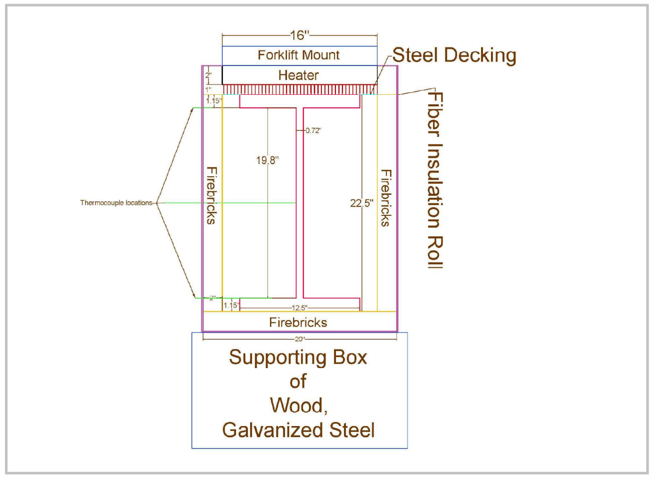
Research Summary

Post-Fire Damage Inspection of Concrete Structures Phase III - In-Situ Experimental Phase

Research Need

Tunnels are a vital part of Massachusetts infrastructure. High-temperature events that result from fuel ignition pose a potential risk to structural members in tunnels. It is critical to investigate the ability of fireproofing to prevent structural members from experiencing damaging tempertures. Tunnel conditions are harsh for fireproofing due to the frequency of truck strikes, so fireproofing protection needs to be evaluated in the damaged and undamaged condition.



Goals/Objectives

1. Evaluate the effectiveness of cementitious fireproofing in reducing the temperatures of steel beams during a fire event.
2. Examine the durability of cementitious fireproofing after a major fireproofing event.
3. Research the reduction in strength of steel after a fire event with and without fireproofing.
4. Determine the ease of application for cementitious fireproofing and assess whether it can be used to quickly prepare damage from truck strikes.
5. Perform a Finite-Element Analysis of a Steel Beam under the ASTM E119 Fire Curve and compare it with laboratory results.

Methodology

Three ceramic heaters capable of reaching temperatures up to 1100 degrees Celcius were used in conjunction with firebricks and ceramic fiber insulation to create a high-temperature environment for the steel beams. Cementitious fireproofing was applied to steel beams by trowel and allowed to set. Using 4 different fireproofing configurations emulating in-situ conditions and a control situation with no fireproofing, steel beams were heated in accordance with the ASTM E119 fire curve. Thermocouples were used to measure the temperature at the top flange (heated surface), middle of the web, and the bottom flange. A finite element analysis using ABAQUS was conducted to validate the experimental results. The fully fireproofed beam was hit repeatedly with a hammer and screwdriver following testing to evaluate the bond between the fireproofing and the steel.

Key Findings

The fireproofing was effective in significantly reducing temperatures of the steel beams by 30-45% in 3 out of 4 fireproofing configurations. However, certain fireproofing configurations create thermal pathways for heat to travel up the beam, significantly decreasing the effectiveness of the fireproofing. The fireproofing exhibits a strong bond with the steel beams. Finite Element models showed satisfactory alignment with experimental data.

Use of Findings

The configurations used in the experiments can be compared with in-situ fireproofing conditions to determine the amount of fire protection provided. The experimental results can be used to determine where fireproofing repairs will be most effective. The durability test proved that the beams can withstand minor strikes, but fireproofing conditions, specifically on the steel decking between beams, should be evaluated after a larger impact. Durability testing also revealed the importance of thoroughly cleaning the steel beams and decking before application to create a stronger bond with the cementitious material. Additionally, fireproofing should be applied in the tunnels using spray-on techniques instead of trowel techniques, which are much more difficult to apply against gravity.

Project Information

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Principal Investigators:

T. Toscano, S. Islam, S. Civjan, S. Gerasimidis

Performing Organization:

University of Massachusetts Amherst

Project Champion:

David P. Kent

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Research and Technology Transfer Section
MassDOT Office of Transportation Planning
Planning.Research@dot.state.ma.us

massDOT
Massachusetts Department of Transportation