Inclusion of damage detection methods for the sustainable life cycle design of bridges in aggressive environments

DOCTORAL PROGRAM IN CONSTRUCTION ENGINEERING

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OBJECTIVES OF THE INVESTIGATION

General objectives

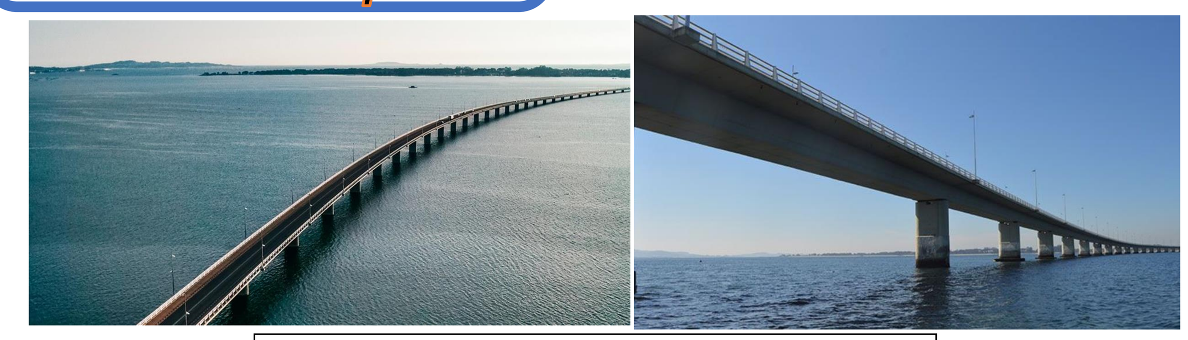
Nowadays, due to the high costs of construction, repair, and maintenance of large structures such as bridges, as well as paying attention to the study of the sustainable life cycle in all the different stages of a structure's life, from the design to the end of the structure's life, paying attention to using a suitable method for repairing and maintaining structures can increase the lifespan of structures and reduce costs, as well as reduce harmful impacts on the environment and society. Therefore, it is crucial to employ diverse methods for identifying damage and evaluating their effectiveness across various structures and conditions to ensure the stability of the structure's life cycle.

Specific objectives

- **Examining the accuracy of different dynamic and non-destructive damage detection methods in identifying the extent, location, and time of damage to the structure during the lifetime of the building.**
- **Evaluate the accuracy and possible changes in the accuracy of each of the damage detection methods in different environments, especially coastal environments and aggressive environments.**
- **Performance evaluation and comparison of different non-destructive damage detection methods for design sustainability and life cycle assessment cases, including economic, environmental and social impacts assessments.**

MAIN STAGES OF RESEARCH DEVELOPMENT

1 Model Description

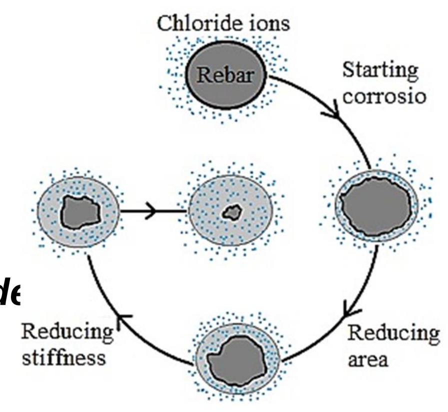


Coastal RC Arosa bridge (1985)

2 Damages causes

Natural marine damage causes

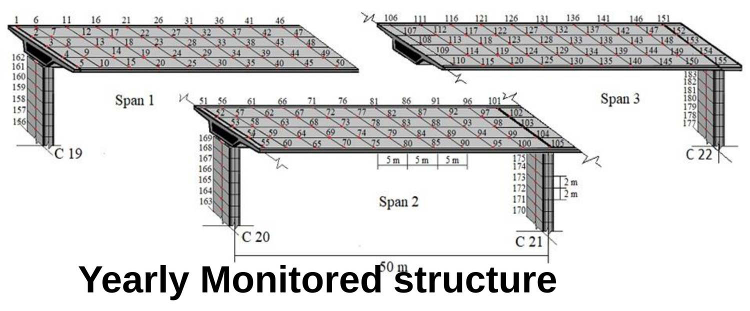
- Carbonation
- Sulfates
- Chloride ions attack



