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Active learning reliability analysis for the design of reinforced concrete rail bridges

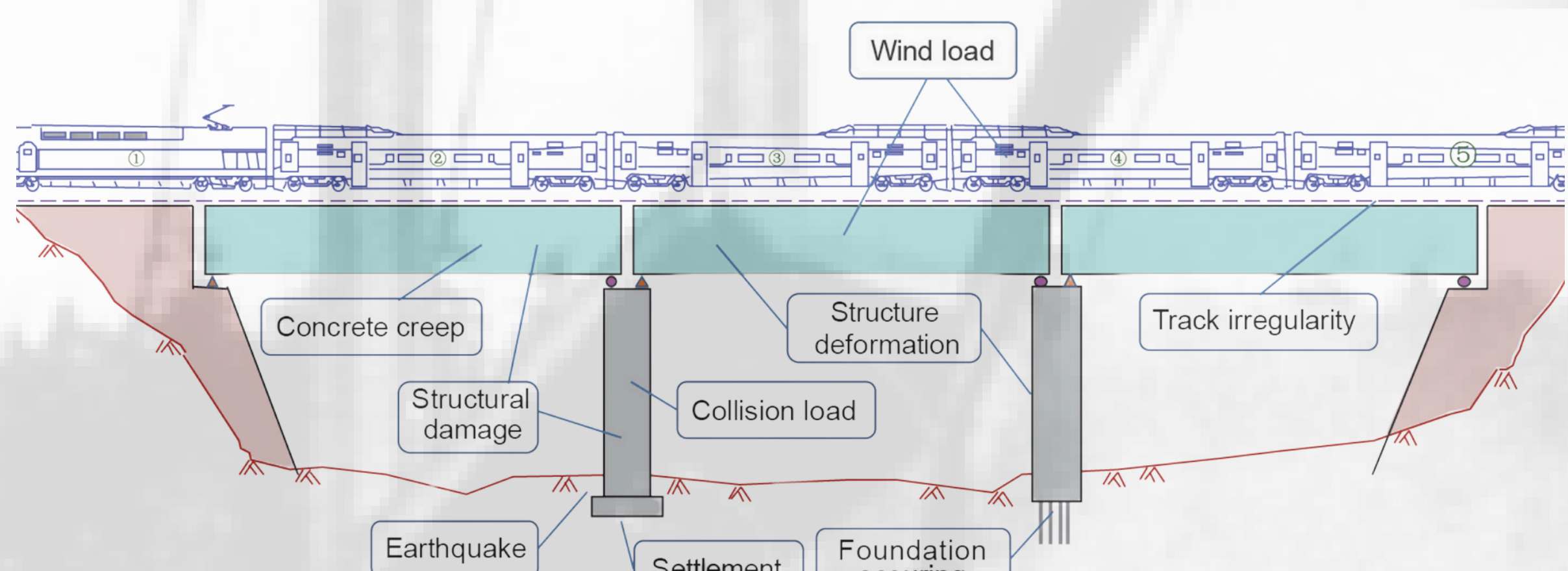
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Reliability analysis, Finite element model, active learning, surrogate model, reinforced concrete.

The design and analysis of reinforced concrete rail bridges is a challenging process, especially in the context of uncertainty propagation. A performant way to select the most performant design scenario is the emulation of the performance functions using surrogate modeling.

