Review of Emergency Egress and Rescue Challenges in Rail Tunnels

Background

The Standard for Fixed Guideway Transit and Passenger Rail Systems, NFPA 130, specifies fire protection and life safety requirements for underground, surface, and elevated fixed guideway transit and passenger rail systems. The current language lacks technical substantiation for distances to point of safety for both 244 m (800 ft) spacing between cross passages, and 762 m (2500 ft) between exits to the surface. Cross passages are tunnels that are constructed between twin tunnel bores in rail and road tunnels to provide alternative means of egress or for operational maintenance purposes. Additionally, the minimum 610 mm (24 in.) emergency walkway widths in NFPA 130 are based upon outdated research, which does not accurately reflect current anthropometric data and limits evacuation to a single file.

Narrow walkway widths and long distances to exit increases egress time, which in some incidents, can increase exposure of passengers to greater levels of heat and toxic gases, which hinder self-evacuation and endanger lives. These conditions present greater challenges to safe evacuation compared to the experience in other public structures. Additionally, the ability of emergency responders to perform rescues in smoke at the 2,500-ft spacing is severely challenging, if not impossible, as their air supply is inadequate to reach evacuees, assist them and return to safety.

Research Goal

Establish a comprehensive understanding of the impact of changing criteria for both exit distances and walkway widths on the probability of egress in rail tunnels, as well as the impact on emergency response capabilities.

Research sponsored by

NATIONAL FIRE PROTECTION ASSOCIATION
The leading information and knowledge resource on fire, electrical and related hazards

Project Tasks

This research project, with technical oversight from the project technical panel, will involve the following tasks:

Task 1: Literature Review

Conduct a literature review that thoroughly assesses and documents the findings on the following issues:

- Task 1.1: Identify and assess tunnel trainway design strategies and requirements for emergency evacuation.
- Task 1.2: Identify and summarize provisions in applicable codes and standards, including but not limited to NFPA 130, NFPA 101, FTA Report No.-0232, and Thematic Network FIT – Fire in Tunnels, that address emergency egress provisions for rail tunnels and document the technical substantiation for existing requirements.

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- Task 1.3: Review guidance and best practices on fire fighting and rescue operations in tunnels. Specifically identify the capabilities and limitations of the fire service and document resources available and needed (air supply limitations, visibility, searching speeds, etc.).
- Task 1.4: Identify, review, and summarize the available technologies to assist responders, e.g., thermal imaging cameras, search aides, emergency evacuation carts, other wheeled transport, or rescue trains. Additionally, review and summarize tunnel operator emergency procedures and training requirements/protocols.

Task 2: Case Study Analysis

Identify, review, and summarize a select number of incident case studies (minimum of five incidents) to identify areas that create challenges for safe egress or emergency response in rail tunnels. These case studies should focus on, but not be limited to the following:

- Tunnel Specifications (where available) including the year the tunnel was constructed, codes or standards referenced at time of construction, tunnel dimensions, walkway widths, emergency egress distances, active and passive fire and life safety systems installed, including signage.
- Firefighter tactics, operations, capabilities, and available resources (air supply, visibility, rescue speeds).
- Passenger Characteristics including unassisted and assisted evacuations and appropriate percentages of the various applicable passenger profiles.
- Quantify the volume of passenger traffic in the rail tunnel, including characterization of bi-directional movement.
- Survivability outcomes, tenability limitations, injuries and fatalities of both civilians and fire service.
- Contributing factors identified in post fire reports.

Deliverable:

- An Interim Report 1 shall be drafted to document the literature review and the case study analysis.

Task 3: Modeling

Using an appropriate evacuation model or set of models, simulate passenger evacuation from a rail tunnel to assess the probability of safe egress for passengers and first responders for a minimum of five scenarios, specified through this task. This task consists of the following sub-tasks:

- Task 3.1: Specify the evacuation modeling platform that will be used to simulate passenger evacuation from a rail tunnel and establish performance criteria to evaluate the model results.
- Task 3.2: Using the information gathered through the previous tasks, define representative fire scenarios and rail tunnel designs for the modeling analysis. Develop representative scenarios to model passenger movement and safe egress. The scenarios should include information found from the literature review and case studies, specifying the tunnel construction specifications, fire protection and life safety systems installed both active and passive, walkway widths emergency egress distances, signage, appropriate passenger characteristics for unassisted and assisted (i.e. children, passenger with special mobility needs or individuals who become disabled during the emergency) passengers, fire and tenability characteristics. First responder characteristics (e.g., delay in moving against the flow of traffic, SCBA limitations, etc.) should also be considered. Provide justification for the selected scenarios to be implemented in the modeling plan.
- Task 3.3: Develop a modeling plan to predict the impact of varying exit distances and walkway widths on the probability of egress in rail tunnels. The modeling plan should include at least five simulations. The selected

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model should be identified, in addition to defining model geometry, variable and other relevant model parameters. The models should apply the scenarios prescribed in Task 3.2.
- Task 3.4: Implement Modeling. Implement the modeling plan, prescribed in the previous tasks.
- Task 3.5: Analyze Modeling Results. Analyze modeling results against the established performance criteria and summarize key findings and recommendations.

