Interior insulation—Characterisation of the historic, solid masonrybuilding segment and analysis of the heat saving potential by 1d, 2d, and 3d simulation

When considering interior insulation of historic, multi-storey buildings with solid masonry walls, it is important to focus on two important factors: How big is the building segment to which it can be applied, and what is the significance of how the multi-dimensional geometry of these facades walls is considered in the assessment of the heat saving potential. The findings show that a large proportion of Danish multi-storey dwellings with solid masonry walls, high energy consumption, and uniform characteristics were found to originate from the period 1851–1930. This segment accounts for 25% of all multi-storey apartments in Denmark. It was investigated, which relative reduction of the average thermal transmittance could be obtained by interior insulation when simulated in different dimensions, degrees of insulation and thickness. The analysis showed that partial insulation of the spandrels below windows on the 2nd/3rd highest storeys accounted for up to 40% of the average thermal transmittance reduction achievable by fully insulating inside walls, while covering 17% of the space needed in the full insulation strategy. Furthermore, the analysis showed an underestimation of average thermal transmittance by 2-dimensional compared to 3-dimensional simulation by up to 57%, indicating that 3-dimensional analysis is needed to obtain realistic results.
Exterior walls in historic multi-storey buildings compared to walls in modern buildings have low thermal resistance, resulting in high energy loss and cold surfaces/floors in cold climates. When restrictions regarding alteration of the exterior appearance exist, interior insulation might be the only possibility to increase occupant comfort. This paper describes an
investigation of the hygrothermal influence when applying 100 mm of diffusion open interior insulation to a historic multi-
storey solid masonry spandrel. The dormitory room with the insulated spandrel had a normal indoor climate with a
maximum observed monthly average humidity by volume excess of 3.2 g/m³ during the experiment. Relative humidity and
temperature were monitored manually using wooden dowels over 2 years and 8 months in two solid masonry spandrels:
one insulated wall and one untreated wall. The investigation showed that installing insulation on a solid masonry spandrel
induced hygrothermal changes: Uniformly distributed higher relative humidity and lower temperature throughout the
masonry, compared to an un-insulated wall. The relative humidity of the un-insulated masonry wall was in the range 50%
on the inside to 60% on the outside, while the insulated wall showed uniformly distributed values around 80%. The risk of
moisture-induced damage was evaluated based on mathematical models for mould and decay of wood, visual inspection
for frost and mould, and on-site measurements for presence of mould spores. The damage evaluation showed no risk of
damage from the changed hygrothermal conditions when applying interior insulation to a solid masonry spandrel.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Design, Section for Indoor Climate and Building
Physics
Authors: Odgaard, T. (Intern), Bjarlev, S. P. (Intern), Rode, C. (Intern)
Pages: 1-14
Publication date: 2018
Main Research Area: Technical/natural sciences

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BFI (2016): BFI-level 1
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Web of Science (2016): Indexed yes
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.093 SNIP 2.49 CiteScore 4.37
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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.938 SNIP 2.797 CiteScore 4.14
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.581 SNIP 2.602 CiteScore 3.57
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.331 SNIP 2.875 CiteScore 3.06
ISI indexed (2012): ISI indexed yes
Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.144 SNIP 2.255 CiteScore 2.76
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 1.235 SNIP 2.001
Web of Science (2010): Indexed yes
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.028 SNIP 1.865
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Conditions for mould growth on typical interior surfaces
Prediction of the risk for mould growth is an important parameter for the analysis and design of the hygrothermal performance of building constructions. However, in practice the mould growth does not always follow the predicted behavior described by the mould growth models. This is often explained by uncertainty in the real conditions of exposure. In this study, laboratory experiments were designed to determine mould growth at controlled transient climate compared to growth at constant climate. The experiment included three building materials with four different surface treatments. The samples were inoculated with 8 common indoor moulds. Even after 40 weeks no growth was observed on any sample. The paper describes different hypotheses for the missing growth, and how these have been tested.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Department of Biotechnology and Biomedicine, Fungal Degradation, Aalborg University
Authors: Møller, E. B. (Ekstern), Andersen, B. (Intern), Rode, C. (Intern), Peuhkuri, R. (Ekstern)
Pages: 171-176
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Conference: 11th Nordic Symposium on Building Physics, Trondheim, Norway, 11/06/2017 - 11/06/2017
Main Research Area: Technical/natural sciences

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Journal: Energy Procedia
Volume: 132
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Scopus rating (2015): SJR 0.365 SNIP 0.561 CiteScore 0.92
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.433 SNIP 0.81 CiteScore 1.09
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.425 SNIP 0.785 CiteScore 1.02
Enhancing demand side flexibility in Nordhavn buildings for integrated multi-energy systems

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Department of Electrical Engineering, Center for Electric Power and Energy, Distributed energy resources
Authors: Li, R. (Intern), Wang, J. (Intern), Zong, Y. (Intern), Foteinaki, K. (Intern), Rode, C. (Intern)
Number of pages: 1
Publication date: 2017

Host publication information
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Publisher: Technical University of Denmark (DTU)
Article number: L-9
Main Research Area: Technical/natural sciences
Conference: Sustain 2017, Kgs. Lyngby, Denmark, 06/12/2017 - 06/12/2017
Electronic versions:
SustainAbstracts2017c.compressed_105.pdf
Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2017

Impact of Building Design Parameters on Thermal Energy Flexibility in a Low-Energy Building
This work focuses on demand-side management potential for the heating grid in residential buildings. The possibility to increase the flexibility provided to the heat network through specific building design is investigated. The role of different parts of the building structure on thermal flexibility is assessed through a parameter variation on a building model. Different building designs are subjected to heat cut-offs, and flexibility is evaluated with respect to comfort preservation and heating power peak creation.

Under the conditions of this study, the thermal transmittance of the envelope appears to have the largest impact on thermal flexibility. The importance of window design, namely the size, U-value and orientation, is underlined due to its critical influence on solar gains and heat losses. It is eventually observed that thermal mass has a secondary influence on the evaluated indicators; its variation only affects thermal flexibility if the thermal resistance of the envelope is sufficient.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Technical University of Denmark
Authors: Sarran, L. (Ekstern), Foteinaki, K. (Intern), Gianniou, P. (Intern), Rode, C. (Intern)
Number of pages: 10
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions:
Untitled.pdf
Impact of Weather and Occupancy on Energy Flexibility Potential of a Low-energy Building

The introduction of renewable energy sources in the energy market leads to instability of the energy system itself; therefore, new solutions to increase its flexibility will become more common in the coming years. In this context the implementation of energy flexibility in buildings is evaluated, using heat storage in the building mass. This study focuses on the influence of weather conditions and internal gains on the energy flexibility potential of a nearly-zero-energy building in Denmark. A specific six hours heating program is used to reach the scope. The main findings showed that the direct solar radiation and the outdoor temperature appeared to have the larger impact on the thermal flexibility of the building. Specifically, the energy flexibility potential of the examined apartment can ensure its thermal autonomy up to 200 h in a typical sunny winter day.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Technical University of Denmark
Authors: Zilio, E. (Ekstern), Foteinaki, K. (Intern), Gianniou, P. (Intern), Rode, C. (Intern)
Number of pages: 10
Publication date: 2017
Main Research Area: Technical/natural sciences
Electronic versions: Untitled.pdf

Implementation of Energy Strategies in Communities (Annex 63) Volume 1: Inventory of measures

This report describes the existing national political framework conditions, energy and land-use planning processes, strategies for energy planning and existing national measures in the field of urban and energy planning. In this research, the term measure refers to any action, program, policy or other activity that can demonstrate or influence a change in process. Amongst other background information, 22 planning processes and 89 measures from 11 countries are described in detail in this report.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy, Aalborg University, Norwegian University of Science and Technology, Osaka University, RWTH Aachen University, University of Minnesota
Number of pages: 107
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Volume: 1
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Main Research Area: Technical/natural sciences
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https://www.annex63.org/app/download/13561884934/Annex63_Volume1_September+2017.pdf?t=1511422950

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This report describes the existing national political framework conditions, energy and land-use planning processes, strategies for energy planning and existing national measures in the field of urban and
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**Implementation of Energy Strategies in Communities (Annex 63) Volume 2: Development of strategic measures**

This report describes the further development of the analysed measures from Volume 1 into strategic measures. As with the term measure, a strategic measure refers to an essential measure in concept that can be used to develop individual implementation strategies on a local level for part or the whole life cycle of a project (from the first vision to monitoring of the implemented solution). The developed strategic measures deal with the following topics: Setting Vision and Targets Developing Renewable Energy Strategies Making Full use of Legal Frameworks Designing an Urban Competition Processes Making use of Tools Supporting the Decision Making Process Implementing Monitoring of Energy Consumption and GHG Emission practices Enhancing Stakeholder Engagement & Involvement Including Socio Economic Criteria Implementing Effective and Efficient Organisational Processes  

The report includes both a summary of each strategic measure supported by nine appendices, each a detailed description of each strategic measure.

**General information**
State: Published  
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy, Aalborg University, Norwegian University of Science and Technology, Osaka University, RWTH Aachen University, University of Minnesota  
Number of pages: 253  
Publication date: 2017

**Intelligent Scheduling of a Grid-Connected Heat Pump in a Danish Detached House**

This study proposes a methodology for intelligent scheduling of a heat pump installed in a refurbished grid-connected detached house in Denmark. This scheduling is conducted through the coupling of a dynamic building simulation tool with an optimization tool. The optimization of the operation of the system is based on a price-signal considering a three-day period for different weather cases. The results show that the optimal scheduling of the system is successful in terms of reducing the peak load during times when electricity prices are high, thus achieving cost savings as well as maintaining good thermal comfort conditions. The proposed methodology bridges dynamic building modelling with optimization of real-time operation of HVAC systems offering a detailed model for building physics, especially regarding thermal mass and a stochastic price-based control.

**General information**
State: Published  
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy  
Authors: Gianniou, P. (Intern), Foteinaki, K. (Intern), Heller, A. (Intern), Rode, C. (Intern)  
Publication date: 2017  

Main Research Area: Technical/natural sciences  
Electronic versions:
Moisture buffering phenomenon and its impact on building energy consumption

Moisture buffering is the ability of surface materials in the indoor environment to moderate the indoor humidity variations through adsorption or desorption. Materials with high moisture buffering capacity could be used to passively control the indoor moisture condition and consequently improve the indoor environmental quality and reduce the latent heat load of buildings. In order to characterize the moisture buffering ability of materials, the basic concept of moisture buffer value (MBV) is adopted. The paper first proposes a new mathematical expression of basic MBV, and then introduces a theoretical correction factor that could be used together with the MBV to calculate the moisture uptake/release by hygroscopic materials exposed to different types of humidity variations. Secondly, a simplified two-bottle test method is proposed to measure the MBV in the present study. The impact of moisture buffering on building energy consumption in different climate conditions is assessed by using numerical simulations. The results show that the potential energy saving rate could be up to 25–30% when using proper hygroscopic materials in the test building in temperate climates and semi-arid climates. Finally, the relationship between MBV and potential energy saving rate is also discussed.
Moisture damage with magnesium oxide boards in Danish facade structures

Magnesium oxide boards have been widely used on facades in Denmark during 2010-2015. However, the magnesium salts absorb humidity from the ambient, and they begin to leak salty water, which is highly corrosive, and leads to moisture and mould problems in wooden members of the structures. MgO-boards were not tested for their hygrothermal function before being used on exterior wall structures, which has had detrimental consequences, such as an expected cost of repair of around 2 billion DKK. Properties for moisture transport and retention properties have been determined and will be shown together with some examples of damaged structures.

**General information**

State: Published  
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Design, Bunch Bygningsfysik ApS
Strengthening requirement specification in sustainable procurement - an investigation of challenges

To reap the benefits of sustainability in the construction sector, it is crucial that the stakeholders involved can implement it in practice. Investigations have shown that choices made in the early phases of the building process are of very great importance for the outcome and the initiatives and decisions taken by the building owner are crucial. This paper presents research on Danish building practitioners' ability to make requirements for sustainability in procurement. On the basis of an action research strategy, we asked practitioners to help identify the challenges involved in requiring sustainable solutions through procurement. These included among others a lack of knowledge or experience in sustainable procurement and interdisciplinary challenges. The research showed that practitioners are able to formulate specific requirements for sustainability in procurement. However, the challenges found imply that a sustainable approach in procurement is not fully implemented in a Danish context. This suggests that there is a need for guidance in the area, if the practitioners are to move from good intentions to making more specific requirements for sustainability in procurement.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Design
Authors: Eriksen, M. S. H. (Intern), Bjarløv, S. P. (Intern), Rode, C. (Intern)
Number of pages: 16
Pages: 107-122
Publication date: 2017
Towards the definition of indicators for assessment of indoor air quality and energy performance in low-energy residential buildings

A major obstacle for integrating energy and indoor air quality (IAQ) strategies in the design and optimization of buildings is the non-existence of an agreed measure, which can quantitatively describes the IAQ and will allow the assessment of measures to improve energy performance. A complication to develop such an IAQ index is that hundreds of chemical compounds are present in indoor air, including residential environments, at concentrations much lower than occurring during occupational exposures. There is a lack of clear consensus on which pollutant or group of pollutants should be used to form such an index as well as on how they should be integrated into one index. IEA EBC Annex 68 was formed with the objective to discuss Indoor Air Quality Design and Control in Low Energy Residential Buildings. The objective of Subtask 1 of this Annex described in this paper was to review, discuss and propose methods and approaches to define an IAQ index and to develop such an index so that it can be used as a key performance indicator to examine the methods to control IAQ, which are integral parts of other subtasks in this IEA EBC project. To meet this objective, the pollutants measured in low-energy houses were compared with pollutants measured in traditional houses. Pollutants measured and known to be harmful for health were identified and selected to be represented on a list of pollutants that should be considered when the IAQ index is defined. The selected pollutants were: acetaldehyde, acrolein, α-pinene, benzene, carbon dioxide, formaldehyde, naphthalene, nitrogen dioxide, PM10, PM2.5, radon, styrene, toluene, trichloroethylene, TVOC and mould. Both short-term and long-term effects of these pollutants were considered. The compound with the highest ratio of concentration to its exposure limit value was proposed as the IAQ index for the short term effects so that the existing exposure limits could be referred to and to avoid problems associated with the aggregation of many air quality indices. The same approach was proposed for the IAQ index for the long-term effects together with the calculation of the burden of disease caused by the compounds of concern expressed as the sum of disability-adjusted life years. It is recognized that the proposed IAQ indices are crude, and the list of compounds is incomplete. It should be progressively updated once new data on exposure limits and pollutants of concern become available.

General information
State: Published
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<tr>
<td>Journal: Energy and Buildings</td>
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<td>Volume: 152</td>
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<td>Scopus rating (2016): CiteScore 4.64 SJR 2.093 SNIP 1.965</td>
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An International Project on Indoor Air Quality Design and Control in Low Energy Residential Buildings

In order to achieve nearly net zero energy use, both new and energy refurbished existing buildings will in the future need to be still more efficient and optimized. Since such buildings can be expected to be already well insulated, airtight, and have heat recovery systems installed, one of the next focal points to limiting energy consumption for thermally conditioning the indoor environment will be to possibly reducing the ventilation rate, or making it in a new way demand controlled. However, this must be done such that it does not have adverse effects on indoor air quality (IAQ).

Annex 68, Indoor Air Quality Design and Control in Low Energy Residential Buildings, is a project under IEA’s Energy Conservation in Buildings and Communities Program (EBC), which will endeavor to investigate how future residential buildings are able to have very high energy performance whilst providing comfortable and healthy indoor environments.

New paradigms for demand control of ventilation will be investigated, which consider the pollution loads and occupancy in buildings. As well, the thermal and moisture conditions of such advanced building shall be considered because of interactions between the hygrothermal parameters, the chemical conditions, ventilation and the wellbeing of occupants. The project is divided into the five subtasks: 1. Defining the metrics. 2. Pollutant loads in residential buildings. 3. Modeling. 4. Strategies for design and control of buildings. 5. Field measurements and case studies. A flagship outcome of the project will be a guidebook on design and operation of ventilation in residential buildings to achieve high IAQ with least possible energy consumption. The paper illustrates the working program of each of these activities.

Detection of fungal growth and its influence on gypsum wallboard – in the process of creating sustainable building materials

Detection of fungal growth and its influence on gypsum wallboard – in the process of creating sustainable building materials

General information
State: Published
Organisations: Department of Systems Biology, Fungal Degradation, Department of Civil Engineering, Section for Indoor Climate and Building Physics, University of Sydney, Aarhus University, Aalborg University
Authors: Lewinska, A. M. (Intern), Lilje, O. (Ekstern), Foley, M. (Ekstern), Trimby, P. (Ekstern), Bjerring, M. (Ekstern), Vosegaard, T. (Forskerdatabase), Peukkuri, R. H. (Forskerdatabase), Rode, C. (Intern), Grumsen, F. B. (Intern), Hoof, J. B. (Intern), Andersen, B. (Intern)
Number of pages: 1
Publication date: 2016
Identification of parameters affecting the variability of energy use in residential buildings

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy, Department of Management Engineering, Systems Analysis, DTU Climate Centre, Centre for IT-Intelligent Energy Systems in Cities
Authors: Gianniou, P. (Intern), Heller, A. (Intern), Nielsen, P. S. (Intern), Rode, C. (Intern)
Number of pages: 2
Publication date: 2016
Event: Abstract from 12th REHVA World Congress, Aalborg, Denmark.
Main Research Area: Technical/natural sciences
Electronic versions:
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Identification of Parameters Affecting the Variability of Energy Use in Residential Buildings

Energy use of buildings varies significantly. When aggregating the demand profiles of a group of buildings, the variations of energy demand are critical to determine the aggregated load profile. Especially when dimensioning district energy systems, it is important to know the variability of energy demand that can guarantee the efficient operation of the system. For this reason, it is useful to distinguish the parameters that affect building energy performance the most and to estimate the magnitude of these variations on each parameter. The aim of the present study is to identify the parameters that lead to the largest variations in energy performance of residential buildings in Denmark. A set of sensitivity analysis has been carried out using an extensive search algorithm. These sensitivity analyses were then applied for modelling a reference building representing Danish single-family houses of the 1940’s. The study was able to determine the key variables that affect energy use in old Danish single-family houses using sensitivity analysis and proposes a methodology for parameter optimization. This analysis pointed out that the insulation in external walls and roof lead to the largest variations in space heating demand. Also, the infiltration rate and occupancy behavior play important role on space heating consumption. It was concluded that these findings highly depend on the specific case study and the characteristics of the buildings that are examined. If outdoor climate and location differ from the current case, a different set of parameters should be investigated upon its effect on building energy use.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy, Department of Management Engineering, Systems Analysis, DTU Climate Centre, Centre for IT-Intelligent Energy Systems in Cities
Authors: Gianniou, P. (Intern), Heller, A. (Intern), Nielsen, P. S. (Intern), Rode, C. (Intern)
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Heat demand, Variability, Sensitivity analysis, Building parameters
Source: PublicationPreSubmission
Source-ID: 125227000
Publication: Research - peer-review › Article in proceedings – Annual report year: 2016
IEA Project on Indoor Air Quality Design and Control in Low Energy Residential Buildings

Both new and renovated existing buildings will in the future need to be optimized in such a way that can achieve to have nearly no energy use while still providing impeccable indoor climates. Since such buildings can already be assumed to be very well insulated, airtight, and to be equipped with heat recovery systems, one of the next focal points to limiting energy consumption for thermally conditioning the indoor environment will be to possibly reducing the ventilation rate, or to make it in a new way demand controlled. However, this must be done such that it has no have adverse effects on Indoor Air Quality (IAQ).

Annex 68, Indoor Air Quality Design and Control in Low Energy Residential Buildings, is a project under IEA's Energy Conservation in Buildings and Communities Program (EBC), which will endeavor to investigate how future residential buildings are able to have very high energy performance whilst providing comfortable and healthy indoor environments. New paradigms for demand control of ventilation will be investigated, which consider the pollution loads and occupancy in buildings. The thermal and moisture conditions of such will be considered because of interactions between the hygrothermal parameters, the chemical conditions, ventilation and the wellbeing of occupants. A flagship outcome of the project is anticipated to be a guidebook on design and operation of ventilation in residential buildings to achieve high IAQ with smallest possible energy consumption.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Energy, Section for Indoor Climate and Building Physics, Universite de La Rochelle, Nanjing University, Technische Universitat Dresden, Ghent University
Authors: Rode, C. (Intern), Abadie, M. (Ekstern), Qin, M. (Ekstern), Grunewald, J. (Ekstern), Kolarik, J. (Intern), Laverge, J. (Ekstern)
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2016

Magnesium-oxide boards cause moisture damage inside facades in new Danish buildings

Magnesium oxide board, “MgO-board”, is a factory-made sheathing board product, which has been widely used in the last 5 years in ventilated facades on new or renovated buildings in Denmark. In winter 2014/15, a number of problems began to appear with these boards since the boards and adjoining building elements seemed to suffer from some sort of disease, which manifested itself by damages such as significant moisture, boards leaking salty water (‘tears’), corrosion of fittings and anchors and mould growth.

The damages were caused by the fact that MgO-boards absorb moisture from outside air in periods with high outdoor humidity (90-100% RH) and form water drops on the surfaces. The drops contain a high amount of soluble chloride ions and appear on the surfaces of the boards and may often run down the boards and to adjacent structures. Metal fixtures for the MgO-and siding boards may corrode heavily within a few years. The binder in MgO-boards is formed by chemical reaction between MgO and MgCl2, known as magnesium oxychloride cement or Sorel cement. Also organic matter can be found in the material. The paper presents results of investigations of properties for moisture ab- and desorption curves and transport of MgO-boards.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Design, Section for Indoor Climate and Building Physics, Bunch Building Physics ApS
Authors: Hansen, K. K. (Intern), Bunch-Nielsen, T. (Ekstern), Grek, B. (Intern), Rode, C. (Intern)
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ISBN (Print): 978-2-35158-178-0
Modeling energy flexibility of low energy buildings utilizing thermal mass

In the future energy system a considerable increase in the penetration of renewable energy is expected, challenging the stability of the system, as both production and consumption will have fluctuating patterns. Hence, the concept of energy flexibility will be necessary in order for the consumption to match the production patterns, shifting demand from on-peak hours to off-peak hours. Buildings could act as flexibility suppliers to the energy system, through load shifting potential, provided that the large thermal mass of the building stock could be utilized for energy storage. In the present study the load shifting potential of an apartment of a low energy building in Copenhagen is assessed, utilizing the heat storage capacity of the thermal mass when the heating system is switched off for relieving the energy system. It is shown that when using a 4-hour preheating period before switching off the heating system, the thermal mass of the building releases sufficient heat to maintain the operative temperature above 20°C for 15 hours. This potential increases with longer preheating period. The thermal behaviour of the external envelope and internal walls is examined, identifying the heat losses of the external envelope and the thermal capacity of the internal walls as the main parameters that affect the load shifting potential of the apartment.
Rapid detection and identification of *Stachybotrys* and *Chaetomium* species using tissue PCR analysis

Indoor fungi are a worldwide problem causing negative health effects for infected building's occupants and even deterioration of building structures. Different fungal species affect buildings and their inhabitants differently. Therefore, rapid and accurate identification of fungi to the species level is essential for health risk assessment and building remediation. This study focuses on molecular identification of two common indoor fungal genera: *Stachybotrys* and *Chaetomium*. This study proposes two new DNA barcode candidates for *Stachybotrys* and *Chaetomium*: the gene encoding mitogen activated protein kinase (hog4) and the intergenic region between histone 3 and histone 4 (h3-h4) as well as it introduces a rapid - 3.5 h - protocol for direct *Stachybotrys* and *Chaetomium* species identification, which bypasses culture cultivation, DNA extraction and DNA sequencing.

**General information**

State: Published
Organisations: Department of Systems Biology, Department of Civil Engineering, Section for Indoor Climate and Building Physics, Eucaryotic Molecular Cell Biology, Aalborg University
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Scopus rating (2009): SJR 0.993 SNIP 1.156
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Sensory ratings of emissions from nontraditional building materials
Twenty-five subjects assessed the emissions from building materials: linoleum, cement mortar with and without fly ash, gypsum board and tiles with air cleaning properties and natural organic sheep wool. The ratings were made at different material loadings and in combinations with linoleum. The results showed that except for natural organic product, increasing loading and combining materials with linoleum increased intensity of odor.

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State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy, Danish Building Research Institute
Authors: Krejcirikova, B. (Intern), Kolarik, J. (Intern), Peuhkuri, R. (Ekstern), Rode, C. (Intern), Wargocki, P. (Intern)
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Visualization of the structural changes in plywood and gypsum board during the growth of Chaetomium globosum and Stachybotrys chartarum
Fungal growth in indoor environments is associated with many negative health effects. Many studies focus on brown- and white-rot fungi and their effect on wood, but there is none that reveals the influence of soft-rot fungi, such as Stachybotrys spp. and Chaetomium spp., on the structure of building materials such as plywood and gypsum wallboard. This study focuses on using micro-computed tomography (microCT) to investigate changes of the structure of plywood and gypsum wallboard during fungal degradation by S. chartarum and C. globosum. Changes in the materials as a result of dampness and fungal growth were determined by measuring porosity and pore shape via microCT. The results show that the composition of the building material influenced the level of penetration by fungi as shown by scanning electron microscopy (SEM). Plywood appeared to be the most affected, with the penetration of moisture and fungi throughout the whole
thickness of the sample. Conversely, fungi grew only on the top cardboard in the gypsum wallboard and they did not have significant influence on the gypsum wallboard structure. The majority of the observed changes in gypsum wallboard occurred due to moisture. This paper suggests that the mycelium distribution within building materials and the structural changes, caused by dampness and fungal growth, depend on the type of the material.