Introduction



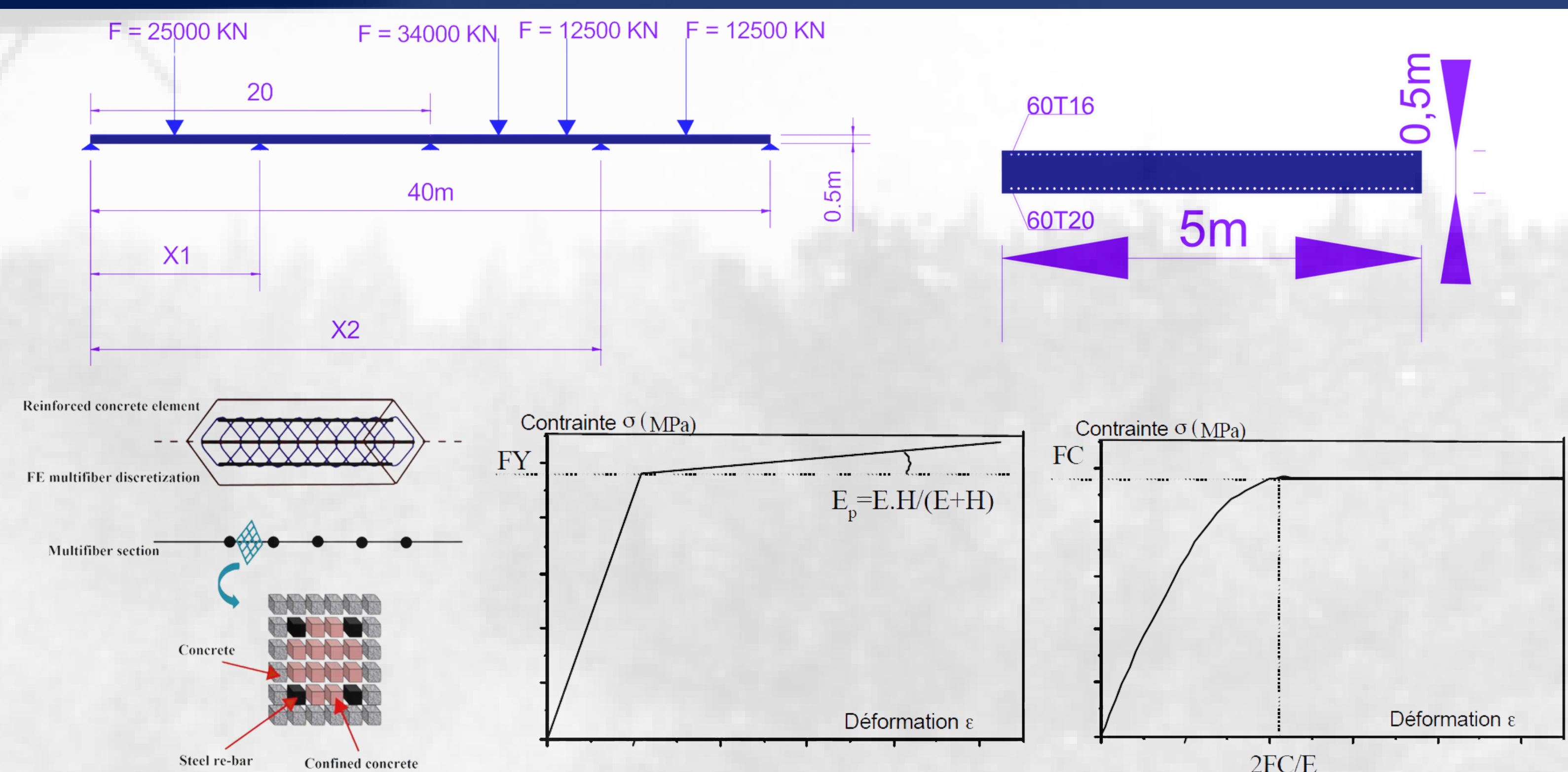
Sources of Uncertainties

Physical properties	Operational conditions	Lack of knowledge
Manufacturing tolerances	Loads uncertainties	Poor site investigations
Material strength	irregularities	Non-destructive tests

Performance Quantities of interest

Ultimate limit state	Service limit state
Stress	Deflection
Strain	Cracking control
Damage	Dynamic acceleration