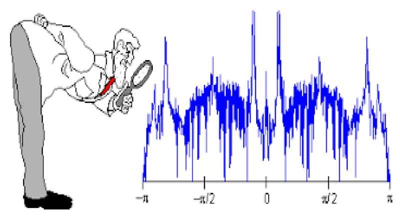
The process of chloride corrosion in rebar

3 Damages detection

Prediction of location and amount of damaged elements through a Non-destructive damage detection methods based on signals



Yearly Monitored structure



Signal frequency response assessment from sensor points

Analyzing and comparing data from the measurement in undamaged and damaged structure frequency

Identify the location and percentage of damages

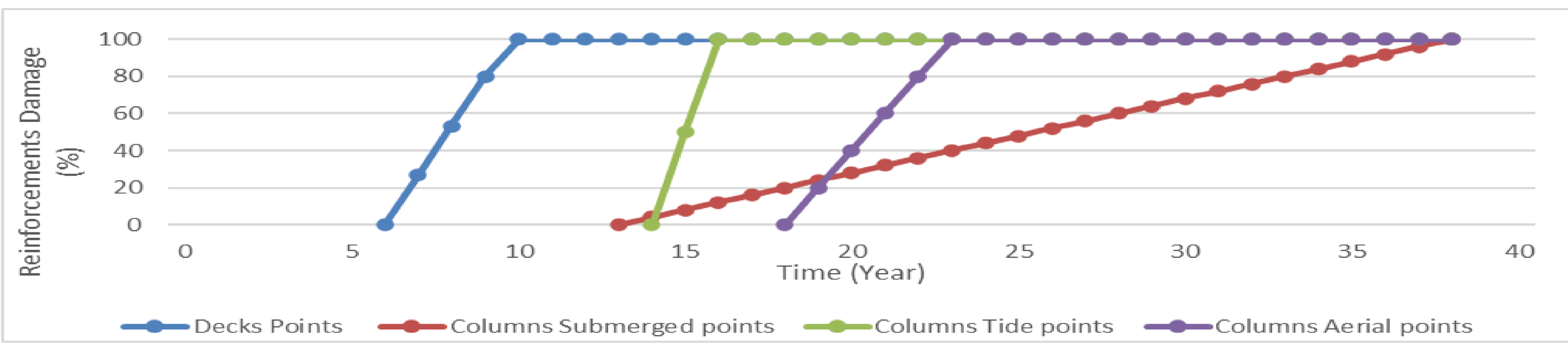
4 Life cycle Assessment

sustainable Life cycle assessment

