Simulating Passenger Train Evacuations Using a Rescue Ladder

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For **safe** and **quick** evacuation
Crews must **evacuate passenger** for the safe place.
Great East Japan Earthquake

Successful Evacuation

No Casualties

The vehicle which was spread in tsunami

Signboard indicating shelter

Hazard map in coastal areas

Growing disaster prevention awareness
Current Status and Issues

Premise of Evacuation

\[ T > t = t_1 + t_2 \]

- **\( T \):** Time to be dangerous
- **\( t \):** Evacuation time
- **\( t_1 \):** Required for get off
- **\( t_2 \):** Required for reach for shelters

An **index of the time** required for getting off a train is necessary

**How much time** for getting off the train would take
Purpose

- Clarify the time required for passengers to leave the train
- Examine the method to getting off the train safely and quickly

Judgment material in case of the evacuation
Consideration by the “Multi-Agent Simulation”

\[ P_{\text{new}} = P + v \cdot \frac{\vec{v}_i + (\vec{E}_i - \vec{F}_i) \cdot dt}{\| \vec{v}_i + \vec{E}_i \cdot dt \|} dt \]

- \( P \): Position
- \( v \): Free walking speed
- \( E \): Attractive force
- \( F \): Repulsive force
Simulation Model

Considered Vehicle

Series E127

Seating capacity: 120
Length: 20 m
Width: 2.8 m

Numerical analysis by the software “Artisoc”
Experiment ① Evacuation Speed

The average speed at the ladder

\[ v \approx 0.15 \, (m/s) \]

Building a simulation model based on this result
Simulation ① Evacuation Speed

Congestion rate 100%: 17 minutes
Congestion rate 50%: 8 minutes

Clarification of the evacuation time
Experiment Posture at the Ladder

Forward-looking posture  Backward-looking posture

\[ v_f \approx 0.20 \text{ (m/s)} \] \[ v_b \approx 0.10 \text{ (m/s)} \]

Simulation Pattern
1. All passengers face forward-looking
2. All passengers face backward-looking
3. Random
Simulation ② Posture at the Ladder

Forward-looking posture takes less time

The evacuation time can be shortened by 20%
Overview of the considered train. (Series E127)

Position of the ladder
1. Head of the train
2. Side of the train

Simulating passenger behavior on the train
Results and Discussion

High population density (3.20 /m$^2$)

Low population density (0.64 /m$^2$)

Head-of-the-train-position reduces congestion near the exit
The evacuation time does not differ with the position of the ladder.

Head-of-the-train-position enables safer evacuation.
Summery

We determined the evacuation time relative to the number of passengers.

The evacuation time can be shortened by 20% when the passengers climb down the ladder facing forward.

It is safer to set up the evacuation ladder at the head of the train.
Thank you for your kind attention