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Hygrothermal performance and durability of highly insulated structures in contact with soil

Summary

A well-insulated building envelope is a key factor in the future zero-emission building stock. The present study mainly deals with the assessment and performance guaranteeing of hygrothermal behaviour and durability of the structures in contact with the soil. A significant lack of experimental data related to ground coupled heat loss and below-ground temperature distribution exists in the literature, specifically in the case of well-insulated floor slabs. Therefore, any new experimental data will improve these studies (to validate the numerical results obtained at this level): temperature profile as well as water content via soil depths and types under different boundary conditions. The main objectives in current doctoral thesis are: 1. Criticality assessment of structures in contact of soil 2. Improvement of calculation method for structures in contact with soil 3. Renovation solutions and durability of plinth walls

Research field:	Building and civil engineering and architecture
Supervisors:	Prof. Dr. Targo Kalamees Dr. Jaanus Hallik
Availability:	This position is available.
Offered by:	School of Engineering Department of Civil Engineering and Architecture
Application deadline:	Applications are accepted between June 01, 2023 00:00 and June 30, 2023 23:59 (Europe/Zurich)

Description

A well-insulated building envelope is a key factor in the future zero-emission building stock. The present study mainly deals with the assessment and performance guaranteeing of hygrothermal behaviour and durability of the structures in contact with the soil.

Current normative methodology for ground-coupled thermal bridges estimates too low internal surface temperatures due to steady-state assessment routine. This might overestimate condensation and mould growth risk and thus prevent the use of some possible renovation solutions when insulating basement walls, basement ceilings and specifically junctions between internal zones, unheated zones and external environment. Careful selection of steady-state boundary conditions with appropriately dimensioned cut-off planes based on measured undersoil temperatures and transient finite element modelling is expected to allow more realistic assessment of critical surface temperatures.

Additionally, the assessment of linear thermal transmittance of ground coupled thermal bridges is poorly described in current European norms (ISO 10211) providing instructions only for most basic situation. Refined methodology for multiple more complex situation for steady state as well as for transient heat loss of ground coupled thermal bridges will be developed during this doctoral study. Possible simplified tools or workflows for general practitioners will be described, refined method will be proposed for updating ISO 10211.

The overview of current publications shows that ISO steady-state calculation methodology underestimates the temperatures under floor construction. Few more detailed studies have shown that ground cover albedo, deep-ground temperature and boundary condition definition in ground coupled models has very small effect on total ground-coupled heat loss, although the effect increases with building size. The thermal conductivity and moisture content of soil has more prominent effect on ground-coupled heat loss through entire floor structure, however the effect to linear thermal transmittance is even higher. Additional research is needed to assess multidimensional heat and moisture transport in thermal bridge analysis as well as to consider the dynamic hygrothermal behaviour of thermal bridges in contact with soil. Additional parameters such as rain effect and evapotranspiration on soil thermal properties and heat losses may be important to consider.

A significant lack of experimental data related to ground coupled heat loss and below-ground temperature distribution exists in the literature, specifically in the case of well-insulated floor slabs. Therefore, any new experimental data will improve these studies (to validate the numerical results obtained at this level): temperature profile as well as water content via soil depths and types under different boundary conditions.

The main objectives in current doctoral thesis are:

1. **Criticality assessment of structures in contact of soil**

- • **Background**. Criticality of thermal bridges is assessed by using stationary conditions that does not consider thermal mass that is high for structures with contact with soil and results unrealistic temperature distribution. The use of dynamic multi-dimensional heat flows has not been realized in current design practice and methods with guaranteed performance are needed.
  - **Methods**. Field measurements ® dynamic (hygro)thermal modelling (2D Delphin, 3D Physibel), ® stationary 2D thermal modelling (Therm as a common design practice).
  - **Expected result**. Design method to assess criticality of thermal bridges for temperature factor (and soil frosting). Which previous period soil temperature (depending on the external climate, the geometry of the building and the internal temperature) must be taken use in the calculation of the structures with contact of soil?

2. Improvement of calculation method for structures in contact with soil

- • **Background**. Heat loss of structures with contact with soil are calculated based on standard EN ISO 13370 “Thermal performance of buildings — Heat transfer via the ground”, which the first version is based on 1998. Today building structures are much highly insulated and simplified calculation method may not be valid anymore.
  - **Methods**. Heat transfer field measurements ® dynamic (hygro)thermal modelling (2D Delphin, 3D Physibel), ® stationary 2D thermal modelling (Therm as a common design practice).
  - **Expected result**. Improved calculation method to calculated heat loss of building structures and their connections with soil.

3. Renovation solutions and durability of plinth walls

- • **Background**. Plinth wall face with the most complicated moisture loads: driving rain and splashing up from the ground, contact with snow, salt from the street etc. In the existing renovation solutions, there are no functional solutions for the plinth.
  - **Methods**. Determination the main challenged regarding the durability and service life ® development of renovation solutions (modelling) , laboratory and field measurements to determine the performance of developed solutions.
  - **Expected result**. Renovation solutions for plinth walls with proven performance

Requirements for the candidate’s background and knowledge: Deep knowledge on hygrothermal design.

Time and place: 2023-2027, Nearly Zero Energy Buildings Research Group in Tallinn University of Technology.

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