Impact of Sea Level Rise on Transportation Infrastructure in Coastal Area

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Introduction

- Sea level rise (SLR) may cause significant deterioration of the coastal road network. It may induce current groundwater table (CGWT) rise, impacting the transporting of people, goods and services for coastal communities.
- When the groundwater rises, the saturated area in the subgrade would expand correspondingly. As a result, the modulus of subgrade soil may significantly decrease, leading to the decrease in the overall strength of pavement foundation and the degradation of pavement performance.
- According to the current studies, rutting and cracking were found to be exacerbated with the rise of groundwater, and the maintenance, rehabilitation, or reconstruction might be required earlier in the pavement design life.

Objective

- Determine the moisture and modulus variation of the pavement as sea level rises.
- Apply hydro-mechanical model to investigate the critical responses of the pavement under different sea levels.
- Analyze the impact of SLR on the pavement service life based on the existing pavement performance models.

Current and future sea level

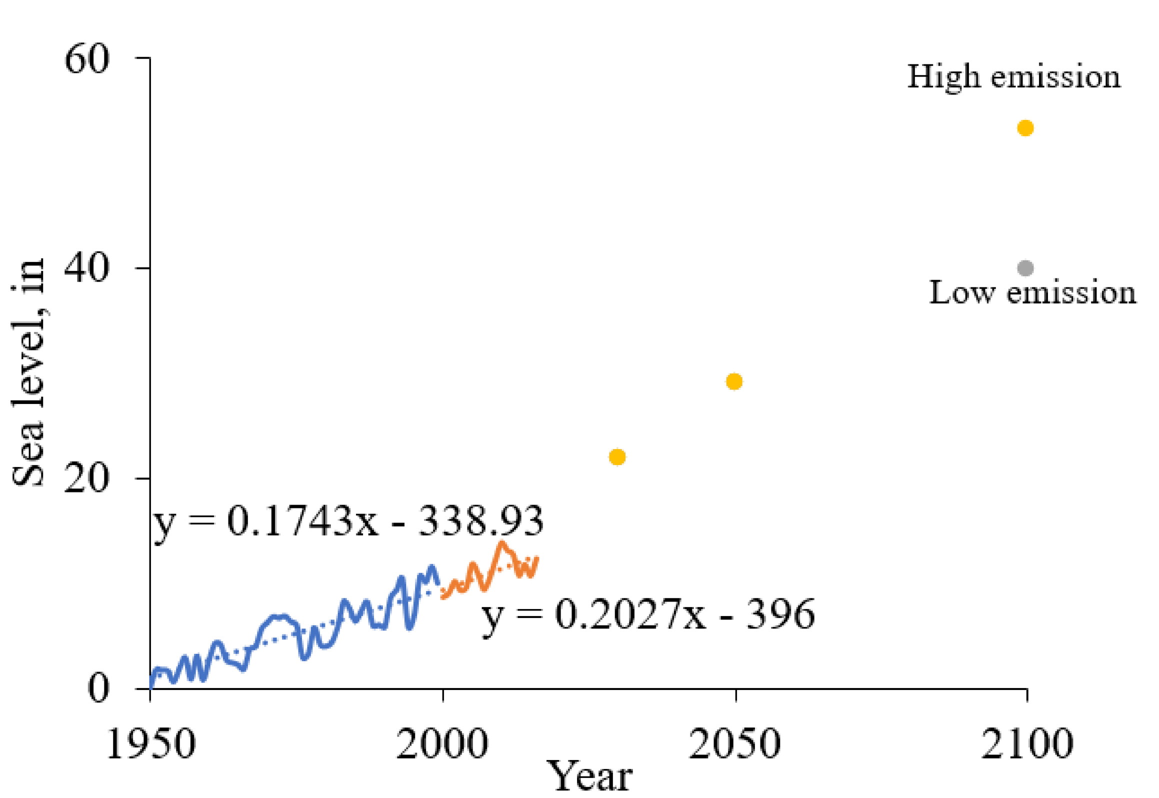


Figure 1. Sea level in New Jersey

- The sea level keeps rising from the past century, and its speed of rise has accelerated over the past ten years.
- Rutgers University estimated the SLR in the future for New Jersey and found that in 2030 and 2050, SLR would meet 0.8ft and 1.4 ft, respectively (Kopp et al. 2019). In 2010, the SLR might be 2.3ft if the emission is low (RCP 6.5), and it would be 3.4ft if the emission is high (RCP 8.5).
- Existing studies found that 1 m SLR would result in mean groundwater rise by 6% to 81% of SLR, which highly depends on the depositional environment.
- In this study, 1 m SRL was assumed to result in 0.6 m in groundwater

