STABILITY

Sustainable Circular Life Extension Strategies for Inner-City Bridges and Quay Walls

Summary

Historic quay walls and bridges are landmarks in many Dutch cities and give them unique character and appearance. The cultural value of these structures is at stake. Accelerated deterioration, deferred maintenance, and changed social, technological, and environmental conditions have drastically decreased their technical and functional performance. Maintaining the cultural heritage of inner-city quay walls and bridges and, at the same time, preparing them for the future is a massive challenge for many Dutch municipalities. Lifespan extension is a promising way to cope with this challenge. It can increase the structural reliability of quay walls and bridges in a sustainable and circular manner while preserving the cultural value. However, less is known about the structural, environmental, economic, and cultural impact of lifespan-extension measures and their assessment for managing quay walls and bridges.

Based on engaged research with municipalities, contractors, engineering firms, and citizens, STABILITY addresses this knowledge gap. It combines the development of an integrated life cycle cost-benefit approach for the sustainable and circular impact assessment of lifespan-extension measures with the development of an assessment method for the structural reliability improvement of these measures and the development of an adaptable planning method to prioritise and schedule lifespan-extension measures optimally. STABILITY equips municipalities with the required decision support to devise rehabilitation strategies for historic inner-city quay walls and bridges that reduce construction waste and emissions, preserve the cultural heritage of cities, and keep cities accessible, attractive, and livable.

Consortium partners

UNIVERSITY OF TWENTE.

TU Delft

SAXION UNIVERSITY OF APPLIED SCIENCES

TAUW

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Boskalis

Gemeente Amsterdam

kennisplatform CROW

Zwolle

Huib Sneep

Den Haag

de Beaufort Bouwadvies

Project Coordinator
Andreas Hartmann
University of Twente
a.hartmann@utwente.nl

Objectives

The **overall objective** of STABILITY is to ***support municipalities, contractors and engineering firms in moving from a linear, conservative and reactive management approach to a circular, less conservative and proactive management*** approach for inner-city quay walls and bridges. Here, considering and implementing lifespan-extension measures as a full alternative to complete renewal is essential since they are expected to have a lower environmental impact, require fewer financial resources, preserve the cultural heritage value, and disturb the life in cities to a lesser extent than the replacement of quay wall and bridge structures. However, this requires that these measures improve the structural capacity of quay walls and bridges to maintain their desired technical and functional performance for a more extended period. Mainly for municipalities to make informed decisions on the application of lifespan-extension measures, insights into the impact of the measures on structural capacity, sustainability, circularity, and planning are needed.

The **main objective** of STABILITY is to ***develop methods and approaches for the structural, sustainable circular, and planning impact assessment of lifespan-extension measures*** for inner-city bridges and quay walls and to ***provide sustainable circular lifespan-extension strategies for implementing these methods and approaches***.

Work plan

STABILITY comprises five work packages (WP) (see Figure 1). WP1 focuses on the development of a qualitative framework for lifespan-extension measures. This framework includes a standardised categorisation of lifespan-extension measures that will serve as a starting point for developing impact assessment methods in WP2, 3 and 4. In WP2, an integrated life cycle cost-benefit approach for the sustainable and circular impact assessment of the categorised lifespan-extension measures for inner-city bridges and quay walls will be developed. In WP3, a structural reliability assessment method for bridges and quay walls will be developed before and after applying categorised lifespan-extension measures. In WP4, an adaptable planning method to optimally prioritise and schedule categorized lifespan-extension measures will be developed. In WP5, the output of WP1, 2, 3 and 4 are brought together to devise sustainable circular lifespan-extension strategies for the portfolio of inner-city quay walls and bridges of municipalities.

