STRUCTURES AND ARCHITECTURE

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Climate, environment and frost damage of architectural heritage

S. Kyllingstad, T. K. Thiis, A. Flø & J. Potac
Norwegian University of Life Sciences, Department of Mathematical Sciences and Technology, Ås, Norway

M. Sykora
Czech Technical University, Klokner Institute, Prague, Czech Republic

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Assessment of historical immovables

A/CZ0046/2/0013

AIMS | PARTNERS | ACTIVITIES | OUTCOMES

Supported by a grant from Iceland, Liechtenstein and Norway trough the EEA Finacial Mechanism and the Norwegian Finacial Mechanism

Klokner Institute ČVUT

Aims

Protection, conservation or renewal of historical immovables is becoming an important task for art historians, architects and civil engineers in many European countries. Inevitable part of a preservation of many historical immovables, including heritage structures such as industrial buildings, bridges and folk architecture, is their reliability assessment and design of adequate interventions taking into account the actual structural conditions and expected performance.

The fundamental research sub-project is aimed at developing the general methodology for the complex assessment of heritage structures with a particular focus on industrial buildings and bridges. The main goal of the sub-project is to provide operational tools and background information for decision making concerning the protection, conservation, renewal and extended use of historical immovables. The primary target group includes researchers, designers, practicing engineers, cultural heritage management and local authorities and other specialists interested in preservation of cultural heritage.

The sub-project is based on the partnership of the Czech Technical University in Prague - Klokner Institute and the Norwegian University of Live Sciences - Institute for Mathematics and Technology. In the period 2009-2010 the sub-project is partly supported by the Research Support Fund (EEA Grants / Norway Grants), Czech state budget and by the partners.

Introduction

- **Frost damage to porous building materials**
- **Numerical Simulations**
  - Building aerodynamics
  - Driving rain
- **Case study**
- **Conclusions**

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Frost damage

- **Porous building materials contain water**
- **When water freeze, internal stress build up in the material and can cause flaking of the material**
- **Important factors in the rate of deterioration are**
  - Water content in the material
  - Number of freeze-thaw cycles (approximately 70 pr. year in Oslo, Norway)

Frost damage

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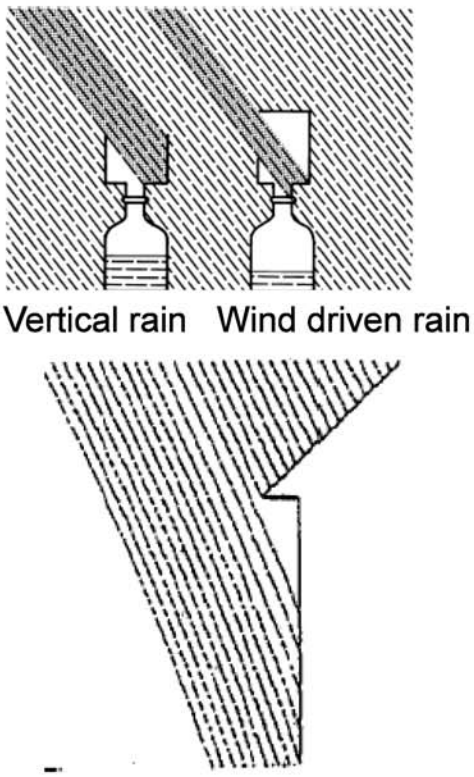
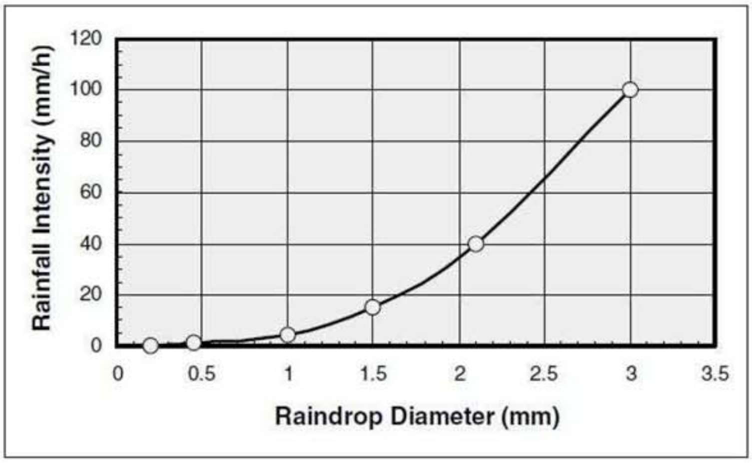
Wind driven rain