**General information**

State: Published  
Organisations: Department of Systems Biology, Eucaryotic Molecular Cell Biology, Department of Civil Engineering, Section for Indoor Climate and Building Physics, University of Sydney, Aalborg University  
Authors: Lewinska, A. M. (Intern), Hoof, J. B. (Intern), Peuhkuri, R. H. (Ekstern), Rode, C. (Intern), Lilje, O. (Ekstern), Foley, M. (Ekstern), Trimby, P. (Ekstern), Andersen, B. (Intern)  
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Scopus rating (2008): SJR 0.926 SNIP 1.031  
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Web of Science (2007): Indexed yes  
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Building energy demand aggregation and simulation tools: a Danish case study

Nowadays, the minimization of energy consumption and the optimization of efficiency of the overall energy grid have been in the agenda of most national and international energy policies. At the same time, urbanization has put cities under the microscope towards achieving cost-effective energy savings due to their compact and highly dense form. Thus, accurate estimation of energy demand of cities is of high importance to policy-makers and energy planners. This calls for automated methods that can be easily expandable to higher levels of aggregation, ranging from clusters of buildings to neighbourhoods and cities. Buildings occupy a key place in the development of smart cities as they represent an important potential to integrate smart energy solutions. Building energy consumption affects significantly the performance of the entire energy network. Therefore, a realistic estimation of the aggregated building energy use will not only ensure security of supply but also enhance the stabilization of national energy balances.

In this study, the aggregation of building energy demand was investigated for a real case in Sønderborg, Denmark. Sixteen single-family houses -mainly built in the 1960s- were examined, all connected to the regional district heating network. The aggregation of building energy demands was carried out according to typologies, being represented by archetype buildings. These houses were modelled with dynamic energy simulation software and with a simplified simulation tool, which is based on monthly quasi-steady state calculations, using a visual parametric programming language (Grasshopper) coupled with a 3D design interface (Rhinoceros). The estimated heat demand of the examined houses from both simulation tools is compared to actual measured data of heat consumption. An assessment of the two different types of tools follows, which will indicate the suitability of each tool depending on the desired accuracy of results and on the purpose of analysis.
Building renovation with interior insulation on solid masonry walls in Denmark - A study of the building segment and possible solutions

The segment size of the Danish multi-story building stock from the period 1851-1930 is established through a unique major database managed by the Danish authorities. The outcome illustrates a large segment with 219,202 apartment units distributed over 14,832 unique buildings, all sharing characteristic geometry. Reduction of average U-value for the exterior facade is investigated in different dimensions, insulation degrees and thicknesses. The analysis shows that compared to insulation of only the infill walls below windows, fully covering insulation yields further 100-150% average U-value reduction. The large segment poses arguments for research into challenges raised by full surface insulation. (C) 2015 The Authors. Published by Elsevier Ltd.

Climate Change and Its Impact on the Operation and Maintenance of Buildings

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Climate Change and Its Impact on the Operation and Maintenance of Buildings

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Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Department of Management Engineering, Centre for Facilities Management, Systems Analysis, DTU Climate Centre, Gentofte Kommune
Coupling and quantifying resilience and sustainability in facilities management

Purpose – The purpose of this paper is to consider how to couple and quantify resilience and sustainability, where sustainability refers to not only environmental impact, but also economic and social impacts. The way a particular function of a building is provisioned may have significant repercussions beyond just resilience. The goal is to develop a decision support tool for facilities managers.

Design/methodology/approach – A risk framework is used to quantify both resilience and sustainability in monetary terms. The risk framework allows to couple resilience and sustainability, so that the provisioning of a particular building can be investigated with consideration of functional, environmental, economic and, possibly, social dimensions. Findings – The method of coupling and quantifying resilience and sustainability (CQRS) is illustrated with a simple example that highlights how very different conclusions can be drawn when considering only resilience or resilience and sustainability.

Research limitations/implications – The paper is based on a hypothetical example. The example also illustrates the difficulty in deriving the costs and probabilities associated with particular indicators.

Practical implications – The method is generic, allowing the method to be customized for different user communities. Further research is needed to translate this theoretical framework to a practical tool for practitioners and to evaluate the CQRS method in practice.

Originality/value – The intention of this research is to fill the gap between the need for increasing sustainability and resilience of the built environment and the current practices in property maintenance and operation.
Energy performance and indoor air quality in modern buildings in Greenland: Case study Apisseq

A new dormitory for engineering students “Apisseq” was built in Sisimiut, Greenland in 2010. Its purpose is not only to provide accommodation for students, but thanks to its complex monitoring system, it enables researchers to evaluate the building’s energy performance and indoor air quality. Some of the installed technologies are not commonly used in the current Greenlandic building stock. Therefore, evaluation of their performance under local conditions is essential for further use and development. The first year of operation has disclosed some errors made during the design process and construction phase, which have negative effects on the energy performance and indoor air quality. The heat demand in 2011 was 26.5% higher than expected. One of the main causes of the extra heat demand is the fact that the ventilation system was over-dimensioned, and although it is running on the lowest fan power it maintains 1.1 ACH in the building. Reduction of the airflows and better frost protection of the heat exchangers are important issues to be dealt with in order to decrease the heat demand. This article describes the building and how it is evaluated after the first year of operation, and it explains some of the revealed problems.
Integrated smart infrastructures

General information
State: Published
Organisations: Department of Electrical Engineering, Center for Electric Power and Energy, Energy system operation and management, Department of Civil Engineering, Section for Indoor Climate and Building Physics, Zhejiang University
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Integrated Smart Infrastructures
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Models for flexible operation of buildings in district energy system Nordhavn

General information
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Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics, Section for Building Energy
Authors: Foteinaki, K. (Intern), Heller, A. (Intern), Rode, C. (Intern)
Number of pages: 1
Simple future weather files for estimating heating and cooling demand

Estimations of the future energy consumption of buildings are becoming increasingly important as a basis for energy management, energy renovation, investment planning, and for determining the feasibility of technologies and designs. Future weather scenarios, where the outdoor climate is usually represented by future weather files, are needed for estimating the future energy consumption. In many cases, however, the practitioner's ability to conveniently provide an estimate of the future energy consumption is hindered by the lack of easily available future weather files. This is, in part, due to the difficulties associated with generating high temporal resolution (hourly) estimates of future changes in air temperature. To address this issue, we investigate if, in the absence of high-resolution data, a weather file constructed from a coarse (annual) estimate of future air temperature change can provide useful estimates of future energy demand of a building. Experimental results based on both the degree-day method and dynamic simulations suggest that this is indeed the case. Specifically, heating demand estimates were found to be within a few per cent of one another, while estimates of cooling demand were slightly more varied. This variation was primarily due to the very few hours of cooling that were required in the region examined. Errors were found to be most likely when the air temperatures were close to the heating or cooling balance points, where the energy demand was modest and even relatively large errors might thus result in only modest absolute errors in energy demand.
Chaetomium and Stachybotrys in water-damaged buildings

Fungal growth occurs when parts of the building envelope get very wet due to unfortunate combinations of factors, e.g. thermal bridges/lack of ventilation, shoddy foundations/flooding or leaks in build-in pipes. Chaetomium and Stachybotrys are not as abundant as Penicillium and Aspergillus (Table 1), however, they may produce volatiles and microparticles that can cause health problems. They are common in wet walls constructed of wood fibre board (OSB/plywood) and gypsum board.

General information
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Organisations: Department of Systems Biology, Fungal Physiology and Biotechnology, Eucaryotic Molecular Cell Biology, Metabolomics Platform, Department of Civil Engineering, Section for Indoor Environment
Authors: Andersen, B. (Intern), Lewinska, A. M. (Intern), Nielsen, J. B. (Intern), Dosen, I. (Intern), Nielsen, K. F. (Intern), Peuhkuri, R. H. (Intern), Rode, C. (Intern), Clausen, G. (Intern), Thrane, U. (Intern)
Publication date: 2014
Characterization of heat dynamics of an arctic low-energy house with floor heating

This paper presents grey-box modeling of the heat dynamics of an apartment in a highly insulated test building located in the Arctic. Data from a 16-day-long experiment is analyzed and used to fit lumped parameter models formulated as coupled stochastic differential equations. The output of the models is the measured indoor air temperature, and the models are fitted using maximum likelihood techniques with the software CTSM-R. Models are compared using likelihood-ratio tests and validated considering autocorrelation and periodograms of residuals. The fitted models facilitate description of both the fast responses to mechanical ventilation and solar radiation through a large window facade, and the slow responses to floor heating and outdoor temperature. To successfully describe the dynamics of the system, solar radiation is given special attention in modeling of both the physical system and the observational noise. The estimated physical parameters which include UA-value, total heat capacity, and time constants for the apartment are discussed. Simulations are performed to illustrate step and impulse responses of inputs.
Dynamic modeling of presence of occupants using inhomogeneous Markov chains

Occupancy modeling is a necessary step towards reliable simulation of energy consumption in buildings. This paper outlines a method for fitting recordings of presence of occupants and simulation of single-person to multiple-persons office environments. The method includes modeling of dependence on time of day, and by use of a filter of the observations it is able to capture per-employee sequence dynamics. Simulations using this method are compared with simulations using homogeneous Markov chains and show far better ability to reproduce key properties of the data. The method is based on inhomogeneous Markov chains with where the transition probabilities are estimated using generalized linear models with polynomials, B-splines, and a filter of passed observations as inputs. For treating the dispersion of the data series, a hierarchical model structure is used where one model is for low presence rate, and another is for high presence rate.

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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Civil Engineering, Section for Building Physics and Services, Danish Building Research Institute
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Scopus rating (2011): SJR 1.506 SNIP 2.536 CiteScore 3.23
Buildings in Arctic climates require large amounts of heat to provide their occupants with a comfortable indoor environment. In recent years the intention to conserve energy has caused buildings in the Arctic (and worldwide) to become more insulated and airtight. The natural infiltration of buildings is being reduced to avoid heat loss and unpleasant air drafts, often without proper compensation. Many studies have shown that living in insufficiently ventilated spaces increases the risk for asthma and allergy symptoms. However, the indoor environment in Arctic dwellings has seldom been investigated. For energy and indoor environmental reasons it is advisable that new airtight buildings be equipped with mechanical ventilation systems with heat recovery. Nevertheless, these systems when exposed to the Arctic winter climate face the risk of frost formation, which may put the ventilation system out of order for long periods or potentially damage it. The main objectives of the work described in this thesis have been: A) to provide new knowledge about optimal operation and performance of low energy technologies in the Arctic and B) to map the indoor environmental quality in dwellings in the Arctic. The first part of this thesis provides an overview of three case studies undertaken in newly built residential buildings in Greenland and Alaska. It was found that ventilation systems in these buildings are either under or oversized which has a significant negative effect on their indoor air quality or energy use respectively. One of the evaluated buildings in Greenland had ventilation units that were not equipped with the frost protection and as a result, serious ice buildups appeared inside the heat exchangers. The prototype heat exchanger developed at the Technical University of Denmark and installed in the Low Energy House in Sisimiut had experienced an unnoticed malfunction for the first 3 years of operation. However, after repairing the heat exchanger it was capable of continuous operation without freezing and reached an average thermal effectiveness of 69 %. In Alaska, three out of four ventilation systems studied in new homes used recirculation as a method of frost protection. This strategy allowed a continuous operation of the ventilation system; however, the fresh air supply was reduced significantly during winter months. The second part of the thesis presents a cross sectional study on indoor air quality performed in Sisimiut, Greenland. A questionnaire as part of the study found that over 30 % of respondents experience cold discomfort during winter months (i.e. cold floors, cold draft or too low indoor temperature), 35 % of the respondents reported frequent condensation on windows. Despite the cool summers 40 % of the respondents complained about summer overheating. It was also found that 34 % of the respondents smoke inside their homes. Additionally it was revealed that ventilation equipment is typically limited to fresh air openings.
on walls, mechanical exhausts from bathrooms (present in 63 % of the dwellings) and kitchen range hoods (installed in 82 % of the dwellings). Presence of balanced mechanical ventilation was not reported by any of the respondents. The questionnaire study was followed by summer and winter measurements in bedrooms of 79 dwellings selected among dwellings inhabited by the questionnaire respondents. The winter measurements indicate that 73 % of the monitored bedrooms experienced average additional moisture higher than 2.5 g/kg or average night CO₂ concentration above 1000 ppm and 59 % of bedrooms had experienced both. This indicates that the majority of the monitored bedrooms were insufficiently ventilated. The problems with poor ventilation were more severe in newer buildings (build after 1990) due to tighter envelopes and unchanged ventilation strategies.

In conclusion, it is possible to provide dwellings in the Arctic with good indoor environment. However, this is largely dependent on the design of buildings and their ventilation systems. The ventilation should not rely on simple wall openings as they prove to be inefficient in providing continuous air change at a sufficient rate without creating thermal discomfort.

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**Indoor environment in bedrooms in 79 Greenlandic households**
The climate in Greenland is cold which means that living inside the heated space requires quite some energy. To avoid large heat losses and cold discomfort, building envelopes are often sealed, which reduces natural infiltration. The combination of reduced infiltration and lack of mechanical ventilation results in low air change and thus elevated concentrations of indoor pollutants. In cold Arctic regions where people spend most of their time during long winters indoors is the effect of poor indoor air quality (IAQ) on occupants' health and comfort considerable. A cross sectional study in 79 dwellings was performed in the town of Sisimiut. The aim was to investigate the indoor climate in Greenlandic dwellings. Temperature, relative humidity (RH) and CO₂ concentration were measured in several rooms in each dwelling. This paper presents the results from measurements in bedrooms. CO₂ concentrations above 1000 ppm and difference in absolute humidity between indoor and outdoor air above 2.5 g/kg as indicators of insufficient ventilation were found in 73% of the bedrooms. The situation was significantly worse dwellings build after 1990. Although the average winter additional moisture was higher than 2.5 g/kg, the RH was low (mean RH = 26%). In summer, 19% of all bedroom temperatures were above 26 °C despite the low outside temperatures. To avoid possible escalation of health problems related to IAQ in the future and to increase comfort of the occupants, properly designed ventilation systems should be introduced in Greenland.

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Novel DNA barcodes for detection, identification and tracking of stachybotrys and chaetomium species

Detection and identification of indoor fungi in water-damaged buildings is crucial for preventi and control of fungal growth. This study focuses on a molecular method called DNA barcoding. evaluates commonly used sequences in DNA barcoding for fungal species identification Chaetomium and Stachybotrys. The existing DNA barcodes: ITS, SSU, LSU, B-TUB, CMD, RP and TEF-1α do not give satisfying species resolution to be considered as DNA barcodes for the two genera. Therefore, novel barcodes for them are needed. Barcode potentials, such as HOG1 a NAHA, were identified using bioinformatics and are being evaluated in laboratory.
Survey of Indoor Air Quality in the University of Alaska

In cold climates living inside the heated space requires considerable amounts of heat. With the intention to decrease the heating demand, people are insulating their homes and make them more air tight. With the natural infiltration being brought close to zero there has been an increase of a new problem which is poor indoor air quality (IAQ). During summer 2012 four student homes were built in Fairbanks, Alaska as a part of Sustainable Village project. The aim of this project is to promote sustainable ways of living in the Arctic and to study new technologies and their applicability in the cold north. This paper presents the results of an IAQ survey performed in the homes during two weeks in December 2012. During this survey the air temperature, relative humidity (RH) and CO₂ concentration were measured in all occupied bedrooms along with monitoring of the ventilation units. The results have shown noticeable differences in IAQ between the four houses caused by different technical solutions. The ventilation rates were reduced by occupants or by frost protecting strategy of the ventilation units and the RH inside the living space was often very low. It is assumed that by introducing more advanced controls of the HVAC systems, better defrosting strategy and moisture recovery from the exhaust air the IAQ can be improved with minimum extra energy demand.

Waste-based materials; capability, application and impact on indoor environment – literature review

This paper reviews and discusses various sustainable materials utilizing waste products with the focus on their properties having an impact on the indoor environmental conditions and indoor air quality (IAQ). Materials included in the review are selected considering the following aspects: sustainability, cradle to cradle perspective, application, their impact on indoor environment and human well-being. The attempt of the paper is to cover a wide spectrum of information so to provide better understanding of waste utilization in construction industry.
ZeroWaste BYG: Hygro-thermal conditions and pollutant emissions from ZeroWaste materials and their effects on humans

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Publication: Research - peer-review › Conference abstract in proceedings – Annual report year: 2014

ZeroWaste BYG: Redesigning construction materials towards zero waste society

The ZeroWaste research group (www.zerowaste.byg.dtu.dk) at the Department of Civil Engineering was established in 2012 and covers the broad range of expertise required for turning waste materials into attractive, new materials. Members of the group have developed methods for removal of heavy metals and phosphorous from waste incineration, sewage sludge and other bio ashes [1], providing the basis to make these ash types an attractive, new material for the building sector. The amount of waste increases and it is both difficult and expensive to handle many waste types as e.g. different ashes. At the same time there are fewer natural resources and the general consumption increases. We wish to utilize alternative and new ash types as raw material in concrete, similarly to what was previously seen with fly ash from coal combustion and microsilica, which were both transformed from problematic waste to valuable raw material. The physical-chemical characteristics of fly ash, such as large uniformity coefficient, clay-sized particles and rich in some metal elements and salts, show the possibility of being a raw material also for bricks and lightweight aggregates. In the future we expect increasing political pressure to change the status of different ashes from waste to raw material and that export for disposal will be no longer be allowed. We wish to influence the consequences from this new situation. In principle some of the ashes can be used already, but the huge variation in ash characteristics and lack of knowledge in the construction industry on the qualities some of the ashes can give the concrete and clay materials means that they are not used today.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Design, Section for Structural Engineering, Section for Indoor Environment, Section for Building Physics and Services
Number of pages: 1
Publication date: 2014
An arctic low-energy house as experimental setup for studies of heat dynamics of buildings
This paper addresses the difficulties in pinpointing reasons for unexpectedly high energy consumption in construction, and in low-energy houses especially. Statistical methods are applied to improve the insight into the energy performance and heat dynamics of a building based on consumption records and weather data. Dynamical methods separate influences from outdoor temperature, solar radiation, and wind on the energy consumption in the building. The studied building is a low-energy house in Sisimiut, Greenland. Weather conditions like large temperature differences between indoors and outdoors throughout long winters, strong winds, and very different circumstances regarding solar radiation compared to areas where low-energy houses are usually built, make the location very interesting for modeling and testing purposes. In 2011 new measurement equipment was installed in the house, which will be used to develop more detailed models of the heat dynamics and energy performance in relation to different meteorological variables, heating systems, and user behavior. This type of models is known as a graybox model and is been introduced in this paper.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science , Dynamical Systems, Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, P. H. D. (Intern), Rode, C. (Intern), Madsen, H. (Intern)
Pages: 488-499
Publication date: 2013
Main Research Area: Technical/natural sciences

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Bevar vores bygninger

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, BAT-Kartellet
Authors: Rode, C. (Intern), Odgaard, G. (Ekstern)
Publication date: 2013

Electronic versions:

Ratings:
ISI indexed (2013): ISI indexed no
Evaluation of Sub-Zonal Airflow Models for the Prediction of Local Interior Boundary Conditions: Natural and Forced Convection Cases

Currently, researchers are striving to advance the possibilities to calculate the integrated phenomena of heat, air and moisture flows in buildings, with specific focus on the interactions between the building zones and building components. This paper presents an investigation of the capability and applicability of the sub-zonal airflow model to predict the local indoor environmental conditions, as well as the local surface transfer coefficients near building components. Two test cases were analyzed for, respectively, natural and forced convection in a room. The simulation results predicted from the sub-zonal airflow models are compared to experimental data and numerical computational fluid dynamics (CFD) results. The study shows that sub-zonal models combined with an appropriate surface transfer coefficient model are able to give reliable predictions of the local indoor environmental conditions and surface transfer coefficients near the building component for the analyzed cases. The relatively short computation time and flexibility of the sub-zonal model makes the application attractive for transient simulation of heat, air and moisture transport in buildings. However, the availability of appropriate reference conditions, for example experimental or numerical results, is a prerequisite for the development of a reliable sub-zonal model.
Global building physics

High ambitions are set for the building physics performance of buildings today. No single technology can achieve fulfilment of these ambitions alone. Integrated, multi-facetted solutions and optimization are necessary. A holistic, or ‘global’, technological perspective is needed, which includes all aspects of the building as defined in building engineering. We live in an international society and building solutions are developed across country borders. Building physics is a global theme. The International Association of Building Physics has global appeal. This brief article reports the keynote lecture and illustrates global relations to highlight some of the challenges that we see today.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
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Web of Science (2018): Indexed yes
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Scopus rating (2016): SJR 0.722 SNIP 0.751 CiteScore 1.1
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Scopus rating (2015): SJR 0.935 SNIP 1.738 CiteScore 1.4
Holistic Energy Renovation of Pre- and Postwar Apartment Blocks in Denmark

A significant proportion of apartments in Denmark are built during the years 1930-1970. This group of buildings generally have not exhausted their lifetime, but suffer from immense needs for renovation, both regarding energy use and functionality, in order to bring them near to the standards of today.

This paper presents the Danish research project Holistic Energy Renovation, which aims at performing a holistic energy renovation of two case buildings. As part of the project nine parameters for a holistic renovation have been defined, a method for developing and assessing a holistic building renovation is developed, development of products especially for building renovation has been facilitated and all stakeholders, among those the users of the buildings, have been involved early in the renovation process.

The paper presents the preliminary results of the project including development and test of the assessment method and an evaluation of how the holistic perspective has influenced the project process and product development.

General information

State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Section for Building Design
Authors: Eriksen, M. S. H. (Intern), Rode, C. (Intern), Bjarløv, S. P. (Intern)
Number of pages: 9
Publication date: 2013
Event: Paper presented at Central Europe towards Sustainable Building 2013, Prague, Czech Republic.
Main Research Area: Technical/natural sciences
Low-energy house in Sisimiut - Data overview

Experiments with persistently exciting heat inputs are a fundamental tool in identification of heat dynamics in buildings. The Low-energy house in Sisimiut, Greenland, provides an advanced experimental setup with frequent measurements of temperatures, heat inputs, and much more. This paper presents an overview of data collected since the installation of the new measurement and control system. Focus is on heat dynamics so only data related to that will be shown. 5 experiments have been conducted. They are described, and resulting data is shown.

General information
State: Published
Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, P. H. D. (Intern), Rode, C. (Intern), Madsen, H. (Intern)
Number of pages: 19
Publication date: 2013

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Number: 18
ISSN: 1601-2321
Main Research Area: Technical/natural sciences
Electronic versions:
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Publication: Research › Report – Annual report year: 2013

Low-energy house in Sisimiut - Measurement equipment

This paper documents the measurement equipment in a low-energy house in Sisimiut, Greenland. Detailed measurements are being taken on energy consumption, indoor temperatures, floor heating, ventilation, open/closed state of doors and windows, and indoors climate. Equipped with a central control unit, experiments can be designed in order to study heat dynamics of the building. It is described how to plan and execute such experiments in one apartment in the building. The building also features both a solar thermal system and extra buffer tank facilitating testing of storage strategies on the power generated by the solar thermal system. A weather station equipped with thermometer, pyranometer and anemometer is installed on the building as well. Finally, it is described how to retrieve data from an SQL server which is configured to take monthly backups. R functions have been implemented to fetch and prepare the data for time series analysis. Examples are given on the use of these.

General information
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Organisations: Department of Applied Mathematics and Computer Science, Dynamical Systems, Department of Civil Engineering, Section for Building Physics and Services
Authors: Andersen, P. H. D. (Intern), Rode, C. (Intern), Madsen, H. (Intern)
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Method for Developing and Assessing Holistic Energy Renovation of Multi-Storey Buildings

A large part of the Danish building stock is from the post-war era, and thus there is an immense need for renovation within a few years. Also there is a persistent focus on energy use in buildings as it corresponds to about 40% of the total energy use in Denmark. However to secure durable solutions a holistic approach is needed, which takes into account also other aspects than energy such as social or economical values of the buildings.

This paper presents a standardised method for developing and assessing a holistic energy renovation of multi-storey buildings. The method is intended to be used both in the design phase of renovation proposals and for evaluation of the improvements that follow from a holistic energy renovation.

The method was developed as part of a Danish research project on holistic approaches in energy renovation of multi-story buildings. In the project, nine overall indicators are established based on the aspects of “people, planet and profit”. The assessment method comprises five elements that span across the nine indicators. The elements consider the economical, architectural, technical and social values of the buildings and also include user involvement as a central element. The assessment method is tested on two case buildings, and the assessment involves all relevant stakeholders including building owner, users, and caretakers.

An element of the project looks to the development of new products and solutions for renovation for buildings. As part of the method, user involvement will be applied in order to guide and optimize the development of proper new products or solutions especially for renovation. The paper will illustrate how this is done in cooperation with manufacturers from the building industry.

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Main Research Area: Technical/natural sciences
Assessment method, Building renovation, Multi-story buildings, Holistic perspective, Product development
Electronic versions: sb13munich_sub_lang.pdf
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Publication: Research - peer-review › Paper – Annual report year: 2013

Models for the energy performance of low-energy houses

The aim of this thesis is data-driven modeling of heat dynamics of buildings. Traditionally, thermal modeling of buildings is done using simulation tools which take information about the construction, weather data, occupancy etc. as inputs and generate deterministic energy profiles of the buildings. This approach often fails in predicting the actual heat consumption of buildings once they are constructed. The approach taken in this work is deriving models from observations collected after the construction, aiming at describing the actual characteristics of the building.

Identification of heat dynamics of buildings is needed both in order to assess energy-efficieny and to operate modern buildings economically. Energy signatures are a central tool in both energy performance assessment and decision making related to refurbishment of buildings. Also for operation of modern buildings with installations such as mechanical ventilation, floor heating, and control of the lighting effect, the heat dynamics must be taken into account. Hence, this thesis provides methods for data-driven modeling of heat dynamics of modern buildings.

While most of the work in this thesis is related to characterization of heat dynamics of buildings, the first topic analyzed is the variation of presence of occupants. As buildings get more energy-efficient, internal loads and user-behavior increasingly influence the energy consumption. Most simulation tools use deterministic occupancy profiles to simulate internal loads. However, such occupancy patterns will largely depend on the specific use of the building, and hence the profiles must be empirically based. A probabilistic method for modeling timedependence and dynamics of presence of occupants is developed and applied by estimation and model validation on data from an office building. The approach to modeling occupants’ presence provides a flexible method where no assumptions in the application.