Model development

Typical pavement structure for local roads in coastal areas were adopted. According to the web soil survey data provided by United States Department of Agriculture, three different subgrade profiles were selected based on the real condition in Cape May County, Cumberland County and Middlesex County in New Jersey, USA.

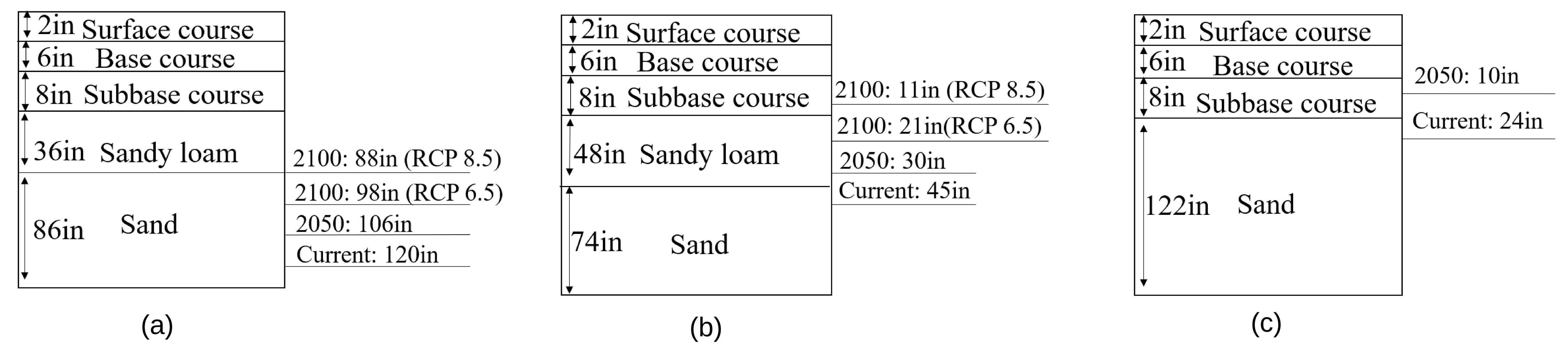


Figure 2. Current and future groundwater tables, (a) Low CGWT case, (b) Medium CGWT case, (c) High CGWT case

As sea level rose, the modulus of the subgrade and subbase might decrease by over 50% and 30%, respectively.