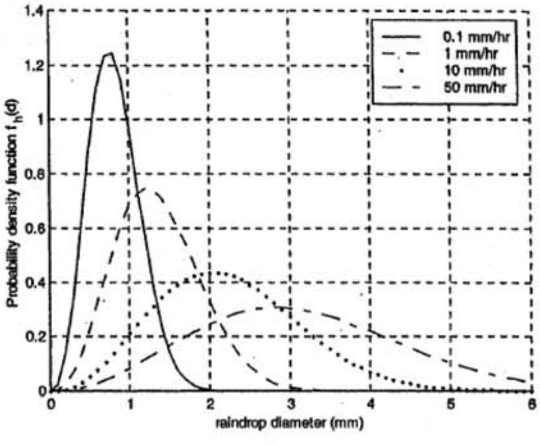
Wind driven rain

- As rainfall intensity increases, so does the mean raindrop diameter



Wind driven rain

- As mean raindrop diameter increases, the drop size spectrum increases

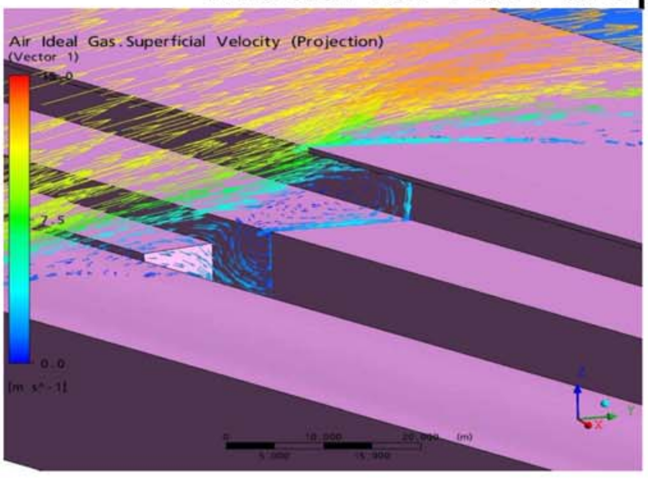


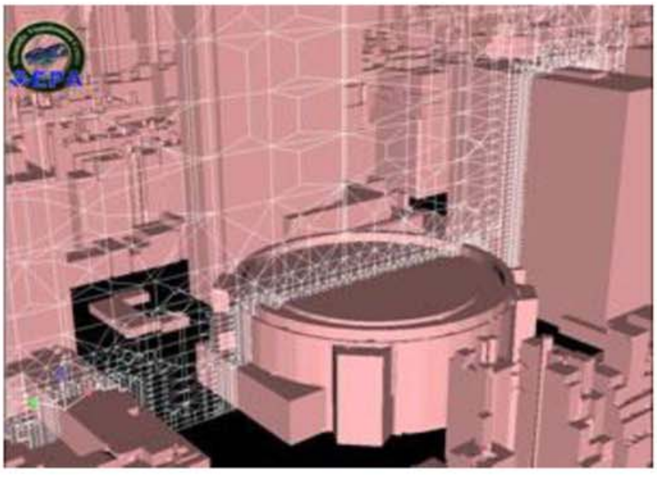
Wind driven rain

- Other important parameters are
  - Wind direction
  - Wind speed
  - Building aerodynamics
  - Temperature

Numerical simulation

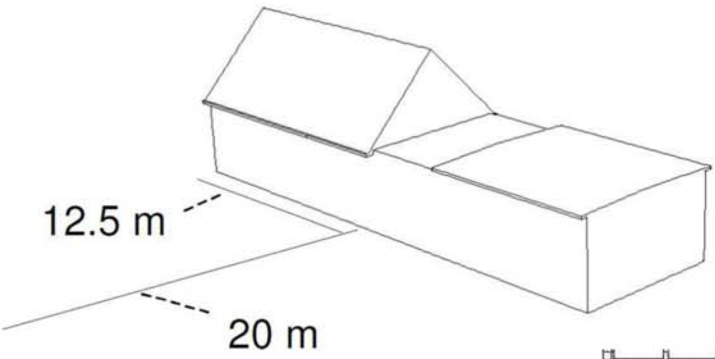
- Computational Fluid Dynamics (CFD)
  - 3D digital model of the building
  - Computational mesh
  - Solve Navier-Stokes equations
  - Turbulence model (k-e)
  - Model for rain drops





Numerical simulation

•Validation of numerical model



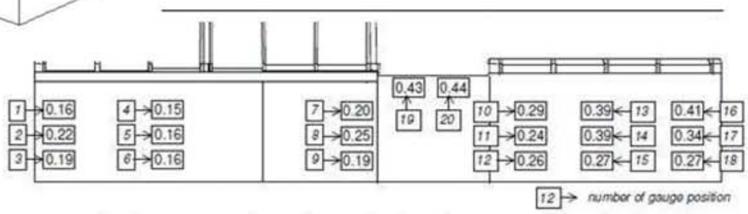


Figure 2: Results from numerical simulations (top) and experimental results (bottom) presented by Blocken and Carmeliet.

