STATIK & DYNAMIK

RUHR UNIVERSITÄT BOCHUM

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RELIABILITY ANALYSIS AND DESIGN OF RC AND SFRC STRUCTURES CONSIDERING POLYMORPHIC UNCERTAINTIES

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Monday, 28. April 2025 – 13:00 - 17:00 – IC 02/158-88

Ensuring structural safety requires a precise understanding of uncertainties in material properties, environmental conditions, and modeling assumptions. This dissertation advances the design of reinforced concrete (RC) and steel fiber-reinforced concrete (SFRC) structures by integrating polymorphic uncertainties – combining aleatory and epistemic uncertainties – into a reliability-based framework. While aleatory uncertainties account for inherent randomness, such as material heterogeneity, epistemic uncertainties stem from limited knowledge, including variations in fiber orientation.

Building on semi-probabilistic safety concepts, this study employs probabilistic methods to quantify failure probabilities across ultimate and serviceability limit states. However, accurately estimating low failure probabilities requires a large number of realizations, making finite element simulations computationally prohibitive. To overcome this challenge, reliability analysis is combined with a Transformer-based model for uncertainty quantification.

Finally, reliability-based design optimization reveals that while steel fibers can partially replace conventional reinforcement, their greatest value lies in complementing its – substantially reducing crack width sensitivity to stochastic loads and enhancing durability. Hence, this thesis underscores the importance of integrating uncertainties and the strategic use of steel fibers in the sustainable and durable design of concrete structures.

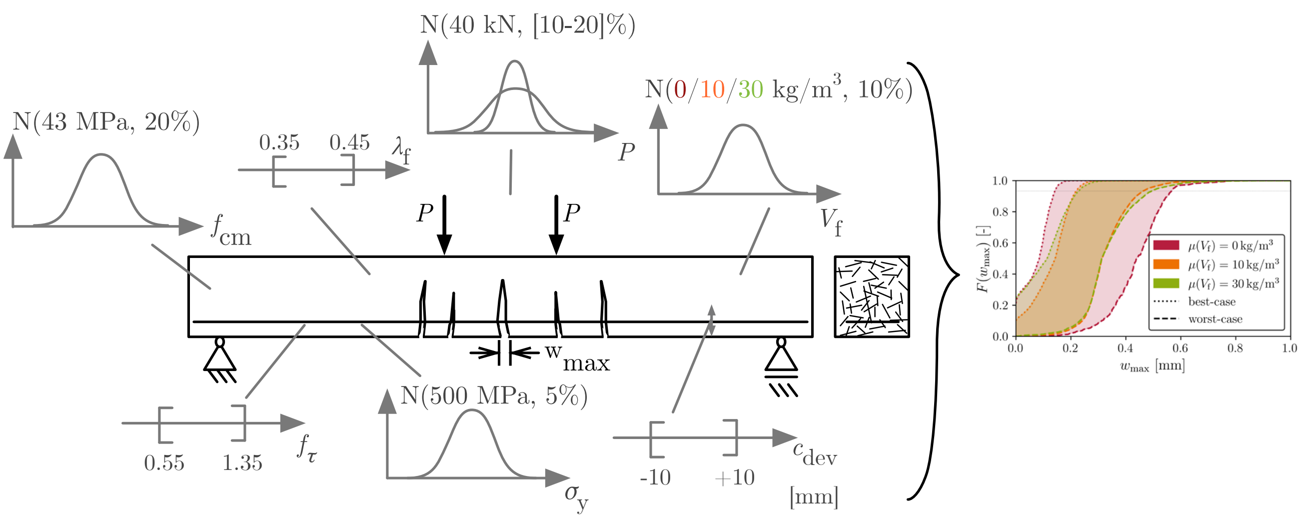

Figure: Propagation of polymorphic uncertainties from input parameters (left) to the cumulative distribution function (CDF) of the maximum crack width (right).

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