The rest of the thesis deals with statistical modeling of heat dynamics of buildings. First, discrete-time models are applied. Discrete-time models are computationally relatively simple and provide a flexible framework for dynamical modeling as a natural extension of the often-used static energy-balance models. The importance of applying dynamical models, even for deriving thermostatic or steady-state properties, is stressed, and methods for doing so are outlined.

Since heat transfer is fundamentally described by partial differential equations, modeling of heat dynamics using differential equations is an obvious approach. A quasi-Gaussian maximum likelihood estimation technique, where the
The likelihood function is evaluated using the extended Kalman filter on state-space models, is used. In this framework - referred to as "grey-box" modeling - one-step predictions can be generated and used for model validation by testing statistically whether the model describes all variation and dynamics observed in the data. The possibility of validating the model dynamics is a great advantage from the use of stochastic differential equations compared to ordinary differential equations.

The strengths of the discrete-time and the continuous-time approach are discussed. Besides the parametrization, which is directly physically interpretable, grey-box models intrinsically provide variable prediction uncertainty, which is important in relation to design of controllers and decision making for comfort requirements. In the framework of stochastic differential equations, there are normally more parameters related to noise processes than in discrete-time models which increases the complexity of the estimation. Here, the state space formulation is often used. Since there is normally infinitely many state space representations corresponding to a transfer function model, structural identifiability is important in relation to state space modeling.

A low-energy building in Sisimiut, Greenland is used as a test-building. The building is well-insulated and features large modern energy-efficient windows and floor heating. These features lead to increased non-linear responses to solar radiation and longer time constants. The building is equipped with advanced control and measuring equipment. Experiments are designed and performed in order to identify important dynamical properties of the building, and the collected data is used for modeling.

The thesis emphasizes the statistical model building and validation needed to identify dynamical systems. It distinguishes from earlier work by focusing on modern low-energy construction and going further into studying and characterizing the dynamical properties of the fitted models.
Blower door tests of a group of identical flats in a new student accommodation in the Arctic

A new student accommodation for engineering students “Apisseq” was built in the town of Sisimiut, Greenland in 2010. Its purpose is not only to provide accommodation for students. Thanks to its complex monitoring system it enables researchers to evaluate the building’s energy performance and indoor air quality (IAQ) as well as performance of some single components. In summer 2012 a blower door test was performed on all 37 living units out of which 33 are identical single room flats and 4 are larger double room flats. The purpose was to evaluate the air tightness of the envelope and to find out how much the flats differ from each other in terms of air tightness. The overall average specific leakage measured was $w_{50} = 2.05 \text{l/(s·m²)}$ of heated floor area corresponding to an air change $n_{50}$ of 2.96 h$^{-1}$. Furthermore, the results showed that the difference between the most and the least tight flat is as high as 400%. This result is without consideration of one particular flat which had the extreme result of being 940% as leaky as the unit with the highest air tightness. The reasons for such poor air tightness are lack of the installation gap between the vapour barrier and the inner wall, and insufficient connections of the vapour barrier to the interior walls as explained in the paper. The large variation in results can be attributed to insufficient consideration of the importance of airtightness during construction of some parts of the building – despite of an intent to make a rather air tight building.

Characterization of fracture patterns and hygric properties for moisture flow modelling in cracked concrete

Several years after their installation, building materials such as concrete present signs of ageing in the form of fractures covering a wide range of sizes, from microscopic to macroscopic cracks. All sizes of fractures can have a strong influence on heat and moisture flow in the building envelope, but their distribution is difficult to predict due to the variety of environmental factors which cause them. This paper aims at applying experimental non-destructive techniques for the
observation of fracture patterns and of fluid flow in fractures, in order to provide this data to models for fluid transfer in fractured porous media. Digital Image Correlation was performed during the fracturing of concrete samples, in which moisture uptake was then monitored using X-ray radiography. Finite-element simulations were then performed based on the measurements of the fracture patterns, in order to recreate the measured moisture concentration profiles. Digital Image Correlation was found suitable as a mean to obtain a complete mapping of the deformations at the surface of the samples, and a first step was made towards the use of non-destructive fracture characterization for the purpose of moisture transfer modelling. 

**General information**

State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Université Lyon, Université de Savoie, Institut National des Sciences Appliquées de Lyon, KU Leuven
Authors: Rouchier, S. (Ekstern), Janssen, H. (Ekstern), Rode, C. (Intern), Woloszyn, M. (Ekstern), Foray, G. (Ekstern), Roux, J. (Ekstern)
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- Web of Science (2018): Indexed yes
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- Web of Science (2017): Indexed yes
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- Scopus rating (2016): CiteScore 3.77 SJR 1.49 SNIP 2.339
- Web of Science (2016): Indexed yes
- BFI (2015): BFI-level 1
- Scopus rating (2015): SJR 1.54 SNIP 2.299 CiteScore 3.24
- Web of Science (2015): Indexed yes
- BFI (2014): BFI-level 1
- Scopus rating (2014): SJR 1.55 SNIP 2.594 CiteScore 2.98
- Web of Science (2014): Indexed yes
- BFI (2013): BFI-level 1
- Scopus rating (2013): SJR 1.88 SNIP 3.043 CiteScore 3.07
- ISI indexed (2013): ISI indexed yes
- Web of Science (2013): Indexed yes
- BFI (2012): BFI-level 1
- Scopus rating (2012): SJR 1.706 SNIP 3.37 CiteScore 3.12
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- Scopus rating (2011): SJR 1.493 SNIP 3.537 CiteScore 2.74
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- Scopus rating (2010): SJR 1.362 SNIP 1.969
- Web of Science (2010): Indexed yes
- BFI (2009): BFI-level 1
- Scopus rating (2009): SJR 1.08 SNIP 1.848
- Web of Science (2009): Indexed yes
- BFI (2008): BFI-level 1
- Scopus rating (2008): SJR 0.914 SNIP 1.479
- Scopus rating (2007): SJR 0.936 SNIP 1.703
- Scopus rating (2006): SJR 1.228 SNIP 1.604
Energy performance and Indoor Air Quality in Modern Buildings in Greenland: Case study Apisseq

A new dormitory for engineering students 'Apisseq' was built in the town of Sisimiut, Greenland in 2010. Its purpose is not only to provide accommodation for students. Thanks to its complex monitoring system it enables researchers to evaluate the building's energy performance and indoor air quality (IAQ) as well as performance of some single components. Some of the installed technologies (balanced mechanical ventilation with heat recovery or solar collectors) are not commonly used in the current Greenlandic building stock. Therefore evaluation of their performance under local conditions is essential for further use and development. The first year of operation has disclosed some errors made during the design process and construction phase which have negative effects on the energy performance and IAQ. The heat demand in 2011 was 26.5% higher than expected. One of the main causes of the extra heat consumption is the fact that the ventilation system was over-dimensioned, and although it is running on the lowest fan power it maintains 1.1 ACH in the building. Reduction of the air flows and better frost protection of the heat exchangers are important issues to be dealt with in order to decrease the heat demand. This paper describes the building and how it is evaluated after the first year of operation, and it explains some of the revealed problems.

Global Building Physics

High ambitions are set for the building physics performance of buildings today. No single technology can achieve fulfilment of these ambitions alone. Integrated, multi-faceted solutions and optimization are necessary. A holistic, or "global", technological perspective is needed, which includes all aspects of the building as defined in building engineering. We live in an international society and building solutions are developed across country borders. Building physics is a global theme. The International Association of Building Physics has global appeal. The keynote lecture and this brief paper will illustrate some global relations and highlight some of the challenges we see today.
Moisture conditions in buildings: how to avoid mould problems

Growth of mould requires the presence of moisture at a certain high level. In a heated indoor environment such moisture levels occur only if there is a reason for the moisture supply. Such moisture can come from the use of the building, because of malfunctioning constructions, or it can be the result of insufficient ventilation. The article will give an overview of these reasons, and thereby also give hints to how problems can be avoided.

General information
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Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
Number of pages: 5
Publication date: 2012

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Conference: Artek Event , Sisimiut, Greenland, 13/03/2012 - 13/03/2012
Electronic versions:
prod21350166041963.Carsten_Rode_article_ARTEK_EVENT.pdf
Source: dtu
Source-ID: u::5190
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

Non-destructive observation of damage in mortar and concrete during mechanical loading for the evaluation of moisture transfer profiles
Coupled heat and mass transfer modelling in building materials now plays an important part in the design of energy-efficient buildings. However, concrete and other construction materials subjected to mechanical loading and atmospheric excitation inevitably develop fractures patterns during their lifespan due to mechanical, chemical or physical damage processes. The target of the present work is to determine whether non-destructive observation of crack patterns can help predict the moisture uptake rate of fractured building materials. Digital image correlation was used to quantify damage in two types of materials. Moisture concentration profiles were then measured by X-ray radiography and calculated by finite element simulations in order to attempt to validate a moisture transfer model based on the fracture characterization. This procedure showed that the coupling of a mechanical characterization with a hygric modelling can provide an appropriate prediction of the water infiltration in fractured porous building materials.

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State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Université Lyon, KU Leuven, Université de Savoie, Institut National des Sciences Appliquees de Lyon
Authors: Rouchier, S. (Ekstern), Janssen, H. (Ekstern), Rode, C. (Intern), Woloszyn, M. (Ekstern), Foray, G. (Ekstern), Roux, J. J. (Ekstern)
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Publication date: 2012

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Main Research Area: Technical/natural sciences
Conference: 5th International Building Physics Conference (IBPC 2012), Kyoto, Japan, 28/05/2012 - 28/05/2012
Digital image correlation, Concrete, Fracture, X-ray radiography, Moisture transfer
Source: dtu
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

Studies of Heat Dynamics in an Arctic Low-energy House
A low energy house situated in Sisimiut, Greenland is used as study object for analysis of dynamic thermal properties of energy efficient buildings. The building is instrumented with a number of energy meters and thermal sensors, and these thermal data are logged with fine time intervals. Statistical methods are being developed in a PhD project to derive the properties to be used in a dynamic thermal model of the whole building. Characteristic of the building is its exposure to the extreme Arctic climate, which is both very cold and where the sun in some periods may shine constantly, or not at all. The house is equipped with a weather station measuring temperature, solar radiation, wind speed and direction. The building is highly energy efficient and its performance has been followed since its inception in 2005. The energy efficiency of the building is due to good thermal insulation, large energy-efficient windows, and heat recovery. The house is divided into two symmetric apartments, of which one is inhabited by a family, and the other is used for experiments and demonstration. The situation provides unique options for measuring and analysis with large signal to noise ratios facilitating observation of thermal response to external temperatures, solar radiation, wind, user behaviour, and heating.

General information
State: Published
Organisations: Mathematical Statistics, Department of Informatics and Mathematical Modeling, Section for Building Physics and Services, Department of Civil Engineering
Authors: Andersen, P. H. D. (Intern), Rode, C. (Intern), Madsen, H. (Intern)
Number of pages: 7
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Main Research Area: Technical/natural sciences
Conference: 5th International Building Physics Conference (IBPC 2012), Kyoto, Japan, 28/05/2012 - 28/05/2012
Low-energy houses, Greybox modelling, Statistical modelling, Arctic climate, Heat dynamics
Electronic versions:
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Source: orbit
Source-ID: 316174
Publication: Research - peer-review › Article in proceedings – Annual report year: 2012

A design build activity for a "design build" course
This paper deals with the CDIO course "Design Build", which is taught in the first semester of the Bachelor of Engineering education at the Technical University of Denmark’s Department of Civil Engineering. A specific design build assignment
has been developed for the course, and the paper describes this course activity. The "Design Build" course revolves around the activity that the students should build a model house of their own during the course. The only demands stipulated are that the house should be made as a scale 1:20 model of a realistic house and that is should be thermally insulated and tight. The students work together in groups of four. As part of the CDIO process, each group of students should work through a conceptualization phase, where the requirements for the house are defined. Then follows the phase where the house is designed as the best possible solution fulfilling the requirements the students had set. Next, for implementation, the model house is constructed in the workshop, and the measuring system is tested and installed in the house. Finally, the house will be operated by putting it on the ground in an outdoor test field where it is exposed to the Danish climate for two weeks while the indoor temperature and heat consumption are logged. The experimental findings shall be compared to a theoretical value for the heat loss, which is found from a calculation method the students learn in a parallel course. While the course has resulted in a lot of enthusiasm among the students towards the specific construction task, it has also led to some initial frustration that the course content was not given as a well described assignment, and that the course curriculum had to be to some extent self-defined. This has been a challenge to the very young students who have participated in the course.

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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Design
Authors: Rode, C. (Intern), Christensen, J. E. (Intern), Simonsen, C. (Intern)
Publication date: 2011

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Title of host publication: Proceedings of the 7th International CDIO Conference
Main Research Area: Technical/natural sciences
Conference: 7th International CDIO Conference, Copenhagen, Denmark, 20/06/2011 - 20/06/2011
Experiments, Group work, Theoretical assessment, Design Build course, Constructing, Team building, Field test
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prod11324648802589.2011.pdf
Links:
http://www.cdio2011.dtu.dk/
Source: orbit
Source-ID: 316136
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

A Low-energy Building under Arctic Conditions - Experiences After Five Years of Operation
In 2005, a low energy house was inaugurated in Sisimiut, Greenland. The house and the plans with it were presented at the third International Building Physics Conference in 2006. The house is characterised by having a highly insulated building envelope which is almost free of thermal bridges, advanced windows, a ventilation system with heat recovery, and a solar collector that supplies a significant proportion of the domestic hot water. A very ambitious target was set for the annual energy consumption for heating, which was less than half of the value for permissible heat consumption according to the Greenlandic Building Regulations. The house has been the base of a number of research and student activities which have studied the house and evaluated how well it has performed. These investigations have clarified how the weather influences the hygrothermal performance of the house, and whether the house matches the expectations regarding low energy consumption and a high indoor climatic standard. The house did not meet the anticipated low target for energy consumption, and some reasons have been found which could explain why. Insufficient air-tightness of the building envelope, malfunction of some building services, insufficient insulation of ventilation ducts, and higher indoor temperatures than anticipated were among the main reasons.

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An energy efficient building for the Arctic climate: Is a passive house sensible solution for Greenland?

The Arctic is climatically very different from a temperate climate. In the Arctic regions, the ambient temperature reaches extreme values and it has a direct large impact on the heat loss through the building envelope and it creates problems with the foundation due to the permafrost. The solar pattern is completely different due to the limited availability in winter, yet, in summer, the sun is above horizon for 24 hours. Furthermore, the sunrays reach the vertical opaque elements at shallow angles. The great winds and storms have large effects on the infiltration of buildings and they heavily influence the infiltration heat loss through the building envelope. The wind patterns have large influences on the local microclimate around the building and create the snowdrift and problems with thawing, icing and possible condensation in the building envelope. The humidity in the interior is driven out through the building envelope in the winter due to the pressure difference, strong winds and low water ratio in the outdoor air. The Arctic is also defined by different conditions such as building techniques and availability of the materials and energy supply. The passive house uses the basic idea of a super energy efficient house in which the normal hydronic heating system can be omitted. The savings in investment for a traditional hydronic heating system are spent on energy conserving components such as increased insulation in a super airtight building shell, super efficient windows to produce the net positive solar gain, and a ventilation system with very efficient heat recovery. To design a passive house in the way it is defined by Wolfgang Feist, the founder of the Passivhaus Institute, its annual heat demand should not exceed 15 kWh/(m²·a) and its total primary energy demand should not exceed 120 kWh/(m²·a) in which the building envelope allows limited air change of 0.6 h⁻¹ at 50 Pa pressurization. The living area of the building is well defined according to the standard conditions as a net area and the heat of 10 W/m² can just be supplied by post-heating of fresh air after the heat recovery unit which ensures a satisfactory indoor air quality. A passive house also takes advantage of free gains such as solar heat, the heat from its occupants and their activities, and the domestic appliances, and other sources. The hypothesis in this dissertation is testing the possibility of a new usage of an extreme energy efficient building in the Arctic. The purpose of this Ph.D. study is to determine the optimal use of an energy efficient house in the Arctic derived from the fundamental definition of a passive house, investigations of building parameters including the building envelope and systems, and investigations of boundary situations in the Arctic regions. The object of the study is to analyse current passive house standards used in the temperate climate through the energy performance of a passive house in the cold climates. In theory, it is possible to completely fulfill the fundamental definition of a passive house in the Arctic and therefore to save the cost of traditional heating, but that would incur high costs for the building materials and the provision of technical solutions of extremely high standards which would take too many years to pay back in the life time of a building. The fundamental definition which applies to all climates can be realized in the Arctic regions at very high costs using fundamental design values and the building technologies available in the Arctic. Based on the investigations, the optimal energy performing building is derived from a passive house concept. The passive house optimisation follows the main design rule in the Arctic and this is focused on minimizing the heat loss before maximizing the heat gains followed by the optimisation of the essential building elements and the implementation of the necessary equipments in the cold regions such as a highly efficient ventilation system with heat recovery. Furthermore, the implementation of a passive house concept in a cold climate needs to be based on sensible solutions regarding material use, and, on a practical level, using available technologies and resources. The adaptation of a passive house in the Arctic needs to take into account also different socioeconomic conditions, building traditions and use of buildings, survival issue, sustainability and power supply, among others. In the Arctic, the energy efficient house based on a passive house concept offers a sustainable solution to the operation of the building with regarding the heating and the consumption of electricity, but, the energy, money investment and CO2 footprint needed to build such a house would be demanding. Yet, using these energy efficient buildings, there is an opportunity to improve indoor climate, health and security towards extreme climate for the inhabitants in the Arctic areas. Furthermore, the development and usage of extremely energy efficient buildings in the Arctic can lead to new experiences with extremely well-insulating building components, airtight constructions and well-functioning ventilation systems.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Vladyková, P. (Intern), Rode, C. (Intern), Nielsen, T. R. (Intern), Pedersen, S. (Ekstern)
Number of pages: 180
Publication date: 2011

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
ISBN (Print): 9788778773234
Original language: English

Series: DTU Civil Engineering Reports
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 317141
Publication: Research › Article in proceedings – Annual report year: 2011
Hysteresis and Temperature Dependency of Moisture Sorption – New Measurements

It is well known that sorption characteristics of building materials exhibit hysteresis in the way the equilibrium curves develop between adsorption and desorption, and that the sorption curves are also somewhat temperature dependent. However, these two facts are most often neglected in models for combined heat and moisture transport in materials. There is a need for further elaboration of the importance of these issues, and it is the intent of this paper to contribute to such elaboration. The paper seeks to contribute to the knowledge base about such sorption characteristic by presenting some new measurements of hysteresis and temperature dependency of the moisture sorption characteristics of three different porous building materials: aerated concrete, cement paste and spruce. Scanning curves are measured for all three materials where periods with adsorption and desorption interrupt each other intermittently. For one of the materials, aerated concrete, the sorption curves are determined at three different temperatures.

Improved experimental setup for observation of non-linear heat dynamics

Modeling of heat dynamics of houses have been reported successful using linear dynamical models. The room they leave for improvement is because of physical relations believed to be partly caused by non-linear relations. As model complexity increases, detailed measurements and highly modular experiments are gaining importance in estimation of model parameters. This paper describes test facilities and new measurement equipment in a low-energy house in arctic area. Furthermore, some of the models that will be applied are described.
Low-energy house in Arctic climate - 5 years of experience

The aim of this article is to present and disseminate the experience gained from a low-energy house in Sisimiut, Greenland, over the 5 years of operation since its inauguration in April 2005. The house was designed to test and present new low-energy technologies in the Arctic climate and to improve sustainability in Greenlandic buildings. The article presents some measurements, analyses and comparisons of theoretical simulations, and also some steps which were taken to improve the house with impacts on the energy consumption. The results include energy consumption, temperatures, and solar heating production. Also presented are the results of several investigations carried out in the house, such as blow-door tests and inspection of the ventilation system. The initial target for the heating demand of the house was that it should be restricted to 80 kWh/(m²·a), but in reality it has varied over the past 5 years from 139 to 150 kWh/(m²·a). Currently the house is on the way to present a good energy solution, and the annual energy consumption for heating in 2010 was 90 kWh/m².
The potential for energy efficient building design - differences between Europe and the Arctic

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Vladyková, P. (Intern), Rode, C. (Intern)
Publication date: 2011

Host publication information
Title of host publication: Proceedings at the 9th Nordic Symposium on Building Physics
Main Research Area: Technical/natural sciences
Conference: 9th Nordic Symposium on Building Physics, Tampere, Finland, 29/05/2011 - 29/05/2011
Electronic versions:
The potential for energy efficient building design - differences between Europe and the Arctic -final.pdf
Source: orbit
Source-ID: 272570
Publication: Research - peer-review › Article in proceedings – Annual report year: 2011

Modeling of the Hygrothermal Interactions between the Indoor Environment and the Building Envelope

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Department of Structural Engineering and Materials
Number of pages: 146
Publication date: Jan 2010

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Series: BYG-Rapport
Number: R-216
Air Tightness and Energy Performance of an Arctic Low-Energy House

A low-energy house has been built in Sisimiut, Greenland, five years ago. An ambitious target was set for its low energy consumption for heating: 80 kWh/(m²·a). But unfortunately, the house has used more energy than planned, approximately 140 kWh/(m²·a). Although higher than anticipated, this is still for Greenland a very low energy consumption. The purpose of the work presented in the paper has been to analyze the energy consumption of the house and to understand why it was different than anticipated. One significant lesson learned is that the house was not built with sufficient air-tightness and that it was one of the main reasons for its higher energy consumption.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Arctic Technology Centre
Authors: Rode, C. (Intern), Vladyková, P. (Intern), Kotol, M. (Intern)
Number of pages: 13
Publication date: 2010

Host publication information
Title of host publication: Proceedings of the 5th International Symposium on Building and Ductwork Air-tightness
Publisher: Energie und Umweltzentrum am Deister GmbH (e.u.[z.])
Main Research Area: Technical/natural sciences
Conference: International Symposium on Building and Ductwork Air-tightness : former “European BlowerDoor-Symposium”, DTU, Kgs. Lyngby/Copenhagen, Denmark, 01/01/2010
Low-energy house, building envelope, heat exchanger, air tightness, blower-door test
Electronic versions:
BUILDAIR2010_Rode_Fullpaper_engl.pdf
Links:
http://www.buildair.de/homepage.html
Source: orbit
Source-ID: 272521
Publication: Research › Article in proceedings – Annual report year: 2010
Low-energy house in Sisimiut: Annual report of Low-energy house performance July 2009 to June 2010

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Design
Authors: Kotol, M. (Intern), Rode, C. (Intern), Vladyková, P. (Intern), Furbo, S. (Intern), Borchersen, E. (Intern)
Publication date: 2010

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
LEH-Sisimiut_year_5_report.pdf
Source: orbit
Source-ID: 272561
Publication: Research - peer-review › Report – Annual report year: 2010

Modeling local hygrothermal interactions

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Steskens, P. W. M. H. (Intern), Janssen, H. (Intern), Rode, C. (Intern)
Publication date: 2010

Host publication information
Title of host publication: Buildings XI : Proceedings of "Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference"
Main Research Area: Technical/natural sciences
Conference: Thermal Performance of the Exterior Envelopes of Whole Buildings XI International Conference, Clearwater Beach, FL, United States, 05/12/2010 - 05/12/2010
Source: orbit
Source-ID: 272228
Publication: Research - peer-review › Article in proceedings – Annual report year: 2010

Non-linear phenomena in greybox-modeling of heat dynamics in buildings

General information
TEMPERATURE DISTRIBUTION MONITORING AND ANALYSES AT DIFFERENT HEATING CONTROL PRINCIPLES

In the last decades significant efforts have been made to reduce energy use in buildings. Heating, cooling and ventilation systems are responsible for 30-40% of the energy consumption in buildings. Although they are evaluated based on the energy performance they should guarantee the desired thermal comfort conditions for the building occupants. During the winter and spring of 2009 a study based on analyses of the local temperatures distribution in a room was performed. The purpose was to compare the temperature distribution in the room with the temperature measured and logged by the heating system control sensor which was already installed. The room was heated by means of electrical radiators, which should be able to control the indoor environment to guarantee the desired thermal conditions for the occupants and to supply heat according to desired load patterns. Five series of experiments were done under different control strategies of the heating system (Pseudo Random Binary Sequence signal controlling all the heaters (PRBS) or thermostatic control of the heaters (THERM)). A comparison of the measured temperatures within the room, for the five series of experiments, shows a better correlation when temperature control strategy THERM was used. Notable vertical temperature gradients were monitored in the occupied zone (especially for the PRBS control strategy) when there were high solar gains.

