

White Paper on Quantitative Risk Analysis in Construction

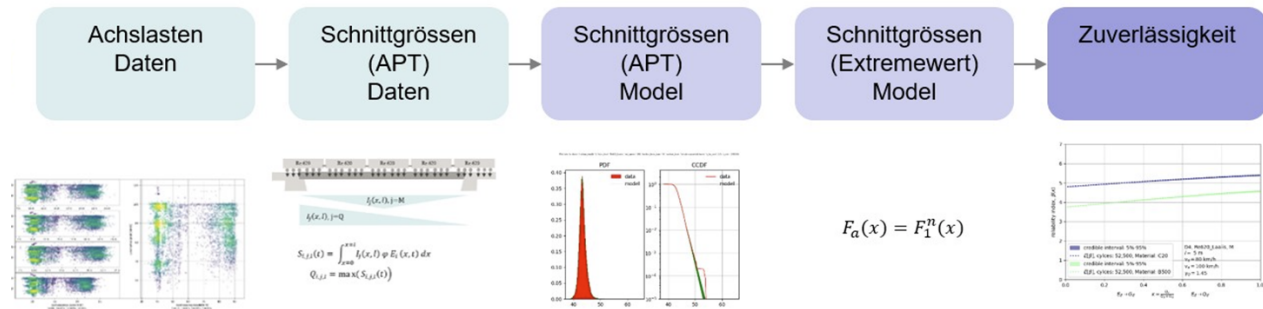


Abb.1: Case Study Example: SBB Railways Bridges Load Model (source: Matrisk GmbH)

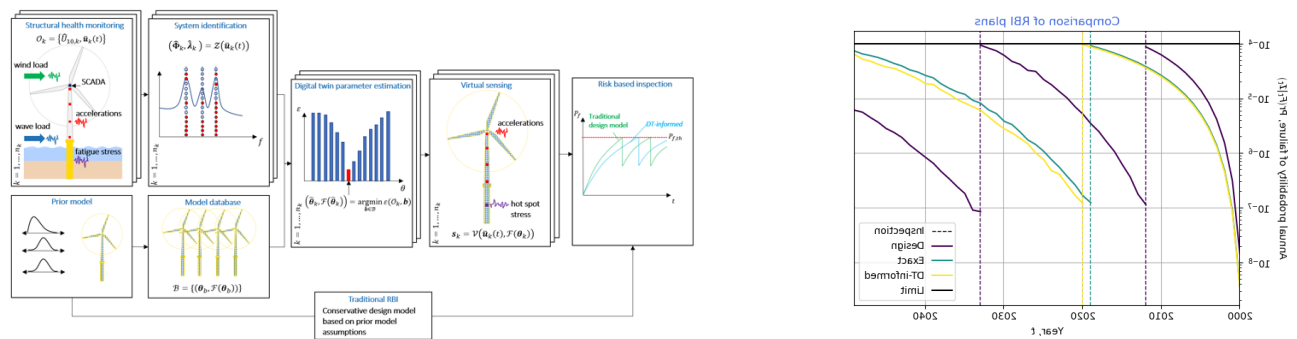


Abb.2: Case Study Example: Offshore Windfarms (source: Matrisk GmbH)

Key Take-Aways:

- **Balancing Safety and Feasibility:** The critical importance of finding a trade-off between ensuring absolute safety and maintaining practical feasibility in construction, highlighting the need for balanced design choices to manage resources effectively.
- **Innovative Approaches for Aging Infrastructure:** Insights into tackling the challenges posed by aging infrastructure in industrialized countries through advanced quantitative risk analysis, emphasizing the growing necessity of such methods for maintaining structural integrity and safety.
- **Real-World Applications and Impact:** Showcasing the benefits of quantitative risk analysis through detailed case studies, including projects on bridge load capacity, fire protection efficiency, and offshore wind farm maintenance, demonstrating the practical impact and added value of this approach in diverse engineering scenarios.

Introduction

This white paper synthesizes the insights from the "Concretely" podcast episode titled "Quantitative Risk Analysis in Construction," featuring an interview with Dr. Paul-Remo Wagner from Matrisk. The episode explores the integration of quantitative risk analysis in assessing and mitigating potential negative impacts on infrastructure systems, with a focus on economic costs and human safety.

Understanding Quantitative Risk Analysis

Quantitative risk analysis in construction involves assessing the probability of failure in structures and finding a balance between absolute safety and practical feasibility. Dr. Wagner points out that clients sometimes find probabilistic concepts difficult to understand. They often prefer more traditional approaches that ignore uncertainties, rather than acknowledging the probabilistic nature of accidents and managing their occurrence accordingly.