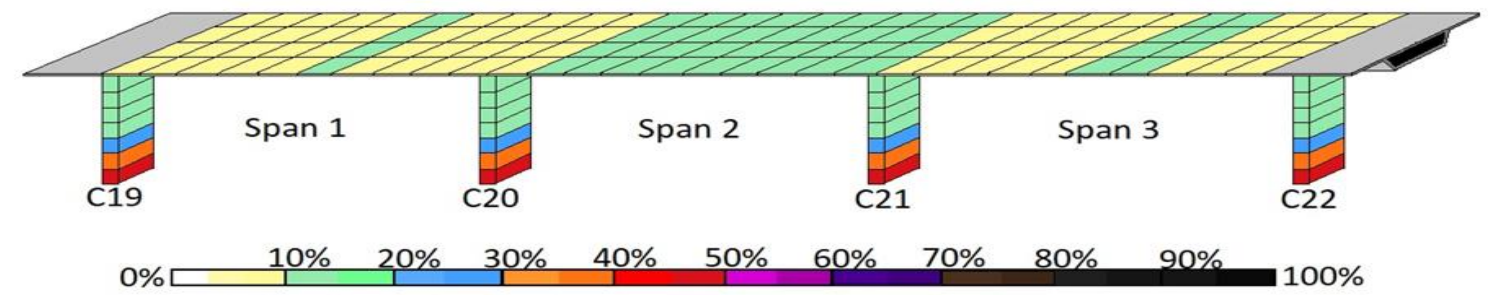
EXPECTED RESULTS AND POTENTIAL PROFITS

Damage detection method results

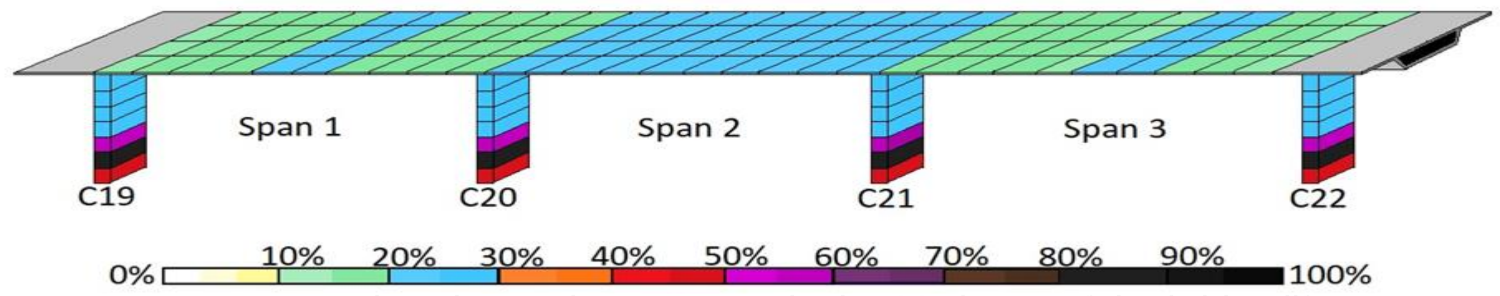
To identify and predict corrosion damages at the coastal bridge use the PSD method to assess the performance of the method to predict the location and amounts of damages during the bridge life (100 Years).



Reinforcements corrosion deterioration according to element situation to seawater



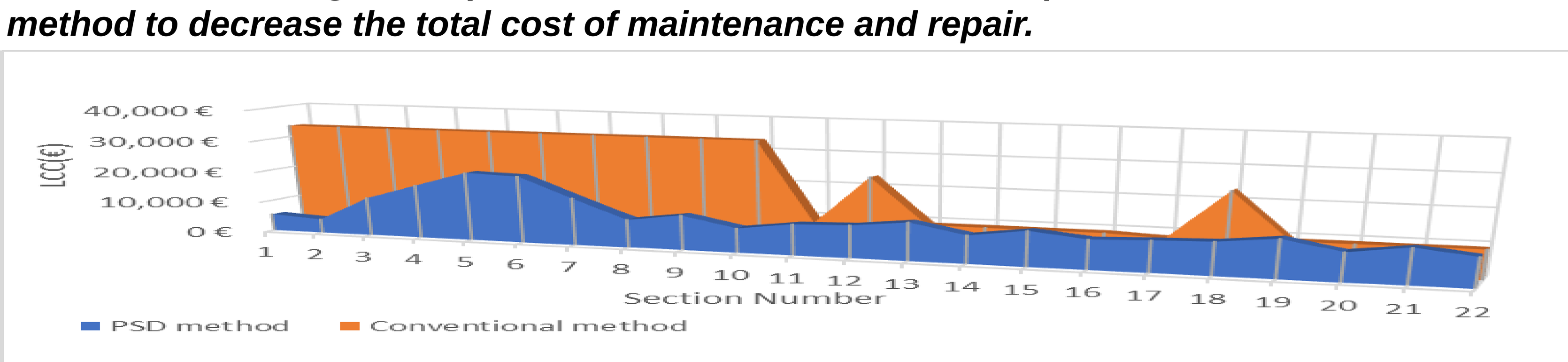
Damages location and percentage in the 10th year after built



