Climate change impacts on asset management of Texas concrete bridges

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Tran-SET

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$ 100,000

Evaluating climate change impact on concrete bridges in Texas

Texas has more than 55,000 bridges, where more than 50% of the bridges are over 40 years old, approaching their design life span with increasing maintenance and rehabilitation needs. There has been a concerning accelerating trend of bridges in Texas transitioning from the "good" to "fair" condition over the past 20 years. Despite these facts, bridge assets are also facing ever-increasing traffic demand due to population increase and urbanization, and are exposed to more intense environmental threats due to climate change which can chronically degrade the bridges' structural condition and traffic carrying functionality. Moreover, there has been strong evidence that greenhouse gas emissions from anthropogenic activities have greatly affected the global climate system. As a result, climate change may cause huge impacts on the performance and functionality of transportation infrastructure, where the changing CO2 concentration, temperature, and relative humidity can exacerbate the material deterioration. The proposed research aims to probabilistically quantify the long-term climate change impacts on the deterioration of Texas concrete bridge portfolios. Specifically, this technical phase of this project will (1) Select and downscale state-of-the-art climate change models for the state of Texas; (2) Develop physics-based bridge deterioration model and calibrate it against historical National Bridge Inventory (NBI) bridge condition data; and (3) Develop a quantitative risk assessment framework that integrates the climate change forecasts with physics-based structural deterioration models to offer probabilistic spatial-temporal forecast of the Texas bridge asset deterioration extent. By linking the deterioration extent to the direct and indirect socioeconomic consequences, new insights will be afforded regarding the efficacy of different risk mitigation strategies to better inform the stakeholders toward better long-term focused and cost-effective bridge asset management.

Problem Statement

Though vital to America's economy, the U.S. bridge infrastructure only received a rating of C according to the 2021 ASCE Infrastructure Report Card. The bridge infrastructure systems have been underfunded with a staggering $125 billion bridge repair backlog, and the rate of repair, rehabilitation, and replacement is surpassed by the rate of deterioration. Texas has more than 55,000 bridges, where more than 50% of the bridges are over 40 years old, approaching their design life span with increasing maintenance and rehabilitation needs. There has been a concerning accelerating trend of bridges in Texas transitioning from the "good" to "fair" condition over the past 20 years. Despite these facts, bridge assets are also facing everincreasing traffic demand due to population increase and urbanization, and are exposed to more intense environmental threats due to climate change which can chronically degrade the bridges' structural condition and traffic carrying functionality. All the above trends will likely impose increasing burden to the readily strained bridge asset management due to limited resources. There has been strong evidence that greenhouse gas emissions from anthropogenic activities have greatly affected the global climate system. According to the 2014 Intergovernmental Panel on Climate Change (IPCC) Climate Change Synthesis Report, continued emission of greenhouse gases will cause further warming and long-lasting changes in all components (e.g., precipitation, humidity, among others) of the climate system. As a result, climate change may cause huge impacts on the performance and functionality of regional transportation infrastructure, where the changing CO2 concentration, temperature, and relative humidity can exacerbate the material deterioration. Nevertheless, limited research has been conducted in the past to study the climate change impacts on the deterioration of transportation infrastructure, particularly highway bridges.

Objectives

The proposed research aims to probabilistically quantify the long-term climate change impacts on the deterioration of Texas concrete bridge

portfolios. Specifically, this technical phase of this project will (1) Select and downscale state-ofthe-art climate change models for the state of Texas; (2) Develop physics-based bridge deterioration model and calibrate it against historical National Bridge Inventory (NBI) bridge condition data; and (3) Develop a quantitative risk assessment framework that integrates the climate change forecasts with physics-based structural deterioration models to offer probabilistic spatial-temporal forecast of the Texas bridge asset deterioration extent.

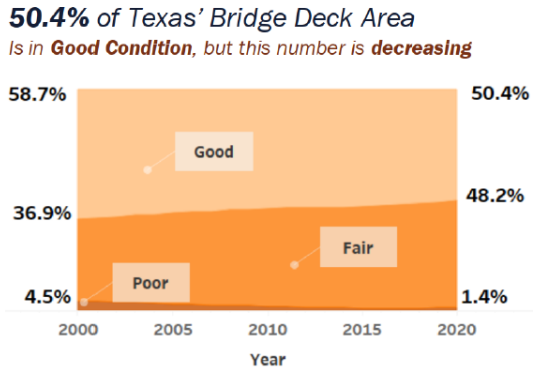

Figure 1. Percentage of Texas statewide bridge deck area in good, fair, and poor condition over the past 20 years.

Intended Implementation of Research

The proposed research marks the first effort to probabilistically assess the climate change impacts on regional highway bridge portfolios, through integration of physics-based deterioration modeling with time-dependent climate stressors to capture the long-term effects of different intervention actions, thereby facilitating better adaptation strategies to climate changes. It is anticipated that the research outcomes will not only better inform the stakeholders about the long-term consequences of different intervention actions in the face of climate change threat, but can also foster the next-generation transportation researchers and practitioners with a risk-informed mindset. Three tasks are proposed for the implementation phase of this project.

Anticipated Impacts/Benefits of Implementation

The research directly addresses Region 6 priority on preservation and enhancing climate resiliency of the transportation infrastructure. By integrating the uncertainties from climate change, bridge-specific features, and physics-based deterioration processes, the proposed methods and tools will provide high-resolution risk estimates of the spatial-temporal climate change impacts on the Texas concrete bridge portfolios. It is anticipated that the proposed risk assessment framework can better inform stakeholders such as TxDOT or more broadly to other Region 6 transportation agencies and FHWA with quantitative and probabilistic estimates of the future climate change impacts on transportation infrastructure assets such as bridges and roadways. The education and outreach activities will also help foster the next-generation transportation researchers and practitioners.

Web links

- Tran-SET's website https://transet.lsu.edu/research-in-progress/

Tran-SET

Tran-SET is Region 6's University Transportation Center. It is a collaborative partnership between 11 institutions (see below) across 5 states (AR, LA, NM, OK, and TX). Tran-SET is led by Louisiana State University. It was established in late November 2016 "to address the accelerated deterioration of transportation infrastructure through the development, evaluation, and implementation of cutting-edge technologies, novel materials, and innovative construction management processes".

Learn More

For more information about Tran-SET, please visit our website, LinkedIn, Twitter, Facebook, and YouTube pages. Also, please feel free to contact Dr. Momen Mousa (Tran-SET Program Manager) directly at transet@lsu.edu.