Overcoming this challenge involves educating clients on the importance and advantages of considering probabilities and preparing for various outcomes, instead of focusing solely on accident prevention. Dr. Wagner emphasizes the necessity of a trade-off, as overly cautious designs contradict the goal of efficient societal spending that is of utmost importance in the face of limited resources.

Key Points:

- Probability of failure is a critical metric in construction risk analysis.
- Designing for excessive safety is impractical and resource intensive.
- A balance must be found between safety and feasibility.

Aging Infrastructure: A Growing Concern

The discussion highlights the aging infrastructure in Europe and the US, pointing out the increasing importance of effective risk analysis in these regions.

Key Points:

- The aging infrastructure in industrialized countries poses new challenges.
- Effective risk analysis is crucial for maintaining safety and functionality.

Case Studies: Application of Quantitative Risk Analysis

Dr. Wagner provides examples of Matrisk's application of risk analysis in various projects, showcasing the practical implications and benefits of their approach.

I. Case 1: SBB Project (Abb.1)

- Collaborated with the Swiss Federal Railways (SBB).
- Developed a probabilistic load model for bridges based on wheel load measurements.
- Result: Identified potential for increased traffic loads on certain bridges.

II. Case 2: Fire Protection Regulation Project

- Partnership with the Association of Cantonal Fire Insurances (VKF).
- Focused on unifying fire protection regulation across Switzerland.
- Evaluated the efficiency of fire protection measures in terms of quantitative risk reduction.
- Result: Ranked effectiveness of fire protection and allow for cost-effective safety improvements.

III. Case 3: Offshore Wind Farms (Abb.2)

- Developed software for probabilistic digital twins for offshore wind farms.
- Implemented tools for risk-based inspection planning considering uncertainties.
- Result: Optimized inspection plans and extended the lifetime of wind farms.

Process of Quantitative Risk Analysis

Dr. Wagner outlines the general steps involved in a quantitative risk analysis project. He emphasizes the importance of good communication with clients for understanding, gathering and interpreting the data.

Steps:

1. **Exploration:** Collaborating with clients to gather necessary data.
2. **Model Development:** Creating a model based on collected data.
3. **Model Calibration:** Adjusting the model to align with real-world data.
4. **Iterative Review:** Reviewing the model with clients for validation and credibility.
5. **Result Generation:** Producing actionable recommendations based on the model.

Potential and Challenges

I. Potential

- **Informed Decision-Making:** Quantitative risk analysis offers the potential for making more informed decisions by understanding and preparing for various levels of risk, rather than aiming for absolute safety which doesn't exist.
- **Resource Optimization:** It allows for the optimization of resources by directing efforts and investments toward mitigating risks that have the highest probability and potential impact, thereby preventing over-engineering and unnecessary expenses.
- **Future-Proofing Infrastructure:** By identifying the probability of rare but catastrophic events, quantitative risk analysis helps in the design and maintenance of infrastructure that can withstand such events, thus future-proofing investments.

II. Challenges

- **Understanding of Probabilistic Concepts:** Clients often struggle with the probabilistic nature of risk analysis, as it requires a shift from a deterministic mindset, which treats accidents as avoidable

deterministic events, to a mindset that acknowledges their probabilistic nature and manages possible outcomes.

- **Communication Barriers:** Effective communication is crucial in explaining the value and implications of quantitative risk analysis to clients who may not be familiar with its principles and benefits.
- **Data Sensitivity:** Accurate risk analysis relies on detailed and sensitive data, which requires trust between the analyst and client for sharing and interpreting such information.

Conclusion

This paper summarizes a podcast episode on quantitative risk analysis, shedding light on its necessity for balancing safety with practicality in construction. It emphasizes the importance of understanding the probability of failures, the impossibility of absolute safety, and the need for a balanced approach. Aging infrastructure requires careful risk management to ensure continued functionality. The paper also covers case studies and outlines the risk analysis process, highlighting the benefits of informed decision-making and the challenges in communication and data management.

For more in-depth discussions and insights, listeners are encouraged to tune into the "Concretely" podcast and share their thoughts on the episode's webpage at www.concrete-ly.com.

Literature

- Book: [Melchers R. E and Beck A. T. \(2017\), Structural Reliability Analysis and Prediction, 3rd Edition](#)
- Book: [Gelman, A. et al. \(2021\), Bayesian Data Analysis, 3rd Edition](#)
- ETH lecture notes: [Structural Reliability and Risk Analysis](#)
- Online handbook: handbook.reliability.space (especially [part 6](#))