RISK-INFORMED DECISION-MAKING FOR EXTENDING THE SERVICE LIFE OF EXISTING STRUCTURES

SDU

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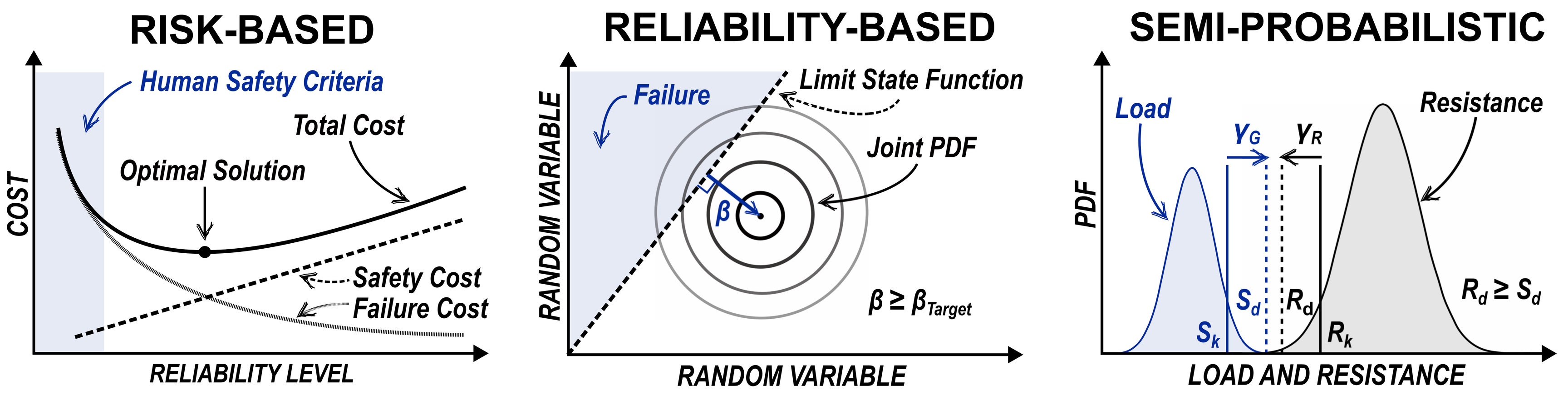
INTRODUCTION

A large amount of virgin material is used in the construction of new structures. Extending the service life of existing structures and preventing unnecessary demolition can significantly reduce further material use. At the same time, structures must be demonstrated to be sufficiently safe by complying with prescribed safety levels. Structural safety can, in principle, be verified using three methods:



RISK-BASED	RELIABILITY-BASED	SEMI-PROBABILISTIC
Advantages:	***Advantages:***	***Advantages:***
• *Informed Decisions*	• *Accounts for Uncertainties*	• *Fast Application*
• *Structures-Specific*	• *Incorporate Existing Data*	• *Design-Oriented*
Challenges:	***Challenges:***	***Challenges:***
• *High Complexity*	• *Moderate Complexity*	• *Limited Flexibility*
• *Hard to Implement*	• *Predefined Target Reliability*	• *Simplified Uncertainty*

PROBLEM STATEMENT

The semi-probabilistic verification is typically used as the default approach for both the design of new structures and the assessment of existing ones. However, its fixed and conservative nature may lead to suboptimal decisions in terms of cost and material use for existing structures.

Risk-based assessment has shown considerable potential in this context, with several studies demonstrating its ability to support more efficient and informed decision-making, including reduced material use and avoidance of unnecessary interventions.

Despite these advantages, practical implementation remains limited for two main reasons. First, such methods are often perceived as complex and time-consuming due to a lack of (standardized) guidance. Second, key methodological aspects for practical application remain insufficiently addressed, including realistic structural behaviour, system-level effects, and representative cost modelling.