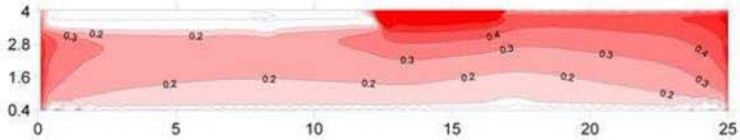


Figure 3: Results from two-phase simulations.

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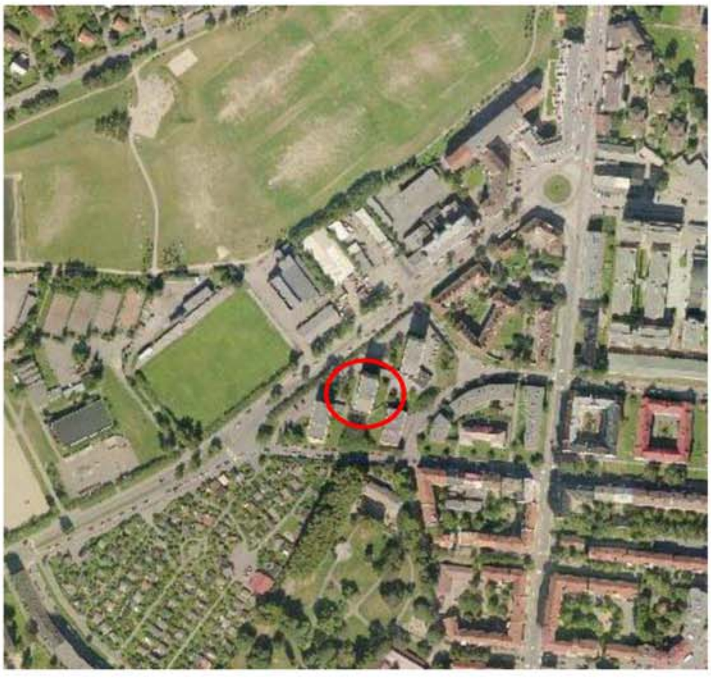
Numerical simulation

•Case study, Stavangergata in Oslo, Norway



Numerical simulation

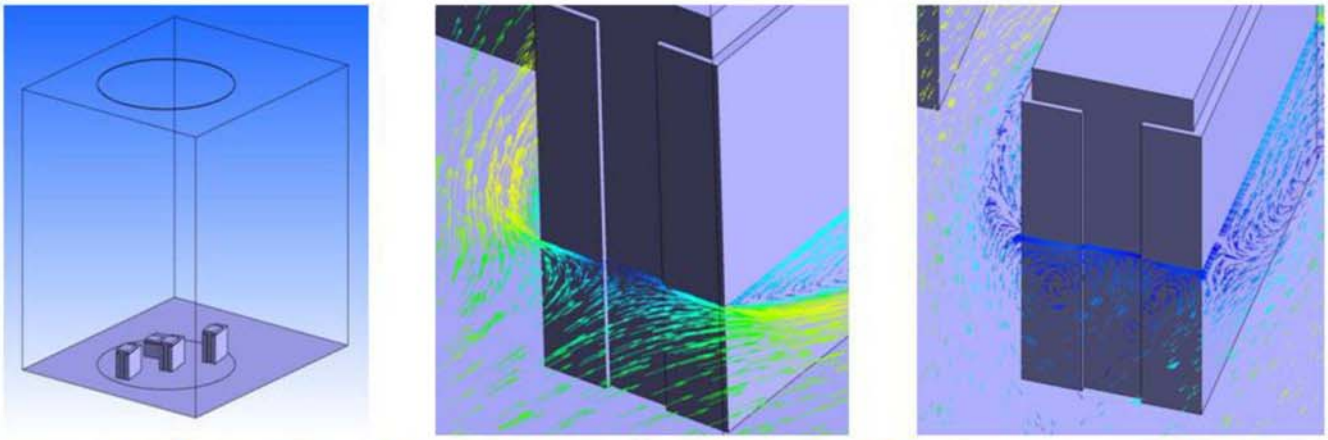
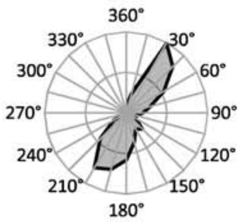


Figure 4: The left figure shows the buildings placed inside the simulation domain. The middle and right picture shows the wind pattern when wind is from 30 degrees and 205 degrees respectively.