Temperatur stabilisering ved brug af faseskiftende materiale - PCM

Electronic versions: temperaturstabilisering_ved_brug_af_faseskiftende_materiale.pdf

Links:
http://www.danvak.dk/index.php?option=com_content&task=view&id=75&Itemid=128
Source: orbit
Source-ID: 272803
Publication: Communication › Paper – Annual report year: 2010
Varmetransmission ved ledning, konvektion og stråling

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Vej-Hansen, C. (ed.) (Ekstern), Rode, C. (ed.) (Intern)
Publication date: 2010

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
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varmetransmission10 21-11-2010.pdf
Source: orbit
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Publication: Education › Compendium/lecture notes – Annual report year: 2010

50 years of research and education on thermal insulation of buildings: an era started by the Thermal Insulation Laboratory, 1959

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (ed.) (Intern), Svendsen, S. (ed.) (Intern), Furbo, S. (Intern)
Publication date: 2009

Publication information
ISBN (Print): 9788778772879
Original language: English
Series: Report
Number: R-209
Main Research Area: Technical/natural sciences
Electronic versions:
byg-r209.pdf
Source: orbit
Source-ID: 250564
Publication: Communication › Report – Annual report year: 2009

Buildings: consuming and conserving energy

General information
State: Published
Organisations: Section for Indoor Environment, Department of Civil Engineering, Section for Building Physics and Services
Authors: Olesen, B. W. (Intern), Rode, C. (Intern)
Pages: 72-81
Publication date: 2009

Host publication information
Title of host publication: Engineering challenges : energy, climate change & health
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Publisher: Technical University of Denmark (DTU)
Editor: Hansen, C. B.
ISBN (Print): 978-87-985544-4-8
Series: DTU research series
Main Research Area: Technical/natural sciences
Electronic versions:
Engineering_challenges_2009.pdf
Source: orbit
Source-ID: 256118
Publication: Research › Book chapter – Annual report year: 2009
Common Exercises in Whole Building HAM Modelling
Subtask 1 of the IEA ECBCS Annex 41 (IEA 2007) project had the purpose to advance development in modelling of integral Heat, Air and Moisture (HAM) transfer processes that take place in “whole buildings”. Such modelling considers all relevant elements of buildings: The indoor air, building envelope, inside constructions, furnishing, systems and users. The building elements interact with each other and with the outside climate. Subtask 1 dealt with modelling principles and the arrangement and execution of so-called common exercises with the purpose to gauge how well it was possible to succeed in such modelling. The paper gives an overview of the Common Exercises which have been carried out in the Subtask.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Thermal Science Centre of Lyon
Authors: Rode, C. (Intern), Woloszyn, M. (Ekstern)
Pages: 346-353
Publication date: 2009

Host publication information
Title of host publication: Building Simulation 2009 : Proceedings of the 11th International Building Performance Simulation Association Conference
Place of publication: Glasgow, UK
Publisher: Energy Systems Research Unit, University of Strathclyde
Editors: Strachan, P. A., Kelly, N. J., Kummert, M.
ISBN (Print): 978-0-947649-40-1
Main Research Area: Technical/natural sciences
Electronic versions:
BS09_0346_353.pdf
Source: orbit
Source-ID: 249574
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Development of Evaluation Procedure for Effective Implementation of CDIO
One of the challenges in modern engineering education is the demand for teaching of high quality where the subject is presented in an interesting and engaging way. By integrating and involving the students in the teaching process, the learning can be increased. At the Technical University of Denmark (DTU), the CDIO approach was started in the autumn of 2008 in the process of reforming the engineering education in order to educate the students to become more effective engineers. One of the goals is to effectively implement CDIO practices and reduce time for implementation. One of the ways to do this is to evaluate the students’ view on the CDIO learning environment. In order to get a high response rate from the students, it was decided to make the first student evaluation of the CDIO learning environment as a two page inquiry form with 16 questions on the front page and possibilities for individual comments on the reverse side of the page. In addition to the paper inquiry form there was the traditional electronic inquiry at the CampusNet. The two forms show significant difference in response rate since the paper inquiry form gave a response rate of 84% (=100% of all students attending the presentation day) compared to only 45% at the electronic inquiry at the CampusNet – giving the paper inquiry form a far more representative value. Altogether, this material has given the CDIO staff very good material for the evaluation of the CDIO Design Build course and input for improvement and effective practices. In general the results show a very high satisfaction with the Design Build course and the students like the practical approach in the CDIO concept. The students are very committed and the course motivates them for added interest in studying constructional engineering.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Design
Authors: Christensen, J. E. (Intern), Rode, C. (Intern), Borchersen, E. (Intern)
Publication date: 2009

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Title of host publication: DEVELOPMENT OF EVALUATION PROCEDURE FOR EFFECTIVE IMPLEMENTATION OF CDIO
Main Research Area: Technical/natural sciences
Conference: the 5th International CDIO Conference, Singapore, 01/01/2009
Design Build course, evaluation, inquiry form, paper inquiry form, effective implementation
Electronic versions:
2009 CDIO paper_Development of Evaluation_3b.pdf
Source: orbit
Examples of Sustainable buildings and renovation projects from Greenland to Denmark

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
Pages: 41-63
Publication date: 2009

Host publication information
Title of host publication: Workshop "Energy self-sufficient and Sustainable Buildings": Proceedings
Place of publication: Brno Technical University, Czech Republic
Main Research Area: Technical/natural sciences
Conference: Energy self-sufficient and Sustaianble Buildings, Brno Technical University, Czech Republic, 01/01/2009
Electronic versions:
CAR Byg - Sustainable buildings and renovation.pdf
Source: orbit
Source-ID: 256023
Publication: Research › Article in proceedings – Annual report year: 2009

From EMPD to CFD – overview of different approaches for Heat Air and Moisture modeling in IEA Annex 41.
This paper provides an overview of the recent developments of Heat, Air and Moisture modeling of Whole Buildings, which were carried out within a collaborative project of the International Energy Agency. The project has strived to advance the possibilities to calculate the integrated phenomena of heat, air and moisture flows while including the important interactions that take place in buildings between the various building materials, components, and room air, and how those conditions are influenced by occupants and HVAC systems. Principles and some applications of different levels of modeling are presented: simplified modeling of moisture buffering, whole building coupled models as well as more detailed contributions for airflow modeling, including CFD models.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Université Lyon
Authors: Woloszyn, M. (Ekstern), Rode, C. (Intern), Kalagasidis, A. S. (Ekstern), Janssens, A. (Ekstern), De Paepe, M. (Ekstern)
Publication date: 2009

Host publication information
Title of host publication: ASHRAE Transactions : Louisville 2009
Volume: vol. 115, pt. 2
Place of publication: Atlanta
Publisher: American Society of Heating, Refrigerating and Air-Conditioning Engineers
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 249563
Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Humidity in air during and after humidifying incidents in three different houses
In three different occupied houses water boilers were set up to release approximately 1 kg of steam during approximately 0.5 hours. Before, during and 40 hours after this incident moisture content in indoor air and outdoor air was measured as well as temperatures, air change rate, air volume in the house and areas of main inner surface structures. The ability of the houses to absorb water in their structures after these experimentally created humidifying incidents was assessed based on mathematical models. Moisture absorption was most significant in the old masonry house during the first four hours after the steam was added. After this period the modern masonry house, with the slowly reacting concrete, had the highest absorption. At all times the least absorption was seen in the wooden house.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Danish Building Research Institute
Implementation of Models for Building Envelope Air Flow Fields in a Whole Building Hygrothermal Simulation Tool

Simulation tools are becoming available which predict the heat and moisture conditions in the indoor environment as well as in the envelope of buildings, and thus it has become possible to consider the important interaction between the different components of buildings and the different physical phenomena which occur. However, there is still room for further development of such tools. This paper will present an attempt to integrate modelling of air flows in building envelopes into a whole building hygrothermal simulation tool. Two kinds of air flows have been considered: 1. Air flow in ventilated cavity such as in the exterior cladding of building envelopes, i.e. a flow which is parallel to the construction plane. 2. Infiltration/exfiltration of air through the building envelope, i.e. a flow which is perpendicular to the construction plane. The new models make it possible to predict the thermal and moisture impact of these air flows which represent either (1) a part of the building envelope which has hitherto not been offered much focus in building simulation, or (2) a transport form which in most cases should be kept minimal but which has immense importance on the overall heat and moisture flows when it occurs. The paper presents the models and how they have been integrated into a whole building simulation tool. Furthermore, the paper shows some calculation results for validation and for illustration of the importance of the phenomena.

Influence of the convective surface transfer coefficients on the Heat, Air, and Moisture (HAM) building performance

Current models to predict heat, air and moisture (HAM) conditions in buildings assume constant boundary conditions for the temperature and relative humidity of the neighbouring air and for the surface heat and moisture transfer coefficients. These assumptions may introduce errors in the predicted HAM conditions. The paper focuses on the influence of the interior surface heat and moisture transfer coefficients, and investigates its effect on the hygrothermal performance. The parameter study showed that the magnitude of the convective surface transfer coefficients have a relatively large influence on the predicted hygrothermal conditions at the surface of a building component and on the heat and vapour exchange with the indoor environment.
Low-energy house in Sisimiut: Annual report of Low-energy house performance July 2008 to June 2009

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Design
Authors: Vladyková, P. (Intern), Borchersen, E. (Intern), Rode, C. (Intern), Furbo, S. (Intern)
Publication date: 2009

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
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Bibliographical note
SR 09-06
Source: orbit
Source-ID: 256081
Publication: Research › Report – Annual report year: 2009

Modeling Local Hygrothermal Interaction: Local surface transfer coefficients
Current models to predict heat, air and moisture (HAM) conditions in building components assume uniform boundary conditions, both for the temperature and relative humidity of the air in an indoor space as well as for the heat and moisture surface transfer coefficients. In order to obtain a reliable prediction of the HAM conditions in a building component, an accurate description of the indoor boundary conditions is required. This paper presents the modelling of the local indoor environmental conditions, using a (sub)zonal airflow model, focussing on the prediction of the local interior surface heat and moisture transfer coefficients. The research showed that the developed model gives good agreement with the local convective surface transfer coefficients predicted from CFD. The main advantage of the presented (sub)zonal airflow model is that the computational effort is relatively small, while the predictions of the local surface transfer coefficients are relatively accurate.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Steskens, P. W. M. H. (Intern), Janssen, H. (Intern), Rode, C. (Intern)
Pages: 826
Publication date: 2009

Host publication information
Title of host publication: Proceedings of the 9th International Healthy Buildings Conference and Exhibition
Main Research Area: Technical/natural sciences
Source: orbit
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2009

Passive Houses for Arctic.: Measures and Alternatives

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Passivhus.dk
Authors: Vladyková, P. (Intern), Rode, C. (Intern), Nielsen, T. R. (Intern), Pedersen, S. (Ekstern)
Publication date: 2009

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Title of host publication: 13th International Passive House Conference 2009
Passive Houses for Arctic: What buildings should we build in Arctic?

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Passivhus.dk
Authors: Vladyková, P. (Intern), Rode, C. (Intern), Pedersen, S. (Ekstern), Nielsen, T. R. (Intern)
Publication date: 2009
Main Research Area: Technical/natural sciences

Performance of the Low-energy House in Sisimiut.
A low-energy house was built in Sisimiut, Greenland in 2004-05 and since its inauguration in April 2005, its performance and operation have been object of study for researchers and students. The house is characterised by a highly insulated building envelope, advanced windows and a ventilation system with heat recovery, which should cut the energy consumption of the building to only half of what in 2006 became the permissible value in the Greenlandic building code. In addition to this, the house is equipped with a solar collector that supplies heat to the domestic hot water system and delivers auxiliary heat to a room in the building. The paper briefly introduces the design and technology of the house before reporting on the performance results until date. It has been a challenge in some aspects to introduce new technologies which have not been commonly used before in an Arctic environment, and the paper illustrates some of the experiences in this regard.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Design
Authors: Rode, C. (Intern), Kragh, J. (Intern), Borchersen, E. (Intern), Vladyková, P. (Intern), Furbo, S. (Intern), Dragsted, J. (Intern)
Publication date: 2009

Renovation of standardized typical single family house to Passive House Standards by means of simulation

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Vladyková, P. (Intern), Rode, C. (Intern)
Publication date: 2009
Temperature distribution in Risø Flexhouse Room 3 with different heating control principles

This report presents the measurements of local thermal conditions in one room ("Room 3") of the so-called "Flexouse" located at Risø DTU. The house is part of Risø DTU's SYSLAB facility used to study the interaction of different facilities that supply and use energy. The facility has been used in winter and spring 2009 to study the distribution of local temperatures in the room – particularly with the purpose to compare with the temperature measured and logged by the heating control sensor which was already installed in the room. The measured data shall be used together with mathematical models to predict the overall dynamic thermal properties of the building. The project is part of a wider complex of projects on predicting the electricity and heating energy consumption in dwellings.

General information
State: Published
Organisations: Section for Indoor Environment, Department of Civil Engineering, Section for Building Physics and Services
Authors: Simone, A. (Intern), Rode, C. (Intern)
Publication date: 2009

Publication information
Original language: English
Series: BYG Sagsrapport
Number: SRc 09-07
ISSN: 1601-8605
Main Research Area: Technical/natural sciences
Electronic versions:
byg-sr0907.pdf
Links:
Source: orbit
Source-ID: 256171
Publication: Research › Report – Annual report year: 2009

Annual Report 2007

General information
State: Published
Organisations: Department of Civil Engineering, Section for Construction Materials, Section for Building Physics and Services, Section for Indoor Environment, Section for Building Design, Section for Geotechnics and Geology, Section for Structural Engineering, Arctic Technology Centre
Number of pages: 34
Publication date: 2008

Publication information
Place of publication: Kgs. Lyngby
Publisher: DTU Byg. Danmarks Tekniske Universitet
ISBN (Print): 978-87-87336-03-1
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Byg_Arsrapport2007.pdf
Source: orbit
Source-ID: 239338
Publication: Communication › Report – Annual report year: 2008
Common Exercises in Whole Building HAM Modelling

Subtask 1 of the IEA Annex 41 project had the purpose to advance the development in modelling the integral heat, air and moisture transfer processes that take place in “whole buildings”. Such modelling comprises all relevant elements of buildings: the indoor air, the building envelope, the inside constructions, furnishing, systems and users. The building elements interact with each other and with the outside climate. The Annex 41 project and its Subtask 1 has not aimed to produce one state-of-the-art hygrothermal simulation model for whole buildings but rather to stimulate the participants’ own development of such models, or advanced use of related existing models. Subtask 1 dealt with modelling principles and the arrangement and execution of so-called common exercises with the purpose to gauge how well we can succeed in the modelling. The paper gives an overview of the Common Exercises which have been carried out in the Subtask.

Based on this activity, some general experiences are reported about how well we are able today to carry out such advanced modelling, and some recommendations for future developments are indicated.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Université Lyon
Authors: Rode, C. (Intern), Woloszyn, M. (Ekstern)
Number of pages: 140
Pages: 37-48
Publication date: 2008

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Place of publication: Copenhagen, Denmark
Publisher: Technical University of Denmark, Department of Civil Engineering
Editors: Rode, C., Hens, H., Janssen, H.
ISBN (Print): 97887777772671
Main Research Area: Technical/natural sciences
Conference: IEA ECBCS Annex 41 , Kgs. Lyngby, Denmark, 19/06/2008
Electronic versions:
ST1C - Common Exercises.pdf
Source: orbit
Source-ID: 238694
Publication: Research › Article in proceedings – Annual report year: 2008

From EMPD to CFD – overview of different approaches for Heat Air and Moisture modeling in IEA Annex 41

This paper provides an overview of the recent developments of Heat, Air and Moisture modeling of Whole Buildings, which were carried out within a collaborative project of the International Energy Agency. The project has strived to advance the possibilities to calculate the integrated phenomena of heat, air and moisture flows while including the important interactions that take place in buildings between the various building materials, components, and room air, and how those conditions are influenced by occupants and HVAC systems. Principles and some applications of different levels of modeling are presented: simplified modeling of moisture buffering, whole building coupled models as well as more detailed contributions for airflow modeling, including CFD models.

General information
HAM-Tools – a whole building simulation tool in Annex 41

HAM-Tools is a building simulation software. The main task of this tool is to simulate transfer processes related to building physics, i.e. heat, air and moisture transport in buildings and building components in operating conditions. The scope of the ECBCS Annex 41 “Whole Building Heat, Air and Moisture Response” was of a high relevance for the testing, development, validation and promotion of the HAM-Tools. The majority of the numerical studies made by this programme were provided for Subtask 1 “Modelling principles and common exercises”. This paper gives an overview of the modelling capabilities of HAM-Tools and some results provided for Subtask 1.

Hygrothermal Properties and Performance of Sea Grass Insulation

In the attempt to obtain knowledge of the hygrothermal properties of sea grass as thermal insulation, experiments have been carried out in the laboratory to determine the thermal conductivity, sorption properties and the water vapour permeability of the material. In order to investigate the hygrothermal performance in the field, four test walls have been built. The relative humidity and temperature in the constructions have been measured during a winter period and are presented in this paper.
Impact of furnishing on room airflow

In building simulation it is common to use idealized empty rooms for simulation. However, furnishing elements may cause local microclimates. These microclimates can be critical for instance if furniture is placed close to poorly insulated external walls in Nordic countries, where the external temperatures in the winter season may lead to condensation or high relative humidity on the internal side of the building envelope. Therefore it was important to investigate the influence of furniture on the airflow patterns in rooms and on the local airflow behind the furniture. The current paper presents an investigation of the airflow patterns behind a piece of furniture placed near a cold external wall. The investigation is based on a combination of Particle Image Velocimetry experiments and Computational Fluid Dynamics. The main topic of the investigation is to highlight the effect of increasing the distance between the wall and the furniture as well as between the wall and the floor. As expected the results showed that increased gap widths give increased airflow rates. Comparison of measurements and simulations indicated a good predictability for the cases, where radiation played a minor role.
Influence of furnishing on indoor airflow near external walls
Simulations of indoor environments in buildings are usually performed assuming uniform distribution of temperature and humidity of the indoor air, such as it would be in an idealised unfurnished room. The flow patterns near external walls may however be very different from the undisturbed airflow distributions, as the walls behind furniture may be colder than the other surroundings of the room, and the furniture to some extent obstructs the airflow. This paper describes an investigation of a room with a piece of furniture placed near an external wall. This was investigated using Particle Image Velocimetry (PIV) measurements. It was found how the pattern of airflow behind furniture placed near cold walls was influenced by the thickness of air gaps behind and below the furniture. But it was also found that even if the furniture was placed directly on the floor, there would be a considerable flow of air behind the furniture.

Influences of the Indoor Environment on Heat, Air and Moisture Conditions in The Building Component: Boundary Conditions Modeling
Current models to predict heat, air and moisture (HAM) conditions in building components assume uniform boundary conditions, both for the temperature and relative humidity of the air in an indoor space as well as for the surface transfer coefficients. Such models cannot accurately predict the HAM conditions in the component and on the surface of the component with non-uniform air temperature or relative humidity distributions in an indoor space. Moreover, the heat and moisture surface transfer coefficients strongly depend on the local air velocity, local temperature, water-material interactions and water content at the material surface and surface texture of the material. The objective of the present paper is to analyze the influence of the non-uniform local air velocity near the surface of a building component on the HAM conditions in the component. A case study and sensitivity study have been used to investigate this influence. The research showed that the indoor environmental conditions and local airflow velocity have a relatively large influence on the predicted HAM conditions in a building component. The influence of the convective surface heat transfer coefficient on the HAM performance of the component is relatively large compared to the influence of the convective surface mass transfer coefficient. With respect to the analyzed building component, the investigations showed that assuming an average value for the surface mass transfer coefficient is acceptable, while assuming an average value is not acceptable for the convective surface heat transfer coefficient. The study showed that the influence on the surface relative humidity is limited.
Influences of the Indoor Environment on Heat, Air, and Moisture Conditions in the Component: Boundary conditions modeling

Current models to predict heat, air and moisture (HAM) conditions in building components assume uniform boundary conditions, both for the temperature and relative humidity of the air in an indoor space as well as for the heat and moisture surface transfer coefficients. The heat and moisture surface transfer coefficients strongly depend on the local air velocity, local temperature, water-material interactions, water content at the material surface, and the surface texture of the material. Moreover, due to local heat and moisture sources, imperfect mixing and microclimatic effects, temperature and relative humidity in the adjacent air are seldom uniform. In order to obtain a reliable prediction of the HAM conditions in a building component, an accurate description of the indoor (and outdoor) boundary conditions is required. The objective of the present paper is to analyze the influence of the variations of the surface transfer coefficients near the surface of a building component on the HAM conditions in the component. A parameter study has been used to investigate this influence. The research showed that the surface transfer coefficients have a relatively large influence on the predicted HAM conditions in a building component. Building researchers and designers should be aware that the appropriate indoor environmental conditions are applied, when performing a HAM component simulation and analysis.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Steskens, P. W. M. H. (Intern), Rode, C. (Intern), Janssen, H. (Intern)
Pages: 653-660
Publication date: 2008

Integrated design and Passive Houses for Arctic Climates

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Passivhus.dk
Authors: Vladyková, P. (Intern), Rode, C. (Intern), Nielsen, T. R. (Intern), Pedersen, S. (Ekstern)
Publication date: 2008
Investigation of airflow patterns in a microclimate by particle image velocimetry (PIV)

Problems with mould growth in dwellings usually occur in bedrooms in the microclimate behind closets placed next to exterior walls with poor insulation. It is anticipated that the problems are caused by lack of airflow behind the furniture in combination with a colder surface temperature and a high moisture production. The lack of air circulation decreases the surface temperature, which can cause problems. A particle image velocimetry (PIV) investigation was performed of the airflow patterns in such a microclimate. This paper describes the experimental set-up and the results. The results indicate that the flow rates behind the furniture will increase with increased distance between the closet and the wall, and even higher airflow rates are seen when the furniture is elevated by legs.

General information
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Organisations: Department of Civil Engineering, Section for Building Physics and Services, VTT - Technical Research Centre of Finland
Authors: Mortensen, L. H. (Intern), Rode, C. (Intern), Peuhkuri, R. (Ekstern)
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Web of Science (2013): Indexed yes
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Web of Science (2012): Indexed yes
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.144 SNIP 2.255 CiteScore 2.76
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
Moisture buffering and its consequence in whole building hygrothermal modelling

Moisture absorption and desorption of materials in contact with indoor air of buildings can be used as a passive, i.e., nonmechanical, way to moderate the variation of indoor humidity. This phenomenon, which is recognized as moisture buffering, could potentially be used as an attractive feature of building products to improve indoor air quality and to save energy. Of interest therefore is to establish a unit to appraise this quality of building products and to investigate the importance of moisture buffering when it is considered in whole building hygrothermal simulation. This paper will illustrate both. A new test method specifies a protocol for determination of what has recently been termed the Moisture Buffer Value (MBV) of building products. The paper presents the definition of MBV and introduces a test protocol which has been proposed for its experimental determination. The MBV is primarily meant as a value to characterize the ability of building products to moderate the variations of humidity in air which is in contact with the products, since it indicates the rate of flow of moisture over the product's surface when exposed to a certain humidity excitation. Hygroscopic interaction between air of the indoor climate and materials in the building envelope is taken into account in a model for whole building heat and moisture simulation. By means of an example, it will be investigated if: 1. it is possible to use the benefits of moisture buffering to save energy by reducing the requirement for ventilation if indoor humidity is a parameter for controlling ventilation rate, 2. it is possible to improve the perceived acceptability of indoor air, as judged by the temperature and humidity of the air, by using moisture buffering to control the indoor humidity. The results of the whole building hygrothermal simulations show that it is possible to rather significantly reduce the amplitudes of indoor relative variation when the moisture buffering effect of building materials is taken into account, compared to a situation with moisture tight interior building surfaces. The modeling also shows some possible benefits on energy consumption if humidity-controlled ventilation is employed, as well some benefit on the indoor acceptability with the hygrothermal quality of indoor air. However, both benefits seem to be somewhat limited in the model room used for analysis.
Non-isothermal Moisture Transport Through Insulation Materials

An experimental investigation was conducted in order to draw some conclusions on the magnitude of moisture transport due to temperature gradient on a range of porous light-weight building materials. A special constructed non-isothermal set-up allowed the creation of a temperature gradient of 10K and given humidity gradient over the sample. The resulting moisture flux as well as the hygrothermal states around and within the material were monitored. The hypothesis of relative humidity being a driving force for non-isothermal moisture transport already in the hygroscopic range could not be
confirmed. On the contrary, indications exist that the temperature gradient itself is driving the moisture from the warm side towards the cold side. An attempt to identify and quantify the single contributions of the different transport forms involved is also presented. The different results gave, however, diverging conclusions and therefore the question about existence of the type of transport forms driven by the non-isothermal effects remains open. Rather surprisingly, all the materials, including the almost non-hygroscopic materials (e.g. rock wool) and very hygroscopic materials (e.g. cellulose insulation) showed the same characteristics.

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Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Hansen, K. K. (Intern)
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BFI (2015): BFI-level 1
Scopus rating (2015): SJR 2.093 SNIP 2.49 CiteScore 4.37
Web of Science (2015): Indexed yes
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 1.938 SNIP 2.797 CiteScore 4.14
Web of Science (2014): Indexed yes
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 1.581 SNIP 2.602 CiteScore 3.57
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 1.331 SNIP 2.875 CiteScore 3.06
ISI indexed (2012): ISI indexed yes
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 1.144 SNIP 2.255 CiteScore 2.76
ISI indexed (2011): ISI indexed yes
Web of Science (2011): Indexed yes
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BFI (2009): BFI-level 1
Scopus rating (2009): SJR 1.028 SNIP 1.865
Web of Science (2009): Indexed yes
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.924 SNIP 1.38
Web of Science (2008): Indexed yes
Scopus rating (2007): SJR 0.788 SNIP 1.778
Passive Houses for Arctic Climates

General information
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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Passivhus.dk
Authors: Vladyková, P. (Intern), Rode, C. (Intern), Nielsen, T. R. (Intern), Pedersen, S. (Ekstern)
Publication date: 2008

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Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (ed.) (Intern)
Publication date: 2008

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Synthèse sur la modélisation thermo-hygro-aéraulique des bâtiments dans l’Annexe 41 de l’Agence Internationale de l’Energie

General information
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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Université Lyon
Authors: Woloszyn, M. (Ekstern), Rode, C. (Intern), Roux, J. (Ekstern)
Publication date: 2008

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The influence of surface treatment on mass transfer between air and building material

The processes of mass transfer between air and building structure and in the material influence not only the conditions within the material but also inside the connected air spaces. The material which absorbs and desorbs water vapour can be used to moderate the amplitude of indoor relative humidity and therefore to participate in the improvement of the indoor air quality and energy saving. Many parameters influence water vapour exchange between indoor air and building material. The aim of this work is to present the change of mass transfer under different climatic and material conditions. The measurements were performed at the Technical University of Denmark (DTU), Department of Civil Engineering. Two climatic chambers were used for the tests, the first one for dynamic and the second for steady state conditions. Two commonly used building materials exposed to the indoor environment were chosen for the experiments: gypsum board and calcium silicate. The wallpaper and paint were used as finishing materials. Impact of the following parameters for changes of RH was studied: coating, temperature and air movement. The measurements showed that acryl paint (diffusion open) can significantly decrease mass uptake. It was shown also that higher air velocity speeds up the process of mass exchange between indoor air and materials but apparently decreases the total amount of exchanged water after a longer period. The experiment allows not only to check the influence of surface treatment on mass transfer, but can be used also as validation for simulation programs. At the end of the article, a mass uptake calculation using the HUMIMUR model is presented.

