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REVIEWER'S REPORT

Manuscript No.: IJAR-52094 Date: 06-06-2025

Title: Study on the Frost Heave Damage Mechanism and Performance Degradation of Concrete Components in Slab Track Structures in Cold Regions

Recommendation:
Accept as it is..................**YES............**
Accept after minor revision..................
Accept after major revision ....
Do not accept (*Reasons below*) ....

Rating	Excel.	Good	Fair	Poor
Originality			√	
Techn. Quality		√		
Clarity			√	
Significance			√	

Reviewer's Name: Tahir Ahmad

Reviewer's Decision about Paper: **Recommended for Publication.**

Comments (*Use additional pages, if required*)
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Reviewer's Comment / Report

Abstract Review:
The abstract effectively encapsulates the study's scope, methodology, and key findings. It addresses a critical issue—frost heave damage in CRTS I slab track systems used in cold regions—by leveraging a 3D finite element model based on plastic damage mechanics. The abstract clearly outlines the analytical framework, including reference to GB 50010-2010 standards, and identifies the primary factors (wavelength, amplitude, and location of frost heave) that influence structural degradation. The findings are specific and well-quantified, offering practical thresholds for damage initiation and escalation (e.g., 8.5 mm and 13 mm frost heave amplitudes). The distinction between the compressive softening behavior of the base plate and the tensile ductility of the track slab is well-articulated. Additionally, the emphasis on damage energy variation with frost peak shifts adds depth to the analysis. The practical implications for design optimization and maintenance are clearly drawn, making the abstract informative and applicable.

Introduction Review:
The introduction provides a relevant and well-contextualized overview of the problem, emphasizing the growing importance of frost heave-induced damage in the context of China's expanding high-speed railway network into seasonally frozen regions. The potential consequences—interlayer separation, geometric irregularities, and structural failures—are clearly stated, underscoring the study's significance.

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The justification for focusing on CRTS I slab tracks, as opposed to CRTS III, is logically presented. The limitations of previous research—primarily relying on linear elastic models—are appropriately highlighted, establishing a strong rationale for the adoption of an elasto-plastic damage mechanics approach. References to earlier experimental studies, such as those by Wang et al., further anchor the study within existing literature and validate the chosen modeling framework.

Scientific Content and Relevance:
The manuscript presents a technically sound and relevant investigation into the mechanisms and progression of frost heave damage in concrete railway components. It leverages finite element modeling grounded in damage mechanics theory, offering a more nuanced understanding than prior linear analyses. The explicit focus on CRTS I systems, which are less studied than CRTS III, adds originality and fills a noted research gap. The damage quantification and the correlation between frost heave parameters and structural responses are clearly laid out and demonstrate the study's scientific rigor and relevance for engineering applications.

Methodological Clarity:
The use of a 3D finite element model based on plastic damage mechanics and conforming to GB 50010-2010 design codes reflects methodological robustness. The approach enables simulation of both tensile and compressive damage mechanisms and accommodates non-linear material behavior under frost conditions. The mention of specific frost heave parameters (wavelength, amplitude, location) and the corresponding damage factors and energy values enhance transparency and reproducibility.

Contribution to the Field:
This study contributes meaningfully to both theoretical understanding and practical engineering by delineating the progression of frost heave damage in different concrete components. The identification of component-specific failure modes and critical thresholds for damage onset provides actionable insight for improving track design and prioritizing maintenance activities. The findings are particularly valuable for high-speed railway infrastructure in cold climates and can inform future guidelines and monitoring strategies.

Overall Evaluation:
This manuscript offers a thorough and scientifically grounded analysis of frost heave effects on CRTS I slab tracks. It bridges a notable gap in current research by moving beyond elastic analysis and providing detailed damage evolution data using advanced modeling techniques. The study's implications for infrastructure resilience, safety, and lifecycle maintenance are substantial and timely. The structure, clarity, and depth of analysis ensure its relevance for researchers, engineers, and transportation authorities engaged in railway infrastructure management in cold regions.