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The co-operation between the University and the Industry association in the application of building physics results to practice

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Abstract

Indoor air questions in Finland have been constantly featured in the media. There are indoor quality deficiencies, not only in existing as well as in new buildings. The problems of indoor conditions can be divided into those caused by design, implementation and use. At the civil engineering department, University of Oulu, you can now specialize in building health. This is a new orientation option, which can be studied at the University of Oulu only. Arctic Construction Cluster Finland was established to restart the once-abolished civil engineering department. The cluster represents all branches of construction, and supports the civil Engineering department. The team for healthy buildings at the Arctic Cluster cooperates with the university's good indoor air and building health team. This is a position paper, where we introduce the operational priorities of the building cluster and the healthy buildings team, cooperation with the indoor air and building health group at Oulu University and the trends which will affect and change the building branch. There are still shortcomings in solutions to indoor conditions problems, which are caused by several factors. Education and training must be developed. Knowledge in hygrothermal performance of buildings is essential to improve it into interdisciplinary and comprehensive approach. Civil engineers must recognize factors that affect building health. Health care staff then investigate the consequences. Different actors should be brought together better than at present.

1. Introduction

Indoor air issues in Finnish homes and workplaces have been constantly featured in the media. The issues have been discussed concerning existing as well as new buildings. The risks related to indoor conditions can be divided into those caused by design, implementation, and use. The costs resulting from the indoor environmental defects, e.g., bad indoor air quality (IAQ) and other factors, resulting in high costs due to reduced work productivity, absenteeism and repair. However, the IAQ is internationally considered relatively good in Finland. In Finland, various actors, such as municipalities and cities, have developed solutions to the problems of indoor conditions. The situation is improving. In the future, with the different players in the construction industry and the university's closer cooperation, the performance and IAQ of the buildings can be improved. Modelling of buildings and, on the other hand, the development of building automation systems and monitoring, in particular, is key to develop building design, implementation and use. However, the current operational model needs time to reach results that benefit everyone. The development of the construction industry is currently affected

by several different trends, the most significant of which in the long term is climate change [1], [2] and its effect on buildings and housing in general. The increase in temperature is especially aimed at the northern parts of the northern hemisphere, (Figure 1) [3].

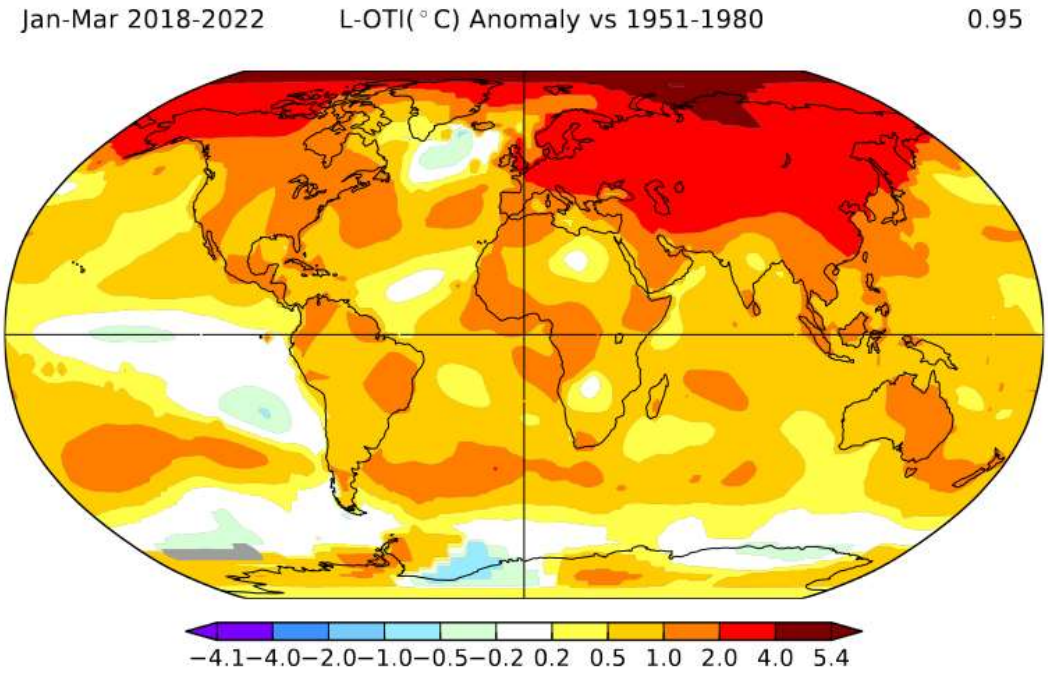

Figure 1. Global warming. Source: NASA National Aeronautics and Space Administration, Goddard Institute for Space Studies. The changes of temperatures, January-March.

