

# Robust cracking predictions for settlement damage



SUMMARY

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## THE REASON FOR THE RESEARCH

- Underground construction implies that existing buildings and architectural city heritage face the risk of being damaged due to settlements. The issue is particularly relevant to cities in Dutch Delta areas, because we have a combination of soft soil, fragile pile foundations and brittle, un-reinforced masonry facades.
- The engineering challenge lies in the development and validation of settlement design rules and damage classification systems for different building typologies.
- The scientific challenge lies in developing more accurate and robust models for crack width predictions at building level.

## THE PLAN OF THE PROJECT

This Delft Cluster project undertakes fundamental research into:

- A new sequentially linear finite element technique for robust cracking predictions. Start-up work has shown that cracking damage due to ground settlement is a highly discontinuous process. Standard incremental-iterative solution techniques often fail. A sequential model has potential as an alternative.
- A 'saw-tooth softening' stress-strain law for concrete and masonry. The key is that cracking and softening for concrete and masonry are not captured via negative stiffness, but via positive saw-tooth stiffness, which improves the robustness.
- Extensions to non-proportional loadings, e.g. due to passage of emerging tunnel fronts, time-dependent delayed settlements.
- Using the new models in parametric studies and case histories, for different building types.
- Translate the results into updates of equivalent beam models that can be used by practising engineers.

The project is attached to COB-project F530 'Monitoring North-South Line', in order to inter-address the engineering and scientific challenges: applied+fundamental research.

## THE RESULTS OF THE PROJECT

- Updated engineering design rules for building response to settlement, including improved cracking information.
- Robust finite element models that set an example to future risk assessments of buildings subjected to settlement.
- Extension of knowledge from masonry facades to complete buildings, including concrete frames.