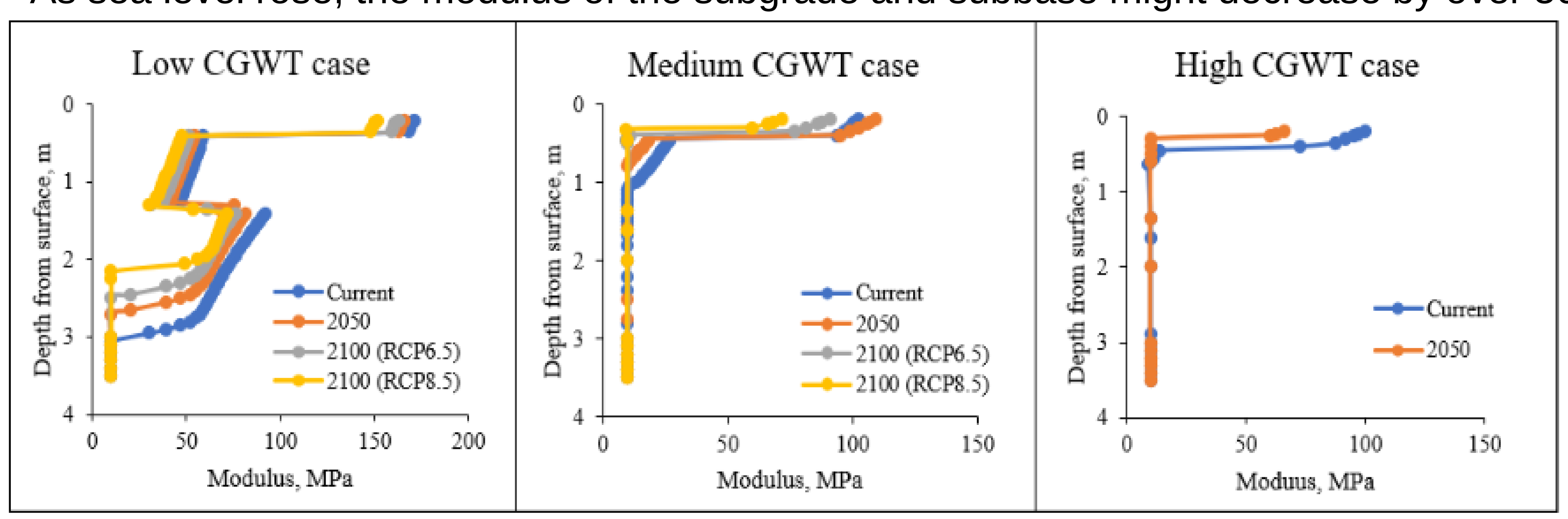


Figure 3. Modulus variation at different depths

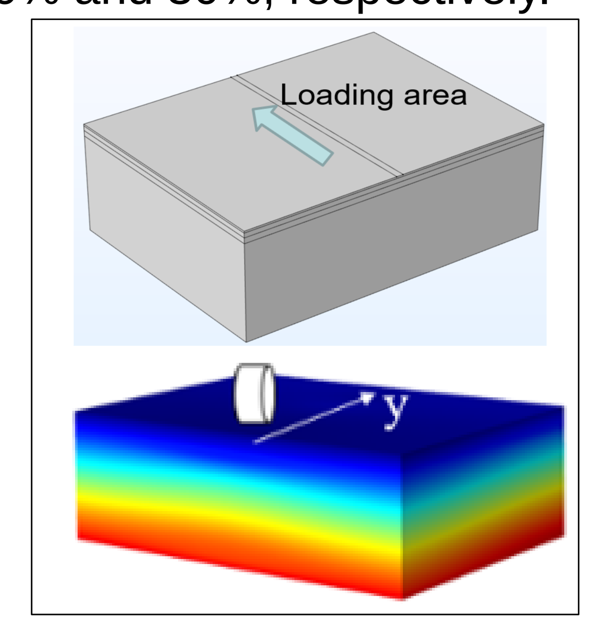
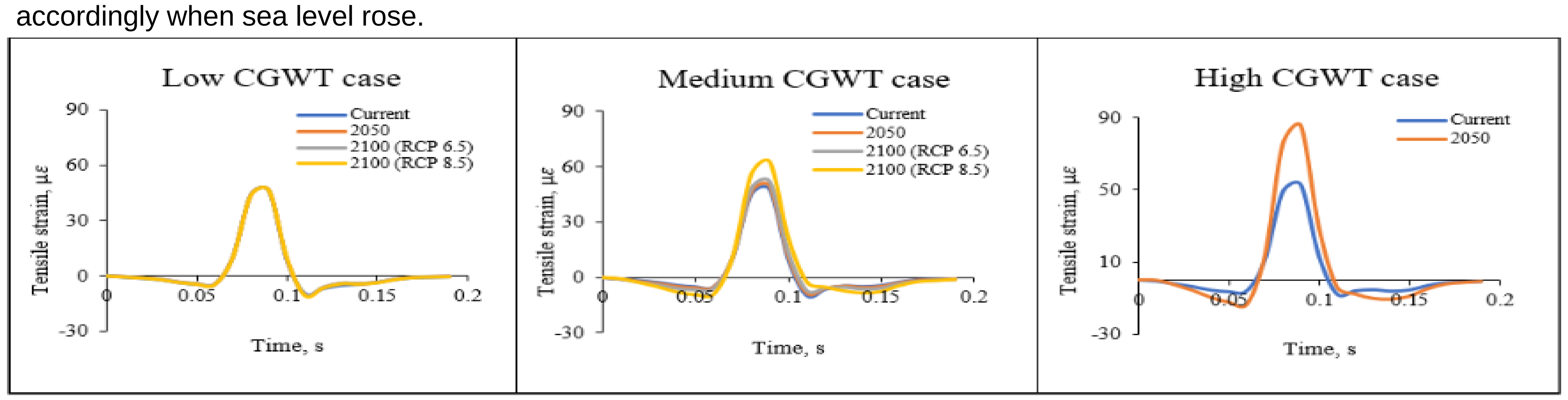


