Scientific activities in

building and construction

2007 **2008** 2009 2010

A STRONG NATIONAL ORGANIZATION WITH INTERNATIONAL IMPACTS

VTT Technical Research Centre of Finland is a multi-technology contract research organization under the auspices of the Finnish Ministry of Employment and the Economy. VTT's mission is to produce research services to enhance the international competitiveness of companies, society and other customers, and thereby create the prerequisites for growth, employment and well-being.

The main drivers of all research at VTT are: a) rapid information and communication technology as an enabler of new products and business models; and b) the global thrust to reach sustainable development of the society. In addition, research is gradually changing from purely technology oriented R&D to cover research on services and business processes. The same trend is valid also regarding building and construction research.

Building and construction research at VTT has more than six decades of history behind it. Covering practically all fields of building and construction, we are one of the largest building research organizations in Europe. Although VTT is considered being part of the government, 2/3 of the funding is based on competitive contracts with funding agencies like the EU or Tekes, the Finnish Funding Agency for Technology and Innovations, or private companies. An increasing portion of funding is from foreign sources. Being to a large extent exposed to competition on the market, we have developed an agile organization culture always aiming at high international standards of research.

Internal basic funding accounts for about 30% of the VTT budget. This allows us to start investigating new areas, which we ourselves deem to be of rising importance. This funding makes it also possible for us to participate in EU and Tekes funded projects in which only partial funding of the work is available.

Figure 1 illustrates the focus of VTT's current public research activities on building and construction technology. We provide solutions to problems faced by practically all sectors of the stakeholders of the built environment. The key cross-sectoral competence areas are:

- services and business processes;
- information management and simulation;
- eco- and energy efficiency;
- safety, health, and functionality of spaces;
- new and modified materials and products.

In all these areas, the building researchers benefit greatly from the in-house competences of special technologies. Particularly, since abolishing the institute structure in the beginning of 2006, multi-technological projects have become common practice. For example, new services for facility management are being developed jointly by the world leading mobile technology experts; application of building information modeling gets a boost from the expertise of virtual technologies; energy efficiency of the built environment enjoys the availability of in-house renewable energy production technologists; safe and functional building design incorporates advanced simulation techniques, and modified building materials can be developed together with the basic nano-material experts.

SERVICES AN AREA OF INCREASED INTEREST

The role of services is increasing in the whole society. The development of information and communication technologies makes it possible to develop completely new services or make the existing services significantly more efficient. VTT has recently invested in developing ICT-based services and aims at being in a major role in

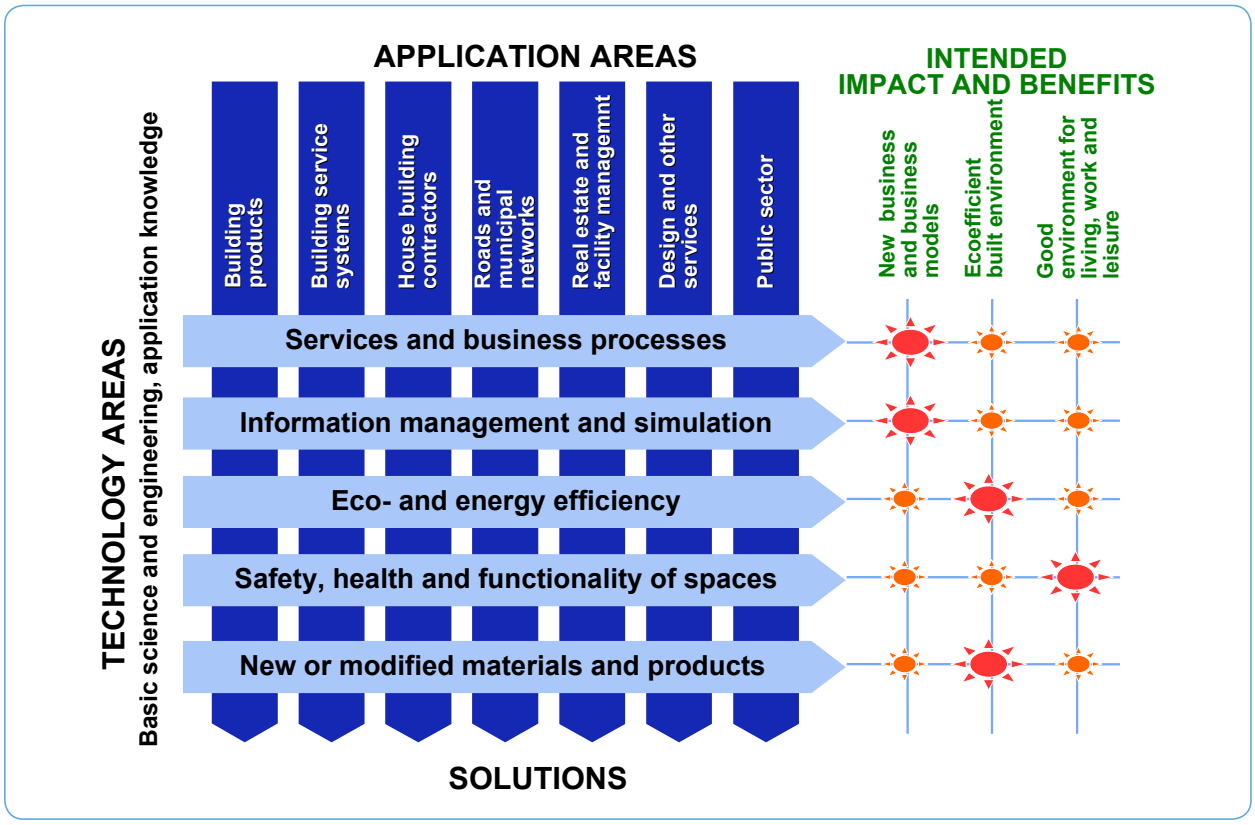


Figure 1. Focus and impact aim of VTT's current public building and construction research activities.

the growing field of service science. The building sector is seen as one of the most potential application areas for new services. The need to improve productivity by technology is evident and, on the other hand, for almost any application there is potential for a large global market.

Our special strength is in combining the expertise of mobile technology with the knowledge of application fields. In this publication a few examples of development projects are given. This sector is also expected to be one of the growing research areas in the future.

LEADERS IN BUILDING INFORMATION MODELING

We have been one of the leading organizations in the world in the research of building product models, or using the contemporary term building information models (BIM) since the late 1980's. When the International Alliance for Interoperability (IAI) was formed in 1996 the topic became internationally important and through Tekes' VERA – Information Networking in the Construction Process 1997-2002 Finland and especially VTT became a major player on the international development and standardization of integrated BIM.

In Finland Building Information Modeling is at the moment making a breakthrough into practice. Our experts are supporting the industry in this transition. Although the integrated BIM technology is functioning sufficiently to support many business cases in the whole sector, there are still technical challenges to expand the coverage and improve the quality of interoperable software applications. However, the most important issues on the technical side are related to the "down-stream" applications – tools that utilize the information in the models – such as different analysis, simulation and process management applications. Especially energy and environmental analysis tools are rapidly becoming a necessity since the only way to reliably evaluate the environmental impacts or lifecycle costs of a unique product, such as a building, are robust analysis and simulation applications. In this area a multi-technology research organization like VTT has the best opportunities to develop methods that require wide expertise in several technical areas.

ECO- AND ENERGY EFFICIENCY

VTT has been a forerunner of R&D in energy efficiency and sustainable construction. For decades we have been in a central role when developing energy efficient building solutions, national regulations or guidance documents for better energy efficiency. Internationally, we have been in key roles e.g. with IEA Annexes developing the basis for novel concepts.

We have also been among the first to study the environmental impacts of the built environment or the sustainability of the built environment in general. The work has extended from material durability modeling to sustainability indexes. Our expectation is that in the future much of this assessment will be applying building information modeling (BIM), making it possible to use the information generated in the design phase also during the use of the building.

PERSONAL SAFETY, HEALTH AND COMFORT

An impartial organization like VTT is well suited for studying performance characteristics concerning health and safety.

Our indoor air studies have been for instance, the basis for national indoor air classifications. The current thrust of research is to extend the work from health issues to comfort as well. Promising results have been achieved, e.g., when developing calculation models for thermal comfort. We believe that when combined with appropriate visualization techniques, we can develop design methods that support the producers and the users of the premises to better meet the end-user requirements.

In the area of safety research, two highlights are worth mentioning. In collaboration with NIST in the USA we have developed fire and evacuation simulation methods which can be used both in design and when analyzing the safety of existing premises. With regards to structural safety, we have developed a unique experimental facility to study the effect of aircraft impact on structural systems. One of the main application areas for this work has been the nuclear power industry with its tough safety requirements.

FUNCTIONAL MATERIALS AND NANOTECHNOLOGY FOR BUILDING MATERIALS

Building material and product research has always been very active at VTT and has had a central role in development of building materials and products in Finland. The key activities cover all areas of material technology, production processes, structural solutions and product development.

The research on building materials and products has its own special characteristic, encompassing aspects such as long service-life of the products, large volumes, a broad fragmented partner network, high environmental impacts, and an impact to all citizens.

The use of advanced materials in the building sector is often based on implementation of results of basic research into construction applications. Typical examples of the topics have been e.g. the application of nanotechnology for improving the surface properties of wood and internal structure of concrete. For improving surface properties on building products, work has been done e.g. in modifying sprayed coatings for better surface hardness and wear resistance, development of self-cleaning surfaces for housing and agricultural facilities as well as indicators for corrosion or mould risks in structures. An example of improving the functionality is development of stimuli-responsive materials for self-healing applications.

The three general trends of functionality, performance and environmental effects are important for material and product research. Functionality means better customer-oriented properties like aesthetics, surface properties, repairability, self cleaning, anti-pollution or other new functionality. Performance typically means better life-time management, longer service life and better control of properties and use. Environmental effects encompass the whole life-span of the materials of products, including the manufacturing, use and demolition. In most cases the use phase is dominant. Due to shortages of material resources, the use of secondary and recycled materials is always a subject of research. Energy efficiency is one of the major research goals in VTT, and therefore it is always taken in account.

THIS PUBLICATION

This publication is a collection of extended abstracts of the research we have carried out recently or which is ongoing at the moment. The targeted readership is the international research community, but we trust the information is of value also to the industry and other stakeholders. Only the public research is included, i.e. proprietary contract work has not been discussed here. The names of key researchers in the work have been given and at the end of the text, the primary contact for the topic of the paper is given.

The primary contact people listed on the next page are currently in charge of setting the direction to the research and taking care that the whole organization delivers what we have promised. We hope this collection of current information helps you to understand what VTT's building research is about and what kinds of competencies we have for serving our customers and for working together with researchers from other organizations.

Matti Kokkala, Prof.
Vice President, Strategic Research
Technology in the community
matti.kokkala@vtt.fi
tel. +358 20 722 4800

Eva Häkkä-Rönnholm, Prof.
Vice President, R&D
Materials and building
eva.hakka-ronnholm@vtt.fi
tel. +358 20 722 4930

Research Coordinators and Technology Managers

Abdul Samad (Sami) Kazi
Research Coordinator
ICT and processes in the built environment
sami.kazi@vtt.fi
tel. +358 20 722 6666

Heli Koukkari
Research Coordinator
Buildings and built environment
heli.koukkari@vtt.fi
tel. +358 20 722 6816

Heikki Kukko, Prof.
Technology Manager
Product and information technology in construction
heikki.kukko@vtt.fi
tel. +358 20 722 6900

Eila Lehmus
Technology Manager
Structural performance
eila.lehmus@vtt.fi
tel. + 358 20 722 6946

Markku Leivo
Research Coordinator
Materials for the built environment
markku.leivo@vtt.fi
tel. +358 20 722 6933

Pentti Vähä, Prof.
Research Coordinator
Service science, business and technology
Research Professor
pentti.vaha@vtt.fi
tel. + 358 20 722 2289

Markku Virtanen
Technology Manager
Building services and indoor environment
markku.virtanen@vtt.fi
tel. +358 20 722 4064

Contents

CONSTRUCTION IT

BUSINESS NETWORKS

BUILDING SERVICES AND FACILITY MANAGEMENT

INFRASTRUCTURE AND GEOTECHNIQUES

MATERIALS AND PRODUCTS

STRUCTURAL ENGINEERING

FIRE SAFETY

RESEARCH UNDERWAY

ANNEX

THE CHARACTERISTICS OF USABLE ROOM TEMPERATURE CONTROL

Sami Karjalainen

The importance of individual temperature control in offices was established in the 1980s and 1990s. Unfortunately, the advantages of individual temperature control have not been well realized in practice, largely because of problems in the usability of thermostats. In this work, usability guidelines for room temperature controls are presented.

INTRODUCTION

Individual thermal control is important for handling individual differences in thermal preference. Several studies have shown that comfort, health and productivity in offices can be improved by individual thermal control. Local controls for temperature are commonly available in modern office buildings. However, office occupants are often still dissatisfied with thermal environments and control options. The overall aim of the work was to improve office occupants' control over room temperature by improving the usability of interfaces of heating and cooling systems.

MATERIALS AND METHODS

Both qualitative and quantitative methods were employed to study office occupants as users of room temperature controls. The work started with qualitative interviews taken in actual context, in the offices of the participants. Twenty-seven office occupants were asked to show and tell us how they use the controls in offices. Next, in a quantitative interview survey, users were studied with a large and nationally representative sample: 1 000 Finnish office occupants answered questions concerning the office environment. Additionally, to simulate the real use of thermostats, controlled experiments were taken.

Based on the results of the preceding user studies, user interface prototypes for room temperature control were next developed with a user-centered approach. Usability tests were conducted several times during the development process.

RESULTS

The interviews taken in the offices of the participants showed that occupants have diverse and fundamental problems with thermostats. Office occupants do not always even know they have a possibility to individually control the room temperature, because the device is not recognized at all, or the purpose of the device remains unclear. Although the room thermostats in offices are simple, symbols in the user interface are often not understood correctly, and it is not always known whether the temperature control is operating or not. In general, users are not satisfied with the feedback they get from the systems. The main reason for many of the problems is that the systems are planned and constructed without a realistic view of their users, i.e. users are supposed to have knowledge they do not have.

The usability tests showed that novice users are able to use the user interface prototypes developed in the work with high effectiveness, high efficiency and high satisfaction. All the 42 participants in the usability tests would like to have that kind of user interface for their own use.

CONCLUSIONS

As the definitive result of the work, usability guidelines for room temperature controls were developed. The usability guidelines are based on the user research performed in this work and the experiences gained from the user interface development. The usability guidelines are: (1) keep occupants in the loop, (2) visibility, identification and reachability of temperature controls, (3) shared temperature controls with heating and cooling systems, (4) acceptable default settings, (5) simplicity of interface, (6) clear way to adjust room temperature, (7) advice on comfortable room temperatures, (8) clear and sufficient feedback after adjustment, (9) fast effect on room temperature, (10) adequate effect on room temperature, (11) informative help, (12) aesthetic design and (13) females as test users in real-life situations.

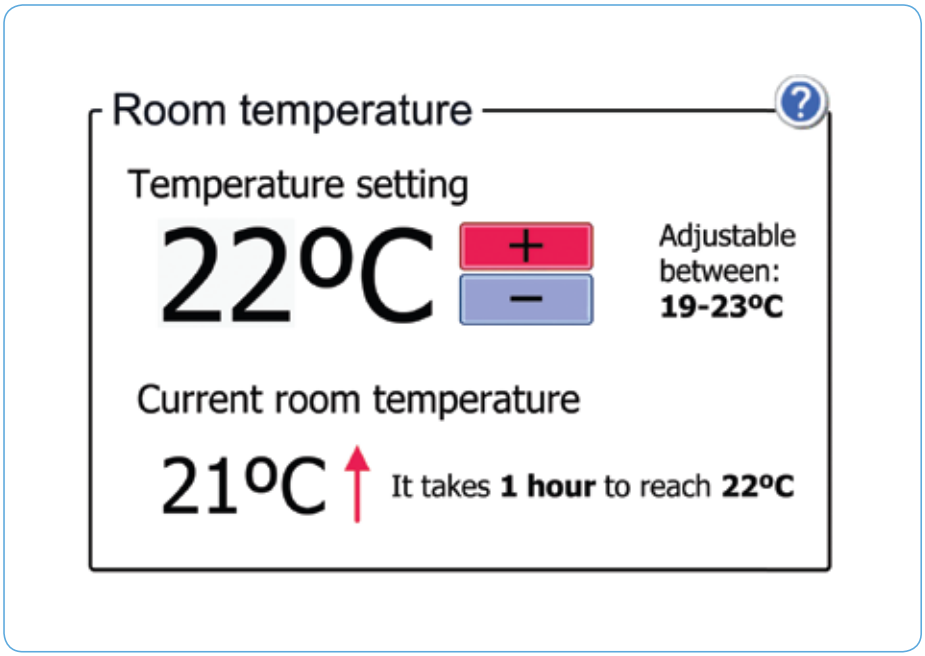


Figure 1. User interface prototype for room temperature control that was developed in the work with a user-centered approach.

EXPLOITATION POTENTIAL

The results of the work help to create user interfaces that users find easy and pleasant to use, which is important in creating comfortable, healthy and productive indoor environments.

ACKNOWLEDGEMENTS

The research has been funded by Tekes, the Finnish Work Environment Fund, the Foundation for Advancement of Technology, VTT and three companies.

REFERENCES

[1] Karjalainen, S. 2007. The characteristics of usable room temperature control. VTT Publications 662.

[2] Karjalainen, S. & Koistinen, O. 2007. User problems with individual temperature control in offices. Building and Environment, Vol. 42, No. 8, pp. 2880–2887.

[3] Karjalainen, S. 2007. Why it is difficult to use a simple device: an analysis of a room thermostat. In Human-Computer Interaction. Interaction Design and Usability, ed. Jacko, J. Proceedings of the 12th International Conference on Human-Computer Interaction (HCII 2007), Part I, Peking, China, 22–27 July 2007, Springer-Verlag Berlin, Lecture Notes in Computer Science, Vol. 4550, pp. 544–548.

[4] Karjalainen, S. 2007. Gender differences in thermal comfort and use of thermostats in everyday thermal environments. Building and Environment, Vol. 42, No. 4, pp. 1594–1603.

[5] Karjalainen, S. & Vastamäki, R. 2007. Occupants have a false idea of comfortable summer season temperatures. In Proceedings of the 9th REHVA World Congress Clima 2007 WellBeing Indoors, eds. Seppänen, O. & Säteri, J. Helsinki, Finland, 10–14 June 2007.

CONTACT

Sami Karjalainen
Senior Research Scientist
sami.karjalainen@vtt.fi
Tel. +358 20 722 4559

REFERENCE VALUES FOR BUILDING MATERIAL EMISSIONS AND INDOOR AIR QUALITY IN RESIDENTIAL BUILDINGS

Helena Järnström

It has been estimated that people spend more than 90% of their time indoors; consequently, indoor air quality (IAQ) is of great importance. Besides causing adverse health effects, poor IAQ may reduce productivity and lead to large economic losses. This research quantified the indoor air concentration levels in new residential buildings in Finland [1].

INTRODUCTION

Building materials are important sources of pollutants indoors. Source control - i.e. lowering emissions from building materials in newly established or renovated buildings - is one way to improve IAQ. Consequently, several labeling systems have been introduced to restrain emissions from building materials [2]. The Finnish Indoor Climate Classification was introduced in 1995 and its revised version in 2000 [3]. Though the classification is voluntary, the use of M1-classified, low-emitting materials has markedly increased and probably improved the IAQ in new Finnish buildings. The objective of this study was to investigate indoor air concentration levels and emissions in new residential buildings that represent the current building practice in Finland and in which low-emitting building materials were used [1].

METHODS

Indoor air concentrations and emissions from structures and interior materials were investigated in eight residential buildings during the time of construction and the first year of occupancy. Volatile organic compounds (VOCs), formaldehyde and ammonia concentrations and emissions as well as temperature, humidity, and ventilation were measured. The standardized Field and Laboratory emission test cell (FLEC) was used for emission measurements [4].

RESULTS

The contribution of the average on-site measured emissions to indoor air concentration was ~550 µg/m^3 (~55% of the measured concentration) for TVOC and ~45/ 40 µg/m^3 (~100% of the measured concentration) for ammonia and formaldehyde in the newly finished building. The TVOC contribution from surfaces decreased to ~200 µg/m^3 in six months whereas the contribution of ammonia and formaldehyde remained about the same. The ceiling structure contributed the most to the concentration levels whereas the contribution from walls was lower than expected on the basis of large surface area. Variables affecting the concentrations of indoor air gaseous pollutants in the buildings were 1) the ventilation system, 2) the floor covering material, 3) the ceiling surface product, 4) the wall surface product, 5) the season, 6) the relative humidity and 7) temperature of the indoor air, and 8) occupancy. The study has been reported in detail in the thesis [1] and references [5] to [8] therein.

DISCUSSION AND CONCLUSIONS

The study confirmed that the Finnish material classification system provides a basis to achieve good IAQ when comparing to the target values for pollutant concentrations given by the classification [3] in real buildings; however, suggestions for its further development are given. For example, the incorporation of target values for VOC groups and critical VOCs in material classification would be advantageous from the consumer's point of view. In addition, supportive testing of material combinations as real structures would be beneficial. Based on the indoor air and emission results, reference values, i.e. "normal" and "abnormal values", were defined for the six- and twelve month-old buildings.

The use of classified building materials did not guarantee good IAQ alone; effective ventilation was also required. To ensure this, the air flow rate recommendations given per floor area presented in the first classification version [9] should be reintroduced.

The contribution of sources other than surfaces was found to be significant. These sources are mainly due to inhabitancy (furniture, cleaning agents, etc.) and the impor-

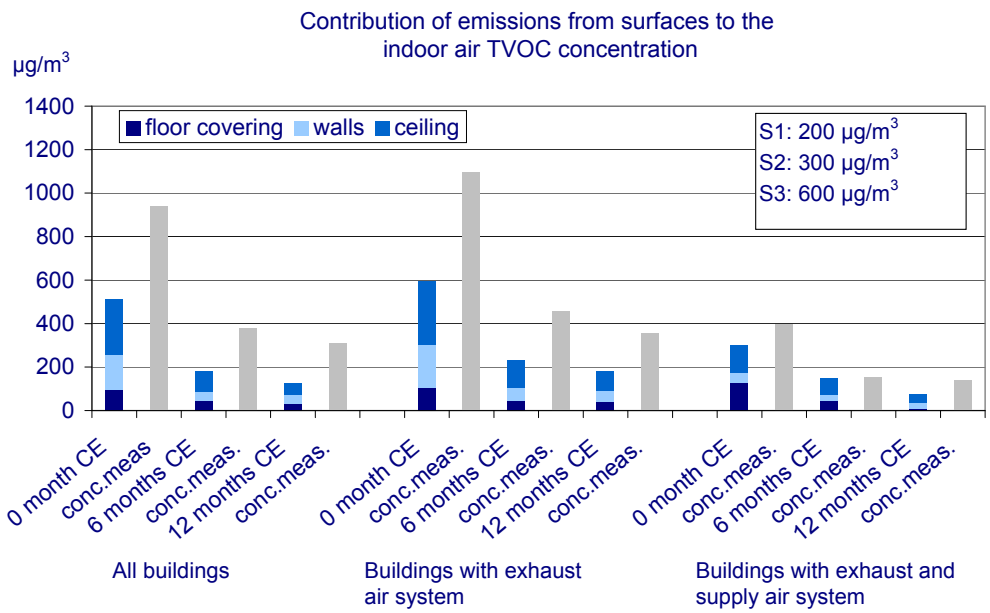


Figure 1. Contributions of the TVOC-emissions (=CE) from surfaces to the indoor air. TVOC concentrations based on the on-site measured emissions, air exchange rates, and the airborne concentrations measured simultaneously (=conc. meas.) in the 0-, 6- and 12-month-old buildings. The S1 target values given in the Finnish Climate Classification are also shown [3].

tance of these sources increased with time. The planned extension of the Finnish classification system to include furniture and cleaning agents is thus welcome.

EXPLOITATION POTENTIAL

The results can be utilized as quality control reference data to ensure proper construction practices and in solving problems related to indoor air. The results can also be used for the further development of material classification.

ACKNOWLEDGEMENTS

The research has been funded by Tekes, The Academy of Finland and VTT.

REFERENCES

[1] Järnström, H. 2007. Reference Values for Building Material Emissions and Indoor Air Quality in Residential Buildings. VTT Publications 672.

[2] ECA, European Collaborative Action. 2005. Harmonization of indoor material emissions labelling systems in the EU. Report No 24. European commission, Office for Publications of the European Communities, Luxembourg.

[3] FiSIAQ. Classification of Indoor Climate 2000. Finnish Society of Indoor Air Quality and Climate, Espoo, 2001.

[4] ISO 16000-10. 2006. Indoor-Air Part 10: Determination of the emission of volatile organic compounds from building products and furnishings-Emission test cell method.

[5] Järnström, H., Saarela, K., Kalliokoski P., & Pasanen, A-L. 2007. The impact of emissions from structures on indoor air quality in newly finished buildings: predicted and levels measured on site. Accepted for publication in Indoor and Built Environment.

[6] Järnström, H., Saarela, K., Kalliokoski P., & Pasanen, A-L. 2007. Comparison of VOC and ammonia emission from individual PVC materials, adhesives and from complete structures. Environment International 34/3, pp. 420–427.

[7] Järnström, H., Saarela, K., Kalliokoski P., & Pasanen, A-L. 2007. Reference values for structure emissions measured on site in new residential buildings in Finland. Atmospheric Environment 41, pp. 2290–2302.

[8] Järnström, H., Saarela, K., Kalliokoski P., & Pasanen, A-L. 2006. Reference values for indoor air pollutant concentrations in new, residential buildings in Finland. Atmospheric Environment 40, pp. 7178–7191.

[9] FiSIAQ. Classification of Indoor Climate, Construction, and Finishing Materials. Publication 5E, Espoo, 1995.

CONTACT

Helena Järnström
Senior Research Scientist
helena.jarnstrom@vtt.fi
Tel. +358 20 722 6123

CONTINUUM MODELING OF QUASI-BRITTLE SOLIDS

Kari Kolari

Modeling failure and behavior of quasi-brittle materials like ceramics and rock is a challenging task. The failure process of quasi-brittle materials is driven by crack propagation, which is difficult to model using the finite element method (FEM). A new continuum damage model, the wing crack damage (WCD) model, was developed for the analysis of brittle failure of transversely isotropic solids. The model was implemented in ABAQUS/Standard FE software. The verification tests revealed the capability of the proposed WCD model in the analysis of brittle materials.

INTRODUCTION

One of the greatest challenges in material failure analysis is the modeling of brittle failure in continuum mechanics. Rock, concrete and ceramics are well known and widely used examples of brittle materials. Formation and unstable growth of cracks due to the material inhomogeneities and external force is considered to be the mechanism of brittle failure.

The finite element method (FEM) is a widely used tool in structural analysis. The elements used in the FE analysis of structures are based on the theory of continuum mechanics. FEM is therefore not well suited to crack propagation analysis, as crack propagation induces geometrical discontinuity in the medium. Despite the contradiction, tools for brittle failure analysis are needed in FEM.

METHODS

The effects of discontinuities due to cracking can be modelled using the continuum damage mechanics (CDM) approach. In CMD the damage-induced anisotropy can be taken into account using a damage vector. The vector represents orientation and size of a crack.

The key issue is the modeling of evolution of damage such, that the predicted failure mechanism fits the mechanism found in the experiments. Especially, modeling of axial splitting under uniaxial compression has been found to be difficult to simulate.

A new continuum damage model, the wing crack damage (WCD) model, was developed for the analysis of brittle failure of transversely isotropic solids. Special attention was paid to the analysis of axial splitting under compression and tensile cracking under tension. The model was implemented in ABAQUS/Standard FE software as a user subroutine.

The proposed method is based on the assumption of pre-existing cracks. The feature can be exploited in studying the effect of orientation and size distribution of pre-existing cracks on the failure of materials. The unilateral response due to crack closure effect is taken into account.

RESULTS

The validity of the proposed WCD model was verified by numerical simulation of five specimens in various loading conditions. The specimens were composed of known transversely isotropic materials like ice and marble, and concrete that was considered an isotropic material.

The behavior of columnar ice cubes both under compression and under tension were verified numerically using the WCD model. The capability of modeling oriented pre-existing cracks was applied in the verification case. Under tension, both the failure modes and the failure loads were in line with the test results.

The numerical simulation of ring tests with Hualien marble revealed the capability of the WCD model in modeling transversely isotropic materials. The capability of modeling-oriented, pre-existing cracks was exploited also in this verification test. The resemblance between the test results and the numerically obtained results was good.

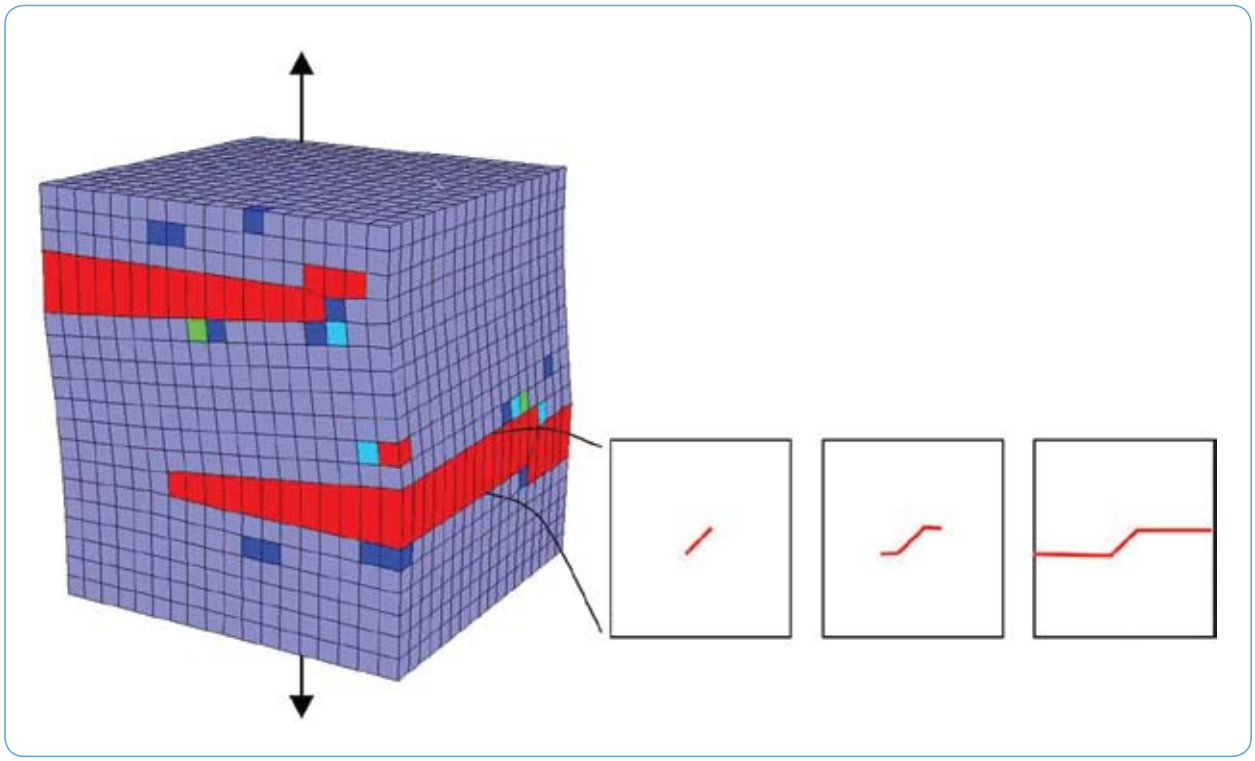


Figure 1. Simulated tensile failure mode and illustration of damage evolution.

DISCUSSION AND CONCLUSIONS

The proposed method was found to be efficient in analyzing the brittle failure of transversely isotropic solids. Both the failure loads and failure modes corresponded well with the reference results. The method can be applied in the analysis of axial splitting and tensile cracking in failure modes.

EXPLOITATION POTENTIAL

New simulation tools are needed in R&D to improve reliability and efficiency of products. The proposed new approach is well suitable for the analysis of e.g. ceramics, ice, rocks and solder materials used in electronic components.

ACKNOWLEDGEMENTS

The author wishes to thank Helsinki University of Technology (TKK) for the two years PhD research position at TKK and VTT for supporting the finalization of the thesis.

REFERENCES

[1] Kolari, K. 2007. Damage mechanics model for brittle failure of transversely isotropic solids, Finite element implementation. VTT Publications 628.

CONTACT

Kari Kolari
Senior Research Scientist
kari.kolari@vtt.fi
Tel. +358 20 722 6682

DEVELOPMENT OF FIRE SIMULATION MODELS FOR RADIATIVE HEAT TRANSFER AND PROBABILISTIC RISK ASSESSMENT

Simo Hostikka

An engineering tool called 'Probabilistic Fire Simulator' (PFS) has been developed for the assessment of fire risks. PFS can be used for Monte Carlo simulations of fire phenomena. In the second part of the work, a new model was developed for the computation of thermal radiation within Fire Dynamics Simulator code, and validated by comparing the model predictions against a series of analytical and experimental results.

INTRODUCTION

An essential part of fire risk assessment is the analysis of fire hazards and fire propagation. In this work [1], models and tools for two different aspects of numerical fire simulation were developed. The primary objectives have been firstly to investigate the possibility of exploiting state-of-the-art fire models within probabilistic fire risk assessments and secondly to develop a computationally efficient solver of thermal radiation for the Fire Dynamics Simulator (FDS) code.

METHODS

In the first part of the work, an engineering tool for probabilistic fire risk assessment was developed. The tool can be used to perform Monte Carlo simulations of fires and is called the Probabilistic Fire Simulator (PFS) [2]. In Monte Carlo simulation, the simulations are repeated multiple times, covering the whole range of variability of the input parameters and thus resulting in a distribution of results covering what can be expected in reality. In practical applications, advanced simulation techniques based on computational fluid dynamics (CFD) are needed because the simulations cover large and complicated geometries and must address the question of fire spreading. Due to the high computational cost associated with CFD-based fire simulation, specialized algorithms are needed to allow the use of CFD in Monte Carlo simulation. By the use of the Two-Model Monte Carlo (TMMC) technique, developed in this work, the computational cost can be reduced significantly by combining the results of two different models [3]. In TMMC, the results of fast but approximate models are improved by using the results of more accurate, but computationally more demanding, models.

In the second part of the work, a numerical solver for thermal radiation was developed for the Fire Dynamics Simulator code [4]. The solver can be used to compute the transfer of thermal radiation in a mixture of combustion gases, soot particles and liquid droplets [5]. The radiative properties of the gas-soot mixture are computed using a RadCal narrow-band model and spectrally averaged [6]. The three-dimensional field of radiation intensity is solved using a finite volume method for radiation. A new model has been developed for the absorption and scattering by liquid droplets [7]. The radiative properties of droplets are computed using a Mie-theory and averaged locally over the spectrum and presumed droplet size distribution. To simplify the scattering computations, the single-droplet phase function is approximated as a sum of forward and isotropic components.

RESULTS

The developed TMMC technique was verified and validated by using different combinations of fire models, ranging from analytical formulas to CFD. The radiation solver was verified by comparing the results against analytical solutions and validated by comparisons against experimental data from pool fires and experiments of radiation attenuation by water sprays at two different length scales.

DISCUSSION AND CONCLUSIONS

The TMMC technique, developed in this work, allows the use of relatively simple and fast models in the collection of the main body of the statistical data of probabilistic fire simulation, while retaining the physical accuracy by running a small set of simulations with more accurate but slower model and introducing a multi-dimen-

sional scaling function to provide a correction to the main data. In the examples presented, the method works well, but there is no general guarantee that the process converges towards the true solution if the fast and slow models differ considerably. The two topics of the work are linked by the numerous applications of FDS as a deterministic model in fire risk analysis. The efficient and robust radiation solver, developed in the second part of the project, will thus benefit the application of the technique developed in the first part.

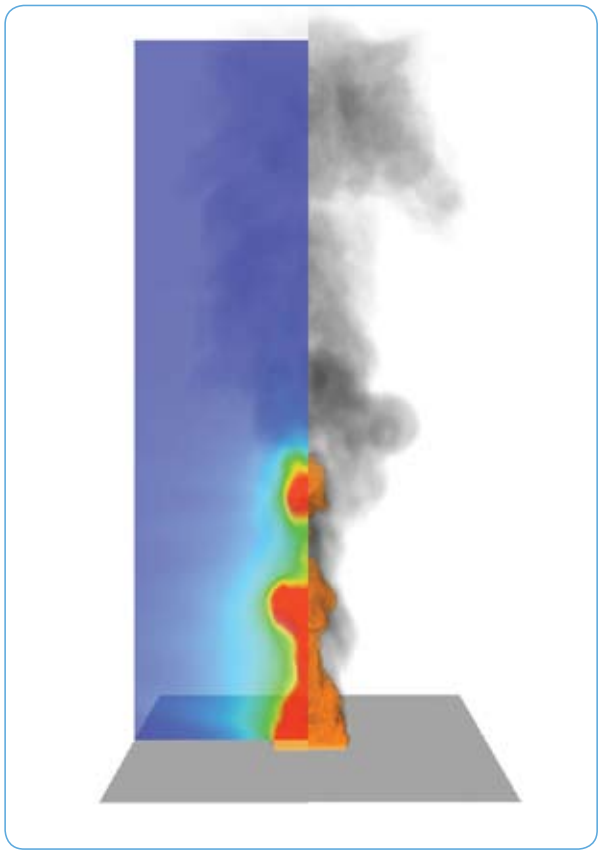


Figure 1. Visualization of a turbulent pool flame using radiative intensity and 3D smoke/flame representation.

ACKNOWLEDGEMENTS

The author thanks the following colleagues for their contribution to this work: Olavi Keski-Rahkonen and Timo Korhonen of VTT and Kevin McGrattan of the National Institute of Standards and Technology (NIST, USA).

REFERENCES

[1] Hostikka, S. 2008. Development of fire simulation models for radiative heat transfer and probabilistic risk assessment. VTT Publications 683.

[2] Hostikka, S. & Keski-Rahkonen, O. 2003. Probabilistic simulation of fire scenarios. Nuclear engineering and design. Vol. 224, No. 3, pp. 301–311.

[3] Hostikka, S., Korhonen, T. & Keski-Rahkonen, O. 2005. Two-model Monte Carlo simulation of fire scenarios. In: Gottuk, D. & Lattimer, B. (Eds.). Proceedings of the Eighth International Symposium on Fire Safety Science. Beijing, China, 18–23 Sept. 2005. International Association for Fire Safety Science. pp. 1241–1252.

[4] McGrattan, K.B., Hostikka, S., Floyd, J.E., Baum, H. & Rehm, R. Fire Dynamics Simulator (Version 5): Technical Reference Guide. Gaithersburg, MD: National Institute of Standards and Technology, October 2007. NIST Special Publication 1018-5.

[5] Floyd, J.E., McGrattan, K.B., Hostikka, S. & Baum, H.R. 2003. CFD fire simulation using mixture fraction combustion and finite volume radiative heat transfer. Journal of Fire Protection Engineering, Vol. 13, No. 1, pp. 11–36.

[6] Hostikka, S., McGrattan, K.B. & Hamins, A. 2003. Numerical modeling of pool fires using LES and finite volume method for radiation. In: Evans, D.D. (Ed.). Proceedings of the Seventh International Symposium on Fire Safety Science. Worcester, MA, 16–21 June 2003. International Association for Fire Safety Science, pp. 383–394.

[7] Hostikka, S. & McGrattan, K. 2006. Numerical modeling of radiative heat transfer in water sprays. Fire Safety Journal, Vol. 41, No. 1, pp. 76–86.

CONTACT

Simo Hostikka
Senior Research Scientist
simo.hostikka@vtt.fi
Tel. +358 20 722 4839

ROADMAP FOR ICT-BASED OPPORTUNITIES IN THE DEVELOPMENT OF BUILT ENVIRONMENT

Satu Paiho, Toni Ahlqvist, Arto Kiviniemi

The built environment provides an increasing sector for application of Information and Communication Technology (ICT) for the benefit of the industry and the users of the built environment. Several related roadmaps have been published in Europe and elsewhere. VTT's roadmap provides a view of the development of both software and hardware applications within the next 10 to 15 years. The focus of the roadmap is in the construction process and finished buildings.

INTRODUCTION

The built environment is a significant part of our national wealth. The built environment is the physical environment created by people. It consists of the buildings and all networks serving the flow of traffic, energy, water, waste and digital information, and the assemblies, equipment and (built) natural elements connected to them [1].

METHODS

The roadmaps were developed in a systematic process which included information collection, identification of technology scenarios and potentials, and formation of the roadmap [1]. The roadmaps were identified and compiled in phased workshops. The first workshop dealt with drivers and technologies, and the second with markets and market actors. The draft roadmap document was evaluated by a small group of external stakeholders. The comments were taken into account while editing the final publication.

RESULTS

The review is presented in the form of four change roadmaps (Figure 1). The "Digital solutions" section presents the development of technologies applied within productions and use of the built environment. The "Operation methods and processes" section presents the changes required and enabled by the new technologies in the operation methods and processes. The "Services" section presents the services enabled by digital solutions and changing operation methods and processes. The "Meta Roadmap" encapsulates the essential ideas of the more detailed sub-roadmaps.

The vision of development prospects in the built environment utilizing information and communication technology is as follows: The technological foundation of the built environment utilizing information and communication technology is based on on-time sharing and utilizing of information. Business is done in networks. This requires compatible processes and operation methods which can utilize commonly available interoperable digital information, such as, building information models and real-time information. These will fulfill the evolving needs of the user or customer and enable good usability and real-time services.

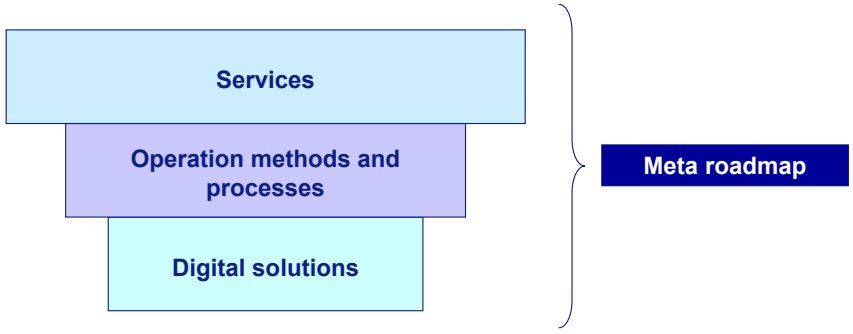


Figure 1. The roadmap structure.

Current state-of-the-art solutions for information and communication technology in the built environment are mainly separate services. Comprehensive customer demand is limited and the suppliers and exploiters of information technology in the built environment are differentiated into nar-

row categories. The service providers offer niche services for specific purposes. Currently there are four state-of-the-art service entities: 1) planning, construction, operation and maintenance services; 2) remote services; 3) security services and 4) new health services. At the moment, the processes used by operators do not yet match the requirements of information modeling applied in the information technology of the built environment. Therefore, model information cannot be fully utilized in the planning and realization of operations. Another area of change for operation methods is the development of commercialization in both technological solutions and in the services packaging them.

In the short term, i.e. 1–5 years, the development paths in the information and communication technology of the built environment will lead towards the utilization of an integrated information model which opens up new ways of connecting products and services. However, the application of information models requires that the integrated information models are understood and explained from the view point of different operators. Products and services utilize user-oriented content production. The services of the built environment are produced with networked operation methods. In the short term, the essential factors will especially include the following four service entities: 1) information model services; 2) data collection, maintenance and management services; 3) information-based additional value services; and 4) the integration of services. The application of information and communication technology in the built environment emphasizes the value of and services targeted at the whole life span of the product.

In the long term, i.e. 5–15 years, the formation of globally integrated operation models will start in planning and production, and large networks will produce services for the built environment. The end-user will be served in the whole design, planning and construction process by offering different mechanisms for visualization, modularization and giving feedback. In the long term, the following service entities will especially increase: real-time building information systems, services based on integrated information models supporting decision-making and operation, experience and health services and automated property assessment services. In the long term, a central factor supporting the change in operation methods will be the applications and tools designed for process management. In this respect, the key solution is found in the applications that utilize visualization and information models and that can be used as references for official building inspection. New kinds of service providers may also be established for the services that exploit information models and integration.

DISCUSSION

The roadmap process helped to recognize five large development paths that will exploit information and communication technology in the future of the built environment. 1) Tools must be developed for the management, analysis and effective use of information to support decision-making. 2) The development of information models, computation methods and computing performance enables more versatile virtual testing of products. 3) The digital and physical worlds are interconnected during the whole life span of a product. 4) Service-based software integration, situation-specific systems, social media and location technologies enable services that are automatically tailored according to users' needs in the built environment. 5) Information modeling of the existing buildings is a significant challenge that requires the development of appropriate methods and technologies.

EXPLOITATION POTENTIAL

The roadmap may be applied by the building services industry as supporting material for developing strategies for transformation of the entire construction sector and those of individual companies. Internally, the roadmap helps the research institute to set research priorities.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Kalevi Piira, Janne Porkka, Pekka Siltanen and Pekka Tuomaala of VTT, and all the other colleagues at VTT who took part in the project workshops. The research was funded by VTT.

REFERENCES

[1] Paiho, S., Ahlqvist, T., Piira, K., Porkka, J., Siltanen, P. & Tuomaala, P. 2008. Roadmap for ICT-based Opportunities in the Development of Built Environment. (In Finnish, English abstract). VTT Research Notes 2427.

CONTACT

Satu Paiho
Senior Research Scientist
satu.paiho@vtt.fi
Tel. +358 20 722 4908

STRATEGIC ACTIONS FOR REALIZING THE VISION OF ICT IN CONSTRUCTION

Abdul Samad (Sami) Kazi, Matti Hannus

The project "Strategic Actions for Realizing the Vision of ICT in Construction", Strat-CON, was a European research project focusing on the development of thematic roadmaps and supporting strategic actions for information and communications technologies (ICT) in the construction industry. Its focus was on value-driven business processes, industrialized production, digital models, intelligent constructions, interoperability, collaboration support, knowledge sharing, and ICT enabled business models.

INTRODUCTION

The construction sector is characterized by delivery of one-of-a-kind product and service delivery through competence sharing between different organizations (some of which may be unknown to others). ICT usage in the sector is limited and lags far behind other manufacturing sectors. The ROADCON project (http://cic.vtt.fi/projects/roadcon) offered a vision for ICT in construction in addition to a set of roadmaps across 12 thematic areas. It did not however provide a means (in terms of research plans) for realization of the vision. The Strat-CON project was initiated to align the ROADCON roadmaps with the main thematic areas addressed by the European Construction Technology Platform's (ECTP, http://www.ectp.org) focus area on processes and ICT. The Strat-CON project furthermore through stakeholder interaction, has identified and developed a set of strategic actions for realizing the vision of ICT in construction.

APPROACH

The main objectives of the Strat-CON project were to identify an overall vision and series of roadmaps supporting realization of the vision for ICT in construction. These were to be supplemented with the definition of a series of short, medium and long term to industry strategic action to support realization of the vision. These strategic actions were to be validated and some of them detailed in a form ready to use as building blocks for research and development, or take-up actions by relevant stakeholders.

Within the project a simple road-mapping template was used to identify the current state, and the corresponding vision (to-be state). A set of key topics in the form of strategic actions were defined corresponding to short, medium, and long-term take up by the industry.

RESULTS

In line with the focus area Processes & ICT of the European Construction Technology Platform, four main thematic groups were identified, each with two corresponding themes:

- Processes: value driven business processes, industrialized production
- Products: digital models, intelligent constructions
- Projects: interoperability, collaboration support
- Enterprises: knowledge sharing, ICT enabled business models

For each of the eight themes, corresponding roadmaps were developed including short, medium, and long-term to industry actions. Each roadmap included key business drivers, relevant business scenarios, and foreseen industrial impacts.

A total of eight thematic roadmaps covering value driven business processes, industrialized production, digital models, intelligent constructions, interoperability, collaboration support, knowledge sharing, and ICT enabled business models respectively were developed. These contained 37 short, 42 medium, and 36 long-term to industry strategic actions. Overall through a series of interactive international workshops, more than 184 research ideas were identified of which 52 were detailed.

DISCUSSION AND CONCLUSIONS

The results of the project have served as an effective means for understanding the current state and corre-

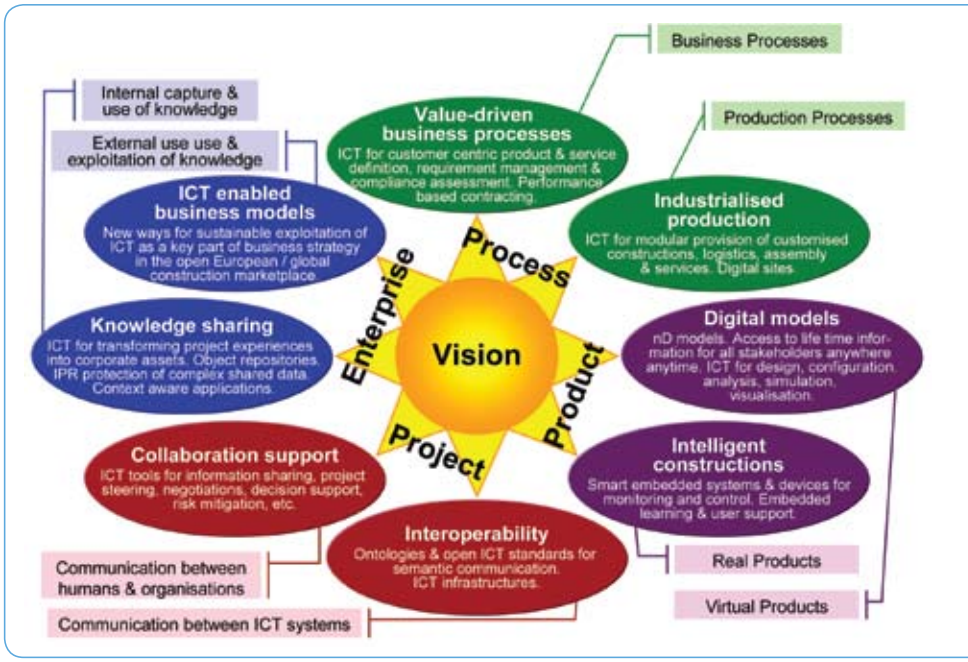


Figure 1. Strat-CON: Main Themes and Corresponding Topics.

sponding vision for ICT in construction. They are currently in use in different countries by different stakeholders including industry, research establishments, academia, and national funding programs. The results are used to benchmark and identify relevant research areas, and at the same time as a possible basis for future funding in areas of national interest.

EXPLOITATION POTENTIAL

The results of the project may be used as a basis for identifying key research that has been done, is currently being done, or will be done. They also serve as a valid mechanism for mapping to different relevant research efforts in different countries as well as mappings to different financial instruments. Through the interactive international workshops, it has been learnt that the results of the project serve as a very strong basis for dialogue and follow-up collaboration.

The Strat-CON project's approach ([3]), has been used in various contexts including road-mapping of configurable products and services, energy efficiency, industrial transformation, university design, strategic planning of organizations, etc. It is noted to be a very simple and at the same time very powerful tool for strategic road-mapping and implementation action planning.

ACKNOWLEDGEMENTS

Key Strat-CON project partners in addition to VTT included Centre Scientifique et Technique du Bâtiment, and Vienna University of Technology whose active contributions are acknowledged. The project was furthermore supported by the ECTP, and its results were validated in interactive workshops held in Austria, Finland, France, South Korea, Spain, the United Kingdom, and the United States of America. The project has been partially funded through the collaboration of different national programs promoting sustainable construction and operation of buildings. This work was funded by Tekes and VTT.

REFERENCES

[1] Public website of Strat-CON project, 2008, www.strat-con.org

[2] Zarli, A., Kazi, A.S., Hannus, M., Bourdeau, M., Ekholm, A. & Andersson, R. 2007. A Strategic and Comprehensive Vision for Future R&D in Construction, Proceedings of the 24th International CIB W78 Conference, Maribor, Slovenia, 26–29 June 2007, pp. 263–270.

[3] Kazi, A.S. 2007. Strategic Roadmapping and Implementation Actions, Hands-On Knowledge Co-Creation and Sharing: Practical Methods and Techniques (eds. Kazi, A.S., Wohlfart, L. & Wolf, P.), pp. 539–556.

[4] Zarli, A., Kazi, A.S., Hannus, M. & Bourdeau, M. 2007. Strat-CON: A Strategic Vision for Future R&D and Innovation in ICT-enhanced Construction, Proceedings of the 13th International Conference on Concurrent Engineering, Sophia Antipolis, France, 4–6 June 2007, pp. 67–76.

[5] Kazi, A.S., Hannus, M., Zarli, A., Bourdeau, M., Martens, B. & Tschuppik, O. 2006. Towards Strategic Actions for ICT R&D in Construction, eWork and eBusiness in Architecture, Engineering and Construction (eds. Martinez, M., & Scherer, R.), pp. 31–39.

CONTACT

Abdul Samad (Sami) Kazi
Chief Research Scientist
sami.kazi@vtt.fi
Tel. +358 20 722 6666

FUTURE SUSTAINABLE BUILDINGS AND COMMUNITIES

Mia Ala-Juusela, Matti Hannus, Satu Paiho, Markku Virtanen

The building and construction sector is one of the key sectors for sustainable development. The construction, use and demolition of buildings generate substantial social and economic benefits to society, causing at the same time serious environmental impacts created by the use of energy, water and other natural resources, by land use and by waste generation. To achieve a sustainable community, these impacts have to be minimized. Any sustainable solution needs to fulfil the demands of ecological, economical as well as social sustainability.

INTRODUCTION

The Future Building Forum (FBF) workshop on "Future Sustainable Buildings and Communities" took place in March 2007 in Espoo, Finland. There were 34 participants from different International Energy Agency (IEA) countries and Implementing Agreements, mostly from ECBCS (Energy Conservation for Buildings and Community Systems), from companies, universities and research organizations. The aim of the workshop was to identify R&D needs and new business opportunities in the scope of sustainable buildings and communities. The expected outcome of the workshop was a vision and a roadmap towards the vision concerning the energy system and the most important components of this system. The timeframe for the outlook is until 2030.

RESULTS

The FBF Workshop resulted in the following vision statement:

"By the year 2030, a powerful and enlightened consumer surrounded by a culture of energy and environmental awareness can select appropriate spaces provided by one business partner offering life-cycle performance based services in a low-energy-consuming built environment that produces carbon free energy according to demand."

There are currently several things working for the introduction of more sustainable buildings and communities, but still many barriers obstruct the way and must be tackled before a real breakthrough. Taking into consideration the recognized drivers and barriers, roadmaps towards the target (research priorities) were presented for four important areas of attention (see also Figure 1):

- end-users: (social point of view)
- energy and environment: (ecological point of view), the focus in the roadmap is on energy issues
- market and business: (economical point of view)
- solutions: different products and solutions are placed differently according to their ability to fulfill the three criteria. The final goal is a solution that fulfils all three criteria in a balanced way.

Many enabling technologies already exist to realize an economic solution for an energy efficient community that operates according to owners' expectations and users' needs. To move towards an energy efficient and environmentally sustainable building and community, some technologies still need to be developed, especially for compact, building-integrated storage of heat, cold and electricity. The developed solutions should be intuitive and robust. The final goal should be integrated and performance-based solutions for energy efficient and environmentally friendly buildings and communities that support sustainability and produce carbon-free energy according to demand.

To improve the social acceptability of the sustainable buildings and communities, information mechanisms have to be improved (e.g. energy issues should be integrated in the education, and policy makers should be provided with concise and accurate information). Energy terminology has to be harmonized internationally. Attractive financial credits for sustainable buildings should be introduced. Reporting buildings must be developed by virtualization and visualization of energy use and per-

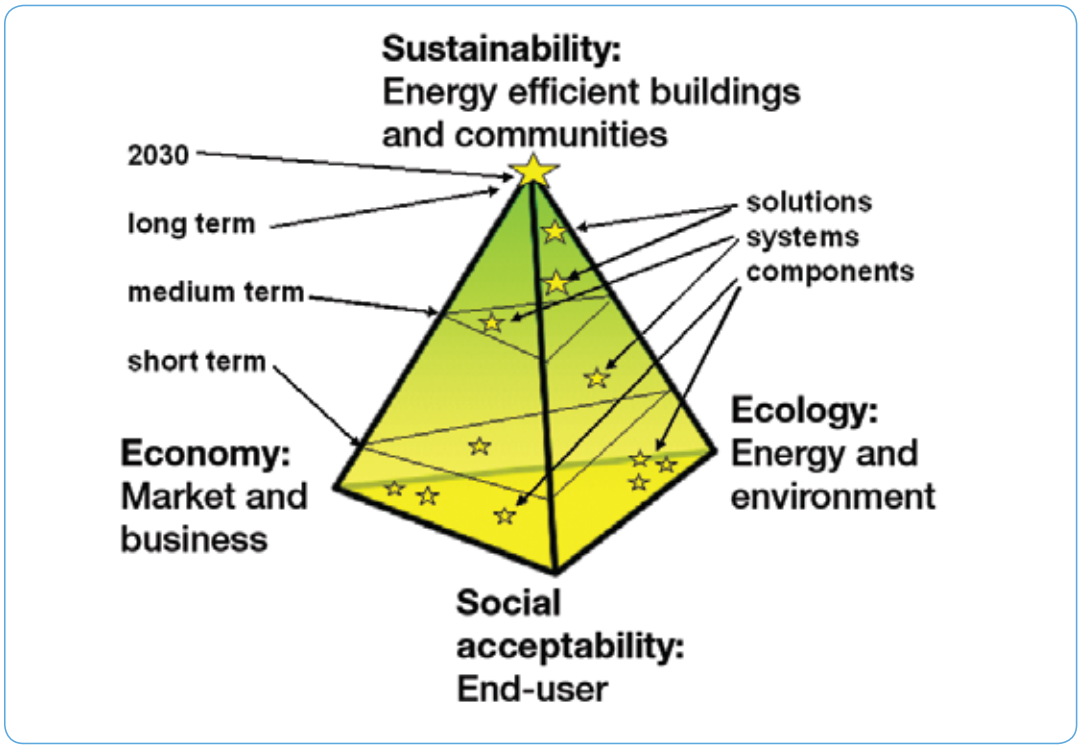


Figure 1. The three aspects of sustainability [1].

formance with Information and Communication Technology (ICT). Demonstration and lighthouse projects act as important information channels.

From the market and business point of view, the development has to lead from partial-optimized-first-cost-based-business towards life-cycle-performance-based business models. The applicability of the solutions to the circumstances in developing countries should also be investigated to achieve a global market and global sustainability.

