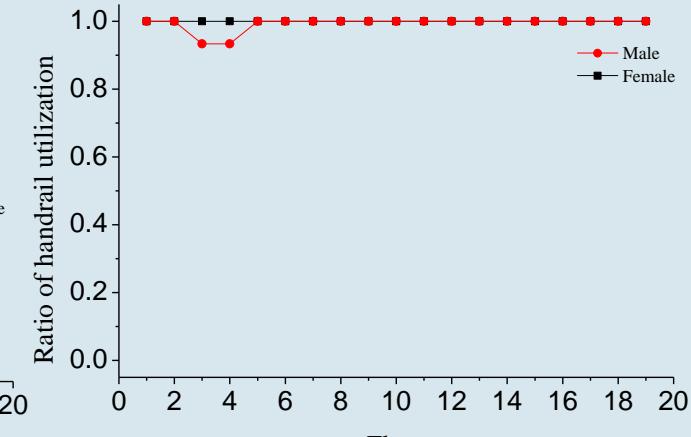
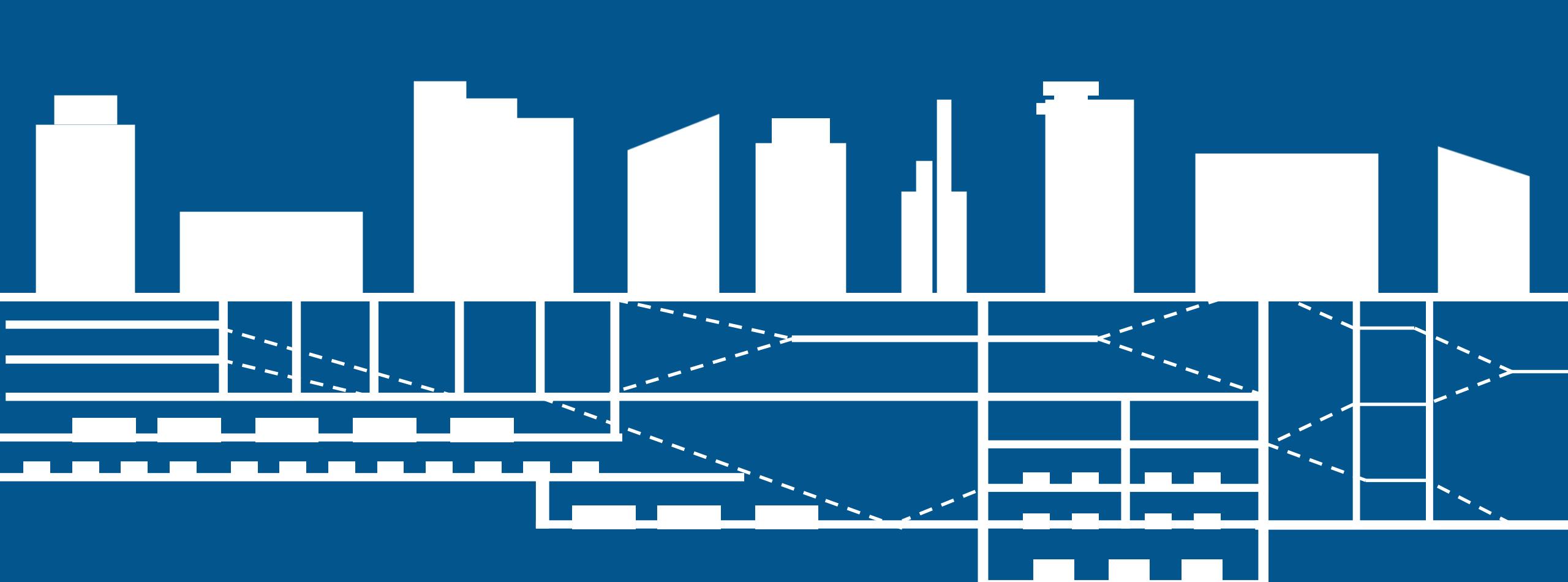


Figure19. Condition 4

4. Conclusions

- ◆ In the condition of changes in visibility by indoor ordinary lights, males' and females' ascent speeds showed a steady trend after the first decrease. In the condition of changes in visibility by smoke, males' and females' ascent speeds showed no obvious changes with the ascending floors.
- ◆ Participants were likely to use the handrail throughout the upward movement. In Condition 1 and Condition 2, participants used the handrail in upward movement process as physical exertion. In Condition 3 and Condition 4, participants used handrail to identify the direction of movement..
- ◆ Females were likely more affected by the visibility of the stairs than males, and males' ability to adapt to the environment were superior to females'.



Thank You !