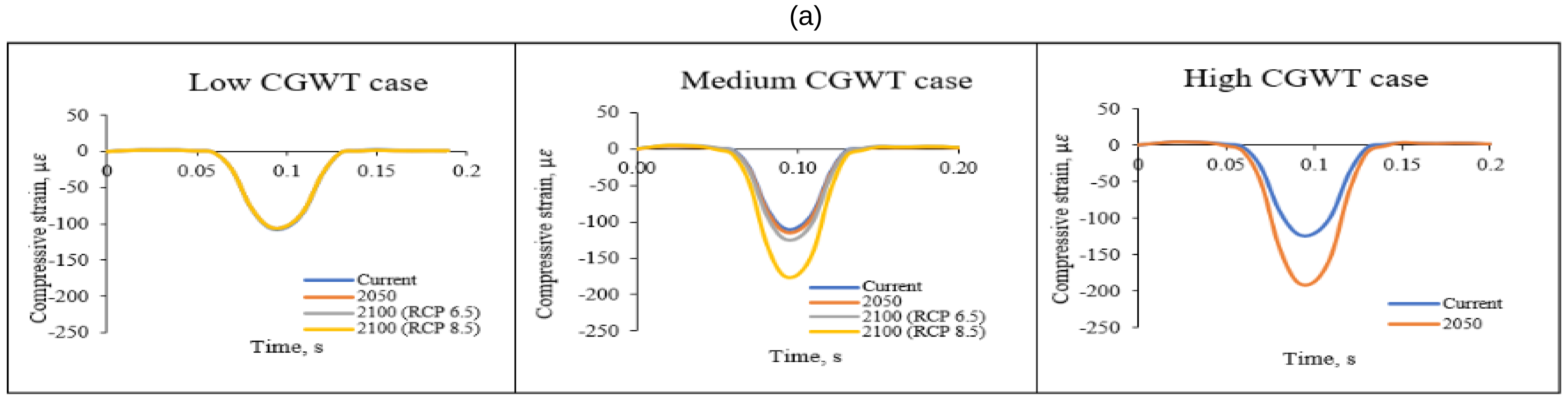
Figure 4. Model geometry

Pavement critical response

In low CGWT case, the tensile and compressive strain did not show a big difference under different sea levels, which means the sea level rise did not lead to a remarkable impact on the fatigue cracking and rutting. While for medium and high CGWT cases, as their current groundwater tables are closer to the ground surface, the pavement ritical responses increased accordingly when sea level rose.



(a)



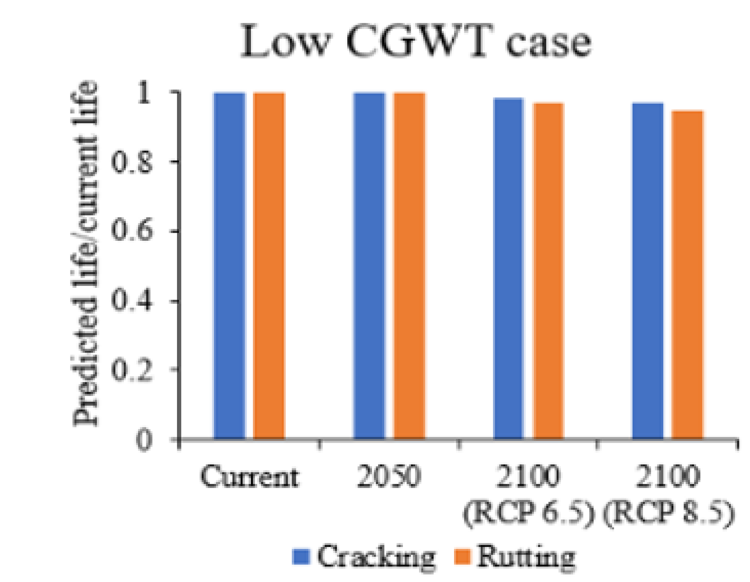
(b)