Climate change causes an increase in temperature, which may lead in summer times to indoor temperature level that can cause health issues of occupants in service and residential buildings. Then, instead of traditional long cold periods in winter, there may be a temperature fluctuation causing periodic freezing-thawing periods. The amount of rain and wind may increase, in which case wind-driven rains will load the structures more than at present. Increased humidity causes flooding, and on the coasts, rising sea water level poses a danger to buildings near the coast [1].

The Building Supervision Office of the city of Oulu (BSO) has participated in research projects [4], where as one part the effect of weather conditions different from the current one, such as wind-driven rain and heavy wind, on the structures in use was evaluated computationally. The result was that some of the existing structures do not perform well enough. In this case, the risk of moisture damage increases.

The trend in real estate management is "knowledge-based management", business intelligence based on data in use. This is possible, created by digitalization. The building performance, indoor conditions and energy efficiency can be monitored in real time. This requires proper instrumentation and metering, results processing and reporting, that could be compared to industrial production and quality control. The final product of the building is planned, healthy and good IAQ. Ensuring the performance of the building from the project planning to the operation phase can be implemented on a monitoring basis, but generally accepted procedures still need to be developed.

With digitalization, building modeling is a commonly used tool (BIM). A digital twin can be created from the building, and various solutions can be tested with it. Planning tools have developed rapidly, but there are still bottlenecks in coordinating different data models, that we have to do manually. The

requirements and needs of building users are also changing. In the future, the built environment and buildings will be required to have resilience, the ability to maintain operational capability in changing conditions, and the readiness to face disruptions and crises and recover from them.
The factors presented above will also affect the educational requirements of the construction and real estate sector. If we want the building to perform "as designed", the importance of managing building physics is increasing in order to ensure the health of building users and the performance of structures and systems.

2. New specialization: Good Indoor Air and Building Health

In response to the new challenges, new building health specialization was established at the Civil Engineering Research Unit at the University of Oulu, Finland and it is possibly the only one worldwide so far [5]. A building health expert must understand the requirements for good indoor air, physical conditions and elated health effects, as well as legislation and regulations related to built environment. The student gets the skills to work as an expert, research and planning tasks related to indoor environment quality, and moisture management. The courses of the new building health study program are implemented across faculty boundaries.

The background for starting the training is the need highlighted by Arctic Construction Cluster Finland to promote building health and indoor air expertise and healthy building in the region and in the country, and to produce experts in the field for the service of business and public organizations. The new training is based on constantly developing research knowledge, with the applications of which it is possible to improve the level of building health and indoor air expertise to an even higher level. Recent research objectives in the field have been, e.g., proactive facility management based on continuous monitoring of the indoor environment and conditions, the effects of improving the energy efficiency of buildings on indoor environmental quality, occupant health and wellbeing. The results opened up interesting development directions (Figure 2).

Main research areas:

- Indoor environmental quality (IEQ)
- Building physics
- Dampness and mold associated with IEQ

Main application areas:

- Continuous monitoring
- School buildings, IEQ, health and learning outcomes
- Assessment of dampness and mold in buildings
- Effects of improved energy efficiency of buildings on IEQ, occupants' health and wellbeing
- Developing new methods to assess and model IEQ in relation to building occupants’ health and wellbeing

A new environmental laboratory is also being planned together with Oulu University of Applied Sciences.