DISCUSSION AND CONCLUSIONS

The common view of the FBF Workshop participants was that, to move towards an energy efficient and environmentally sustainable building and community, the emphasis has to shift from technology development to market development. New thinking is required to move from the current way of making first-cost-based-business towards life-cycle-performance-based business. This will benefit both the consumer and the environment as well as the industry. There is still room for technological development, too.

EXPLOITATION POTENTIAL

The results of the workshop have been and will be exploited by IEA ECBCS and the participating organizations in directing and planning their future research and development activities.

ACKNOWLEDGEMENTS

The authors wish to thank the participants of the workshop for their active contribution to the outcome: the vision and roadmap for future sustainable buildings and communities. The compilation of the workshop results has been funded by VTT.

REFERENCES

[1] Virtanen, M. et al. (ed.). 2007. Vision and Research Roadmap for Future Sustainable Buildings and Communities. IEA Future Buildings Forum Think Tank Workshop, Finland.

CONTACT

Mia Ala-Juusela
Senior Research Scientist
mia.ala-juusela@vtt.fi
Tel. +358 20 722 6947

REVIEW OF SUSTAINABLE BUILDINGS RESEARCH

Pekka Huovila, Mia Ala-Juusela, Tarja Häkkinen, Heli Koukkari

Sustainable buildings meet the needs of their present and future users in an environmentally sustainable way. This study describes good international practices and new trends in research, development and technologies for sustainable buildings. Recommendations on sustainable building research are given based on analysis of collected background information and interviews of a wide international expert network.

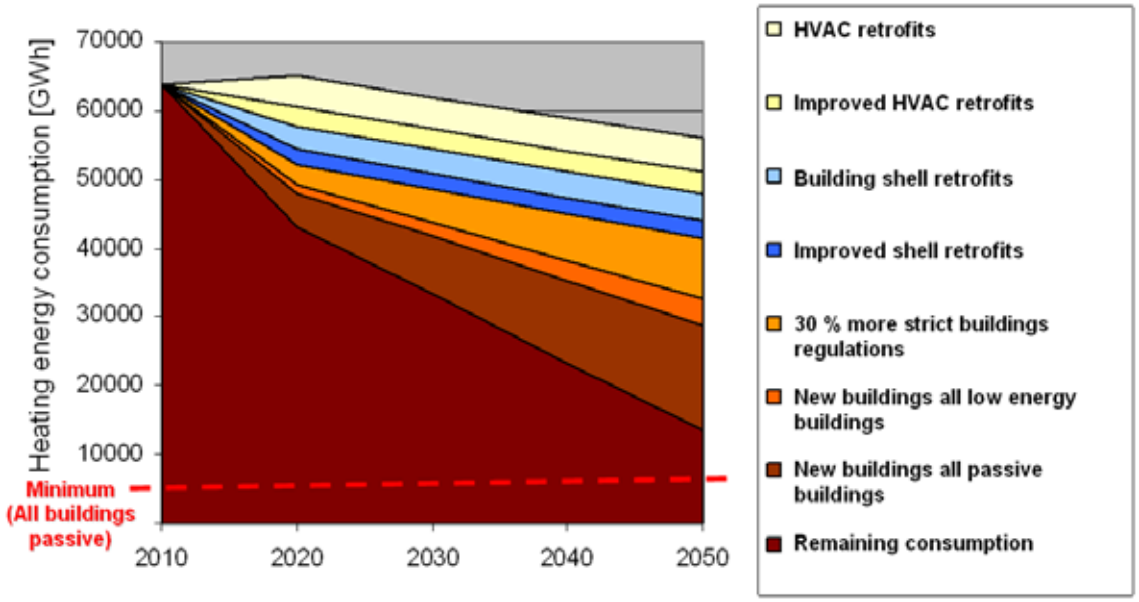
INTRODUCTION

Tekes, the Finnish Funding Agency for Technology and Innovation, commissioned four studies to direct research activities in their Sustainable Community technology program for 2007-2012. The commissioned topics were sustainable communities, sustainable buildings, energy and well-being. This study deals with sustainable buildings. It proposes promising research topics to be supported in the Finnish national technology program.

APPROACH

The selected approach was

- to study information about recent sustainable building research
- to analyze trends in Sustainable Building conferences 1994-2008
- to interview international sustainable building experts
- to exchange information between three other commissioned studies carried out by HUT
- to brainstorm the conclusions together with VTT experts.



Tuominen, P. (2008) The potential effects of low energy buildings on the Finnish national economy. Master's Thesis at HUT/VTT.

Figure 1. The effect of different energy saving measures.

RESULTS

The results were documented as PowerPoint slides with additional text notes. They were presented to a wide national audience in August 2008, and the study was completed in autumn 2008 after the international SB08 Conference in Melbourne.

The following general recommendations were given as the key project findings

- all construction should follow the sustainability principles from now on
- minimize heating and electricity consumption in all buildings
- provide hard facts and marketing arguments about sustainable buildings for demanding clients.

The following objectives are proposed to be obtained through future research and funding

- zero energy and energy positive building technologies at a competitive price
- methodologies for total optimized life cycle performance that meets the needs of end users
- indoor conditions, adaptability, usability, comfort, safety and deterioration risk
- suitability to the society and citizens
- solutions that fit with the existing built environment
- easily refurbished and well maintainable
- renovation procedures that lead beyond the existing quality
- sustainable building processes
- detailed description of tasks and tools
- buildingSMART, business logic, new business models, risk management
- passive solutions
- to reduce the need for additional electricity consuming devices with the help of good design with outdoor or earth cooling and heating, shading, orientation etc.
- assessment methods for environmental impacts, life cycle economy and sustainable development based on a holistic scientific foundation
- scenario development for facilities in future sustainable communities
- guidance and control mechanisms, impacts, cost and value, technologies and performance.

In addition, the following topics were identified to be considered

- user behavior, sustainable lifestyles, horizontal studies involving social sciences competence and understanding of the human technology interface
- technologies that support sustainable development and energy conscious decision making.

DISCUSSION AND CONCLUSIONS

The analysis of the Sustainable Building conferences (1994 to 2008) was unique and provided interesting information about the trends in research on sustainable buildings. Interviews with an international expert network provided a fresh outlook to weak signals and raise potential future research topics.

EXPLOITATION POTENTIAL

The proposed research recommendations are to be implemented in the Tekes technology program, thus leading to new research knowledge, processes and tools, business opportunities and improved sustainability of the built environment.

ACKNOWLEDGEMENTS

The author wants to thank Tommi Rissanen, now working at Ramboll, for collecting the background information to the study, Pekka Tuominen for his MSc work and all VTT experts contributing to internal brainstorming. The research has been funded by Tekes and VTT.

CONTACT

Pekka Huovila
Chief Research Scientist
pekka.huovila@vtt.fi
Tel. +358 20 722 5903

BUILDING SERVICES ROADMAP

Satu Paiho, Toni Ahlqvist, Erkki Lehtinen

Building service systems are becoming an operating system for the whole building. In many cases the share of building services in the cost of buildings is increasing. In 2007 VTT published the first technology roadmap of building services in Finland. The main outcomes of the systematic road-mapping process are presented in this paper.

INTRODUCTION

Building services create customized, user-oriented and controlled conditions for the various activities taking place in buildings and other facilities. These include, for example, the supply of air, water, heat, energy, lighting and information, electrically controlled security and access services, as well as other services that are based on the movement of matter, electricity, sound waves etc. Building services consist of technical systems and equipment, as well as services relating to them. [1, 2]

METHODS

The roadmaps were developed in a systematic process which included information collection, identification of technology scenarios and potentials, and formation of the roadmap [1, 2]. First, references were collected and analyzed. Then, three workshops took place in which experts in different sub-sectors of building services technology participated and thereafter provided written material for the formation of the roadmaps. The roadmap was then compiled by a smaller core team. The draft report was evaluated by a selected group of customers. The comments were then taken into account while preparing the final version of the roadmaps and the report.

RESULTS

The building services roadmap consists of six separate roadmaps (Figure 1). The 'meta-roadmap' summarizes the results of the entire process [1]. The sub-level roadmaps are for 1) building services systems and equipment, 2) for networked building services, 3) for building services life-cycle design processes, 4) the interfaces from building services to both buildings and their infrastructure, and 5) for the business models and service concepts of building services.

Today building services are mainly based on individual technology-driven solutions from different suppliers, from which different designers then compile the building-specific systems. Inter-equipment communication is nearly nonexistent, and the equipment is not compatible with each other. The building services market is fragmented into highly specialized fields, and its basic mechanism is driven by sub-optimization. The development of service business models is not very advanced.

In the short-term (1–5 years), the role of low-exergy technology, low-energy buildings, product modeling and other ICT, as well as measurement and sensor technology, will be emphasized in the development of modular building services in particular. In products and services, different ways of packaging and branding user-oriented services, solutions for non-disruptive repairs and maintenance, as well as integrated user interfaces and other integrated solutions, will be of greater significance. In market activities, the emphasis will be in the development and supply of different service concepts.

In the long-term (5–15 years), the focus will be on adaptation to building information modeling applications, low-exergy technology, integrated infrastructure and the utilization of sensor networks and new materials. Product solutions underline integrated and user-oriented services, which are assembled by collecting the required information from wireless equipment and supported by inconspicuous and adjustable user interfaces. The main business ideas in the market focus on comprehensive deliveries and packaged services. A competitive business plan will be based on managing the service performance and productivity of a real estate.

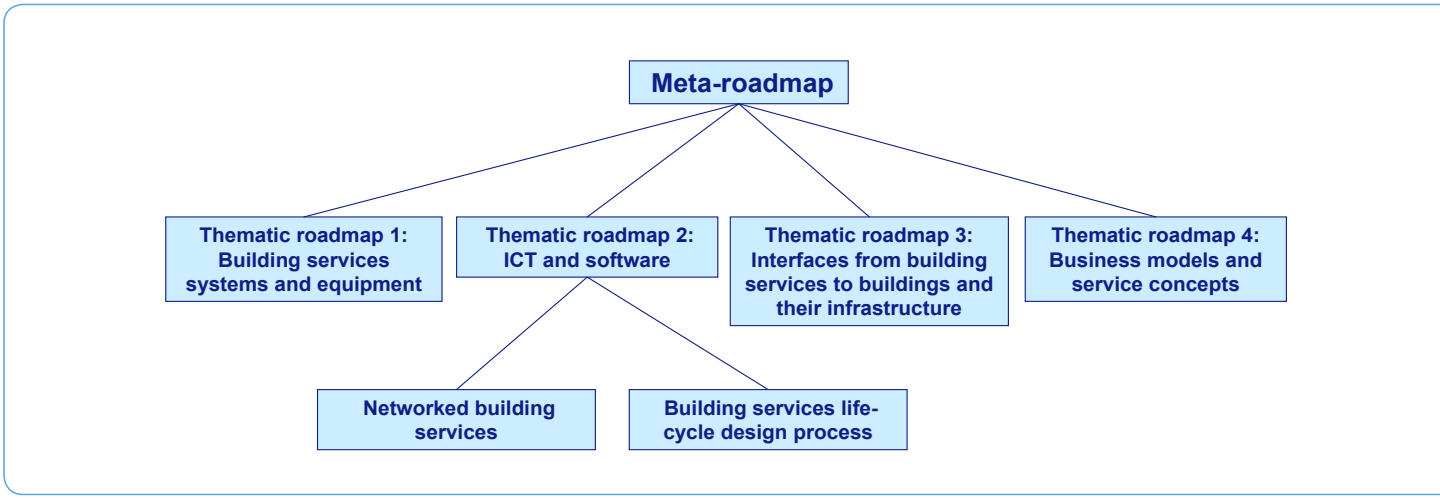


Figure 1. The general structure of the roadmap.

DISCUSSION

The roadmap process helped to recognize seven large development paths of building services:

1. The markets will polarize into a "low-end" market filling the minimum requirements, and a customer-oriented "high-end" market.
2. In construction, there will be a shift from contracting and price competition towards property and service competition.
3. Information and communication technology (ICT) will be tightly integrated into operation and control of building services as well as into life-cycle management.
4. Increased customer requirements and possibilities provided by improved financial situations will increase building services technologies and related services in buildings.
5. User requirements will be better taken into consideration in design of building services systems and equipment and in the development of user-interfaces.
6. Aging people in aging buildings are a great challenge. Flexible renovation services and new product and service solutions can help to meet this challenge.
7. Tightening eco- and energy-efficiency requirements necessitate efficient and economical use of raw materials, recycling, improvement of eco- and energy-efficiency of buildings and building services, utilization of low-exergy energy sources, and interfacing to regional and local distributed energy production.

EXPLOITATION POTENTIAL

The roadmap may be applied by the building services industry as supporting material for developing company strategies. Internally, the roadmap helps the research institute to set research priorities.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Jari Laarni, Kari Sipilä, Pekka Ala-Siuru and Tommi Parkkila of VTT, and all the other colleagues at VTT who took part in the project workshops. The research was funded by VTT.

REFERENCES

[1] Paiho, S., Ahlqvist, T., Lehtinen, E., Laarni, J., Sipilä, K., Ala-Siuru, P. & Parkkila, T. 2007. Building services road-map. Technologies and markets. (in Finnish, English abstract). VTT Research Notes 2379.

[2] Paiho, S., Ahlqvist, T. & Lehtinen E. 2008. Building Energy and Environmental Issues in a Finnish Technology Roadmap of Building Services. Proceedings of The First International Conference on Building Energy and Environment 2008 (COBEE 2008), Dalian, China, 13–16 July 2008, pp. 2277–2283.

CONTACT

Satu Paiho
Senior Research Scientist
satu.paiho@vtt.fi
Tel. +358 20 722 4908

TOWARDS INDIVIDUALITY - QUALITY CHANGES IN HOUSING PRODUCTION

Terttu Vainio, Erkki Lehtinen, Liisa Jaakkonen

The technical quality of residential buildings has been developed on many fronts. Material and technology development cannot be seen by occupants. Architecture and design development can be seen by occupants and also by people walking in new areas. Better technology solutions are typically of low cost when compared with costly parking house and façade solutions.

INTRODUCTION

This report provides a summary of the changes that have taken place in the construction operating environment, housing construction and apartments from 1990-2006 and of the way in which they are reflected in the safety, healthiness, environmental qualities, functionality and pleasantness of new residential buildings. The Quality Changes in Housing Production 1990–2015 is an environment cluster project [1].

MATERIALS AND METHODS

The research material consisted of statistics, comparison pairs, expert interviews and literature. Statistics were used to describe as broadly as possible the changes that have taken place in the structure of demand and product properties. The resulting picture was supplemented by examining the changes by means of six comparison pairs. Literature was used to provide a picture of the changes that have taken place in the housing construction environment from 1990–2006 and an overview of future challenges.

CHANGES IN ENVIRONMENT

The economic recession of the early 1990s was an ordeal for capital-intensive sectors and sectors serving them, such as new building construction. The 1990s may be characterized as a decade of unification, cooperation and internationalization. National-level re-organizations of companies had already occurred in the sector, and the time of Nordic and, to some extent, European level reorganizations had arrived.

In the last few years construction has been driven strongly by the change in regional structure and internal migration, which concentrates population in appealing cities and surrounding municipalities.

CHANGES IN PRODUCTS

New residential buildings are safer, healthier and more pleasant than before, and their functionality and environmental properties are better. The changes in housing construction are the result of several factors. In residential buildings and apartments, the changes stem from the wishes expressed by customers, and it has been possible to address these thanks to a broader supply of products and customers' increased wealth. Efforts have been made to improve the environmental properties and healthiness of buildings during their lifetime and to make new apartments suitable for all user groups.

COSTS OF CHANGES

The effect of the changes on the price per square meter in apartment blocks varies from 300 euros to 650 euros. Some changes concern all types of housing construction while some are closely connected with location. With respect to environmental properties, for example, costs will be significantly higher as a result of soil replacement and piling, if the building is erected in a former industrial area or on soil with poor load-bearing capacity. Location can also place special requirements on facades and courtyard structures.

Factors increasing functionality costs include the location of the building in an area where an underground or multi-storey car park is required for parking. Building a lift as new facility increases the square meter price considerably. Other factors contributing to functionality are the apartment's materials and fittings, the quality of which has improved and very expensive products have become more common.

EFFECTS OF CHANGES ON LIFECYCLE COSTS

Many of the changes have improved the functionality and pleasantness of apartments, which in terms of lifespan costs only shows as an investment without affecting maintenance costs.

Maintenance costs have been reduced for instance by improved thermal insulation, energy-effective household appliances, water-saving sanitary equipment and structures improving moisture resistance. Higher maintenance costs result from new electrical equipment, such as lifts, car heating outlets, under floor heating and heat recovery systems.

CONCLUSIONS

The most important guidance for the future is that housing construction must be developed as a whole, not one single aspect at a time. In housing construction it is important to pay attention to prevention of climate change and at the same time be prepared to it´s effects. It is also important to add cost awareness and effectiveness. The biggest technology challenge is to remodel building service systems in housing construction. Also it is important to be aware of health and safety issues.

ACKNOWLEDGEMENTS

The authors wish to thank the members of the project steering group: Harri Hakaste, Raija Hynynen, Timo Saarinen and Erkki Laitinen from the Ministry of the Environment, Alpo Uski from the State Housing Fund and Jukka Pekkanen from the Construction Industry Association and colleagues Hannu Kauranen, Eero Nippala and Kim Närhi from the Tampere University of Applied Sciences who also contributed to collecting housing-specific data.

The work was funded by the Ministry of Environment and VTT.

REFERENCES

[1] Vainio, T. 2008. Towards individuality - Quality Changes in Housing Production 1990–2005. (In Finnish). VTT. www.vtt.fi/inf/julkaisut/muut/2008/VTT_asuntotuotannon_laatumuutokset.pdf.

CONTACT

Terttu Vainio
Senior Research Scientist
terttu.vainio@vtt.fi
Tel. +358 20 72 3419

LIFE CYCLE MODELS IN BUILDING SERVICE TECHNOLOGY

Ismo Heimonen, Markku Mikkola, Tapani Ryynänen

There is a need for advanced life cycle service models based on an options selection framework. Five such types of models for indoor environment and building services were developed in the context of the CUBENet project.

INTRODUCTION

Customer-focused building services and service technologies for the life cycle are changing the operations and networks of companies. New requirements and value-creating mechanisms fall extensively on the various fields of business and different stages of projects. Output-based procurement methods affect the risk transfer and combination of tasks in a new way. Competitive procurement procedures and output-based long-term contracts enable new business strategies. Additionally, international consideration has broadened views on development.

APPROACH

The project entitled "Life Cycle Models in Indoor Environment and Building Services (CUBENet)" was comprised of several tasks including procurement, measurement and verification (M&V), risk management, contract documents, business models. Several case studies were done, particularly in testing the M&V methods in existing building stock, in the development of the risk assessment tool and the CUBENet life cycle cost calculation method, as well as in the generation of the contract model templates.

BACKGROUND

The models developed in the project were selected using a so-called option selection framework of thinking in which the construction project is divided into three subsets based on the size and scope of the target, the service provider's tasks of the project, and the payment base (Figure 1). These subsets are independent of each other; by combining them, other models can be formed alongside the main models defined. Five life cycle models were created:

1. Full responsibility building life cycle service
2. Full responsibility supply of building service technology
3. Life cycle service of building service technology renovation
4. Building service technology renovation with competitive dialogue
5. Savings-funded building service technology renovation.

RESULTS

A set of tools was applied for investigating life cycle models. These included the following aspects.

Service level descriptions: In order to set targets, service level descriptions were created for building services technology services that are also presented as an independent part of facility management services. In the future, more building service technology services that meet life cycle demands will be introduced to the market.

Risk management: Methods in risk sharing and assessment were developed for risk recognition and management. To assess the success factors of projects, corresponding assessment tables were drawn to help recognize the special features of successful projects.

Procurement and contract models: All life cycle models in building services technology accentuate cooperation between contractual parties. This cooperation starts in the bidding phase and continues throughout the service stage to the termination of the contract. In life cycle models in building services, the contract acts as the basis for successful cooperation.

Verification and measurement: The project provided instructions on agreeing on the measurement and verification tasks and methods and taking implementation into account as demands of the building automation system. Further, methods and tools were developed for a partly

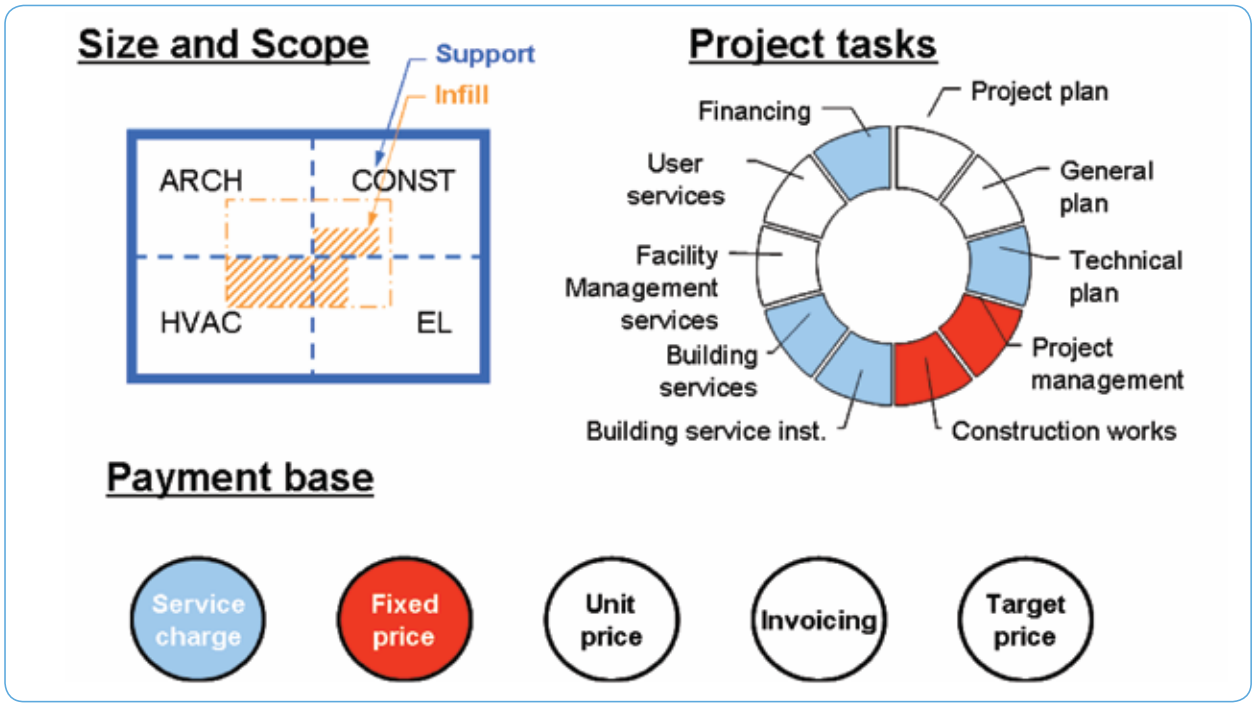


Figure 1. Options in different life-cycle models.

automatic and, if necessary, manual operational measurement utilizing a building automation system.

Comparison of life cycle economy: A calculating tool is needed to perform a rough comparison between a project produced with life cycle services and a project implemented with a traditional method.

DISCUSSION

The CUBENet project has acted as an ice breaker in the field of building services. It has introduced the life cycle paradigm to the experts in the field in a very serviceable manner. Strong co-work between scientists and representatives of Finnish companies and municipalities has taken place. It has not only taken into consideration the needs of experts in building service technology, but also communicated the needs of cooperation to building managers, both in the private sector and in the municipalities. Furthermore, considering the whole life cycle of the building, co-operation between other sectors in construction, from the design team to the property and facilities management operators, is essential.

ACKNOWLEDGEMENT

The research work was performed in cooperation with Helsinki University of Technology and Motiva Oy. The cooperation and funding support provided by Tekes and the 17 participating companies is gratefully acknowledged.

REFERENCES

[1] Heimonen I. et. al. 2007. Three papers in CLIMA 2007 Well being Indoors, 9th REHVA World Congress, 10–14 June 2007, Helsinki. Proceedings, Vol. 3. FINVACry. 1) Life cycle models in building services technology. pp. 437–444. 2) Tools for life cycle models in building service technology. pp. 445–452. 3) Risk management for planning and use of building service systems. pp. 485–494.

[2] Pulakka, S., Heimonen, I., Junnonen, J.-M. & Vuolle, M. 2007. Life cycle costs of building services. VTT Research Notes 2409.

[3] Mikkola, M. & Ryynänen, T. 2007. Business models and life cycle building services. VTT Research Notes 2410.

CONTACT

Ismo Heimonen
Senior Research Scientist
ismo.heimonen@vtt.fi
Tel. +358 20 722 4907

NATURAL HAZARDS TO INFRASTRUCTURE IN A CHANGING CLIMATE

Lasse Makkonen, Maria Tikanmäki

Methods of the extreme value analysis have been developed and regional climate model simulation data analyzed in order to reveal the effects of global climate change on the built environment. The results show that many adaptation measures are required in structural design and land use planning, as well as in upgrading the transport system.

INTRODUCTION

Global climate change will affect not only the mean climate but also the return periods of extreme events. Significant climate change is predicted by the global climate models already within the typical design life-time of infrastructure. Therefore, the first step in the adaptation to climate change must be that engineering practices, recommendations and building codes are re-evaluated based on predictions of the probabilities of extreme events in the future climate.

METHODS

A new probabilistic method has been developed to estimate the return periods of natural hazards [1-3]. This was necessary because the commonly used theoretical extreme value distributions are not valid when analyzing very rare events, and because theoretical foundations for the so called plotting positions have been missing.

The new statistical methods have been applied to evaluate the effects of climate change on the occurrence of natural hazards [4, 5]. The data are from simulations by the Nordic regional climate model of the Swedish meteorological and hydrological institute. Extreme events were selected from the simulated climate data and analyzed, as well as extrapolated to the 50 year return values.

RESULTS

Various problems with the commonly used extreme value analysis methods have been revealed and corrected [1-3]. It was also shown that the plotting positions of the extreme value analysis are independent of the parent distribution [3]. An improved method to fit a distribution to the plotted data has also been developed.

The new statistical methods have been applied to the analysis of simulated climate data. Some examples of the results are shown in Figures 1 and 2 for changes from the period 1961-1990 to 2071-2100.

Qualitatively, the most significant results of these simulations are:

- Short-term precipitation extremes increase in Finland by 25 - 50%.
- No significant changes in the extreme wind speeds are projected, except on the Southern coast. In Denmark and Southern Sweden extreme wind speeds may increase as much as 20%.
- Summer extreme maximum temperatures will rise by about 5°C and winter extreme minimum temperatures by about 10°C in Finland.
- The extreme snow load will be reduced by 50% in Southern Finland but increase in some parts of the country.
- The intensity of extreme snowfalls will increase in spite of the general reduction in snow.
- The climate will become wetter, so that corrosion of steel and decay of wood will increase.
- The number of freeze/thaw cycles will increase in the cold areas and decrease in the warm areas.
- Driving rain will increase considerable.

DISCUSSION AND CONCLUSIONS

Using the conventional methods of extreme value analysis typically result in underestimation of the risk. Adoption of the new methods developed at VTT will thus improve the safety of the built environment.

The new climate simulations showed that several adaptation measures to global climate change are necessary. The changes in the extreme temperatures suggest the possibility to reduce the maximum capacity of heating

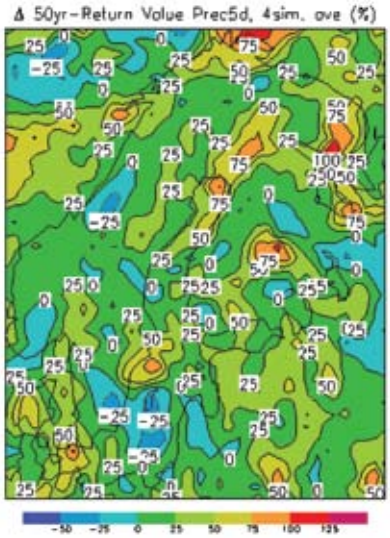


Figure. 1. Projected change (in %) during this century in the precipitation amount in five days that is exceeded once in 50 years in the mean.

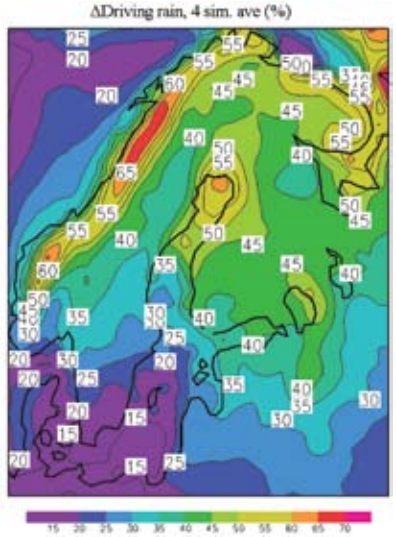


Figure 2. Projected change (in %) during this century in the mean annual driving rain impinging on a vertical surface.

systems and the need to increase the maximum capacity of refrigeration systems.

The simulated increase in extreme winds in Denmark and the southern tip of Sweden indicate a need to increase the reference wind velocity for the building codes in these areas.

The results showed a generally increasing trend in the precipitation. These changes are so large that, renovation in the drainage capacity is required, particularly in urban areas. In addition, management of the water level of water reservoirs should be re-evaluated in view of flooding and dam safety.

The analysis suggested that, despite a widespread decrease in total annual snowfall in a warmer climate, extreme snow precipitation will increase in most parts of the Nordic area, thus requiring increased awareness and resources for securing transport under severe winter conditions.

The extreme cumulative snow amount will decrease in most of the Nordic area but increase in some parts of it. This suggests that for optimal structural design, the snow load maps of building codes should be updated taking the local differences carefully into account.

More attention will have to be paid to the selection of building materials used on exterior walls, because driving rain, freeze/thaw cycles and the conditions resulting in corrosion will change.

EXPLOITATION POTENTIAL

The results of the theoretical part of the work will be used in re-analyzing the probabilities of natural hazards that are based on conventional statistical methods. This will improve the risk analysis already in the existing climate.

The first step in the adaptation to climate change in the building sector must be that engineering practices, recommendations and building codes, based on historical climate data are re-evaluated. The results of this work regarding the projected climate change in terms of extreme weather have the key role in this adaptation process.

ACKNOWLEDGEMENTS

The authors wish to thank Markku Rummukainen from SMHI in Sweden, as well as Leena Ruokolainen and Jouni Räisänen, from the University of Helsinki. The work has been supported by the Finnish Ministry of Environment.

REFERENCES

[1] Makkonen, L. 2006. Plotting positions in extreme value analysis. Journal of Applied Meteorology and Climatology, Vol. 45, pp. 334–340.

[2] Makkonen, L. 2008. Problems in the extreme value analysis. Structural Safety, Vol. 30, No. 5, pp. 405–419.

[3] Makkonen, L. 2008. Bringing closure to the plotting position controversy. Communications in Statistics - Theory and Methods, Vol. 37, No. 3, pp. 460–467.

[4] Makkonen, L., Ruokolainen, L., Räisänen, J. & Tikanmäki, M. 2007. Regional Climate model estimates for changes in Nordic extreme events. Geophysica, Vol. 43, No. 1–2, pp. 19–42.

[5] Saarelainen, S. & Makkonen, L. 2007. Adaptation to climate change in the road management. Finnish Road Administration, Finnra Reports, 4/2007, 53 p.

CONTACT

Lasse Makkonen
Senior Research Scientist
lasse.makkonen@vtt.fi
Tel. +358 20 722 4914

CLIMATE CHANGE IN URBAN PLANNING

Irmeli Wahlgren, Lasse Makkonen, Kimmo Kuismanen (Subcontractor)

Control of and adaptation to climate change should be an established practice in urban planning. Predictions of climate change in the next hundred years were made for six study localities and their impact on plans were analyzed. "The golden rules for planner" emphasize local conditions, determining flood risk areas, completion of urban form and avoiding urban sprawl, forming good microclimate, control of storm water, relatively compact structure, district heating and renewable energy sources, prerequisites of public transport, walking and cycling, mixing functions and impact assessment.

INTRODUCTION

Control of climate change is a major global and national goal. The aim of the study is to promote adaptation to and mitigation of climate change in urban planning and, thereby, to reduce damages caused by floods and storms as well as to reduce greenhouse gas emissions. The study analyses plans at different levels: regional, master and detailed plans. The bases for analyses are estimations about essential impacts of climate change in the case localities.

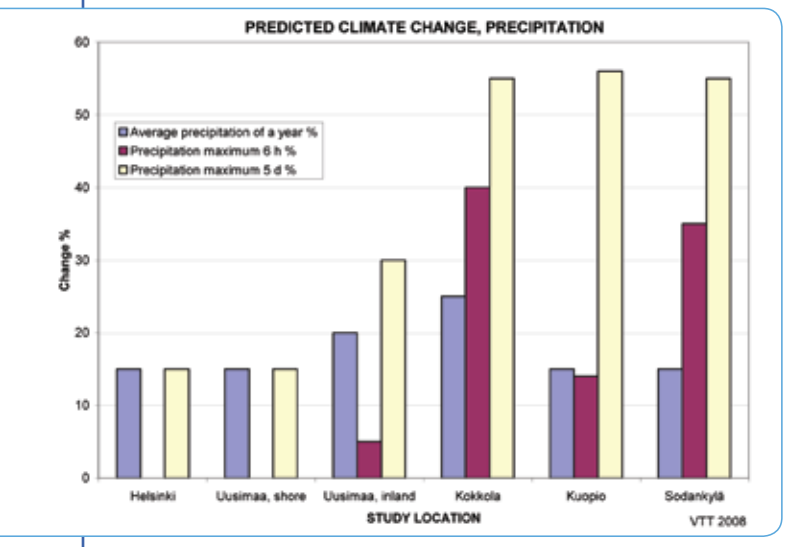


Figure 1. Predicted climate change in study locations, precipitation.

Results of the project are recommendations of practical procedures and means for taking climate change into account in urban planning and impact assessment.

METHODS

The research was based on ongoing planning processes. The study areas and plans were the Kalasatama master plan in Helsinki, the Vanhansatamanlahti master plan in Kokkola, the urban structure alternatives of Uusimaa region, the development plans of Tahko tourist center in Nilsiä, the City of Islands in Kuopio and the new dwelling area of the former race track in Sodankylä. Plans were considered on the basis of local climate conditions and of the microclimate they will form. Mitigation of climate change was considered by assessing greenhouse gas emissions from realizing the plans.

RESULTS

Predictions of climate change with regards to extremes and certain average changes in the next hundred years were made for all the study localities. The predicted variables were average temperature of a year, maximum temperature, minimum temperature, melting freezing cycles, average wind speed of a year, maximum wind speed, average precipitation of a year, 6 hours precipitation maximum, 5 days precipitation maximum, 6 hours snow maximum, snow cover maximum, duration of snow cover and duration of sea ice cover (see Figure 1). Changes in many variables are significant and differences between localities are great. Near shorelines, changes of sea level and flood risk areas were also estimated.

With regards to adaptation to climate change in plans at general levels, important issues are mapping of flood risk areas and avoiding location of functions in such areas (Figure 2). Wind conditions and increasing precipitation form challenges to detailed planning. Good micro climate can be formed by planning of quarters, plots and houses. Near shore areas, sea level rise and splash of waves, as the sea will be open longer, form special challenges.

Regarding climate change mitigation, advantageous areas are those which are located favorably with respect to traffic conditions, especially those having possibilities to walk, bicycle and use public transportation and which can use district heating or use renewables in separate heating. Study areas in Helsinki, Kokkola, Kuopio and Sodankylä are located favorably in the urban structure. The urban structure alternatives in the Uusimaa region make it possible to form an advantageous structure (Figure 3). The prerequisites of forming a railway connection to Tahko are worth defining. Well-defined urban areas make it possible to form continuous nature and recreational areas and ecological corridors and networks. Rural building scatters natural areas. New areas should be located in connection to existing urban structure. Functions should be located near each other and mixing of functions should be promoted instead of differentiating.

DISCUSSION AND CONCLUSIONS

The research shows that mitigation of and adaptation to climate change can be considered at the same time. There were no conflicts between these targets in the study areas. The report introduces planning directions and recommendations for taking climate and its changes into account in spatial planning and building on different planning levels. "The golden rules for planner" emphasize local conditions, determining flood risk areas, completing of urban form and avoiding urban sprawl, forming good microclimate, control of storm water, relatively compact structure, district heating and renewable energy sources, prerequisites of public transport, walking and cycling, mixing functions and impact assessment.

Accelerating climate change demands effective means to provide for. Reducing greenhouse gas emissions will be more important as international commitments will be tighten. Thus every action to reduce emissions is important.

EXPLOITATION POTENTIAL

The results can be utilized in different levels of urban planning. The report presents ideas for further development to minimize greenhouse gas emissions of built environment and transportation and to apply means for adaptation to climate change in urban planning.

ACKNOWLEDGEMENTS

The research has been funded by the Ministry of the Environment (Environmental Cluster Research Programme), VTT, City of Helsinki, City of Kokkola, Regional Council of Uusimaa, Regional Council of Pohjois-Savo and Architects' Office Kimmo Kuismanen. The City of Kuopio and Municipality of Sodankylä have submitted planning material for the research.

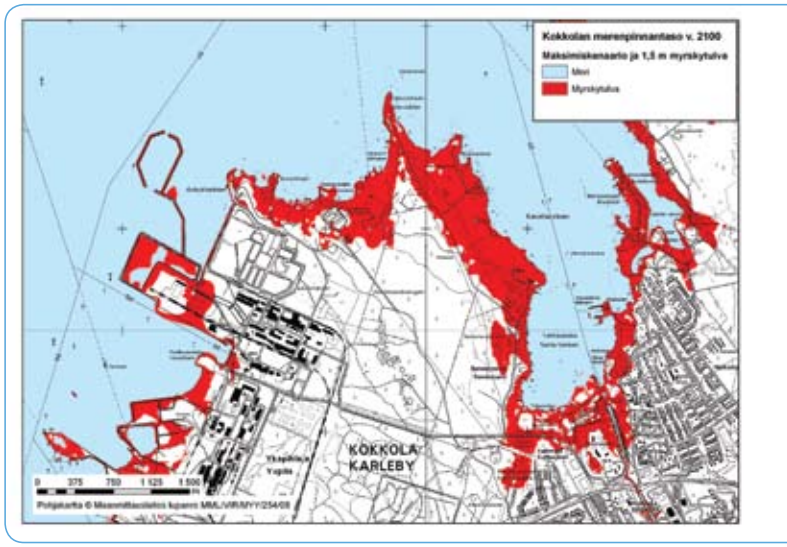


Figure 2. Sea level in Kokkola in 2100 in maximum scenario and 1.5 m storm flood indicated in red (source: City of Kokkola, Astra project).

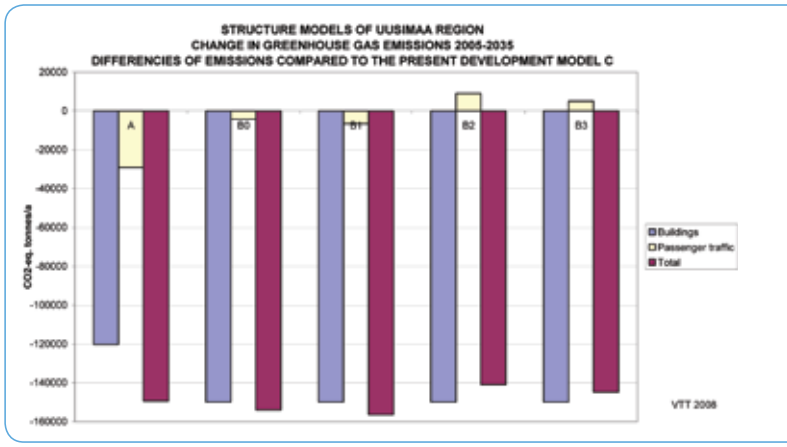


Figure 3. Greenhouse gas emissions of alternative structure models of Uusimaa region, differences of emissions in models A, B0, B1, B2 and B3 compared to the present development model C. Reductions of emissions are about 10% of emissions in model C.

REFERENCES

[1] Wahlgren, I., Kuismanen, K. & Makkonen, L. 2008. Climate Change in Urban Planning – Case Studies. (In Finnish). VTT Research Report VTT-R-03986-08.

CONTACT

Irmeli Wahlgren
Senior Research Scientist
irmeli.wahlgren@vtt.fi
Tel. +358 20 722 6289

COST BENEFIT ASSESSMENT OF FLOOD PROTECTION OF BUILDING STOCK

Tony Rosqvist, Markus Porthin, Riitta Molarius

Extreme floods can cause substantial economic losses to the infrastructure, industry and households in flood risk areas. A methodology for the assessment of the cost and benefits of different flood protection measures was developed in the recent TOLERATE-project.

INTRODUCTION

The results of the earlier FINADAPT (2004-05) study [1] indicated that in terms of a long term average expectation the gradual changes in climate most probably do not significantly affect the Finnish economy at the macro level, apart from possibly more profound changes in foreign trade conditions. However, the various sectoral studies of FINADAPT showed that extreme weather conditions would be capable of causing significant damage, at least at a local level. Extreme weather events are expected to increase in terms of frequency of occurrence and/or severity.

In light of the above considerations, it becomes evident that economic impact predictions purely based on expected average changes in climate conditions could provide a misleading picture for decision making. When extreme weather events occur in the future with higher frequency as well as severity, the resilience of local and regional infrastructure and even of the regional economy at large is more seriously put to test. In the case of clustered and severe extreme weather events, misjudgment of the resilience and consequential ill suited risk strategies may lead to disruptions of the regional economy for longer time spans (e.g. weeks or months). Prevention of such disruptions or at least the reduction of their likelihood almost certainly pays off. The project entitled "Towards Levels of Required Adaptation To Cope with Extreme Weather Events (TOLERATE)" was the follow up work to address these considerations, and was completed in 2008.

METHODS

The approach adopted in the project was scenario-based impact assessment, based on climate-hydrological scenarios, economic development scenarios of different building stock such as dwelling houses, production plants and infrastructure. The case study for application of the basic approach was the Pori area of Finland which is known to be flood prone. The assessment framework is shown in Figure 1.

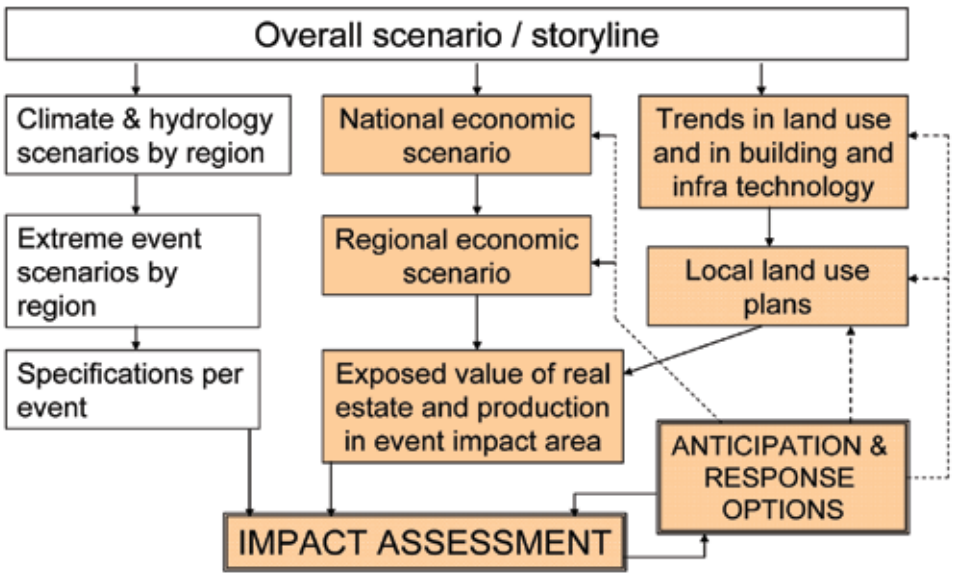


Figure 1. Assessment framework of the TOLERATE-project.

Different models were utilized to assess quantitative levels of precipitation, discharge of rivers, flood maps to show flood levels and economic losses incurred to the building stock. A test decision panel consisted of decision-makers at the national and the municipal level, as well as representatives from

Table 1. The summary of implementation and maintenance costs, and other (non-monetary) effects per flood protection alternative.

	Estimated cost (M€)	Other effects
0 – alternative	2 ~ 4	few; perhaps limitations in land use (zoning)
1.a. stronger embankment R = 50	15 ~17	landscape effects, with possible spin-off on real estate values
1.b. stronger embankment R = 250	25 ~ 28	more outspoken landscape effects, with possible spin-off on real estate values
2.a. dredging R = 50	14 ~ 16	environmental effects for the river ecology
2.b. dredging R = 250	19 ~ 22	even more extensive environmental effects for the river ecology
3. new river arm	35 ~ 50	comprehensive implications for land use in Pori; landscape effects; environmental effects for the river ecology
4. building specific measures	20 ~ 30	no large effects; possible effects on the outside looks of buildings

academia, civic organizations and the insurance sector. Table 1 shows the pre-defined decision options depicting different levels of protection as well as investment consequences for two climate-hydrological scenarios R=50 and R=250, where R denotes the return period in years. The experts' valuations of the considered decision alternatives produced subjective average scores for comparison purposed. The group decision support system ThinkTank was used and processed by the Web-HIPRE multi-criteria decision aid tool.

RESULTS

The TOLERATE-project developed a framework for assessing the impacts of extreme flood events on the building stock in flood prone areas. The cost-benefit assessment of flood protection alternatives were assessed using multi-criteria decision-making methods. The methodology was tested in a decision panel that was conducted using the group decision support system ThinkTank.

DISCUSSION AND CONCLUSIONS

The general feedback of the panelist was that the approach gives a systematic and transparent way to analyze extreme events to support decision-making. The complexity of the approach requires, however, a lot of processing of basic data before moving to the decision-making phase. It was noted that the methodology supports a multi-disciplinary approach deemed necessary in addressing the impact of extreme events on societal functions in general.

EXPLOITATION POTENTIAL

The methodology was developed to support regulatory decision-making related to land-use planning and engineering solutions for flood protection. It can be customized for industrial applications, in particular, for assessing the impacts of weather extremes on the performance of supply chains that are partly located in weather risk areas.

ACKNOWLEDGEMENTS

The authors wish to thank the Finnish Environmental Institute SYKE, Finnish Meteorological Institute and the Government Institute for Economic Research (especially Dr. Adriaan Perrels). The research was funded by the Research Program for Climate Change Adaptation and VTT.

REFERENCES

[1] Carter, T. (Ed.) 2007. Assessing the adaptive capacity of the Finnish environment and society under a changing climate: FINADAPT. Finnish Environment Institute, 78 p.

CONTACT

Tony Rosqvist
Senior Researcher
tony.rosqvist@vtt.fi
Tel. +358 20 722 6773

THE FINNISH HIGH TECH ECOCITY IN CHINA – MENTOUGOU ECOCITY

Jyri Nieminen, Pekka Lahti, Sun Nan, Miimu Airaksinen

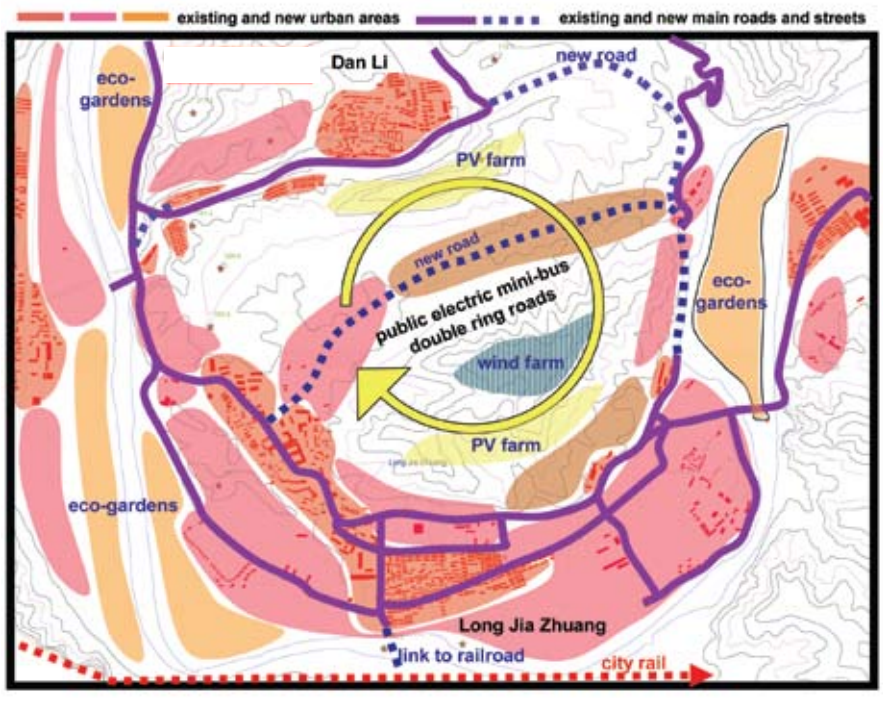
Climate change can make the globe uninhabitable. To maintain the globe habitable, greenhouse gas emissions need to be reduced to reduce the rise in global temperature. The International Panel of Climate Change (IPCC) has estimated that to limit the temperature rise to a maximum of 2°C, there needs to be a reduction in the emission by 80 – 90 % by the year 2050. The EcoCity projects drives directly to this goal.

INTRODUCTION

An EcoCity essentially has high ecological quality but at the same time it is technologically sophisticated and most modern. This is a kind of town that has not yet been realized anywhere in the world. The attempts to build an EcoCity so far have resulted in optimization of different sectors or technologies and thus compromises between the high level targets and present level of design. However, there is not just one EcoCity concept but a variety of possibilities that need to be adjusted to fit the local context, local culture and local economic realities. This is the way to achieve a possible solution with regards to the local resources, but at the same time to meet the high goals set for an EcoCity. High-tech solutions are one way to the EcoCity, but they are not the only goal of an EcoCity.

METHODS

This project is a first of a kind environmental project between the People's Republic of China and the Republic of Finland. The concept development produced a vision of an EcoCity to be built in Beijing Mentougou District, along with a concrete plan including short-term actions for the near future. It also included practical guidelines for implementation of the vision as a long term development. The project combines Chinese and Finnish expertise and experiences on sustainable communities. The development is based on the Finnish experiences on production of environmentally friendly materials, buildings and sustainable communities combined with the Chinese culture and local know-how.



RESULTS

The future eco-city will be part of the existing town and village structure. The EcoCity is based on conserving the significant environmental values of the area by utilizing brownfields in the development. The EcoCity is a human-friendly environment that fits to all population groups. The project produces necessary information for the planning and design of the EcoCity.

Figure 1. Example of a land use plan. All the villages are connected to a network of villages by low-emission public transport. The villages are self-sustainable in terms of energy.

Figure 2. Clean environment, energy-efficient housing, water management and environmental restoration are among the key features of the Mentougou EcoCity.

The key development areas of the project are:

- Land-use plan for the EcoCity area including future growth of population, housing, transport, infrastructure, services, primary production and processing of raw materials
- Energy-efficient buildings and built environment with sustainable energy systems
- Waste management with home waste sorting and municipal recycling
- Water management with storm water management and rain water
- Food production and agriculture
- Restoration of the damaged green environment and landscaping
- Socio-economic development and quality of life.

DISCUSSION AND CONCLUSIONS

The conflict between the environment and the economy is a serious problem in Mentougou. Resolving the conflict between ecological quality and economic development is the greatest expected result to be achieved in the future EcoCity. This development includes adoption of new technologies into the local culture and way of life in a way that supports the life of a versatile and diverse population. Cooperation between the Chinese and Finnish experts and stakeholders is the key to the success.

EXPLOITATION POTENTIAL

The project serves as a long-term development plan of EcoCities in China and other countries. The project demonstrates the aims of an EcoCity, and how these aims can be met in planning, design, construction, and use of the EcoCity. The outcome also helps to understand the importance of local specific conditions in the development of an EcoCity.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Pekka Huovila, Jari Shemeikka, Tuija Tukiainen, Antti Nikkanen and Ulla-Maija Mroueh of VTT. The research has been funded by the Local Government of Beijing Mentougou District.

CONTACT

Jyri Nieminen
Senior Research Scientist
jyri.nieminen@vtt.fi
Tel. +358 20 722 4922

INFORMATION AND TOOLS FOR IMPROVED ENERGY EFFICIENCY IN BUILDINGS

Jorma Pietiläinen, Teemu Vesanen, Hannu Komulainen

Today the major concern in all countries is the CO_2 emissions produced mainly by energy consumption in buildings, transport etc. The project e4Portal provides ICT-based tools to monitor and assess the energy performance of buildings and to improve it by energy saving actions. New type of tools to motivate building owners and other local actors to climate combat has been created and taken into use both in Estonia and Finland.

INTRODUCTION

In Finland and the EU, buildings play a key role in climate combat. Despite new saving technologies available, energy efficiency is developing very slowly especially in existing building stock. Increasing use of electricity in new services and equipments has in many cases eliminated the achievements in the heating sector. Also the knowledge about energy usage in different type of buildings is lacking and reliable analyses of energy performance levels and development is hard to conduct. New approaches are necessary if the building sector wants to meet the demanding saving targets set in international agreements.

METHODS

The pilot version of the portal was originally established by VTT in the Inno-Elli program and developed further in Estonian-Finnish collaboration as part of Interreg IIIA activities. Internet-based data warehouse and toolset have been developed and via it local governments and other building owners have been activated to participate in climate combat. The e3Portal [1] provides continuously updated information and interactive tools for local energy management activities as well as for the planning and implementation of energy conservation measures in buildings. While monitoring the energy consumption of buildings and transferring the data to portal's database building owners and operators act as content providers of the portal as well. Based on the portal ebusiness-type activities can also be developed and results of successful saving actions can be disseminated in a new way.

RESULTS

The portal allows local actors to get a real-time picture of the energy efficiency and water usage levels of various buildings. Comparisons and benchmarking of performance indicators can be carried out on both sides of the Gulf of Finland. The portal contains tools for internet-based monitoring and analyzing of energy consumption but includes also a platform for very cost effective produc-

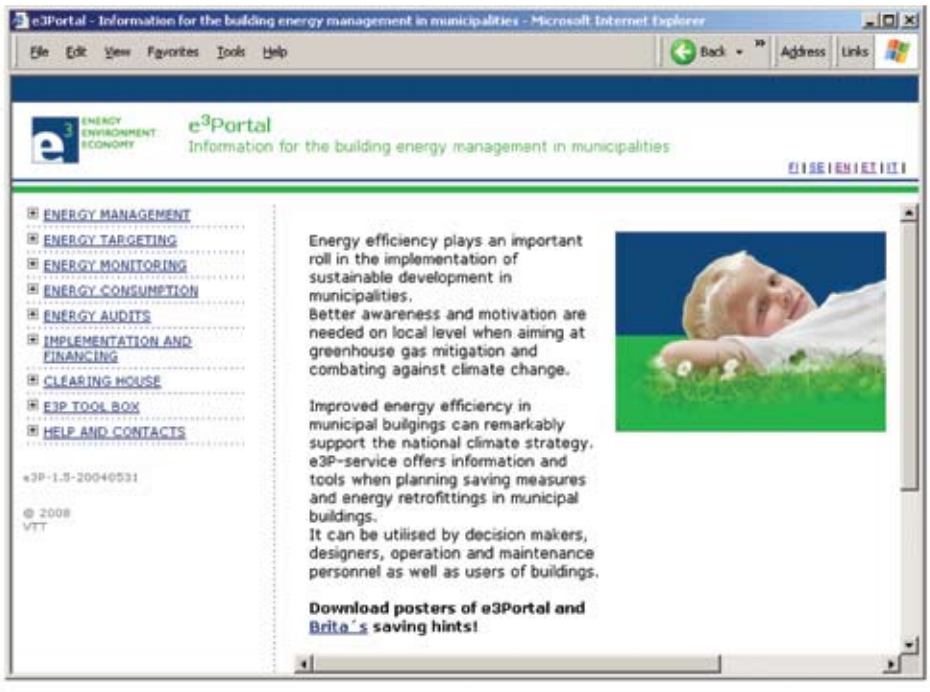


Figure 1. The user interface of e3Portal supports several languages.

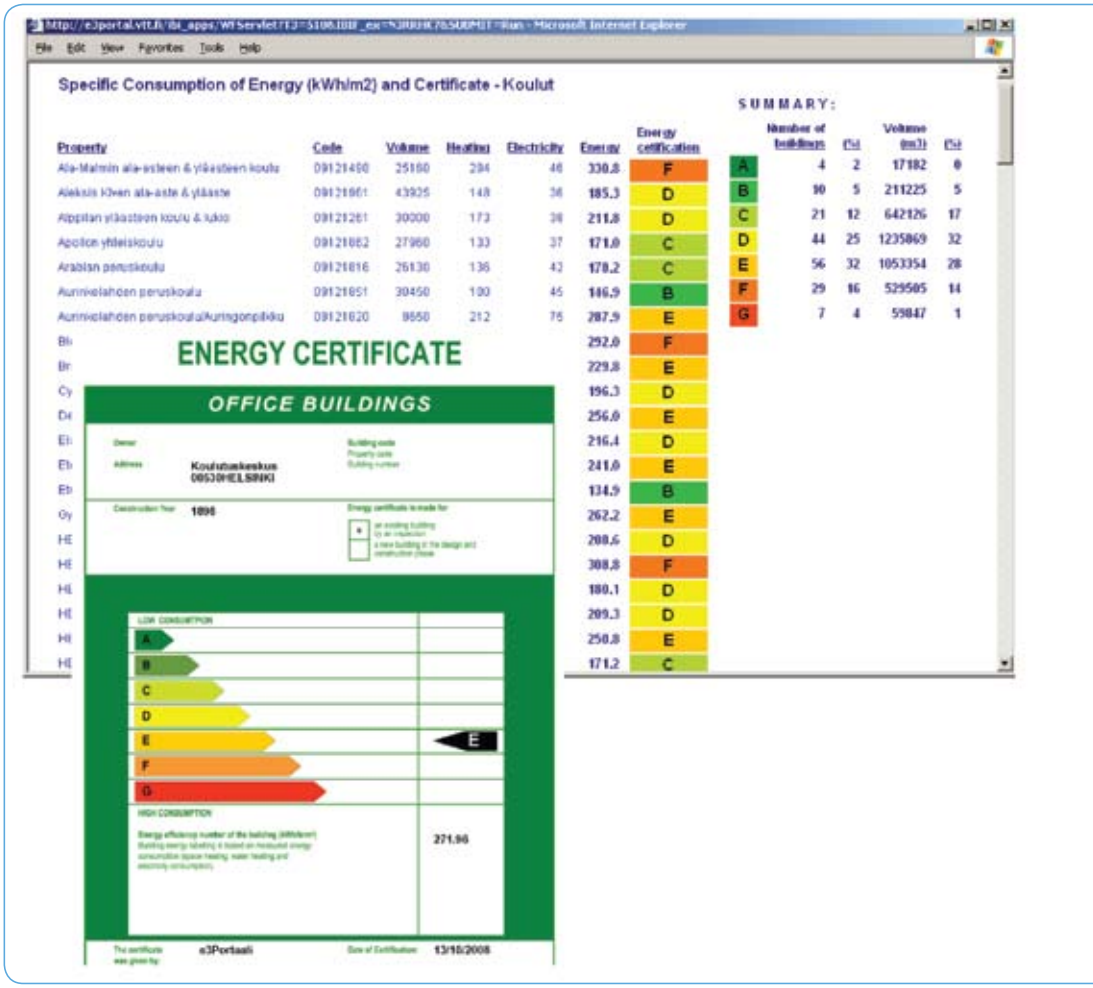


Figure 2. Examples of Portal's outputs: energy performance certificate and rating.

tion of a kind of "electronic" energy performance certificate for an individual building or the building portfolio. Cost and greenhouse gas effects of energy usage can also be reported. Via portal successfulness and real effects of saving policies and actions can be analyzed and awareness of decision makers, owners, operation and maintenance personnel as well as other stakeholders can be improved.