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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Construction Materials, Université Lyon
Tools for Performance Simulation of Heat, Air and Moisture Conditions of Whole Buildings

Humidity of indoor air is an important factor influencing the air quality and energy consumption of buildings as well as durability of building components. Indoor humidity depends on several factors, such as moisture sources, air change, sorption in materials and possible condensation. Since all these phenomena are strongly dependent on each other, numerical predictions of indoor humidity need to be integrated into combined heat and airflow simulation tools. The purpose of a recent international collaborative project, IEA ECBCS Annex 41, has been to advance development in modelling the integral heat, air and moisture transfer processes that take place in “whole buildings” by considering all relevant parts of its constituents. It is believed that full understanding of these processes for the whole building is absolutely crucial for future energy optimization of buildings, as this cannot take place without a coherent and complete description of all hygrothermal processes. This paper will illustrate some of the modelling work that has taken place within the project and present some of the simulation tools used.

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Authors: Woloszyn, M. (Ekstern), Rode, C. (Intern)
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Scopus rating (2015): SJR 1.016 SNIP 1.154 CiteScore 1.74
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.827 SNIP 1.264 CiteScore 1.41
Web of Science (2014): Indexed yes
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Whole Building Heat, Air, Moisture Response: Modelling Principles and Common Exercises

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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Université Lyon
Authors: Woloszyn, M. (Ekstern), Rode, C. (Intern)
Publication date: 2008

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Whole-Building Hygrothermal Modeling in IEA Annex 41: Towards a new Annex?

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Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern)
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Rode - Future Annex - Champs Seminar ed2.pdf
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Hygrothermal Microclimate on Interior Surfaces of the Building Envelope

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Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Mortensen, L. H. (Intern), Rode, C. (Intern), Peuhkuri, R. H. (Intern)
Publication date: Aug 2007
Investigation of Microclimate by CFD Modeling of Moisture Interactions between Air and Constructions

There is a strong demand for accurate moisture modeling since moisture poses a risk for both the constructions and the indoor climate. This investigation has special focus on moisture modeling. The paper describes a new model based on a CFD tool enhanced to include both detailed modeling of airflows in rooms and heat and moisture transfer in walls by applying them as fluid walls. In a 3D configuration it is investigated what the impacts are of different boundary conditions and how this influences microclimates in rooms. The studied microclimate is a piece of furniture placed near a cold exterior wall.

General Information
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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Université Lyon
Authors: Mortensen, L. H. (Intern), Wolosyn, M. (Ekstern), Rode, C. (Intern), Peuhkuri, R. H. (Intern)
Pages: 279-315
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Main Research Area: Technical/natural sciences
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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Structural Engineering
Authors: Rode, C. (Intern), Borchersen, E. (Intern), Fan, J. (Intern), Furbo, S. (Intern), Kragh, J. (Intern)
Publication date: 2007

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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Design, Arctic Technology Centre, Rambøll Danmark A/S
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Moisture Buffer Value of Building Materials

When building materials are in contact with indoor air they have some effect to moderate the variations of indoor humidity in occupied buildings. But so far there has been a lack of a standardized quantity to characterize the moisture buffering capability of materials. It has been the objective of a recent Nordic project to define such a quantity, and to declare it in the form of a NORDTEST method. The Moisture Buffer Value is the figure that has been developed in the project as a way to appraise the moisture buffer effect of materials, and the value is described in the paper. Also explained is a test protocol which expresses how materials should be tested for determination of their Moisture Buffer Value. Finally, the paper presents some of the results of a Round Robin Test on various typical building materials that has been carried out in the project.

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Organisations: Section for Building Physics and Services, Department of Civil Engineering, VTT - Technical Research Centre of Finland, SINTEF Building and Infrastructure, Lund Institute of Technology
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BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.152 SNIP 0.471
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.153 SNIP 0.435
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BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.214 SNIP 0.455
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BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.419 SNIP 0.482
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BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.265 SNIP 0.521
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.267 SNIP 0.509
BFI (2008): BFI-level 1
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Scopus rating (2007): SJR 0.189 SNIP 0.413
Scopus rating (2006): SJR 0.165 SNIP 0.556
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The importance of moisture buffering for indoor climate and energy conditions of buildings

A new Nordic test method specifies a test protocol for determination of the so-called Moisture Buffer Value (MBV) of building materials. But how important is moisture buffering to determine the indoor humidity condition of buildings? The paper will present the new MBV-definition. Although it is primarily a value meant to characterise the moisture buffer property of building materials, can it also be used as a calculation parameter in design of buildings? And how does moisture buffering compare with the effect of ventilation of buildings? Is it possible for instance to use the benefits of moisture buffering to save energy by reducing the requirement for ventilation in periods, and still maintain the same quality of the indoor climate? The paper will outline some possibilities for analytical/numerical calculations, and will answer some of the posed questions on the probable benefit of taking moisture buffering into account as a design parameter.

The International Building Physics Toolbox in Simulink

The International Building Physics Toolbox in Simulink
Whole-Building Hygrothermal Modeling in IEA Annex 41

Annex 41 of the International Energy Agency's (IEA) Energy Conservation in Buildings and Community Systems program (ECBCS) is a cooperative project on “Whole-Building Heat, Air, and Moisture Response” (MOIST-ENG). Subtask 1 of that project set out to advance development in modeling the integral heat, air, and moisture transfer processes that take place in whole-buildings. Such modeling comprises all relevant elements of buildings: indoor air, the building envelope, inside constructions, furnishing, systems, and users. The building elements interact with each other and with the outside climate. The IEA Annex 41 project runs from 2004–2007, coming to conclusion just before the Thermal Performance of the Exterior Envelopes of Whole Buildings X conference. The Annex 41 project and its Subtask 1 do not aim to produce one state-of-
the-art hygrothermal simulation model for whole buildings, but rather aim to stimulate the participants’ own development of such models or advanced use of related existing models. Subtask 1 deals with modeling principles and the arrangement and execution of so-called common exercises with the purpose of gauging how well we can succeed in the modeling. To direct the modeling, free scientific contributions have been invited from specific fields that need the most attention in order to better accomplish the integral building simulations. This paper will give an overview of the advances in whole-building hygrothermal simulation that have been accomplished and presented in conjunction with IEA Annex 41, Subtask 1. In addition, the paper will give an overview of the Common Exercises that have been carried out in the subtask. Based on these two activities, some general experiences are reported about how well we are able today to carry out such advanced modeling, and some recommendations for future developments are indicated.

A low-energy building under arctic conditions – a case study
Greenland is a relatively small community with limited natural resources, which results in the necessity to import all supplies, including a big share of the energy. Because of this, it is important to decrease the energy consumption. This can be done by developing new construction technology with larger focus on energy efficiency. Therefore a low-energy house, located in Sisimiut, has been constructed. The low-energy house will be a forerunner for the development of new building element designs and technologies in Greenland. In the forthcoming years, the house will also be a base for scientific projects which will evaluate the design of the low-energy house including an assessment of the effect of the highly insulated building envelope, advanced windows and a ventilation system with heat recovery, all of which cuts the energy consumption of the building to half of what will be the requirement in the new Greenlandic building regulations.

A Model for Air Flow in Ventilated Cavities Implemented in a Tool for Whole-Building Hygrothermal Analysis
A model for calculating air flows in ventilated cavities has been implemented in the whole-building hygrothermal simulation tool BSim. The tool is able to predict indoor humidity conditions using a transient model for the moisture conditions in the building envelope.
Danish and Brazilian Modeling of Whole-Building Hygrothermal Performance
The humidity of rooms and moisture conditions of materials in the enclosure of buildings depend much on each other because of the moisture exchange that takes place over the interior surfaces. These moisture influences also depend strongly on the thermal conditions of indoor spaces and enclosure elements of buildings. In turn, the moisture and humidity conditions have significant impact on how buildings are operated. In hot-humid climates it may be desirable to keep the ventilation rates low in order to avoid too high indoor humidity, while in cold climates ventilation can be used to keep the humidity low and thus reduce the risk of moisture damage in the building enclosure. In either case the indoor humidity has a direct or indirect impact on the energy performance of the HVAC system of a building. To analyze this situation, one could benefit from some recent developments in integrated computational analysis of the hygrothermal performance of whole buildings. Such developments have led to new hygrothermal models for whole buildings. The paper gives examples of such recent developments and will illustrate some calculation results that can be obtained. Finally the paper will mention some further developments and international collaboration on the subject.
Drying of aerated cellular concrete

Effect of airflow velocity on moisture exchange at surfaces of building materials

Lavenergihuset i Sisimiut.: Notat om aktiviteter udført som led i KVUG-projekt: Indlejring af erfaringer fra lavenergihus i Sisimit.

Moisting the Hygrothermal Interaction Between Materials and the Indoor Climate

Moisture buffer value: A comprehensive analysis of essential parameters
There is an increasing focus on the possibilities of utilizing the absorptive ability of porous materials to create passive control of relative humidity (RH) variations in the indoor air. This has led to the need for determination of a new parameter that can be used for characterization of materials. The dynamic nature of the buffering phenomena makes it difficult to use the standard hygrothermal material properties directly for this purpose. In this paper some experimental results on aerated cellular concrete are used for pointing out the methodological and experimental use of dynamic tests for determination of the moisture buffer value of building materials. Special focus is given to the significance of e.g. the equilibrium state, the step size in the RH and whether one is studying absorption or desorption steps. In addition, the paper summarizes shortly the experience until now of studying the moisture buffer phenomenon. In the experiments the material samples were exposed to a sudden change in the RH of the ambient air which were either consecutive absorption and desorption steps or periodically varying cyclic steps.
Moisture Buffer Value of Building Materials

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Norwegian Building Research Institute, Lund University, VTT - Technical Research Centre of Finland
Authors: Rode, C. (Intern), Peuhkuri, R. H. (Intern), Time, B. (Ekstern), Svennberg, K. (Ekstern), Ojanen, T. (Ekstern)
Publication date: 2006

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Main Research Area: Technical/natural sciences

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Working paper A41-T4-DK-06-1 for IEA Annex 41 Meeting, April 3-5, 2006. Kyoto
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Publication: Research › Report – Annual report year: 2006

Simulation Tests in Whole Building Heat and Moisture Transfer

An important part of the International Energy Agency project, ECBCS, Annex 41 is about modelling the integral heat, air and moisture transfer processes that take place in "whole buildings". Such modelling deals with all most relevant elements of buildings: The indoor air, the building envelope, the inside constructions, furnishing and systems. These building elements interact with each other and they are influenced by the use of the building, the building services, and the outside climate. IEA Annex 41 aims to reach new modelling possibilities in integral building simulation, and to document these. The paper explains about some new simulation tests used in IEA Annex 41 and elaborates about the challenges brought by these exercises.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Institut National des Sciences Appliquees de Lyon
Authors: Rode, C. (Intern), Peuhkuri, R. H. (Intern), Woloszyn, M. (Ekstern)
Pages: 527-534
Publication date: 2006

Host publication information
Title of host publication: Research in Building Physics and Building Engineering : 3rd International Building Physics Conference
Publisher: Taylor & Francis
Editors: Fazio, P., Ge, H., Rao, J., Desmarais, G.
ISBN (Print): 04-1541-675-2
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 184891
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006
The Concept of Moisture Buffer Value of Building Materials and its Application in Building Design

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern), Peuhkuri, R. H. (Intern)
Pages: 57-62
Publication date: 2006

Host publication information
Title of host publication: Healthy Buildings 2006
Volume: III
ISBN (Print): 978-989-95067-0-1
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 188132
Publication: Research - peer-review › Article in proceedings – Annual report year: 2006

The Wick-Concept for Thermal Insulation of Cold Piping
The wick-concept for thermal insulation of cold piping is based on capillary suction of a fiber fabric to remove excess water from the pipe surface by transporting it to the outer surface of the insulation. From the surface of the insulation jacket, the water will evaporate to the ambient air. This will prevent long-term accumulation of moisture in the insulation material. The wick keeps the hydrophobic insulation dry, allowing it to maintain its thermal performance. The liquid moisture is kept only in the wick fabric. This article presents the principle of operation of cold pipe insulation using the wick-concept in either of two variations: the self-drying or the self-sealing system. Experiments have been carried out using different variations of the two systems to investigate the conditions for exploiting the drying capabilities of the systems, and the results are presented. The results show that the variations of these types of insulation systems work for pipes with temperature above 0°C and for ambient conditions within common ranges for industrial applications.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, VUT, Brno, CZ
Authors: Koverdynsky, V. (Ekstern), Korsgaard, V. (Intern), Rode, C. (Intern)
Pages: 313-327
Publication date: 2006
Main Research Area: Technical/natural sciences

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Journal: Journal of Building Physics
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Web of Science (2018): Indexed yes
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Web of Science (2017): Indexed Yes
BFI (2016): BFI-level 2
Scopus rating (2016): SJR 0.722 SNIP 0.751 CiteScore 1.1
BFI (2015): BFI-level 2
Scopus rating (2015): SJR 0.935 SNIP 1.738 CiteScore 1.4
BFI (2014): BFI-level 2
Scopus rating (2014): SJR 1.031 SNIP 1.351 CiteScore 1.62
BFI (2013): BFI-level 2
Scopus rating (2013): SJR 0.682 SNIP 1.06 CiteScore 1.17
ISI indexed (2013): ISI indexed yes
Web of Science (2013): Indexed yes
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ISI indexed (2012): ISI indexed yes
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Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences

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Source: orbit
Source-ID: 184886
Publication: Research - peer-review › Journal article – Annual report year: 2006

Effect of airflow velocity on moisture exchange at surfaces

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Mortensen, L. H. (Intern), Rode, C. (Intern), Peuhkuri, R. H. (Intern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences

Bibliographical note
Source: orbit
Source-ID: 185245
Publication: Research › Report – Annual report year: 2005
Effect of method, step size and drying temperature on sorption isotherms

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Hansen, K. K. (Intern)
Pages: 31-38
Publication date: 2005

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Place of publication: Reykjavik
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

Energy efficient building

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics, Arctic Technology Centre
Authors: Rode, C. (Intern), Iversen, A. (ed.) (Ekstern), Pedersen, A. (ed.) (Ekstern), Villumsen, A. (Intern)
Publication date: 2005

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Series: BYG Rapport
Number: R-115
Main Research Area: Technical/natural sciences
Electronic versions:
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Links:
Source: orbit
Source-ID: 183318
Publication: Research - peer-review › Report – Annual report year: 2005

Full scale tests of moisture buffer capacity of wall materials
Moisture buffer capacity of hygroscopic materials can be used to moderate peaks in the relative humidity (RH) of indoor air as well as moisture content variations in building materials and furnishing. This can help to ensure healthier indoor environments by preventing many processes that are harmful such as growth of house dust mites, surface condensation and mould growth. Therefore a series of experiments has been carried out in a full scale test facility to determine the moisture buffer effect of interior walls of cellular concrete and plaster board constructions. For the cellular concrete, the buffer performance is investigated first for the untreated material, then after adding rendering on the surfaces, and finally with latex paint. Similarly for the walls of plasterboard construction, the buffer effects are investigated first for the insulation (cellulose or mineral wool), then after adding untreated plasterboards as cladding, and finally with additional latex paint. The walls were exposed to cyclic humidity variations like in an inhabited indoor environment, and the response of the indoor humidity was followed over time. The investigations also comprised simultaneous determination of the changes of moisture content in specimens of the wall composites exposed to the same environment. It was found that the finishes had a big impact on the buffer performance of the underlying materials. Even though the untreated cellular concrete had a very high buffer capacity, the effect was strongly reduced even with the supposedly highly vapour permeable rendering finish, not to mention the case when the latex paint was used. In the same way, the experiments for the plaster board construction demonstrated how cellulose insulation, as a very hygroscopic material, is a good buffer compared to the almost non-hygroscopic mineral wool. For example, it was found that if half of the surface area of the walls in a test room consists of cellulose insulation, the variation in RH can be reduced to nearly half of the variation seen for a similar room using non-absorbing materials and the same moisture load. However, subsequent tests demonstrate that for daily
humidity variations it is not possible to take advantage of the moisture buffer capacity of the interior layers of a composite wall if the absorbing layers are covered with plasterboard, painted or not.

**Investigation of airflow patterns in microclimates with Particle Image Velocimetry (PIV)**

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Katholieke Universiteit
Authors: Mortensen, L. H. (Intern), Mertens, J. (Ekstern), Rode, C. (Intern), Peuhkuri, R. H. (Intern)
Publication date: 2005

**Bibliographical note**

**Investigation of microclimate between wall and furniture with CFD**
In ordinary building simulation tools for moisture modelling it is common to look very detailed on heat and moisture distributions in constructions while assuming fully mixed conditions in the room air so it is represented by only one node. Opposite, CFD models are used for detailed analysis of airflow patterns in rooms but here the surrounding constructions are described as fixed boundary conditions for the air. In this paper a moisture model for buildings with both airflow velocities and diffusion transport in constructions is presented. The focus of the investigation is on multi-dimensional moisture transfers. Where other models have focused on either the airflows in the room or on the moisture distribution in the constructions this paper will attempt to combine them. The moisture interactions between air and constructions depend strongly upon the airflow conditions close to the surface, which is influenced by the airflow patterns in the room. Thus, it is important to investigate the airflows carefully and to estimate their influence on the moisture transport. Hence, a CFD tool has been used for this investigation. In this paper a moisture model for buildings with both airflow velocities and diffusion transport in constructions is presented. It is a CFD model where the air is modelled as a mixture of dry air and water vapour and walls fluids modelled with ordinary wall characteristics as material properties. This enables easy modelling of moisture transfer within the walls. This investigation has special focus on the coupling of the moisture transfers in the wall and the moisture content of the air. The microclimate in a room is studied for different geometrical configurations, meaning that the moisture and temperature conditions are analysed and discussed using different distances between wall constructions and furnishing.

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State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Université Lyon
Moisture and Indoor Climate in Buildings

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Arctic Technology Centre
Authors: Rode, C. (Intern), Hansen, C. R. (Ekstern), Mouritsen, R. K. (Ekstern)
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Publisher: Technical University of Denmark, Department of Civil Engineering
Editor: Rode, C.
ISBN (Print): 87-7877-183-8

Series: Report
Number: R-115
Main Research Area: Technical/natural sciences

Moisture Buffering of Building Materials

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics, Norwegian Building Research Institute, Norwegian University of Science and Technology, VTT - Technical Research Centre of Finland, Lund University
Authors: Rode, C. (ed.) (Intern), Peuhkuri, R. H. (Intern), Mortensen, L. H. (Intern), Hansen, K. K. (Intern), Time, B. (Ekstern), Gustavsen, A. (Ekstern), Ojanen, T. (Ekstern), Ahonen, J. (Ekstern), Svennberg, K. (Ekstern), Arfvidsson, J. (Ekstern), Harderup, L. (Ekstern)
Number of pages: 78
Publication date: 2005

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ISBN (Print): 87-7877-195-1
Original language: English

Series: BYG Report
Number: R-127
Main Research Area: Technical/natural sciences
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State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 184615
Publication: Research - peer-review › Report – Annual report year: 2005

Moisture Buffer Value of Materials in Buildings

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics, Norwegian Building Research Institute, Lund University, VTT - Technical Research Centre of Finland
Authors: Rode, C. (Intern), Peuhkuri, R. H. (Intern), Hansen, K. K. (Intern), Time, B. (Ekstern), Svennberg, K. (Ekstern), Arfvidsson, J. (Ekstern), Ojanen, T. (Ekstern)
Pages: 108-115
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Main Research Area: Technical/natural sciences
Conference: 7th Nordic Symposium on Building Physics, Reykjavik, Iceland, 13/06/2005 - 13/06/2005
Source: orbit
Source-ID: 184888
Publication: Research - peer-review › Article in proceedings – Annual report year: 2005

NORDTEST Project on Moisture Buffer Value of Materials

Building materials and furnishing used in contact with indoor air have some effect to moderate the variations of indoor humidity in occupied buildings. Very low humidity can be alleviated in winter, as well as can high indoor humidity in summer and during high occupancy loads. Thus, materials can possibly be used as a passive means of establishing indoor climatic conditions, which are comfortable for human occupancy. But so far there has been a lack of a standardized figure to characterize the moisture buffering ability of materials. It has been the objective of a Nordic project, which is currently being completed, to develop a definition, and to declare it in the form of a NORDTEST method. Apart from the definition of the term Moisture Buffer Value, the project also declares a test protocol which expresses how materials should be tested. Finally as a part of the project, some Round Robin Tests have been carried out on various typical building materials. The paper gives an account on the definition of the Moisture Buffer Value, it outlines the content of the test protocol, and it gives some examples of results from the Round Robin Tests.

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics, Norwegian Building Research Institute, Lund University, VTT - Technical Research Centre of Finland
Authors: Rode, C. (Intern), Peuhkuri, R. H. (Intern), Hansen, K. K. (Intern), Time, B. (Ekstern), Svennberg, K. (Ekstern), Arfvidsson, J. (Ekstern), Ojanen, T. (Ekstern)
Pages: 47-52
Publication date: 2005
Requirements of inverted roofs with a drainage layer.
This contribution illustrates the application of the standard EN ISO 6946 regarding the heat loss of an inverted roof for different regions of Europe. An addendum to the standard (EN ISO 6946:1996/A1, 2003) introduces a correction to the thermal transmittance of inverted roofs due to rain water flowing between the insulation and the waterproofing membrane. It is possible to calculate the extra heat loss of inverted roofs caused by rain water below the heat insulation. The extra heat loss depends on the average rainfall and on which fraction of the rain water that will drain between the waterproofing membrane and the thermal insulation. This paper explains the application of the standard for areas of Europe. Furthermore, some constructions are proposed, which have such small extra heat losses caused by rain water that they may be disregarded in the calculation.

Response of insulation materials on non-isothermal moisture transport: Final results

Subtask 1- Modelling principles and common exercises
Summary Report for Common Exercise 1

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern), Peuhkuri, R. H. (Intern)
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Original language: English
Main Research Area: Technical/natural sciences

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Using dynamic moisture loading tests for determination of Moisture Buffer value: Working paper IEA Annex 41 Meeting, Montreal

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences
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Source-ID: 184616
Publication: Research › Report – Annual report year: 2005

Whole Building Heat Simulation With A Multizone Air Flow Model

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Danish Building Research Institute
Authors: Grau, K. (Ekstern), Rode, C. (Intern)
Publication date: 2005

Publication information
Original language: English
Main Research Area: Technical/natural sciences

Bibliographical note
Source: orbit
Source-ID: 185246
Publication: Research › Report – Annual report year: 2005
A Review of Humidity Buffering in the Interior Spaces

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Fraunhofer Gesellschaft
Authors: Rode, C. (Intern), Holm, A. (Ekstern), Padfield, T. (Ekstern)
Pages: 221-226
Publication date: 2004
Main Research Area: Technical/natural sciences

Publication information
Journal: Journal of Thermal Envelope and Building Science
Volume: 27
Issue number: 3
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Original language: English
DOIs:
10.1177/1097196304040543
Source: orbit
Source-ID: 154076
Publication: Research - peer-review › Journal article – Annual report year: 2004

Evaluation of Moisture Buffer Effects by Performing Whole-Building Simulations

The humidity of rooms and the moisture conditions of materials in the enclosure of buildings depend much on each other because of the moisture exchange that takes place over the interior surfaces. These moisture influences also depend strongly on the thermal conditions of indoor spaces and enclosure elements of buildings. In turn, the moisture and humidity conditions have significant impact on how buildings are operated. In hot, humid climates, it may be desirable to keep the ventilation rates low in order to avoid too high indoor humidity, while in cold climates, ventilation can be used to keep the humidity low enough to ensure only a small risk of moisture damage in the building enclosure. In either case, the indoor humidity has a direct or indirect impact on the energy performance of the HVAC system of a building. To analyze this situation, it is today possible to benefit from some recent developments in integrated computational analysis of the hygrothermal performance of whole buildings. Such developments have led to models for whole buildings (the indoor climate, the enclosure, and the systems), which not only predict the thermal performance, such as in contemporary building energy simulation. A growing number of building energy simulation tools have added models for transient moisture migration. The paper gives examples of two such recent developments and will highlight some calculation results that can be obtained. Finally, the paper will mention some further developments and international collaboration for the near future, introducing a proposal recommendation for a common numerical test case.

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State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern), Mendes, N. (Ekstern), K., G. (Ekstern)
Pages: 783-794
Publication date: 2004
Main Research Area: Technical/natural sciences

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Journal: A S H R A E Transactions
Volume: 110
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Scopus rating (2016): CiteScore 0.42 SJR 0.329 SNIP 0.613
Fugtforhold i grønlandske boliger

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 154092
Publication: Communication › Paper – Annual report year: 2004

Introduction to BSIm

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
Publication date: 2004
Main Research Area: Technical/natural sciences

Bibliographical note
Moisture buffer capacity of different insulation materials

There is an increasing focus on the possibilities of utilizing the absorptive ability of porous materials to create passive control of humidity variations in the indoor air. These variations result in peaks in the indoor air humidity due to moisture production, or in the exterior building envelope due to the diurnal variations of outdoor air temperature and humidity. A passive control of the humidity of the indoor air - particularly together with passive thermal control - may lead to smaller energy use for climatization of buildings. For exterior envelopes, the choice of right materials can lead to more durable constructions. In this paper, a large range of very different thermal insulation materials have been tested in specially constructed laboratory facilities to determine their moisture buffer capacity. Both isothermal and nonisothermal experimental set-ups have been used. In the isothermal tests the material samples were exposed to the same change in the relative humidity of the ambient air on both sides, while the samples were exposed to variations in relative humidity only on the cold side in the non-isothermal tests. The results of these rather different measurement principles are discussed, and different ways are presented how to determine the moisture buffer capacity of the materials using partly standard material parameters and partly parameters determined from the actual measurements. The results so far show...
that the determination of moisture buffer capacity is very sensitive to the used analysis method and therefore great care has to be taken when comparing results of different experiments. This paper discusses this issue and will come with a recommendation of a simple and consistent way to present the moisture buffer capacity of the materials in contact with the indoor air on the basis of experimental results.