3. Measures in the construction sector: Arctic Construction Cluster Finland

3.1. Arctic Construction Cluster Finland

The cluster unites Northern Finland's construction industry companies, educational institutions and authorities to work for the best of the construction industry and regional development. At the moment, almost 100 experts are involved in Cluster's activities, mainly company and community members, but

also individual members. They are divided to work by industry in six divisions and in one cross-cutting industrial team, healthy buildings [6].

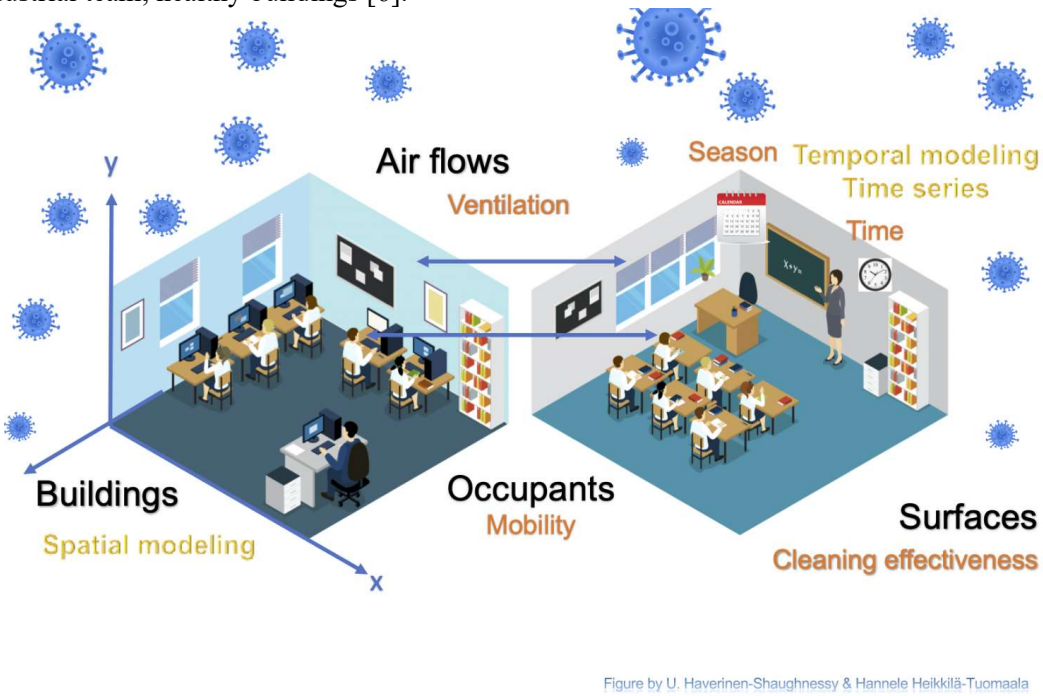

Figure 2. Research towards healthy, productive and sustainable indoor environments. (www.oulu.fi/en/university/faculties-and-units/faculty-technology/civil-engineering-research-unit)

The university chain includes the University of Oulu as well as the universities of applied sciences in the region and Oulu region's vocational school. The activities are coordinated by a board formed by the division heads. The cluster is a platform for industries and members to meet, an active cooperation network with agreed goals, rules of the game and organized mutual communication, which the parties can utilize in a planned manner. In the cluster, industrial branches highlight productive or necessary training, research or investigation needs in the field, for which the training chain or divisions seek solutions also with the resources supported by the cluster. Through cooperation, border fences are opened within the construction industry and efforts are also made to streamline control processes.

3.2. Main goals in general

One of the core missions of Arctic Construction Cluster Finland is to increase collaboration across borders both for business as well as education. The main goals are: 1. Youth - attractiveness of the building sector, how to get young people to all levels of education and how to get labor force, 2. Circular economy (incl. taxonomy) 3. House of the future including subthemes such as Dry Construction Chain, Indoor Environment, Energy Efficiency and Management, Architecture, Cultural Issues.

3.2.1. Healthy Buildings-team.

Healthy Buildings-team of Arctic Construction Cluster brings companies' perspectives and problems to the university's attention, and at the same time can disseminate the latest research results for the use of companies and different communities. The current focus of the healthy buildings-team is commissioning the performance of buildings, which also covers indoor conditions and health of buildings.