EXPLOITATION POTENTIAL

The portal's first implemented version focused on public buildings and especially municipal building owners. Though the number of municipalities joining the portal in the first phase was limited, the portal already includes data from thousands of buildings and creates a sound bases for further utilization and development. In collaboration with Motiva Oy (Finnish Agency for Energy Efficiency), the portal will be marketed to new users and it will be utilized in the implementation of national climate strategy. In the future the concept implemented in portal will be used for other building types and Estonian-Finnish activities can be widened to other European countries as well.

ACKNOWLEDGEMENTS

Development of the e3Portal has been funded by EU's structural funds (INTERREG IIIA Southern Finland – Estonia Program). Additional co-funding originated from national sources including the cities of Helsinki, Espoo, Turku, Kotka, Motiva Oy (the Finnish Agency for Energy Efficiency) and the Ministry of Interior. Respective organizations in Estonia have been supporting development activities there. The author thanks all organizations in Finland, Estonia and the EU providing funding and knowledge for the implementation of portal.

REFERENCES

[1] Information for the building energy management in municipalities, e3Portal web site, 2008, http://e3portal.vtt.fi.

CONTACT

Jorma Pietiläinen
Senior Research Scientist
jorma.pietilainen@vtt.fi
Tel. +358 20 722 6275

OPEN ICT BASED PLATFORM FOR ENERGY PERFORMANCE EVALUATION OF EXISTING BUILDING STOCK

Jorma Pietiläinen, Pekka Koponen, Timo Kauppinen, Janne Peltonen, Hannu Pihala, Marja-Leena Pykälä, Kari Sipilä, Teemu Vesanen

The building sector is responsible for 40 % of the total European energy consumption but simultaneously offers the best technological opportunities to reduce greenhouse gas emissions as shown in the recent IPCC WGIII Assessment report [1]. Major challenge lies in the existing building stock, which is renewing very slowly. Basic information about energy usage and its variation because of various factors is fundamental when monitoring and assessing the performance, planning saving measures, motivating different stakeholders and verifying results. Information needs vary depending on purpose of use and the level of action (Figure 1) but measured data is a prerequisite for success.

INFORMATION ON ENERGY CONSUMPTION IS FUNDAMENTAL IN CLIMATE COMBAT

Energy usage in buildings is one of the most critical factors when aiming at mitigation of green house gas emissions and global warming. A vast amount of consumption data is collected every day to the operational databases of energy and water utilities but this critical data is mainly used only for invoicing and not supporting the energy saving activities. In principal however this data should be easily utilized by the modern ICT and provided to the use of end users, service providers etc. Based on the reliable and up to date consumption data new services and business models can be developed. The eCertification project aimed at developing and piloting open internet-based platform (interfaces) making possible the utilization of existing data [2]. In the future energy performance evaluation will be realized automatically over the internet by sophisticated software modules (agents) and new types of services for building owners and other stakeholders can be implemented (Figure 2).

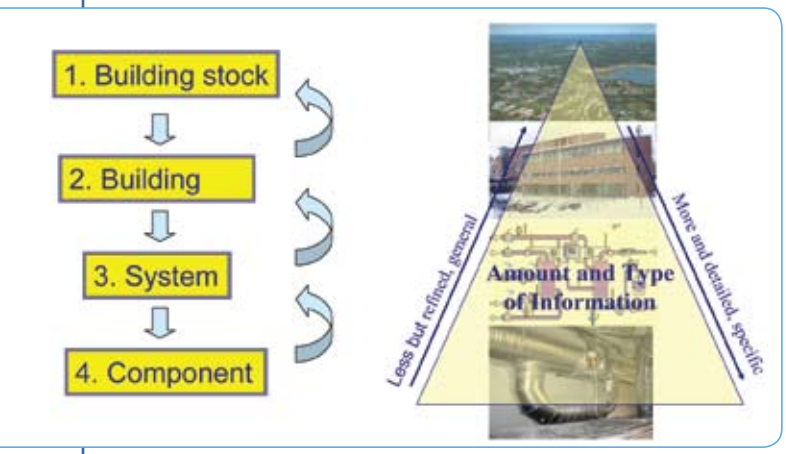


Figure 1. Different levels of energy performance assessment.

SMART METERS MULTIPLY THE ENERGY DATA AVAILABLE

New automatic meter reading technology (AMR) combined with modern Information Communication Technology (ICT) is rapidly taking place all over the world. Thousands of so called smart-meter systems are under installation at the moment. A smart meter measures electronically the consumption in short intervals (with hourly or better resolution), and can communicate this information to another devices or systems which in turn allows the

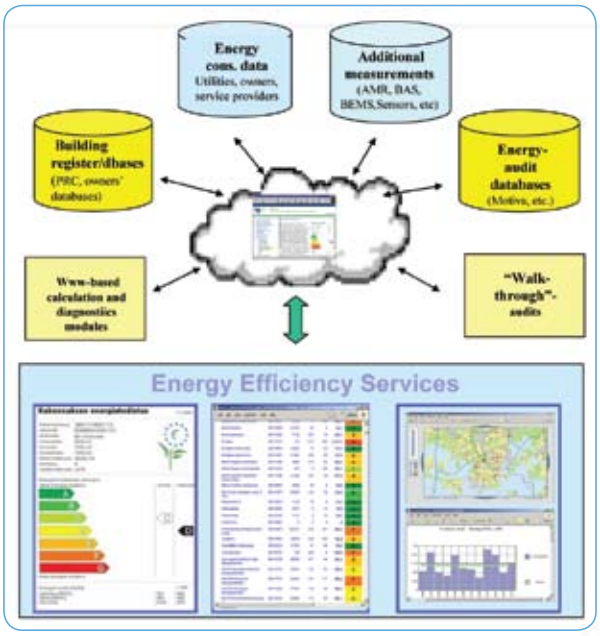


Figure 2. Scheme of eCertification platform.

customer or service provider to view how much and when energy is used and where is the biggest saving potential. Typical smart meter interfaces are described in Figure 3 [3]. Essential for the real time energy efficiency services on building or system level is that the measured data is available directly to the diagnostic modules e.g. of building automation systems (P1 in Figure 3), which in turn will optimize the building services systems (like HVAC) according to the outdoor temperature, occupational factors and targeted thermal comfort. For many other energy efficiency services measurement data is not needed in real time but consumption data should be easily available for low cost via a standard interface. To avoid expensive changes of meters in the near future these kinds of needs should be taken into account in the legislation and regulations, and common requirements for interfaces should be defined on national and European level [4, 5, 6].

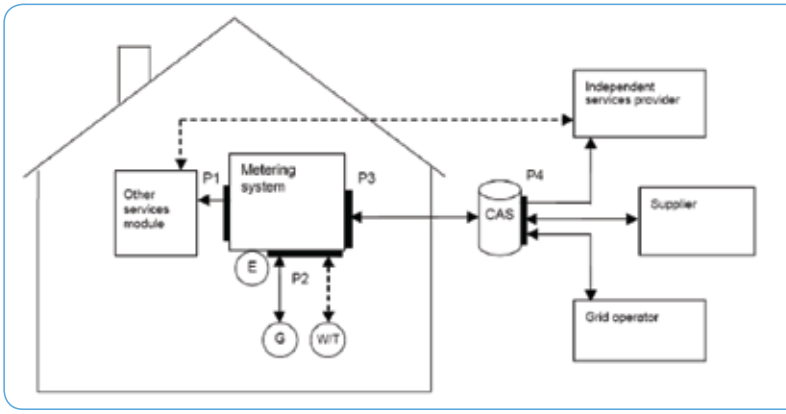


Figure 3. Interfaces of smart metering system (P1-P4).

ENERGY DATA CAN BE LINKED WITH THE BUILDING INFORMATION

In Finland basic information about every existing building is stored in the national building register maintained by the Population Register Centre. New data will be updated continuously during the building permission procedure. In the future this building data can be accessed via standardized services (based on XML, SOA, etc.) and linked with energy data available from different sources. Modules for performance analyses can be developed and a kind of electronic performance rating of a big building portfolio can be made on-line over the internet (Figure 4). Owners and users of buildings can easily follow the environmental impact of their own building stock and energy efficiency of buildings can be assessed e.g. on neighborhood, regional or national levels. Policy developers and decision makers can have real time information on performance level and development of certain buildings types and measures of improvements can be focused in an efficient way.

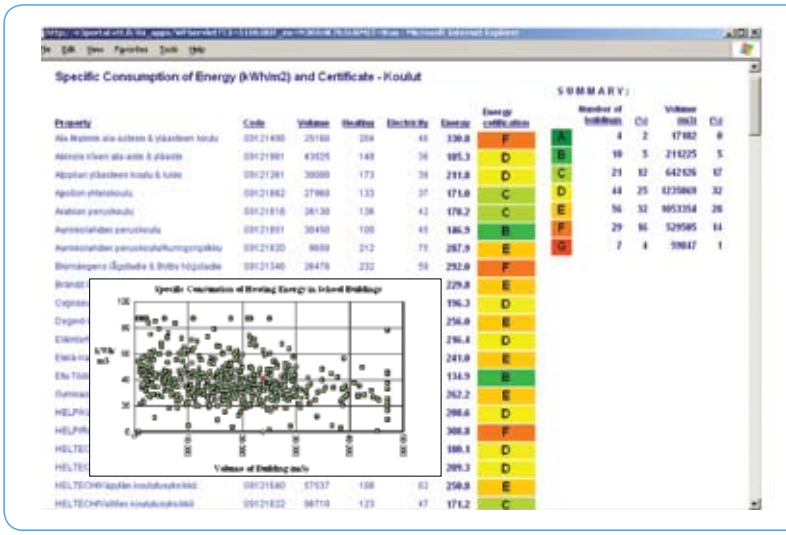


Figure 4. Energy performance rating of big building portfolio (schools owned by city of Helsinki) as tabular and graphical presentation.

ACKNOWLEDGEMENTS

The project was funded by Tekes, VTT and 11 private and public organizations.

REFERENCES

[1] Intergovernmental Panel on Climate Change, Working Group III – Mitigation of Climate Change, 2008, www.mnp.nl/ipcc/index.html.

[2] eCertification project public web page, 2008, www.vtt.fi/proj/ecertification/.

[3] Netherlands Technical Agreement NTA 8130:2007, Minimum set of functions for metering of electricity, gas and thermal energy for domestic customers.

CONTACT

Jorma Pietiläinen
Senior Research Scientist
jorma.pietilainen@vtt.fi
Tel. +358 20 722 6275

BETTER ENERGY EFFICIENCY AND INDOOR CLIMATE BY LIFE-CYCLE COMMISSIONING OF BUILDINGS

Jorma Pietiläinen, Timo Kauppinen, Keijo Kovanen, Veijo Nykänen, Mikko Nyman, Satu Paiho, Janne Peltonen, Hannu Pihala

Numerous studies and everyday experiences prove that even new buildings do not perform as expected. Dissatisfaction with indoor air quality and thermal comfort is common and the energy performance is not on the targeted level regardless of the new technologies utilized and advanced systems installed. New methods and procedures are needed to improve the current practices in the building sector.

INTRODUCTION

Building commissioning in Finland nowadays is not a standard procedure applied during the life-cycle of a building. Most often it is used only for new buildings when handing-over the results of construction work to the owner and user. Sometimes it is used as a separate measure in existing buildings as well but in general applying commissioning type activities is still more an exception than rule, and in the best case these kinds of quality control activities take place only at the end of the construction process.

To assure the overall quality of construction output it is not sufficient to check only the quality of a final product. Instead the whole process and life cycle of a building should be taken into account [1]. In order to improve the quality assurance procedures and start commissioning activities in Finland a research and development project was carried out as part of the Finnish Building Services Technology Program (CUBE). The collaborative project included many public and private actors from the construction sector with international collaboration under IEA [2]. A general guidebook for commissioning was developed and for the commissioning a Finnish term "Toimivuuden Varmistaminen" (ToVa) was created which, directly translated refers to performance control and quality assurance [3].

RESULTS

In the guidebook general procedures for ToVa activities are described covering the whole life cycle of the building. "ToVa" means clear definition, capturing and documentation of end user requirements and their compliance assessment and verification in all the phases starting from design through construction to the operation and use. In the guidebook special focus has been put on indoor air quality (IAQ) and energy efficiency. The guidebook includes general instructions for the assessment and verification of IAQ and energy efficiency but also gives check-lists to be used in different phases of the building process. Organizing and responsibilities of ToVa-activities as well as methods to be used in different phases are discussed in the guidebook. In a separate report useful measurements for ToVa are discussed and instructions for practical work are given. For the deployment and further development of ToVa-activities, an internet site [4] was established and www-based tools for some ToVa-activities were developed.

DISCUSSION AND CONCLUSIONS

Prerequisites for the thermal performance of the building, the energy efficiency and indoor conditions are already basically set in the design phase. Figure 1 shows where during the process there are the biggest possibilities to have an influence on the performance. Paradoxically the users will find the deficiencies and failures when it is very expensive, or at least more difficult, to improve or repair them. Therefore it is very important that already in the design phase the designer pay attention to the details, which may cause problems in the installation phase or during the use. In cold climate conditions, especially, the proper functioning of the building envelope is very essential in terms of thermal conditions.

According to the guidebook, commissioning activities should be launched already in the very early phase of programming to check that owner's and users' needs and targets are clearly defined and documented, and that indoor and energy performance requirements are included to the owner's program. In addition, an audit should be done to check that design solutions and installation

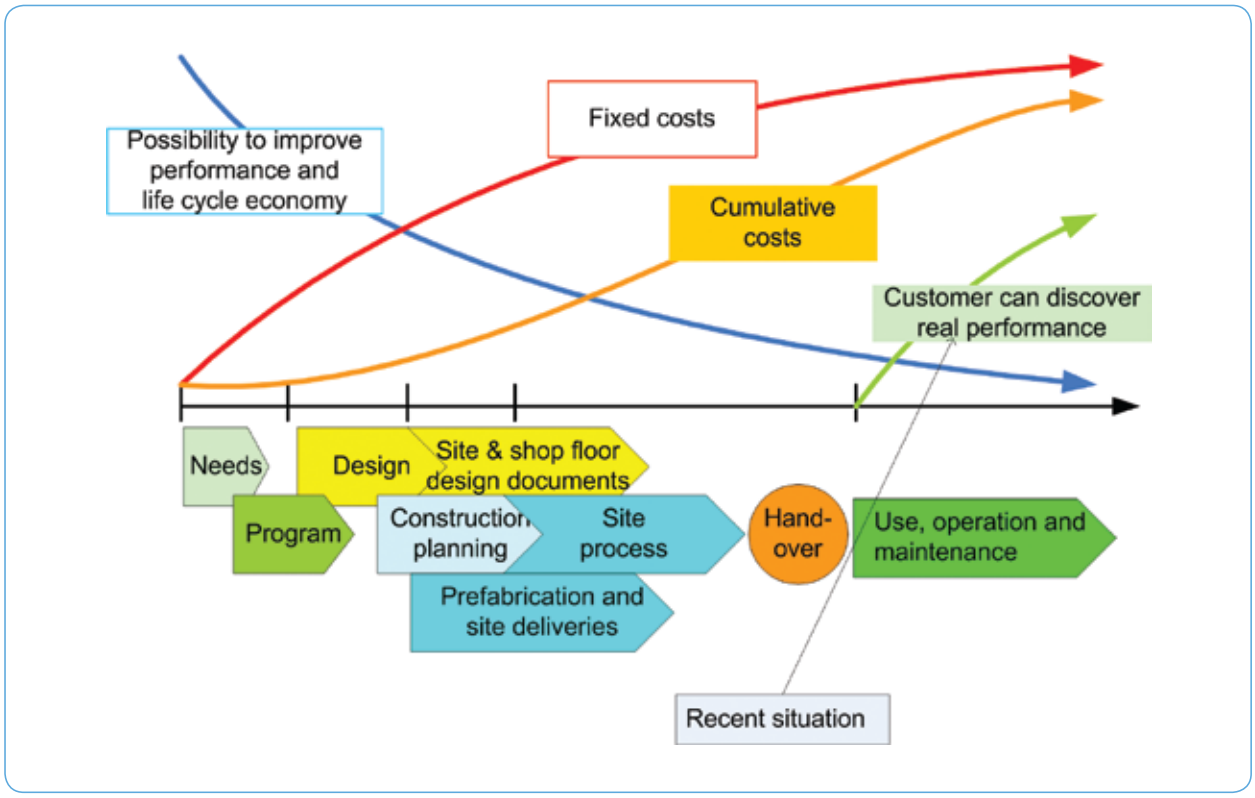


Figure 1. Potential to affect the performance of a building.

outputs meet the given objectives, and verified that the building satisfies all given requirements for indoor conditions and energy performance when in use. Commissioning should also take care that the needs of the operation and maintenance (O&M) phase are considered already in the previous phases and the O&M personnel have knowledge and skills to take care of the systems installed. Finally during occupation, commissioning should be included as a continuous routine of the facility management process over the building life cycle. The guidebook developed can offer only general instructions and applying ToVa as a rule still requires a lot of efforts like training, marketing, piloting and future development.

ACKNOWLEDGEMENTS

Development of the guidebook was funded by Tekes, VTT and 19 other private and public organizations participating in the project. The author thanks everybody who provided funding or contributing otherwise to the project.

REFERENCES

[1] ASHRAE Guideline 0 – 2005, The Commissioning Process.

[2] Visier, J.C. (ed.) 2004. Commissioning tools for improved energy performance. Results of IEA ECBCS Annex 40. 201.

[3] Pietiläinen, J. et al. 2007. Guidebook for life-cycle commissioning of buildings energy efficiency and indoor climate. (In Finnish). VTT Research Notes 2413.

[4] ToVa public web page, 2008, www.tova.fi.

CONTACT

Jorma Pietiläinen
Senior Research Scientist
jorma.pietilainen@vtt.fi
Tel. +358 20 722 6275

ECO-EFFICIENCY OF LEISURE TIME LIVING AND SECONDARY HOMES

Pekka Lahti, Minna Halonen

As the general level of income and wealth is increasing, the amount of weekend cottages and other holiday houses is increasing. Some of the holiday houses become secondary homes. People are visiting their holiday houses more often and also during winter time. The use of cars, electric appliances and other motorized equipment are increasing accordingly. This is a challenge to the required eco-efficiency of the whole society.

INTRODUCTION

The need to study eco-efficiency of leisure time living was raised after results of a study concerning the development of eco-efficiency of the whole living environment in Finland until 2030 [1, 2]. The results showed that in a business-as-usual scenario the eco-efficiency of the built environment is decreasing monotonously and will by 30 % until the year 2030 if no new measures are introduced. This is because of the growing living standard, including increased volume of housing, electrical appliances and mileage driven by cars. The same phenomena were assumed to take place also in leisure time living, although the level of information was found insufficient to make further conclusions. The pre-study of the eco-efficiency of leisure time living was finalized in 2006 [2]. The main results of the pre-study [2] and some preliminary results of the on-going study [3, 4] are presented here.

Figure 1. Hybrid housing development.

APPROACH

The study is based on literature studies, analyses of the numerical and geographical data bases of the Finnish population and building stock, transport networks, travel behavior, socio-economical and other statistics, questionnaire studies, in-depth interviews and experimental field research (implementation of innovative structural and technological solutions, monitoring and analysis, some of them still underway).

RESULTS

The study results gave a picture of leisure time living in Finland and their related eco-efficiency impacts. There are about half a million summer cottages and other types of leisure time homes in Finland (2004). The amount has grown by 4 000-8 000 each year since 1970. More than 800 000 Finnish people belong to a household owning a holiday house and 1.8 million people are regular users. About 80 000 cottages are owned by enterprises or other communities. The average floor area of a summer cottage is growing. The share of the largest groups (above 40 m2 floor area) has grown from 38 to 48 percent of the whole stock in 34 years (1970-2004).

Eco-efficiency can be determined as quality of life compared to the harm to the environment, resource use and costs [5]. In the case of leisure houses this is usually measured by the amount of materials and energy consumed plus emissions and waste per floor square meter produced during the lifecycle of a leisure home.

The total mileage of the trips to leisure time houses driven by the residents is more than 5 billion person-km each

year, meaning on the average 1 000 km per inhabitant (including those who do not make these trips at all). The total amount of energy consumed during these trips is 1 070 GWh per annum, which is more than twice as much as the electricity consumed in the holiday houses. The longest trips are made from the Helsinki Metropolitan Area, over 110 km/trip (one-way).

About 70 percent of the holiday houses have electricity and the share is growing. About one third are habitable also during winter time. Ever more cottages are linked to permanent water supply and waste water systems. Every sixth is equipped with washing machines and every tenth with dish washers and indoor WCs. The space heating is turned on already well before arrival to maximize living comfort. By keeping the houses, their water and other technical systems at least above freezing level and preventing moisture and damages to all structures all year round naturally increases the energy demand. There are a lot of different "natural reasons" for growth of energy demand in summer houses. However, there are also a lot of alternative paths of development. New innovative technologies and other solutions are developed and investigated during the on-going study. Another way is to improve the standard of permanent living so that at least some of the qualities of holiday houses are brought to normal urban living environment [6]. One way is to promote hybrid homes, where urban and countryside values are combined through actions such as using local energy sources, gardening, and other close-to-nature hobbies. (as shown in Figure 1, [7]).

DISCUSSION AND CONCLUSIONS

The results will be useful for people designing or retrofitting their weekend cottages or alternative leisure-time activities to reach better sustainability. Hopefully they will be more aware of the consequences and ecological impacts of their individual choices. They will also have more concrete alternatives to diminish their ecological footprint in leisure-time living.

ACKNOWLEDGEMENTS

The project was funded by the Finnish Environment Cluster (Ministry of Environment and a few other partners). The project consortium consisted of five partners.

REFERENCES

[1] Lahti, P. 2006. Modelling Eco-Efficiency in Finnish Housing Environment. COST C23 Low Carbon Built Environment MC Trento 4–5.12.

[2] Lahti, P. & Halonen M. 2006. The Change and Eco-efficiency of Housing Environment in Finland 2000–2030. The Development of Assessment Model and Its Implementation in Two Urban Scenarios: Business as Usual and Urban Townhouse Alternative. (In Finnish). VTT Research report R-03399–06.

[3] Kasanen, P., Ahlqvist, K., Aho H., Heljo, J, Komulainen V., Kurnitski, J., Lahti, P., Massa, I., Perrels, A., Reijonen, H., Rytkönen, A., Santala, E., Vilpas, R. & Vinha, J. 2006. Leisure-time Living and its Ecoefficiency. Pre-study. Preliminary Review of Eco-efficient Innovations and Practices. (In Finnish) TTS Report and Guide 30. 54 p.

[4] Ahlqvist, K., Santavuori, M., Mustonen, P., Massa, I. & Rytkönen, A. 2008. Weekend Cottages as a Way of Life and the Acceptance of Eco-efficient Practices. (In Finnish). TTS Research Report and Guide 36. 65 p. + app. 17 p.

[5] Lahti, P., Calderón, E., Jones, P., Rijsberman, M. & Stuip, J. (eds.) 2006. Towards Sustainable Urban Infrastructure. Assessment, Tools and Good Practice. European Science Foundation ESF/COST Publication. 336 p.

[6] Lahti, P., Heinonen, S., Halonen, M. & Sinivuori, P. 2007. Increasing dwelling diversity - foresight and evaluative views of experts. (In Finnish). Research report VTT-R-09436-07. 169 p.

[7] Dunster, B. 2007. Building the micro-generation. Practice specialising in Zero (fossil) Energy Development (ZED) buildings in the UK. COST C23 Conference, Vienna, 17 April 2007.

CONTACT

Pekka Lahti
Chief Research Scientist
pekka.lahti@vtt.fi
Tel. +358 20 722 6276

KARELIAN VILLAGES – INTELLIGENT ENERGY SERVICES

Veli Möttönen, Harri Katajala, Timo Kauppinen, Jussi Rönty, Kauko Tulla

Two tightly connected projects, called Interreg and Tacis, were done at VTT in cooperation with Russian experts to address the needs for improved energy use and technology implementation.

INTRODUCTION

In Russia and in Finland's neighboring areas in particular, there is a pressing need to improve the heating systems of communities and buildings, to increase operational reliability and, as a result of these, to generate significant energy savings. Finnish companies have already been working in Russia for a long time, designing, refurbishing and constructing systems. According to the experiences of these companies, Finnish expertise and systems are well suited to Russian needs. Comprehensive management of energy supply and the energy usage chain creates significant added value for both the Finnish and the Russian parties.

The project "Karelian Villages - Intelligent Energy Services" aimed at creating a "virtual village" concept, making it possible to assess energy supply and produce more effective solutions for the selection and execution of technologically feasible investments. Another goal was to train experts within the heating energy industry while establishing a network for continuation of effective implementation of energy services.

APPROACH

The project was a joint venture by Finnish and Russian experts and specialists. The INTERREG project was implemented as an expert venture in cooperation between the research institute and the companies and other parties in the industry. The parallel TACIS project included the Russian team of experts who had extensive knowledge of the general conditions in Northwest Russia and matters related to heating energy and community.

RESULTS

The networking of different actors has established many new contacts and networks. The project network partners have agreed to continue and tighten cooperation in activities related to the energy sector. The Project network partners have established a joint-stock company.

The project created community energy roadmaps for the Russian pilot villages Pudozh, Olonets, Pryazha and Kontoki Area of the City of Kostomuksha.

The project organized two training sessions in Finland for the Russian project group. The training consisted of heat distribution network design, utilization of the virtual concept, making assessments of heat distribution networks and real estates, introduction to Finnish dimensioning practice, methods and equipment.

The project also organized two study tours to Finland. Participants of the tours got familiar with both normal and technologically modern Finnish solutions and equipment. They also deepened the cooperation and established new networks.

Two training courses were organized in Russia. The purpose of training was to give the local partners in pilot villages the basic knowledge of community heating energy systems and arrangement and also to enable interactive learning by the village experts as well as trainers to get more knowledge about the Finnish target villages compared to those in Russia.

DISCUSSION AND CONCLUSIONS

The project gathered, analyzed and reported information on the energy systems and the property base in the project area. On the basis of the gained understanding the Finnish parties can continue the co-operation and development in the target area.

The created Virtual Village concept and roadmaps have aroused fruitful discussions and comments from project partners and other stakeholders. The project has given good understanding of project implementation phases: Master Plan - Roadmap – Project design - Construction.

The created road maps give a good starting point and direction for the development of the district heating systems in the target area, boiler houses, district heating networks, and the energy efficiency of the buildings. The implementation of delivered Road maps will be carried out in the near future.

People from the target groups have participated in the study tour in Finland and gained information on the Finnish district heating solutions in different municipalities. They are willing to use these methods also in their own municipalities in the Republic of Karelia. One big problem in the target area seems to be the difficulty in financing the development of district heating systems.

The most important results are the new contacts and the networks that have been established during the project. This gives a good base for future co-operation with different actors (state, regions, municipalities, companies etc.) in the target area and also in the other parts of Russia.

EXPLOITATION POTENTIAL

The rough calculations showed that the market potential (total costs) of the renovation of the district heating systems in the Republic of Karelia are over 400 million euros. Results and developed competence is usable also in other regions of Russia.

ACKNOWLEDGEMENTS

The project was mainly funded by the European Commission. The author wishes to thank the colleagues and participants of the project for their contribution to this work: Planora Oy, The State Committee of the Republic of Karelia on Reforming of Housing and Communal Services, Regional Energy Commission of the Republic of Karelia, Petersburg Power Engineering Institute of Professional Development (PPEIPD), Saint Petersburg, Oulu Region Centre of Expertise, Suomussalmi municipality, City of Kuhmo and City of Oulu.

CONTACT

Veli Möttönen
Senior Research Scientist
veli.mottonen@vtt.fi
Tel. +358 20 722 2032

THERMAL COMFORT WITH VARYING ROOM TEMPERATURE

Miimu Airaksinen, Pekka Tuomaala, Riikka Holopainen, Jouko Piippo

Thermal comfort standards determine indoor conditions in buildings as well as the energy consumption for heating and cooling purposes. Existing thermal comfort standards are based on steady-state thermal conditions, and according to recent research these standards can not describe thermal comfort accurately enough with transient boundary conditions. In this paper, a method based on Hui [1] is presented to calculate local and overall human body thermal sensations in time dependent and non-uniform conditions. In addition, local and overall thermal comfort predictions can be performed based on these thermal sensation values. The method is validated against laboratory measurement.

INTRODUCTION

Increasing concern about building sector energy consumption and the simultaneous need for an acceptable thermal environment makes it necessary to estimate in advance what effect different thermal factors will have on occupants [2]. The aim of this paper is to present a method how to predict human thermal sensation and comfort under transient and non-uniform boundary conditions. It also gives the preliminary results of the calculated comfort and laboratory measurements about comfort.

METHODS

The model used in this study is based on Hui's study [1] which includes results from 109 human subject tests that were performed under non-uniform and transient conditions in the UC Berkeley Controlled Environmental Chamber. In those experiments, local body surfaces of the subjects were independently heated or cooled while the rest of the body was exposed to a warm, neutral or cool environment. Skin temperatures, core temperature, thermal sensation and comfort responses were collected at one- to three-minute intervals [1]. Figure 1 shows the flow chart how the overall thermal comfort was calculated.

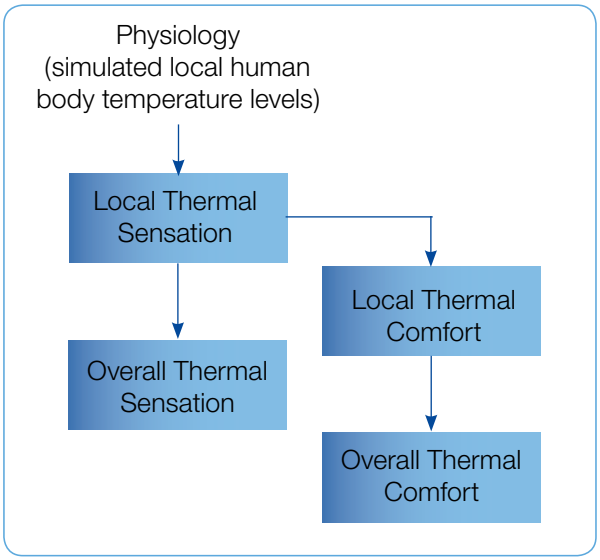


Figure 1. Overall thermal comfort calculation flow chart.

Following the earlier model, a new study was done on groups of students of ages 20-25 years, with 10 people in each measurement. The measurements were carried out during the summer period thus the clothing was light. The male persons were wearing jeans/long trousers and T-shirt and shoes while the female persons were wearing skirts, shirts and shoes or sandals. All subjects first stayed 20 min in a room at 20°C and then entered a test chamber with either 25°C or 30°C and also stayed there 20 min. After this period they returned for 20 min to the 20°C room. The skin temperatures of the test persons were measured every 30 seconds and thermal sensation and comfort were voted every 2 minutes. Temperature measurement points were in the forearm, lower leg and chest.

RESULTS

In the test conditions the female subjects were clearly more sensitive, which was probably partly because they were wearing lighter clothing. According to these preliminary results it seems that the model estimates the

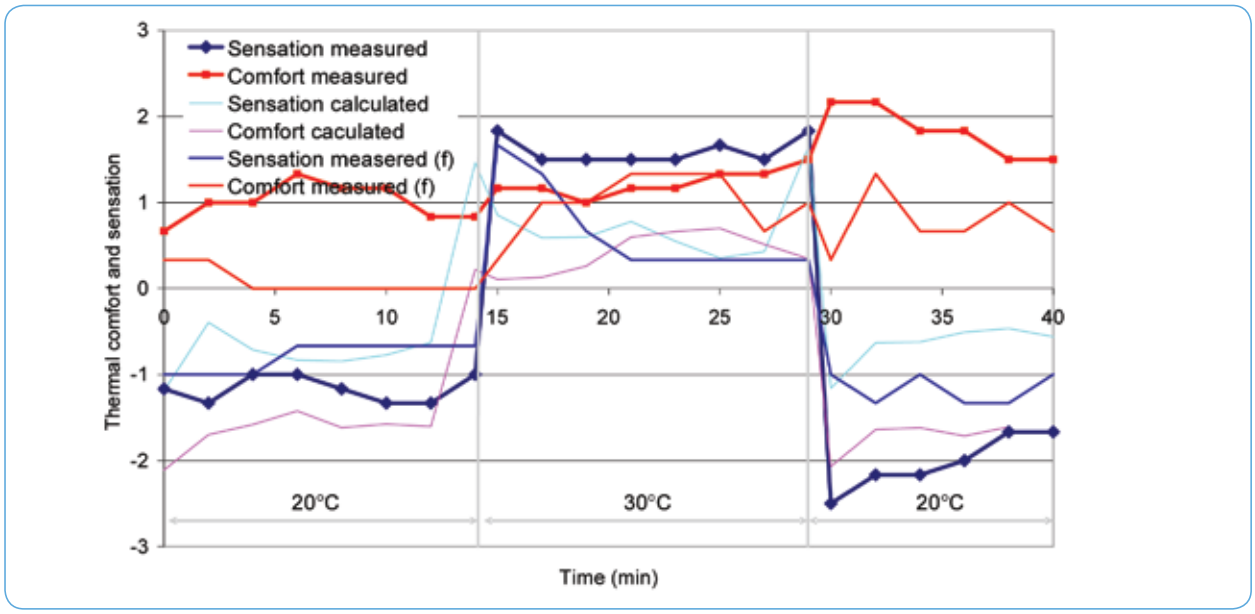


Figure 2. Calculated and measured thermal sensation and comfort, (f) indicates the voters were female.

thermal sensation rather well but the thermal sensations were different in test persons' votes. Especially the comfort values were different when returning back from the warmed room. The results were similar but noted lower changes in scale for the test environment where the subjects were in 20°C-25°C-20°C test conditions.

DISCUSSION AND CONCLUSIONS

Measuring thermal comfort is always a challenge since it is always a subjective vote. However, this study showed that the model gives new understanding about the thermal comfort and how changes in thermal environment effect on human thermal sensation.

The model is based on conditions were the temperature was mainly local with local heaters or coolers. In the measurement, the heating and cooling load was changed by changing the room, thus all the body parts were in the same environmental conditions. Also the test period (summer) and the heating with air could have had importance even though the air velocities were kept low. In the future, the winter test period measurements will provide new information.

The model based on Hui's study [1] gives new understanding about the thermal comfort and how changes in thermal environment effect human thermal sensation. The new knowledge is valuable in designing and developing new indoor environments. It would also help in finding the most suitable renovation alternatives for old buildings with respect to indoor environment comfort.

ACKNOWLEDGEMENTS

VTT funding is greatly acknowledged for supporting this research. Also Dalian University is greatly acknowledged for carrying out the measurements in the study.

REFERENCES

[1] Hui, Z. 2003. Human Thermal Sensation and Comfort in Transient and Non-Uniform Thermal Environments. Doctoral Dissertation, University of California, Berkeley, USA.

[2] Nilsson, H. 2004. Comfort Climate Evaluation with Thermal Manikin Methods and Computer Simulation Models. Doctoral Dissertation, University of Gävle, Sweden.

CONTACT

Miimu Airaksinen
Senior Research Scientist
miimu.airaksinen@vtt.fi
Tel. +358 20 722 4923

INFLUENCE OF MOISTURE CAPACITY OF BUILDING MATERIALS ON INDOOR AIR QUALITY

Miimu Airaksinen

The aim of the study was to determine how hygroscopic material such as wood influences the comfort of indoor conditions (humidity). For the field measurement 14 single family houses were chosen, which represented massive hygroscopic, massive non-hygroscopic, light hygroscopic and light non-hygroscopic structures. According to the measurements there is not significant differences in behavior when monthly values (temperature and relative humidity) where compared. However, when daily values were studied differences can be found. The interior (furnishing, textiles, carpets etc.) have a high impact on hygroscopic behavior of indoor climate. Thus, the non-hygroscopic structures were actually somewhat hygroscopic due to the interior.

INTRODUCTION

Relative humidity indoors has a very important role with respect to indoor air quality, thermal comfort, occupant health, material emissions and energy consumption. A too low relative humidity indoors may cause respiratory illnesses and asthma. However, also too high relative humidity has negative effects such as mould and moisture problems, dust mites and it might also cause respiratory illnesses. In most of the previous studies the temperature and air pollutants are well analyzed, but the indoor air humidity has far less notice although it can have important consequences.

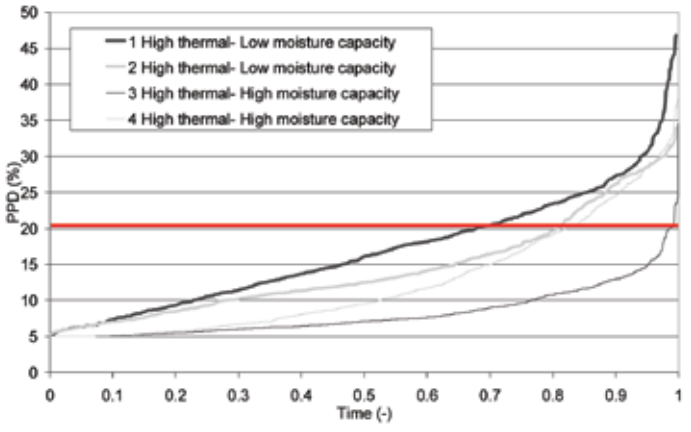


Figure 1. Duration curve of predicted percentage of dissatisfied for 4 different constructions, all with high thermal capacity in August.

Typically the humidity in indoor climate has rapid changes due to behavior of inhabitants such as cooking, showering etc. In a northern climate the relative humidity is at its lowest during winter months and at its highest during summer period. In Finland the main concern has been too low relative humidity. Studies focusing on high humidity are far less common.

The aim of this study was to determine the influence of hygroscopic properties of wood-based structures on indoor air humidity, temperature and comfort. This paper focuses on results based on field measurements.

METHODS

In this study four different kinds of buildings were selected for measurements: 1) construction with high thermal- but without moisture capacity, 2) construction with high thermal and moisture capacity, 3) construction with low thermal- but high moisture capacity, 4) construction with low thermal- and moisture capacity. 14 buildings were selected for the measurements. Six of the buildings had mechanical exhaust ventilation and the rest of them had mechanical supply and exhaust ventilation.

Measurements of temperature and relative humidity (RH) were done in the living room, master bedroom and in the shower room.

The air flow rates and pressure differences between indoor and outdoor air were measured at different stages of the ventilation system. The air tightness of the building was also measured according to standards EN 13829:2000 and ASTM E779-87.

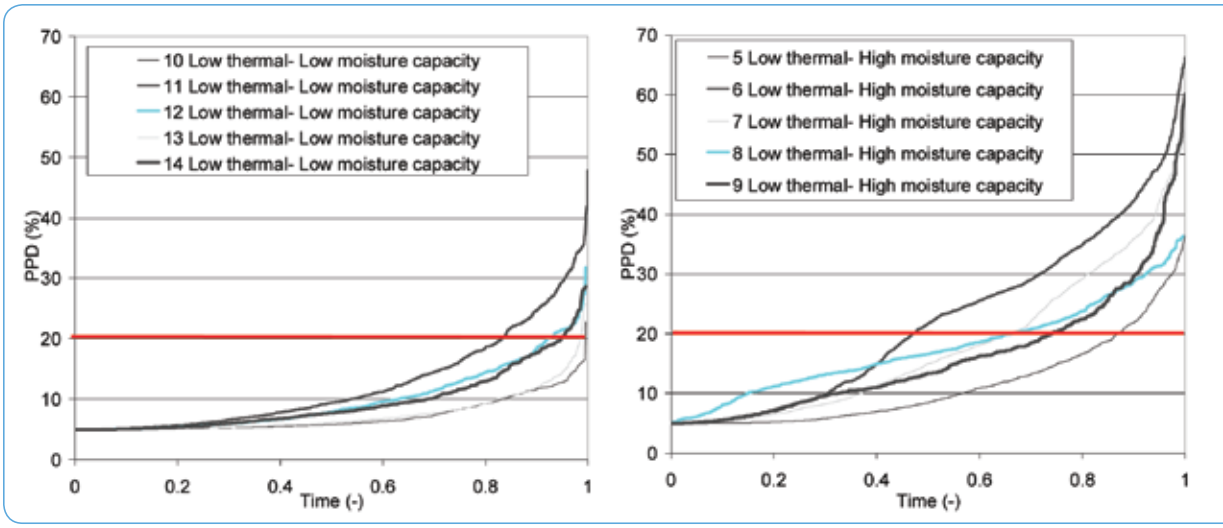


Figure 2. PPD values for constructions with low thermal capacity.

The acceptability of the indoor climate was analyzed according to ISO 7730 standard by calculating the Predicted Percentage of Dissatisfied (PPD). The PPD values can be calculated from predicted mean values (PMV).

RESULTS

The average of the air tightness, n50, was 3.7 ach, which is rather typical for dwellings in Finland. The pressure difference between indoor and outdoor air with normal use of the ventilation system was small, in average -1.7 Pa, indicating a slight under pressure inside the building. Only one building had a slight over pressure, 1 Pa. Exhaust air flow was in average 0.31 L/s,m^2.

The PPD was clearly lowest in the buildings whose temperatures were lowest, Figure 1. In building 3 only 2% of the time the recommended value of dissatisfaction of 20% was exceeded. The construction with high thermal and low moisture capacity exceeded the value of dissatisfied 20% of the time.

Building 11 had the highest value of dissatisfaction of buildings with low thermal and low moisture capacity, PPD 48%, Figure 2. In that construction 17% of the time the limit value PPD 20% was exceeded. Buildings 10 and 13, which had the lowest temperatures, had also very low PPD values; their PPD values exceeded 20% limit value only in a few percentages of the time in August. Building 6 with low thermal but high moisture capacity exceeds the limit value 53% of the time in August, this building also had the highest temperatures, and it has the highest peak value of PPD 66%.

DISCUSSION AND CONCLUSIONS

The variation of the relative humidity in the bedrooms had the widest range. However when the levels of absolute humidity were compared, the differences were small. It seems that the temperature had a stronger effect on humidity in the buildings than the moisture capacity of the construction.

When the values of predicted percentage of dissatisfied, PPD, was compared the lowest values were achieved in buildings with the lowest temperatures in August. The buildings with high thermal capacity did not always have the lowest temperatures, as it seems the location of the building and the amount of solar radiation probably had a great impact.

Although there were no significant differences in duration curves of relative humidity between the studied constructions, the differences were clear when the daily behavior was studied. A construction with a low moisture capacity could not bind the moisture flow from inhabitants in the bedroom during night time, and the relative humidity was higher in the night time. In buildings with moisture capacity the daily difference between bedroom and living room was not significant.

ACKNOWLEDGEMENTS

This study was funded by Tekes and the Finnish wood industry which are greatly acknowledged.

CONTACT

Miimu Airaksinen
Senior Research Scientist
miimu.airaksinen@vtt.fi
Tel. +358 20 722 4923

ROLE OF BUILDING MATERIALS IN OPTIMIZATION OF INDOOR AIR QUALITY

Ruut Peuhkuri, Tuomo Ojanen

There is a need to find methods and tools for implementation of theoretical and experimental research results on moisture buffering to practical design of buildings and especially having a good indoor environment.

INTRODUCTION

The purpose of this research project was to enable the continuation of the fundamental and practically applicable research on integration of the "complete" building in the establishment of good indoor air quality (IAQ). The special focus was on the utilization of "passive" systems to create healthy indoor climate, as the focus recently has moved more towards minimizing energy use in buildings at the same time. This project is based on recent state-of-art research work by the authors on understanding the moisture dynamics in building materials and implementing these mechanisms in a whole building hygrothermal approach. A recent important international research cooperation was a Nordic NORDTEST project entitled "Moisture Buffering of Building Materials" (2003-2005), where a method for experimental determination of moisture buffering capacity of building materials was developed [1].

A continuation of these approaches was in part to relate the moisture buffering phenomena to practical use in building design and in part the inclusion of some of the "missing" parameters in the studies: e.g. the role of pollutants and air flow. The overall goal of this research was to understand and to model in an integrated way the mechanisms of transport and storage capacity of heat, air and moisture, as well as pollutants, in indoor spaces, exterior and interior constructions and materials, and technical systems.

APPROACH

The whole building hygrothermal simulation can be used to carry out analysis of the impact of the building, with its layout, choice of materials, structures and systems for heating, cooling and ventilation, on indoor air quality, productivity, durability and energy consumption. Development of this kind of complex models was one of the main purposes of the recently finished IEA Annex 41 Hygrothermal Performance of Whole Building Heat Air and Moisture Response (2003-2007). The key researchers of this project participated actively on e.g. the modeling work [2] and also on implementation of the results of hygrothermal calculations on long term performance and

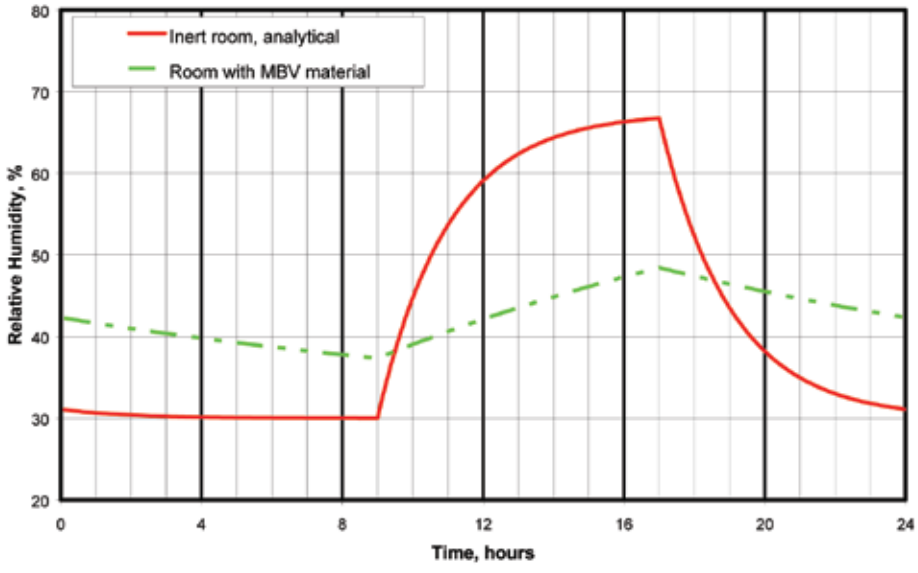


Figure 1. Effect of moisture buffering on the indoor humidity variation in a room with a given moisture source from 9 am to 5 pm. MBV material is uncoated autoclaved aerated cellular concrete, which is a relatively good moisture buffer.

durability of structures. These complex simulation models are mostly used for research purposes and therefore there was a need for knowledge transfer to practice and more practical tools.

RESULTS

The focus was on preliminary research, with the aim to establish larger research projects:

- Transfer of knowledge on moisture buffering: From the present theoretical and experimental definition to a concept that can be used by the building industry and designers
- Parameter studies on the impact of the buffering phenomena on: Comfort, perceived indoor air quality, occupant health and productivity, energy requirement for heating, cooling and ventilation and on durability without moisture related damage, like risks for mould growth.

This was achieved by development of a simple calculation tool [3], by introducing the methodology and possibilities for building designers and indoor environment specialists on seminars in Finland [4] and by actively attending international state-of-the-art workshops on this topic [5].

DISCUSSION AND CONCLUSIONS

The nature of this project was to initiate activities on these research topics, thus concrete results are therefore not dominating the output. The main scope was achieved and project participants are now actively bringing this research on implementing moisture buffering know-how further in Finland and internationally.

EXPLOITATION POTENTIAL

A part of the project was allocated to implementation of the idea of active use of buffering materials in an innovative framework. An international group of experts on innovative material development technologies were invited to prepare a common research proposal on this topic for future funding. Such materials that can actively improve e.g. indoor air quality without using energy are very interesting for many industrial sectors besides the building industry. The amount of interested business partners has been encouraging.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work, among others: Ismo Heimonen, Hannu Viitanen and Miimu Airaksinen of VTT. The research has been funded by the Academy of Finland and VTT.

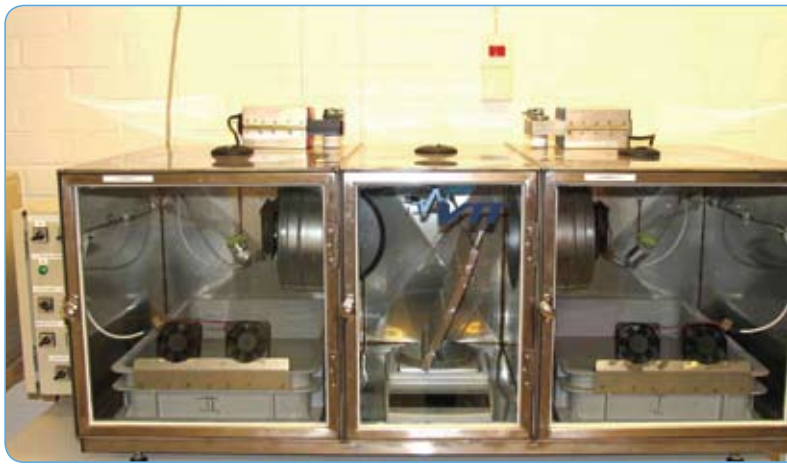


Figure 2. The experimental set-up for determination of the moisture buffer value. The sample is placed in the middle chamber and exposed to dynamically cyclic changes in the relative humidity of the air.

REFERENCES

[1] Rode, C., Peuhkuri, R., Hansen, K.K., Time, B., Svennberg, B., Arfvidsson, J. & Ojanen T. 2006. Moisture Buffer Value of Building Materials. American Society of Testing and Materials. ASTM Symposium on Heat-Air-Moisture Transport: Measurements on Building Materials. Toronto, 23 April 2006.

[2] Rode, C., Peuhkuri, R. & Woloszyn, M. 2006. Simulation Tests in Whole Building Heat and Moisture Transfer. 3rd International Building Physics Conference, Montreal 2006.

[3] Rode, C. & Peuhkuri, R. 2006. The Concept of Moisture Buffer Value of Building Materials and its Application in Building Design. Healthy Buildings 2006, Lisboa, Portugal. 4–8 June 2006.

[4] Peuhkuri, R. & Ojanen, T. 2007. Building materials as moisture buffers. (In Finnish). Paper to Rakennusfysiikka 2007 Symposium.

[5] Ojanen, T., Viitanen, H. & Peuhkuri, R. 2007. Modelling of mould growth in building envelopes – Existing models, discussion on improvement aspects, sensibility analysis. Working Paper to IEA ECBCS Annex 41 Working Meeting, Porto.

CONTACT

Ruut Peuhkuri
Research Scientist
ruut.peuhkuri@vtt.fi
Tel. +358 20 722 4125

PROTECTION OF AIRPORTS AGAINST CHEMICAL, BIOLOGICAL OR RADIOLOGICAL HAZARDS

Ilpo Kulmala, Matti Lehtimäki, Arto Säämänen, Raija Koivisto

The AIRSECURE project developed means to manage invisible airborne threats at airports by developing monitoring and protective ventilation equipment and risk assessment to integrate the equipment with the airport in the most beneficial way.

INTRODUCTION

Airports are vital to the social and economic development of European countries. To help maintain the free flow of passengers and goods effectively, security measures are needed to improve the protection against new terrorist threats. Of particular concern are chemical and biological agents, which can cause a large number of casualties among exposed passengers and the airport personnel after a potential release. To mitigate the impacts due to the dispersion of hazardous agents, monitoring and protective ventilation systems can be applied. To do this in a cost effective way, risk assessment may be used to rank and prioritize the risks and identify the most beneficial locations for the monitoring and protecting devices.

The project entitled "Risk-Based Detection and Protective Filtration System for Airports Against Airborne Chemical, Biological or Radiological Hazards, (AIRSECURE)," was a European project to develop a system that consisted of air filtration and detection solutions against airborne threats at airports [1, 2]. The design and operation of the system was based on risk analysis and risk management.

MATERIALS AND METHODS

The main idea of the AIRSECURE project solution was to combine promising new filtration technologies for removal of both biological and chemical agents with chemical detectors into a protective ventilation system. These distributed units can be flexibly and quickly installed in the supply or exhaust air ducts of high-risk areas. The very low flow resistance of the filter allows its installation without extensive modifications to the ventilation systems. An important part of the system was the new chemical detector which was developed to continuously monitor the inlet and indoor air quality for maximum security. The optimum number and location of both gas detectors and protective filtration systems are based on risk analysis, in this case a procedure to systematically identify, analyze and assess the risks caused by hazardous airborne substances at the airports.

RESULTS

The secure air-filtration and advanced warning systems can deter attacks, and reduce the effects of a chemical, biological or radiological agent release by removing the toxic agents from supply air of a building. The modular system is realized based on risk analysis and it gathers together the important aspects of protection:

- Risk analysis methods for airborne threats in confined spaces.
- Combination of high efficiency particulate filtration with novel gas phase filtration to offer continuous and efficient protection against chemical and biological hazards.
- Low-cost particle detectors to monitor the performance of filters to ensure a high protection level at all times.
- Distribution of filters in high risk areas where protection is mostly needed.
- Utilization of distributed chemical detectors with central monitoring, to trigger alarms and to ensure timely response to imminent danger.

DISCUSSION AND CONCLUSIONS

The AIRSECURE system will help to deter, withstand, and recover from possible terror attacks. The risk assessment is always case based, but the systematics to identify, model and assess the risks are more generic and may be tailored to the application area. A tailored procedure for airport risk assessment was developed in the AIRSECURE project. The procedure, however, was not published because of security reasons. The other limiting factor for

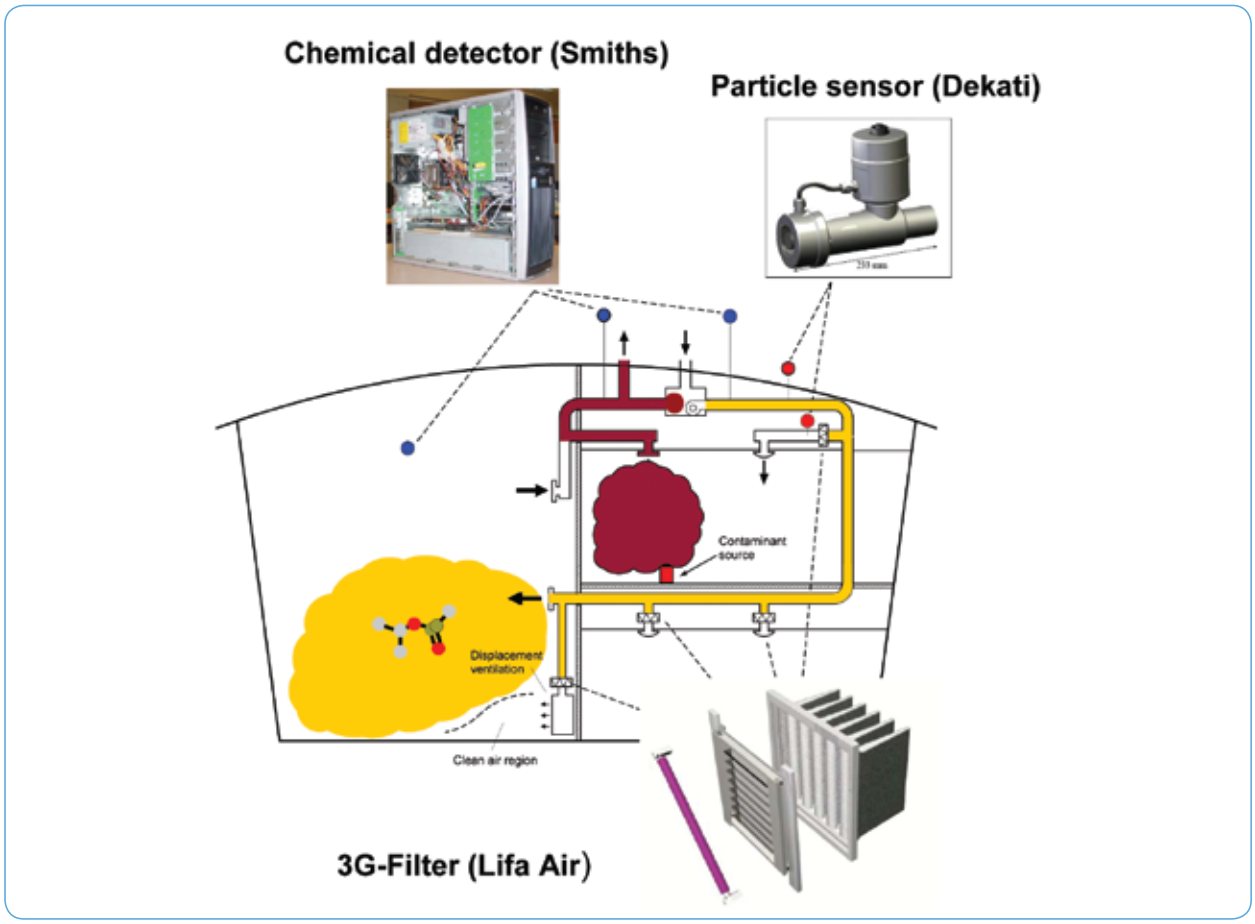


Figure 1. Principle of the developed Airsecure system.

the publication of the results was the confidentiality of the data used when testing the method and other key components of the system.

EXPLOITATION POTENTIAL

The improved filtration and detection system can be used to control the spreading of naturally occurring, accidental, or intentional releases of airborne pollutants. The enhanced filtration will also effectively remove major outdoor pollutants such as submicron particles, volatile organic compounds, odors and ozone from the supply air resulting in comfortable and healthier indoor air.

