Impact of Sea Level Rise on Transportation Infrastructure in Coastal Area

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Introduction

Sea level rise (SLR) may cause significant deterioration to the coastal roadway 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

- 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 0.24m and 0.43m, respectively (Kopp et al. 2019). In 2010, the SLR might be 0.7m if the emission is low (RCP 6.5), and it would be 1.04m 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

Pavement responses

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 have 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 critical responses increased accordingly when sea level rose.

The pore pressure slightly increased under traffic load, and then decreased to its initial condition. In this process, the pore pressure increased then decreased, and then increased again, the positive-negative- positive pore pressure may lead to hydraulic scour of subgrade soil. However, it did not show significant impact on pavement critical responses.

Pavement service life reduction

Rutting and fatigue cracking models in MEPDG were adopted to calculate the pavement service life reduction. 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.

Summary

- When the CGWT is high, pavement critical response significant increased in 2050. While when the CGWT is low, pavement critical response did not change remarkably even when the emission is high in 2100.
- The pore pressure was not found to impact the pavement critical response, while it may lead to hydraulic scour.
- 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.