Numerical model



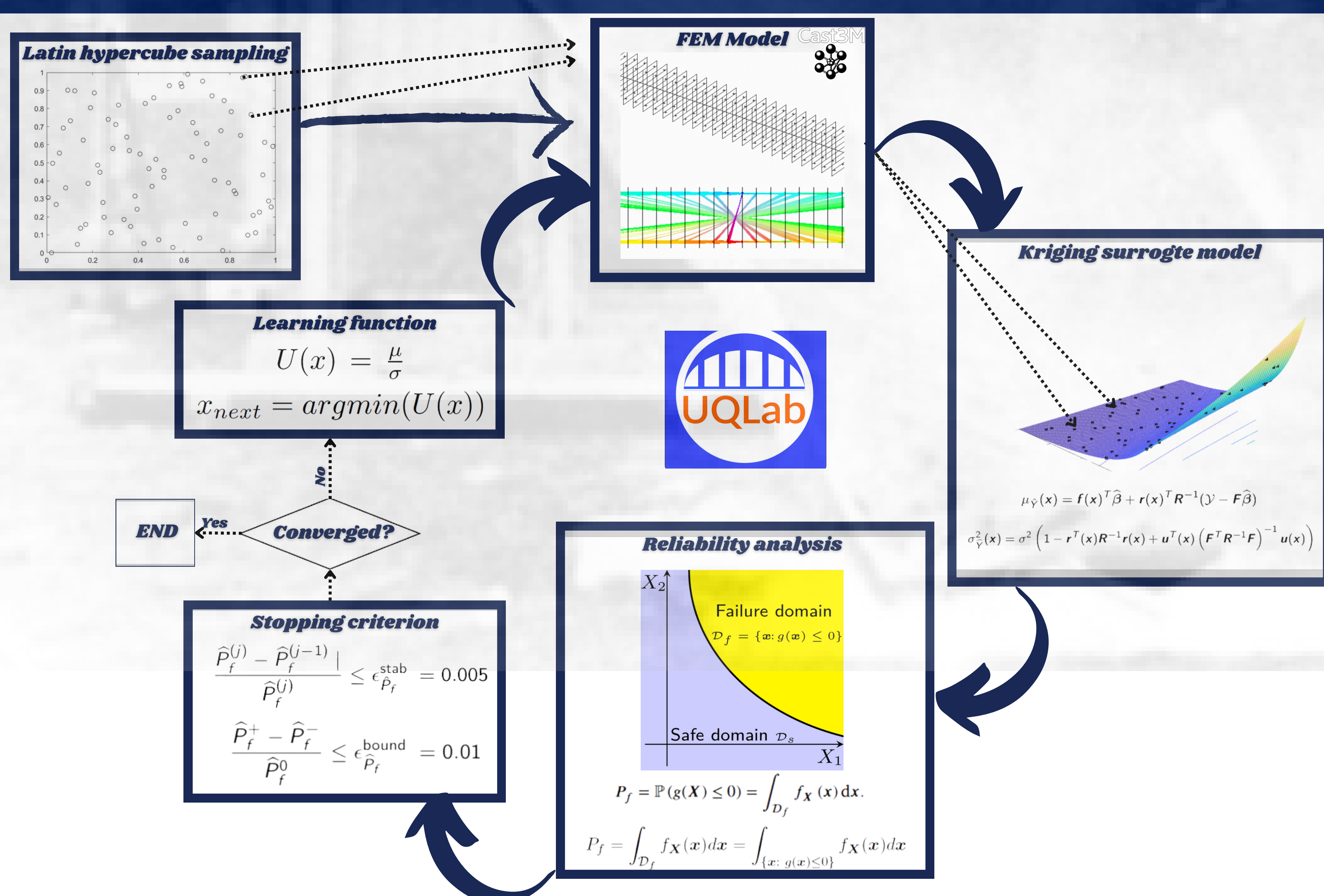
- Continuous reinforced concrete beam.
- Timoshenko Multi-fiber Cast3M finite element model
- Béton-Bael (concrete); plastic hardening (steel)