ACKNOWLEDGEMENTS

The authors wish to thank the following persons for their contribution to this work: Jyri Vikström, Timo Koivisto, Timo Tuomainen and Martin Alm from Finavia, Markus Heiskanen from Police Counter-Terrorist Unit, Jari Näveri from Finnish National Traffic Police, and Raymond Pronk from Rotterdam Airport. The research has been funded by the European Commission, and industry partners including Lifa Air, Smiths and Dekati.

REFERENCES

In addition to the confidential reports (which formed the main results), the following were published:

[1] Kulmala, I., Väkevä, M., Arnold, P., Kekki, A. & van Gulijk, C. 2006. AIRSECURE – Risk-based detection and protective filtration system for airports against airborne chemical, biological or radiological hazards. Proceedings of NBC 2006 seminar.

[2] Väkevä, M., Kulmala, I., Kekki, A., Laurent, K., Madeira, J., Arnold, P. & Brasser, P. 2007. AIRSECURE-safety through filtration and detection. Proceedings of Clima 2007 congress.

CONTACT

Ilpo Kulmala
Senior Research Scientist
ilpo.kulmala@vtt.fi
Tel. +358 20 722 3263

HIGH PERFORMANCE VENTILATION IN LARGE FARM BUILDINGS

Ismo Heimonen, Jorma Heikkinen, Keijo Kovanen

The performance of ventilation is the key aspect for improving the indoor air quality in occupancy and working spaces. Ventilation has a big influence on health and productivity of the animals in farm buildings and it improves the working environment of farmers. As a long period result this project aimed at high performance, high productive indoor environment with high performance ventilation.

INTRODUCTION

The increase of farm sizes and other changes in production environments in last 20-30 years are a reality in Finland and this is setting new requirements for the ventilation and energy systems of farm buildings. The quality of ventilation systems in farm buildings varies a lot. There are a lot of good cases, but too many bad cases as well. The quality of ventilation is improved by developing national building codes, developing the technology and bringing the best available technological solutions to the markets. The utilization of the best available systems is improved by information and dissemination. The objective of the project "High performance ventilation in large farm buildings" was to affect animal welfare and productivity by improving the functionality and risk management of ventilation in animal houses. The project presented basic principles for designing ventilation for cold climates, system concepts for ventilation and methodology for commissioning and performance evaluation. The performances of typical ventilation systems in farm buildings were studied during the project and 10-15 case studies were measured. The development and research needs and ideas on how to improve the performance of ventilation and energy systems in farm buildings in a cold climate were presented.

RESULTS

The main steps and results of the project are summarized below.

- The state-of-the-art of ventilation in farm buildings and research needs were evaluated in an international workshop at the beginning of the project [1].
- State-of-the art of indoor air quality and ventilation systems in case study animal buildings (dairy cattle, pig, poultry, horse) in Finland were presented.
- The need for updating building codes, regulations and recommendations (requirements for indoor climate/concentration, temperatures, RH, ventilation rates, loads etc.) is an important part of the development. The indoor climate requirements are set from point-of-view of animals, workers, buildings (structures and components) and productivity.
- Development needs and ideas based on the case studies were presented [2]. This task gave development principles for the systems, including analysed cases (measurements and theoretical studies). The ventilation concepts and models for systems for different type of animal houses in cold climates were presented. The main concepts are mechanical exhaust ventilation, mechanical supply and exhaust ventilation and hybrid ventilation utilising principles of natural ventilation. These main concepts have lots of variations which can be selected. The economical viability and usability of heat recovery systems in different type of animal houses and climates were evaluated. The principles and solutions for controlling air change rate according to weather and internal gains were evaluated.
- General design rules and principles for designer were disseminated: Information packages for education, and workshops were presented for the whole the chain from designers to end users. The practical commissioning methods are presented for farm workers and ventilation experts [3].
- The effects of indoor climate on productivity were evaluated by cost-benefit analyses methods and case analyses.

Figure 1. Pig house for ~900 sowing pigs at Padasjoki.

- An information package for manufacturers of components and systems, designers, authorities checking the designs/plans is one expected result after the project.

DISCUSSION AND CONCLUSIONS

As a long period result the project aimed at high performance, high productive indoor environment with high performance ventilation. The project summarizes indoor air quality (IAQ) requirements and development needs of national building codes in Finland. The key actions are to improve the level of design practice in ventilation design and take commissioning procedures in use to guarantee the quality of ventilation systems. The different concepts for ventilation systems used in cold climates have been evaluated and critical design aspects in cold climate were presented. The case studies give examples on how to evaluate the performance of ventilation systems and show the benefits of commissioning of ventilation performance in practice. All the case buildings measured during the project had needs to repair or improve the performance of ventilation based on measurements - most of them had needs only for minor changes in control settings or places of sensor. The case studies have shown the needs for research and product development in the near future.

EXPLOITATION POTENTIAL

The project developed the design methods and principles and commissioning methods for ventilation design in animal houses. The principles were evaluated in case studies to improve the dissemination of the methods. The project improved the implementation of modern ventilation technologies in farm buildings.

ACKNOWLEDGEMENTS

The authors wish to thank colleagues from the following institutes for their contribution to this work: VTT, TTS Institute (Work Efficiency Institute), Finnish Institute from Occupational Health and MTT Agrifood Research Finland. The authors would also like to thank the farmers, 7 private companies and the Ministry of Agriculture and Forestry, MELA (Pension Institution of Farmers), The Finnish Meat Trade Association, Research Foundation for Farming Machinery, and Finland's Poultry Association for the financial aid and other support for this project.

REFERENCES

[1] Heimonen, I. 2006. State-of-the art and development needs for ventilation in farm buildings. (In Finnish). Summary of workshop Ventilation and IAQ in farm buildings, 21 September 2006.

[2] Heimonen, I. 2008. Improving the performance of ventilation in large farm buildings in cold climate. Published in Proceedings of AgEng2008 Conference. Crete, Greece, June 2008.

[3] Kovanen, K. et al. The commissioning procedure of farm building performance in Finland. Published in Proceedings of AgEng2008 Conference. Crete, Greece, June 2008.

CONTACT

Ismo Heimonen
Senior Research Scientist
ismo.heimonen@vtt.fi
Tel. +358 20 722 4907

MODELING MOULD GROWTH ON BUILDING MATERIALS

Hannu Viitanen, Ruut Peuhkuri, Tuomo Ojanen, Leena Paajanen

The requirements for durability of the buildings and indoor air quality are growing. Therefore the focus in hygrothermal modeling of whole buildings is moving towards a kind of risk analysis. One of the main risks in this sense is the growth of micro-organisms, following indoor air quality problems and biodeterioration of the building materials.

INTRODUCTION

During the service life of buildings, natural aging and eventual damage of materials due to different chemical, physical, and biological processes can take place. In order to provide durable and healthy buildings, we need to manage the conditions – especially in the microclimate and around the envelope constructions – and therefore to be able to reduce the risk for mould growth in the wrong place. Biodeterioration, e.g. mould, decay and insect damage in buildings is caused by moisture exceeding the tolerance of structures which may be a critical factor for durability and usage of different building materials. Mathematical modeling of mould growth has been a research topic at VTT for many years. The research has included several experimental studies on conditions for mould growth primarily on wood, but also on other building materials. The present VTT model consists of a mathematical model that also takes into account the delay in mould growth rate due to un-favorable conditions. The model has also been connected to building physics calculation methods.

RESULTS

A classical way to express suitable exposure conditions is to use so-called isopleth diagrams. Based on large laboratory studies, mathematic modeling on mould growth has been developed at VTT (Figure 1). According to the model, the lowest humidity level for mould growth is around RH 75 – 80 % and for decay development above RH 95 - 98 % [1]. The response times proved to be short (from a few days to a few weeks) in pine sapwood in conditions favorable to the growth of micro-organisms and long (from a few months to a year) in conditions close to the minimum and maximum moisture or temperature levels. The favorable temperature range for growth is mould fungi is 0-50°C, and the critical relative humidity required for initiation of mould growth is a function of temperature.

When comparing two models, the hygrothermal model by Sedbauer [2] and the VTT mould growth model using a climate data from Tampere area (Figure 2), the time periods in the hygrothermal model for spore germination are shorter than for the start of growth (mould index 1) used in the model by Viitanen et al [3]. Also different types of materials have an effect on the time periods needed for spore germination. In Figure 3, a comparison is shown of

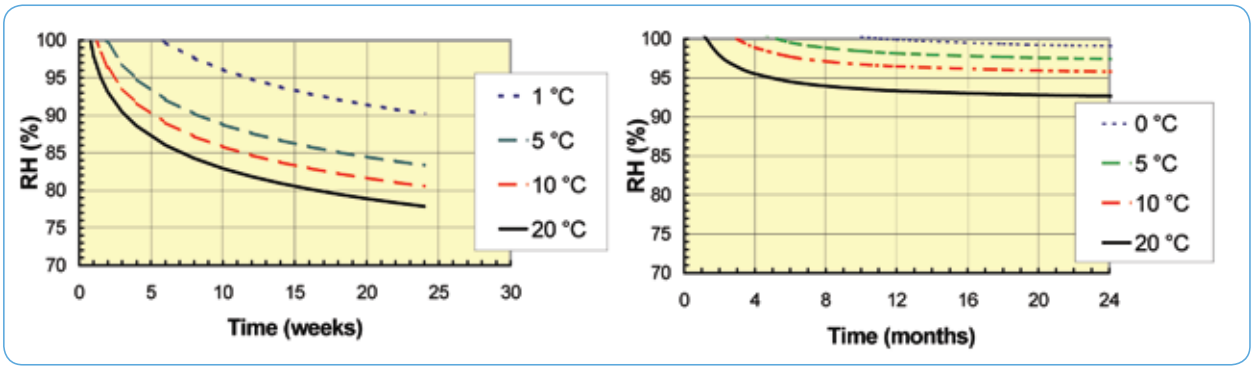


Figure 1. Critical humidity (RH %), time (weeks / months) and temperature needed to start mould growth on pine sapwood (A) and early stage for brown rot development (B) in pine sapwood [1].

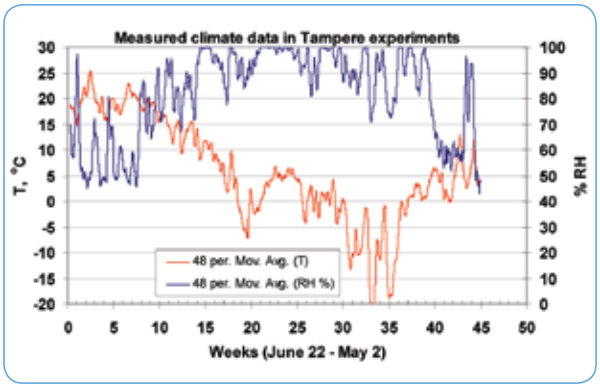


Figure 2. Measured climate data presented using 48 hour moving average values. The simulations use the original hourly measured data.

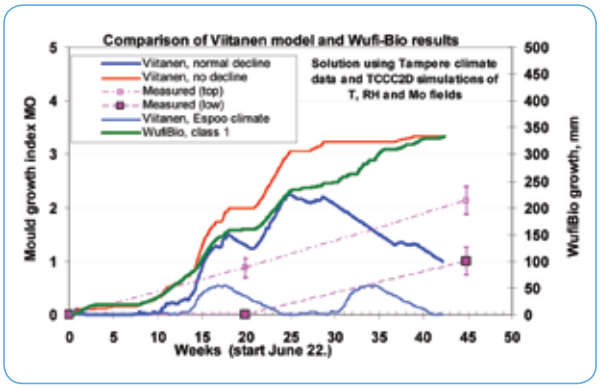


Figure 3. Comparison of VTT Model and WufiBio – and measured mould index – on pine sap wood. Results with VTT Model has been calculated under several assumptions. Viitanen, no decline is assumed to most comparable with the biohygrothermal model behind WufiBio.

the critical conditions for mould growth assumed by some of models proposed. Effectively, these curves represent lower limiting isopleths for mould growth.

DISCUSSION AND CONCLUSIONS

There are several factors involved with the biodeterioration of materials and buildings, and mathematic modeling that may help in understanding the complicated interaction of many factors. Mathematic modeling, however, will not give the answers for all problems and users should be aware of the limitations to give the true picture of the complicated process of biodeterioration and damage development in buildings. Future research will provide more knowledge to allow development of more applicable models.

EXPLOITATION POTENTIAL

The growth of micro-organisms in building constructions may increase the risk for durability failure and reduce the indoor air quality if present on the inner surfaces. In order to avoid these problems in existing and new buildings, there is a need for a tool, which can easily be incorporated to commonly used building simulation tools. At present, this issue has great interest and some model developments exist in different research institutions. Among them, there is some kind of consensus about the overall criteria for mould growth as a function of temperature, relative humidity and time. Nevertheless, there is very little knowledge on mould growth on different kinds of materials and the effects of the aging of materials, coatings and dust accumulation on mould growth. The modeling of mould growth and decay development is an area for developing more advanced tools for building design and work execution in the future [4, 5].

ACKNOWLEDGEMENTS

The project has been financed by Tekes and VTT.

REFERENCES

[1] Viitanen, H. 1996. Factors affecting the development of mould and brown rot decay in wooden material and wooden structures. Effect of humidity, temperature and exposure time. Doctoral thesis. The Swedish University of Agricultural Sciences, Department of Forest Products. Uppsala. 58 p.

[2] Sedlbauer, K. 2001. Prediction of mould fungus formation on the surface of/and inside building components. University of Stuttgart, Fraunhofer Institute for building Physics, Doctoral thesis. Stuttgart. Germany

[3] Viitanen, H., Ritschkoff, A-C, Ojanen, T. & Salonvaara, M. 2003. Moisture conditions and biodeterioration risk of building materials and structure. Proceedings of the 2nd International Symbosium ILCDES 2003. Integrated Lifetime Engineering of Buildings and Civil Infrastructures, Kuopio, Finland, 1–3 December 2003. pp. 151–156.

[4] Viitanen, H., Vinha, J., Salminen, K., Ojanen, T., Peuhkuri, R., Paajanen, L. & Lähdesmäki, M. 2008. Moisture and biodeterioration risk of building materials and structure. BEST! Conference, Minneapolis, USA. 10–12. June 2008.

[5] Ojanen, T., Viitanen, H. & Peuhkuri, R. 2007. Modelling of mould growth in building envelopes – Existing models, discussion on improvement aspects, sensibility analysis. Working Paper to IEA ECBCS Annex 41 Working Meeting, Porto.

CONTACT

Hannu Viitanen
Senior Research Scientist
hannu.viitanen@vtt.fi
Tel. +358 20 722 5528

OPEN BUILDING MANUFACTURING

Matti Hannus, Pekka Huovila, Juha Hyvärinen, Kalle Kähkönen

The European project "Open Building Manufacturing", MANUBUILD, aims at open manufacturing in construction, ambient manufacturing methods, and value driven business processes, appropriately supported by ICT. It aims to provide affordable, customized and flexible (configurable on demand) buildings improving the quality of life and providing better value to the customer through a diverse range of "plug-and fix" modules and components and related services offered by knowledge-driven Small and Medium Sized Enterprises (SMEs).

INTRODUCTION

There is a need to produce high quality affordable homes that reflect changing demographics, particularly with respect to smaller family units, intelligent support systems for the elderly and infirm and the increasing requirement for higher density living. These new homes must be sustainable, eco-efficient and manufactured in a clean and safe environment where much greater control can be exercised over build processes.

APPROACH

The goal of the project was to create an "Open Building Manufacturing System", a new paradigm for building production by combining efficient manufacturing in factories and construction sites, and an open system for products and components offering diversity of supply in the open European market.

A holistic approach is used in research activities for open system manufactured buildings, value driven business

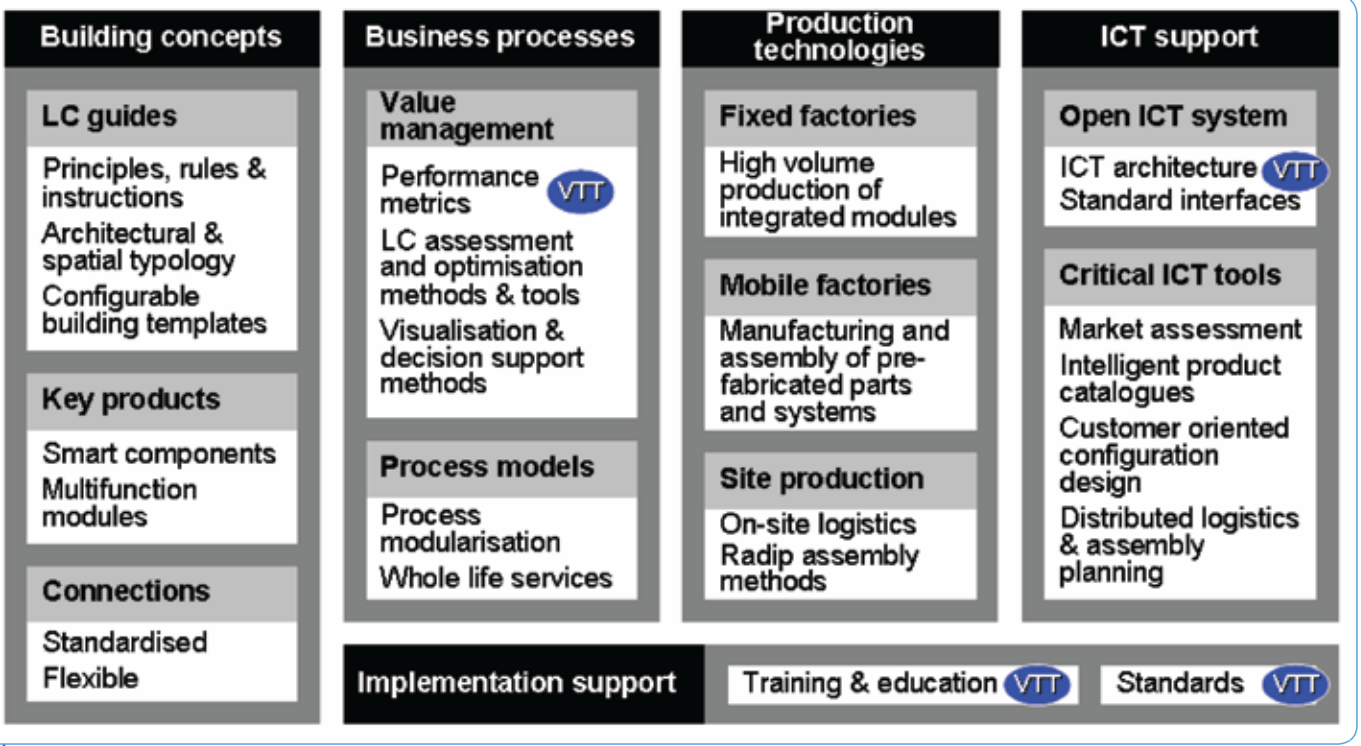


Figure 1. Summary of the main results of the project. The role of VTT in the project is highlighted.

processes, ambient and scalable manufacturing methods, and ICT support. The results are validated and demonstrated in several full scale building projects.

The project targeted a radical paradigm shift from the current "craft and resource based construction" towards "open building manufacturing" that enables highly customized buildings using manufactured, knowledge-based components from the open market and assembling them efficiently on-site.

RESULTS AND EXPECTED IMPACTS

The expected results are summarized in Figure 1.

Potential impacts include: construction cost reductions in excess of 50%, time reductions in excess of 70%; reduction in work related accidents of 90%; new knowledge based industry offering quality jobs (mainly for SMEs) all over the EU; new business opportunities; safety at work; reduced waste; better job satisfaction; more value to customers (society); housing in less developed parts of EU, etc.

A core focus of ManuBuild will be the delivery of inspirational and affordable housing designs through a highly efficient process that reduces wasted labor, time and materials.

DISCUSSION AND CONCLUSIONS

The project has developed new technologies and approaches in several key areas /Figure1). These are being demonstrated and validated during the last phase of the project, which will end in spring 2009.

An example of a unique breakthrough result is a standards-based method to describe catalogues of parametric building components / modules. Until now it has been possible to publish only fixed product designs. The project catalogue objects include rules and constraints for customization. This is a key prerequisite for the creation of an open market for manufactured building products that are suited to customized building solutions. This new technology enables, not only custom design and flexible manufacturing, but also the industrialization of engineering design, and thereby the transformation of construction from a craft-based sector into a knowledge-based industry.

EXPLOITATION POTENTIAL

The project results contribute to increased use of manufacturing methods in construction, thereby increasing productivity and quality, job satisfaction and safety - improving the image of the construction sector as a provider of attractive career opportunities.

ACKNOWLEDGEMENTS

The research was funded by the European Commission, Tekes and VTT. The project consortium included 22 participants from 9 countries.

REFERENCES

[1] Public web site of MANUBUILD project, 2005, www.manubuild.org.

[2] Proceedings of the 1st MANUBUILD international Conference, 25–26 April 2007, Doelen Congress Centre, Rotterdam, the Netherlands, www.manubuild.net/.

[3] Kazi, A. S., Hannus, M., Boudjabeur, S. & Malone, A. (eds.) 2007. Open Building Manufacturing – Core Concepts and Industrial Requirements, http://cic.vtt.fi/kazi/MB_Book_01.zip.

[4] Huovila, P. Measuring performance and value in manufactured housing. In Revaluing Construction 2007 Conference. Copenhagen-Malmö, 9–10 October 2007.

[5] Huovila, P., Kähkönen, K. & Navarro, J. 2006. Performance Metrics for Residential Building Business. In Joint CIB W65/W565/EW86 Symposium in Rome, 18–20 October 2006.

CONTACT

Matti Hannus
Chief Research Scientist
matti.hannus@vtt.fi
Tel. +358 20 722 6948

INDUSTRIALIZED, INTEGRATED, INTELLIGENT CONSTRUCTION

Veijo Lappalainen, Matti Hannus, Iris Karvonen, Kalevi Piira

It is important to take a whole life cycle view in the development of industrial construction, where high performance buildings and services deliver end-user value and sustainability.

INTRODUCTION

The ongoing European integrated project "Industrialized, Integrated, Intelligent Construction (I3CON)" [1] supports the transformation of construction towards sustainability, and provision of life cycle performance and value to users with Industrially produced, Integrated processes and Intelligent building systems.

The project aims at increasing the sustainability, performance and life cycle value of buildings to the users and customers. This requires holistic technological development, like new materials and components, information technology and control systems, as well as development of processes, services and business models. This paper presents the first approaches in three specific focus areas of the I3CON project.

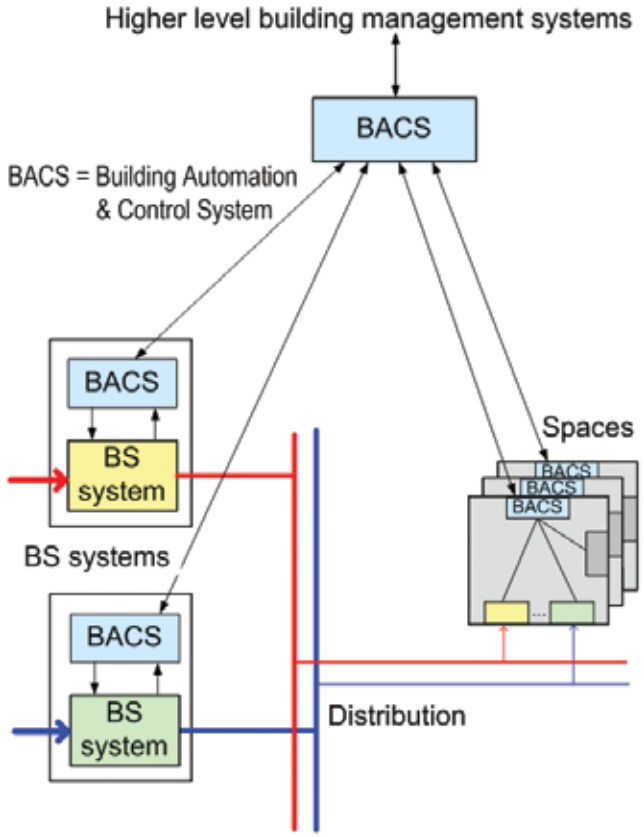


Figure 1. Building Services (BS) system architecture.

VALUE BASED BUSINESS MODELS AND PERFORMANCE METRICS [2]

By developing performance/value based business models and supporting performance metrics, the project aims at increasing the building value to the customer. The objective is to go beyond the selling of products to delivering value through the building and related services. Thus a performance based business model links the logic of earning money to the appreciation of the value by the customer and thus to the performance. The I3CON project's performance-based business model defines the value proposition, transactions and relationships within the process of selling the performance of built environments over their entire life-cycle as an end product. The payments from the customer are dependent on the delivered value which is measured by the performance metrics.

To implement performance/value based business models, methods and metrics for intelligent performance measurement of buildings, taking into account the whole lifecycle, are thus needed. There is already a large variety of different approaches, categories and standards for performance measurement in construction. In many cases the focus is more on the construction processes than the end product in operation. Some of the approaches are focused on a specific item like decreasing energy consumption or other objectives related to the environment.

The challenge of the project is not to invent new Building Performance measures as such but to develop a reference model how building performance measures could be de-

fined and used to support Value-based Business Models in the construction industry. In the first step towards the reference model, a performance measurement template was defined. The template aimed at defining the characteristics and relationships of a performance measure and a framework to organize the previous approaches and metrics.

REFERENCE ARCHITECTURE FOR INTEGRATED BUILDING SERVICES (BS) SYSTEMS [3]

The overall BS system is composed of different BS subsystems, which produce technical building services into the spaces to be consumed in order to create safe & secure, productive and effective i.e. high performance space conditions throughout the life cycle of building. The development of flexible and interoperable subsystems, modules and components requires reference architecture for the overall BS system.

The definition of the reference architecture is based on top-down systems approach, which covers the requirements, the overall systems architecture and system concepts.

The main components of the overall architecture are the BS systems, space systems and the building automation control system (see the figure). For BS systems the architecture is based on the generic structural model of BS system consisting of generation, center, transfer and space modules.

INTEGRATED BUILDING INFORMATION SERVICE [4]

The I3CON project information system enables easy access for users and applications to core building management information from real-time building automation, sensor networks as well as facility management information.

The project information system is based on Service Oriented Architecture, a generally used enterprise level integration approach. Well-defined services enable different applications to use the information provided by different systems without necessarily knowing the details of these systems beyond the service interface (Figure 2).

A key component of the I3CON project information system is the Building Service Gateway. It enables the supporting applications for high performance, productive buildings and related new life cycle services.

DISCUSSION AND CONCLUSIONS

This project takes the whole life cycle view in the development of industrial construction. The wide scope ties together different components and approaches with the objective of high performance buildings and services delivering end-user value and sustainability.

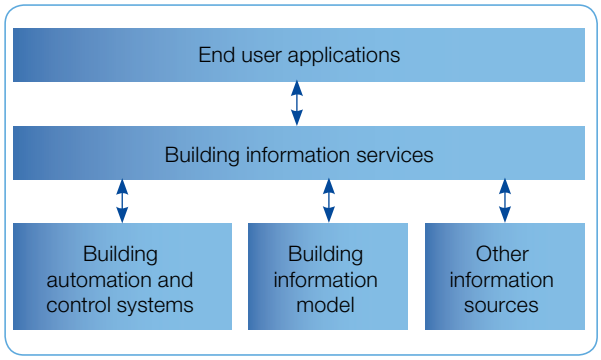


Figure 2. Building information systems architecture.

ACKNOWLEDGEMENTS

The I3CON integrated project was co-funded by the European Commission, Tekes and VTT, and will be completed in autumn 2010. The contributions of the 29 consortium members from 14 countries are acknowledged.

REFERENCES

[1] Public web site of I3CON project, 2008, www.i3con.org.

[2] Karvonen, I., Nissinen, K., Kauppinen, T. et al. 2008. Towards a Reference Model for Building Lifecycle Performance Measurement. Proceedings of the 1st International Conference on Industrialised, Integrated, Intelligent Construction I3CON. Loughborough, UK, 14–16 May 2008, pp. 149–157.

[3] Lappalainen, V. & Piira, K. 2008. Integrated Overall Building Services Systems Architecture. Proceedings of the 1st International Conference on Industrialised, Integrated, Intelligent Construction (I3CON). Loughborough, UK, 14–16 May 2008. pp. 255–265.

[4] Piira, K. & Lappalainen, V. 2008. Integrated Building Information Service through Building Services Gateway. Proceedings of the 1st International Conference on Industrialised, Integrated, Intelligent Construction I3CON. Loughborough, UK, 14–16 May 2008, pp. 267–274.

CONTACT

Veijo Lappalainen
Senior Research Scientist
veijo.lappalainen@vtt.fi
Tel. +358 20 722 4726

INTEGRATED SUPPLY CHAIN INFORMATION SYSTEMS

Antti Permala, Arto Kiviniemi (Project Manager), Ari Sirkiä, Harri Hiljanen, Jani Granqvist, Jarkko Lehtinen

A construction supply chain is a network that performs functions of procurement, transformation, and installation of components in a project. The supply chain significantly affects a construction project based on its ability to deliver in a timely and efficient manner. Recently, supply chain management (SCM) has received a lot of attention in the construction industry. The project entitled "Integrated Supply Chain Information Systems," ISCIS, addressed the problem of information transparency in the construction supply chain. Web service integration technology and building information models (BIM) were applied to enable real-time information sharing.

INTRODUCTION

In today's economy, a "virtual" supply chain system is a vital element of success. The effect of information technologies on SCM has led to significant cost savings in many industry sectors [1]. It is commonly agreed that a construction supply chain includes a lot of waste and unnecessary cost that could be eliminated by applying these techniques.

The coordination and integration of materials, information, and financial flows within and across companies are critical in effective SCM. Among these, sharing information is a key component for tight integration to optimize the performance and it has been facilitated due to the recent advances in information technology [2].

To enable information sharing, Information and Communication Technology (ICT) has been extensively leveraged in SCM. In contrast to the manufacturing industry, the construction industry has a wide spectrum of speed, uncertainty, and complexity [3]. It is not likely that the strategies and techniques used in other industries can be introduced without appropriate modification. Therefore, it is necessary to identify suitable technologies and to validate them from the construction-specific point of view.

Several surveys [4] have shown that the supply chain related problems are the highly ranked causes for delays in construction projects. Due to the long information lead-time and lack of coordination, it is difficult for practitioners to have appropriate information to make sure that all materials and equipment arrive on site in time. Furthermore, a large number of participants in a construction project make problems intractable as well as undetectable in advance.

APPROACH

The research was based on three perspectives of SCM: 1) current practice in the construction industry, 2) SCM in the manufacturing industry, and 3) applicability of web service integration and BIM as the information source to construction supply chain.

RESULTS

The project found logistical practices for construction material procurement. These practices created a conceptual model for the roles of web service integration and identified trends and needs to improve supply chains. A prototype and a small scale test for Web Services, called CS Collaborator was developed in the ISCIS project by Chalmers University in Sweden. A web portal is a useful tool to integrate all scattered web contents into one. It is customized and personalized so that each role and each person will get different information. A web portal also allows single authentication. With one login, the user is logged into multiple applications.

The CS Collaborator service is suitable for construction supply chain management because it uses the SOA structure and integrates web applications by the web portal platform. It uses open source software so it is free to install. It can be plug-and-use, and it is extensible. This model currently focuses on the purchasing side and does not include the actual construction process, but this is a potential future development.

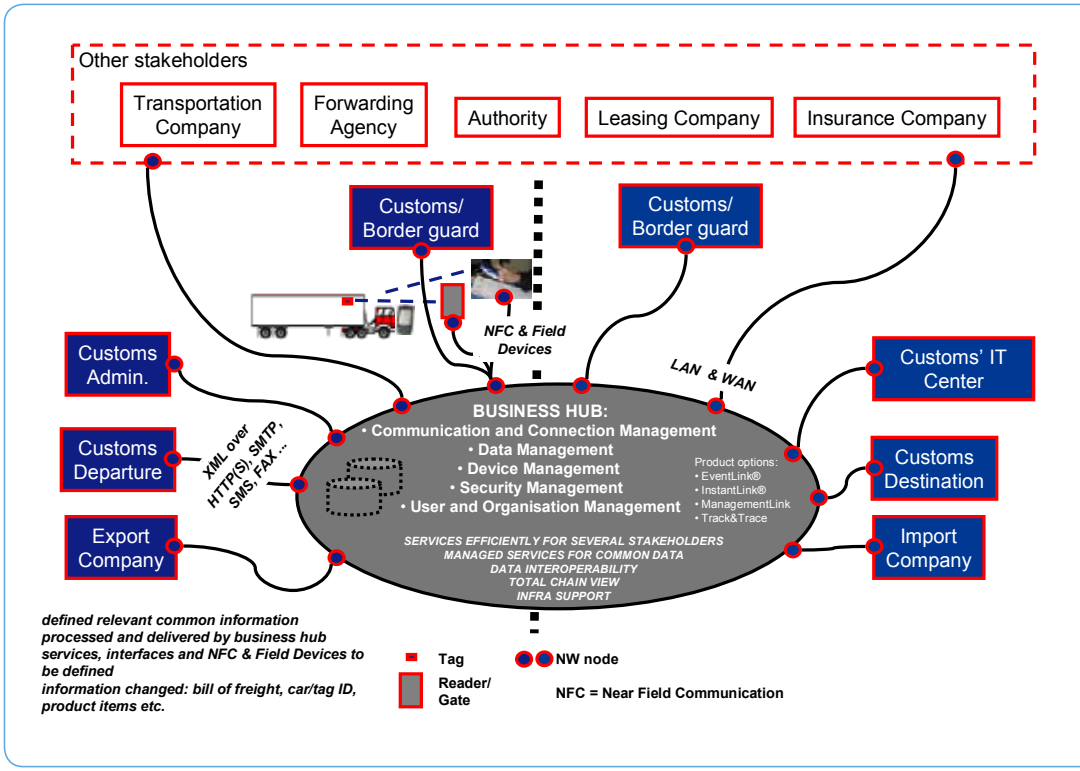


Figure 1. Future scenario of hub-based supply chain management.

The server-side of SC Collaborator consists of 3 tiers: the web server tier, the business implementation tier and the database tier. As an example of the web service, the real-time project schedule information can be shared to all subcontractors involved in the construction project. The tool increases the transparency of the project progress.

DISCUSSION AND CONCLUSIONS

Actual drivers in supply chain management are cooperation, transparency and outsourcing. Many new logistics concepts have been adopted during the last decade. Key components of the ICT-based construction process development are the product model and the time tables. The scheduling of the construction site also plays an important part. A product model is used today mostly in the tendering phase for calculation of material quantities. Web Service technology offers a standardized way of integrating different applications via the internet using open protocols and interfaces. In cases where the amount of information is small, a net portal is an easy solution. In case of more information being transferred, a Service Oriented Architecture SOA is needed. The CS Collaborator program was one of the first attempts to build a BIM-based Web service for the construction industry.

EXPLOITATION POTENTIAL

Web services allow organizations to communicate without detailed knowledge of other's ICT systems. In logistics, web services are used to rationalize the transfer of information through complex supply chains and also to reduce cost of production and distribution. A core concept of web service integration is the connectivity and interoperability of software components. Dynamically and automatically composed web services provide flexibility and transparency to SCM for the construction industry. Future exploitation includes providing web service solutions for industry and tailoring the needs for static or dynamic web tools compared with SOA applications of mobile solutions.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Hans Björnsson, Anna Dubois, Jackie Cheng and Lars Bankwall from Chalmers University. The project has been funded by Tekes and VTT.

REFERENCES

[1] Health Care Procurement and Supply Chain Benchmarking Association, 2008, www.abhc.org/hcpscba.html.

[2] Lee, Hau L. & Whang, Seungjin. 2000. Information Sharing in a Supply Chain. Int. J. of Manufacturing Technology and Management, Vol. 1, No.1, pp. 79–93.

[3] Koskela, L. 1992. Application of the New Production Philosophy to Construction. CIFE Technical Report No.72, Stanford University.

[4] Assaf, Sadi A., Al-Hazmi, Muhammad & Al-Khalil, Mohammed. 1995. Causes of Delay in Large Building Construction Projects. Journal of Management in Engineering, Vol. 11, pp. 45–50.

CONTACT

Antti Permala
Chief Research Scientist
antti.permala@vtt.fi
Tel. +358 20 722 4535

COLLABORATIVE URBAN PLANNING – CASE VUORES

Veijo Nykänen, Pekka Huovila, Pertti Lahdenperä, Pekka Lahti, Markku Riihimäki

Using the Vuores suburb of Tampere as a real case study, co-operation models for urban development have been introduced, in which a city or municipality selects collaboration partners already at the initial stage of planning. The interactive planning procedure enables concurrent exchange of ideas between city planners and companies when preparing the city plans and developing the companies' project plans. The procedure is called collaborative urban planning.

INTRODUCTION

In Finland, towns typically first acquire land and start urban planning thereafter. The general procedure is a sequential process where developers can buy or hire plots when the town plan is ratified. The aim of the "Beyond Vuores" project was to develop and research a procedure where city and developers collaborate during the urban planning process. The detailed themes were vision in urban planning, quality and performance criteria, selection of partners for neighbouhood development, networking during urban collaboration and information platform for urban planning process.

METHODS

In the Beyond Vuores project the used methods were action research and case studies. The researchers developed for the Vuores area together with urban planners and developers' vision, quality and performance criteria and methods to select partners. The developed collaborative urban planning procedure was tested in two planning areas, Mäyränmäki and Vuores Centre. During the process the researchers implemented several questionnaires and workshops in order to get feedback. To find new and successful ideas for managing urban development resulting in good environment altogether 17 cases were analyzed both in Finland and in the Netherlands, Sweden, France, UK and USA.

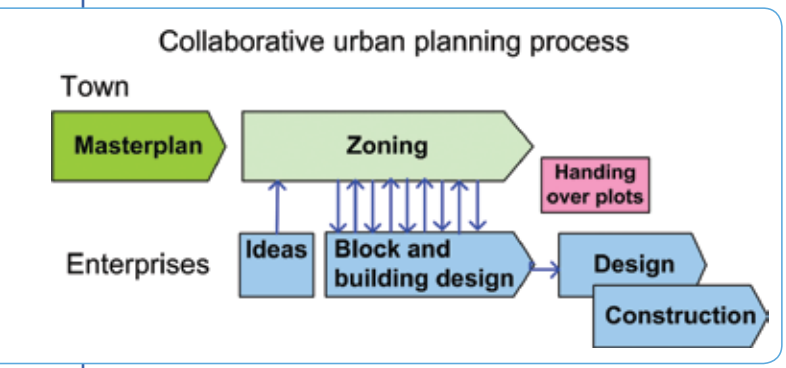


Figure 1. Partnership process in zoning between town and enterprises.

RESULTS

Collaborative urban planning builds on a few key principles. It is worthwhile launching the co-operation between enterprises and a municipality with a joint vision-creating process concerning the urban development project. It allows complementing the goals and visions set earlier by the municipality or city through ideas suggested by companies. The content of the vision is approved by a decision-making body of the city or municipality. The design and control of an urban development project requires quality and performance criteria. They are used to define the desired properties and quality levels of the area. Related goals can be set already when creating the vision for the area. Quality and performance criteria are needed in establishing the company selection program and later in plan preparation and control of companies' project planning.

The Beyond Vuores project developed and tested two different methods for selecting the companies. They are based on an assessment of companies' references and a limited design and idea competition. The municipality selects as partners those companies whose design proposals and ideas are found best.

DISCUSSION AND CONCLUSIONS

Collaborative urban planning was experimented with in two sub areas in Vuores. The developers were highly ea-

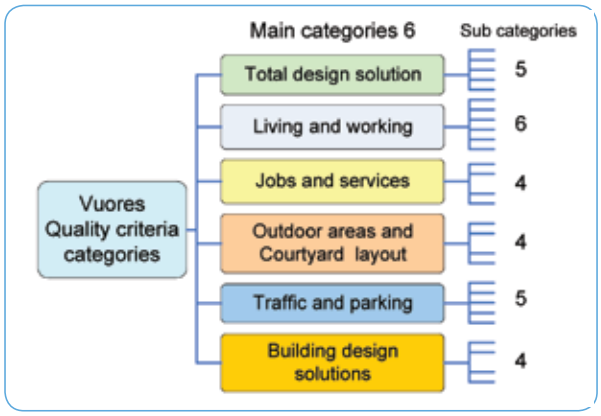


Figure 2. Vuores quality and performance criteria.

ger to participate in collaborative urban planning which allowed selecting first rate design proposals and ideas for further design. The benefits and added value from partnership in urban planning are the result of cooperation between the designers of the municipality and companies. The municipality can utilize the design resources of companies without a finalized plan limiting the work of designers. Companies, again, are more motivated to participate and invest resources in design when they have the opportunity to implement an area clearly larger than a single plot, for instance, a quarter.

EXPLOITATION POTENTIAL

Collaborative urban planning is potential for all cities or municipalities which need more planning resources and ideas from the private sector. Actual regulations do not prevent the use of a collaborative process. In Finland a bottleneck in regulations is possible during complaints against area plans in several phases and this slows official processing, which altogether may stop the planning process for two years.

ACKNOWLEDGEMENTS

The authors wish to thank also Jyri Nieminen and Jarmo Karlund VTT, Marko Vanhatalo EERA, Pertti Tammminen Tampere City and Jukka Terhonen Rakennustoimisto Palmberg Oy for their contribution to the Beyond Vuores study. The research has been funded by Tekes, the City of Tampere and 13 industrial partners.

REFERENCES

[1] Nykänen, V., Huovila, P., Lahdenperä, P., Lahti, P., Riihimäki, M. & Karlund, J. 2007. Collaborative urban planning. Case Beyond Vuores. (In Finnish). VTT Research Notes 2393.

Figure 3. Mäyränmäki competition entry.

[2] Riihimäki, M. & Vanhatalo, M. 2006. Vision as a tool to develop town district planning. (In Finnish). VTT Working Papers 58.

[3] Lahdenperä, P. 2007. Systematic selection of partners for areal development projects. (In Finnish). VTT Research Notes 2380.

[4] Huovila, P., Lahti, P. & Nieminen, J. 2007. Performance Based Collaborative Planning in Neighborhood Development. In Multidisciplinary Scientific Workshop by Decomb, Opus & Beyond Vuores: Innovations in Urban Planning and Design. 18 January 2007. @ SimLab, Espoo, 22 p.

CONTACT

Veijo Nykänen
Chief Research Scientist
veijo.nykanen@vtt.fi
Tel. +358 20 722 3415

VIRTUAL BUILDING ENVIRONMENTS

Tarja Mäkeläinen, Arto Kiviniemi (Project Manager), Stephen Fox, Tiina Järvinen, Tiina Koppinen, Kalle Kähkönen, Jussi Markkanen, Jukka Rönkkö

Technology for use of integrated Building Information Models (BIM) in the real estate and construction cluster (RECC) is available, but its adoption has been relatively slow because of lacking evidence of potential benefits, incompatible processes and insufficient knowledge and skills in the industry.

INTRODUCTION

One of the problems in the RECC is information management in the fragmented, project-based value network. Integrated BIM has been seen as a crucial element in solving this problem. This project, "Virtual Building Environments", VBE, was a continuum to the long-term research in this area at VTT. The project consisted of four main work packages: 1) Company Strategies and Benefits, 2) Data Transfer Technologies, 3) Decision Support Technologies, and 4) Model-based RE/FM Business Processes. The project collaborated internationally with International Alliance for Interoperability (IAI) and several leading universities.

APPROACH

The approach methods varied in different work packages. Data collection was based on case studies, interviews, reviews of existing software, and analysis of current design, decision making and construction processes and their shortcomings related to the BIM. Based on the results new process models, measurement methods and software prototypes were developed in the different work packages.

RESULTS

Company Strategies and Benefits: Auditing of VBE capabilities and suggested further steps in the participating companies were reported in confidential reports.

Five general findings from research investigating the use of building information models (BIM) in Finland were defined:

Finding 1: BIM authoring software has high functionality

Finding 2: Many BIM analysis / simulation options are available

Finding 3: BIM analysis / simulation software has high functionality

Finding 4: Inter-organizational use of BIMs can enable increased building life-cycle performance and reduced life-cycle costs.

Finding 5: Inter-organization use of BIMs can enable transformational business opportunities

Based on the general findings a measurement method for VBE benefits was developed and tested [1]. As a part of the communication of VBE maturity and processes a new visual language, VBE Traffic Light System, was developed.

Data Transfer Technologies: The main result was a new format for IFC (Industry Foundation Classes) Model View Definitions (MVD), which was chosen as the official format of the IAI [2]. In addition to the format the work package developed a software tool for creating MVD content.

Decision Support Technologies: Development of VBE decision support utilizing an advanced meeting room concept. The visualization prototype was extended to handle IFC-object model information. Also, some initial tests were made for two-way communication between the model server and visualization component [3]. This work package developed also a new process model for requirements management and critical decision points, which also utilizes the VBE Traffic Light System developed in work package 1 [4].

Model-based RE/FM Business Processes: Analysis and documentation of the required data content and necessary transformation processes of building models for maintenance purposes. Analysis of the use of BIM-based methods in real estate business [5].

DISCUSSION AND CONCLUSIONS

The VBE project was the first major effort studying the possibilities, obstacles and effects of the cross-domain use of integrated BIM in the industry and the largest ef-

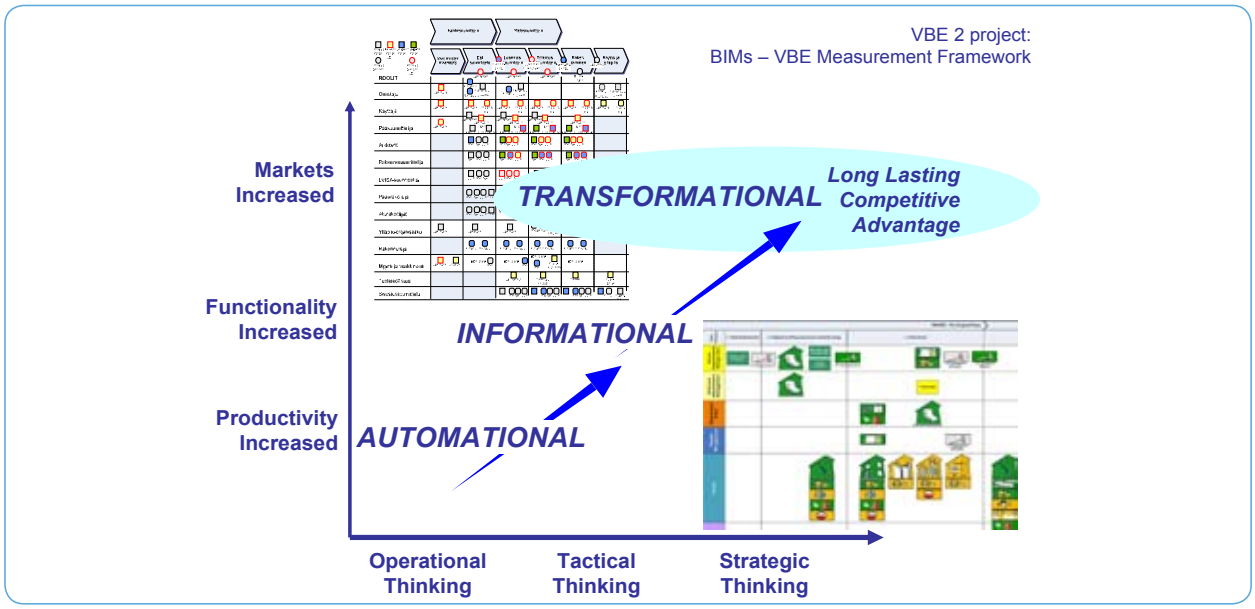


Figure 1. Decision points of the investment process.

fort in this area in the SARA technology program. The project significantly influenced the strategy and processes in the participating companies, and also helped to identify some of the remaining technological challenges of BIM.

EXPLOITATION POTENTIAL

Most of the participating companies have already adopted at least some of the VBE project results. BIM and especially its adoption into the business processes is one of the top priorities in Finland and the use of BIM is also expanding rapidly on the global level.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work at Tampere University of Technology: Jarmo Laitinen, Jiri Hietanen, Mauri Laasonen, Sakari Lehtinen, Tero Karlakari, Salla Kuusela and Timo Saari. The research has been funded by Tekes, 18 participating companies and VTT.

REFERENCES

[1] Fox, S. & Hietanen, J. 2007. Interorganizational use of building information models: potential for automational, informational and transformational effects. Construction Management and Economics. Vol. 25 No: 3, pp. 289–296.

[2] International Alliance for Interoperability, Model View Definition, 2008, www.iai-international.org/software/mvd.shtml

[3] Kiviniemi, A.& Bazjanac, V. Reduction, Simplification, Translation and Interpretation in the Exchange of Model Data.
Porkka, J. & Kähkönen, K. Software Development Approaches and Challenges of 4D Product Models.
Rönkkö, J. & Markkanen, J. Lightweight 3D IFC Visualization Client.
Woodward, C., Rönkkö, J., Honkamaa, P., Hakkarainen, M., Jäppinen, J., Rainio, K., Siltanen, S., Hyväkkä; J. & Lahti, J. Case Digitalo – A Range of Virtual and Augmented Reality Solutions in Construction Application.
Above mentioned articles in Proceedings of 24th W78 Conference Maribor 2007. Bringing ITC Knowledge to Work. Slovenia, 26–29 June 2007.

[4] Koppinen, T. & Kiviniemi, A. 2007. Requirements management and critical decision points. VTT Working Paper 74.

[5] Laasonen, M & Karlakari, T. 2006. Maintaining data in building model-based facility management systems. CIB W70 Symposium Proceedings, pp. 306–316.

CONTACT

Tarja Mäkeläinen
Research Scientist
tarja.makelainen@vtt.fi
Tel. +358 20 722 6912

PERFORMANCE, ENVIRONMENTAL AND ICT STANDARDS TO ENHANCE INNOVATION IN CONSTRUCTION

Pekka Huovila, Juha Hyvärinen, Tarja Häkkinen

The project entitled "Integration of performance based building standards to business process using IFC standards to enhance innovation and sustainable development," abbreviated as STAND-INN, addressed new manufacturing processes based on IFC (Industry Foundation Classes) standards and performance based standards for sustainable construction. The aim was to create new and more efficient business processes in the construction sector. All this should facilitate the sector's great potential for increased productivity and competitiveness, furthering sustainable development and cost reduction.

INTRODUCTION

The STAND-INN project brings together IFC based standards for improved information exchange in the design, production and management of buildings, and the performance based set of standards for sustainable development. It develops

- guidance for business processes, building products and sustainable housing
- a handbook on good practices and innovative cases
- policy recommendations to enhance innovation

and disseminates widely achieved development and documented information. Innovative solutions in these areas will give a competitive edge to the European construction industry.

METHODS

The work plan entailed developing guidance material for improved innovation with respect to the IFC based design of business processes with links to design and performance of building products, to sustainable housing and public procurement.

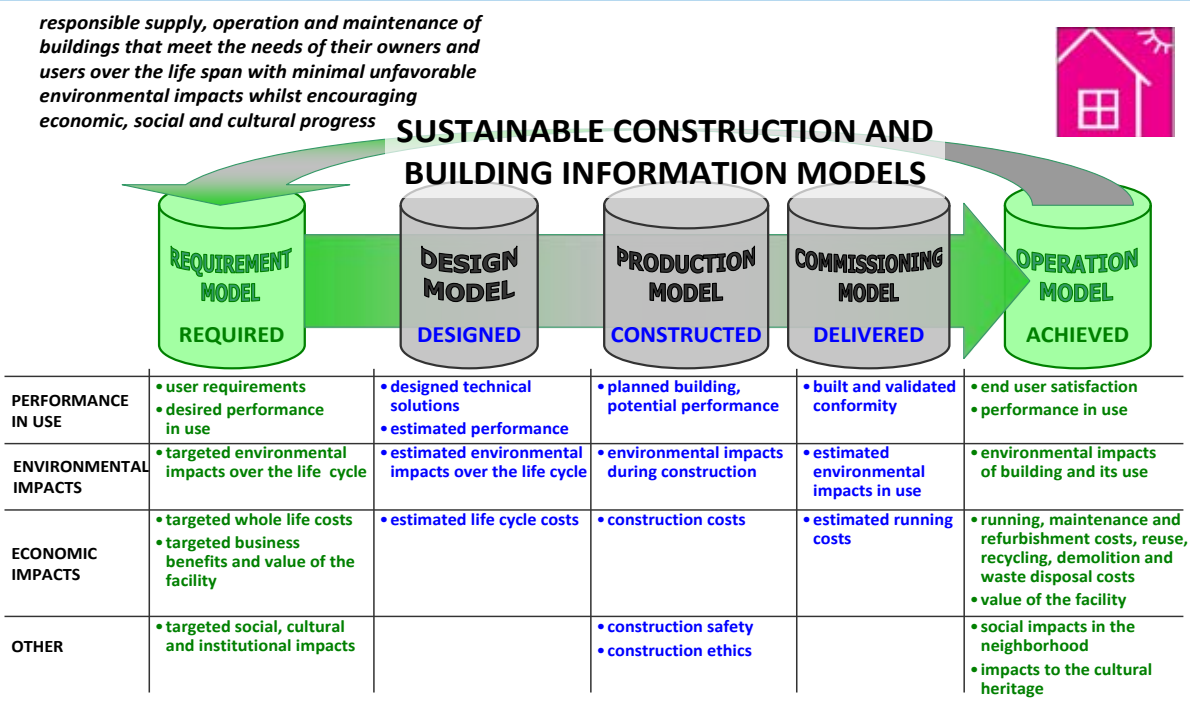


Figure 1. Building Information Models.

The scope of the task was defined to collect good examples of responsible supply, operation and maintenance of buildings that meet the needs of their owners and users over the life span with minimal unfavorable environmental impacts whilst encouraging economic, social and cultural progress.

RESULTS

The main output of the project was a handbook. In addition, guidance to public procurement procedures, best practice examples and policy recommendations are documented to enhance innovation.

Some of the main project conclusions were

1. The IFC and use of Building Information Modeling (BIM) have great potential for value creation during the whole life of buildings at least in the following areas
   - Focus on customer and end-user requirements and sustainability within the building process and life cycle phases
   - Increased transparency in the decision-making process and re-engineering the building process with new business opportunities for new and existing actors
   - Cost saving to all actors and a better project economy
   - Improved possibilities for early stage analysis about: best practice design, construction cost, energy consumptions, environmental impacts, life cycle cost, performance in use, flexibility, adaptability, indoor climate, usability and maintainability
   - A comprehensive and common international knowledge model database with standardized Information Communications Technology (ICT) tools, objects and communication rules and available best practices examples.
2. Standards act as a catalyst for innovation and the integration of sustainability standards onto the suite of open IFC standards facilitating BIM, will greatly enhance the construction sector's need towards sustainable development.
3. Government (public procurement) plays an essential and decisive part in this transformation of the construction sector, acting as the policy maker, regulator and by far the biggest customer, thus as the key player driving innovation and sustainable development.

DISCUSSION AND CONCLUSIONS

The approach of integrating BIM/IFC with sustainable construction is both novel and innovative.

EXPLOITATION POTENTIAL

The Stand-Inn results may be exploited in different ways, such as

- direct guidance with further development of standards and regulation
- implementation of a handbook on how to take IFCs and sustainability in use
- public procurement recommendations for implementation
- examples of good practices and useful background information.

ACKNOWLEDGEMENTS

The research has been co-funded by the European Commission and VTT, and the project received the Europe Innova Award for the Best Network (October 2008). The project consortium was comprised of 28 members from 11 European countries and included five Europeanwide networks as well as two partners from China.

REFERENCES

[1] Huovila, P. 2008. Building Information Models and Innovative Sustainable Housing. SB08 Melbourne, 21–25 September 2008.

[2] Häkkinen, T. & Kiviniemi, A. 2008. Sustainable Building and BIM. SB08 Melbourne, 21–25 September 2008.

[3] Haagenrud, S., Wix, J., Bjørkhaug, L., Trinius, W., Huovila, P. & Perez, J. 2008. EU-project STAND-INN - Integration of standards for sustainable construction into business processes using IFC standards. ECPPM 2008 - eBusiness and eWork in AEC, Sophia Antipolis, France, 10–12 September 2008.

[4] Huovila, P. 2008. Building Sustainability in Practice. State of the Art on Methods and Tools. CEN/CENELEC Workshop. Brussels, 21 May 2008.

[5] Haagenrud, S., Wix, J., Bjørkhaug, L., Trinius, W. & Huovila, P. 2008. Integration of standards for sustainable construction into business processes using IFC standards. 11 dbmc International Conference on Durability of Building Materials and Components. Istanbul, 11–14 May 2008.

[6] Huovila, P. 2007. IFC and IFD in Innovative Sustainable Housing. IAI Italian Dissemination event. Milan, 21 September 2007.

[7] Huovila, P. 2007. Sustainable Housing. IAI/Cite Summer Event and AGMs. BuildingSmart for a Sustainable Future. London, 21 June 2007.

CONTACT

Pekka Huovila
Chief Research Scientist
pekka.huovila@vtt.fi
Tel. +358 20 722 5903

ENGINEERING AND CONSTRUCTION PROJECT INFORMATION PLATFORM

Tarja Mäkeläinen, Arto Kiviniemi (Project Manager), Jun Kojima, Mirkka Rekola

The project "Engineering and Construction Project Information Platform," ECPIP, was a collaborative international project in which the main objective was to improve the quality and productivity of the Real Estate and Construction Cluster (RECC) through customer driven development and implementation of new processes utilizing an integrated information platform.

INTRODUCTION

The information flow over the building life cycle crosses different phases. Currently industry uses Information Communication Technology (ICT) tools which are optimized to certain tasks in each phase. This makes transfer, share and reuse of information over the entire building lifecycle problematic. The RECC industry is aware of the need to move towards integrated building information models (BIM) and product life cycle management (PLM).

Recent R&D projects in Finland, such as the ProIT and VBE projects, have addressed this need by investigating the use of BIM. However, besides the technical integration of BIM, it is equally important to define reference models for life cycle processes; linking business and technical objects, relationships and management [1]. This highlights the importance of addressing inter-organizational practices at the interfaces between firms when implementing boundary spanning technological changes [2].

This ECPIP project brought RECC processes and BIM into an innovative dialogue by using process simulation. The way of realizing this in practice was to involve some of the leading companies from the Finnish RECC industry – owners, designers, contractors, software developers and academic research units – into a series of simulations.

The challenging goal of the project required coordinated capabilities from the research partners in the consortium, including TKK SimLab and VTT in collaboration with CIFE and Columbia University. Close collaboration of the participating researchers was pivotal in studying and facilitating change in a complex whole. Equally important has been the input from the participating companies which provided the real-life basis for the development of new work processes, tools and business models.