4. Trends: Climate change

4.1. *Increasing temperatures and changing conditions*

Global climate change causes challenges in buildings in Finland [7]. The climate in Finland has warmed about two degrees during the last hundred years. According to forecast, Finland's climate will warm especially in winter. The wind-driven rain load received by structures exposed to the weather, such as facades, balconies and roofs, will may cause a significant need for repairs in the existing building stock. The durability of old structures is often defective. Structural details such as joints and junctions should operate properly. Freezing-thawing-phenomena will load structures more than continuing cold period in the winter. With increasing moisture content increases risk of moisture and microbial damages, that are one of the health threats caused by the climate change. Repairing moisture damages in the existing building stock has been estimated already approximately 10 years ago to be 30 billion euros [7], [8]. Majority of Finland's building stock is 30–60 years old. These buildings are designed according to the regulations and practices of the time. Part of these buildings has already been renovated; some buildings are approaching the next renovation cycle the other buildings are waiting the renovation. So called repair dept is almost continuous in some building groups.

The calculated and observed temperatures of service buildings and apartments are already high in the current climate. The insulation level is improved and the air tightness is better. Sun protection solutions alone are not enough to keep room temperatures at a sufficiently low level during the warm season. Active cooling is also needed, especially during heat waves. Increased balcony glazing has also caused increase indoor temperatures. Air heat pumps are more general in one-family houses and apartments mainly for cooling, but also for heating. Cooling should be especially aimed at buildings where elderly people live, like service homes. They have the greatest health risks. Without further actions high temperatures will increase significantly in Finland and cause health problems for elderly people as the population is aging.

4.2. Increasing moisture and wind

Stormwaters, heavy rains and melting snow can cause flooding of waterways - mainly in rivers and lakes [7]. Flooding of surface waters can also be caused by high water levels in lake areas as a result of consecutive wet periods, ice damming at the time of ice run, clogging of flow openings and channels, and ice damming of subcooled water, i.e. ice flood. The effects of climate change on waterway floods depend on the causes of the floods and the location of the waterways. Floods can be divided into three different types of floods: stormwater, waterway and seawater floods. Flood types depend on how they are generated, in which case the effects of climate change vary by flood type. The essential thing is that there are lot of buildings in risky areas even the construction in such areas is regulated. Every year there are red flood damages by the rivers as well as in urban areas.

5. Trends – digitalization, modelling and knowledge-based management

The value of data-managed built assets in Finland is EUR 500 billion, traffic EUR 55 billion and infrastructure approx. EUR 42 billion. It has been estimated that data loss is a brake on productivity growth in the real estate and construction industry: 50% of data is lost when at the same time we want significant productivity growth. The benefits of digitization in the construction sector have also been evaluated: Increase in productivity 12-20% with the help of digitization. This means better and more construction per year worth 2–3 billion euros. Estimated benefits over the life cycle – design are: Benefits in design costs 8%, in planning time 30%, and benefits during the life cycle – construction: Construction costs 3%, lead time 10% [9]. A significant problem is the integration of data and data models of the built environment [10]. Data does not flow over interfaces, if no interfaces are defined. For this reason, construction documentation must be developed, for example by defining generally

acceptable and required criteria. A well-documented construction ensures the quality of operation. At least the minimum criteria for documentation had to be defined. The same also applies to measurements and data processing during the use stage of the building [11], [12]. From the management perspective of data-driven service innovation, one question is: How the data created in the building construction phase can be utilized in the use phase? Combined with the costs of mold and moisture repairs, the repair debt, and the savings potential obtained through digitalization, we talk about very large sums.

6. Summary

Changing conditions set challenges and demands on construction, while new tools and procedures are in use. These must be prepared and adopted for both, practice and teaching. The importance of building physics will be particularly emphasized. Its teaching may have previously been left behind or its skills are not up to the current requirements. When evaluating the performance of buildings, a holistic view is important. The building performance is the sum of several factors, and these factors are also dependent on each other. The importance of building services and HVAC-technology increases. Renovation to the existing building stock will be essential, and in some cases must have to consider demolishing an old building. The recent trends of building stock should be integrated for better performing buildings, in the aim to have safe and healthy cost-optimized spaces.

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