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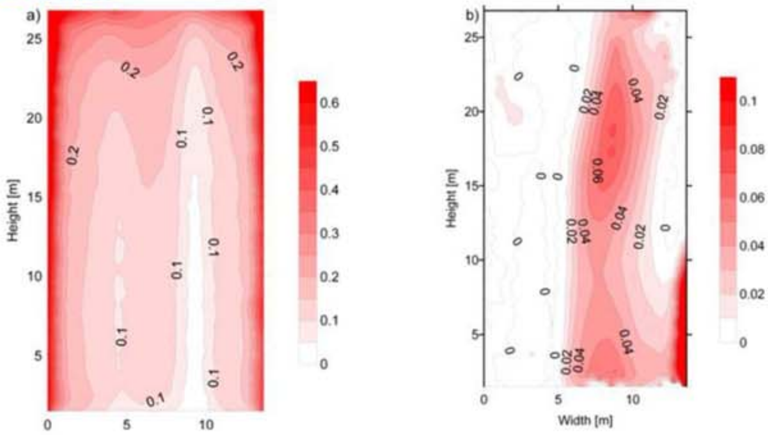
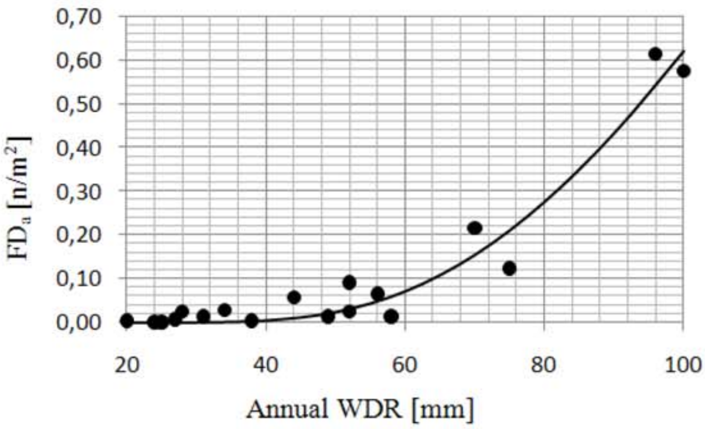
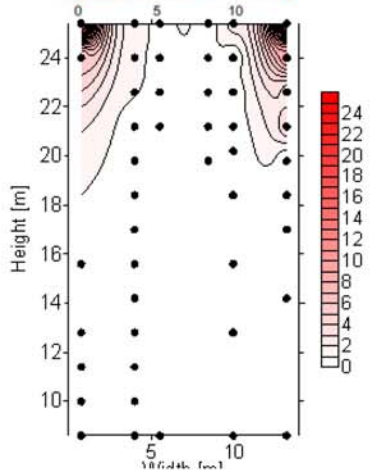
Damage characterisation

- **Damage characterisation**
  - Identify damages from pictures

Results







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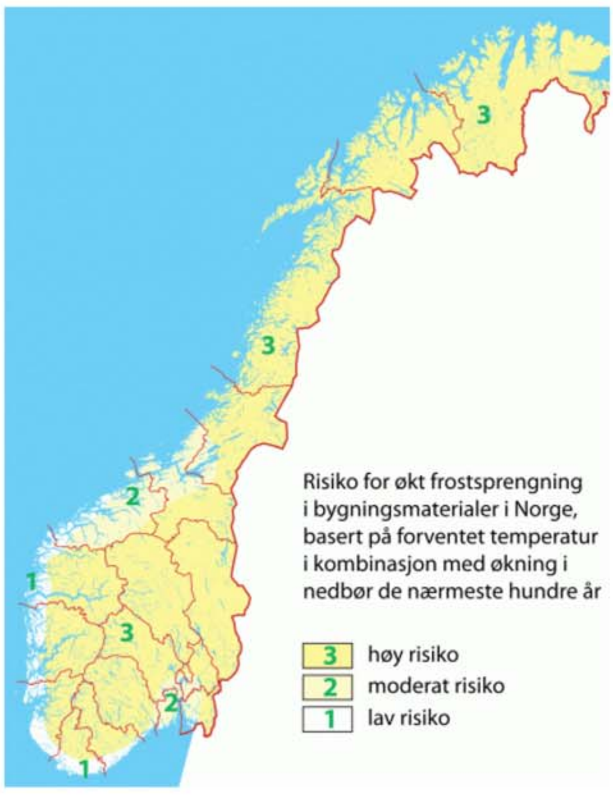
Conclusions and further work

- Characterise the damages to a building façade caused by driving rain and freeze thaw processes
- Climate change will change the damage pattern



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