**General information**
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Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Hansen, K. K. (Intern)
Publication date: 2004

**Host publication information**
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Publisher: American Society of Heating, Refrigerating and Air-Conditioning Engineers
Main Research Area: Technical/natural sciences
Source-ID: 154057
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

**Moisture Buffer Performance of a Fully Furnished Room**
The moisture buffer capacity of hygroscopic materials can be used to moderate the relative humidity of indoor air as well as moisture content variations in building materials and furnishing. Since moisture plays a significant role in the development of many processes that affect the quality of the indoor air, such as growth of house dust mites, emissions from materials and mould growth it is anticipated that the moisture buffer effect can help to ensure healthier indoor environments. The building materials as well as furniture and other furnishing materials exposed to the indoor air will contribute to the moisture buffer capacity of the room. There is few studies made on the impact of furnishing materials in comparison with traditional building materials this paper will present such a study conducted in a full scale climate test cell. A series of experiments have been carried out in a climate test cell to show the moisture buffer performance of various furnishing objects. The objects will be exposed to cyclic humidity variations like in an inhabited indoor environment, and the response of the indoor humidity will be followed over time. It will be a step-by-step investigation starting with an empty room and going towards a fully decorated room. Comparisons are made with previous studies covering traditional building materials and calculations. The study shows that the furnishings have to be included in the understanding of the moisture buffering performance of a room and that more material data in this area is needed.

**General information**
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Lund University
Authors: Svennberg, K. (Ekstern), Hedegaard, L. G. (Ekstern), Rode, C. (Intern)
Publication date: 2004

**Host publication information**
Title of host publication: Performance of the Exterior Envelopes of Whole Buildings IX
Main Research Area: Technical/natural sciences
Conference: Moisture Buffer Performance of a Fully Furnished Room, Clearwater, Florida, 01/01/2004
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Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

**Moisture Transport by Convection in Lightweight Exterior Facades**

**General information**
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Birch & Krogboe A/S
Authors: Gudum, C. (Ekstern), Rode, C. (Intern)
Publication date: 2004

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NORDTEST project: Moisture Buffering of Building Materials

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Authors: Rode, C. (Intern)
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Main Research Area: Technical/natural sciences

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Overraskende resultater fra måling af ydervægges isoleringsevne

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Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Holck, O. (Intern), Rode, C. (Intern)
Pages: 14-19
Publication date: 2004
Main Research Area: Technical/natural sciences

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Journal: H V A C Magasinet
Volume: 40
Issue number: 10
ISSN (Print): 1603-6913
Ratings:
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ISI indexed (2012): ISI indexed no
ISI indexed (2011): ISI indexed no
Original language: Danish
Source: orbit
Source-ID: 154083
Publication: Communication › Journal article – Annual report year: 2004

Varmeisoleringsevne for ydervægge målt i Borup Seniorby

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Teknologisk Institut
Authors: Holck, O. (Intern), Olsen, L. (Ekstern), Rode, C. (Intern)
Publication date: 2004

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Publisher: DTU Byg, Danmarks Tekniske Universitet
ISBN (Print): 87-7877-160-9
Original language: Danish
Series: BYG Rapport
Number: R-095
Main Research Area: Technical/natural sciences
Electronic versions:
Water and Dirt Repellent Treatments for Building Surfaces

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Birch & Krogboe A/S
Authors: Møller, E. (Ekstern), Rode, C. (Intern), Christoffersen, L. D. (Ekstern)
Publication date: 2004

Host publication information
Title of host publication: Performance of Exterior Envelopes of Whole Buildings IX: International Conference
Place of publication: Oak Ridge, TN, USA
Publisher: Oak Ridge National Laboratory
Main Research Area: Technical/natural sciences
Links: http://www.ornl.gov/sci/buildings/
Source: orbit
Source-ID: 154081
Publication: Research - peer-review › Article in proceedings – Annual report year: 2004

Whole Building Heat, Air and Moisture Response. IEA ECBCS Annex 41

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Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
Publication date: 2004
Event: Paper presented at Indeklimaforum, Arbejdsmiljøinstituttet
Main Research Area: Technical/natural sciences

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Presented May 10, 2004
Source: orbit
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Publication: Research › Paper – Annual report year: 2004

Whole-Building Hygrothermal Analysis

General information
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Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (Intern)
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Publication date: 2004

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Title of host publication: Simulationsmethoden bei der Planung von Naubauten und Instandsetzungen
Place of publication: München
Publisher: WTA, Wissenschaftlich-Technische Arbeitsgemeinschaft für Bauwerkserhaltung und Denkmalpflege
Series: WTA-Schriftenreihe
Number: 24
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 154077
Moisture Dynamics in Building Envelopes

The overall scope of this Thesis "Moisture dynamics in building envelopes" has been to characterise how the various porous insulation materials investigated performed hygrothermally under conditions similar to those in a typical building envelope. As a result of the changing temperature and moisture conditions in the exterior weather and indoor climate the materials dynamically absorb and release moisture. The complexity of the impact of these conditions on the resulting moisture transport and content of the materials has been studied in this Thesis with controlled laboratory tests. The first part of the Thesis consists of a theory and literature review on the moisture storage and transport processes (Chapter 2), on the non-Fickian moisture transport (Chapter 3) and on the methods for determining the moisture properties (Chapter 4). In the second part, the conducted experimental work, results, and analysis are presented (Chapters 5-7). The major findings are discussed (Chapter 8), before the final conclusion (Chapter 9). The Appendices include the material parameters used, some additional results and the description of the simulation models.

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services, Section for Construction Materials
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Hansen, K. K. (Intern)
Number of pages: 243
Publication date: Oct 2003

Publication information
ISBN (Print): 87-7877-133-1
Original language: English
Series: BYG-Rapport
Number: R-071
Main Research Area: Technical/natural sciences
Electronic versions:
byg-r071app.pdf
byg-r071.pdf
Source: orbit
Source-ID: 60977
Publication: Research › Ph.D. thesis – Annual report year: 2003

Moisture transport and convection in building envelopes

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Gudum, C. (Intern), Rode, C. (Intern)
Publication date: Feb 2003

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
ISBN (Print): 87-7877-107-2
Original language: English
Series: BYG Rapport
Number: R-047
Main Research Area: Technical/natural sciences
Electronic versions:
Gudum_Appendix.pdf
gudum.pdf
Source: orbit
Source-ID: 274633
Publication: Research › Ph.D. thesis – Annual report year: 2003

A Procedure to Determine the Design Value of Thermal Conductivity of Thermal Insulation Materials

General information
Comparison of Experimental Methods for the Measurement of Non-Isothermal Moisture Transport

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Hansen, K. K. (Intern), Kelly, D. (Ekstern), Baker, P. (Ekstern), Galbraith, G. (Ekstern), McLean, R. (Ekstern)
Publication date: 2003

Host publication information
Title of host publication: Proceedings of the 2nd Int. Building Physics Conference
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 23795
Publication: Research - peer-review › Article in proceedings – Annual report year: 2003

Fugtfordeling i absorberende isoleringsmaterialer: Moisture distribution in absorbent insulation

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Construction Materials
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Padfield, T. (Ekstern), Hansen, K. K. (Intern), Mortensen, L. H. (Intern)
Publication date: 2003

Publication information
Original language: Danish
Series: BYG Sagsrapport
Number: SR 03-11
Main Research Area: Technical/natural sciences
Electronic versions: SR-03-11.pdf
Source: orbit
Source-ID: 190467
Publication: Research › Report – Annual report year: 2003

Fugtfordeling i absorberende isoleringsmaterialer: Moisture distribution in absorbent insulation

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Building Materials and Geotechnics
Authors: Peuhkuri, R. H. (Intern), Rode, C. (Intern), Padfield, T. (Ekstern), Hansen, K. K. (Intern), Hedegaard, L. G. (Intern)
Number of pages: 53
Publication date: 2003
integrated hygrothermal analysis of ecological buildings

general information
state: published
organisations: department of civil engineering, vtt - technical research centre of finland, university of saskatchewan, danish building and urban research
authors: rode, c. (intern), salonvaara, m. (externe), ojanen, t. (externe), simonson, c. (externe), grau, k. (externe)
pagination: 61
publication date: 2003
main research area: technical/natural sciences

hele bygninger

general information
state: published
organisations: department of civil engineering
authors: rode, c. (intern)
pagination: 30-33
publication date: 2003
main research area: technical/natural sciences

komplet beregning af bygnings varme- og fugttekniske forhold

general information
state: published
organisations: department of civil engineering, by og byg
authors: rode, c. (intern), grau, k. (externe)
pagination: 30-33
publication date: 2003
main research area: technical/natural sciences

Methods to design and predict moisture levels in buildings

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
Publication date: 2003
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61085
Publication: Communication › Paper – Annual report year: 2003

Modellering af fugtforhold i "hele" bygninger

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Rode, C. (Intern)
Publication date: 2003
Event: Paper presented at Indeklimaforum '03, Arbejdsmiljøinstituttet, .
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 61084
Publication: Communication › Paper – Annual report year: 2003

The Use of Spreadsheets to Calculate Water Vapour Diffusion According to the Glaser Method

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics
Authors: Rode, C. (Intern)
Number of pages: 11
Publication date: 2003

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
Spreadsheets_281003.pdf
Source: PublicationPreSubmission
Source-ID: 127863545
Publication: Communication › Report – Annual report year: 2003

Whole-building Hygrothermal Simulation Model

An existing integrated simulation tool for dynamic thermal simulation of building was extended with a transient model for moisture release and uptake in building materials. Validation of the new model was begun with comparison against measurements in an outdoor test cell furnished with single materials. Almost quasi-steady, cyclic experiments were used to compare the indoor humidity variation and the numerical results of the integrated simulation tool with the new moisture model. Except for the case with chipboard as furnishing, the predictions of indoor humidity with the detailed model were in good agreement with the measured values.

General information
State: Published
Organisations: Department of Civil Engineering, Danish Building and Urban research
Workshop on moisture buffer capacity
Summary report of a Nordtest workshop on moisture buffer capacity held at Copenhagen August 21-22 2003

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (ed.) (Intern)
Publication date: 2003
Workshop on Moisture Buffer Capacity - Summary Report

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering
Authors: Rode, C. (ed.) (Intern)
Publication date: 2003

Application of a Computer Model for Integrated Hygrothermal Building Analysis

General information
State: Published
Organisations: Department of Civil Engineering, Danish Building and Urban research, Birch & Krogboe A/S
Authors: Rode, C. (Intern), Grau, K. (Ekstern), Sørensen, L. C. (Ekstern), Christoffersen, L. D. (Ekstern)
Pages: 652-660
Publication date: 2002

Integrated Calculation of Hygrothermal Conditions of Buildings

General information
State: Published
Organisations: Department of Civil Engineering, Danish Building and Urban research
Non-isothermal water vapour transmission through porous insulation. Part 2

General information
State: Published
Organisations: Department of Civil Engineering, Technical University of Denmark
Authors: Peuhkuri, R. H. (Intern), Padfield, T. (Ekstern), Rode, C. (Intern), Hansen, K. K. (Intern)
Number of pages: 920
Pages: 421-428
Publication date: 2002

Host publication information
Title of host publication: Building Physics in the Nordic Countries
Volume: Volume 1
Place of publication: Trondheim, Norway
Publisher: Norwegian University of Science and Technology
ISBN (Print): 82-91412-02-2
Main Research Area: Technical/natural sciences
Conference: 6th Symposium on Building Physics in Nordic Countries, Trondheim, Norway, 17/06/2002 - 17/06/2002
Source: orbit
Source-ID: 64023
Publication: Research - peer-review › Article in proceedings – Annual report year: 2002

Ny metode til modellering af fugt i bygninger

General information
State: Published
Organisations: Department of Civil Engineering, Section for Building Physics and Services
Authors: Rode, C. (Intern)
Publication date: 2002
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 90461
Publication: Communication › Paper – Annual report year: 2002

Simulation of Whole-Building Hygrothermal Conditions

General information
State: Published
Organisations: Department of Civil Engineering, Danish Building and Urban research
Authors: Grau, K. (Ekstern), Rode, C. (Intern)
Publication date: 2002

Host publication information
Title of host publication: ROOMVENT : International Conference on Air Distribution in Rooms
Publisher: DANVAK - Danish Society of Heating, Ventilating and Air-Conditioning Engineers
Main Research Area: Technical/natural sciences
Conference: ROOMVENT : International Conference on Air Distribution in Rooms, Copenhagen, 01/01/2002
Source: orbit
Source-ID: 64297
Publication: Research › Article in proceedings – Annual report year: 2002

Test Cell Measurements of Moisture Buffer Effects

General information
State: Published
Organisations: Department of Civil Engineering, Tohoku University, National Museum of Denmark
Authors: Rode, C. (Intern), Mitamura, T. (Ekstern), Schultz, J. M. (Intern), Padfield, T. (Ekstern)
Pages: 619-626
Publication date: 2002
Modelling and Experimental Investigation of indoor humidity levels

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Rode, C. (Intern)
Publication date: 2001
Main Research Area: Technical/natural sciences

Bibliographical note
March 20, 2001
Source: orbit
Source-ID: 90465
Publication: Research › Paper – Annual report year: 2001

Omfang af og risici for fugt og skimmel i konstruktioner og materialer - beregningsmetoder

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Rode, C. (Intern)
Publication date: 2001
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 64323
Publication: Communication › Paper – Annual report year: 2001

Omfang af og risiko for fugt og skimmel i konstruktioner og materialer: beregningsmetoder

General information
State: Published
Organisations: Department of Civil Engineering, Section for Indoor Climate and Building Physics
Authors: Rode, C. (Intern)
Number of pages: 29
Publication date: 2001

Publication information
Media of output: Powerpoint
Original language: English
Main Research Area: Technical/natural sciences
Electronic versions:
DANVAK_Carsten_Rode.pdf
Publication: Research › 2D/3D (physical products) – Annual report year: 2001

Procedure for Determining the Design Value of the Thermal Conductivity of Thermal Insulation Materials

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Rudbeck, C. C. (Intern), Rode, C. (Intern)
Publication date: 2001

Publication information
Publisher: Technical University of Denmark, Department of Civil Engineering
Original language: English
Series: BYG Sagsrapport
Number: SR 01-02
Main Research Area: Technical/natural sciences
Udstyr til undersøgelse af fugtfordeling i absorberende isoleringsmaterialer

General information
State: Published
Organisations: Department of Civil Engineering, National Museum of Denmark, Danish Building and Urban research
Authors: Padfield, T. (Ekstern), Rode, C. (Intern), Nicolajsen, A. (Ekstern), Hansen, K. K. (Intern)
Publication date: 2001

Publication information
Publisher: Department of Buildings and Energy, Technical University of Denmark
Original language: Danish
Series: SR
Number: 0028
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 64325
Publication: Research - peer-review › Report – Annual report year: 2001

Whole Building Hygrothermal Modelling

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Rode, C. (Intern)
Publication date: 2001
Event: Paper presented at CEN TC89 WG10 WI29.3 meeting, Chalmers University of Technolg, Gothenburg, Sweden,
Main Research Area: Technical/natural sciences

Bibliographical note
June 18-19, 2001
Source: orbit
Source-ID: 90464
Publication: Research › Paper – Annual report year: 2001

Egenkonvektion i fåreuld og papirisolering

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Kristiansen, F. H. (Intern), Rode, C. (Intern)
Publication date: 2000

Publication information
Publisher: DTU Byg, Danmarks Tekniske Universitet
Original language: Danish
Series: BYG Sagsrapport
Number: SR 00-05
Main Research Area: Technical/natural sciences
Electronic versions:
ie-SR0005.pdf
Source: orbit
Source-ID: 190307
Termisk bygningssimulering

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (ed.) (Intern)
Number of pages: 108
Publication date: 2000

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175331
Publication: Research › Report – Annual report year: 2000

Transient Heat Conduction

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 25
Publication date: 2000

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175328
Publication: Research › Peer-review › Book – Annual report year: 2000

Varmeledningsevne ved forskellige fugtforhold

General information
State: Published
Organisations: Department of Civil Engineering
Authors: Kristiansen, F. H. (Intern), Rode, C. (Intern)
Publication date: 2000

Publication information
Publisher: DTU Byg, Danmarks Tekniske Universitet
Original language: Danish
Series: BYG Sagsrapport
Number: SR 00-04
Main Research Area: Technical/natural sciences
Electronic versions:
ibe-SR0004.pdf
Source: orbit
Source-ID: 190306
Publication: Research › Report – Annual report year: 2000

Beregne fugtforhold i konstruktioner: Del af "Varme- og fugttekniske undersøgelser af alternative isoleringsmaterialer"

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern), Rasmussen, N. T. (Ekstern)
Number of pages: 41
Publication date: Dec 1999
Kommentarer og supplement til DS 418

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern), Saxhof, B. (Intern)
Number of pages: 30
Publication date: 1999

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175325
Publication: Research - peer-review › Book – Annual report year: 1999

Natural convection in sheep's wool and paper insulation: Part of technical heat and moisture investigations of alternative insulation materials

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Kristiansen, F. H. (Intern), Rode, C. (Intern)
Number of pages: 29
Publication date: 1999

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 174763
Publication: Research - peer-review › Report – Annual report year: 1999

Rammeprogram for forskning, udvikling, demonstration og information. Opfølgning af Energi 21 på området: Energibesparelser i den eksisterende bygningsmasse.: Status august/september 1999

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 40
Publication date: 1999

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Links: http://www.efp-bygninger.dk/
Source: orbit
Source-ID: 173918
Publication: Research - peer-review › Report – Annual report year: 1999

Stråling

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Thermal conductivity at different humidity conditions: Part of technical heat and moisture investigation of alternative insulation materials

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Kristiansen, F. H. (Intern), Rode, C. (Intern)
Number of pages: 24
Publication date: 1999

Transient Heat Conduction

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 25
Publication date: 1999

Varmetransmission ved ledning

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern), Gudum, C. (Intern)
Number of pages: 22
Publication date: 1999

Energiforbrug i den eksisterende bygningsmasse

General information
State: Published
Latent Heat Flow in Light Weight Roofs and its Influence on the Thermal Performance

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern), Rudbeck, C. C. (Intern)
Pages: 930-940
Publication date: 1998
Main Research Area: Technical/natural sciences

Publication information
Journal: A S H R A E Transactions
Volume: 104
Issue number: 2
ISSN (Print): 0001-2505
Ratings:
BFI (2018): BFI-level 1
BFI (2017): BFI-level 1
BFI (2016): BFI-level 1
Scopus rating (2016): CiteScore 0.42 SJR 0.329 SNIP 0.613
BFI (2015): BFI-level 1
Scopus rating (2015): SJR 0.408 SNIP 0.583 CiteScore 0.36
BFI (2014): BFI-level 1
Scopus rating (2014): SJR 0.359 SNIP 0.408 CiteScore 0.32
BFI (2013): BFI-level 1
Scopus rating (2013): SJR 0.417 SNIP 0.44 CiteScore 0.32
ISI indexed (2013): ISI indexed no
BFI (2012): BFI-level 1
Scopus rating (2012): SJR 0.413 SNIP 0.73 CiteScore 0.29
ISI indexed (2012): ISI indexed no
BFI (2011): BFI-level 1
Scopus rating (2011): SJR 0.391 SNIP 0.881 CiteScore 0.35
ISI indexed (2011): ISI indexed no
BFI (2010): BFI-level 1
Scopus rating (2010): SJR 0.48 SNIP 0.661
BFI (2009): BFI-level 1
Scopus rating (2009): SJR 0.663 SNIP 0.728
BFI (2008): BFI-level 1
Scopus rating (2008): SJR 0.528 SNIP 0.562
Scopus rating (2007): SJR 0.551 SNIP 0.793
Scopus rating (2006): SJR 0.406 SNIP 0.702
Scopus rating (2005): SJR 0.472 SNIP 0.822
Scopus rating (2004): SJR 0.419 SNIP 0.753
Scopus rating (2003): SJR 0.456 SNIP 0.678
Scopus rating (2002): SJR 0.439 SNIP 0.672
Scopus rating (2001): SJR 0.516
Scopus rating (2000): SJR 0.353
Scopus rating (1999): SJR 0.213
Original language: English
Source: orbit
Multidimensional Heat Conduction: Undervisningsnotat

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 16
Publication date: 1998

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170000
Publication: Research - peer-review › Book – Annual report year: 1998

Opfølgning af Energi 21 på området: Energibesparelser i den eksisterende bygningsmasse: Rammeprogram for forskning, udvikling, demonstration og information.

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern), Engelmark, J. (Intern)
Publication date: 1998

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 170015
Publication: Research - peer-review › Report – Annual report year: 1998

Organic Insulation Materials, the Effect on Indoor Humidity, and the Necessity of a Vapor Barrier

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Pages: 109-121
Publication date: 1998

Host publication information
Title of host publication: Proceedings, Thermal Performance of the Exterior Envelope of Buildings VII
Place of publication: Atlanta, GA, USA
Publisher: American Society of Heating, Refrigerating and Air-Conditioning Engineers
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169386
Publication: Research - peer-review › Article in proceedings – Annual report year: 1998

Termisk bygningssimulering

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (ed.) (Intern)
Number of pages: 70
Publication date: 1998
**Publication information**
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175312
Publication: Research - peer-review › Book – Annual report year: 1998

**Transient Heat Conduction: Undervisningsnotat**

**General information**
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 20
Publication date: 1998

**Publication information**
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169998
Publication: Research - peer-review › Book – Annual report year: 1998

**Udeklima og vejrdata**

**General information**
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 6
Publication date: 1998

**Publication information**
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175314
Publication: Research - peer-review › Book – Annual report year: 1998

**Varmetransport ved konvektion**

**General information**
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 31
Publication date: 1998

**Publication information**
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175313
Publication: Research - peer-review › Book – Annual report year: 1998

**Eine wasserdurchlässige Dampfbremse als Hygrodiode**

**General information**
State: Published
Organisations: Department of Buildings and Energy, Bauphysik
Authors: Sagelsdorff, R. (Ekstern), Rode, C. (Intern)
Pages: 703-706
Publication date: 1997
Main Research Area: Technical/natural sciences

Elektriske apparater

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 6
Publication date: 1997

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175316
Publication: Research - peer-review › Book – Annual report year: 1997

Finite Difference Approximations to Derivatives

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 4
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169185
Publication: Research - peer-review › Book – Annual report year: 1997

Grundkursus i Bygningsenergiteknik: Undervisningsnotat

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (ed.) (Intern)
Publication date: 1997

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169353
Publication: Research - peer-review › Book – Annual report year: 1997

Numerical Integration, Simpson's Formula

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
The Explicit and Implicit Numerical Methods for Steady State and Transient, 2-D Heat Conduction

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 12
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169186
Publication: Research - peer-review › Book – Annual report year: 1997

The Explicit and Implicit Numerical Methods for Calculating Transient, 1-D Heat Conduction

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 9
Publication date: 1997

Publication information
Original language: English
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 169184
Publication: Research - peer-review › Book – Annual report year: 1997

Varmetransmission

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern), Gudum, C. (Intern)
Number of pages: 3
Publication date: 1997

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 175315
Publication: Research - peer-review › Book – Annual report year: 1997

Extra Heat Loss Through Light Weight Roofs Due to Latent Heat

General information
State: Published
Organisations: Department of Buildings and Energy
Fugt II.