APPROACH

The project approach was to gather information through interviews, from which models were built and then simulation workshops were held to validate the models. The SimLab™ process simulation [3] is an interactive, participative group simulation for business process learning and development. SimLab™ process simulations are organized for selected case projects. The simulations progress from addressing current processes towards envisioning new processes, thus supporting learning in the company network. The core of the simulation is a carefully prepared and facilitated discussion about selected processes in front of a visual process model. All actors from the differ-

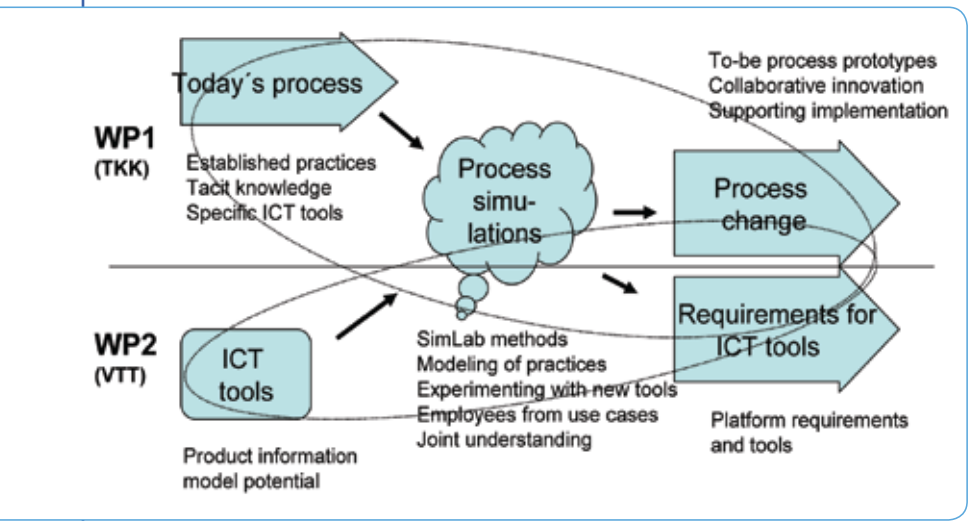


Figure 1. ECPIP Project Structure.

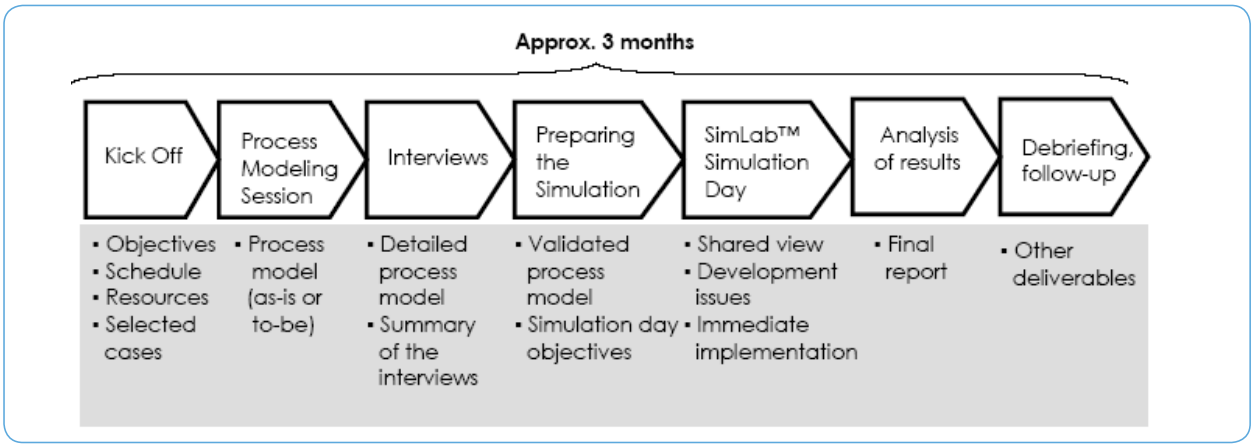


Figure 2. The SimLab™ process simulation [3].

ent partner organizations, who are involved in the process, are present in the simulation.

RESULTS

Each simulation day was the culmination of a three month in-depth action research of one business process. In the simulations, tacit experiential knowledge about the case process was externalized and shared, problems revealed, and improvement ideas developed. The simulations were realized during one day divided into a morning session with the actual simulation and afternoon group work sessions, where the participants in smaller parallel groups developed solutions to the challenges that were detected during the simulation.

During the simulation, a mutual understanding about the roles and activities of the interacting practices in the collaborative process was built up. Different terminologies began to give way to shared concepts, and development ideas were created concerning local practices as well as the collaborative process as a whole.

DISCUSSION AND CONCLUSIONS

This project was the first in-depth process analysis of several real BIM projects and it revealed several problems which prevent the utilization of full potential of BIM in the current RECC processes and developed improvements to the future processes. In addition, the project improved significantly the mutual understanding of the needs of different shareholders in the projects.

EXPLOITATION POTENTIAL

Several of the participating companies have already started to implement the identified change needs into their processes. However, the ECPIP project was just the first step towards the full utilization of the possibilities of new technologies in RECC.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Riitta Smeds, Antero Hirvensalo, Hanna Björkstrand, Kaarina Kaste, Juha Kujala, Teemu Lehtinen, Antti Maunula and Sami Ruotsalainen in TKK, Martin Fischer, John Haymaker and Timo Hartmann in CIFE/Stanford University, John Taylor in Columbia University and all participating company representatives. The research has been funded by Tekes, nine Finnish partners and VTT.

REFERENCES

[1] Tucci, M., Bandinelli, R. & Carli, D. 2006. Building a Reference Model for the PLM Processes in Engineering and Contracting Sector. Proceedings of the Advanced Production Management Systems Conference hosted by Wroclaw University of Technology.

[2] Taylor, J. 2005. Three Perspectives on Innovation in Interorganizational Networks: Systemic Innovation, Boundary Object Change, and the Alignment of Innovations and Networks, Doctoral Dissertation, Department of Civil and Environmental Engineering, Stanford University.

[3] Smeds, R. & Alvesalo, J. 2003. Global business process development in a virtual community of practice. Production Planning and Control, Vol. 14, No. 4, pp. 361–371.

CONTACT

Tarja Mäkeläinen
Research Scientist
tarja.makelainen@vtt.fi
Tel. +358 20 722 6912

ENABLING SUSTAINABLE BUILDING WITH INFORMATION MANAGEMENT AND ASSESSMENT TOOLS

Tarja Häkkinen, Sirje Vares, Pekka Siltanen, Pekka Huovila, Erkki Vesikari, Arto Kiviniemi

Sustainable construction brings about the required performance with the least unfavorable environmental impact, while encouraging economic, social and cultural improvement at a local, regional and global level (ISO TS 21929). The concept of sustainable building (SB) is wide; there is a need for a structured approach for the implementation of sustainability practices and methods within construction projects. Methods of information management are important when seeking solutions for the problems of SB processes, and there integrated Building Information Modeling (BIM) offers a potential. The scope of the research was to analyze the management of SB with help of BIM [1-6]. This paper introduces the results with help of one example.

METHODS

Design for sustainable building needs integrated methods which should provide the process with comprehensive product information and integrated calculation and simulation facilities that enable the comparison of design options automatically or with reasonable extra work. The use of BIM is currently emerging around the world. BIM denotes the creation of coordinated, consistent, computable information about a building project during design, construction, building operation and management. BIM can also be defined as the collection of objects that describe a building. Because of enabling the sharing of information and because of working with objects, BIM may significantly support the management of information needed in design for SB. Important questions are how to integrate and what is the degree of linkage or inclusion of different data bases and tools with domain specific BIMs. The research analyzed and discussed the integration of different SB tasks with BIM. The analyses and description of SB tasks included the following issues: Data contents, methods, phase of the BIM process, and integration with BIM.

RESULTS

The following tasks were considered as essential SB tasks:

- environmental assessment of design options
- energy-efficiency assessment of design options
- service life assessment
- creating care and maintenance instructions
- optimization of refurbishment
- considering sustainability indicators in all stages of the process.

There are different solutions for integrating life cycle analysis software and BIM. These include separate software that can use file exchange with BIM or be integrated with a BIM server using a specific API. The analysis software can then have its own library for those pieces of information that are not included in BIM. The analysis software could also be implemented by programming new functionality to BIM software. An intermediate solution for these is integration with help of parametric formats (e.g. GDL) that allow representing not only product information but also calculations used in this analysis. The research dealt with the needed contents of product information assuming that separate software connected to BIM is the most likely in terms of easiness to realize and use.

VTT has also developed prototype software which uses design information represented by IFCs (Industry Foundation Classes) together with separate product information represented in Product Modeling Ontology (PMO) and calculates environmental results by combining the effects of different building elements [6]. IFCs aim at providing an open definition for data structures to capture and exchange information [7]. PMOs are used for describing product classes, properties and interrelationships on products of different complexity levels including standard catalogue items and complex configurable products.

Service life (SL) design needs information about the effect of different parameters. For instance, the ENNUS

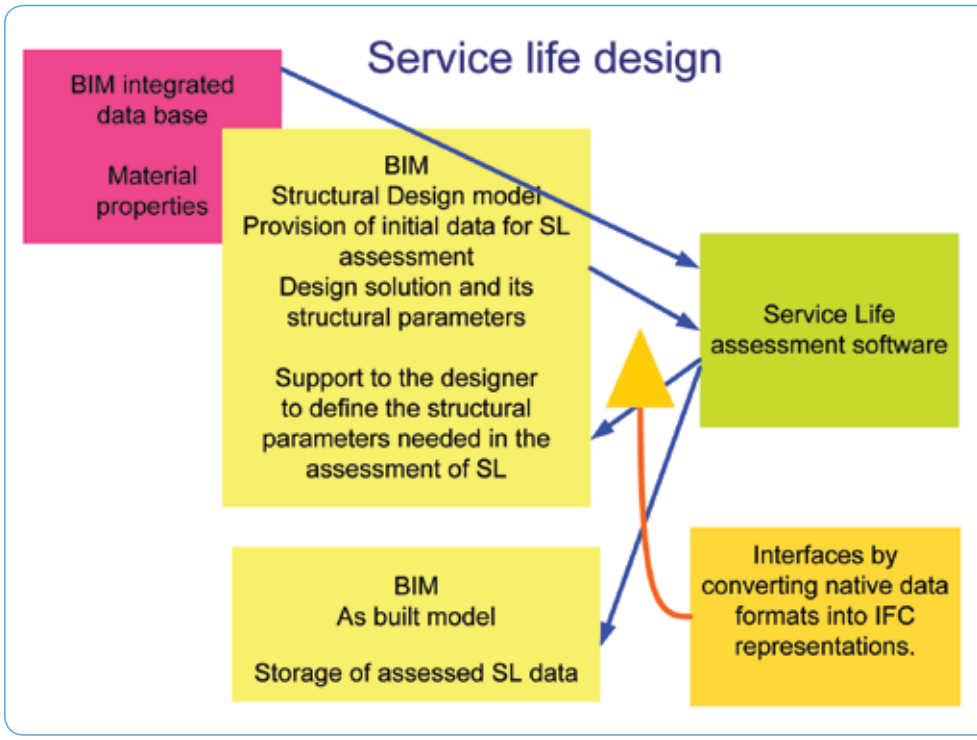


Figure 1. Integration of sustainable building tasks with BIM.

programs developed at VTT help designers to predict SL and determine parameters that affect the SL. These parameters include materials, details, assembling, outdoor and indoor conditions, use conditions, and care and maintenance.

When integrating SL assessment with BIM, the initial data needed for defining the values of parameters should be available through the properties of the model or with help of integrated databases. The latter may concern for example material properties. However, also the design solution itself affects SL. Thus for example the structural model should include all information about the quality of structures that is needed as initial information for the SL assessment of structures. The structural model software should support the designer to define the structural parameters needed in the assessment of SL.

The assessment software itself can remain a separate tool that is compatible with the model. The interfaces can be made by converting native data formats into IFC representations. The integration of the ENNUS tool with BIM was done by converting an XML file produced by standard Excel methods to IFC. The results of the assessment for different building parts and systems should be imported as SL indicators to BIM. BIM can be used for transferring data between life cycle phases, as well as getting initial information from the BIM.

CONCLUSIONS

Tools of life cycle assessment, energy efficiency assessment, service life assessment, maintenance manual, optimization of refurbishment, and SB rating are important methods in design, use and refurbishment of sustainable buildings. The use of these methods requires the availability of tools and a lot of additional information compared to a traditional building process. In order to rationalize and support the use of methods, those should be integrated with BIM processes.

REFERENCES

[1] Häkkinen, T. & Kiviniemi, A. 2008. Sustainable Building and BIM. SB08 Melbourne, 21–25 September 2008.

[2] Häkkinen, T. & Pulakka, S. 2007. Use of LC guides in open building manufacturing. In Open Building Manufacturing: Core Concepts and Industrial Requirements. Ed. Kazi, Abdul Samad (Sami).

[3] Häkkinen, T. 2007. Sustainable building related new demands for product information and product model based design. ITcon, Vol. 12, pp. 19–37.

[4] Häkkinen, T. et al. 2007. ICT for whole life optimisation of residential buildings. VTT Research Notes 2401.

[5] Häkkinen, T. et al. 2007. Sustainable management of buildings. SB07 Lisbon.

[6] Siltanen, P. et al. 2008. IFC and PMO for estimating building environmental effects. ICE 2008. 14th International Conferece on Concurrent enterprising.

[7] IFC 2007, IFC specifications, www.iai-international.org/Model/IFC(ifcXML)Specs.html

CONTACT

Tarja Häkkinen
Chief Research Scientist
tarja.hakkinen@vtt.fi
Tel. +358 20 722 6920

INTEGRATING BUILDING PRODUCT MODELS WITH LIVE VIDEO STREAM

Kalle Kähkönen, Charles Woodward, Jouko Hyväkkä, Janne Porkka, Sanni Siltanen

This work aimed at integration of building product models with Augmented Reality technologies. The project explored hardware, middleware and software platforms for the named purpose whilst the main target was to study emerging new sector specific business processes and changes arising from these solutions.

INTRODUCTION

Managing aspects of modern building project are changing from individual tools towards integrated solutions and enhanced information technology tools, such as Building Information Model (BIM) authoring and advanced 4D tools. These tools are used for capturing as many cross-discipline design and planning aspects as possible. At the same time construction operations are increasingly networked and geographically decentralized. It is considered that integration of building product models with live video stream can particularly result in new kinds of communication solutions that can bring together distributed organizations and their people. An example of a possible solution is 4D construction animations that are superimposed on the live site image to be shown to stakeholders who are influenced by the plans and whose knowledge is needed for developing the plans further.

APPROACH

The project entitled "Integrated Building Product Models with Live Video Stream (4D Live)" addressed proof-of-concept studies of several potential solutions where video multi-camera system technologies are combined with BIM technologies.

RESULTS

The main results gained were comprises of three software and hardware prototypes:

i) Live Internet based 4D. Software prototype where the core of the result is a lightweight IFC model viewer, a visualization client based on OpenSceneGraph open graphics library. The solution increases convergence between virtual and real live environments by communicating 4D model viewpoints and adjusting live camera picture to the model background [2].

ii) Augmented reality web camera. The prototype solution enables transmission of live video picture via the Internet from a construction site using one or several cameras.

iii) Multi-Camera studio for BIM-Human interaction. One of the main targets in this study was to construct a multi-camera studio for interaction and visualization purposes. A human, say an architect or a structural engineer, who is located in the studio is virtualized and converted into a real-time 3D model which can be transferred over the network and inserted into a virtual world where also BIM is visualized simultaneously.

DISCUSSION AND CONCLUSIONS

Structurally the described applications include two different elements: 1) 4D building model (design object), and 2) Image of site and/or human(s) (locational and situational context). This combination together with interactive functions provides a promising starting point for successfully meeting various key communication needs in building projects. These key communication needs are related to collaborative working practice where a dialogue between different partners, who even can be geographically dispersed, is continuously facilitated for developing their commitment further and for taking full advantage of their knowledge. Possible applications and the use of them are initially based on speculative thinking but during the second stage the research will culminate with a proof-of-concept study of potential industrial innovations.

EXPLOITATION POTENTIAL

Several possible targets for applications of 4D Live technologies have been identified. Examples of those are:

Project development; Collaborative building concept testing and its further development with client, end

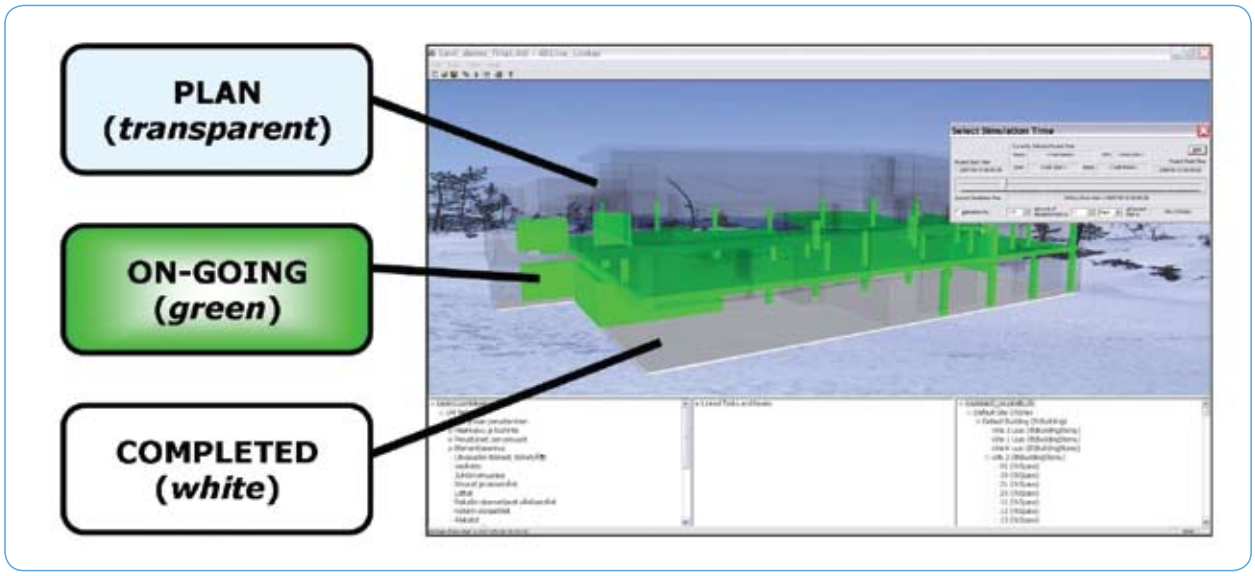


Figure 1. 4DLive Linker application, building models with video stream.

users and other key stakeholders. This is particularly addressing commercial construction and capital construction projects.

Co-planning; Construction animations (4D) are superimposed on the live site image to be shown to stakeholders who are influenced by the plans and whose knowledge is needed for developing the plans further.

Monitor the progress; The actual site image is combined with as-planned status of the building (according 4D model) for realizing deviations.

A follow-up project to this project is planned, entitled "Augmented Reality for Building Construction (AR4BC)". This next project is a strongly industry-driven research and development effort, targeting commercial applications of such solutions described in this paper.

ACKNOWLEDGEMENTS

The project was funded by Tekes and VTT. The researchers would like to express their gratitude also to the industrial steering committee that provided valuable feedback, guidance and support.

REFERENCES

[1] Kähkönen, K., Hyväkkä, J., Porkka, J., Siltanen, S. & Woodward, C. 2007. Integrating building product models with live video stream. Proceedings of 7th International Conference on Construction Applications of Virtual Reality, Penn State University, USA, October 23–24, pp. 176–188.

[2] Porkka, J. & Kähkönen, K. 2007. Software development approaches and challenges of 4D product models, Proceedings of 24th CIB W78 Construction ICT Conference, Maribor, Slovenia, 26–29 June 2007, pp. 85–90.

CONTACT

Kalle Kähkönen
Chief Research Scientist
kalle.kahkonen@vtt.fi
Tel. +358 20 722 4560

APPLICATION OF A WIRELESS TECHNOLOGY FOR DATA COLLECTION FROM A ROAD BUILDING PROCESS

Pekka Kilpeläinen, Tommi Parkkila, Vesa Pentikäinen, Esa Viljamaa, Esa-Matti Sarjanoja, Jari Rehu, Matti Annala

This research studied how a group of machines (an asphalt mixing plant, asphalt trucks and pavers) and the process they constitute can be managed better by applying ICT, embedded sensors and wireless communication technologies.

INTRODUCTION

A pavement laying process consists of production of the asphalt mass, transportation of the mass to the work site, asphalt laying and compacting. VTT has studied the use of mobile technology and wireless data transfer technology in collecting data from road building processes in different projects, e.g. the project "Wireless construction site (LATO)" in the years 2002-2003 [1]. In the project entitled "Automation and wireless communication technologies in road repairing and road surfacing (TIMARA)" from years 2005-2007 the focus was on automatic data collection from the asphalt paving process. The current project "Mobile, distributed and networked data management system for real-time control of construction process (RAMO)" focuses on short range wireless communication between machines in a construction site and adaptive user interfaces [3]. This paper summarizes the development within the three projects.

METHODS

To gather background information, professionals working in asphalt production and spreading were interviewed. The co-ordination and synchronization of the asphalt production in the asphalt mixing plant, asphalt transportation and asphalt spreading in the work site was chosen for a case study (Figure 1). A concept of an asphalt process management system was developed [2] where trucks, asphalt pavers and the asphalt plant have real time wireless link to a process control. Sensors are installed to the machines to measure in real time the process variables, such as asphalt mass temperature. A primary goal was to make the data collection as automatic as possible and minimizing user involvement. The concept was further developed in the RAMO project to include short range communications between the vehicles [3] and adaptive user interfaces (Figure 2).

RESULTS

The first prototype system (Figure 3) was developed and tested in a real construction site in the year 2007. It consisted of an embedded measurement modules with IR sensor (1), inductive proximity sensor (2), GPRS modem (3) and GPS positioning (4). These modules were installed in asphalt trucks and an asphalt spreader. Modules send data automatically to MySQL database using a standard XMPP protocol, which is typically used in instant messaging applications. From the collected data dynamical web pages were generated, which showed the location and the status of the machine on a map as well as measured values in real time.

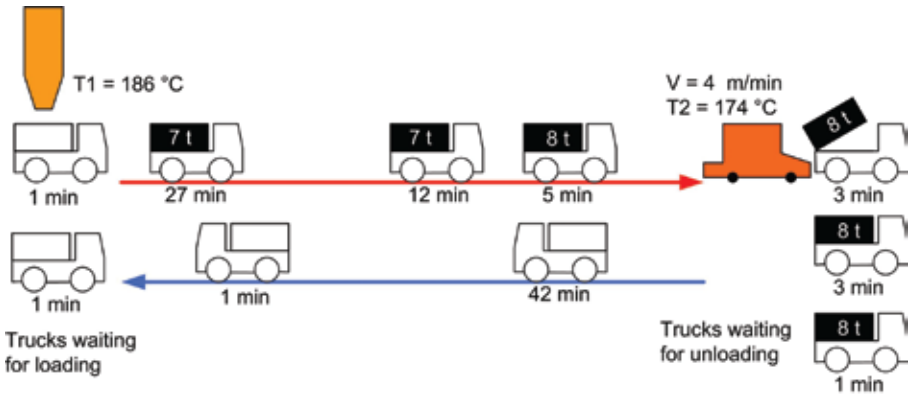


Figure 1. Typical asphalt pavement work flow.

DISCUSSION AND CONCLUSIONS

With the developed concept, data from the asphalt paving process can be collected automatically for quality assurance and process management purposes. For example unloading location, time

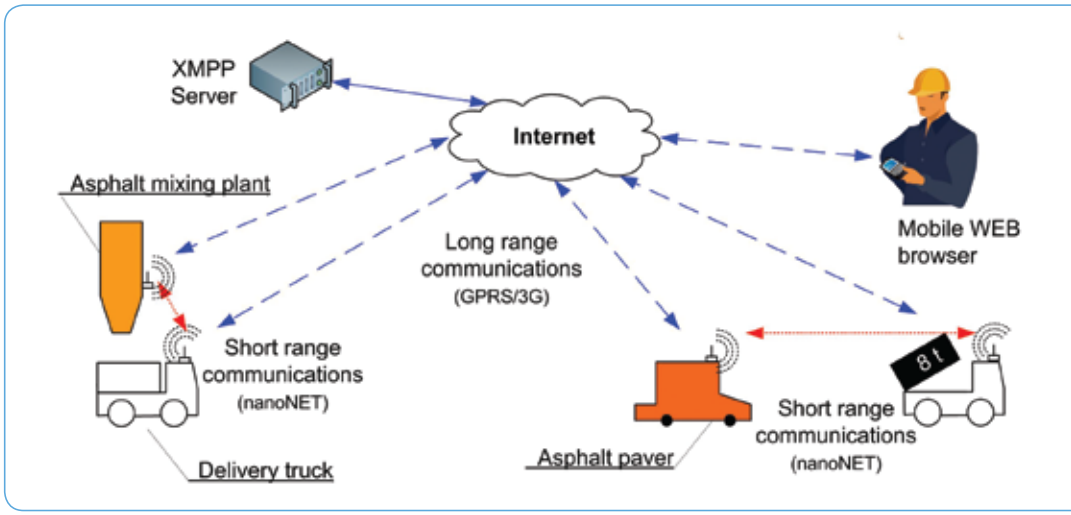


Figure 2. Prototype system extended with short range wireless links.

and temperature for each individual truckload can be registered automatically. Collected data can be used also for evaluating the performance of the process. Different key figures of the process, e.g. work achievement of the spreader or waiting times of the trucks, can be calculated in real time. This can offer a tool for better synchronization of tasks in asphalt spreading.

EXPLOITATION POTENTIAL

Mobile technology and handheld devices offer an easy way of collecting data or spreading information to the workers in the construction site [1]. Automatic data collection suits best for collecting data directly from the machines or vehicles using sensors. Research work is still needed to explore the potential of such technology in road construction. The research work in this area is currently continued in the RAMO project.

ACKNOWLEDGEMENTS

The authors wish to thank the 14 companies participating in the projects as well as the research unit of Construction Technology from the University of Oulu. The research has been funded by Tekes, project partners and VTT.

REFERENCES

[1] Rannanjärvi, L. & Känsälä, K. 2003. Remote control and monitoring over Internet - Wireless Construction Site, 7th IFAC Workshop on Intelligent Manufacturing Systems. Budapest, HU, 6–8 April 2003. Elsevier Science, pp. 205–210.

[2] Kilpeläinen, P., Heikkilä, R. & Parkkila, T. 2007. Automation and Wireless Communication Technologies in Road Rehabilitation. ISARC'2007, The 24th International Symposium on Automation and Robotics in Construction, 19–21 September 2007, Kochi, Kerala, India, pp. 35–40.

[3] Pentikäinen, V., Heikkilä, T., Määttä, K., Tukeva, P., Korkalainen, M., Saavalainen, P. & Kilpeläinen, P. 2008. Industrial and non-consumer applications of wireless sensor networks. Proceedings of SPIE - The International Society for Optical Engineering, Vol. 6983.

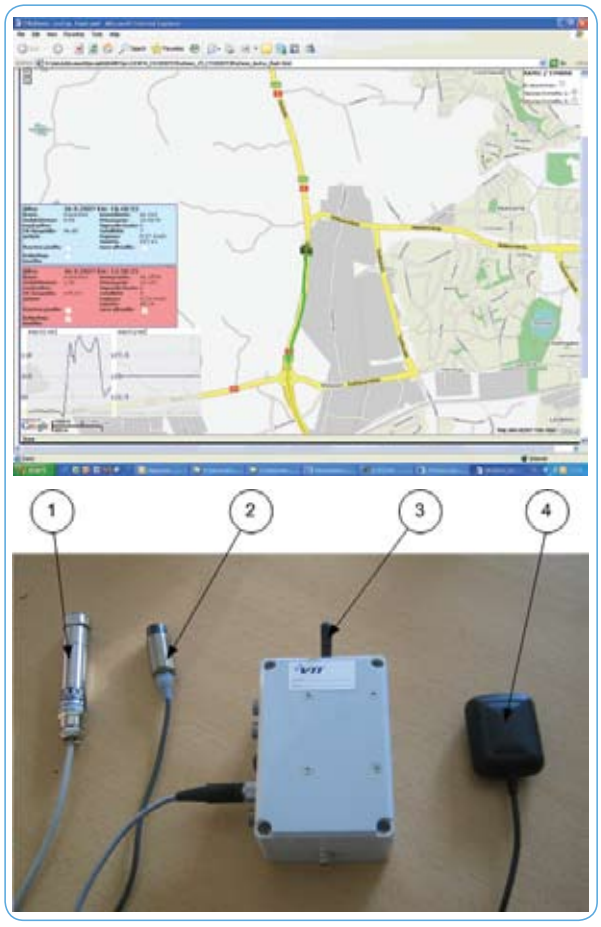


Figure 3. Embedded measurement module and the Web based user interface of the first prototype system (see Results text for number definitions).

CONTACT

Pekka Kilpeläinen
Research Scientist
pekka.kilpelainen@vtt.fi
Tel. +358 20 722 2243

TAKING E-COLLABORATION TECHNIQUES INTO PRODUCTIVE USE IN THE CONSTRUCTION INDUSTRY

Kalle Kähkönen, Arto Kiviniemi (Project Manager), Janne Porkka

The project "Taking E-Collaboration Techniques Into Productive Use in the Construction Industry (FoundIT)", was aimed at industrial use of virtual collaboration technologies such as virtual reality, ICT enabled team work and the use of building information models for communication in the construction business. The project focus was on academic research and it consisted of several individual doctoral dissertations and licentiate thesis. Thus as a whole, the FoundIT project can be considered as "an umbrella project" that provided infrastructure and support for researcher pursuing high academic degrees.

INTRODUCTION

Finland is widely recognized as one of the leading countries concerning the development of the construction process using advanced Information and Communication Technology (ICT) applications, and a number of companies from both the construction industry and from software engineering are pioneering novel techniques, for example, information modeling. Applied research at the leading edge of international developments has been carried out in particular by VTT in co-operation with companies, but this has not been matched by a an equally high level of basic long-term research, and the results of the technical universities, both in research contributions and doctoral education have remained modest.

In the FoundIT project the research focus is on complex problems involved in getting different kinds of virtual collaboration techniques into productive large-scale use. This relates both to information models, document management systems, e-commerce, process modeling, virtual reality, etc. Such problems relate to economic, legal, psychological and behavioral issues and deal with management and implementation issues. An important aspect was how companies can align the use of sophisticated IT with their business models.

APPROACH

Each individual dissertation selected its own methodology based on the specified research questions. The project connected individual doctoral students to a wider pool of knowledge consisting of professors, senior researchers and doctoral students in other domains. The project has arranged several domestic and international workshops where doctoral students can present their work and get feedback from other participants, Figure 1 [1]. The general approach for this research was through proof-of-concept studies that characterized many of the research needs in parallel studies. Typically, the named research included the formation of solutions such as prototype software that was then experimentally tested in industrial cases.

RESULTS

The research carried out in the FoundIT project can in broad terms be grouped into three major categories: 1) implementation and management issues of virtual collaboration techniques, 2) impacts of building product modeling in the construction process and in the virtual construction enterprise consisting of the companies participating in a project, and 3) usability of the virtual reality techniques for building design and construction planning.

The FoundIT project has resulted in one finalized doctoral dissertation [2], two licentiate theses [3, 4], several on-going doctoral dissertations and licentiate thesis, numerous journal and conference articles, and some software prototypes.

DISCUSSION AND CONCLUSIONS

Earlier research in the areas of the FoundIT project have concentrated mainly on the development of new technologies. However, the human issues of the technological changes, such as usability and organizational impacts, have not been thoroughly investigated earlier. The early results of the project suggest that these issues may be

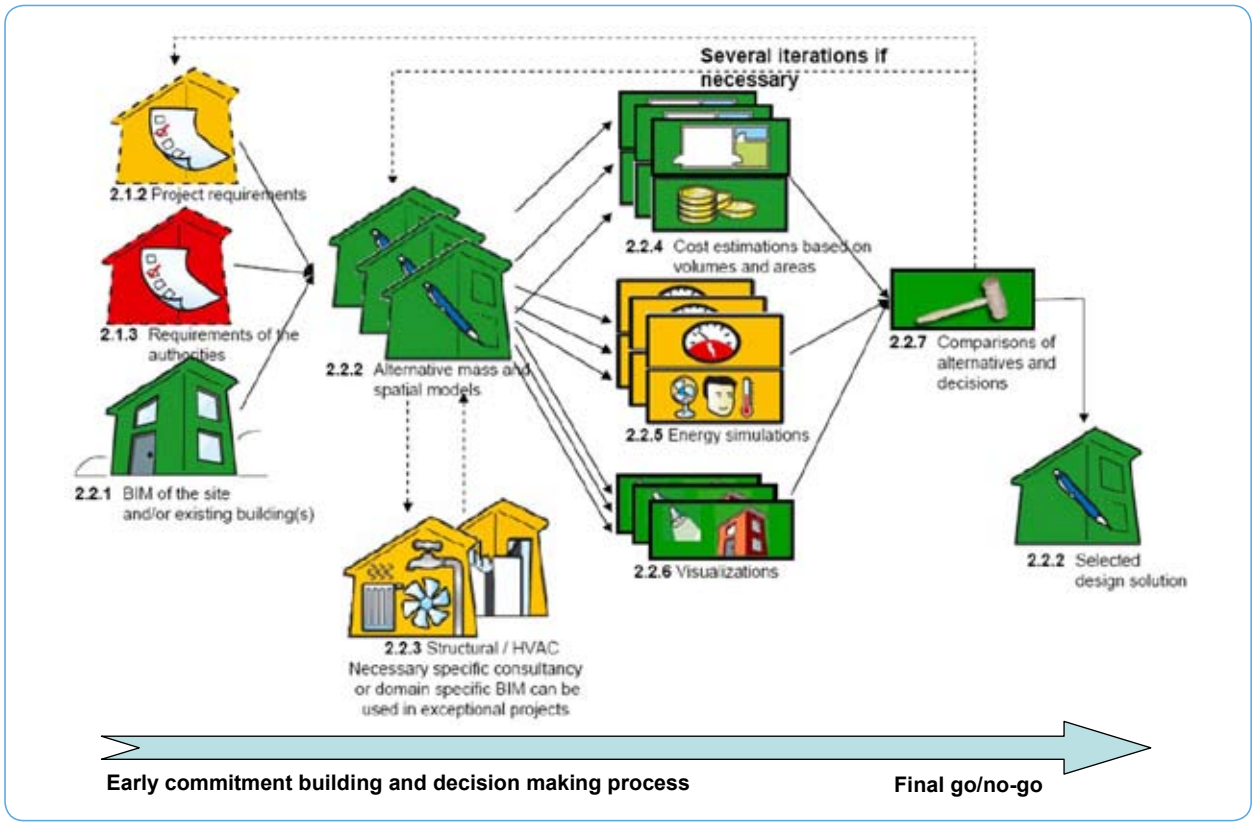


Figure 1. Research focused on further understanding the use of building information models in marketing.

among the main reasons for the slow adoption of the new technological possibilities.

EXPLOITATION POTENTIAL

Since the scope of the project is in academic and basic research, most of the results have no immediate business applicability. However, Finne's doctoral dissertation [2] has already affected the business strategy of his employer, Building Information Ltd, and Rönkkö's licentiate thesis [3] has resulted in a spin-off company. In the long term, several of the FoundIT sub-projects can lead to similar business impacts.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Tor-Ulf Weck, Lauri Savioja and Juhani Kiiras in the Helsinki University of Technology, Bo-Christer Björk in the Swedish School of Economics and Business Administration and all the doctoral candidates who have participated in the project. This project was also strongly connected to both the KIRSU research school initiated by the Finnish Ministry of Education, and internationally with the University of Salford in the UK. The research has been funded by Tekes and VTT.

REFERENCES

[1] Construction Field Research Consortium, FoundIT project web page, 2008, http://213.173.156.168/foundit/index.html

[2] Finne, C. 2008. Opportunities in the use and provision of information in the construction value chain. Doctoral Dissertation, Helsinki University of Technology.

[3] Rönkkö, J. 2007. Building a virtual reality interactions system using game tools. Licentiate Thesis, Helsinki University of Technology.

[4] l-Neshawy, F. 2007. A network system for monitoring the thermal and moisture performance of repaired concrete facades. Licentiate Thesis, Helsinki University of Technology.

CONTACT

Kalle Kähkönen
Chief Research Scientist
kalle.kahkonen@vtt.fi
Tel. +358 20 722 4560

COLLABORATIVE VIRTUAL ENGINEERING FOR SMEs

Abdul Samad (Sami) Kazi

The project "Collaborative Virtual Engineering for SMEs (CoVES)" was a European specific targeted research project developing a flexible collaboration environment including access to rich data and applications for nomadic professionals and partners of SMEs.

INTRODUCTION

Real-time interactive collaboration is key to the success of organizations providing customized products/services to clients. This is especially the case when managers and engineers are on the move and need to communicate with and access data from not only the head office, but from other partners and clients engaged in the definition, development, delivery, or maintenance of the product/service. This problem of remote collaboration is currently further exacerbated by the growing use of more enterprise and productivity applications by SMEs (Small and Medium Enterprises). These systems and their data are usually not available remotely and thus people "on the road" do not have the basis for meaningful collaboration and decision making.

The main objectives of the project were to:

- Define new working models and functionalities for effective (mobile) collaboration.
- Develop a flexible and open service integration architecture that allows wrapping of enterprise applications and integration of collaboration services.
- Develop a user centric client concept especially for mobile devices.
- Implement a pilot system geared towards the engineering domain through a user driven development methodology in living labs.

APPROACH

The project used an iterative approach to capture user requirements, set priorities, and then provide specifications for solutions. These solutions are to then within a set of living lab environments be tested, validated, and recommendations for improvement made.

RESULTS

The project solutions (including model-based collaboration, access to heterogeneous data sources, capability to port applications to mobile devices, etc.) support three main business scenarios:

1. Manager on a Business Trip: Despite being away for several days, he must guide the engineering team, be accessible for fast decision making, and interact with customers or partners if required. This must be based on current data like engineering designs and calculations, project status, and real-time interaction with the team even in small time slots between meetings, on the train or in the airport lounge.
2. Engineer on Remote Site: Engineers or other technical specialists must install or maintain equipment at customer sites. They require access to the latest information, but must also collaborate with colleagues to solve problems and be in contact with management for decision making.
3. Virtual Team Collaboration: Professionals do not only need to collaborate with their colleagues at the "home base" but are engaged in inter-organizational and freelance teams for joint opportunities.

DISCUSSION AND CONCLUSIONS

This was an SME centric project aimed at providing simple, easy to use, and easy to implement solutions supporting nomadic engineers in their work. It provided a set of solutions supporting the nomadic worker to access and use proprietary applications from different sources through mobile devices. The project solutions include model-based collaboration, access to heterogeneous data sources, capability to port applications to mobile devices, and finite element analysis services bundled together with different collaboration platforms/portals through a Web 2.0 mashup and widget portal system architecture concept.

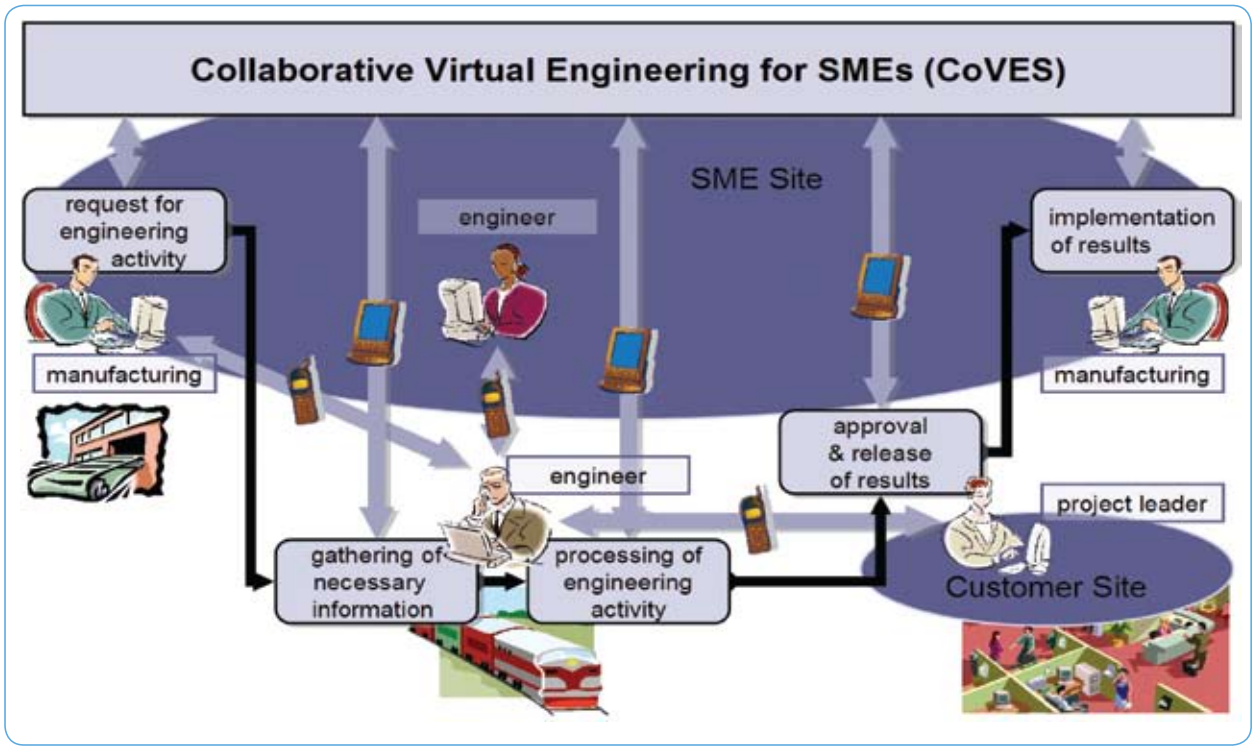


Figure 1. CoVES: Concept.

EXPLOITATION POTENTIAL

The results of to the project support SMEs, to connect heterogeneous data sources, build applications on the fly for use on mobile devices, and do model-based design and collaboration. All this is at a fraction of the cost of large scale ERP systems, and furthermore supports flexibility and quick set-up/configuration of data exchange and collaboration in inter-enterprise settings.

ACKNOWLEDGEMENTS

VTT's work in this project has been funded by the European Commission and VTT. The project consortium included 12 partners from 7 countries.

REFERENCES

[1] Public web site of the CoVES project, 2008, www.coves/project.org.

[2] Kürümlüoglu, M., Eichert, J., Finger, J., Kazi, A.S, & Sari, B. 2008. Requirements for Collaborative Virtual Engineering for SMEs with Special Focus on Mobility Aspect. Proceedings of the 14th International Conference on Concurrent Enterprising, 23–25 June 2008, Lisbon, Portugal.

[3] Dryndos, J., Kazi, A.S., Langenberg, D., Löh, H., & Stark, R. 2008. Collaborative Virtual Engineering for SMEs: Technical Architecture. Proceedings of the 14th International Conference on Concurrent Enterprising, 23–25 June 2008, Lisbon, Portugal.

[4] Kazi, A.S., Ristimaki, T., Balkan, O., Kürümlüoglu, M., Eichert, J., & Finger, J. 2008. From Machine Drawings to Model-based Collaborative Virtual Engineering. Proceedings of the 14th International Conference on Concurrent Enterprising, 23–25 June 2008, Lisbon, Portugal.

CONTACT

Abdul Samad (Sami) Kazi
Chief Research Scientist
sami.kazi@vtt.fi
Tel. +358 20 722 6666

DEVELOPMENT OF COMPETITIVE AND BUSINESS INTELLIGENCE IN THE CONSTRUCTION SECTOR

Markku Riihimäki, Paula Ala-Kotila, Tuula Grönfors, Liisa Jaakkonen, Terttu Vainio, Erkki Lehtinen

Timely information has a significant role in operative and strategic decision making. By utilizing business intelligence, organization can systematically process, manage and share information.

"Development of the Competitive and Business Intelligence in the Construction Sector – ComBI" was a research project focused on industry specific business intelligence.

INTRODUCTION

The role of information of business has grown. Information is one of the most important resources in a modern organization. In practice companies have to constantly make decisions based on incomplete information. Every existing piece of information cannot be detected, externalized or understood.

Business intelligence (BI) is a function which manages and analyzes essential information for company's other functions. Information processed by BI gives decision makers a clearer view of a company's competitive position and factors affecting it. BI gives the decision makers early warnings about markets, trends and changes in the business environment and competitors that might affect the company critically.

The aim of this project was to generate knowledge related and industry specific business intelligence by develop business intelligence process, and apply the results in companies in the construction sector. The project aims were also to develop the acquiring of business information and to increase the knowledge about international markets.

METHODS

Business information is internal information about a company's operations and external information concerning a company's business environment, markets, competitors, technologies, customers etc.

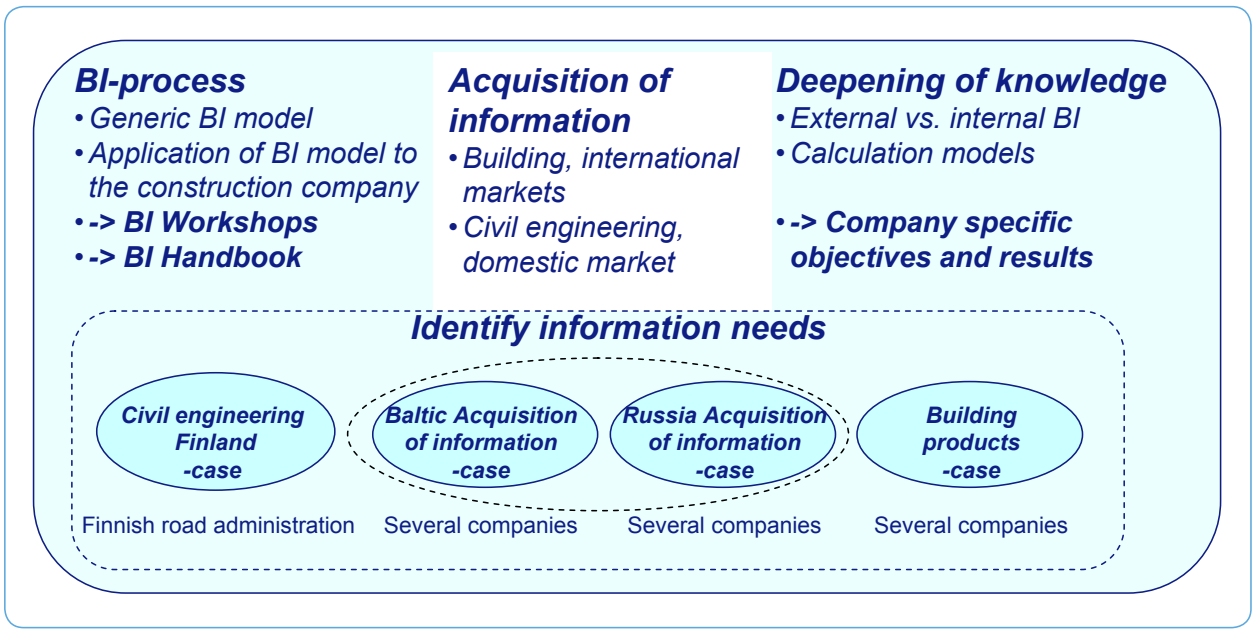


Figure 1. ComBI project's point-of-views and work packages.

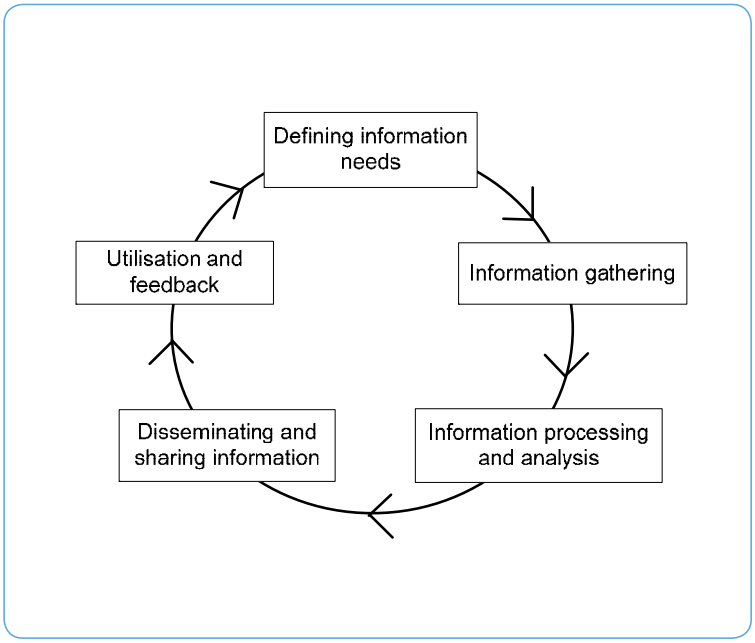


Figure 2. A general business intelligence process [1].

Identifying information needs, finding relevant information and sharing it are considered problematic in many organizations. By information management functions which are defining information needs, information gathering, processing, analyzing, use and feedback, this problem can be executed separately of each other. This could be called a business intelligence process. A general BI process with its different phases is illustrated in Figure 2. The BI process in the construction sector should not be different than in any other industry.

In addition to academic studies, research and interviews, the project has had workshops which spread the best practices from other companies and other industries to the construction sector. The workshops have followed the phases of business intelligence process.

RESULTS

Construction companies' interest to develop BI activities has increased in Finland. Globalization has affected the construction sector and nowadays many construction companies operate internationally throughout wide geographical areas. Information is needed i.e. about construction market, big building projects and building trends. The state of business intelligence in construction companies in Finland varies from some of the phases in BI process to highly organized and systematic BI units.

Results of the project have given the construction companies extensive guidelines to develop business intelligence process more systematically. The project's central public result was an industry specific business intelligence handbook for companies in the construction sector.

Project results were supplied in the project's case studies. Case studies consider development or build up of the company's BI process and BI situations state-of-the-art surveys. The project's aim was also to increase the knowledge about international markets, especially the Russian and Baltic construction markets. VTT produced many market reports to companies and developed markets forecasting methods and information gathering to the area.

EXPLOITATION POTENTIAL

Globalization in construction business continues. EU area and East Europe will be the real domestic market to the Finnish construction companies in near future. Systematic business intelligence and information gathering is more and more important. This research assists both information providers as well as companies to utilize the generated knowledge.

ACKNOWLEDGEMENTS

The project was done by VTT in cooperation with the Institute of Business Information Management, Tampere University of Technology (TTY). The authors wish to thank the colleagues from VTT and TTY for their contribution to this work. The project was funded by Tekes and by seven construction companies or organizations.

REFERENCES

[1] Vuori, V., Myllärniemi, J., Hannula, M., Nippala, E., Ala-Kotila, P. & Riihimäki, M. Guide for Construction Business Intelligence. (In Finnish). To be published September 2008. Rakennustieto Oy, 79 p.

CONTACT

Markku Riihimäki
Senior Research Scientist
markku.riihimaki@vtt.fi
Tel. +358 20 722 3453

BUILDING INNOVATION IN THE EUROPEAN CONSTRUCTION SECTOR

Abdul Samad (Sami) Kazi, Tarja Mäkeläinen, Isabel Pinto-Seppä

The project "Building Innovation in the European Construction Sector (BUILD-NOVA)", was a coordination action aimed at establishing a network of relevant organizations (consumers, providers, and financers) engaged in innovation activities in the construction sector. The project facilitated interaction and collaboration between organizations through a series of interactive business forums.

INTRODUCTION

Within the BUILD-NOVA project, a key aim was to facilitate interaction between three key stakeholders in the innovation process of smart products and services within the construction sector. Through engagement of the market (users of solutions), technology (providers of solutions), and financing (financers of innovation) within areas of mutual interest, BUILD-NOVA aimed to achieve a better understanding of the success factors involved in innovation funding in the construction sector. The ultimate objective being to improve the innovation process by, on the one hand, helping technology firms (both high-tech and less technology intensive companies) to find suitable funding for their new innovative products and services, and on the other, helping investors to have a better understanding of the technology and market possibilities of such new ideas. The project's main objectives were:

- Creation of a network composed of market, finance and technology representatives.
- Identification of construction's needs which are relevant to innovation financing.
- Organization of business forums with participation of the different parties focused on the discussion of sector relevant issues related to technology and innovation.
- Linking with other European networks already working on innovation as well as with projects and initiatives around the ECTP (European Construction Technology Platform).

APPROACH

Initially, a sectoral study was conducted within the countries represented in the consortium to identify key trends and topics for innovation and identification of available regional, national, and European level financing instruments. This study was used as a basis for development of the context for dialogue and collaboration between the different stakeholders (market, technology, financing) in the form of interactive business forums [2]. These business forums typically followed the principle of inspire (an inspirational talk), interact (interactive dialogue and group work on topics of interest to stakeholders), and innovate (take-up of ideas from group work and translation into funded innovation projects). Within countries represented by the consortium, a series of business forums were conducted. In Finland, the focus was primarily on the proper development and utilization of building information models for design, construction, maintenance, and refurbishment of buildings.

RESULTS

The key results from the project [1] included:

- Reports on characteristics of the construction sector – technology and market tendencies
- Finance guides
- Innovation funding map
- Business plan navigation guide
- Policy recommendations for financing of innovation in the European construction sector
- Results of business forums in Finland, France, Ireland, Poland, and Spain.

DISCUSSION AND CONCLUSIONS

The project validated that innovation and its financing is possible through proper interactive dialogue and collaboration of different relevant stakeholders (market, technology, and finance). Such dialogue is appropriately undertaken through business forums focusing on a given topic and facilitated through a process of inspiration, interaction, and innovation.

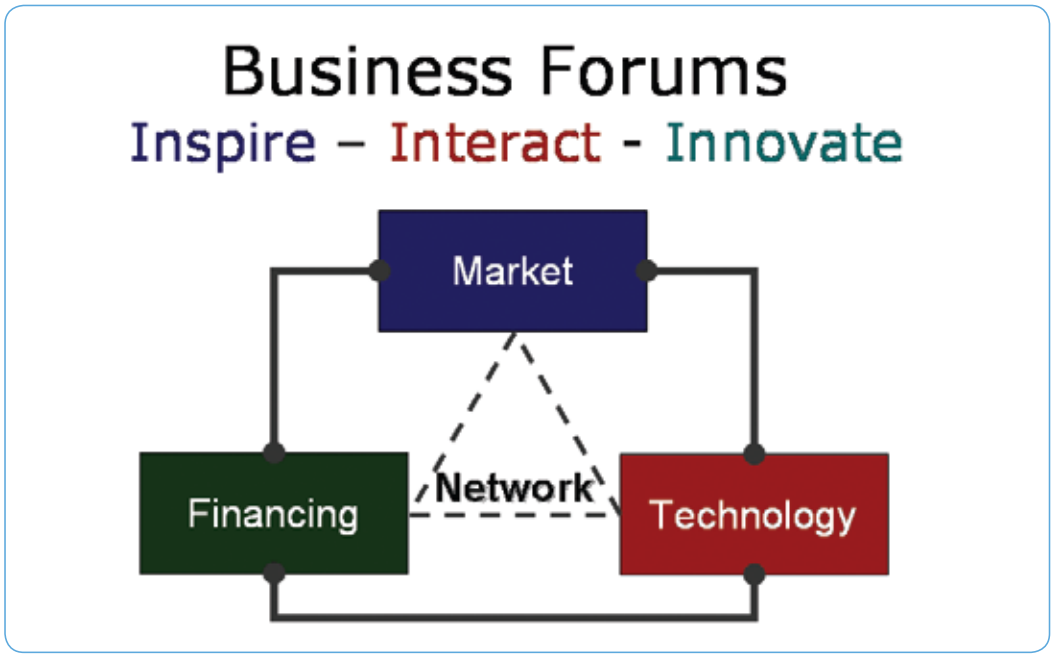


Figure 1. BUILD-NOVA: Business Forum Concept.

A salient feature of the agenda for the business forums was use of the 3I approach developed during the project. This was based on Inspiration, Interaction, and Innovation. It was found necessary to start all sessions with an inspirational talk that would set the basis for interactive group-work around a particular theme or topic. During later stages, it was observed that an additional I was required. The 3I approach was then transformed to the 4I approach: Inspiration, Interaction, Imagination and Innovation. This refined approach was used as a basis for open interactive project idea development within a collegial atmosphere.

EXPLOITATION POTENTIAL

The project's approach for organizing and facilitating business forums based on principles of open interactive idea development and facilitated through inspiration, interaction, and innovation may serve as a basis for identification and financing of new innovative products and services.

VTT is currently in the process of packaging the developed approach (4I) alongside two other approaches: REED (retain, eliminates, enable, disable); strategic roadmapping and implementation action planning. The package will serve as a value co-creation solution through which VTT will help its clients to better understand their business, foresee and plan innovation, and identify tangible actions to achieve identified business goals and strategies.

The policy recommendations developed within the project serve as a basis for regulatory change and innovation financing focus within regional, national, and European funding programs.

ACKNOWLEDGEMENTS

This project was funded by the European Commission and VTT. The project consortium included 8 partners from 6 countries.

REFERENCES

[1] Public web site of the BUILD-NOVA project, 2008, www.europe-innova.org/index.jsp > Financing Networks > Construction > BUILD-NOVA.

CONTACT

Abdul Samad (Sami) Kazi
Chief Research Scientist
sami.kazi@vtt.fi
Tel. +358 20 722 6666

NEW RISK MANAGEMENT PARADIGMS AND TOOLS

Kalle Kähkönen, Mikko Tuomisto

Although its significance for modern business is widely acknowledged, risk and opportunity management is still an emerging discipline that is under continuous development and change. Enterprise-wide risk management solutions or those covering the whole project life cycle require wide scope risk management solution, which is one main research and development target at present. Additionally, risk and opportunity management still suffers conceptual complexity and its models and tools are inadequate. There are many aspects to be investigated in this area to gain improved understanding and to develop new innovative tools that can provide competitive advantage to companies. There is a need for wide and long term research efforts to reshape risk management content, its procedures and tools by presenting new paradigms and corresponding tools.

INTRODUCTION

The ultimate target in this research was to make risk and uncertainty management an easy and fun task where both positive opportunities and averse risks are tackled in a balanced manner. An important finding from live risk management meetings is that the term "risk" should be used only in the context of severe enough events. Otherwise it can be difficult to separate risks and their management from regular management operations, the value of risk management procedures will be unclear and, finally, the overall interest for risk management can disappear. This is an example of principles that are omitted in the conventional risk management paradigm.

Human behavior as an enabler for effective risk management meetings is another aspect of interest. Naturally, good facilitators play an important role and thus it is worthwhile to study their performance and behavior. Individuals who can be called good facilitators put clear emphasis on creating common understanding, visually showing the current risk structure, and, updating all this continuously during discussions. Seemingly, such effort leads to proper dialogue, shared risk understanding and high commitment to needed actions.