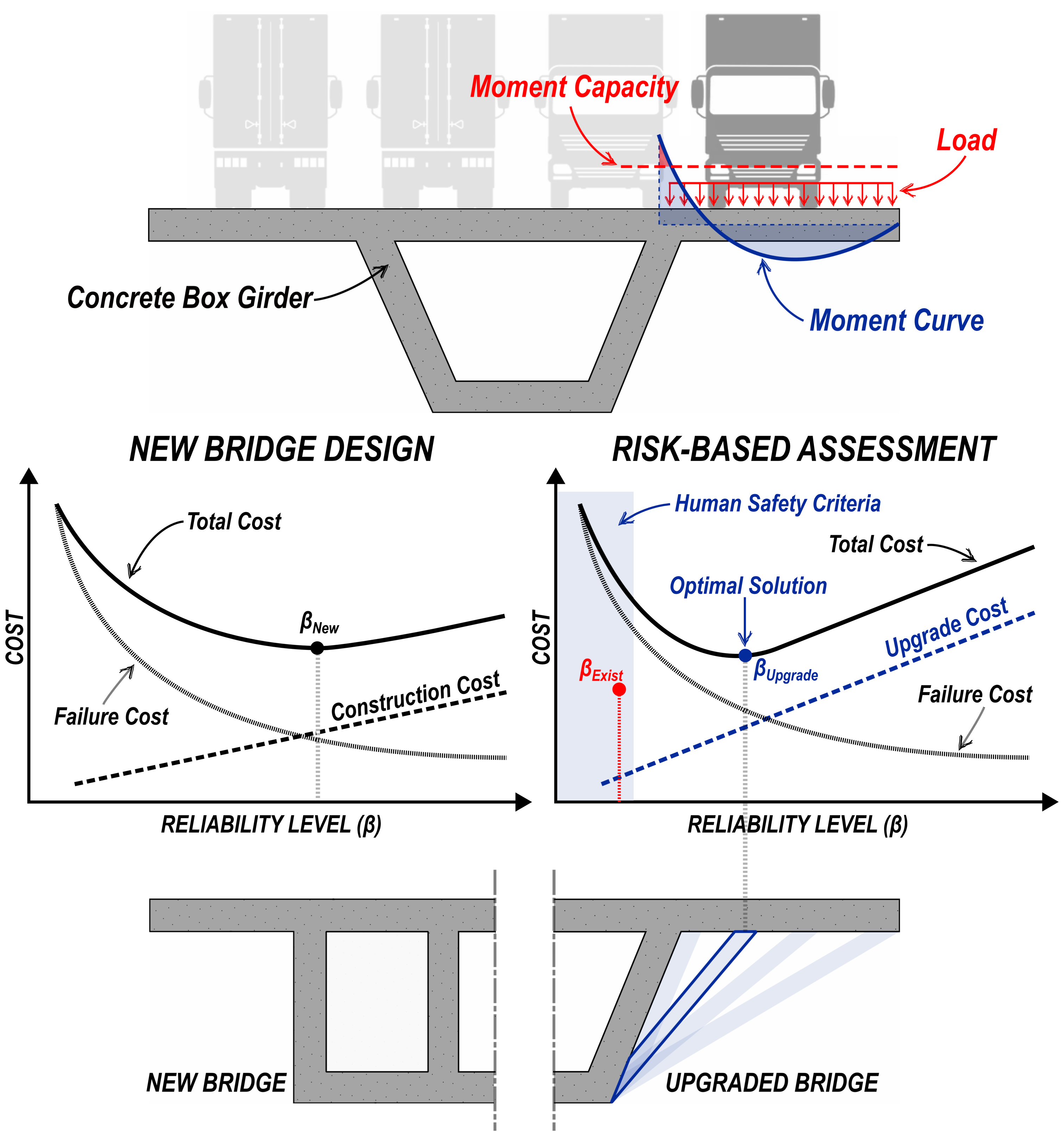
RISK-BASED DECISION-MAKING EXAMPLE

Traffic loads have exceeded the design capacity of many existing bridges, necessitating assessment and, in some cases, demolition. The figure on the right illustrates a box girder bridge assessed for bending capacity. In this case, the risk-based assessment proceeds as follows:

1. **Determine reliability index of the existing bridge (β_{exist})**
2. **Estimate remaining service life.** *(modeling choice)*
3. **Define retrofitting strategy:** *(modeling choice) Stiffeners are added to provide an additional load path and relieve stress in the connection.*
4. **Establish total cost function (G).** *(Failure + upgrade cost)*
5. **Define optimization parameters.** *(modeling choice) (Stiffener location)*
6. **Define Human Safety Criteria (β_{min}).** *(modeling choice) Multiple approaches exist.*
7. **Comparison:** *If $G(\beta_{exist}) \leq G(\beta_{upgrade}) \rightarrow$ keep*
   If $\beta_{min} > \beta_{exist}$, $\rightarrow$ upgrade or replace;
   If $\beta_{min} > \beta_{upgrade}$, $\rightarrow$ bridge is unsafe. ------ New Bridge ------ or

Different Retrofitting Strategy

The safety level found here is for the remaining service life of the bridge (e.g. 25 years). The safety level for new bridges is higher; however, reliability depends on time, with a 120-year reference period for new bridges.



AIM

Enable Risk-Based Decision-Making

Support more informed and efficient assessment of existing structures.

Evaluate Methodological Choices

Identify and assess key factors influencing decision-making.

Quantify Decision Impacts

Examine how modelling choices affect reliability, costs, and outcomes.

CEBE

Develop a risk-based decision-making framework that incorporates inputs from research in the CEBE program (see description in the footnote) and provides a foundation for future work.

METHODOLOGY

1. Component-Level Analysis

Review and compare methodological approaches, and develop a parametric framework to evaluate modelling choices.

2. System-Level Methodology

Develop approaches incorporating system reliability into risk-based decision-making.

3. Case Studies

Apply the framework to real structures, including realistic cost modelling and comparison with existing verification methods.

4. Synthesis

Consolidate findings and develop practical recommendations aligned with current codes and safety philosophy.

VILLUM FONDEN

This project is financially supported by the Villum Foundation as a part of the Civil Engineering and the Green Transition in the Built Environment (CEBE) program

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