General information
State: Published
Organisations: Department of Buildings and Energy, Narvik University College
Authors: Nielsen, A. F. (Ekstern), Rode, C. (ed.) (Intern)
Number of pages: 26
Publication date: 1996

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Moisture sources, Moisture retention, Drying, Capillary suction, Convection, Surface condensation
Source: orbit
Source-ID: 165519
Publication: Research - peer-review › Book – Annual report year: 1996

Opstilling af regneark til beregning af fugtdiffusion efter Glasers metode

General information
State: Published
Organisations: Department of Buildings and Energy
Authors: Rode, C. (Intern)
Number of pages: 10
Publication date: 1996

Publication information
Original language: Danish
Main Research Area: Technical/natural sciences
Source: orbit
Source-ID: 165520
Publication: Research - peer-review › Book – Annual report year: 1996

Combined heat and moisture transfer in building constructions

General information
State: Published
Organisations: Section for Building Physics and Services, Department of Civil Engineering, Section for Construction Materials, Technical University of Denmark
Authors: Rode, C. (Intern), Hansen, P. N. (Ekstern), Hansen, K. K. (Intern)
Publication date: 1990

Publication information
Place of publication: Kgs. Lyngby, Denmark
Publisher: Technical University of Denmark (DTU)
Original language: English
Series: BYG Rapport
Projects:

**Synthesis, characterization and application of composite phase change humidity control materials**

Department of Civil Engineering  
Period: 01/01/2018 → 31/12/2020  
Number of participants: 3  
Phd Student: Feng, Xiaoxiao (Intern)  
Supervisor: Rode, Carsten (Intern)  
Main Supervisor: Qin, Menghao (Intern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Institut stipendie (DTU)  
Project: PhD

**Tools for Reliable Energy Performance Characterisation of Buildings**

Department of Applied Mathematics and Computer Science  
Period: 01/01/2017 → 31/12/2019  
Number of participants: 3  
Phd Student: Rasmussen, Christoffer (Intern)  
Supervisor: Rode, Carsten (Intern)  
Main Supervisor: Madsen, Henrik (Intern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Samfinansieret - Andet  
Project: PhD

**Building clusters and their impact on flexibility when including the prosumer aspect**

Department of Civil Engineering  
Period: 01/10/2016 → 30/09/2019  
Number of participants: 5  
Phd Student: Larma, Marijana (Intern)  
Supervisor: Heller, Alfred (Intern)  
Li, Rongling (Intern)  
Pedersen, Allan Schrøder (Intern)  
Main Supervisor: Rode, Carsten (Intern)  

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: Forskningsrådsfinansiering
Implementation of flexible operational schemes for buildings in a district with smart energy systems

Department of Civil Engineering
Period: 01/11/2015 → 31/10/2018
Number of participants: 4
Phd Student:
Luc, Katarzyna Marta (Intern)
Supervisor:
Andersen, Rune Korsholm (Intern)
Rode, Carsten (Intern)
Main Supervisor:
Heller, Alfred (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

Models for flexible operation of buildings in district energy system Nordhavn

Department of Civil Engineering
Section for Indoor Climate and Building Physics
Section for Building Energy
Period: 15/09/2015 → …
Number of participants: 3
Phd Student:
Foteinaki, Kyriaki (Intern)
Supervisor:
Heller, Alfred (Intern)
Main Supervisor:
Rode, Carsten (Intern)

Relations
Parent project:
EnergyLab Nordhavn - New Urban Energy Infrastructures
Project

Models for flexible operation of buildings in district energy system Nordhavn

Department of Civil Engineering
Period: 15/09/2015 → 14/09/2018
Number of participants: 4
Phd Student:
Foteinaki, Kyriaki (Intern)
Supervisor:
Andersen, Rune Korsholm (Intern)
Heller, Alfred (Intern)
Main Supervisor:
Rode, Carsten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

EnergyLab Nordhavn - New Urban Energy Infrastructures
Department of Electrical Engineering
Performance analysis of heat pumps utilizing different low temperature heat sources to supply district heating
Efficient Control of Active Transformers for Increasing the PV Hosting Capacity of LV Grids
Optimal Design of DC Fast-Charging Stations for EVs in Low Voltage Grids
Cost-Benefit Analysis of a Novel DC Fast-Charging Station with a Local Battery Storage for EVs
Active and reactive power support of MV distribution systems using battery energy storage
Efficient Control of Energy Storage for Increasing the PV Hosting Capacity of LV Grids
Optimal usage of low temperature heat sources to supply district heating by heat pumps
DC Fast-Charging Stations for EVs Controlled by a Local Battery Storage in Low Voltage Grids
Methods and Strategies for Overvoltage Prevention in Low Voltage Distribution Systems with PV

Assessment and Optimization Methods for Implementation of Energy Strategies in Communities
Department of Civil Engineering
Period: 15/02/2015 → 17/03/2018
Number of participants: 4
PhD Student:
Petersen, Jens-Phillip (Intern)
Supervisor:
Heller, Alfred (Intern)
Kolarik, Jakub (Intern)
Main Supervisor:
Rode, Carsten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD

RIBuild
RIBuild will strengthen the knowledge on how and under what conditions internal thermal insulation is to be implemented in historic buildings, without compromising their architectural and cultural values, with an acceptable safety level against deterioration and collapse of heavy external wall structures. The general objective of RIBuild is to develop effective, comprehensive decision guidelines to optimise the design and implementation of internal thermal insulation in historic buildings across the EU. RIBuild focuses on heavy external walls made of stone, brick and timber framing, as most historic buildings are made of these materials. The general objective is achieved through three main activities:

• To obtain a thorough knowledge level to characterise the eligibility of the building for a deep internal thermal insulation renovation. This knowledge is obtained through screening of historic buildings, investigation of material properties and threshold values for failure
• To determine the conditions under which different internal insulation measures are reliable and affordable measures based on probabilistic modelling of the hygrothermal performance, the environmental impact and the cost/benefit
• To develop a set of comprehensive decision guidelines, which are demonstrated in a number of buildings. RIBuild addresses the most difficult retrofitting measure of historic buildings: internal thermal insulation. The adoption of knowledge developed by RIBuild contributes to sustainable historic buildings with improved energy efficiency implying an easier conversion of energy supply from inefficient fossil fuels to efficient renewable energy sources. RIBuild also assesses the hygrothermal performance of the building construction, thus no collateral damage occurs; in case of failure an easy roll back of the measures is possible. The guidelines developed in RIBuild strongly support the deep and holistic retrofitting approach which historic buildings face in the coming years

Work packages
The RIBuild research programme is divided into eight inter-correlated work packages (WPs). For a short description of each work package, please see the following.

WP1: Pre-renovation assessment
Examines common structural elements of historic buildings, determines their physical properties and classifies them according to type. The objective is to observe and describe the main symptoms of a deteriorating building envelope and study their possible causes.

WP leader: RTU
Participants: AAU, TUD, KUL, UNIVPM, DTU, SP, HES-SO

WP2: Material characterisation
Provides data for material properties and threshold values for historic building materials and existing insulation materials
as a background for material characterisation models and guidelines for safe retrofitting measures.

WP leader: AAU
Participants: RTU, TUD, KUL, UNIVPM, DTU, SP, HES-SO, INTROFLEX

WP3: Case studies and laboratory measurements
Supports the research with high quality measurement data from both laboratory experiments on components and on-site monitoring of test buildings.

WP leader: TUD
Participants: AAU, RTU, KUL, UNIVPM, DTU, SP, INTROFLEX

WP4: Probabilistic assessment of internal insulation solutions
Develops an efficient strategy for the probabilistic hygrothermal assessment of internal solutions.

WP leader: KUL
Participants: AAU, TUD, HES-SO

WP5: Development of cost/benefit analysis and environmental impact assessment methodologies
Develops a probabilistic assessment methodology for assessing the environmental impact and cost/benefit of internal insulation solutions. The methodologies are based on Life Cycle Impact Assessment (LCA), Life Cycle Cost (LCC) and Cost-Optimal (CO) analysis.

WP Leader: UNIVPM
Participants: AAU, RTU, DTU, HES-SO

WP6: Application and evaluation of guidelines
Develops and assesses the methodology for internal insulation of historic buildings, based on the methodologies developed in WP4 and WP5.

WP Leader: DTU
Participants: AAU, RTU, TUD, KUL, UNIVPM, SP, HES-SO, INTROFLEX, EMA

WP7: Communication and dissemination
Coordinates the overall communication and network partners of RIBuild.

WP Leader: AAU
Participants: RTU, TUD, KUL, UNIVPM, DTU, SP, HES-SO, INTROFLEX, EMA

WP8: Project management
WP 8 is in charge of the overall management of RIBuild.

WP leader: AAU

Department of Civil Engineering
Section for Building Design
Section for Indoor Climate and Building Physics

Campus Service
Period: 01/01/2015 → 31/12/2019
Number of participants: 5
Internal insulation
Project ID: RIBuild
Project participant:
Hansen, Tessa Kvist (Intern)
Rode, Carsten (Intern)
Perkov, Thomas Holmer (Intern)
Nielsen, Ole Christian Kongsgaard (Intern)
Project Manager, academic:
Bjarløv, Søren Peter (Intern)

Relations
Related projects:
Hygrothermal performance of internal insulation in historic buildings
Interior insulation of buildings from 1850 to 1930 with massive external masonry walls and embedded wooden beam floor structure

Activities:

**TEMAKØDE FOR ANVENDELSE AF INVNEDIG EFTERISOLERING**
**PROJEKTKONFERENCE**

Documents:

Annex 1 - Description of the action (part A)
Annex 1 - Description Of Action (part B)

Timing of the different work packages

Project

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**Buildings for Smart Energy Cities**

Centre for IT-Intelligent Energy Systems in Cities
Department of Civil Engineering
Section for Indoor Climate and Building Physics
Department of Management Engineering
Systems Analysis
DTU Climate Centre
Energy Systems Analysis

Section for Building Energy
**Period:** 15/09/2014 → 15/09/2017
Number of participants: 4
Phd Student:
Gianniou, Panagiota (Intern)
Supervisor:
Nielsen, Per Sieverts (Intern)
Heller, Alfred (Intern)
Main Supervisor:
Rode, Carsten (Intern)

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**Buildings for Smart Energy Cities**

Department of Civil Engineering
**Period:** 15/09/2014 → 31/01/2018
Number of participants: 7
Phd Student:
Gianniou, Panagiota (Intern)
Supervisor:
Heller, Alfred (Intern)
Nielsen, Per Sieverts (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Kolarik, Jakub (Intern)
Hensen, Jan (Intern)
Jensen, Søren Østergaard (Ekstern)

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**Financing sources**
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD
A wide range of research activities have arisen to support the Danish target of a 100% renewable energy system by 2050. Projects focused on individual aspects of the energy system, such as zero emissions buildings or intelligent power systems provide valuable insight, that facilitates flexibility throughout the energy system. CITIES will address this deficiency by establishing an integrated research centre covering all aspects of the energy system, including gas, power, district heating/cooling and biomass, and most importantly methods to forecast, control and optimize their interactions through the use of advanced ICT solutions.

The high densities of population, energy consumption, and energy and communications networks in cities offer the greatest potential for flexibility at the last cost, and the fact that cities account for 80% of global energy consumption and emissions [1] make the urban environment an ideal setting for energy systems integration research. CITIES will pioneer research into fully integrated city energy systems, building short-term operational models that feed longer term planning models, considering the spatiotemporal variations, interactions, dynamics and stochastics in the energy system. Low level models of system components will inform higher-level aggregate models employed in market and control framework design. The leading position of European academia and industry and the rapidly growing market for smart energy solutions indicates substantial scope for increased competitiveness and job creation within this field. CITIES will, in collaboration with its industrial and academic partners, conduct research with a view to developing tools for the implementation of integrated energy system solutions.

Center granted by Strategic Research Council.
Executive Development Programme with Technical University of Denmark
The 40th International IAEE Conference
Big Data as a tool for controlling the cities energy: Data aspects and data management
30th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems
3rd International Workshop on Design in Civil and Environmental Engineering
Status and Results of Energy Supply Modelling in CITIES: Illustrated using Data from the Case of Sønderborg
CITIES Annual Conference
Publications:
Model Identification for Control of Display Units in Supermarket Refrigeration Systems

Interior insulation of buildings from 1850 to 1930 with massive external masonry walls and embedded wooden beam floor structure

Department of Civil Engineering
Period: 15/12/2013 → 05/02/2018
Number of participants: 10
Phd Student:
Odgaard, Tommy Riviere (Intern)
Supervisor:
Brendstrup, Jens (Ekstern)
Rasmussen, Merete Hjorth (Ekstern)
Rode, Carsten (Intern)
Thorsen, Peter Schjermann (Ekstern)
Vesterløkke, Michael (Ekstern)
Main Supervisor:
Bjarløv, Søren Peter (Intern)
Examiner:
Svendsen, Svend (Intern)
Hansen, Ernst Jan De Place (Intern)
Harderup, Lars-Erik (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Industrial PhD
Project: PhD

Developing semi-empirical models for predicting climate inside electronic device enclosures

Department of Mechanical Engineering
Period: 15/10/2013 → 22/07/2017
Number of participants: 8
Phd Student:
Staliulionis, Zygimantas (Intern)
Supervisor:
Ambat, Rajan (Intern)
Jellesen, Morten Stendahl (Intern)
Mohanty, Sankhya (Intern)
Main Supervisor:
Hattel, Jesper Henri (Intern)
Examiner:
Rode, Carsten (Intern)
Park, Seungbae (Ekstern)
Tamulevicius, Sigitas (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Samfinansieret - Andet
Project: PhD
IEA EBC Annex 63 - Implementation of Energy Strategies in Communities

The outcomes from previously completed projects on energy optimization at a community scale showed that the transformation of approaches suitable for buildings to communities needs more than simply an up-scaling of individual building solutions. This newly approved project will therefore focus on development of standards for implementation of optimized energy strategies at the scale of communities. The project objectives will be

- Development of a methodology for the effective translation of a city's energy / CO2 reduction goals to the community scale
- Optimization of policy instruments for the integration of energy / CO2 reduction goals into ordinary urban planning,
- Development of new techniques for stakeholder cooperation along with holistic business models, and
- Creation of methods for the monitoring and evaluation of both energy-related criteria, as well as the effectiveness of policy instruments.

The target audiences will primarily be government and urban decision makers and urban planning departments.

Participants: Austria, Belgium, Canada, Denmark, France, Ireland, Japan, the Netherlands, Switzerland, USA

Centre for IT-Intelligent Energy Systems in Cities
Department of Civil Engineering

Section for Building Energy
Period: 01/06/2013 → 01/06/2018
Number of participants: 3
Project participant:
Heller, Alfred (Intern)
Petersen, Jens-Phillip (Intern)
Rode, Carsten (Intern)

Project Resistance and susceptibility of the building envelope to fungal growth

Department of Systems Biology
Period: 01/04/2013 → 15/02/2017
Number of participants: 8
Phd Student:
Lewinska, Anna Malgorzata (Intern)
Supervisor:
Hoof, Jakob Blæsbjerg (Intern)
Peuhkuri, Ruut Hannele (Intern)
Rode, Carsten (Intern)
Main Supervisor:
Andersen, Birgitte (Intern)
Examiner:
Frisvad, Jens Christian (Intern)
Adan, Olaf C. G. (Ekstern)
Jensen, Bo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Eksternt finansieret virksomhed
Project: PhD

Hygro-thermal conditions and pollutant emissions from zero waste materials and their effects on humans

Department of Civil Engineering
Period: 01/01/2013 → 31/07/2017
Number of participants: 8
Phd Student:
Krejcirikova, Barbora (Intern)
Innovative Insulation Materials with Hygric Properties
Department of Civil Engineering
Period: 01/11/2012 → 28/02/2014
Number of participants: 3
PhD Student:
Juhl, Lasse (Intern)
Supervisor:
Heller, Alfred (Intern)
Main Supervisor:
Rode, Carsten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Skimmelsvampe i Grønland
Department of Systems Biology
Center for Microbial Biotechnology
Department of Civil Engineering
Section for Building Physics and Services
Period: 29/07/2012 → 04/08/2012
Number of participants: 2
Project participant:
Andersen, Birgitte (Intern)
Rode, Carsten (Intern)

Energirenovering af Etagebyggerier med vidtgående Energibesparelser
Department of Civil Engineering
Period: 01/11/2011 → 19/03/2015
Number of participants: 5
PhD Student:
Harrestrup, Maria (Intern)
Main Supervisor:
Svendsen, Svend (Intern)
Examiner:
Rode, Carsten (Intern)
Björk, Folke (Ekstern)
Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Climate Change and its Impact on Lifetime and Maintenance of Buildings
Department of Civil Engineering
Period: 15/08/2011 → 09/12/2015
Number of participants: 6
Phd Student:
Cox, Rimante Andrasjunaite (Intern)
Supervisor:
Nielsen, Susanne Balslev (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Heller, Alfred (Intern)
Jones, Keith (Ekstern)
Kalagasidis, Angela Sasic (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

Betingelser for skimmelsvampevækst på byggematerialer
Department of Systems Biology
Center for Microbial Biotechnology
Department of Civil Engineering
Section for Building Physics and Services
Period: 04/04/2011 → …
Number of participants: 4
Project participant:
Andersen, Birgitte (Intern)
Møller, Eva B. (Intern)
Rode, Carsten (Intern)
Peuhkuri, Ruut Hannele (Intern)

Helhedsorienteret energirenovering
Section for Building Design
Department of Civil Engineering
ALECTIA A/S
BSAA Architects
Period: 01/01/2011 → 31/12/2013
Number of participants: 6
Project participant:
Bjarlev, Søren Peter (Intern)
Rode, Carsten (Intern)
Eriksen, Marlene Stenberg Hagen (Intern)
Løgberg, Ejvind (Ekstern)
Simonsen, Gert (Ekstern)
Project Manager, organisational:
Stang, Birgitte Friis Dela (Ekstern)

Project

Bæredygtighed ved renovering af eksisterende byggeri

Department of Civil Engineering
Period: 01/11/2010 → 04/07/2016
Number of participants: 6
Phd Student:
Eriksen, Marlene Stenberg Hagen (Intern)
Supervisor:
Bjarløv, Søren Peter (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Jensen, Lotte Bjerregaard (Intern)
Hansen, Hanne Tine Ring (Ekstern)
Thuvander, Liane (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Energy use and indoor environment in new and exiting dwellings in arctic climates

Department of Civil Engineering
Period: 01/11/2010 → 24/04/2014
Number of participants: 7
Phd Student:
Kotol, Martin (Intern)
Supervisor:
Clausen, Geo (Intern)
Nielsen, Toke Rammer (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Svendsen, Svend (Intern)
Nielsen, Anker Frank (Ekstern)
Simonson, Carey (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD

Climate change and its impact on lifetime and maintenance of buildings

Department of Civil Engineering
Period: 01/09/2010 → 30/11/2010
Number of participants: 3
Phd Student:
Hørmann, Philip (Intern)
Supervisor:
Nielsen, Susanne Balslev (Intern)
Main Supervisor:
Rode, Carsten (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: 1/3 FUU, 1/3 inst 1/3 Andet
Project: PhD

**Durability of buildings and energy renovation**

Department of Civil Engineering
Period: 01/07/2010 → 26/08/2014
Number of participants: 5
Phd Student:
Lauritsen, Diana (Intern)
Main Supervisor:
Svendsen, Svend (Intern)
Examiner:
Rode, Carsten (Intern)
Björk, Folke (Ekstern)
Rudbeck, Claus Christian (Intern)

**Financing sources**
Source: Internal funding (public)

**Innovationsnetværket for energieffektivt og bæredygtigt byggeri**

Department of Civil Engineering
Period: 01/06/2010 → 31/05/2014
Number of participants: 3
Acronym: InnoBYG
Project ID: 26128
Project participant:
Bjarløv, Søren Peter (Intern)
Eriksen, Marlene Stenberg Hagen (Intern)
Project Manager, organisational:
Rode, Carsten (Intern)

**Financing sources**
Source: Forskningsrådene - Andre
Name of research programme: Forskningsrådene - Andre
Amount: 1,440,000.00 Danish Kroner

**Models for the energy performance of low-energy houses**

Department of Informatics and Mathematical Modeling
Period: 01/05/2010 → 24/01/2014
Number of participants: 6
Phd Student:
Andersen, Philip Hvidthøft Delff (Intern)
Supervisor:
Rode, Carsten (Intern)
Main Supervisor:
Madsen, Henrik (Intern)
Examiner:
Hattel, Jesper Henri (Intern)
Heiselberg, Per (Ekstern)
Roels, Staf (Ekstern)

**Financing sources**
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU)
Project: PhD
Performance Modeling for Product Development of Advanced Window Systems

Department of Civil Engineering
Period: 01/06/2009 → 28/09/2012
Number of participants: 6
Phd Student: Appelfeld, David (Intern)
Supervisor: Nielsen, Toke Rammer (Intern)
Main Supervisor: Svendsen, Svend (Intern)
Examiner: Rode, Carsten (Intern)
Duer, Karsten (Intern)
Hellström, Bengt (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Energirenoering af bygninger til lavenerginiveau

Department of Civil Engineering
Period: 01/12/2008 → 27/08/2013
Number of participants: 6
Phd Student: Morelli, Martin (Intern)
Supervisor: Nielsen, Toke Rammer (Intern)
Main Supervisor: Svendsen, Svend (Intern)
Examiner: Rode, Carsten (Intern)
Björk, Folke (Ekstern)
Rudbeck, Claus Christian (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Institut stipendie (DTU) Samf.
Project: PhD

Dynamic effects in porous media flow in the built environment

Department of Civil Engineering
Period: 01/05/2008 → 30/04/2010
Number of participants: 4
Project participant:
Scheffler, Gregor Albrecht (Intern)
Janssen, Hans (Intern)
Rode, Carsten (Intern)
Hansen, Kurt Kielsgaard (Intern)

Financing sources
Source: Forskningsrådene - Andre
Name of research programme: Forskningsrådene - Andre
Amount: 1,800,000.00 Danish Kroner
Project
Passive Houses for Arctic Climates

Department of Civil Engineering
Period: 01/08/2007 → 29/06/2011
Number of participants: 7
Phd Student:
Vladyková, Petra (Intern)
Supervisor:
Nielsen, Toke Rammer (Intern)
Pedersen, Søren (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Villumsen, Arne (Intern)
Johansson, Dennis (Ekstern)
Tywoniak, Jan (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Model for Multidimensional Heat, Air and Moisture Conditions in Building Envelope Components

Department of Civil Engineering
Period: 01/08/2006 → 06/01/2010
Number of participants: 8
Phd Student:
Steskens, Paul Wilhelmus Maria Hermanus (Intern)
Supervisor:
Hjorslev Hansen, Morten (Intern)
Janssen, Hans (Intern)
Dela, Birgitte Friis (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Toftum, Jørn (Intern)
Christoffersen, Lars D. (Intern)
Janssens, Arnold (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Model for Multidimensional Heat, Air and Moisture Conditions in Building Envelope Components.

Purpose, hypotheses and relevance Moisture and temperature levels and variations in time and space play a crucial role in degradation processes of building materials, such as silicate materials, metals and polymeric materials where also UV-radiation is a very important factor. An exterior wall can consist of more than 10 different material layers. Furthermore, a wall element is often inhomogeneous in the plane because of counteracting structural and insulating properties. The moisture and temperature conditions inside such a wall are highly dependent on the material combinations and the climate conditions on both sides of the wall. The background and motivation for the project is that most damages that happen to building components occur in places with a complex geometry that cannot be handled correctly by today's design tools. This could for instance be where different materials meet in joints and where conditions most often have a multidimensional nature. Also apparently regular construction elements have multidimensional parts and features whose hygrothermal conditions should be considered better in the design of buildings, e.g. near beams and columns in common building elements. These loci often represent thermal bridges in the constructions, and they involve the assembly of different components and materials, so there is an increased risk of unintentional airflow or accumulation of moisture. The combination of these factors too often lead to the degradation of materials. Purpose It is the purpose of the project to develop a computational model for multidimensional transient Heat, Air and Moisture (HAM) flow in building constructions. The model should provide a suitable toolbox for fast and sound computations of moisture and temperature conditions in building components. This project intends to produce a tool that enables the analysis of conditions leading to degradation of building components. Critical temperature and moisture conditions and UV-exposure are partly known and partly
collected from field tests and controlled experiments in a laboratory environment. It is the intention that with such a combination of models and systematic collection of empirical knowledge, it will be possible to predict better those degradation processes of building products, which are realised in practice.

Department of Civil Engineering

Danish Building Research Institute
Period: 01/04/2006 → 31/03/2009
Number of participants: 4
Acronym: MD-HAM
Project ID: 25721
Project participant:
Stang, Birgitte Dela (Ekstern)
Hansen, Morten Hjorslev (Ekstern)
Møller, Jacob Steen (Intern)
Rode, Carsten (Intern)

Financing sources
Source: Forskningsrådene - STVF
Name of research programme: Forskningsrådene - STVF
Amount: 1,623,114.00 Danish Kroner
Project

Indlejring af erfaringer fra lavenerghus Sisimiut
Department of Civil Engineering
Period: 01/03/2006 → 31/12/2006
Number of participants: 5
Project ID: 25743
Project participant:
Fan, Jianhua (Intern)
Borchersen, Egil (Intern)
Kragh, Jesper (Intern)
Furbo, Simon (Intern)
Rode, Carsten (Intern)

Financing sources
Source: Program. Andre statslige danske - Andre prog.midler
Name of research programme: Program. Andre statslige danske - Andre prog.midler
Amount: 96,120.00 Danish Kroner
Project

Moisture Buffer Tests
Department of Civil Engineering
H+H Celcon GmbH
Period: 21/02/2006 → 01/09/2006
Number of participants: 2
Project ID: 25741
Contact person:
Bodner, Hans R. (Ekstern)
Rode, Carsten (Intern)

Financing sources
Source: Indtægtsdækket virksomhed UK 90
Name of research programme: Indtægtsdækket virksomhed UK 90
Amount: 135,750.00 Danish Kroner
Project

Department of Civil Engineering
The Danish Society of Engineers, IDA

Danish Building Research Institute
Period: 01/11/2005 → 30/06/2008
Number of participants: 4
Project ID: 25702
Project participant:
Svendsen, Svend (Intern)
Møller, Eva B. (Ekstern)
Hansen, Morten Hjorslev (Ekstern)

Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: [Ordinær drift UK 10]
Name of research programme: [Ordinær drift UK 10]
Amount: 0.00 Danish Kroner

IEA Annex 41 : Funding from EFP 04, Danish Energy Agency

Department of Civil Engineering
Danish Building Research Institute
Number of participants: 4
Project ID: 25688
Project participant:
Møller, Jacob Steen (Intern)
Grau, Karl (Ekstern)
Hansen, Morten Hjorslev (Ekstern)

Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 399,000.00 Danish Kroner

IEA Annex 41 : Funding from Tagpapbranchens Oplysningsråd, TOR

Department of Civil Engineering
Number of participants: 2
Project ID: 25687
Project Manager, organisational:
Møller, Jacob Steen (Intern)
Rode, Carsten (Intern)

Financing sources
Source: Sam.arb.aftaler, Private danske - Andre virksomheder
Name of research programme: Sam.arb.aftaler, Private danske - Andre virksomheder
Amount: 30,000.00 Danish Kroner
Konference i Florida, USA: Støtte fra Otto Mønsteds Fond

Department of Civil Engineering
Period: 01/11/2004 → 31/12/2004
Number of participants: 2
Project ID: 25630
Project participant:
Møller, Jacob Steen (Intern)
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Gaver, Private danske Fonde
Name of research programme: Gaver, Private danske Fonde
Amount: 7,305.00 Danish Kroner

Guest Ph.D. student Vít Koverdynsky

Department of Civil Engineering
Period: 01/08/2004 → 31/07/2005
Number of participants: 1
Project ID: 25611
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Sam.arb.aftaler - Udenlandske offentlige og private
Name of research programme: Sam.arb.aftaler - Udenlandske offentlige og private
Amount: 20,000.00 Danish Kroner

Whole Building Heat, Air and Moisture Response: IEA ECBCS Annex 41, Subtask 1 leadership

Section for Building Physics and Services

Department of Civil Engineering
Period: 01/08/2004 → 31/12/2007
Number of participants: 3
Project ID: 25617
Contact person:
Rode, Carsten (Intern)
Project participant:
Peuhkuri, Ruut Hannele (Intern)
Mortensen, Lone Hedegaard (Intern)