METHODS

The project approach included development of new concepts and relating tools that can be considered as competing paradigms compared with the traditional risk management. These were tested by companies that were participating in the research or who are customers of risk management consultancy (see Figure 1).

RESULTS

The project resulted in a Temper System for risk management. In particular, this software tool provides means for localizing risk management procedures for the needs of different situations and stakeholders. This is called situation specific risk management procedures that present a different approach compared with "standardized" risk management procedures [1]. Additionally, in order to enhance communication and avoid "paper work" feelings, the Temper System provides interactive risk and action mapping techniques for visualization of the effects of various risks and benefits of suggested actions.

In the forthcoming stages if the project, additional tools will be developed, including: 1) Continuous monitoring of degree of project complexity 2) Interactive Risk Mapping (IRM) as a new type of tool for risk management which entails a computer program that takes advantage of interactive computer graphics to support human communication in risk management meetings, 3) Integration of qualitative and quantitative risk analysis for having improved flexibility to meet the needs of different situations [2], 4) Integrated opportunity and risk management targets for a well-balanced solution where the users can explore the potential chances for improved performance together with negative threats [3].

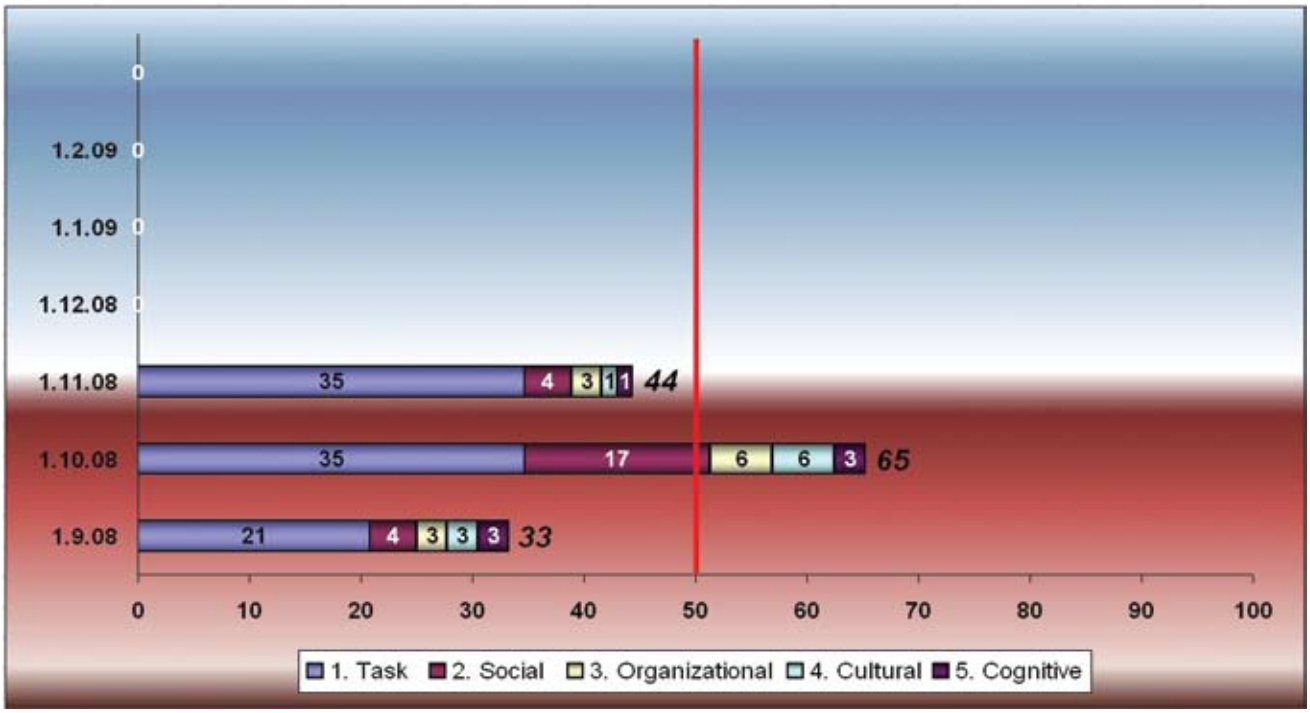


Figure 1. Tool for monitoring degree of complexity in projects. Example of monthly subjective estimates (applying scale 1-5), calculations and final output

DISCUSSION AND CONCLUSIONS

Traditional risk management seems to have a well-established nature. Thus it is almost too easy to anchor ones mind and thinking to the basic model where the core of risk management means "a cyclic process of risk identification, risk analysis, risk response and risk control". One obvious shortcoming of this approach is that there is too much emphasis on mechanical risk identification, analysis and response cycle, i.e. it has a normative nature. The project's mission is to overcome this shortcoming with new kinds of competitive risk management paradigms and corresponding tools.

ACKNOWLEDGEMENTS

This work has been funded by Tekes, VTT and 5 private companies and will be completed in spring 2009.

REFERENCES

[1] Kähkönen, K. 2006. Management of uncertainty, a chapter for the Commercial Management of Projects book by Blackwell Science Publishing Ltd, February 2006, pp. 211–233.

[2] Kähkönen, K. 2007. Quantitative risk management for construction, Proceedings of 4th Nordic Conference in Construction Economics and Organisation, 14–15 June 2007, Luleå, Sweden.

[3] Kähkönen, K. 2005. Fundamental enablers for wide-scope project risk and opportunity management. Proceedings of IPMA World Congress, 13–16 November 2005, New Delhi, India, 4 p.

CONTACT

Kalle Kähkönen
Chief Research Scientist
kalle.kahkonen@vtt.fi
Tel. +358 20 722 4560

PROFILING BUSINESS NETWORKS ORIENTED TO RUSSIA

Kalle Kähkönen, Iris Karvonen, Martin Ollus

The objective of the international network profiling project called "COP" was to develop a management and leadership patterns for Finnish businesses and networks operating in Russia.

INTRODUCTION

Trade and business between Finland and Russia have been growing and changing rapidly but generally in a very positive manner. Successful cooperation requires mutual understanding and participation in true dialogue in order to solve seemingly insurmountable problems. Understanding will be facilitated through knowledge and operational models that help bring problems to the surface and find flexible solutions. Advanced managerial frameworks and technology can considerably help in structuring and for understanding thoroughly the underlying caused of problems, challenges and opportunities.

APPROACH

As a starting point of this research it was realized that the business conditions in Russia are very dynamic, rather unpredictable and different compared with the more familiar conditions in EU countries. Managerial paradigms, their theories and practical tools are not usually applicable as such rather additional understanding and knowledge need to be gained via research. The research focused on three different topics:

1. Risk analysis, to gain practical and reliable data on risks involved in the business activities in the Russian market
2. Company network modeling and understanding of the current status of company's partners
3. Management knowledge and skills mapping. Skill profiles and team evaluation were used in order to evaluate learning needs, work ability etc.

This research effort was an example of a constructive proof-of-concept study. The actual 'constructions' were solutions that have gone through a limited field tests with the company representatives who participated the in research.

RESULTS

Three level management patterns and evaluation tools were developed:

1. Risk Analysis for Business Operations in Russia,
2. Quick Test of Business Network (Figure 1) and
3. Skill Profiling Tool for Companies operating in Business Networks.

Risk Analysis and Quick Test are oriented towards the early stage of a life-cycle of a business network or mapping of business networks. The skill profiling tool is orientated for more mature stages in the life-cycle of the business networks. Management patterns have been developed with a constructive approach. Piloting of the developed models has been carried out with Finnish companies and experts working in Russia.

Modelling of networked operations is a rather new topic that has an obvious connection to business process modelling. Still at present the modelling principles and methods are not well-established for this purpose. The work presented in this paper addresses subjective status modelling of company networks. Evidently, in nowadays' turbulently changing market conditions it is of importance for an increasing number of companies to monitor continuously the status of their company network. This seems to be a common need in many business disciplines but the context of the work presented here are the companies from construction sector.

DISCUSSION AND CONCLUSIONS

Participation in and support of this project was by companies who have business operations in Russia where, due to dynamics of markets, it is in their interest to continuously monitor the current status of their company networks and to further understand the lacking skills and new skills needed to be successful. The COP project

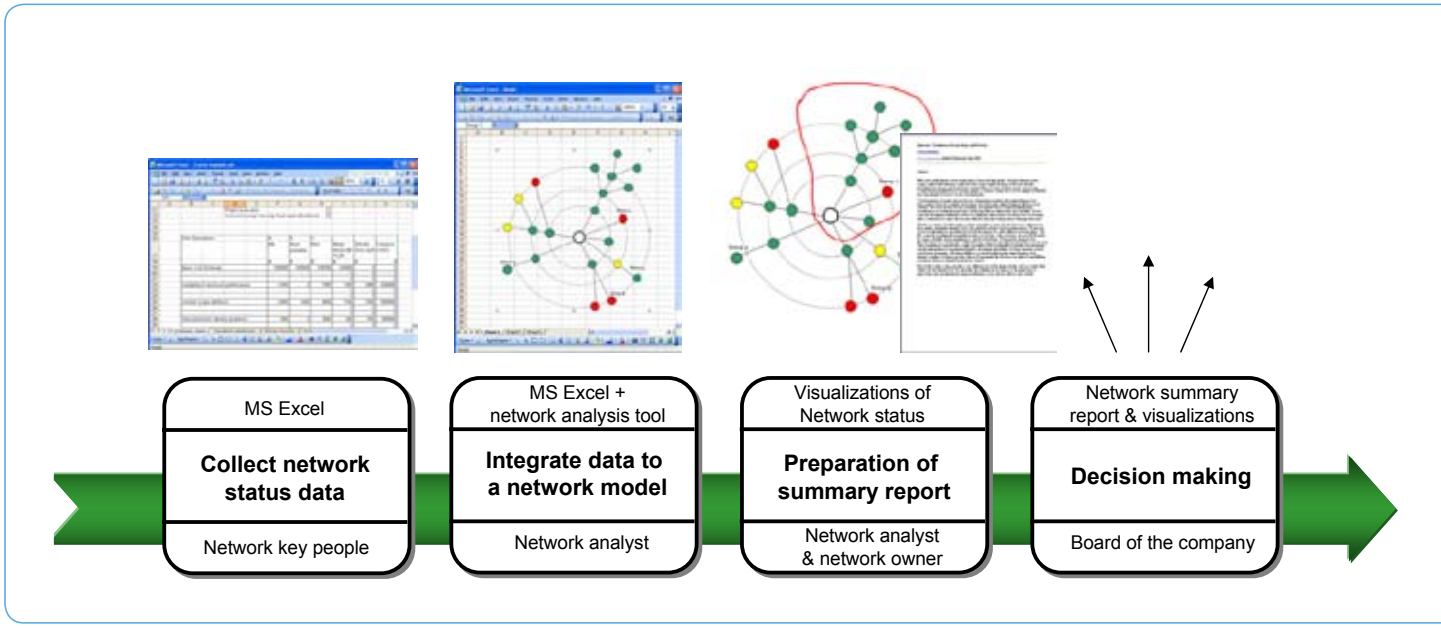


Figure 1. Tool for modeling the status of company networks [2].

has produced tools and new knowledge to analyze enterprise networks and to map a company's management knowledge and skills.

Furthermore risk management is of high importance in Russian market conditions. A clear research-based conclusion is that as the volume and complexity of operations increases, the effort for risk assessment and risk management must be increased correspondingly. This is the way to achieve a significant competitive advantage.

The current work by the authors is addressing the evolution of company networks from early stages to next levels. The modelling is then to include time dimension and the relating changes of company networks.

ACKNOWLEDGEMENTS

The financing bodies of the COP project were Tekes, the European Regional Development Fund (ERDF), VTT and participating companies. The researchers would like to express their gratitude to the seven industrial partners of the project.

A follow up project entitled STROI Network is underway at VTT in cooperation with HAMK and Tampere University of Technology. The project is funded by Tekes and will be completed at the end of 2009 [1].

REFERENCES

[1] Niittymäki, S., Tenhunen, L., Weck, M., Karvonen, I., Kähkönen, K. & Ollus, M. 2007. Profiling business Networks Oriented to Russia. HAMK University of Applied Sciences.

[2] Kähkönen, K., Karvonen, I. & Ollus, M. 2007. Modelling of Networked Construction Operations. Proceedings of Second International Conference World of Construction Project Management, Delft, The Netherlands, October 2007.

CONTACT

Kalle Kähkönen
Chief Research Scientist
kalle.kahkonen@vtt.fi
Tel. +358 20 722 4560

RUSSIAN-FINNISH STROI-BUSINESS NETWORK

Anna-Leena Perälä, Markku Riihimäki, Kalle Kähkönen

Strategic management and business networking is relative new in Russia. Creating a strategic network is prerequisite for the successful business.

INTRODUCTION

Trade and business between Finland and Russia are growing and changing. Finnish construction sector companies are interested in increasing construction and service markets with Russia. Companies and clients act in different ways than in Finland, while more cooperation is needed in the future.

The objective of the Stroi-business network is to develop management and leadership models for Finnish – Russian business networks operating in Russia.

METHODS

Profiling present business networks oriented to Russia was the first phase of this research project. Profiling and evaluation were made by three level management patterns and evaluation tools that were developed in Finland. Tools and methods are: 1) Risk Analysis for Business Operations in Russia, 2) Quick Test of Business Networks and 3) Skill Profiling Tool for Companies Operating in Business Networks. After this profiling, targets were select and set for development activities within the Stroi-network companies.

Stroi-business networks products or networked business sectors are:

- New regional building or large single targets business and industry buildings
- Small houses (wooden houses)
- Residential buildings
- Service business (life cycle services and maintenance, services during building)

Business networks need better understanding about drivers and trend knowledge of different perspectives of construction in Russia. The project prepared a presume model for total demand of the markets for different kinds of products from the building, real estate and environmental sectors in Russia, primarily targeting the St. Petersburg and Moscow regions.

The result was a forecast model for total demand of the products, which are targets for the research. A working model was created for defining the product range and realization network for companies operating with building, real estate and environmental sectors. The model helps to receive the marketing situation information for the conclusion base from customers and network.

The second part of the project is to create a model to produce a vision for a business network operating in Russia. A strategic business network needs a strong vision. The vision must be concentrated on the desired future of the business, not on its present state. All network activities should be connected in the network's vision, to ensure future wishes being met. The question is which kind of vision working model could be applied in strategic networks operating in Russia and their target visioning?

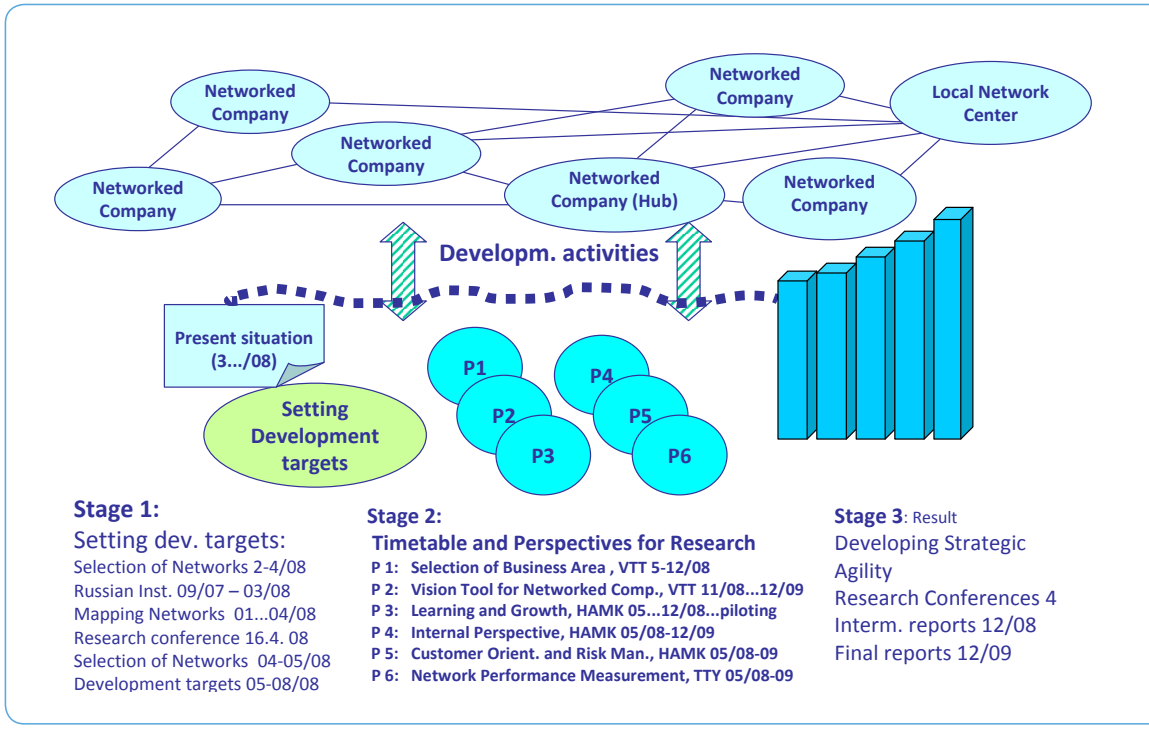
During vision processing, the common idea as well as more detailed strategic part objectives and guidelines are being developed for the operating networked companies. A co-operational model for supporting the vision fulfillment is being prepared. The main results are a competition strategy developing tool and working model for generating a strategic network vision.

RESULTS

The aim of the research is to develop management and leadership models for Finnish – Russian Business networks working in Russia. Applied models are created to lead and manage business networks operating in Russia with the following perspectives:

- Selection of growing business sector within construction, industrial maintenance or environmental services

Figure 1. Developing action pattern for strategic agility in three stages in Russian business networks.



- A model to build up a vision (vision tool) for selected business network
- Learning and growth
- Internal Development of Business Network (Operational Excellence, Customer Management, Innovation)
- Customer orientation: Internal Business Partners, External Customers, Risk Management
- Performance Measurement and Financial Perspective

The final result will be management and leadership model and toolbox for Russian oriented networks from the above listed perspectives. These tools ensure competitiveness of Finnish business networks in Russian markets. Management and leadership model and tools will be developed for six perspectives, with four of these being based on the Balanced Scorecard point-of-views.

DISCUSSION AND CONCLUSIONS

Between Finland and Russia there are a lot of differences in national, industrial, functional, professional and company cultures. The construction industry or one network is also a very heterogeneous combination of localized needs, various services and products and their providers. Network operations, management and modeling are a rather new topic in business network development especially in Russia. The project aim to develop management and leadership models for Finnish – Russian business networks operating in Russia will support the growth of networks and business activities in Russia.

EXPLOITATION POTENTIAL

Globalization in the construction business continues. Russian markets will be like a domestic market to the Finnish construction companies and their networks in the near future. This research gives potential to growing competitiveness of Finnish business networks in Russian markets and allows companies to utilize the generated knowledge.

ACKNOWLEDGEMENTS

The project is being done by VTT, the University of Applied Sciences (HAMK) and Tampere University of Technology (TUT). Russian research institutions and partners are The State University Higher School of Economics in Moscow and St. Petersburg State University. The project is funded by Tekes and 13 companies or organizations and will be completed in 2009.

REFERENCES

[1] Niittymäki, S., Tenhunen, L., Weck, M., Karvonen, I., Kähkönen, K., & Ollus, M. 2007. Profiling Business Networks Oriented to Russia. HAMK University of Applied Sciences.

CONTACT

Anna-Leena Perälä
Senior Research Scientist
anna-Leena.perala@vtt.fi
Tel. +358 20 722 3407

BRINGING RETROFIT INNOVATION TO APPLICATION IN PUBLIC BUILDINGS

Timo Kauppinen, Jorma Pietiläinen, Harri Katajala, Jussi Rönty, Anne Tolman

The goal of the project "Bringing Retrofit Innovation to Application in Public Buildings (Brita in Pubs)" was to increase the market penetration of innovative and effective retrofit solutions for improving energy efficiency and to implement renewables at reasonable additional costs. This was realized by the energy related renovation of 8 demonstration public buildings in the four participating European regions. The general target of the retrofits at the demonstration buildings was to reduce the primary energy demand 50 % from the consumption before renovations, and at the same time to improve the user satisfaction. In addition, research, training and dissemination work has been done.

INTRODUCTION

Different types of public buildings were chosen as demonstration buildings, where the energy related retrofit measures would reach various groups of interest. The buildings included a nursing home, education/university buildings, social and cultural centers, ecological library and old wooden church. In three cases the original use was changed. One building was before a brewery/warehouse, one was a factory building, and one a residential and commercial building. The research issues included a social-economic study to recognize real project-planning needs, financing strategies and the development of design guidelines. The project also developed an internet-based knowledge tool on retrofit measures and case studies and a quality control-tool box to ensure optimal life-cycle costs and performance of buildings and systems.

RESULTS

The planned energy saving goals were reached in all demonstration buildings. Energy savings varied from 48 % to 253 % and payback time from 7 years to 23 years, depending on the target. In all 5 demonstration buildings the following measures were taken: Additional insulation of the walls, window replacements, and improvements of HVAC- and Control systems. In 4 buildings solar thermal and solar PV-systems were installed. The church was a special case because it was a historically listed building for preservation.

The demonstration projects included development of a set of tools to be used during the project and in future work. The tools created in the project included the following:

- Retrofit Design Guidelines
- BIT-Brita in Pubs Information Tool
- BISH-Blackboard Information Sheets
- E-learning and Student Courses
- Analysis and reports
- Website
- Quality Control Tool Box
- Facility Managers' training courses

Partially based on earlier projects, the quality/performance control toolbox was created. This is a concept of having information from design to post construction life long management, using Building Energy Management System – type procedures and using prevailing methods. Figure 1 shows how the requirements and goals were checked between each stage of the project. Each diamond contains a list of tasks and operations or checklists.

Another key result was the training program for facility managers to ensure proper handover procedures for retrofitted buildings. The training also aimed at ensuring efficient operation and maintenance to achieve optimum energy performance. The content of the training courses was based on the results of project subtasks, together with the experiences from demonstration buildings. The courses were arranged in 6 cities around Europe and were held in spring 2008. The participation varied from 10 to 30 persons.

DISCUSSION AND CONCLUSIONS

The project showed that the energy consumption goals were reached in general terms in all of the demonstration buildings. Energy-related renovation concepts are need-

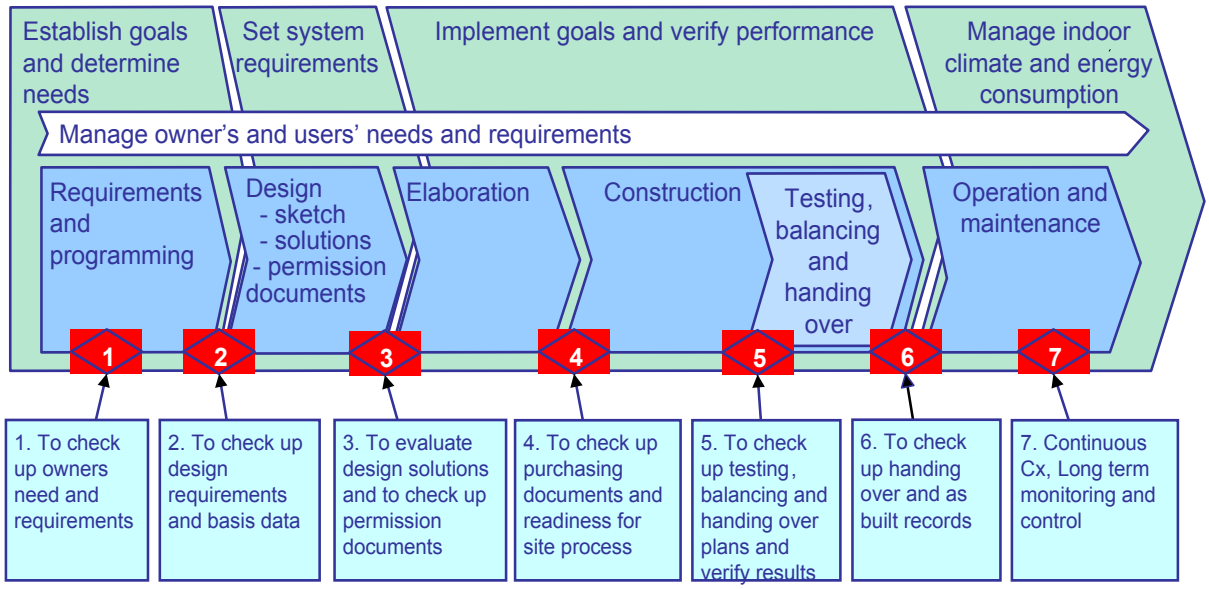


Figure 1. Building Commissioning process.

ed; the existing buildings have the main part of energy consumption. The demonstration buildings and approach to renovation were very different; therefore better targeting to similar building types would have been beneficial. One factor is also to have a proper monitoring and analyzing system of buildings, as well as the procedure to ensure and verify that the requirements will be qualified during the building process and during the use stage. The training and dissemination activities are very important for lowering possible barriers.

EXPLOITATION POTENTIAL

According to the various groups of interests, the results of the project can be utilized. The fastest way is to organize training and dissemination activities based on these results for decision makers, building owners, facility managers and designers.

ACKNOWLEDGEMENTS

The research was funded by the European Commission and VTT and included 23 partners from 9 countries.

REFERENCES

[1] Public web site of the Brita-in-Pubs project, 2008, www.brita-in-pubs.eu.

CONTACT

Timo Kauppinen
Senior Research Scientist
timo.kauppinen@vtt.fi
Tel. +358 20 722 2013

DATA MANAGEMENT AND EXPLOITATION DURING FACILITY USE

Tommi Parkkila, Anne Tolman, Pentti Vähä

Applying Information and Communication Technology (ICT) during the life cycle of facilities upgrades the facility maintenance process. The improved process provides added value to the facility, enhances user utility and optimizes services.

INTRODUCTION

Performance of a facility is its ability to provide the services expected. It is becoming the item of initial procurement and client criteria during the tenancy. In the building and facility sector there are several inspections buildings have to pass before owners or occupants can settle down. It is important for the project delivery team to be able to predict not only the performance of the parts, but also how the whole will perform when all the parts are synthesized [1]. In the PBB (performance based building) environment the design/build team must warrantee and maintain structural performance to the level stated in the contract, for the duration of the contract. This requires data on variation of the performance, enabling interventions for tuning of operating systems or diagnosis of a fault. Therefore a tool concept of lightweight service platform for Facility Management (FM)-services to monitor and report environment conditions in residencies was designed and developed.

METHOD

Continuous sensing requires a measuring system with sensors to provide data on variations of the stated performance, and applied research method is a natural choice. Hence, we applied the latest technology to this practical problem by developing a service platform and testing it in residential buildings.

RESULT – A SENSOR NET BASED SERVICE SYSTEM

A lightweight service platform was designed and developed to provide valid performance information about targets of inspection and commissioning services. This sensor net-based service system consists of two main service levels: embedded-level services and Internet-level services. The embedded-level does continuous multipoint and multivariable (temperature, humidity, electrical power consumption and light) measurement of living circumstances and behavior of the electrical heating system of a residential building. The Internet-level offers dynamical views of measured and analyzed data for end users through web browsers. With information about intervals and levels of temperature and humidity changes and data

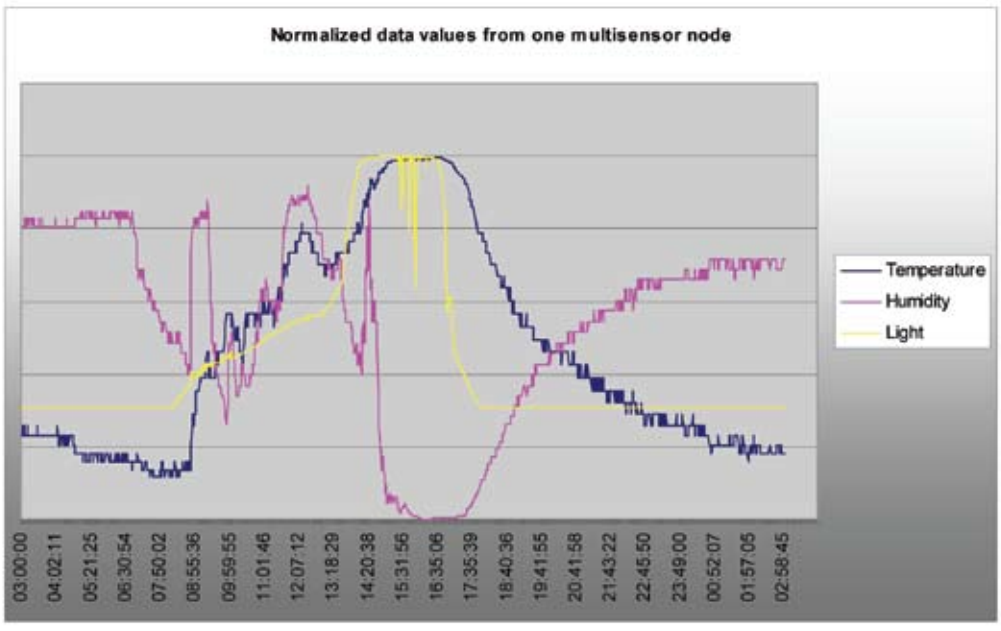


Figure 1. Normalized data values of a multisensor node.

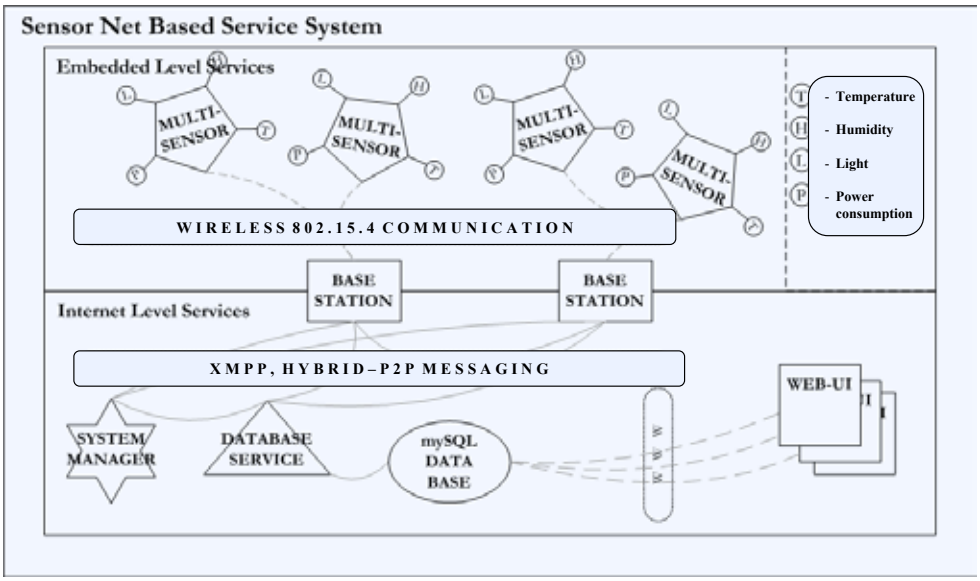


Figure 2. Overview of the developed service system.

how the electrical heating system is working, the performance of a building can be defined. Multipoint measuring with wireless sensor network from different parts of the building provides a comprehensive picture of the performance. A graph of measured and normalized data values of a multisensor node during one day and night is seen in Figure 1. When analyzing the graph the correlation between temperature, humidity and light data is obvious. The base station of the system collects and saves the received data from multisensor nodes into flash memory and sends the collected data to a database service through GPRS (General Packet Radio Service) connection with standard XMPP point-to-point messages. This very lightweight hybrid peer-to-peer messaging protocol does not need any complicated software drivers to realize a client application; therefore it is useful when connecting embedded devices to the Internet [3]. An overview of the sensor net based service system is described in Figure 2.

CONCLUSIONS

In the building and facility sector there are several inspections buildings have to pass before owners or occupants can settle down. During the operation phase, continuous sensing provides data on variation of the performance, enabling interventions for tuning of operating systems or diagnosis of a fault. Multipoint measuring with wireless sensor network from different part of a building provides comprehensive picture of the performance.

ACKNOWLEDGEMENT

The authors would like to thank the Academy of Finland for supporting this project.

REFERENCES

[1] Glaser, S. D. & Tolman, A. 2008. Sense of Sensing: From data to informed decisions for the built environment. Journal of Infrastructure Systems, Vol. 14, No. 1, pp. 4–14.

[2] Szigeti, F. & Davis, G. 2001. Functionality and Serviceability Standards: Tools for Stating Functional Requirements and for Evaluating Facilities, in Federal Facilities Council, Technical Report 145. Learning from Our Buildings: A State-of-the-Art Practice Summary of Post-Occupancy Evaluation, National Academy Press.

[3] Parkkila, T. 2005. Application and platform management of an embedded system. Smart Systems 2005, Seinäjoki, Finland, 3–4 May 2005.

CONTACT

Tommi Parkkila
Research Scientist
tommi.parkkila@vtt.fi
Tel. +358 20 722 2362

NEW SERVICES IN DIGITAL HOME

Heikki Pentikäinen, Kalevi Piira, Teppo Kivento, Juha Koivisto, Arto Laikari

Research has been done on developing Internet, wireless and mobile -based networking solutions and services for home environments. This paper describes the results of the work done in the "Digihome Services" project [1] for creating a technical platform for end user services.

INTRODUCTION

The Internet penetration in home has been one of the biggest success stories in the Consumer Electronics (CE) product markets in recent years. Today tens of millions of consumers have home networks based on Internet technology. It is mainly used for accessing web services in global Internet, but the Internet at home posses a large unused capacity to get all home and house appliances connected and managed over a network. It is expected that home networking is entering a new phase in its evolution driven largely by connected CE products for home and related Web-based services that will lay the ground for connected Digital home markets.

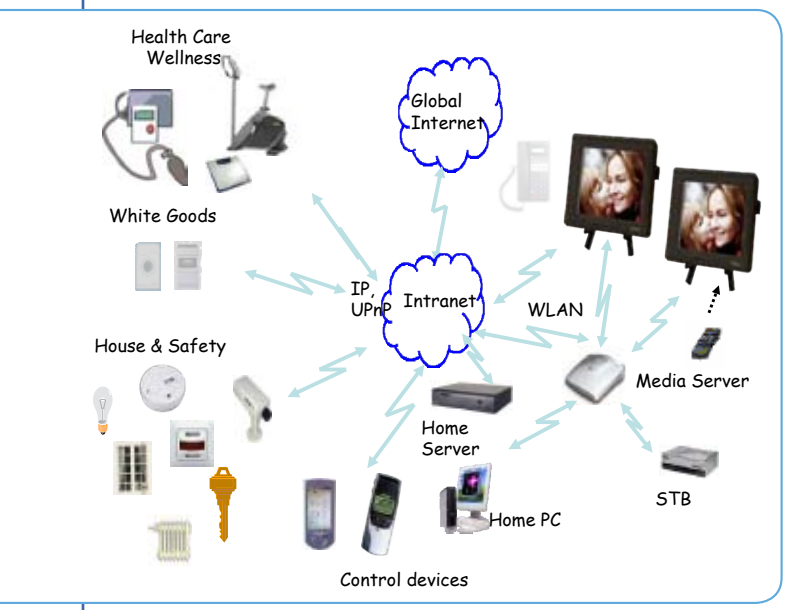


Figure 1. DHS system architecture

METHODS

VTT has made several studies [2] to adapt office-based Internet, IP, UPnP, Web and mobile and wireless technologies to connecting home and house appliances and devices. In the studies, a technical concept was analyzed and defined a technical concept to apply Internet, wireless and mobile technologies for a home environment in a feasible and secure way. The concepts were facilitated in a real life pilothouse at VTT's pilot house area within the "Digihome Services" project. A prototype of the platform was implemented and taken in use in the pilothouse with basic home services and some building automation services.

RESULTS

The Digihome system provides an easy way to monitor and control home and house appliances and functions over a network. The users can view the status of the connected appliances and control them. The service is available locally over the home network, inside the home and through global Internet outside the home. A build-in security system ensures that only authorized users can get access to appliances and control them.

The Digihome energy consumption monitoring service gives real-time feedback to occupants on their energy consumption and the costs. The consumption and costs figures are presented for each electrical device connected to the house electrical power network. The basic consuming information of all household electronic devices is stored in a home maintenance database. With help of such data it is possible to define for instance, when the washing machine or television is turned on and off by using analysis tools and comparing the collected data on energy consumption with reference information of the devices.

The Non-Intrusive Appliance Load Monitoring (NIALM) method was used and tested for measuring the

accurate device related consuming information. The idea was to analyze online the electric power trend (including RMS power/reactive power), so-called electrical fingerprints, and to identify active devices and how much each device consumes electricity. The study found that it was possible to identify several devices per measured phase, how ever it was difficult to identify electrical fingerprints of all active devices at the same time and especially when they had very similar fingerprints. Therefore, the method needs to be combined with a device identification and status information received from devices. When combining the identification and status information of a device with power meter data, a reliable, device level consumption data can be offered.

The Digihome Energy conservation service was defined as an external service that is implemented on top of the Digihome environment. It is based on the data from the power meter of the house and device activity data. The gathered data are regularly sent to an external service provider. The service provider performs analysis and comparison of data and sends a feedback report to the Digihome server. The report describes in details the energy consumption for each day, gives suggestions on several measures to save energy, and presents estimates on saving possibilities. The service provider can, for example, suggest to the customer to defrost the freezer based on an increase in its energy consumption or even change the device to a new one, based on the savings in energy consumption that results into an exceptionally short repayment period.

DISCUSSION AND CONCLUSIONS

It was concluded that office-based IP-networking technology is suitable for home services and it reduces amount of investments in networks to the level of CE products for home. The usage of Internet/IP-technology in networking of houses, compared to fieldbus-based networking solutions, simplifies network structures and reduces networking investments radically. As a consequence, the installation of networks becomes easier, the usage is simpler and maintenance can be taken care of by the users. The Internet/IP–networks can be easily combined by wireless and mobile technologies. These offer additional flexibility and make the installation easier in existing houses and buildings, without major upgrades in contractions or drawing of new wires.

EXPLOITATION POTENTIAL

The success of the Internet in networking at home and in private homes paves the way even for Internet-connected and web browser–managed house and building automation products. The new product generation will be marketed as CE products.

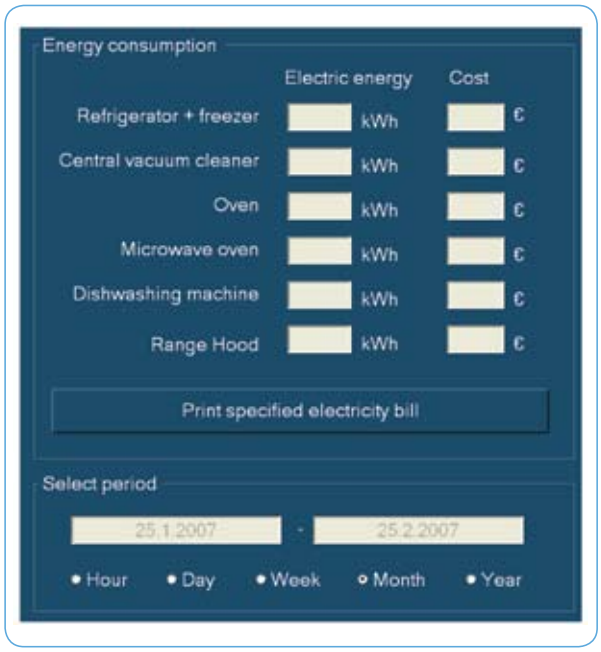


Figure 2. The consumption monitor display of household equipment

As the price of electricity and energy continuously grows, the services supporting the decreasing of energy consumption will become profitable. Potential parties for implementation of the service concept are electric companies, electric meter manufacturers, analysis software companies, and consulting firms.

ACKNOWLEDGEMENTS

The author wishes to thank the involved companies and the Digihome project team colleagues that have made the research possible, as well as acknowledging VTT's support.

REFERENCES

[1] Public web site of the Digihome Services project, 2008, www.vtt.fi/digihome

[2] Laikari, J. Koivisto. 2007. UPnP for controlling the home. (In Finnish). Prosessori, Sanoma Magazines, pp. 50–52, 11/2007.

CONTACT

Heikki Pentikäinen
R&D Manager
heikki.pentikainen@vtt.fi
Tel. +358 20 722 5959

BRIDGING PHYSICAL, DIGITAL AND NEAR FIELD COMMUNICATION TECHNOLOGIES

Minna Isomursu, Tuomo Tuikka, Tapio Matinmikko, Esko Strömmer, Juha Häikiö, Arto Wallin

The SmartTouch project [1] has explored the use of near field communication (NFC) technology for providing access points for digital services in everyday living environments. Successful service concepts have been constructed and evaluated, for example, to provide elderly people access to digital services in their homes, supporting logistics and integrating payment and ticketing with a mobile phone.

INTRODUCTION

The vision of ubiquitous computing [2] envisions that digital services would seamlessly integrate with our physical environment. Digital services would be easily available everywhere in our everyday lives. The SmartTouch research project has explored the use of near field communication (NFC) technology for bridging the physical world and the digital services. NFC is a short-range wireless technology that allows electronic devices to exchange data upon touching. NFC standards have been built over existing radio frequency communication standards (e.g. RFID and smart card standards) [3]. The most common scenario for NFC use is to integrate the NFC reader into a mobile device, such as a mobile phone. A mobile phone can then be used to read NFC tags, or to communicate with other NFC enabled devices upon touch. NFC tags are small and cheap, and they can be attached to virtually any object or surface. The tag can then act as a link between the physical and digital worlds. Accessing information in the digital space through a link in a physical world, such as a NFC tag, is called physical browsing [4].

METHODS

VTT has been active in the development of NFC technology from its very early days. However, at its current stage, the technology is already quite stable and available as commercial products. Therefore, the main focus of the SmartTouch project was on the applications and services that are enabled by NFC technology. As services do not exist before they are actually used, the project adopted a research approach that was driven by the field trials where the service concepts were evaluated in a realistic usage settings. The evaluation focus was on the business aspects, user experience, and security and privacy issues. Some of the most successful service concepts include NFC enhanced meal service for elderly people [5], supporting the logistic chain of meal service personnel, and NFC for public transportation ticketing and information services (Figure 1).

RESULTS

The results show that the NFC technology can cost-effectively provide possibilities for various types of digital services to users with varying capabilities and needs. For example, elderly users who did not use PC computers and had difficulties in operating a standard mobile phone, were quite able to learn and use NFC-based services in their everyday lives. As NFC tags are relatively cheap and easy to install, building a service infrastructure is possible without extensive modifications in existing buildings and environments. However, management of a tag-based service infrastructure can be challenging. The tags placed in public places are subject to unpredictable conditions of the real world, such as vandalism and extreme weather conditions. As distributing tags is easy and cheap, supervising tag-based service providers is impossible, and variation in digital services provided can cover the whole gamut of human life. In addition to services and tagging, VTT has developed the first NFC-enabled active and fully passive sensors, which could be used for buildings and construction sites. Fully passive sensors do not need a battery and can be positioned permanently anywhere in the building for various kinds of measurements. The measurement readings can be easily collected using a commercially widely available mobile phone.

DISCUSSION AND CONCLUSIONS

The experiences from the SmartTouch project provide evidence that tag-based service access can provide a feasible light-weight infrastructure for providing digital serv-

Figure 1. NFC-enabled services in a bus

ices in versatile contexts, and it is accessible and easy to use for a wide variety of users. The challenges lie in building business models and infrastructures for providing such services, and value creation evaluation models for estimating and assessing the effects of the services in our everyday lives.

EXPLOITATION POTENTIAL

Only time will tell how quickly NFC technology penetrates markets and become ubiquitously accessible for all mobile users, if it will make it at all. The first mobile devices with NFC capabilities have been on the market already for some time, but the low quantities still hinder application development. Adoption of NFC technology is in a typical egg-and-hen situation, where the device manufacturers are waiting for signals from application providers and users for a need to integrate NFC technology into devices, and the application providers and end users are waiting for the technology to become more common for allowing large amounts of uses and thus economies of scales.

ACKNOWLEDGEMENTS

The project has been partly funded by Tekes and was part of the EUREKA program.

REFERENCES

[1] Public web site of the SmartTouch project, 2008, www.smarttouch.org

[2] Weiser, M. 1991. The computer of the 21st century. Scientific American, September 1991.

[3] Near Field Communication, 2008, www.nfc-forum.org

[4] Ailisto, H., Pohjanheimo, L., Välkkynen, P., Strömmer, E., Tuomisto, T. & Korhonen, I. 2006. Bridging the physical and virtual worlds by local connectivity-based physical selection. Journal of Personal and Ubiquitous Computing, Vol. 10, Issue 6, pp. 333–344.

[5] Häikiö, J., Isomursu, M., Matinmikko, T., Wallin, A., Ailisto, H. & Huomo, T. 2007. Touch-based user interface for elderly users. Proceedings of MobileHCI, Singapore, 9–12 September 2007.

CONTACT

Minna Isomursu
Senior Research Scientist
minna.isomursu@vtt.fi
Tel. +358 20 722 2081

MOBILE FACILITY MANAGEMENT SERVICES

Kauko Tulla, Pentti Vähä, Tapio Matinmikko, Anne Tolman, Veli Möttönen

Mobility is characteristics for Facility Management (FM) work and hence mobile phones are heavily used for speech and text messaging (SMS) communications, but usage of other mobile phone services has not been established as a part of operation processes according to the market study [1]. However, usage of mobile phones for sending and receiving e-mails is increasing. Today RFID is one of the promising technologies that will change service deliveries and also generate a new business for FM and construction site applications.

INTRODUCTION

New mobile technology enablers such as location-based services, vastly improved web technologies and accelerated mobile telecommunications have enabled new ways of working that have not been possible earlier. This paper presents new facility services promoted by possibilities of mobile systems in facility management as well as benefits and obstacles of the utilization of the said systems. In the construction and FM sectors there are several identified potential application areas for RFID (Radio Frequency Identification) technology including component tracking, inventory management and equipment monitoring [2]. In general, RFID utilization in construction and the FM industry is slight due to the fragmented market with no dominant actor to enforce ICT solutions [3]. However, FM is a rather big single investment flow and one of the fastest growing service sectors. It is obvious that cost-effective applications will be those that offer exploitable technology and services throughout the whole service life of the building and not just during construction. In this paper, RFID technology is shortly reviewed, including near field communication (NFC) which evolved from a combination of earlier RFID contact-free identification.

METHOD

Elaboration of service concepts requires co-innovation with service providers and potential customers, and hence interviews and workshops were used. Due to its strong competence in IC technology and know-how in Real Estate and Facility Management (FM) domain, VTT was able to introduce and demonstrate new innovative ways to provide services. These co-innovations yielded some pilots made in cooperation with service providers (FM and IT), building owners and building users (customer). Used applications are very generic, and hence widely usable.

RESULTS

The study resulted in the state-of-the art in mobile FM applications as well several mobile concepts and building blocks to be utilized when implementing FM and construction site services utilizing NFC/RFID, internet and mobile technology. Demonstrated concepts included management of maintenance work with mobile application, key-lock concept and mobile access rights management for construction site and quality control of facility services. The solutions were flexible and easy to use enabling the management of information in real time. In the maintenance case the personnel could get information and give starting and completing

Figure 1. Principle of service and quality management of maintenance work using mobile application (e.g. cleaning and building maintenance)

Figure 2. Principle of construction site access control

information of the needed work e.g. by touching an RFID tag attached in the place or room related to the service task with a mobile phone having add-on RFID reader. The user interface could be made very simple, after touching the RFID tag the user ticks the start or completed box shown on the phone screen and pushes the send button, then the phone connects to the server and updates the information (Figure 1). In the access rights management model the permission to enter and work on a construction site was controlled by utilizing NFC/RFID, internet, mobile technology as a service fulfilling the new law from the year 2006 [4, 5]. The solution allowed adding or updating new access and working passes to the construction site, as well as enabling a state authority to check on site the legal standing of the worker at the construction site (Figure 2).

CONCLUSIONS

Today new mobile and wireless communication technologies provide platforms for advanced communications. For short range communications RFID is one of the promising technologies to be used with human operator. New technology will change service deliveries and also generate new business for the service sector. In services the communication with customers is important, and therefore some service concepts for FM and construction site applications have been demonstrated. Although RFID utilization in construction and FM industry is still slight there is such great potential that it will certainly enter that branch of business.

EXPLOITATION

In FM applications benefits mainly lie in the time and cost savings and therefore there are also great opportunities to increase productivity. By exploiting RFID tags and mobile technology with access to updated information in the server, the owner, service provider and tenant can strengthen mutual communication and confidence, and hence increase customer experience. Today FM owners and service providers are starting to comprehend the benefits the use of RFID and mobile technologies can provide not only by improving the communication with customer, but also operational efficiency and productivity resulting in increased customer satisfaction with new opportunities.

ACKNOWLEDGEMENT

We would like to acknowledge cooperation with service providers, building owners and building users for inspiring discussions and for VTT as a source of funding.

REFERENCES

[1] Leskinen, S. 2006. Mobile Solutions and the Construction Industry - Is it a working combination? VTT Publications 617.

[2] Wing, R. 2006. RFID applications in construction and facilities Management. ITcon Vol. 11, pp. 711–721.

[3] Erabuild, RFID in Construction; Review of the current state of Radio Frequency Identification (RFID) Technology, its use and potential future use in Construction, ERABUILD final report, June 2006, 100 p.

[4] Tolman, A., Matinmikko T., Möttönen, V., Tulla K. & Vähä P. 2008. The benefits and obstacles of mobile technology in FM service procurement. In Healthy and Creative Facilities. Proceedings of the CIB W070 International Conference in Facilities Management. Heriot Watt University, Edinburgh, 2008. CIB Number 315. pp. 127–132

[5] Vähä, P., Matinmikko, T., Tulla, K., Tolman, A. & Möttönen, V. 2008. RFID technology changes FM services deliveries. In Healthy and Creative Facilities. Proceedings of the CIB W070 International Conference in Facilities Management, Heriot Watt University, Edinburgh, 2008. CIB Number 315. pp. 119–126.

CONTACT

Kauko Tulla
Senior Research Scientist
kauko.tulla@vtt.fi
Tel. +358 20 722 2012

USER-ORIENTED HOSPITAL SPACE

Esa Nykänen, Janne Porkka, Miika Aittala

The "User-Oriented Hospital Space (HospiTool)" project introduced an interactive approach to health facility planning, construction and renovation. Tools were developed that enable end user participation in the planning through evaluation of hospital spaces in order to match the spaces with user needs and requirements.

INTRODUCTION

In conventional design relatively clear relationship exists between designers and paying clients, but this can leave important gaps in understanding between the clients and the end-users and between the designers and users [1]. The project introduced an interactive user-oriented approach to health facility planning, construction and renovation. Tools were developed that enable end-user participation in the planning and evaluation of hospital spaces in order to match the spaces with user needs.

METHODS

In the project, user needs were formulated to user requirements. The process was managed by applying software for systematic requirements management. The developed set of user requirements were evaluated in virtual reality by making use of new visualization technologies. The term Virtual Reality is used here to describe applications in which one can interact with spatial data in real-time [2, 3]. EcoProP software was used to capture the requirements systematically. Unique software was designed for developers, owners and consultants, to help capture needs in the early stage of the project.

The developed 3D-model was used both in the Computer Aided Virtual Environment (CAVE), see Figure 2, and in VTT's Lumeviewer. The CAVE was in the facilities of the School of Information and Communication Technology at the Seinäjoki University of Applied Sciences (SeAMK). CAVE-based virtual reality was used for user visits, nurses and patients, together with a designer or an interviewer. The nurses performed a detailed walkthrough in four different patient room concepts and discussed with a nurse with experience on hospital design. The discussions with nurses focused both on work processes and space related matters. In addition, six patients from a rehabilitation ward and an acute ward of the Health Centre of Seinäjoki and from a neurological rehabilitation ward of the Seinäjoki Central Hospital were interviewed in the CAVE. The pre design interview was done by social psychologist repeating the same pattern every time (Figure 3).

RESULTS

This project was aimed to test a user oriented approach to health facilities planning and therefore the results are discussion of the findings of the approach. In the end of the interview the patients were asked how they felt about being in the CAVE, how real the experience of being inside a patient room or bathroom was, and did they have any unpleasant feelings whilst being inside the CAVE. The interviews were recorded and videotaped and analyzed using the Atlas.ti -program.

Figure 1. Research approach consisting from capturing user needs, managing user requirements and evaluating compliance of requirements in virtual reality.

The following subjects were discussed by patients in the CAVE: colors, windows, surface materials, other patients (good company), furniture, paintings, TV (size, form, placement), room size. Patients were also asked if they would like to change anything in the environment. A few other subjects were not discussed in the CAVE though they were discussed in a parallel study performed in the three wards.

It might not be possible to evaluate perfectly issues relating to room size, furniture and moving in the CAVE but on the basis of respondents' behavior it can be estimated that the CAVE produced a strong illusion of being inside a modeled room. Clearly it was much easier for them to express their opinions during a visit in the CAVE than on the basis of reading documents such as architectural drawings.

DISCUSSION AND CONCLUSIONS

Generally, all respondents expressed either that evaluating rooms in the CAVE was a positive experience or that at least it was not a negative experience. The HospiTool process was successful in creating a platform for development of user-driven innovations in the operating environment: process innovations for healthcare and product innovations for industry. Ultimately, the main objective is to develop a generic concept for inclusive design: to make spaces support processes within the spaces. The evidence based design (EBD) is also taken into consideration in the concept.

Conventional construction process is mainly production driven although buildings should be made for users. During last decades EBD has challenged the conventional hospital design arguing that by improving physical environment hospital facilities would provide a healing environment for patients, better places to work for staff and attractive environments to visitors supporting patients. Much of the EBD research is covering issues reducing stress induced by poor environment such as lack of natural light, lack of positive distractions and noise. Therefore the CAVE environment is a useful tool for feedback from users and there is a great need for developing it further.

EXPLOITATION POTENTIAL

The project has already been creating a real feed-back from end-users (both nurses and patients) to new hospital buildings that are in the planning phases. Different stakeholders (architect, bathrooms deliverer, door deliver etc) are planning and participating in the projects. The project continuation will be done directly through the South Ostrobothnia hospital district, in supporting the on-going design process of a new hospital.

Figure 2. View from patient tool in CAVE.

Figure 3. A patient interview in the CAVE.

ACKNOWLEDGEMENTS

The authors wish to thank all the partners, including two Finnish universities, four companies as well as the National Research and Development Centre for Welfare and Health (STAKES), and the hospital districts of Southwest Finland and South Ostrobothnia. Funding by Tekes and VTT is gratefully acknowledged.

REFERENCES

[1] Barrett, P. & Stanley, C. 1999. Better Construction Briefing. Oxford, Blackwell Science Ltd. 157 p.

[2] Whyte, J. 2002. Virtual Reality and the Build Environment. Oxford, Architectural Press. 150 p.

[3] Cruz-Neira, C., Sandin, D.J. & DeFanti, T.A. 1993. Surround-Screen Projection-Based Virtual Reality: The Design and Implementation of the CAVE. In Proceedings of SIGGRAPH '93 Computer Graphics Conference, ACM SIGGRAPH, August 1993, pp. 135–142.

[4] Nykänen, E., Porkka, J. & Kotilainen H. 2008. Spaces Meet Users in Virtual Reality. In Proceedings of ECPPM2008. 10–12 September 2008.

CONTACT

Esa Nykänen
Senior Research Scientist
esa.nykanen@vtt.fi
Tel. +358 20 722 6914

THE HOSPITAL RENOVATION PROCESS DEVELOPMENT

Hannu Koski, Tarja Mäkelä

In the next few years the renovation of hospital real estates will increase outstandingly. Most designers and contractors do not have enough experience in hospital renovations. In this project a model for the renovation process was defined to ensure good quality and economical and safe repair work. Particular attention was given to the flow of information between renovation project participants, with special attention also paid to the demands and confines of the hospital operations contributing to the repair work.

INTRODUCTION

The renovation of old hospital real estates is especially challenging for owners, designers and contractors because it requires well combined participation and work contribution of all different parties. Another special characteristic is that the technical systems of the hospital operations also must be functioning during the renovation phase. The third special characteristic causing supplementary challenges is the fact that the hospital maintains operation during renovation and the patients and the operations of the ward under renovation need to be relocated. The aim of the project was to develop a functional and effective renovation model, taking into account the above listed special characteristics of hospitals renovations.

METHODS

The project determined the renovation-project owner's management procedures by evaluating four hospital districts. Moreover, the project modeled and analyzed the thorough renovation process of a ward as a typical case and determined the problems and development needs of the process through expert work. Flow of information, renovation site logistics, co-ordination of users' activities and the renovation process, defects in planning, the hospital environment itself, renovation techniques and risk management were found to be the key problems and subjects of development.

Contractors, designers/planners and representatives of the customer were engaged to develop the process with VTT having the principal responsibility. The participants formed a development group to define during several workshops what are the problems and requirements of a renovation process of a hospital. The developing group also identified improvements and reformations to the current process. On the grounds of collected information VTT defined the revised process and its operational principles.

VTT was responsible for the process development. The renewed process practices were piloted in the renovation of the Pediatric Intensive Care Unit of Oulu University Hospital in spring and summer 2008.

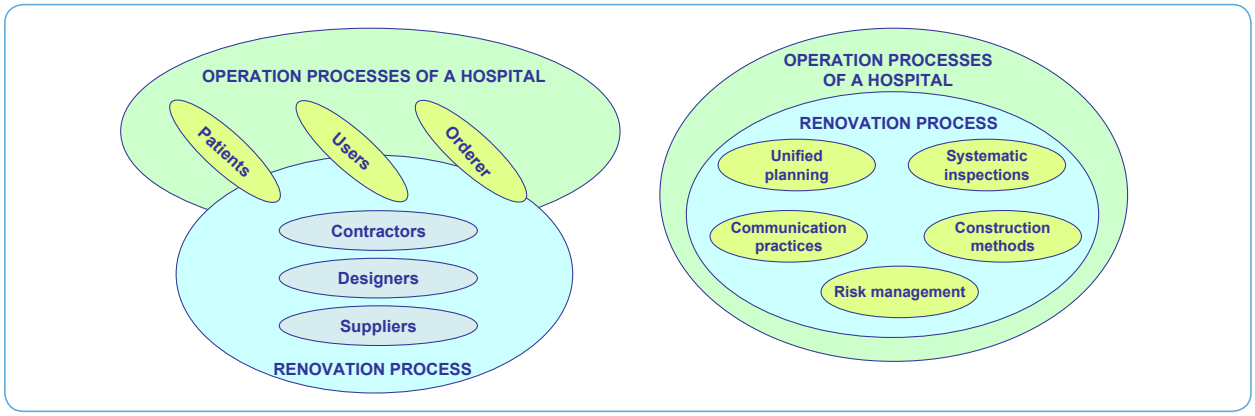


Figure 1. Main actors and development topics of the hospital renovation process.