$$(\epsilon_x)_i = \epsilon_x - y_i \cdot \phi_z + z_i \cdot \phi_y$$

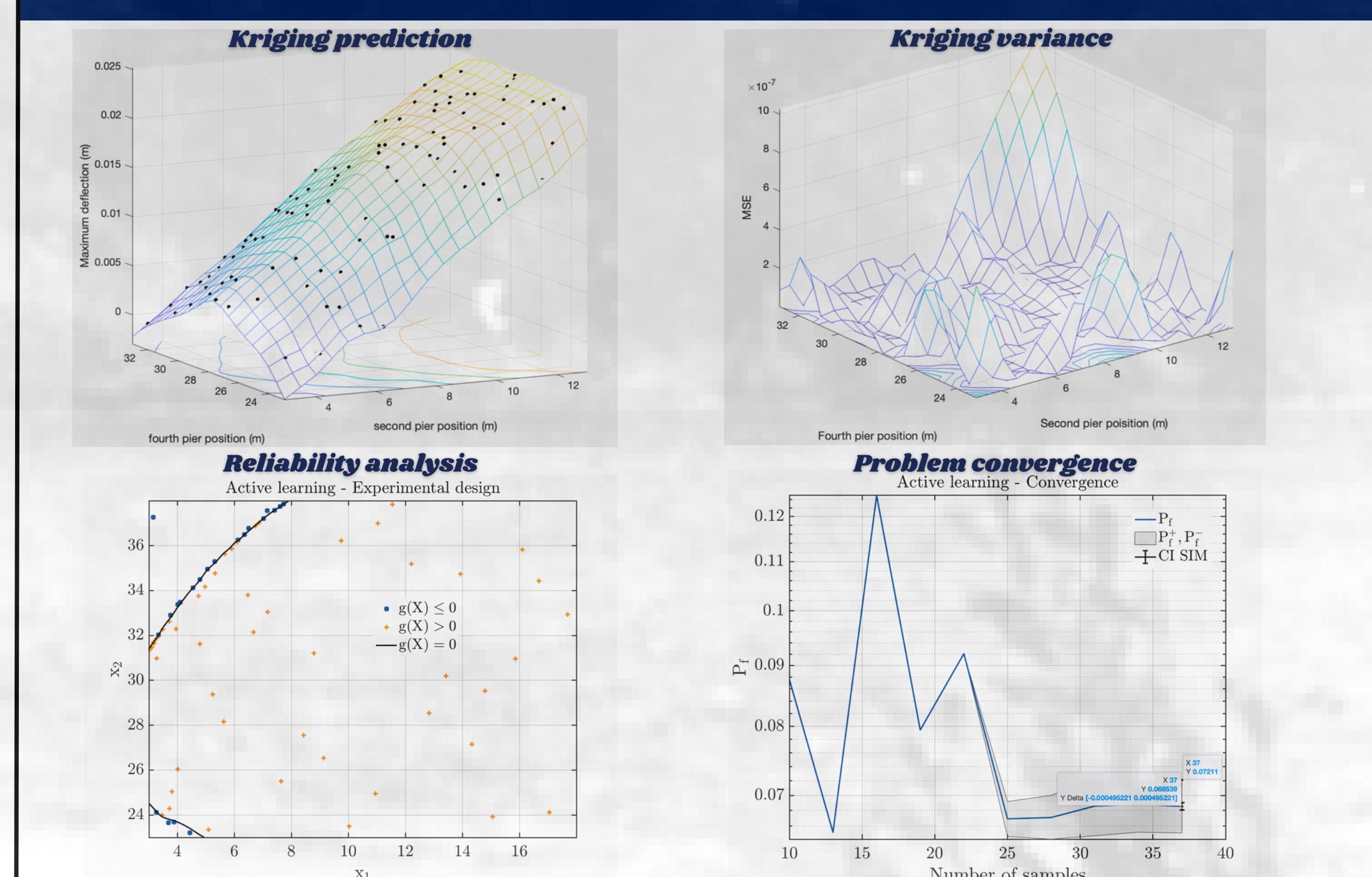
$$(\gamma_y)_i = \gamma_y - z_i \cdot \phi_x$$

$$(\gamma_z)_i = \gamma_z + y_i \cdot \phi_x$$

Methodology: Active learning reliability analysis



Results



Discussion

- Active learning reliability analysis is efficient for the design of complex structures
- More complex non-linear dynamic models should be considered.
- Civil Engineering structures are complex redundant structures: their failure can depend on the failure of multiple elements and about multiple quantities of interest. (System reliability to be considered).

References

Maliki Moustapha, Stefano Marelli, and Bruno Sudret. Active learning for structural reliability: Survey, general framework, and benchmark. Structural Safety, 96:102174, 2022.

Nan Zhang, Yuan Tian, and He Xia. A train-bridge dynamic interaction analysis method and its experimental validation. Engineering, 2(4):528–536, 2016.

MINERVE: methods and tools for sectoral collaboration and digital continuity over the life cycle of railway infrastructure
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