Deliverables:
- An Interim Report 2 shall document the performance criteria, selected scenarios, and the modeling plan. This shall be reviewed with the project technical panel prior to the implementation of the modeling plan.
- Interim Draft Report 3 shall be developed to document the results of the modeling analysis in Tasks 3.4. and 3.5. The results shall be reviewed with the project technical panel.

Task 4: Comparative Analysis
Using the tunnel evacuation distances and emergency walkway widths specified in the latest editions of the applicable codes and standards as a benchmark (as identified in Task 1), compare the outcomes of the case study incidents (Task 2) and the modeling analysis against scenarios utilizing the benchmark requirements to clarify the impact of the following tunnel characteristics, on the probability of safe egress in rail tunnels:
- Walkway widths (e.g., current minimum walkway width of 24 in. versus wider widths which allow the formation of double-file lines for faster evacuations).
- Spacing between cross passages.
- Distances between exits to the surface.

Task 5: Gap Analysis & Research Plan
Based on the findings from tasks 1 through 4, conduct a gap analysis to identify any knowledge gaps and propose a research plan to fill these gaps.

Deliverable:
- The findings from Tasks 4 and 5, shall be included in the draft final report, which shall include the analysis and results from the entire effort.

Deliverables
- Interim 1 Report: Literature Review and Case Study Analysis (Tasks 1 and 2)
- Interim 2 Report: Modeling Plan (Tasks 3.1 – 3.3)
- Interim 3 Report: Modeling Results (Tasks 3.4 – 3.5)
- Draft Final Report (Tasks 1 – 5)
- Final Report
- Minimum of one presentation to a technical committee or similar venue/conference

Schedule and Implementation
This research project is led by the Fire Protection Research Foundation and will be conducted in accordance with the "Research Foundation Policies for the Conduct of Research Projects". The project will be guided by a Project Technical Panel who will provide input to the project, recommend contractor selection, review periodic reports of progress and

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research results, and review the final project report. At a minimum, three Panel meetings will be held: project kick-off, review of interim report, and review of draft final report. The Foundation will provide documentation of all meetings.

Intellectual Property

The Research Foundation will retain rights to all project deliverables including, the project report, which will be published on the Foundation website. The project deliverables may also include data collected over the course of the project.

Schedule and Costs

This is a fixed price project in the amount of $35,000. All indirect and travel costs incurred are intended to be included within this fixed price. The Foundation does not have a limit on indirect costs, but the total proposal cannot exceed this fixed price. Proposals for this project shall include a breakdown of costs by task. The proposed scheduled is provided in the table below. Suggested modifications to the proposed schedule can be provided with substantiation.

Tasks	Deliverable Timeline	Estimated Dates
Proposals due		April 7, 2023
Selection of Contractor	3 weeks from proposals due	April 28, 2023
Panel Kick-Off Call	2 weeks from project initiation	May 12, 2023
Interim 1 Report	2 Months from project initiation	July 7, 2023
Interim 2 Report	3 Months from project initiation	August 4, 2023
Interim 3 Report	4 Months from project initiation	September 1, 2023
Draft Final Report	5 Months from project initiation	September 29, 2023
Final Report	6 Months from project initiation	October 27, 2023

How to Respond

Letter proposals shall be submitted electronically to Jacqueline R. Wilmot, Research Project Manager, of the Foundation, at jwilmot@nfpa.org no later than 5:00 pm Eastern time April 7, 2023. For additional details see the "Research Foundation Policies for the Conduct of Research Projects", the Foundation Operating Principles, and "Research Project Guidelines for Contractors" on the Foundation website at: https://www.nfpa.org/foundation.

Each proposal shall include a description of the following weighted evaluation criteria: problem understanding (30 %), technical merit (including scope and approach) (30 %), prior relevant experience and personnel expertise (30%) and the current level of active foundation engagement, will be considered as the remaining 10 % weighted evaluation criteria.

Please note, the body of the research proposal submittals shall not exceed six pages in length, including a short bio of the proposed personnel and not including the cover page. Any additional relevant information (e.g., Project participants' CVs or resumes, letters of support, detailed description of past relevant experience, detailed description of RFP-Respondent's organizational facilities, competencies, other capabilities, and references) not covered in the body of the proposal should be appended to the proposal, with a maximum combined page limit of 12 pages, including the body of the proposal and appendices.

Additionally, all bidders must submit a completed disclosure statement with the proposal (this does not count towards the page limit). This form can be downloaded here.

Note: This project will proceed only on the basis of receipt of a proposal deemed acceptable to the Foundation and the project sponsor(s). Information on the Foundation's policies for the conduct of research can be found on our website. Services received are subject to our standard contractual terms.