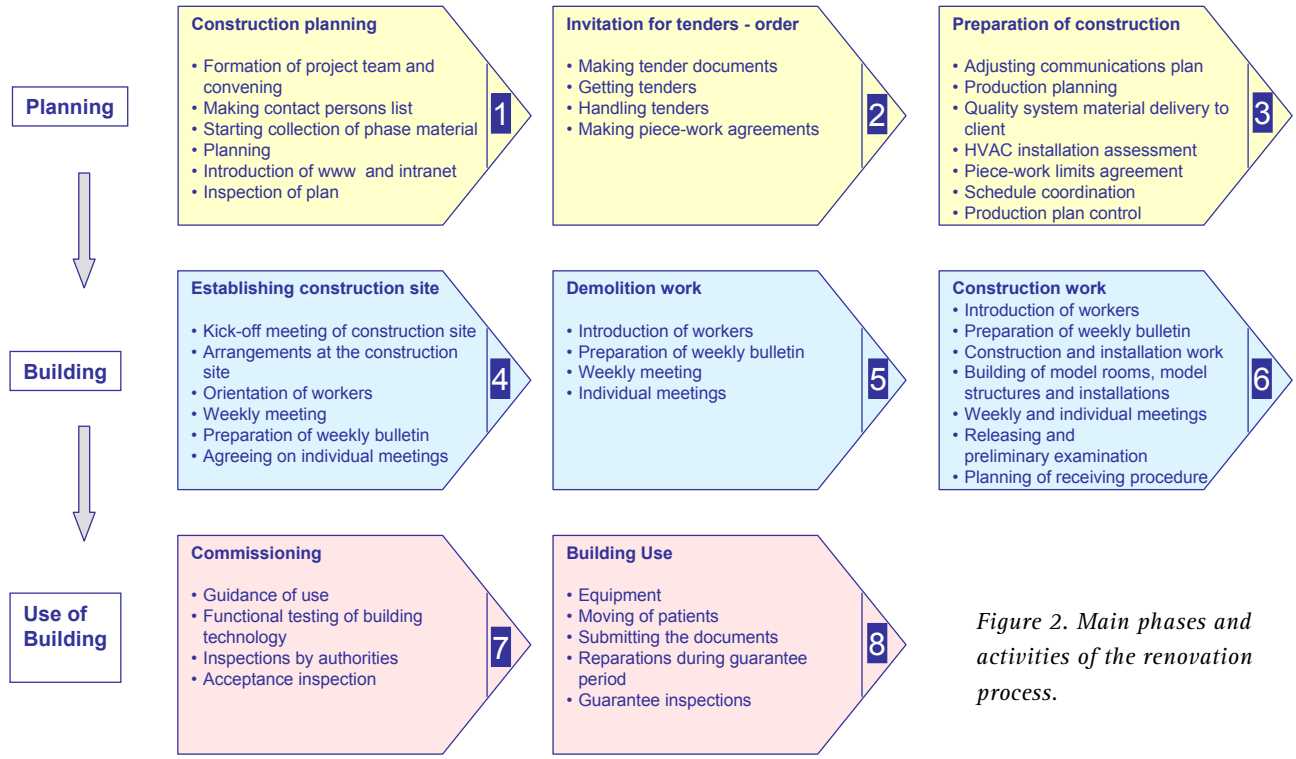


Figure 2. Main phases and activities of the renovation process.

RESULTS

The main result was a model for a hospital renovation process where special attention was given to planning with many parties, systematic inspections and information services. In addition to the changes to the process, the project also developed material and tools to facilitate and ensure the high quality of the implementation of hospital renovations. The material includes, for instance, the production planning task form, the hospital-renovation risk management forms, the renovation worker orientation form, the model health-and-safety file applied in hospital renovation and the hospital-renovation equipment file.

DISCUSSION AND CONCLUSIONS

The operations that buyers and contractors need to do in a building project are nowadays defined very specifically stated in their operational systems. Even so, almost every building project has unexpected problems that can cause quality failure, delays of schedules, additional costs and workplace accidents. When a renovation is made in a functioning hospital environment, sudden difficulties may have serious consequences. By developing the renovation process, instructions and simple easy-to-use tools, which have been accomplished in this project, it is possible to recognize and to reduce potential risks and to execute the repair work of hospital environment in a controlled way.

EXPLOITATION POTENTIAL

The operations needed to renovate a functioning hospital are easy to execute and to adopt. To increase co-planning, to improve methods of communication and to systemize and develop inspections are easy to decide early on. The enhancement of the above mentioned issues is possible by allocating calendar time of buyer, users, designers and contractors and the funds needed.

Developing risk management and using competent industrial engineering requires contracting parties to upgrade their level of knowledge and skills, which is possible by careful orientation. Using an outside consultant to make changes of process concrete and in communicating to the parties of the renovation work accelerates the best practices

ACKNOWLEDGEMENTS

The research has been funded by Tekes, five Finnish hospital districts and two companies.

CONTACT

Hannu Koski
Senior Research Scientist
hannu.koski@vtt.fi
Tel. +358 20 722 3411

USABILITY RATING OF SHOPPING CENTERS

Kari Nissinen

The project entitled 'Usability Rating of Shopping Centers' aimed at developing methods to assess usability of shopping spaces to provide information for future development and marketing by owners.

INTRODUCTION

The shopping center industry is an increasingly competitive and complex market place. New shopping center formats and a changing consumer environment are challenges for shopping center management. A shopping center provides a physical, social, and virtual interface for different actors. It should be usable for consumers as well as for tenant organizations. A shopping center is a workplace for tenant organizations and for consumers it is a consumption and entertainment environment. This project concentrated on both user groups. Its intention was to find a way to assess usability and create usability profiles of different types of shopping centers. In the project the Shopping Center Usability Rating Tool was developed.

METHODS

The Shopping Center Usability Rating Tool was mainly based on a wide literature survey and on benchmarking of the usability features of some 40 shopping centers. The research method also included interviews of over 2000 consumers and several tenant organizations and experts in the areas of shopping center planning, design and management. Prior knowledge was also utilized that has been produced in several research projects dealing with usability of workplaces.

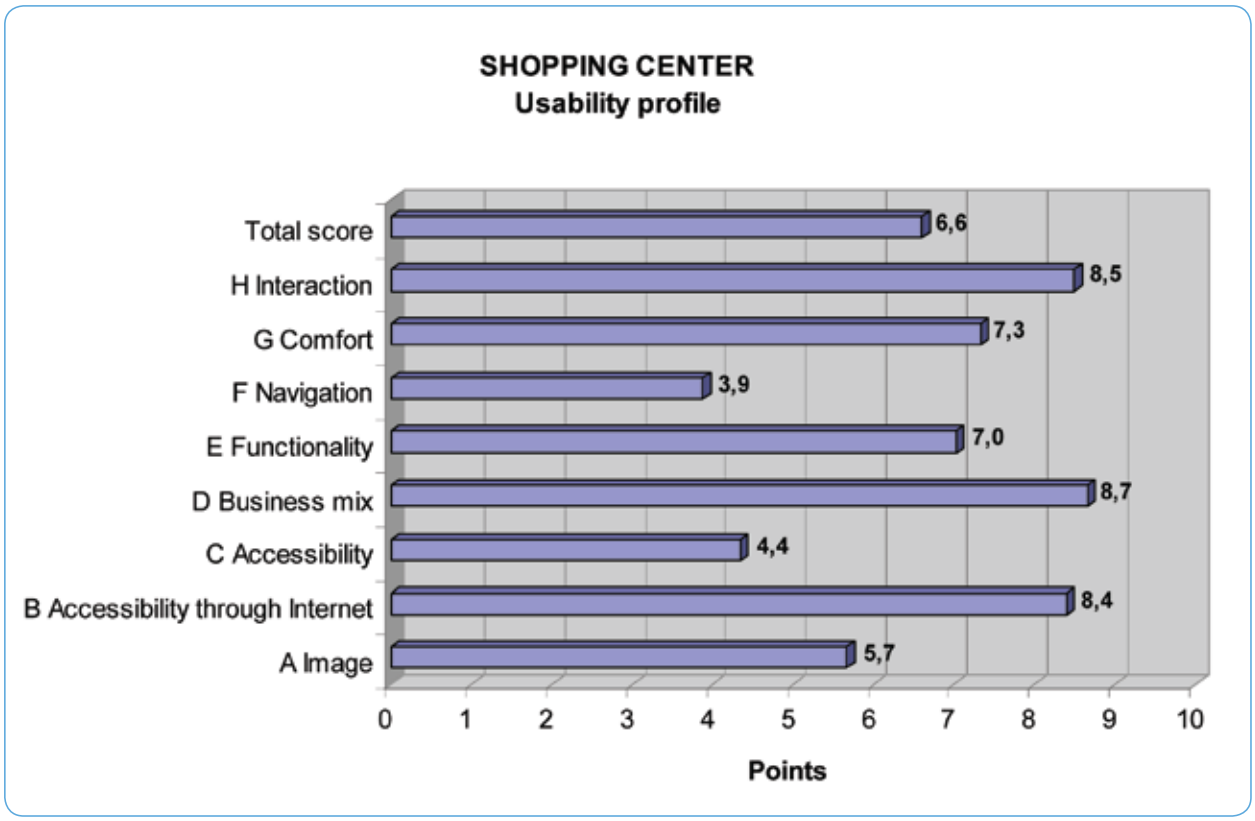


Figure 1. Example of usability profile of a shopping center.

Table 1. Minimum values, averages and maximum values of usability factors among 10 audited shopping centers.

Usability factor	Minimum	Average	Maximum
Image	2.7	4.8	9.0
Accessibility through Internet	1.1	6.0	8.2
Accessibility	2.8	4.2	5.4
Business mix	3.0	6.5	8.5
Functionality	5.5	6.6	7.9
Navigation	3.7	4.7	6.1
Comfort	5.0	6.8	7.7

RESULTS

According to the study, usability of the shopping center consists of several factors like image, accessibility, business mix, building and premises functionality, easiness of navigation, comfort, atmosphere and features dealing with interaction. In addition things like image and brand can influence the usability experience of the consumer. All of these factors include several items. Altogether the Tool contains over 150 items to evaluate. Every item can be evaluated by the scale from 0 to 10 and every item has its own weighted value in the evaluating process. The total value (the total usability of the shopping center) can be expressed by a single number. Finally the software version was created and it was tested by auditing usability of 10 shopping centers in practice. The testing results showed that there are significant differences in usability profiles between different types of shopping centers. The total usability value varied from 4.4 to 7.0 among these audited centers. Table 1 illustrates the range of variation.

DISCUSSION AND CONCLUSIONS

According to the ISO 9241-11:1998 standard usability is: "[...] the effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment". Standard indicates that there is a general level of usability, which has been often captured by analyzing different kind of usability attributes. However, usability is not at all easy to investigate. Often usability is easier to notice in its absence. In this project a systematic approach to evaluate usability features of shopping centers was created.

EXPLOITATION POTENTIAL

There are about 60 large shopping centers in Finland today. The results of the study can be utilized in maintaining, managing and renovating this valuable building stock. The Tool can be exploited also in designing and constructing more usable shopping centers in the future. Some of the results can be applied in designing and constructing other types of business premises too.

ACKNOWLEDGEMENTS

The author wishes to thank the colleagues and participants of the project for their contribution to this work, including Jussi Rönty from VTT and Suvi Nenonen, Johanna Alho and Juha Ainoa from Helsinki University of Technology, nine project partners and seven Finnish shopping centers. Funding was provided by Tekes and project partners.

REFERENCES

The final report will be published in October 2008. Additional information at: http://www.erikoiskaupanliitto.fi/cms/media/Tutkimuspv_2008/Nissinen_esitys.pdf

CONTACT

Kari Nissinen
Senior Research Scientist
kari.nissinen@vtt.fi
+358 20 722 2039

SAFETY IN INDUSTRIAL PARKS

Anna-Mari Heikkilä, Yngve Malmén, Minna Nissilä

In industrial parks several independent companies operate within a limited geographical area. This requires cooperation between the parties and raises new contractual issues. This study evaluated how well the current Finnish legislation takes into consideration various safety aspects that are typical for industrial parks in general and chemical parks in particular. Based on this study, guidelines were developed for landowners, companies operating in industrial parks, and companies intending to enter into such an industrial area.

INTRODUCTION

The trend of companies focusing ever stronger on their core businesses has led companies to sell out parts of industrial plants also in Finland. Clusters of companies, called industrial parks, have been formed. A project on the safety in industrial parks has studied how the safety and environmental issues can be best managed in multi-company industrial parks, and how the current legislation in Finland supports companies facing problems accentuated in or specific to industrial parks. The outcome outlines the identified challenges as well as the benefits of cooperation between the independent companies in industrial parks.

METHODS

In the project, the main focus was on industrial centers, in which hazardous chemicals and their use increase safety problems and the need for mutual agreements between companies. Laukaa, Parainen and Pori industrial parks were used as research objects. Also an oil refinery in Naantali, an industrial park in Harjavalta, and an industrial site in Kokkola were studied as reference points. The practical examples were formed by combining daunting questions raised in several companies within the project as well as during organized workshops or visits by researchers.

RESULTS

Compared to traditional one-company industrial sites, companies in industrial parks face a new situation: the closest neighbor is inside the same fences or even in the same building, and companies in the same area have their own, sometimes conflicting management systems and strategies. This complicates at least communication, internal utilities management and traffic planning as well as contracting between companies. In these multi-company parks, safety and environmental responsibilities are not always clear and risk-map has also changed.

Finnish legislation has not followed this development of the industrial sector and the formation of industrial parks. The current legislation in Finland, and probably in most European countries, does not acknowledge industrial parks and their specific problems. Thus, there are very few supporting guidelines for the companies trying to form fair and balanced operational environment within their park. And it is not always clear to the companies themselves, which laws are binding them and their operations next to each other inside the park.

To ensure a safe, reliable and undisturbed production environment, there is a strong need for cooperation and common agreements between companies in the same industrial park. The recommendations and solutions to various types of problems, which might be faced in an industrial park, have been published in a guidebook [1] as a result of this project. The guidebook also contains some examples of paragraphs that should be made part of contracts drawn up between the stakeholders in an industrial park in order to secure the safety of those working at the site and of the environment.

DISCUSSION AND CONCLUSIONS

Based on the experience of this project, it is evident that companies operating in industrial parks face open questions related to the guidelines of cooperation and sharing of responsibilities. It can be seen that there is a need to further study the specific problem areas in industrial parks and develop guidelines or even legislation for their support.

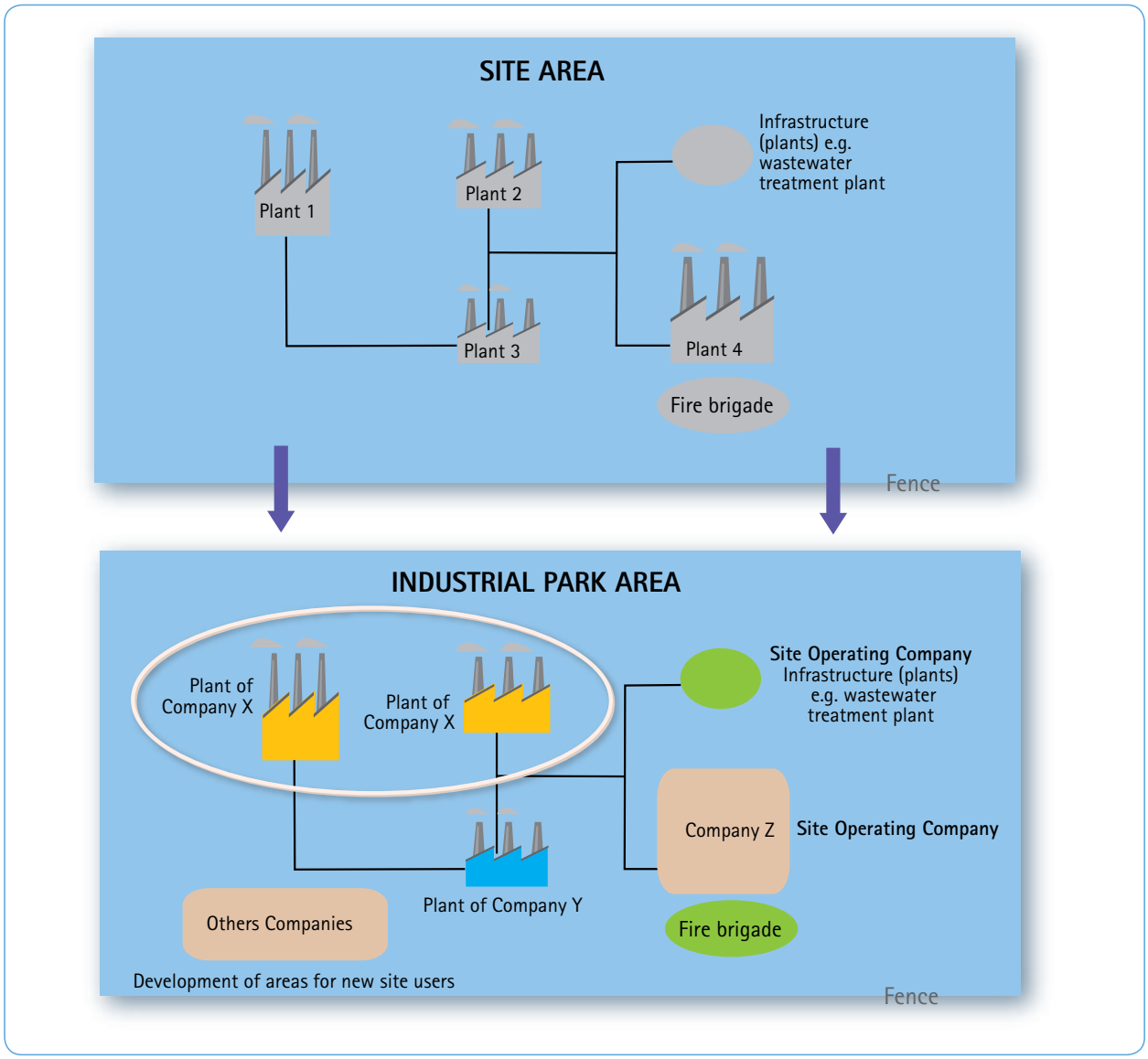


Figure 1. Change from the industrial area to a multi-company industrial park.

EXPLOITATION POTENTIAL

The results of the project have been and will be exploited by the participating companies in their own development activities. VTT is exploiting these results in its research and consultation projects.

ACKNOWLEDGEMENTS

The cooperation with Dr Hanna Leppäaho and Professor Raimo Lahti, University of Helsinki, Faculty of Law, and with companies in the Laukaa, Parainen and Pori industrial parks is gratefully acknowledged. Also the reference points Neste Oil Oyj's oil refinery in Naantali, Harjavalta industrial park, and Kokkola industrial area are thanked. The funding especially from the Finnish Work Environment Fund is gratefully acknowledged.

REFERENCES

[1] Malmen, Y., Nissilä, M. & Leppäaho, H. 2008. Safety in the industrial parks. Guidelines for the companies operating in industrial parks. (In Finnish). http://virtual.vtt.fi/virtual/teollisuuspuisto/Teollisuuspuisto_opas.pdf

CONTACT

Anna-Mari Heikkilä
Research Scientist
anna-mari.heikkila@vtt.fi
Tel. +358 20 722 3490

ECONOMIC EFFICIENCY OF ROAD PROJECT DELIVERY SYSTEMS

Pertti Lahdenperä

The road authority has many options to organize road management and it is not always clear which one would be the most efficient. To assist in the strategic selection of the most efficient project delivery methods, this research determined the performance of major project delivery options.

INTRODUCTION

A project delivery system (PDS) refers to the organizational framework of a project that defines the control mechanisms and the relationships between actors and their incentives. It is of major importance to the project owner as it, for instance, contributes to the project's level of efficiency. This research compares the economic efficiency of Design-Bid-Build (DBB), Construction Management at-fee (CM), Design-Build (DB), Design-Build-Operate (DBO) and Design-Build-Finance-Operate (DBFO) in road management. Here, PDSs are applied to a relatively large project in well-known conditions and involving no factors of uncertainty due to third parties.

METHODS

To define PDSs' operational performances, this research entity charted the performance of different PDSs in actualized road projects in England, Australia, New Zealand, the United States, and Finland. A total of 66 persons were interviewed. The charting resulted in information on relative activity cost, schedule and value generation performances. An analysis of reference project data made is possible to determine comparative costs and timing of all related project activities in a certain PDS. On these premises a financial analysis that takes into account financing arrangements and corresponding payment systems was made to determine the systems' present costs to a road authority based on relevant market estimates. The study focused also on differences in speed of delivery which result in expenses or savings to the user community.

RESULTS

The financial analysis of the costs to the owner revealed that, apart from the evenly matched DBB and CM, the broader the scope of services supplied by one contract in the case of public-financed systems (DBB, CM, DB and DBO), the more cost efficient the PDS. If the early commissioning advantage is included in the analysis (Figure 1), especially CM, but also DB improves its competitiveness in relation to the other PDSs. DBFO's competitive position is not absolutely clear, but it seems to be in the middle category with DB. Consideration of the early commissioning advantage, however, makes CM (that enables fastest commissioning) nearly equal or in some cases even better than DBFO, which, on the other hand, increases its superiority over DBB. On the other hand, more services are included into a contract, the more value the system generates on average. Therefore also the economic efficiencies can be determined at least indicatively (Figure 2).

DISCUSSION AND CONCLUSIONS

In light of the study, it is obvious that owners should increasingly adopt more long term contracts for their major projects. The scheme is, in general, sensitive to project properties and constraints, and fluctuations in the financial and construction markets. Yet, the results can be said to make a major contribution to knowledge on the subject matter. While there may be a lot of fragments of information around, more comprehensive knowledge like this has not been reported earlier.

EXPLOITATION POTENTIAL

The results of this study are aimed more at supporting selection between PDSs as part of the road owner's strategy than individual projects. Various cascade effects are obvious.

ACKNOWLEDGEMENTS

The research was initially commissioned by the Finnish Road Administration, the Confederation of Finnish Construction Industries (RT) and some other industry actors. The work has also been funded by Tekes.

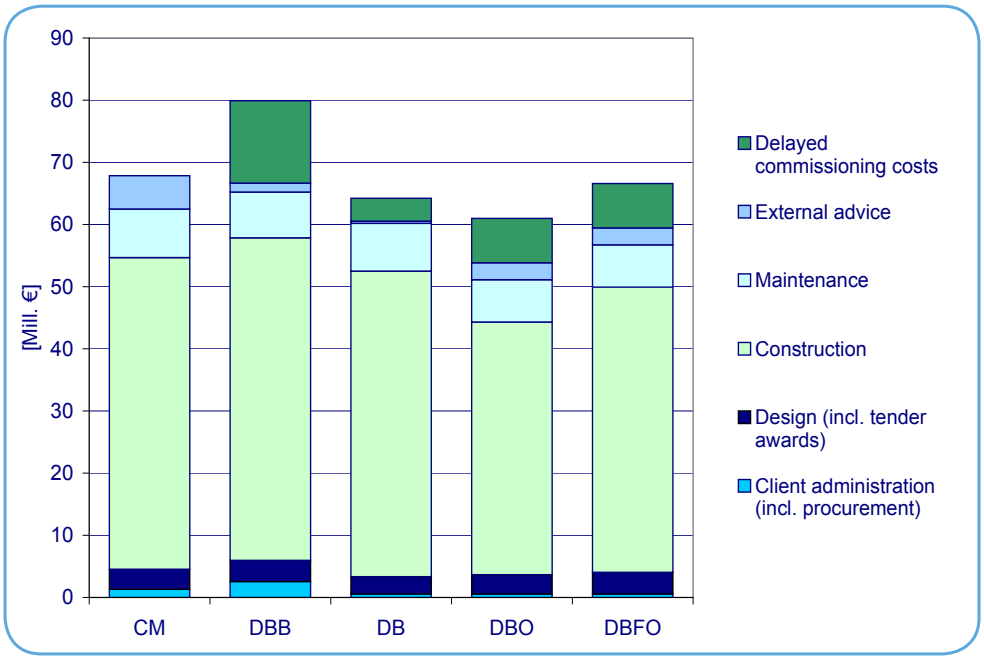


Figure 1. PDS's comparative present costs including late delivery costs.

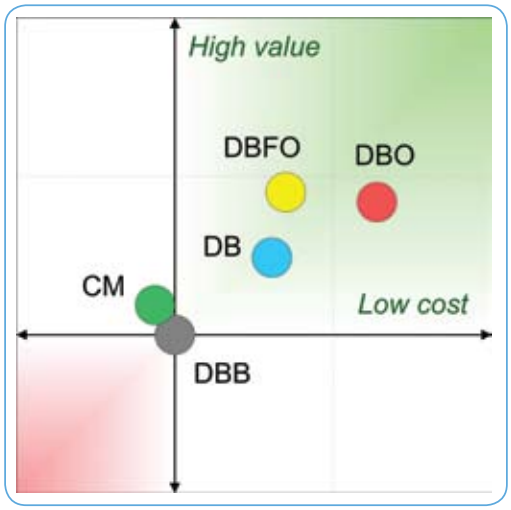


Figure 2. PDS's economic efficiencies from the owner's viewpoint.

REFERENCES

[1] Koppinen, T. & Lahdenperä, P. 2004. Road sector experiences on project delivery methods. VTT Research Notes 2260.

[2] Koppinen, T. & Lahdenperä, P. 2004. The current and future performance of road project delivery methods. VTT Publications 549.

[3] Koppinen, T. & Lahdenperä, P. 2005. DBB, DB or DBM? Performance of road project delivery methods. In Kazi, S. (ed.) Systemic Innovation in the Management of Construction Projects and Processes. Combining Forces - Advancing Facilities Management & Construction through Innovation Series. VTT Technical Research Centre of Finland & RIL Association of Finnish Civil Engineers, pp. 263–271.

[4] Koppinen, T. & Lahdenperä, P. 2007. Realized economic efficiency of road project delivery systems. Journal of Infrastructure Systems, Vol. 13, No. 4, pp. 321–329.

[5] Lahdenperä, P. 2008. Financial analysis of project delivery systems. Road projects' operational performance data revisited. VTT Research Notes 2445.

CONTACT

Pertti Lahdenperä
Research Professor
pertti.lahdenpera@vtt.fi
Tel. +358 20 722 3440

DEVELOPMENT OF GROUND IMPROVEMENT PROCESS

Jouko Törnqvist, Leena Korkiala-Tanttu, Markku Juvankoski, Petri Valasti

The project "Development of Ground Improvement Process" (POHVA1) [1] aimed at development of an interactive 3D model for deep mixing and piling including site investigation methods, data processing and analyzing methods which meet the needs of an automated production management system.

INTRODUCTION

In recent years Finnish infra-structure research has focused on automated construction systems, like the two-phase ground improvement project. The objective of the first phase was to develop an interactive 3D model for deep mixing and piling including site investigation methods, data processing and analyzing methods which meet the needs of an automated production management system. Another objective was to develop the resistivity sounding method for deep mixing purposes. The first phase created readiness for the more economic, ecoefficient and better performance deep mixing method. By refining the 3D water content space created from the resistivity sounding results to the strength estimation of the deep mixing the amount of binder agent can be optimized along the columns. So the homogeneity of the deep mixing can be improved. This together with the more exact placement of the columns achieved by machine automation will improve the quality and performance of the product.

The purpose of the POHVA1 project has been to develop and produce process parts and turn them into an integrated system:

- for refining subsurface information for deep stabilization (and piling) into design control data for product strength,
- for optimizing the product manufacturing parameters (quantity of binding agent, mixing, driving),
- for converting the product strength control data into the format required for machine automation, and
- for steering earth construction towards industrial production: an automated 3D control process increases the efficiency of the work and substantially improves quality; the 3D control process developed for stabilization machines is also applicable to other earth construction machines such as pile driving machines, bench drilling machines, excavators, etc.

The networked operating process for ground improvement (Figure 1) consists of initial data measurements, associated processing and analysis, geotechnical 3D design, simulation of the work process and virtual design, as well as automatic work control.

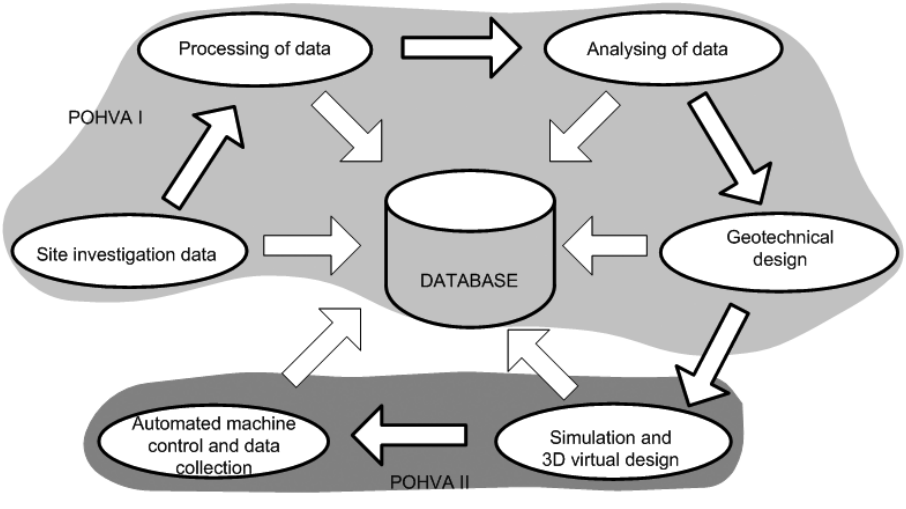


Figure 1. The networked operating process for ground improvement.

DEVELOPMENT OF SITE INVESTIGATION METHODOLOGY

The study focused in particular on the development of an electrical resistivity sounding method for the needs of deep stabilization. To determine a 3D image of the soil us-

ing resistivity sounding, line measurements of resistivity were done on-site to provide 2D cross-sections of resistivity along the lines. An inversion was applied to the cross-sections, and they were combined into a single 3D graph consisting of 1 m^3 blocks.

The calculated water content values and corresponding resistivity values were used to create a calculated resistivity-water content conversion curve. In Figure 2, the resistivity distribution is presented as vertical 2D sections. The figure indicates a thinning of the clay layer towards the southern end (left side) of the area where the resistivity values are high.

Besides the development of a resistivity sounding method the study included many other aspects of soil improvement. For deep stabilization purposes a database of the Finnish stabilization tests, a literature review of the contaminants detrimental to stabilization and the strength comparison between laboratory and on-site results were made. In general for all soil improvement methods a risk assessment for subsurface information and linking subsurface information to the design environment were also made.

CONCLUSIONS AND EXPLOITATION POTENTIAL

The study developed the skills and capabilities to create more economical, ecologically efficient and functional deep stabilization method. By refining three-dimensional site investigation data into a strength estimate for column stabilization and forwarding this information to machine automation, the quantity of binding agent can be optimized on a column-specific basis in the depth direction. The coarse estimations suggest that the optimization can decrease the use of binder agent from 10...30 %, which means savings from 5...20 % depending on the site characteristics. The objective is to create columns that are homogenous in strength in the depth direction. Together with the more precise positioning of columns allowed by machine automation, this will improve the quality and functionality of the end product and reduce the risk arising from the non-homogeneity of the structure. This will improve the management of settlement, for example [2].

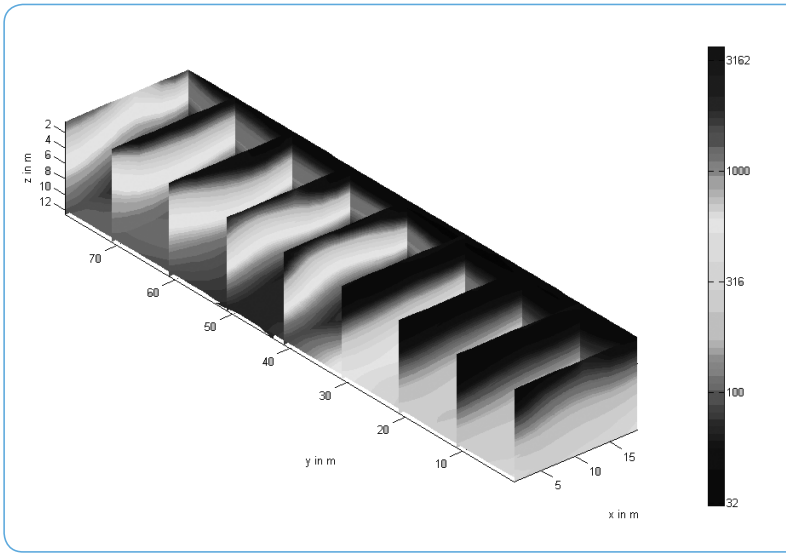


Figure 2. Resistivity distribution at the Vanttila site.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Hans Rathmayer and Markku Tuhola (VTT), Rauno Heikkilä, Mika Jaakkola (Oulu University), Asko Aalto (Technical University of Helsinki) and Juha Liukas (SITO Oy). The research has been funded by Tekes, City of Helsinki, City of Espoo, Finnish Road Administration, four companies and VTT.

REFERENCES

[1] Korkiala-Tanttu, L., Juvankoski, M. & Valasti, P. 2008. Development of ground improvement process, Summary report VTT-R-11157-07, 19 p. www.vtt.fi/inf/julkaisut/muut/2007/VTT-R-11157-07.pdf

[2] Korkiala-Tanttu, L. & Juvankoski, M.A. 2008. Automated ground improvement process. Proceedings of the 2nd International Workshop on Geotechnics of Soft Soil, Glasgow, 3–5 September 2008. (In Print).

CONTACT

Jouko Törnqvist
Senior Research Scientist
jouko.tornqvist@vtt.fi
Tel. +358 20 722 4860

MONITORING OF BRIDGES

Ilkka Hakola, Matti Halonen, Erkki Järvinen, Erkki Vesikari, Jukka Mäkinen

Monitoring of structures has become a common and important method to get accurate and updated information on the condition of infra structures.

INTRODUCTION

Monitoring of bridges is one part of infra structures monitoring. Bridges are important and valuable structures, which are supposed to be in a good condition in all circumstances. Monitoring and analyzing the measuring results is a way to be aware of the real condition and load bearing capacity of the bridge. The monitoring and analyzing techniques have been developed during the recent project entitled "Monitoring of Bridges."

METHODS

The bridge monitoring system is comprised of sensors, data collection equipment and data analyzing methods. All the equipment used in this work was commercially available and no new sensors or measuring equipment was developed.

Figure 1. Kirjalansalmi suspension bridge in Parainen.

Most of the sensors and measuring equipment have been installed outdoors on the bridge deck in a reasonably severe climate exposure, e.g., with moisture, temperature and vibrations. One of the main purposes during the monitoring research was to test monitoring equipment under realistic ambient conditions. The data was then transmitted to a server in the laboratory using realistic GSM-modems.

Five different kinds of bridge types situated in southern or middle Finland were selected as test cases. The main type of bridge has been s concrete bridge or steel bridge and monitoring has been executed using sensors of vibration, moisture, weather condition and strain gage. As an example, the Kirjalansalmi suspension bridge (Figure 1) in Parainen on the southwestern coast of Finland is one of the monitored bridges. The solar-powered monitoring system in this case included strain gages, deflection transducers and accelerometers as well as a computer vision camera in order to recognize traffic vehicle positions and speeds on the bridge (Figure 2). The Finnish Road Administration has also installed a traffic camera, weather station and inductive sensors to measure traffic volume and climate conditions on the bridge. The behavior and load bearing capacity of the bridge has been tested using heavy vehicles and heavy carriages as test loads. The bridge was modeled using a geometric nonlinear Finite Element model and the load was taken into account as a moving load according to tests vehicles crossing the bridge.

Another monitored bridge was the Boxby concrete bridge on a highway to Porvoo, east of Helsinki. The condition of the concrete was measured using moisture and temperature sensors. The weather parameters (wind speed, wind direction, precipitation and solar radiation) was also measured and used to estimate and calculate the life cycle behavior of the bridge. The moisture of the air and moisture inside the concrete have been measured by moisture sensors and optical fibers, which have been installed during renovation of the bridge concrete deck.

Figure 2. Wireless sensor and measuring system in Kirjalansalmi.

RESULTS

The main purpose of bridge monitoring is to develop a management system for the owner of infra structures. The data collected shall be used to calculate and predict the condition and service life of bridges. Using measured data and information of prices of work and materials enables prediction of future maintenance costs. This makes it possible to identify bridges that need urgent renovation and maintenance.

The Boxby bridge is a massive concrete structure and the bridge temperature was not changing according to the air temperature. Therefore the relative humidity was not directly depended of the air temperature and moisture.

The suspension bridge in Hännilänsalmi in the middle part of Finland is an example of a bridge that will be exhausted until the new bridge is build and opened for traffic. In the Hannilansalmi bridge the fatigue life of steel connections is calculated from the measurements using Rainflow analysis and the stresses are calculated using strain gages glued on the main beams of the bridge.

DISCUSSION AND CONCLUSIONS

The bridge monitoring system is part of a wider infra monitoring system. When designing bridge monitoring, the whole infrastructure has to be included and many of the monitoring techniques can be applied to other infrastructures, e.g. roads, tunnels, railways, towers, masts and important buildings.

This bridge monitoring project lasted for three years and during that period users gained valuable information of the reliability of measuring equipments and also good knowledge of the wireless sensors and operation life of batteries. Also measured data was used to estimate the life cycle behavior of the concrete bridge and evaluate the accuracy of design calculations methods of steel bridge.

The monitoring sensors and equipment have worked quite well and measured data transfer to an office has been successful. The only difficulty was that the wireless sensors did not always operated well due to problems caused by power supply and long distances. The testing of the sensors will continue in future monitoring projects.

EXPLOITATION POTENTIAL

Infra monitoring is a popular and fast developing research area. The prices of sensors and measuring equipment have dropped and also wireless sensors can be used in static periodical measurements. There is a possibility for new business concerning monitoring, installing of sensors and data analysis of infra structures. Foreign co-operation is necessary, because the companies and manufacturers of monitoring techniques are already now working worldwide. Especially the owners of bridges (Cities, Finnish Road Administration and Rail Administration) are very interested in the monitoring of bridges in order to have more reliable information of the condition of bridges.

ACKNOWLEDGEMENTS

The authors wish to thank Juha Juntunen and Juha Kurkela for their contributions to this work, in addition to the Finnish Road Administration, Tekes and all the project partners for the co-operation and funding of the project.

REFERENCES

[1] Halonen, M. 2007. Wireless bridge monitoring system. (In Finnish). Thesis publication, Helsinki University of Technology.

CONTACT

Ilkka Hakola
Senior Research Scientist
ilkka.hakola@vtt.fi
Tel. +358 20 6685

ASSESSMENT OF TRAFFIC-INDUCED VIBRATIONS IN BUILDINGS

Asko Talja, Ari Vepsä, Juha Kurkela, Matti Halonen

A method for vibration design of the frame and floor of a building is presented for traffic-induced vibrations. The method takes into consideration the direction and frequency content of the ground vibration. The evaluation is based on two different approaches. One considers the uniform magnification of the vibration and the other the magnification due to resonance.

INTRODUCTION

With regard to traffic-induced vibrations clay fields with surrounding rocky or gravely hill areas are especially problematic in Finland (Figure 1). The thickness of the soft layer is often 5–20 meters. The vibrations spread effectively in such layers and they are difficult to evaluate. Often the horizontal vibrations of ground can be higher than a vertical component and frequencies of 5–10 Hz with very narrow band are dominating.

METHODS

The design method is based on the vibration measurements of buildings, on Finite Element (FE) calculations and on a literature study. Altogether 36 buildings were measured. Seven of them are at least three-storey houses and the other 29 are one- or two-storey low-rise houses. All the high-rise buildings are from clay areas. Seven of the low-rise buildings are from sand or gravel and the others are from clay areas. The vibration is induced by railway traffic in 22 houses and by street traffic in 14 houses. FE analysis of the frame is based on a simple two- to three-storey plane model and the examination of the floor on a simply supported beam model. The FE study

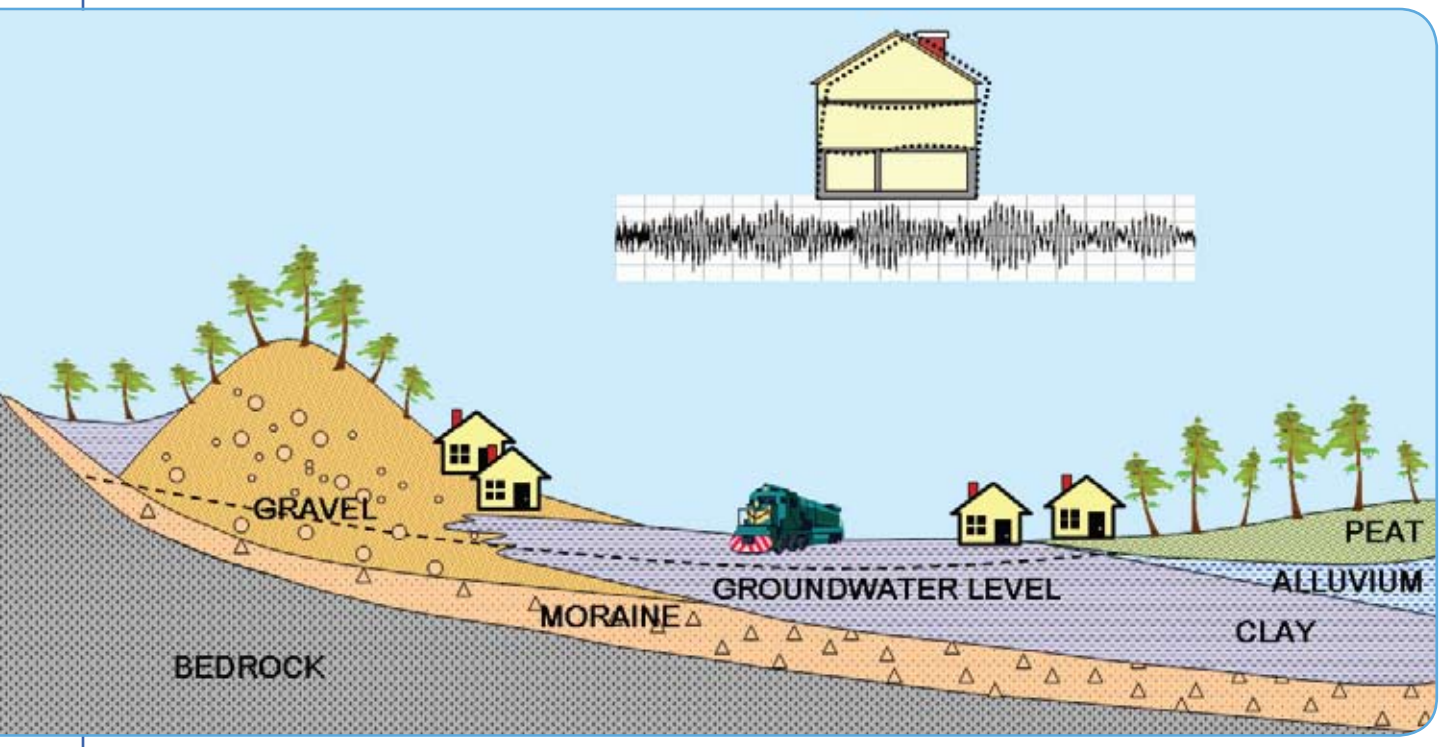


Figure 1. Typical soil conditions of Finnish coastal areas, where traffic-induced ground vibrations may cause problematic resonance vibration of frame and floors.

was based both on the statistical resonance study and on the measured vibration signals. In addition occupant surveys were used for giving recommendations for disturbance-based vibration classification of dwellings.

RESULTS

Vibration level $v_{w,95}$, which is a statistical maximum of frequency weighted rms velocity during one week, is used as the vibration measure. Based on the measured data and on the opinion survey of annoyance, $v_{w,95} < 0.6$ mm/s is proposed for existing building areas and $v_{w,95} < 0.3$ mm/s for new building plan areas or new traffic routes.

The design is based on the ground vibration level $v_{w,95}$ and normalized vibration spectrum, which are determined by measurements from the building site. The vibration of a foundation is determined in three orthogonal directions. The design of a building is based on two different approaches; one considers the uniform magnification of the vibration, and the other the magnification in the resonance. In the case of uniform magnification the vibrations are assumed to be magnified equally by a factor of 1.5 in all three orthogonal directions. In resonance design the vibration of building frame and floors are studied separately. The resonance design of the frame is based only on the horizontal vibrations, and the resonance design of the floor only on the vertical vibrations of the ground. The magnification factor in resonance design is given for the 1/3 octave band which coincides with the fundamental frequency of the frame or floor. For the frame, the magnification factor is 4.0 and for floors 6.0.

DISCUSSION AND CONCLUSIONS

The magnification factors given in literature are usually given for the vertical ground vibration and are based on uniform magnification of vibrations. Because of the randomness of resonance phenomenon, the magnification factors for design are high and vary greatly in literature. The advantage of the proposed method is that the undesired resonance may be avoided by design. A high vibration magnification factor shall only be used if the resonance vibration of the floor or frame is probable and otherwise a lower magnification factor may be used.

EXPLOITATION POTENTIAL

The Land Use and Building Act (132/1999) of Finland together with the National Building Code (RaMK B3/2002) require, that the vibration must not cause damage to the building nor excessive disturbance to the people inside the building, but they do not present limit values or ways how to evaluate the vibrations. The written design guidelines [1] are very important for planners and decision-makers so that the vibration nuisance can be considered in community, traffic and construction planning.

ACKNOWLEDGEMENTS

The study is based on results of the LIIKEVÄ project, which have been carried out in three phases by VTT. The project have been financed by VTT, Tekes, six cities, four companies as well as government ministries and administrations. Their support is gratefully acknowledged.

REFERENCES

[1] Talja, A., Vepsä, A., Kurkela, J. & Halonen, M. 2008. Assessment of traffic-induced vibrations in buildings. VTT Research Notes 2425.

CONTACT

Asko Talja
Senior Research Scientist
asko.talja@vtt.fi
Tel. +358 20 722 6831

NOISE CRITERIA FOR TRAFFIC-INDUCED GROUND-BORNE NOISE

Ari Saarinen, Asko Talja, Matti Halonen

Traffic-induced noise may cause unacceptable nuisance for people living near the traffic lanes. Suitable noise criteria, limit values and guidelines will ensure the adequate protection of existing sensitive land uses.

INTRODUCTION

Operations on roads and railways generate vibration. Ground-borne noise propagates through the ground as vibration and is then radiated in buildings by vibrating wall and floor surfaces. This noise has a rumbling character and may cause unacceptable levels of noise especially in buildings near railway or metro lines.

In Finland several new or modified traffic lane projects are in the process of being realized. Because of the high population density (existing or rated) nearby the traffic lanes there is often a conflict with line side inhabitants sensitive to ground-borne sound which affect health or threaten acceptable living conditions.

As national noise control regulations in Finland do not deal with ground-borne noise issues there is a need for developing national limits and suitable guidelines for noise criteria to reduce the impact of noise on the local community. Also the land use planners need instructions how to take the phenomena into account.

METHODS

There are no mandatory traffic lane related ground-borne noise impact criteria in Finland or in most countries. Therefore it was necessary to review the situation and to make recommendations for appropriate limit values to be used as the reference base and assessment criteria. The following are some of the basic considerations for the recommended ground-borne noise impact criteria:

- to be realistic and coherent to national and international quantities
- to take into consideration the underlying rationale of the standard ISO 14837-1 [1]
- to be tested in practice and are considered to be applicable as the basis for the recommendations of noise limits.

To respond to these targets, a literary review was done as well as measurements of ground-borne noise in a few buildings. The noise criteria and limit values aim to reduce the impact of ground-borne noise on noise-sensitive buildings located near traffic lanes. The guidelines have been prepared to assist those involved in the planning and design of building construction that are potentially affected by ground-borne noise.

RESULTS

The current approach used for determining land use noise impact criteria as related to transport in the European countries, USA and Australia are all similar in that the noise sensitivity of various land use type areas are used to provide the primary indicator of an acceptable noise impact level. Specific maximum noise levels L_{pAmax} or equivalent noise levels L_{Aeq} for given periods of the day as related to these noise sensitive areas are specified.

The proposed noise criteria calculation value L_{prm} in Finland is related to the measured average value of maximum noise levels L_{pASmax} and 95 % confidence interval. The following L_{prm} quantity based reference values have been proposed as the ground-borne noise impact criteria for the defined noise sensitive land uses: 30 dB for residences (single and multifamily residences, hotels) and nursing institutions (hospitals, day care center), 35 dB for indoor noise sensitive areas (places of worship, educational facilities, libraries), 25-30 dB for special indoor noise sensitive areas (concert halls, auditoriums, recording/broadcast studios) and 40 dB for indoor noise less sensitive areas (museums, offices, markets). The measurements indicate that most of the cases the measurement values go below these reference values.

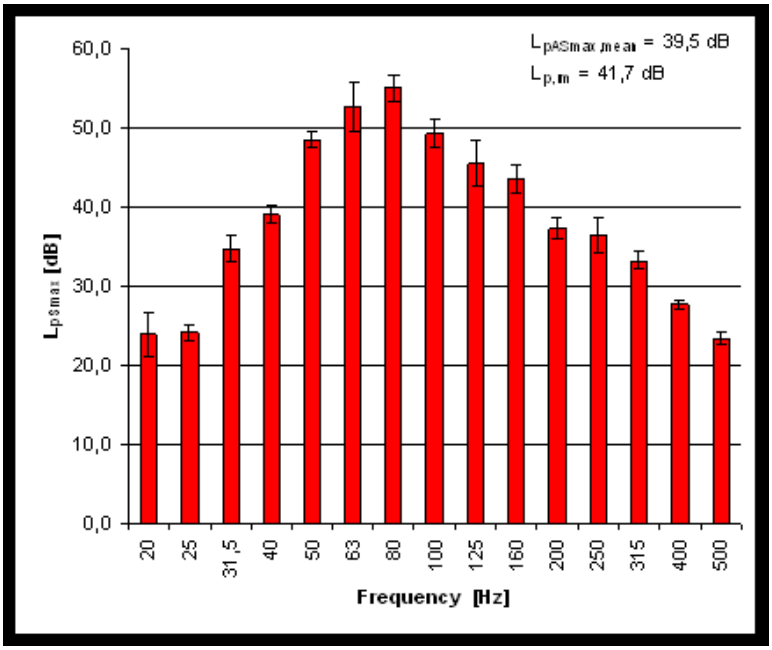


Figure 1. Average sound pressure levels and standard deviations of measurements in school building.

DISCUSSION AND CONCLUSIONS

Where buildings are constructed near traffic lanes, ground-borne noise may be present. In these cases, residential buildings, for example, should be designed and constructed such that ground-borne criteria value complies with an L_{prm} reference value of 30 dB. At 35 dB, the rumble of ground borne noise will already be clearly audible.

The limits for ground-borne noise impact criteria are set at lower (more stringent) levels than those for the airborne noise. In using the A-weighted sound level, sounds dominated by low frequency components (like ground-borne noise) are perceived to be louder than broadband sounds that have the same A-weighted level.

EXPLOITATION POTENTIAL

The basic rationale behind the proposed ground-borne noise impact criteria, limit values and guidelines is one that will ensure the adequate protection of existing sensitive land uses. Ground-borne noise from traffic lanes will need to be of an appropriately low value to meet the land use noise impact criteria either directly or by means of the implementation of appropriate attenuation measures in the intervening ground between track/road and noise sensitive receptor sites.

ACKNOWLEDGEMENTS

The following organizations are highly acknowledged for funding the project: cities of Helsinki, Vantaa, Espoo, Kerava, Turku and Tampere, the Finnish Rail Administration (RHK), the Ministry of the Environment, the Ministry of the Transport and Communications and VTT.

REFERENCES

[1] ISO 14837-1. 2005. Mechanical vibration – Ground-borne noise and vibration arising from rail systems – Part 1: General guidance. Geneve: The International Organization for Standardization.

CONTACT

Ari Saarinen
Senior Research Scientist
ari.saarinen@vtt.fi
Tel. +358 20 722 6986

THERMAL MONITORING AND SIMULATION SYSTEMS OF MOTORWAY TUNNELS

Harri Kivikoski

Thermal monitoring and simulation of tunnel structures improves safety and functionality of tunnels through assessment of frost and ice risks.

INTRODUCTION

In cold climate regions, as in Finland, frost protection is vital against icing when designing tunnel lining structures. Especially in road tunnels the frost action connected with water leakage may cause extensive tunnel maintenance and usage safety problems. During frost period icicles may form on the tunnel profile and they may fall down during thawing periods and on the other hand frost expansion behind tunnel lining reduces the stability of the rock which with ice forming may cause structural damages of the lining. Also the drainage system of the road structure may freeze and extended icing can lead to wide damages of a road structure if frost protection is insufficient. With thermal monitoring it is possible examine thermal behavior of tunnel structures during frost periods and predict how frost protection works with different freezing index analysis.

METHODS AND RESULTS

Thermal monitoring and simulation systems were developed prior to construction of the new E18 motorway tunnels. The E18 motorway Muurla–Lohja project included, for example, the construction of 51.3 km of new motorway, seven motorway tunnels with a total length of 5.2 km, eight interchanges and 48 bridge sites. VTT's thermal monitoring system was composed of wired and mobile sensing solutions with data simulation platform. The basic wired thermal monitoring system consisted of RTD sensors instrumented in different thermal insulation structures; a road drainage system, single 2 meter and 4 meter wide insulation structure and extended insulated structures, as seen in Figure 1.

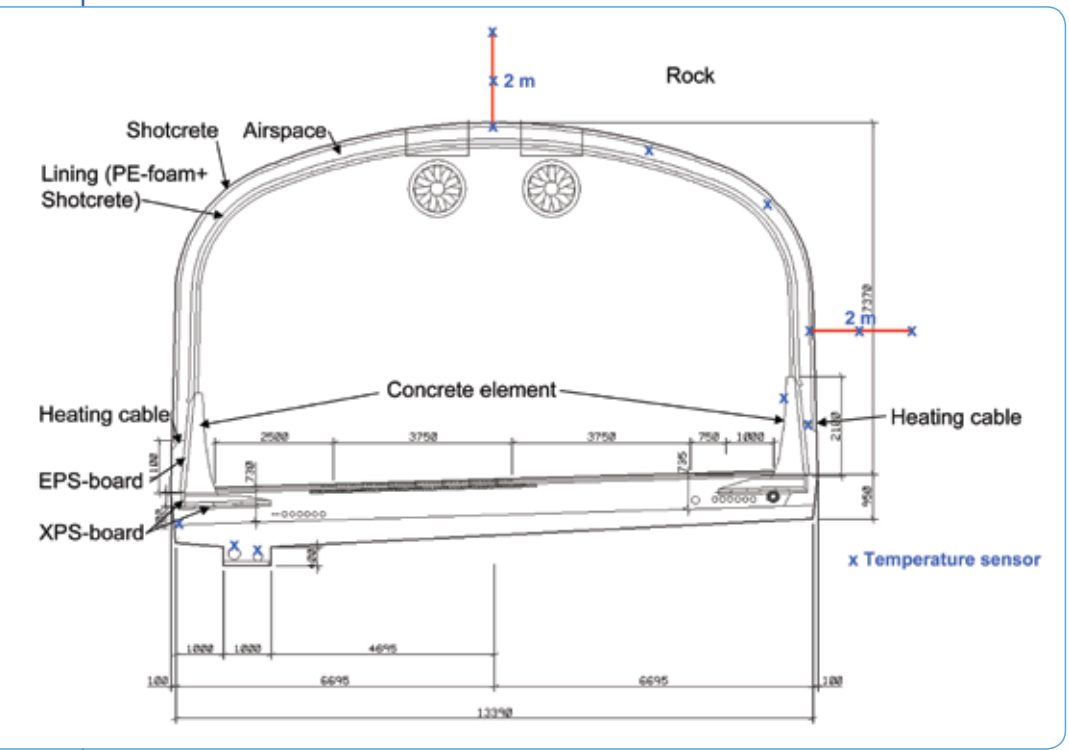


Figure 1. Typical E18 tunnel cross-section with instrumented wired RTD temperature sensors.

In addition to the wired system, two wireless sensor networks, Shinkawa SS1 and SensiNet, were instrumented in the Karnainen tunnel for comparison between permanent wired and mobile wireless solutions (Figure 2). Wireless monitoring has benefits compared to wired solutions. Many sensors can be freely attach as desired and sensors can be embedded in structures as well, and compared to a wired system the data transmission to the gateway is wireless without cabling. Sensors communicate

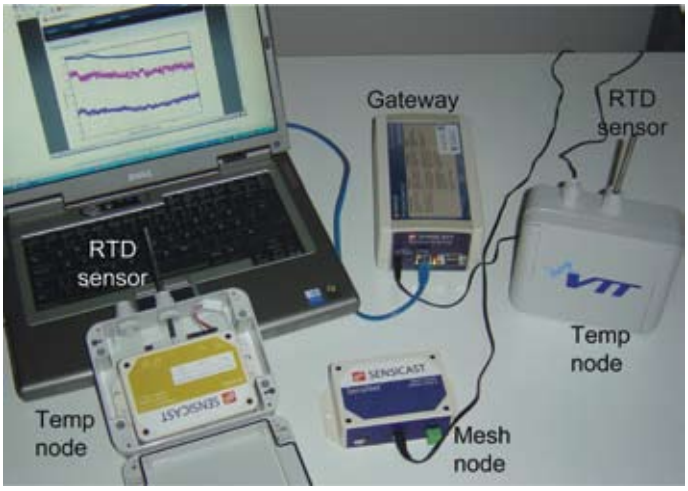


Figure 2a. SensiNet sensor network. System operates with 2.4 GHz radios and radio range is up to 240 meters in outdoors.

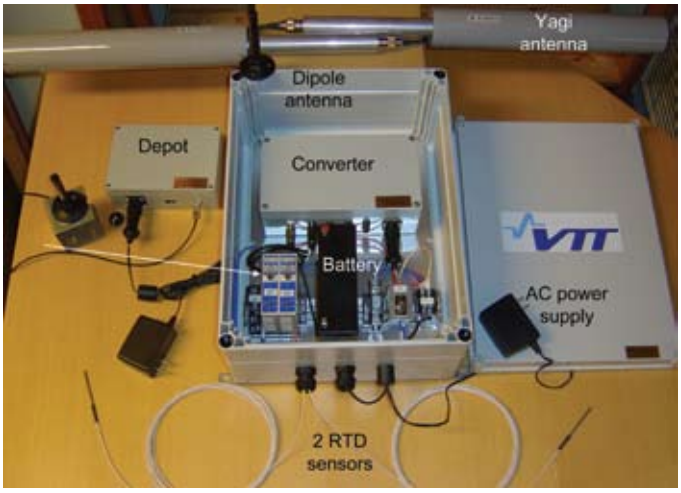


Figure 2b. SS1 sensor network. 2.4 GHz radio and Yagi antennas extend radio range over 300 meters in tunnel.

by radio using a router or straight with a gateway that is connected over Ethernet to a computer where data is stored to HDD. The SS1 system is fully battery-operated and can measure independently for many months without a PC, because every sensor node has its own non-volatile memory and data can be downloaded wirelessly through a gateway to a PC when needed. The tested sensor networks proved to be workable thermal monitoring systems even in a harsh tunnel surrounding during construction works. Both wired and wireless monitoring systems have remote access via Ethernet, which can then be mobilized when optic fibers are ready for use in the E18 tunnels.