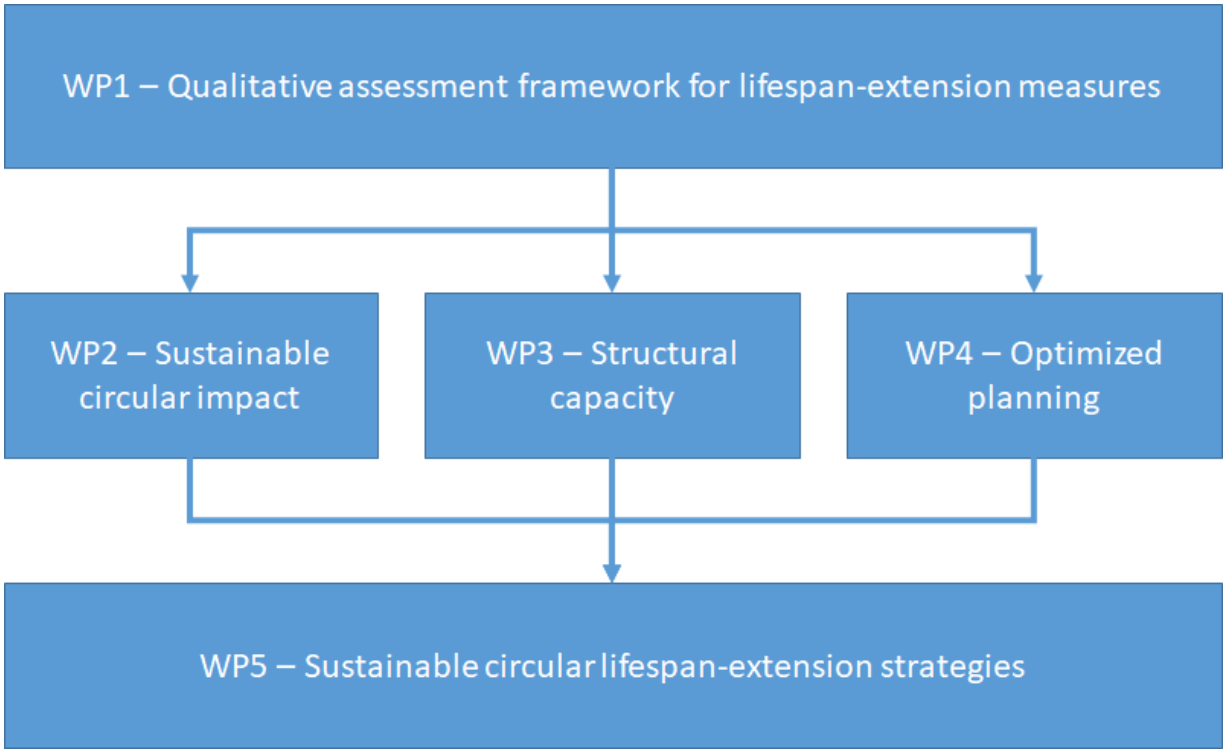

Figure 1: Project structure

Planned Output

STABILITY will generate several direct and immediate insights and products that can change the current practice at municipalities, contractors and engineering firms.

Key Output 1: STABILITY will deliver as key output a **qualitative assessment framework for lifespan-extension measures,** which consists of (i) a catalogue of typical inner-city bridge and quay wall situations with their potential failure mechanism, (ii) a categorisation of potential life-extension measures for inner-city bridges and quay walls, and (iii) Key Performance Indicators (KPI) for impact assessment of life-extension measures. This framework will allow municipalities, contractors, and engineering firms to identify, design and construct appropriate lifespan-extension measures for a specific inner-city bridge or quay wall and qualitatively assess their performance for the local context of this structure.

Key Output 2: STABILITY will provide as key output an **integrated life cycle cost-benefit approach for the sustainable and circular impact assessment** of lifespan-extension measures for bridges and quay walls. The approach combines (i) a life cycle assessment model for the environmental and circular impact assessment, (ii) a life cycle costing model for the economic impact assessment, and (iii) a valuation model for the cultural heritage impact assessment. This approach will support municipalities, contractors, and engineering firms in developing an understanding of the impact of lifespan-extension measures from a sustainable, circular, and cultural heritage perspective and thus support informed decision-making on the renovation/renewal of inner-city bridges and quay walls.

Key Output 3: STABILITY will provide as key output a **structural reliability assessment method for inner-city quay walls and bridges before and after a lifespan-extension method is applied**. The method will be based on fully probabilistic, numerical models for the superstructure and substructure of quay walls and bridges and their interaction. This method will allow municipalities to determine the true safety level and assess the most likely failure mechanism and the most appropriate lifespan-extension measures.

Key Output 4: STABILITY will deliver an **adaptable planning method to optimally prioritise and schedule lifespan-extension measures for bridges and quay walls on asset and network levels.** The planning method integrates (i) a deep reinforcement learning-based planning algorithm and (ii) a simulation model to account for the complex and uncertain urban context of bridges and quay walls. This planning method will allow municipalities to decide on which lifespan-extension measure should be where and when applied as part of an overall optimised planning of network-wide renovation of quay walls and bridges.

Key Output 5: STABILITY will generate a set of **sustainable circular lifespan-extension strategies** for inner-city quay walls and bridges. These strategies bring together (i) the qualitative assessment framework, (ii) the integrated life cycle cost-benefit approach, (iii) the structural reliability assessment, and (iv) the adaptable planning method. They will describe how municipalities can use the different outputs in an integrated manner to manage their portfolio of bridges and quay walls and what changes are needed to implement these outputs.