Figure 5 Pavement responses, (a) Tensile strain at bottom of asphalt layer, (b) Compressive strain at top of subgrade

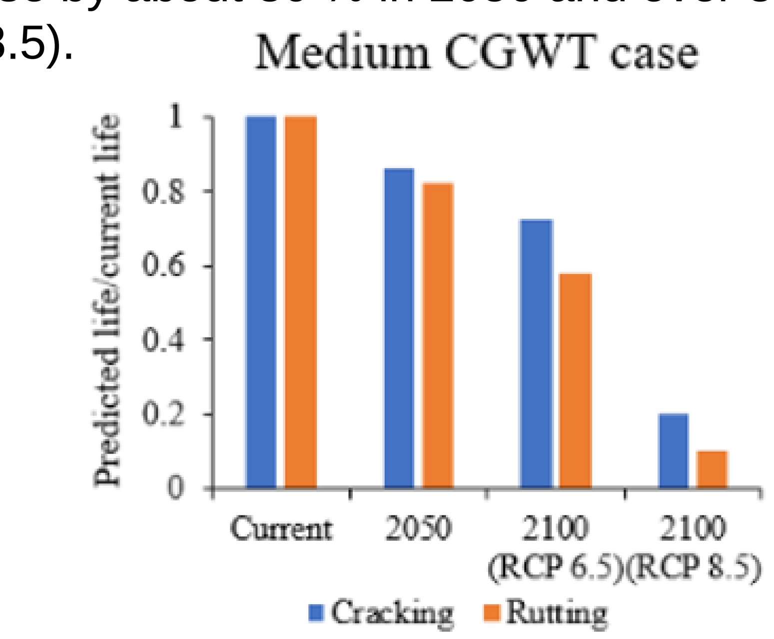
Service life reduction

AASHTO Mechanistic-Empirical Pavement Design Guide proposed Rutting and fatigue cracking models were adopted to calculate the pavement service life reduction.

In low CGWT case, the SLR did not show a remarkable impact on reduction in pavement service life.



In medium CGWT case, the pavement service life would decrease by about 30 % in 2050 and over 80% in 2100 (RCP 8.5).



The decrease in pavement service life in high CGWT case would also be about 75 % in 2500.

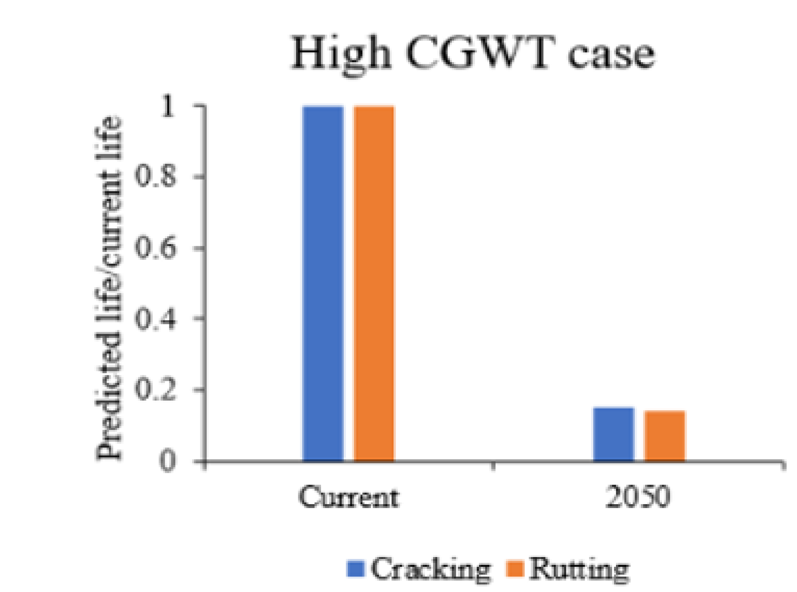


Figure 6. Pavement service life reduction

Summary

- The modulus of the unbound material were found to have non-linear relationship with the distance from the point of interest to the groundwater table.
- In low CGWT case, SLR did not show a remarkable impact on pavement service life, while in medium and high CGWT cases, the pavement service life reduced significantly as sea level rose.
- This study is still ongoing, and the relationship between sea level rise and groundwater rise will be further evaluated in the future.