Damage location and percentage in the 33rd year of the bridge life

Life cycle cost assessment through damage detection method

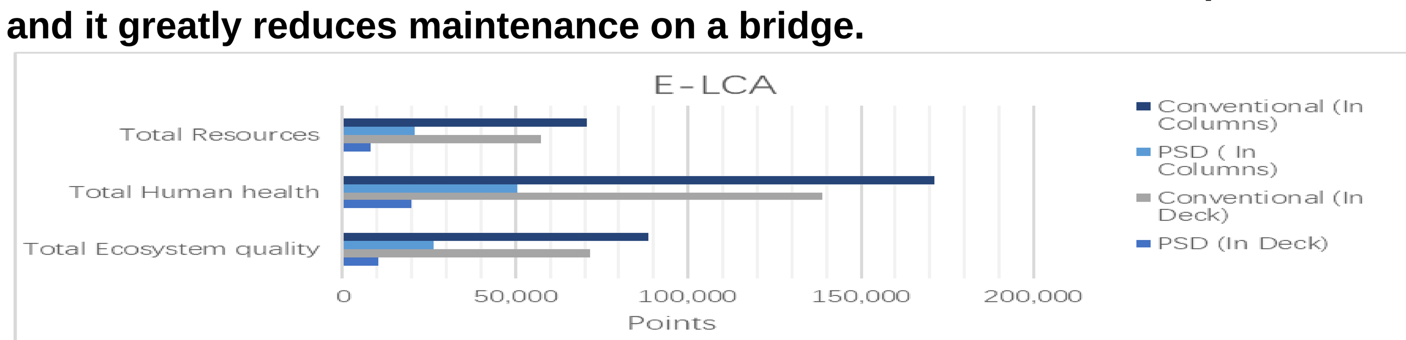
The results of the PSD approach to damage detection and the performance of this method in reducing the repair and maintenance costs compared to the conventional method to decrease the total cost of maintenance and repair.



Compare the life cycle cost assessment for a span of the bridge until the end life of the bridge with PSD and Conventional damage detection methods

Environmental life cycle assessment by damage detection method

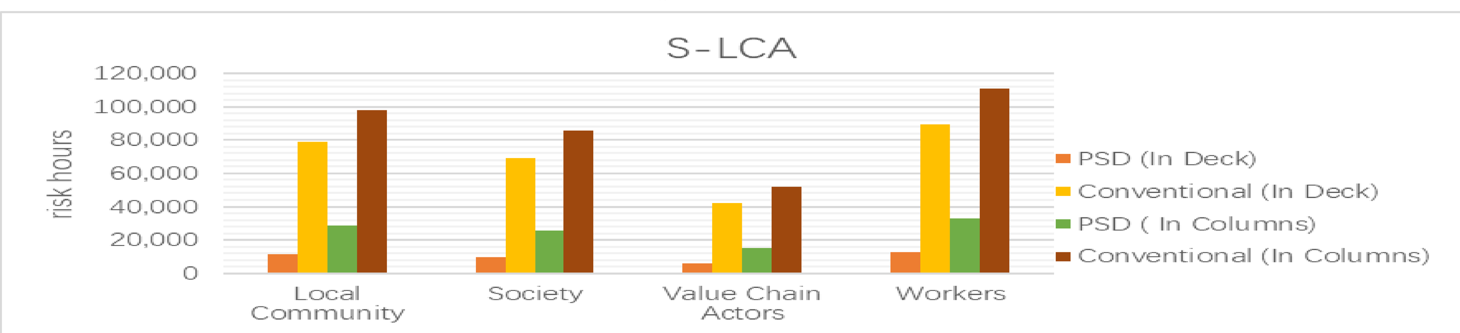
The results of using a non-destructive damage identification method in comparison with a common identification method show that the use of this damage identification method greatly reduces the harmful effects of the environment, such as environmental pollutants in the repair stage, and it greatly reduces maintenance on a bridge.



Compare the environment life cycle assessment for a span of the bridge until the end life of the bridge with PSD and Conventional damage detection methods

Social life cycle assessment by damage detection method

The results of using a damage identification method show that the destructive effects on society and humans are greatly reduced compared to other common methods for the repair and maintenance of a coastal concrete bridge.



Compare the Social life cycle assessment for a span of the bridge until the end life of the bridge with PSD and Conventional damage detection methods

CONCLUSIONS

In conclusion, the findings indicate that these non-destructive technologies for detecting damage may be effectively used by experts and engineers in the field, resulting in decreased expenses for the repair and upkeep of buildings. In addition, the use of damage detection technologies for maintenance and repair operations might result in notable environmental and social consequences when compared to a traditional strategy of damage prevention, in terms of both time and quantity.

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