Financing sources
Source: Forsk. Private danske - Fonde
Name of research programme: Forsk. Private danske - Fonde
Amount: 300,000.00 Danish Kroner

Reduktion af energiforbrug til udtørring af bygninger

Section for Building Physics and Services

Department of Civil Engineering
Teknologisk Institut
Period: 01/07/2004 → 30/06/2006
Number of participants: 1
Project ID: 25597
Project participant:
Rode, Carsten (Intern)
Financing sources
Source: Program. Andre statslige danske - Miljø
Name of research programme: Program. Andre statslige danske - Miljø
Amount: 35,000.00 Danish Kroner
Project

Moisture Buffering of Building Materials
Section for Building Physics and Services
Department of Civil Engineering
Norwegian Building Research Institute
VTT - Technical Research Centre of Finland
Lund Institute of Technology
Period: 01/04/2004 → 30/06/2005
Number of participants: 4
Project ID: 25596
Project participant:
Time, Berit (Ekstern)
Ojanen, Tuomo (Ekstern)
Arfvidsson, Jesper (Ekstern)
Project Manager, organisational:
Rode, Carsten (Intern)

Reflekterende undertage
Section for Building Physics and Services
Department of Civil Engineering
Period: 31/01/2004 → 29/02/2004
Number of participants: 2
Project ID: 25544
Project participant:
Holck, Ole (Intern)
Project Manager, organisational:
Rode, Carsten (Intern)

Udarbejdelse af pjece: Indeklima og tegl
Section for Building Physics and Services
Department of Civil Engineering
MURO/Danske Tegl
Period: 01/11/2003 → 31/03/2004
Number of participants: 2
Project ID: 25530
Project participant:
Bøgh, Søren (Ekstern)
Project Manager, organisational:
Rode, Carsten (Intern)

**Financing sources**

Source: Indtægtsdækket virksomhed UK 90  
Name of research programme: Indtægtsdækket virksomhed UK 90  
Amount: 15,000.00 Danish Kroner  

**Project**

Udvikling af elbesparende reguleringsstrategier og optimering af ventilationsanlæg og varmepumper i svømmehallen  
Section for Building Physics and Services  
Department of Civil Engineering  
Birch & Krogboe A/S  
Period: 01/08/2003 → 31/12/2005  
Number of participants: 2  
Project ID: 25548  
Project participant:  
Rode, Carsten (Intern)  
Project Manager, organisational:  
Jensen, Martin Lykke (Ekstern)

**Financing sources**

Source: Forskningsprojekter - Miljø- og Energiministeriet  
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet  
Amount: 46,500.00 Danish Kroner  

**Project**

Hygrotermisk mikroklima på indvendige overflader af klimaskærmen  
Department of Civil Engineering  
Period: 01/05/2003 → 15/08/2007  
Number of participants: 6  
Phd Student:  
Mortensen, Lone Hedegaard (Intern)  
Supervisor:  
Peuhkuri, Ruut Hannele (Intern)  
Main Supervisor:  
Rode, Carsten (Intern)  
Examiner:  
Svendsen, Svend (Intern)  
Brohus, Henrik (Ekstern)  
Hagentoft, Carl-Eric Hartvig (Ekstern)

**Financing sources**

Source: Internal funding (public)  
Name of research programme: Forskningsrådsfinansiering  
Project: PhD

**Project**

Hygrothermal Performance of Whole Buildings  
Section for Building Physics and Services  
Department of Civil Engineering  
Period: 01/05/2003 → 01/05/2006  
Number of participants: 3  
Project ID: 25.466  
Project participant:  
Peuhkuri, Ruut Hannele (Intern)  
Mortensen, Lone Hedegaard (Intern)  
Project Manager, organisational:  
Rode, Carsten (Intern)
Financing sources
Source: Forskningsrådene - STVF
Name of research programme: Forskningsrådene - STVF
Amount: 2,600,000.00 Danish Kroner

Project

Cold Bridge Problem in Sandwich Panels, Clinic Buildings, Thule
Section for Building Physics and Services
Department of Civil Engineering
PP Consult
Period: 01/02/2003 → 31/03/2003
Number of participants: 2
Project participant:
Nielsen, Hans Jørgen (Ekstern)
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Indtægtsdækket virksomhed UK 90
Name of research programme: Indtægtsdækket virksomhed UK 90
Amount: 3,774.00 Danish Kroner

Project

Moisture Buffering of Building Materials : Workshop
NORDTEST Workshop
Section for Building Physics and Services
Department of Civil Engineering
Period: 01/01/2003 → 31/12/2003
Number of participants: 1
Project ID: 25472
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Forsk. Andre offentlige og private - Nordiske
Name of research programme: Forsk. Andre offentlige og private - Nordiske
Amount: 74,000.00 Danish Kroner

Project

Beregning af U-værdier for bygningsdele til VIF's U-værdi tabel : U-værdi 2003
Section for Building Physics and Services
Department of Civil Engineering
Varmesoleringssforeningen
Period: 01/12/2002 → 30/10/2003
Number of participants: 5
Project ID: 25441
Project participant:
Rose, Jørgen (Intern)
Weitzmann, Peter (Intern)
Henriksen, Torben (Ekstern)
Petersen, Michael (Ekstern)
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Indtægtsdækket virksomhed UK 90
Name of research programme: Indtægtsdækket virksomhed UK 90
**Evaluering af udviklingsprojekt**

Section for Building Physics and Services

Department of Civil Engineering

Period: 01/08/2002 → 30/11/2002

Number of participants: 1

Project ID: 25395

Project Manager, organisational:

Rode, Carsten (Intern)

**Financing sources**

Source: Indtægtsdækket virksomhed UK 90 KUP

Name of research programme: Indtægtsdækket virksomhed UK 90 KUP

Amount: 24,375.00 Danish Kroner

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**U-værditabel efter EU-standarder**

Section for Building Physics and Services

Department of Civil Engineering

Landsforeningen Økologisk Byggeri

Period: 01/08/2002 → 30/09/2002

Number of participants: 1

Project ID: 25388

Project Manager, organisational:

Rode, Carsten (Intern)

**Financing sources**

Source: Indtægtsdækket virksomhed UK 90

Name of research programme: Indtægtsdækket virksomhed UK 90

Amount: 58,000.00 Danish Kroner

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**Metoder til optimering på bygningsenergiområdet**

Department of Civil Engineering

Period: 01/03/2002 → 09/03/2007

Number of participants: 7

Phd Student:

Pedersen, Frank Ørbech (Intern)

Supervisor:

Bøhm, Benny (Intern)

Nielsen, Hans Bruun (Intern)

Main Supervisor:

Svendsen, Svend (Intern)

Examiner:

Rode, Carsten (Intern)

Christiansen, Edmund (Ekstern)

Gustafsson, Stig-Inge (Ekstern)

**Financing sources**

Source: Internal funding (public)

Name of research programme: DTU-lønnet stipendie

Project: PhD

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**Praktisk U-værdi samt fastlæggelse af korrektionsfaktorer for isoleringsevne/U-værdi ved prak-tisk udførelse af isolering af bygningskonstruktioner med alternativ/økologisk isolering**
Section for Building Physics and Services

Department of Civil Engineering

Teknologisk Institut
Period: 01/01/2002 → 30/06/2004
Number of participants: 3
Project ID: 25385
Project participant:
Holck, Ole (Intern)
Olsen, Lars (Ekstern)

Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Forskningsprojekter - Erhvervsministeriet
Name of research programme: Forskningsprojekter - Erhvervsministeriet
Amount: 413,000.00 Danish Kroner

Sekretariatsbistand, bygninger : Carsten Rode

Section for Building Physics and Services

Department of Civil Engineering
Period: 01/06/2001 → 31/12/2001
Number of participants: 1
Acronym: EFP2002
Project ID: 25013
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 32,925.00 Danish Kroner

Fugtfordeling i absorberende isoleringsmaterialer : Moisture distribution in absorbent insulation

Section for Building Physics and Services

Department of Civil Engineering
Period: 01/12/2000 → 30/04/2003
Number of participants: 5
Project ID: 25.204
Project participant:
Peuhkuri, Ruut Hannele (Intern)
Padfield, Tim (Intern)
Hansen, Kurt Kielsgaard (Intern)
Mortensen, Lone Hedegaard (Intern)

Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 138,412.00 Danish Kroner

Overfladens betydning for varme- og fugtforhold i bygningers klimaskærm og de drift- og vedligeholdelsesmæssige konsekvenser heraf
Investigation and Optimisation of Heat Storage Tanks for Low-Flow SDHW Systems

Department of Civil Engineering
Period: 01/09/2000 → 26/05/2004
Number of participants: 4
Phd Student:
Knudsen, Søren (Intern)
Main Supervisor:
Furbo, Simon (Intern)
Examiner:
Rode, Carsten (Intern)
Vajen, Klaus (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Moisture Transport in Wood A Study of Physical-Mathematical Models and their Numerical Implementation

Department of Civil Engineering
Number of participants: 6
Phd Student:
Krabbenhøft, Kristian (Intern)
Supervisor:
Hoffmeyer, Preben (Intern)
Main Supervisor:
Damkilde, Lars (Intern)
Examiner:
Rode, Carsten (Intern)
Petersson, Hans (Ekstern)
Ranta-Maunus, Alpo (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: Forskningsrådsfinansiering
Project: PhD

Fugtteknisk grundlag for fastsættelse af designværdier for varmeledningsevnen
Section for Building Physics and Services

Department of Civil Engineering

Danish Standards Association
Period: 09/05/2000 → 31/10/2001
Number of participants: 3
Project ID: 25065
Project participant:
Rudbeck, Claus Christian (Intern)
Project Manager, organisational:
Rode, Carsten (Intern)
Dufour, Jørgen (Ekstern)

Financing sources
Source: Forskningsprojekter - Miljø- og Energiministeriet
Name of research programme: Forskningsprojekter - Miljø- og Energiministeriet
Amount: 290,000.00 Danish Kroner
Project

Eksperimentel og analytisk fugtdynamik i sammensatte bygningskonstruktioner

Department of Civil Engineering
Period: 01/02/2000 → 17/10/2003
Number of participants: 6
Phd Student:
Peuhkuri, Ruut Hannele (Intern)
Supervisor:
Hansen, Kurt Kielsgaard (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Hjorslev Hansen, Morten (Intern)
Holm, Andreas (Intern)
Time, Berit (Ekstern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-lønnet stipendie
Project: PhD

Moisture based determination of the design value of thermal conductivity based on the declared values for thermal insulation materials in typical building constructions

The project is financed by the Danish Energy Agency's programme on thermal insulation methods that are friendly both to the external environment and to the working environment. The purpose of the project is to create a basis for determining the practical thermal conductivity for insulation materials by taking into account the moisture that is found in building constructions under typical conditions. The determination of the practical thermal conductivity will mainly be based on theoretical calculations of heat and moisture conditions in selected building constructions. The method is developed for generic insulation materials, but will mainly be used to examine conditions in constructions with alternative insulation materials, e.g., cellulose fibre, sheep's wool, and flax, which by nature have a substantial amount of hygroscopic moisture. Determination of the practical thermal conductivity is of importance for the manufacturers of insulation materials, especially the alternative insulation materials.

Department of Buildings and Energy

Department of Civil Engineering

Danish Standard
Period: 01/02/2000 → 31/05/2000
Number of participants: 3
Project participant:
Rudbeck, Claus Christian (Intern)
Dufour, Jørgen (Ekstern)
Equipment to investigate moisture distribution in absorbing insulation materials

Moisture absorption in organic thermal insulation material may level out the distribution of moisture in the material. Two mechanisms substantiate this hypothesis: 1. The insulation absorbs a considerable amount of water vapour - enough that short term condensation may not form. 2. A number of lab tests and case-studies show that water is transported through absorbing materials partially driven by gradients in moisture content. As a result, absorbing insulation may be less susceptible to condensation during winter. The experiment developed in this project will confirm or reject these assumptions in a scale and in an environment that resembles the conditions in a roof or wall construction. The setup makes it possible to control the temperature, humidity, and air pressure conditions across an experimental wall.

Department of Buildings and Energy

Department of Structural Engineering and Materials

Department of Civil Engineering

Danish Building Research Institute

Period: 01/04/1999 → 31/05/2000

Number of participants: 3

Project participant:

Padfield, Tim (Intern)

Nicolajsen, Asta (Ekstern)

Project Manager, organisational:

Rode, Carsten (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 130,000.00 Danish Kroner

Project

Energy efficient, demand controlled ventilation for dwelling for the future

An evaluation is carried out to determine whether it is possible to reduce the base ventilation of different types of residential buildings, and to determine the requirement for increased ventilation in certain rooms and periods. It will be determined whether it is possible to reduce the net energy consumption and environmental load by using demand controlled ventilation. A calculation model is developed which predicts the indoor humidity conditions and CO2 levels from weather data given by the test reference year.

Department of Buildings and Energy

Department of Civil Engineering

Danish Building Research Institute

Period: 01/03/1999 → 30/06/2000

Number of participants: 2

Project participant:

Bergsøe, Niels C. (Ekstern)

Project Manager, organisational:

Rode, Carsten (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 296,000.00 Danish Kroner

Project

Energy efficient, demand controlled ventilation for dwelling for the future

An evaluation is carried out to determine whether it is possible to reduce the base ventilation of different types of residential buildings, and to determine the requirement for increased ventilation in certain rooms and periods. It will be determined whether it is possible to reduce the net energy consumption and environmental load by using demand controlled ventilation. A calculation model is developed which predicts the indoor humidity conditions and CO2 levels from weather data given by the test reference year.

Department of Buildings and Energy

Department of Civil Engineering

Danish Building Research Institute

Period: 01/03/1999 → 30/06/2000

Number of participants: 2

Project participant:

Bergsøe, Niels C. (Ekstern)

Project Manager, organisational:

Rode, Carsten (Intern)

Financing sources

Source: Unknown

Name of research programme: Ukendt

Amount: 685,000.00 Danish Kroner

Project
**Metode til optimering af bygninger med hensyn til energi og indeklima**

Department of Civil Engineering  
Period: 01/02/1999 → 21/01/2003  
Number of participants: 5  
Phd Student:  
Nielsen, Toke Rammer (Intern)  
Main Supervisor:  
Svendsen, Svend (Intern)  
Examiner:  
Rode, Carsten (Intern)  
Gustafsson, Stig-Inge (Ekstern)  
Olsen, Lars (Intern)

**Financing sources**  
Source: Internal funding (public)  
Name of research programme: DTU-lønnet stipendie  
Project: PhD

**Calculation of U-values for building components for VIF’s Table of U-values**  
Heat transmission coefficients (U-values) are calculated for a number of typical building construction types. The result will go in new edition of a catalogue of such U-values to be published by the Danish Association of Manufacturers of Thermal Insulation Materials (VIF). The project is requested by VIF.

Department of Buildings and Energy  
Period: 01/01/1999 → 31/08/2000  
Number of participants: 2  
Project participant:  
Rose, Jørgen (Intern)  
Project Manager, organisational:  
Rode, Carsten (Intern)

**Financing sources**  
Source: Unknown  
Name of research programme: Ukendt  
Amount: 125,000.00 Danish Kroner  
Project

**Moisture problems in the floor of a congress centre**  
Advising a consulting engineering company with some directions about problems in newly laid floors that have swollen.

Department of Buildings and Energy  
Period: 01/01/1999 → 31/08/1999  
Number of participants: 1  
Project Manager, organisational:  
Rode, Carsten (Intern)

**Financing sources**  
Source: Unknown  
Name of research programme: Ukendt  
Amount: 3,500.00 Danish Kroner  
Project

**Secretarial assistance, Energy Research Programme 2000**  

Department of Buildings and Energy  
Period: 01/01/1999 → 29/02/2000  
Number of participants: 1  
Project Manager, organisational:  
Rode, Carsten (Intern)
**Financing sources**

Source: Unknown
Name of research programme: Ukendt
Amount: 79,313.00 Danish Kroner

**Heat and moisture characteristics of alternative thermal insulation materials.**

The research is divided between Department of Buildings and Energy (IBE), which focus on heat characteristics of alternative insulation materials and moisture calculations of constructions, and Department of Structural Engineering and Materials (BKM), which focus on measurements of moisture characteristics of alternative insulation materials. The BKM part concerns measurements of sorption curves, water vapour permability, capillary suction and the moderating influence of absorbent materials on the relative humidity of large, leaky enclosures. Alternative thermal insulation materials are made from organic fibres: paper, sheep's wool or flax. Also perlite insulation belongs to this group.

Department of Structural Engineering and Materials

Department of Buildings and Energy

Number of participants: 5

Project participant:

Hansen, Ernst Jan De Place (Intern)
Padfield, Tim (Intern)
Rode, Carsten (Intern)
Kristiansen, Finn Harken (Intern)

Project Manager, organisational:

Hansen, Kurt Kielsgaard (Intern)

**Investigation of Heat and Moisture Performance of Alternative Insulation Materials**

Investigations are carried out on some insulation products which are "alternative" to the ones that are traditionally used in Danish constructions. The alternative products are claimed to be friendly both to the environment and to the labour force. The materials investigated are: cellulose insulation, sheep wool, flax, and perlite. These materials, except for the last one, are very hygroscopic. The following investigations are carried out: 1. Experimental investigation of the thermal conductivity at different humidity conditions. The thermal conductivity is determined for the different materials with a guarded hot plate apparatus in which different vapour pressure conditions can be maintained over the specimens. 2. Experimental investigation of the effect of natural convection on heat transfer. Heat transfer is measured in full size walls with insulation of either cellulose or sheep's wool when installed in a hot box/cold box facility. The dimension of the insulation's measuring area is 1000 mm width x 3000 mm height x appr. 400 mm thickness. 3. Computational analysis of the hygrothermal performance of constructions with alternative insulation products. The hygrothermal performance of constructions with alternative insulation products is analysed with a computational model for combined heat and moisture transfer. The analysis concerns both traditional wall and roof constructions with the alternative insulation products, and some alternative designs prescribed by manufacturers of alternative insulation materials. All three investigations are compared against similar results when mineral fibre is used. The moisture transport properties of the materials (sorption, vapour transmission, and suction) are investigated in a companion project by the Department of Structural Engineering and Materials, DTU.

Department of Buildings and Energy

Department of Structural Engineering and Materials

Number of participants: 2

Project participant:

Kristiansen, Finn Harken (Intern)
Rode, Carsten (Intern)
Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 408,495.00 Danish Kroner
Project

Framework programme on Energy Conservation in the Existing Building Stock
Framework programme: A plan for research, development, demonstration, and information on Energy Conservation in the Existing Building Stock - the requirements needed to fulfil the intentions of the Danish government's plan "Energy 21".

Department of Buildings and Energy
Danish Ministry of Housing and Urban Affairs
Danish Energy Agency
Period: 01/01/1998 → 31/08/1998
Number of participants: 2
Project participant:
Engelmark, Jesper (Intern)
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 50,000.00 Danish Kroner
Source: Unknown
Name of research programme: Ukendt
Amount: 11,867.00 Danish Kroner
Project

Humidity in Buildings
Contribution to the International Centre for Indoor Environment and Energy: Modelling and experimental investigation of humidity transfer and energy consumption in buildings. The research aims at establishing complete modelling capabilities of the hygrothermal conditions in buildings with their spaces, building materials, furnishing, activity of occupants, and influence from exterior conditions.

Department of Buildings and Energy
Section for Indoor Environment
Department of Civil Engineering
Period: 01/01/1998 → 31/12/2002
Number of participants: 2
Project participant:
Fanger, P.O. (Ekstern)
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 0.00 Danish Kroner
Project

Secretarial assistance, Energy Research Programme 1999
Evaluation of proposals for the Energy Research Programme 99
Department of Buildings and Energy
Period: 01/01/1998 → 31/12/1998
Number of participants: 1
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Simulation of moisture conditions in sealed window units with acrylic glazing
An investigation requested by a manufacturer of acrylic window panes to predict by calculation the amount of accumulation of moisture in sealed window units.

Department of Buildings and Energy
Period: 01/11/1997 → 31/12/1997
Number of participants: 1
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 39,094.00 Danish Kroner

Secretarial assistance, Energy Research Programme 98
Evaluation of proposals for the Energy Research Programme 98

Department of Buildings and Energy
Period: 10/10/1997 → 31/12/1997
Number of participants: 1
Project Manager, organisational:
Rode, Carsten (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 6,400.00 Danish Kroner

Fugttransport og konvektion i bygningskonstruktioner

Department of Civil Engineering
Period: 01/08/1997 → 18/02/2003
Number of participants: 5
Phd Student:
Gudum, Charlotte (Intern)
Main Supervisor:
Rode, Carsten (Intern)
Examiner:
Hagentoft, Carl-Eric Hartvig (Ekstern)
Andersen, Karl Terager (Intern)
Svendsen, Svend (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: DTU-Su Stipendium, Eksperiment
Project: PhD

Contribution to formulation of development programme for alternative thermal insulation material
A programme is written for development of thermal insulation materials that are healthy both to the labour force and to the external environment. The programme is written on behalf of the Danish Energy Agency. Contribution is given to the formulation of the programme.

Department of Buildings and Energy
The role of absorbent building materials in moderating changes of relative humidity
A Ph.D. study for BA Tim Padfield, The Conservation Department at the Danish National Museum. The project is described in detail on the home page of the National Museum. Main supervisor: Anders Nielsen Co-supervisors: Kurt Kielsgaard Hansen, BKM and Carsten Rode, IBE

Department of Structural Engineering and Materials
Department of Buildings and Energy
Department of Civil Engineering

National Museum of Denmark
Number of participants: 4
Project participant:
Hansen, Kurt Kielsgaard (Intern)
Padfield, Tim (Intern)
Rode, Carsten (Intern)
Project Manager, organisational:
Nielsen, Anders (Intern)

Træs mekanosorptive egenskaber
Department of Civil Engineering
Period: 01/04/1996 → 10/04/2003
Number of participants: 6
PhD Student:
Jensen, Signe Kamp (Intern)
Supervisor:
Damkilde, Lars (Intern)
Main Supervisor:
Hoffmeyer, Preben (Intern)
Examiner:
Rode, Carsten (Intern)
Kliger, Robert (Ekstern)
Olesen, Per (Intern)

Financing sources
Source: Internal funding (public)
Name of research programme: Ansat eksternt
Project: PhD

IEA, ECBCS, Annex 24, Heat, Air and Moisture Transfer in Insulated Envelope Parts, HAMTIE
Summary The objectives of this annex are to model and study the fundamental physical phenomena behind and the consequences of heat, air and moisture transfer through new and retrofitted insulated envelope parts. A special emphasis will be put on the energy quality, depending on air tightness, on the hygric behaviour and on the durability aspects of the
construction. The knowledge gained by this analysis will be applied to performance formulation and to checking the design and production of new retrofitted parts. It is divided into the following five subtasks: Subtask 1: Model and Algorithm Development: This task includes improving modelling techniques and testing simplified models for predicting the combined effects of HAM-transport on insulation quality, hygic behaviour and durability. Subtask 2: Inside and External Environmental Conditions: This task includes selecting environmental parameters and a methodology of handling them and the development of exemplary sets of environmental conditions. Subtask 3: Material and Layer Properties: This task includes data collecting on thermal hygic and air properties of materials and layers and substantial fresh measuring work, especially on the moisture and air properties. Subtask 4: Experimental Verification: Experimental verification includes hot box and field tests on HAM- transport in envelope parts and comparing measurement results with model prediction. Subtask 5: Performances and Practice: This task includes the translation of HAM-knowledge in correct design and execution of highly insulated new and retrofitted envelope parts.

Department of Buildings and Energy

Danish Building Research Institute
Period: 04/07/1991 → 21/01/1997
Number of participants: 2
Project participant:
Rode, Carsten (Intern)
Project Manager, organisational:
Korsgaard, Vagn (Intern)

Financing sources
Source: Unknown
Name of research programme: Ukendt
Amount: 460,000.00 Danish Kroner
Source: Unknown
Name of research programme: Ukendt
Amount: 75,000.00 Danish Kroner

Activities:

Research activities with DTU’s Department of Civil Engineering of relevance for CHAMPS Development and Application
Period: 1 Jun 2012 → 3 Jun 2012
Carsten Rode (Speaker)
Department of Civil Engineering
Section for Building Physics and Services

Description
Invited Lecture

Related event

9th International Forum and Workshop on Combined Heat, Air, Moisture and Pollutant Simulation
01/06/2012 → 03/06/2012
Tokyo, Japan
Activity: Talks and presentations › Conference presentations

5-års seminar om Lavenerghuset i Sisimiut
Period: 2 Jun 2010
Carsten Rode (Organizer)
Department of Civil Engineering
Section for Building Physics and Services
Arctic Technology Centre
Links:

Related event
Siden 1. august har beboerne i det grønlandske selvstyres lejeboliger måttet gribe dybere i lommerne for at betale deres varmeregning. Og der skal skrues godt op for varmen, for en stor del af selvstyrets lejligheder er utætte og plaget af skimmelsvamp.

To ph.d-projekter sætter fokus på grønlandsk byggeri og skimmelsvamp

Når tusinder af lejeboliger i Grønland ikke er bedre end at rive ned, så skyldes det især slid og dårligt vedligehold.

Sidste år blev 101 boliger i og uden for Nuuk skimmelrenoveret. Der er også fundet skimmelsvamp i andre bebyggelser.

Der er altså nok at tage fat på i Grønland med at renovere, rive ned og bygge nyt. Men måske er der hjælp på vej fra DTU i Danmark, som lige nu søger penge til to ph.d. projekter. Hvoraf det ene skal se på det byggetekniske.

Department of Civil Engineering, Section for Building Physics and Services

Media contribution (1)

Selvstyrets boliger i miserabel stand
06/09/2012
DR P1 - Orientering, Radio
Birgitte Gadegaard
10:31
http://www.dr.dk/P1/orientering/indslag/2012/09/06/154016_1_1_1_1_1_1_1_1.htm

Radioindslag
Carsten Rode
Department of Civil Engineering, Section for Building Physics and Services
Press / Media