The thermal simulation platform was based on Temp-W software. Different frost protection structures can be tested in a platform with various outdoor temperature records. Using the freezing index of dimensioning winters it is possible to produce thermal behavior forecasts of various frost protection solutions in tunnels.

DISCUSSION AND CONCLUSIONS

VTT has developed and instrumented thermal monitoring systems to manage thermal behavior of frost protection solutions of the E18 motorway tunnels in Finland. The monitoring systems cover wired Pt-100 sensors and dataloggers for long-term sensing situated in critical places in frost protection structures in almost every motorway tunnel. With the sensor network manufactures, two different types of wireless sensor networks were developed to cover mobile thermal monitoring needs in traffic tunnels. The systems are battery-operated and therefore still for short term monitoring in critical places where it is necessary to know the thermal behavior and functionality of structures. Specified thermal simulation platform can be used in different types of tunnels to determine forecasts of thermal behavior of frost protection solutions using measured temperature data from the tunnel or dimensioning freezing index of former winters in Finland.

EXPLOITATION

The most potential users of the thermal monitoring and simulation systems are contractors, Finnish Road Administration and Finnish Rail Administration RHK.

ACKNOWLEDGEMENTS

The author would like to thank earlier VTT colleague Jaakko Vuopio, now at Pöyry Infra Oy, for his contributions to this work. This project was funded by Tekes, the Finnish Road Administration, two private companies and VTT.

CONTACT

Harri Kivikoski
Senior Research Scientist
harri.kivikoski@vtt.fi
Tel. +358 20 722 4840

ELECTRODIALYTIC REMOVAL OF COPPER, CHROMIUM, AND ARSENIC FROM CCA-TREATED WOOD

Eila Lehmus, Pirjo Isosaari, Pieti Marjavaara

In this study, electrodialytic remediation process was used for copper, Cu, chromium, Cr and arsenic, As (CCA) removal from CCA-treated wood waste. In the electrodialytic process the electric current acts as the cleaning agent and activates the movement of metallic ions. The project had two objectives: first to study the effect of alternating current (AC) to the electrodialytic treatment and secondly to combinate oxalic acid diffusion as pre- and after-treatment for electrodialysis. The treatment costs were also estimated.

INTRODUCTION

The rules concerning wood treated with arsenic compounds changed in December 2006 when the European Commission Directive 2006/139/EC was published. The new directive clearly distinguishes the first placing on the market and the reuse of such wood. The Member States may allow wood treated with other types of CCA solutions (B- and C-type) to be used on the second hand market if they are in accordance with directive. The amount of CCA treated poles removed from service will increase in the near future and part of them need to be disposed. CCA treated wood can not be used as energy without special production plant. There is a need to develop cost-effective technology for handling the large amount of CCA treated poles removed from service.

MATERIALS AND METHODS

The tests were done in laboratory scale. The inside dimensions of the acrylic test box were 250 mm x 150 mm x 150 mm. The middle part of the box was filled with wood chips which were made of sapwood of CCA treated pole. The particle size was between 3 to 7 mm. The material had quite uniform metal (Cu, Cr, As) distribution. The anode and cathode plates were made of titan net coated with platinum in order to prevent the dissolution of harmful metals. The test equipment also consisted of two DC-power sources, AC-amplifier, signal generator, data logger and a pump for draining (Figure 1). The concentration of Cu, Cr and As were determined by atomic absorption spectroscopy (AAS).

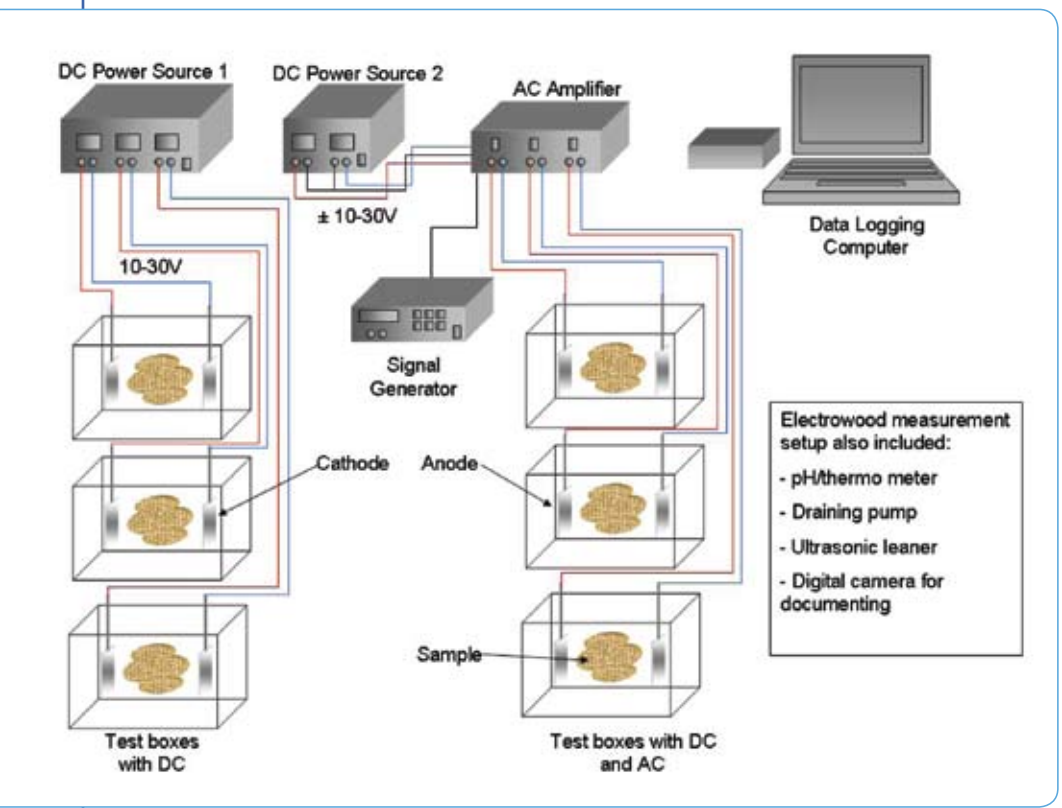


Figure. 1. The scheme of the equipment used in electrodialytic tests.

RESULTS

The test results showed that the removal efficiency varies depending both on the metal type and the first method used. The best remediation results were obtained for copper by three phase combination electrokinetic + diffusion + electrokinetic

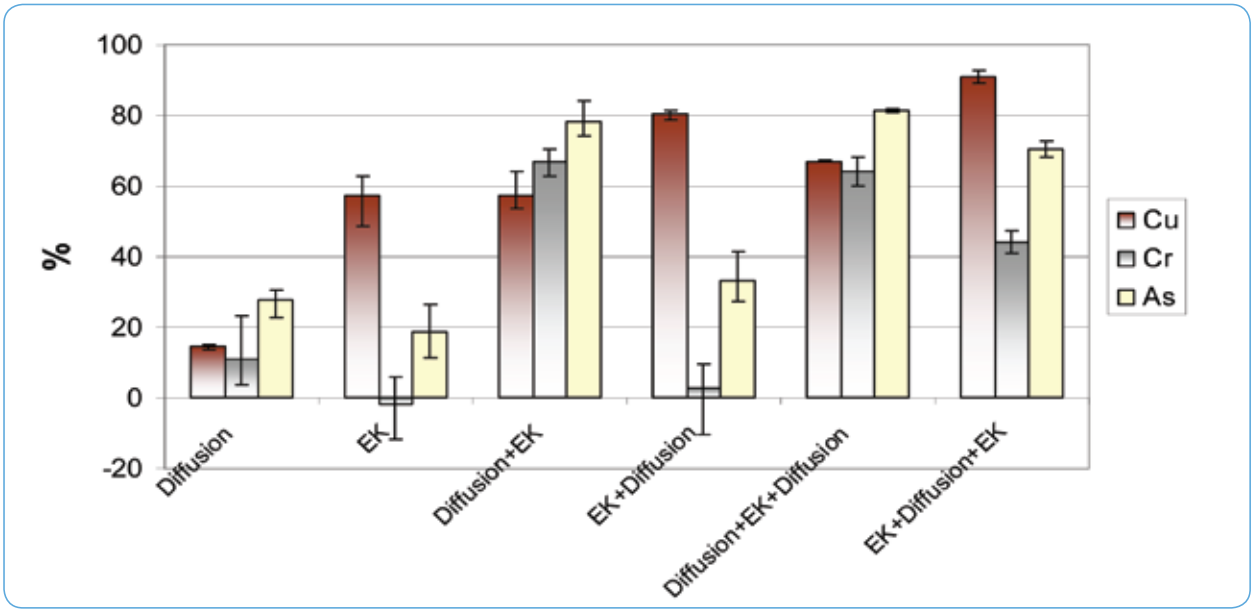


Figure. 2. The results of the removal of metals, including the range of similar tests. Diffusion: n = 3, EK: n = 8, Diffusion + EK: n = 6, EK + Diffusion, n = 1, Diffusion + EK + Diffusion: n =2, EK + Diffusion + EK : n = ?. (EK = electrokinetic treatment).

(90 %), chromium by pre-diffusion and electrokinetic (67 %) and arsenic by three phase combination pre-diffusion + electrikinetic + after-diffusion (81 %) (Figure 2).

The removal percent of copper by diffusion was small. The three phase combination having electrokinetic + diffusion + electrokinetic showed some extra removal compared with a two phase treatment. The removal percent increased from 81 % to 95 %. Similar result was obtained in the case of arsenic: with the three phase treatment having extra diffusion increased the removal percent from 78 % to 81 %. According to these laboratory scale tests the best process would be the combination of pre-diffusion with electrokinetic method.

DISCUSSION AND CONCLUSIONS

The project produced some new results which are comparable with the results published earlier by other research scientists. One parameter which has not been studied earlier was the use of alternating current. According to the test results the AC-component did not have an effect on the removal efficiency in the case of CCA treated wood chips. This result differs from the earlier test made with solid wood samples where the test result indicated some improvement of removal efficiency.

EXPLOITATION POTENTIAL

The remediation of CCA treated wood with electrodialytic process has been studied for about ten years. There is even pilot scale test equipment with 2 m^3 sample size. In all tests the results are similar and the removal percents are quite high. It may be possible to find some remediation method by combining different treatments but the process would probably be both expensive and time-consuming. According to this project the costs of energy and chemical materials were estimated about 200€/ton of chip wood. The treatment lasted seven days.

ACKNOWLEDGEMENTS

The authors wish to thank VTT for funding this project. The power distribution companies gave the pole material for the tests. The authors are grateful for their interest in the test program.

REFERENCES

[1] Isosaari, P., Marjavaara, P. & Lehmus, E. 2007. The electrokinetic remediation of CCA treated wood. (In Finnish). Research Report number VTT-R-07157-07.

CONTACT

Eila Lehmus
Technology Manager
eila.lehmus@vtt.fi
Tel. +358 20 722 6946

BREATHABLE THIN COATINGS FOR WOOD

Saila Jämsä, Riitta Mahlberg, Juha Mannila, Juha Nikkola, Amar Mahiout, Anne-Christine Ritschkoff

Nanostructures with functional properties provide a new way to modify material properties and to gain added value to wood based materials. Nano-coatings provide a new transparent coating system with controlled properties and functionality. The newly developed nano-coatings have shown to have selective barrier, easy to clean, abrasion and scratch resistance properties.

INTRODUCTION

Wood and wood-based composites are favorable construction, furnishing and decorating materials for ecological reasons and due to the appealing appearance of wooden surfaces. However, due to its chemical and structural composition wood easily absorbs water and water vapor, which causes dimensional changes in wooden products and even biological problems if the moisture loads are severe and prolonged. The main objective of this research was to increase competitiveness of wood-based materials in the global markets. Nano-coatings with functional properties provide a new way to modify material properties and to gain added value to wood based materials.

METHODS

In this study, sol-gel hybrid coatings were used to improve the moisture behavior of coniferous wood (Pinus sylvestris, thermally treated Picea abies). The performance of the hybrid coatings on wood substrates was evaluated by means of contact angle measurements, water vapor permeability and water floating tests. In addition, the performance of the coatings after short term natural weathering was respectively evaluated.

RESULTS

The study included two sol-gel coatings based on multifunctional alkoxysilanes developed at VTT. The coatings differed from each other in terms of the length of the attached organic aliphatic chain. The analysis (SEM-EDS, FTIR-PAS) results showed that both sol-gel nano-coatings were able to penetrate into the wood. In addition, the length of the organic aliphatic chain determined the penetration ability of the coating. The results obtained from the contact angle measurements and water floating tests showed that both nano-coatings improved the water repellence properties of pine sapwood and thermally-treated spruce forming quite hydrophobic surface properties and decreased the water uptake of the lateral surfaces of the wood samples. The water uptake properties of the treated wood specimens remained unchanged after three months' outdoor weathering. The nano-treatments had no effect on the water vapor permeability of the samples.

DISCUSSION AND CONCLUSIONS

The newly developed silane-based sol-gel hybrid coatings have provided efficient barrier treatment against unwanted water uptake by wood-based materials. In addition it was observed that the sol-gel based nano-treatments did not affect the water vapor permeability which allows for improvement of the natural functionality of the wood based materials. This leads to the conclusion that sol-gel hybrid nano-coatings designed for wood material have selective barrier properties with prevention of water penetration while permitting water vapor movements.

EXPLOITATION POTENTIAL

Sensitivity to moisture has often been sited as one of the disadvantages of wood as a building material for certain applications. The results of this project can be easily used to give new value added products with improved properties for outdoor and indoor use.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the cooperation and financial support from Tekes, 4 industry partners and Åbo Akademi University.

Figure 1. Nano-coating prevents water entry to wood and permits water vapor movements.

REFERENCES

[1] Ritschkoff, A., Mahlberg, R., Kallio, M., Mannila, J. & Vesa, A. 2004. Improved anti-soiling properties for wood products by sol-gel based functional thin coatings. Proceedings for the Fourth International Woodcoatings Congress: Developments for a sustainable Future. The Hague, The Netherlands, 25–27 October 2004.

[2] Ritschkoff, A., Mahlberg, R., Kallio, M., Mannila, J. & Vesa, A. 2005. Sol-gel hybrid coatings for wood products with improved surface durability and repellence properties. Proceedings of Nano and Hybrid Coatings Conference. Manchester, UK, 24–25 January 2005.

[3] Mahlberg, R., Jämsä, S., Löija, M., Takala, S., Mannila, J., Pahkala, A., Kallio, M. & Ritschkoff, A. 2006. Improved UV resistance of wood with nano-hybrid coatings. VTT Symposium 244. Applied Material Research at VTT. Symposium on Applied Materials. Espoo, Finland, 8 June 2006. pp. 145–153.

[4] Wang, S., Mahlberg. R., Jämsä, S., Nikkola, J., Mannila, J. & Peltonen, J. 2008. Surface characterization of pine and heat treated spruce modified with alkoxysilanes by sol-gel process. International Woodcoatings Congress: Preserve, protect, prolong. Amsterdam, The Netherlands 14–15 October 2008.

[5] Nikkola, J., Mahlberg, R., Mannila, J. & Jämsä, S. 2008. Effect of curing process on soil repellent properties of sol-gel coating on pine sapwood. (Submitted for publication).

[6] Jämsä, S., Mahlberg, R., Nikkola, J., Mannila, J. & Ritschkoff, A. 2008. Enhanced moisture behaviour of wood with nano-hybrid coatings. (Submitted for publication).

[7] Mahlberg. R., Jämsä, S., Nikkola, J., Mannila, J. & Ritschkoff, A. 2008. UV-resistance of wood with nano-hybrid coatings. (Submitted for publication).

CONTACT

Saila Jämsä
Senior Research Scientist
saila.jamsa@vtt.fi
Tel. +358 20 722 5543

BUILDING HEATING AND COOLING SYSTEMS UTILIZING BEDROCK ENERGY

Jouko Ritola

VTT and the city of Espoo have made experiments on indoor air cooling systems that use geoenergy. The cooling concept is especially suitable for special premises in schools and offices. The operating costs are extremely low because the cooling system runs with energy stored in the ground and no heat pump is needed for operation.

INTRODUCTION

An indoor air cooling system was developed and a pilot system was built in VTT's new office building for computer rooms using geoenergy in 1999 – 2000. Following the development, an experimental building project and a follow-up study were done in 2000 – 2005, both at VTT and at Ruusutorppa elementary school where indoor air cooling for special premises ran using geoenergy. Experiences of utilizing energy stored in the ground with free cooling have been so promising that additional productized indoor air cooling application will be delivered to two new school buildings in Espoo in the near future.

Ruusutorppa School was the ecological experimental building project in the city of Espoo. VTT proposed to pilot build a free bedrock cooling system for specific school rooms and technical spaces of the school (2 data processing classrooms with computers, school library, information center, a small computer and server space, and 2 electricity center; total floor area 425 m^2). A natural ventilation system without mechanical cooling had been planned for the school spaces and specific technical spaces need cooling around the year. VTT planned and carried out the three years follow-up research connected to the pilot building project of free bedrock cooling of the school.

METHODS

Borehole Thermal Energy Storage (BTES) involves free cooling by direct usage of underground cold or, more accurately, an active storage and recovery of cold in the soil and rock mass. In a BTES system, thermal energy is transferred to the underground by means of conductive flow from a number of closely spaced boreholes. The boreholes can be equipped with different kinds of borehole heat exchangers, making the boreholes act as a large heat exchanger between the system and the ground.

The BTES-cooling system in Ruusutorppa school consists of 6 boreholes 150 meters in depth. The boreholes are situated in line, at a distance of 10 m from each other, outside the building in green areas between the school building and the street (Figure 1). A closed pipe heat exchanger exists in the boreholes where pure water is circulated using a water pump but without a heat pump. The cooling system works at a relatively low temperature level.

The BTES-cooling system of VTT's LK2 building also consists of 6 boreholes. In this case the 135 meter deep boreholes have been borred diagonal in a fan shape in the bedrock under the office building. All boreholes begin at nearly the same point in a small HVA-space of the house. At the base of the boreholes, the greatest distance between diagonal boreholes is about 60 m.

From the closed borehole heat exchanger system, pure cooling water is circulated to the water/air cooling radiator of the computer rooms by mixing to a suitable cooling temperature using a 3-way valve. The base cooling effect taken from bedrock is about 5 kW year around.

RESULTS

The bedrock cooling system of Ruusutorppa school was began operation in August 2002 at the same time the new school building was opened. Since then the BTES-cooling system has been in use full-time without any problems. At the moment the free cooling system has delivered about 400 MWh of cooling energy from the rock. The base cooling effect has been about 15 kW.

The BTES-cooling of VTT's LK2 office building has been in use since 2001, providing a base cooling effect of 4-5

Figure 1. The bedrock cooling system of Ruusutorppa school in Espoo.

kW. To date this free cooling system has produced about 250 MWh cooling energy from the bedrock, at very low operating costs for cooling computer- and server spaces of the building.

DISCUSSION AND CONCLUSIONS

BTES systems are very useable and ecological energy solutions both for heating and cooling purposes in public buildings, because these energy systems can reduce discharges of carbon oxygen of buildings.

As the requirements for better energy efficiency and more ecological buildings tighten, construction companies will be more interested in renewable energy sources such as geoenergy. Geoenergy used for heating and cooling at the same time improves the efficiency of the system and makes the investment more cost-effective.

The payback times of BTES-cooling systems are relatively long, normally over 10 years due to expensive borehole investments. However, the BTES systems with combined heating and cooling using the same boreholes is much more economical and the experience in the Nordic countries has shown that the payback time of such hybride system is normally 6-10 years.

EXPLOITATION POTENTIAL

The owners and the users of BTES-cooling systems, both at Ruusutorppa school and the VTT office building, have been very satisfied with this kind of cooling system utilizing renewable cooling energy from the bedrock. Two new school buildings with the same kind of BTES-cooling are also now under construction in Espoo. The aim of the City of Espoo and VTT is to continue versatile utilization of geoenergy in other school buildings. The next target is to develop and build the next generation hybrid geoenergy system for a new school under design in the City of Espoo. The combined heating and cooling system with energy storage in bedrock is very interesting and feasible for investors and owners of estate.

ACKNOWLEDGEMENTS

The author wishes to thank the following colleagues for their contribution to this work: Pekka Sipola and Tom Bremer, House Planning Services, City of Espoo. The research projects have been funded by the City of Espoo, Finnish Ministry of Trade and Industry and VTT.

REFERENCES

[1] Ritola, J. 2005. The bedrock cooling system of Ruusutorppa school. (In Finnish). VTT Research Report RTE 1725/05.

CONTACT

Jouko Ritola
Senior Research Scientist
jouko.ritola@vtt.fi
Tel. +358 20 722 6177

UTILIZATION OF LOW-QUALITY AGGREGATE IN INFRA NETWORKS

Markku Juvankoski, Leena Korkiala-Tanttu, Harri Kivikoski, Markku Kiviniemi

The project "Development of Ground Improvement Process" (HUUMA) aimed at improving the utilization of Finnish low quality aggregates, especially moraines in the construction of infra networks.

INTRODUCTION

In construction of infra networks (here roads, streets and railways), remarkable amounts of low quality natural aggregates, like moraines and silts have to be treated yearly. There have been only occasional trials to utilize these materials. The reason for this is that the utilization is believed to be difficult and expensive, because so far the availability of high quality aggregates has been good and their price has been low. Today in many parts of Finland it is no longer as easy to find locations for dumping low quality materials and the prices of good quality materials and their transporation have risen remarkably.

Finland's Environmental authorities are financing the UUMA-programme [1], including the project "Development of Ground Improvement Process" (HUUMA) [2]. This UUMA-programme aimed at improving the utilization of Finnish low quality aggregates, especially moraines in the construction of infra networks. The HUUMA project concentrated on the utilization problems in general. From the low quality materials, moraine was chosen to be the main focus. Moraine is the most common soil material and different kinds of moraine materials have spread around all of Finland due to the Ice Age. Moraines typically have a high bearing capacity and it is a long-term material. What make moraines weak quality material are the stones, boulders and content of fines. The content of fines causes sensitivity towards circumstances, especially during freeze and thaw cycles and excess water. The utilization of moraine has been studied in earlier projects, but so far the utilization trials have been occasional.

METHODS

This research project tried to determine new approaches to moraine utilization problem. The research included mesurements and analysis of earlier done trial tests. The analyses were accomplished with model calculations, estimations of environmental impacts, functional and economical evaluations. Also new methods and structural proposals were made. The processing and refining methods suitable for moraines were mapped. The utilization potential was studied more carefully for the Vuores-case in Tampere.

RESULTS

Five different low quality trial tests, with ages varying from 10 to 21 years, were analyzed (Figure 1). All the trial test structures have served better or at least as well as the reference structures. The homogenization of the subgrade moraine (removal of stones and boulders to the depth of frost access) is a cost efficient, environmental friendly on-site method to improve the quality of the road pavement for the low-volume roads. Also the stabilization of either subgrade of pavement layers lengthens the service life of the road. This method is more expensive and it has some environmental impacts. Also the use of reinforcements remarkably increases the service life of the pavement and diminishes the damages.

The study also included mathematical modelling of a sandwich type pavement structure to evaluate the effect of the moraine on the general water content in the pavement. The modelling showed that if moraine with a bit higher content of fines is used as a subbase material there should be at least a filter layer beneath the subbase. Also other drainage layers or solutions could be used to further improve the functionality of the structure during all seasons.

The research identified some of the problems associated with utilization of weak quality materials, for which utilization plans easily stop. The most common reason is the

Figure 1. Example of use of moraine from earlier trial test of low-volume road.

permission policy of the authorities and the complaint process. Other reasons are the problems with timetables, the lack of refining and storage areas, the lack of environmental and economical incentives and the lack of guidance, products and working methods. In the Vuores-case a new problem arose from competition demand by the public bodies. Thus, new approaches are needed to even the balance of cut and fill. The approaches could be better utilization guidance, as well as incentives regarding price level of refining areas together with different taxation methods and the environmental demands during invitations of tenders.

CONCLUSIONS AND EXPLOITATION POTENTIAL

The research proved that the utilization of weak quality materials can be increased in Finland to substitute high quality natural aggregates like sand and gravel. The project estimated that the use of refined moraine can be increased to about 15 % in road structures. The utilization decreases the need for virgin natural materials, their transportation and dumping areas. Their utilization on-site is an even better solution. So far the biggest problem has been the lack of guidelines and products for users. The most promising refining methods are crushing, mixing and stabilization. The homogenization of the subgrade is also a cost efficient method.

Low frost-susceptible moraines can be used in low-volume pavement layers, if they are combined together with a more efficient drainage system. Even better pavement performance can be achieved if reinforcements are added to the pavements. The earlier studies have proven that the service life of a low volume road can be lengthened from 50 to 100 % by using reinforcements. The results of this work can be utilized and implemented by infrastructure owners and cities, design consults and constructors when they are looking for the alternative pavement solutions. Full results of the project will be available on the project web page at the end of 2008.

ACKNOWLEDGEMENTS

The authors wish to thank the following colleagues for their contribution to this work: Jouko Törnqvist and Veijo Nykänen (VTT), Paula Eskola from Motiva Oy, Pirjo Kuula-Väisänen (Technical University of Tampere), Paavo Härmä (Geological Survey of Finland) and Juhani Ilmonen (Skanska Infra). The research has been funded by Finland's Environmental Administration, City of Tampere, City of Helsinki, Finnish Road Administration, two companies and VTT.

REFERENCES

[1] Finnish Environmental Authorities, UUMA programme web page, 2008, www.environment.fi/default.asp?contentid=200340&lan=fi

[2] Public web site of the HUUMA project, 2008, www.environment.fi/defaultasp?contentid=202738&lan=fi

CONTACT

Markku Juvankoski
Senior Research Scientist
markku.juvankoski@vtt.fi
Tel. +358 20 722 4890

CONCRETE DURABILITY FIELD TESTING

Hannele Kuosa, Erkki Vesikari, Erika Holt, Markku Leivo, Liisa Salparanta

The target in field testing is to establish the true weathering rate of concrete and determine the correlation between field tests and laboratory tests and finally also with concrete mix design. This information is needed to assess how performance models and specifications should be adjusted to account for high performance materials and the utilization of more environmentally friendly mineral by-products, thus increasing the service life of structures. [1] A wide range of concretes with different cements and ecological binding materials are needed.

INTRODUCTION

A series of four projects have been underway since 1996 to establish and expand extensive concrete durability field tests. The original BTB-project consisted of a field station along a roadway in Borås, Sweden. Finland established their first field station within the "CONLIFE high performance concrete" EU project in 2001 and then additional stations in the parallel national project (YMPBETONI) with ecological binding materials [2]. The most recent project incorporating continued monitoring and expansion of field station studies is the DuraInt project [1], where the newest field testing area is located in southern Finland, beside Highway 7. In addition to field and laboratory testing, DuraInt includes theoretical studies and service life modeling on the effect of interacted deterioration parameters on service life of concrete structures in cold environments.

METHODS

Field testing includes evaluation of frost-salt or frost scaling, internal frost deterioration, carbonation and chloride penetration without and partly also with protective impregnations or the use of form linings. There are field testing areas in southern and northern Finland without de-icing salt exposure containing both high-strength mixtures and e.g. ecological mixtures and industrial facade mixtures. The new roadway testing area including about 30 different concrete types for road environments having salt exposure. Weather data is collected and variation of concrete temperature and relative humidity are measured. Optical fibers are used to get concrete temperature and water content profiles.

Exact chloride profiles are determined after field exposure at various ages and compared with chloride diffusion coefficients measured by laboratory method. Deterioration of specimen for salt-frost scaling and internal frost deterioration is monitored by measuring internal deterioration and surface scaling. Optical microstructural studies give information on e.g. cracking. Carbonation of the concretes is studied both by accelerated and non-accelerated laboratory methods and by studying concretes in the field.

Parallel accelerated laboratory testing also includes frost-salt or frost testing, where scaling and internal deterioration are measured. This testing is performed several times to get valuable information on the interacted effect of ageing and carbonation on concrete scaling. Hardened concrete air void analysis and total air content measurements give useful information. Interaction of deterioration is also studied to get information for service life models. In all projects, the initial and later aged lab testing results and models are compared to long term field testing results.

MIX DESIGN AND RESULTS

Field testing besides Highway 7 includes mainly air entrained concretes with water-binder ratio 0.40 – 0.60, with the majority about 0.42 and compressive strength up to 60 MPa. CONLIFE-concretes in northern Finland are with water-cement ratio 0.30 – 0.42 and strength over 60 MPa. Air entrained and not air entrained high strength concretes with silica fume, blast furnace slag or fly ash are included. YMPBETONI-concretes in southern and northern Finland include up to 60 % fly ash or 70 % slag. These ecological 30 – 45 MPa concretes were cured with or without heat treatment.

Figure 1. Highway 7 in Finland, frost-salt and chloride penetration samples.

Surface scaling in frost salt test as tested initially in the laboratory has usually been low enough. Yet for concretes with poor or no air entrainment it typically has been high. Laboratory data is compared with frost deterioration interacted with ageing and healing effects in the field over 10 – 20 years. The effect of different binding materials, air entrainment and concrete water-binder ratio is studied. The effect of concrete mix and chloride diffusion coefficient is compared with chloride penetration profiles in the road environment to be able to create truthful models. Protective surface impregnation or with the use of form linings has been found to reduce chloride penetration. A good linear correlation has been found to exist between carbonation sheltered outdoors and in accelerated or non-accelerated laboratory testing.

EXPLOITATION POTENTIAL

Establishing the relation between initial laboratory testing and field performance is a key factor for proper implementation of durability and performance concepts in the EN206-1 concrete standard.. Field testing will give valuable input to the ongoing international work to update this standard and concrete practice.

ACKNOWLEDGEMENTS

Concrete field testing research has been funded by the European Commission, VTT and several participants including companies, organizations and cities in Finland and Sweden

REFERENCES

[1] Kuosa, H. 2008. Concrete durability field testing – Durafield-project. Proceedings Nordic Concrete Research, Bålsta, Sweden, pp. 48–49.

[2] Holt, E., Wirtanen, L., Råman, T. & Tulimaa, M. 2004. Implementing environmentally-friendly and durable concrete to Finnish practice, Nordic Concrete Research. Vol. 2, No. 32, pp. 77-92.

CONTACT

Hannele Kuosa
Research Scientist
hannele.kuosa@vtt.fi
Tel. +358 20 722 6911

REDUCE COSTS OF CEMENT-BASED PRODUCTS BY UTILIZING MICRO TECHNOLOGY

Hannele Kuosa, Markku Leivo, Erika Holt

Concrete is the most common building material worldwide, with cement having the highest material cost as well as a high environmental burden during production. If alternative materials can be utilized in traditional cement-based materials, then the material properties can be enhanced and alternative high-quality products can be developed.

INTRODUCTION

The main aim of the European MICROCON project [1] was to develop and use methods for the reduction of raw material costs in the field of cement-based building products by utilizing microtechnology. The objective was to develop new, energy-efficient building products to market readiness. Microstructure of concrete and mortars has a great impact on the properties of fresh and hardened concrete. The project seeks to improve these properties through development of waste based filler composites, which can help to optimize microstructure of cementitious products and reduce the need for high cement and admixture amounts. Due to the wide range of very specialized topics, the research tasks were divided between the partner institutes. The portion of the work done at VTT concentrated mainly on rock injection grouts, façade and balcony concrete and floor screeds.

The goals of the MICROCON project were to:

- improve the competitiveness of the companies by reducing their raw material costs,
- develop high performance products by using microtechnology and optimization of microstucture – e.g. strength development, durability and dimensional stability,
- reduce ecological impacts,
- optimize use of commercial cement based microcomposites.

MATERIALS AND METHODS

VTT's main tasks were in the field of mix design and testing of new mixes with micronized raw materials. This included studies on long term ageing properties as well as preliminary official approval tests according to EN-standards. Testing of products from pilot production was included, and was done in comparison with the base-products. The environmental comparison of the base- and end-products was done using a partial LCI (Life Cycle Inventory)-analysis based on raw materials and transport. An international public symposium was held accompanied by a workshop related to testing methods, which focused on self compacting and reactive powder concretes (SCC and RPC) and rock injection grouts.

RESULTS

The results included detailed technical, economical and ecological data on the end-products:

Figure 1. Freshly mixed rock injection grout ready for testing: flowability, injectability, setting time and strength properties.

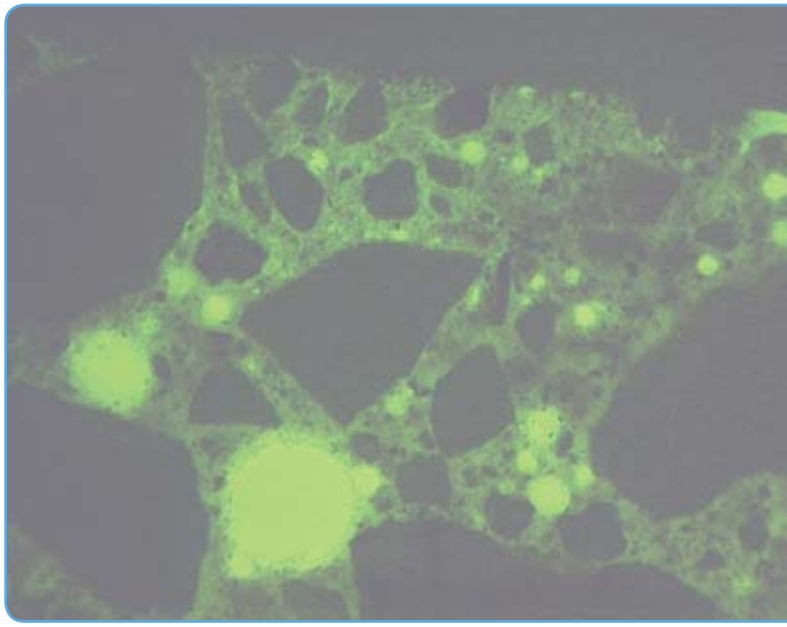


Figure 2. Dense microstucture in an air entrained balcony concrete as seen in a petrographic thin section impregnated by fluorescent epoxy. Height of the picture is less than 3 mm.

- detailed analysis of micronized raw material properties,
- mix design data,
- fresh mix properties: workability, injectability, alkalinity, pH, shear strength, setting time,
- strength properties, wear resistance and shrinkage,
- durability properties: freeze-thaw durability, microstructure, optical thin section studies, air pore parameters, carbonation, leaching, porosity, capillary water uptake and water vapor permeability.

The output from the LCI included quantifying the following environmental burdens: Use of Energy Resources, Raw Material Consumption, Global Warming Potential, Acidification Potential and Photochemical Ozone Creation Potential.

Using mix design data it was possible to compare the costs for base- and end-products.

DISCUSSION AND CONCLUSIONS

The introduction of micronized by-products in a cement based material is a way to diminish environmental burdens. The results of LCI should be considered when selecting mixture designs in practice. In combination with performance and economic assessments, environmental investigations should also be made. In this way it is possible to decide the feasibility of using a certain mix design or product. As cement production is energy intensive, it is a big benefit if cement can be replaced with a microfiller or microcomposites with higher environmental friendliness. It is a benefit if microfillers can be produced with as small as possible energy input. The transportation cost should also be considered, as they will increase environmental burdens as well as price.

EXPLOITATION POTENTIAL

A set of newly developed products became available for the medium-size enterprises who participated in the project. These microcomposite products are often special products with special or even extraordinary technical properties (rock injection grouts, floor screeds, RPC and grouts with specific properties).The enterprises got familiar with the technical, economical and ecological benefits that specific micronized raw materials can offer, as well as testing methods and official approval demands.

ACKNOWLEDGEMENTS

The author wishes to thank all eight partners from five countries who participated in the project. The work was funded by industry, the European Commission and VTT.

REFERENCES

[1] MICROCON project fact sheet, European Union 6th Framework database, 2008, http://cordis.europa.eu/fp6/projects.htm

CONTACT

Hannele Kuosa
Research Scientist
hannele.kuosa@vtt.fi
Tel. +358 20 722 6911

EASY-TO-CLEAN COATINGS FOR BUILDING MATERIALS

Juha Mannila, Saila Jämsä, Riitta Mahlberg, Juha Nikkola, Anne Pahkala, Amar Mahiout

Within various recent research projects, a set of dirt-repelling and easy-to-clean sol-gel coatings have been developed for different substrates and end uses. A couple of applications have already been launched to the markets by Finnish SME companies. In one recent work, VTT and a surface coating manufacturer developed a dirt-repelling ventilation surface for a Finnish company.

INTRODUCTION

Soiling of surfaces is a major problem in everyday life as well as in many industrial processes. Development work on new dirt-repelling coating solutions has been carried out for several years in cooperation between VTT, several companies and research institutes. Research has been conducted on how grease and dust, as well as dirt transported by water, adhere to different types of surfaces and how the adherence of dirt can be prevented. Dirt adherence depends, among other things, on the chemical properties of the surface material, the coarseness of the surface material, potential chemical reactions between the dirt and the surface, as well as electrostatic phenomena.

Sol-gel hybrid coatings provide a new approach to improve surface properties of different materials. By optimising the composition of these coatings, surfaces with different functionality such as superior scratch resistance or cleanability can be created [1, 2, 3, 4]. The coatings are usually transparent, only a few microns thick and can be applied on a wide range of substrates e.g. on metals, ceramics, glass, polymers, concrete and on wood.

MATERIALS AND METHODS

The new surface coatings developed by VTT and coating developer and manufacturer Millidyne Oy are composite materials, in which the good properties of several different materials are combined. Various elements are typically mixed on a very small scale, even at the molecular level. The application of these new, nano-structured composite coatings takes place while the material is in a liquid-like state, and the surface coatings can be made very thin. Most of the surface coatings are transparent, and due to the ceramic raw materials, they increase the durability of the components. The performance of the coatings can be evaluated e.g. by means of infrared microscopy (IR) techniques by measuring how easily oily contaminants can be removed from the coated surfaces compared to the uncoated substrates. In addition, water and oil repellence properties of the surfaces can be determined by so-called contact angle measurements.

RESULTS

The new coatings can repel dust-like dirt as well as grease-like dirt and dirt due to humidity in particular. Recent research showed that 40% less dirt adheres to the surface of the coated valves than the surface of traditional valves and after cleaning, the coated products have only a fourth of the amount of dust-like dirt of an ordinary valve. The difference in relation to greasy dirt is even greater.

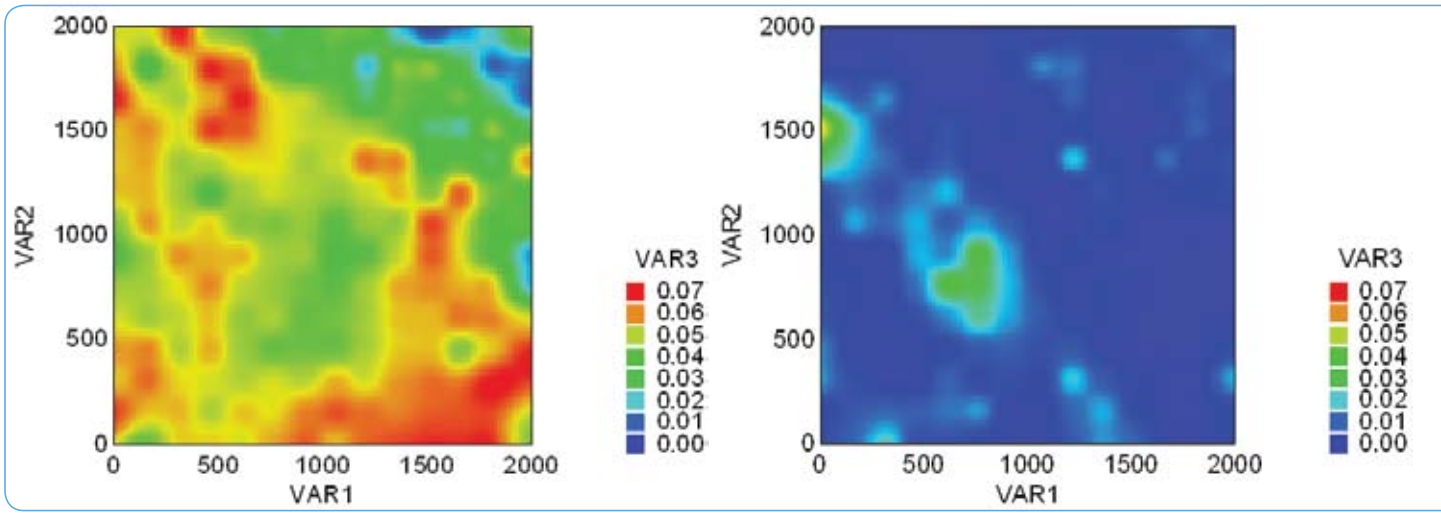
In addition, dirty valves treated with the coatings are much easier to clean even without using any chemicals. A result of the cleanability determination is seen in Figure 1.

DISCUSSION AND CONCLUSIONS

In the recent project, a new kind of dirt-repelling coating was developed that can be used to promote the cleanliness and easy cleaning of ventilation system components, such as supply and exhaust air valves. The coating makes it harder for dust particles and grease to adhere to the surfaces of valves and makes them easier to clean. Similar coating solutions to those developed here can be created and applied to other building applications, as well, e.g. on walls and furniture surfaces.

EXPLOITATION POTENTIAL

In addition to industry, the results of the research will benefit consumers. In building applications, dirt-repel-



a) *b)*

Figure 1. Image maps of grease dirt created using IR technology of an uncoated (a) and coated (b) valve after the grease has been cleaned with a microfiber cloth. The red coloring shows where the surface is very greasy and the blue where the surface is clean. IR technology is used when identifying chemical compounds, in this case grease.

ling surfaces improve the welfare of people. For instance, dirt-repelling ventilation devices require less cleaning and maintenance, improve the quality of indoor air and have an energy-saving impact on ventilation by preventing increased flow resistance due to dirt in valves, for example.

The new coatings are expected to improve the position of the companies with the new products in the existing markets. Entirely new markets are expected to be found, as well. As a result of the recent research, the company Fläkt Woods is currently applying for a patent for the dirt-repelling coating in ventilation applications and markets the new products [5].

REFERENCES

[1] Ritschkoff, A.-C., Mahlberg, R., Kallio, M., Mannila, J. & Vesa, A. 2004. The durability and anti-soiling properties of sol-gel-based easy-to-clean and fingerprint-resistant coatings for steel surfaces. The Fifth Nordic Conference on Surface Science, Tampere, 22–25 September 2004.

[2] Ritschkoff, A.-C., Mahlberg, R., Hakkarainen, T., Salparanta, L., Mannila, J., Posti, O., Kallio, M., Vesa, A., Löija, M., Iitti, H., Takala, S., Mäntylä, T. & Levänen, E. 2005. Functionalization of building material surface properties. (In Finnish). VTT Research Notes 2294.

[3] Pahkala, A., Mannila, J., Kallio, M., Nikkola, J., Mahiout, A., Siivinen, J., Ritschkoff, A.-C., Mahlberg, R., Posti, O., Löija, M. & Takala, S. 2006. Anti-fouling and scratch resistant hybrid sol-gel coatings. VTT Symposium 244. Applied Material Research at VTT. Symposium on Applied Materials. Espoo, Finland, 8 June 2006. pp. 177–187.

[4] Mahlberg, R., Mannila, J., Romu, J., Nikkola, J., Ilola, R., Söderberg, O., Koskinen, J., Hannula, S.-P. & Mahiout, A. 2008. Soil resistant and self-cleaning surfaces of stainless steel with new sol-gel and ALD coatings. Proceedings of the 6th European Stainless Steel Conference, Helsinki, Finland, 10–13 June 2008, Jernkontoret, The Swedish Steel Producers' Association, pp. 101-107.

CONTACT

Juha Mannila
Research Scientist
juha.mannila@vtt.fi
Tel. +358 20 722 3702

RESEARCH METHODS FOR NANO-LEVEL DEVELOPMENT OF MATERIALS

Liisa Salparanta, Päivi Varis, Harri Joki, Anna Suurnäkki, Tomi Mattila, Mikko Aronniemi

Nano-level research methods were used for examining the structure of materials on the molecular level. The modern methods enable studying of even unstable and wet samples. They also made it possible to trace changes of materials on the nano-level, e.g. development of crystal structures. In building materials like concrete these methods open new opportunities for material development.

INTRODUCTION

Nanotechnological research and development work requires special nanotechnological methods, but in practice their use is limited by their expense. This is due to the cost of the equipment and the skill and training that their use demands. VTT has a selection of own nano-research tools and possibilities to benefit equipment in other institutes and laboratories. A prerequisite for efficient nanotechnological research is knowledge of available research tools and their capabilities. The most applicable method and instrument depend on the sample material and the property to be studied.

MATERIALS AND METHODS

The work for developing the research capabilities on nano-level was performed in various steps. The main tasks were:

- surveying the visual methods applicable for challenging materials (e.g. unstable or wet)
- collecting information on research laboratories with nano-research preparedness
- establishing and activating networks for nano-technological research methods and
- visulization of three different materials (fresh and hardened concrete, an electro-functional polymer material and a biopolymer).

RESULTS

Information on the equipment and ability for nano-technological research with complex materials was collected by VTT. The visualization methods on nano-level may be light-, electron- or X-ray-microscopical. The methods investigated included the following:

- light microscopy
- electron microscopy
- transmission electron microscopy
- scanning electron microscopy
- environmental scanning electron microscopy (ESEM)
- atomic force microscopy
- X-ray crystallography

The parameters of these methods were identified, such as sample preparation, sample limitations (i.e. wet or dry material), test procedure, and visualization resolution. The studies of material examples and strengthening of cooperation will be completed at the end of 2008. As a result of the project,

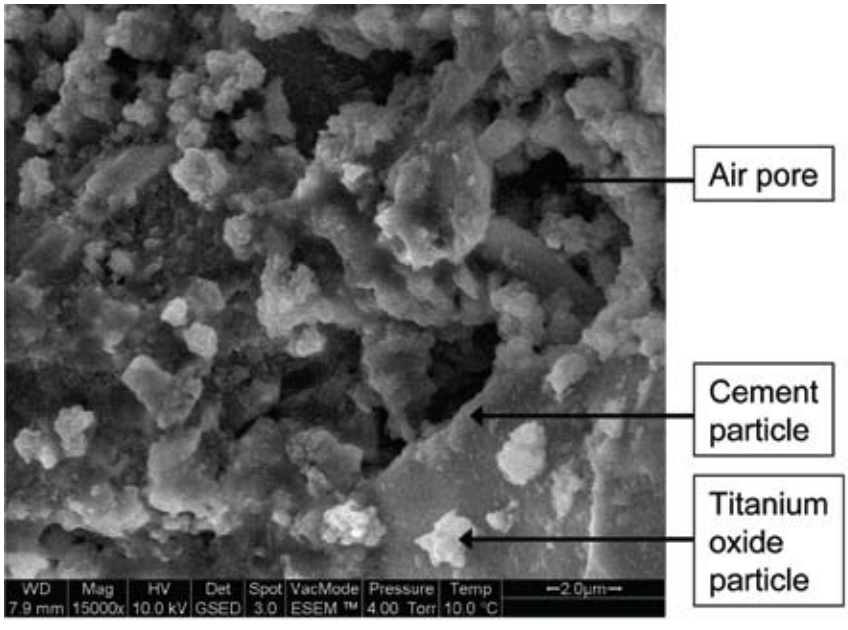


Figure 1. Fresh cement paste.

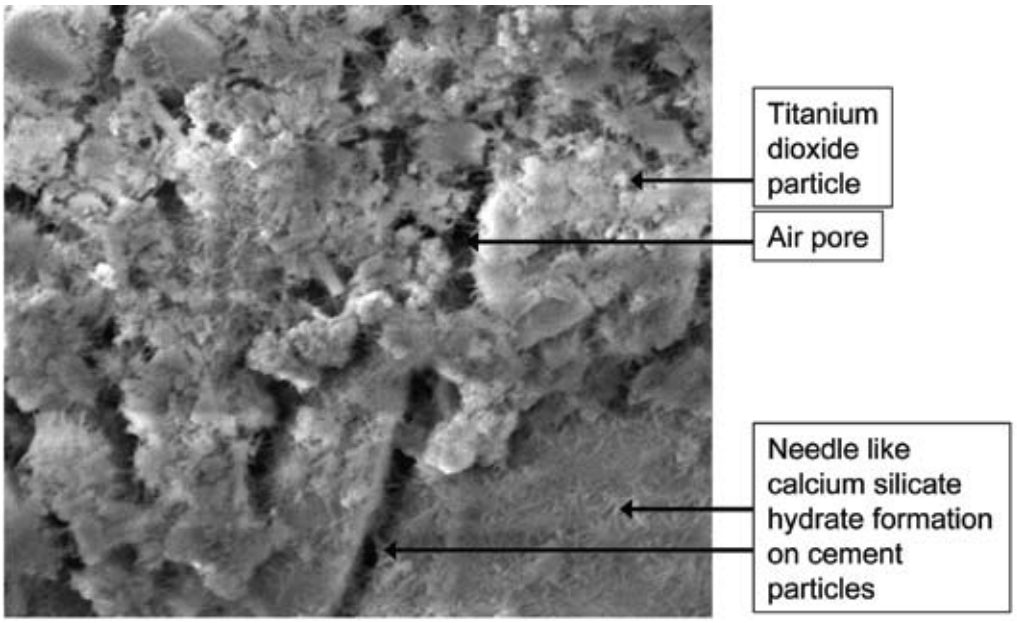


Figure 2. 16 days old cement paste.

an active co-operative network of nano-technological research has been established. The partners in the network possess an extensive selection of different types of microscopes and skills to apply the equipment on different materials. The most challenging sample studied so far is fresh concrete, where the crystal formation was studied. Some examples are shown in Figures 1 and 2 taken using ESEM FEI Quanta 200 FEG. Figure 1 shows fresh and Figure 2 shows 16 days old cement paste made of white cement. The water-cement ratio is 0.40 and there are titanium oxide particles in the mix.

DISCUSSION AND CONCLUSIONS

In many areas of technology, e.g. in building technology, biotechnology and electrical engineering, nanotechnology is a powerful tool for development. The research methods of materials in these areas are quite complex and also costly. The best results are achieved by distributing information on available methods and their possibilities. In this way combining of the national resources by networking gives the best results. The final results of this project will be published in

EXPLOITATION POTENTIAL

The information on the methods and abilities investigated in this project will be used in creating cooperation in both research close to basic research and in product development. The final results of this project will be published at the end of 2008. Utilizing the contacts and know-how created in this project and another concrete technological cooperation project, a new larger project has begun. The new project is on nano-level electro-functional polymers for building materials, and is done in cooperation with Finnish industry to be completed in spring 2011.

ACKNOWLEDGEMENTS

The authors wish to thank the following people for their contribution to this work: Helsinki University of Technology (especially prof. Esko Kauppinen), Professor Markku Leskelä of Helsinki University, Dr. Esa Vanhala of the Finnish Institute of Occupational Health, and colleagues in Oulu, Joensuu and Kuopio Universities as well as Åbo Akademi University. The research has been funded by VTT.

CONTACT

Liisa Salparanta
Research Scientist
liisa.salparanta@vtt.fi
Tel. +358 20 722 6913

LIFE CYCLE MANAGEMENT TOOLS FOR CIVIL INFRASTRUCTURE

Erkki Vesikari, Tarja Häkkinen

Several life cycle management tools were developed in Finland during the years 2002 - 2008. The tools were designed applicable to bridges, roads, building envelopes and nuclear power plants. All these systems were based on the ideas of the European Union Project LIFECON in 2001-2003. The objective of the LIFECON project was to develop a model of a predicted and integrated life cycle management system for infrastructures.

INTRODUCTION

The aging of infrastructure and the uncertainty on future costs of maintenance, repair and rehabilitation (MR&R) have led to the need of special life cycle (LC) management tools for civil infrastructure. Consequently, several life cycle management tools were developed in Finland during the years 2002 - 2008. The tools are applicable to bridges, roads, building envelopes and nuclear power plants. The tools were designed taking into account the requirements of many stakeholders such as owners, designers and maintainers. The purpose of the LC management tools is to ensure safety, accepted structural performance and uninterrupted service of structures. They are able to predict future condition of structures, give timing to the future MR&R actions and to determine the life cycle costs and the environmental impacts relating to the MR&R actions.

PROCESS

The process of the life cycle management systems is presented in Figure 2. The process starts from the inspection of structures and ends in the implementation of MR&R actions. The life cycle management tool uses the database which contains data tables on structures, modules (structural parts) and MR&R systems, and makes the preliminary plans for the MR&R actions. Starting from the MR&R action design the designer may with some of tools continue to project design and annual resources design. The project design means grouping of the MR&R actions into projects with possible small changes in the timings of actions. Annual resources design means balancing the annual project costs with the annual budget. The database contains data tables on structures, modules (structural parts), and MR&R systems.

Figure 1. Life cycle management tools for bridges, roads, building envelopes and concrete structures in nuclear power plants.

Basically the LIFECON management system is generic i.e. independent on the structures to which the system is applied. Only the degradation models and the MR&R actions are specific to the structures for which the system is developed. The LIFECON management system is described in references [1] and [2].

The core of the LC management tools is the combined condition, cost and environmental impact analysis. The condition analysis which is based on Markov Chain is capable of

predicting year by year the probability of the module to be at any of the condition states. The analysis consists also of an automatic condition guarding system which is programmed to trigger MR&R actions whenever the predefined limit state of condition is exceeded with the maximum allowable probability. When the MR&R actions are defined the total costs and the environmental impacts due to MR&R actions are calculated by the side of the condition analysis.

RESULTS

The designer can view the results of LC analyses through displays. Although the calculations have been made automatic many displays are interactive enabling the designer to do modifications to the design by:

- changing initial data
- adding, changing and removing MR&R actions
- recalculating the analyses

CONCLUSIONS

Several life cycle management tools were developed in Finland during the years 2002 - 2008. The tools were designed applicable to bridges, roads, building envelopes and concrete structures in nuclear power plants. All these systems were based on the ideas of the European Union Project LIFECON in 2001-2003.

The life cycle management tools can be used for life cycle design, systematic maintenance of structures. The tools make it possible to plan, organize and optimize all MR&R actions for a continuous upkeep of structures.

EXPLOITATION POTENTIAL

The basic system of the life cycle management tools can be applied to any structures subject to degradation. It is a valuable tool for owners of infrastructure and real estate.

ACKNOWLEDGEMENTS

The author wishes to thank the following organizations for their contribution to this work: The Finnish Road Administration, Tekes, and SAFIR (The Finnish Research Program on Nuclear Power Plant Safety).

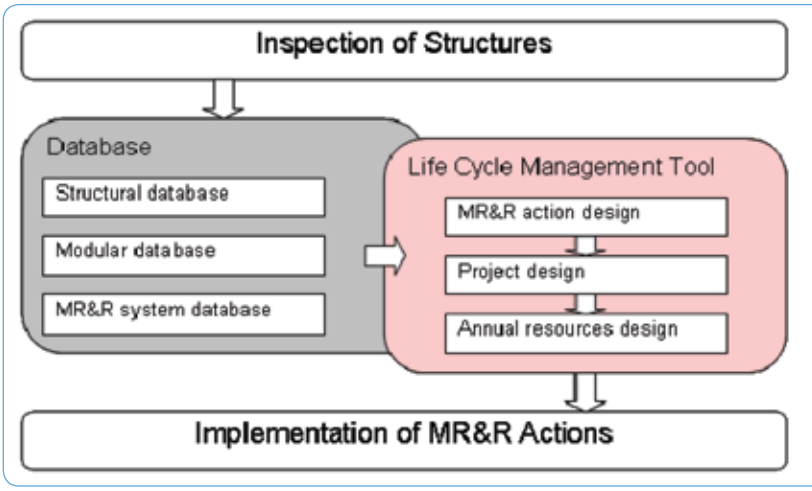


Figure 2. Life Cycle Management System.

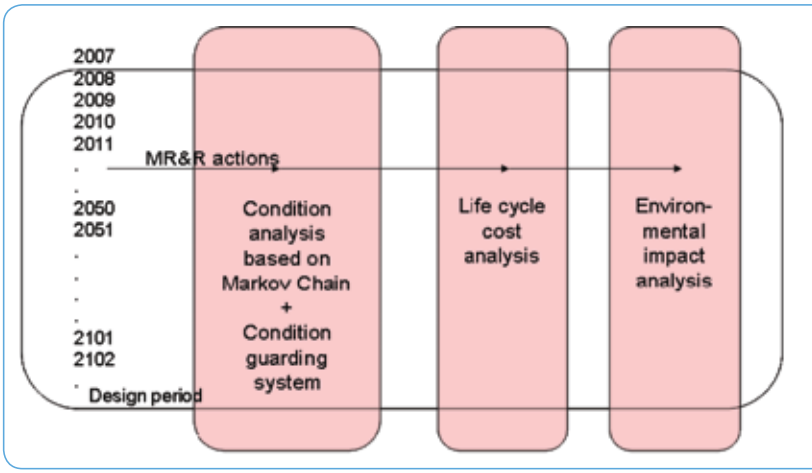


Figure 3. Combined Life Cycle Analysis.

REFERENCES

[1] Söderqvist, M.-K. & Vesikari, E. 2003. Generic technical handbook for a predictive lifecycle management system of concrete structures (LMS). Lifecon Deliverable D1.1, Final Report. http://lifecon.vtt.fi/.

[2] Vesikari, E. 2003. Statistical Condition Management and Financial Optimization in Lifetime Management of Structures. Part 1: Markov Chain Based Lifecycle Cost (LCC) Analysis. Part 2: Reference Structure Models for Prediction of Degradation, Lifecon Deliverable D2.2, Final Report. http://lifecon.vtt.fi/.

CONTACT

Erkki Vesikari
Senior Research Scientist
erkki.vesikari@vtt.fi
Tel. +358 20 722 6922

RIDGE-STRUCTURE INTERACTION SIMULATION

Jaakko Heinonen, Kari Kolari

A numerical model for 3-dimensional ridge-structure interaction simulation has been developed. Model development for ridge loads includes material modeling, both for the consolidated layer and ice rubble. The model is based on continuum mechanics. The numerical implementation has been made using Finite Element Method (FEM). The model was verified utilizing data from full-scale measurements. The numerical model can be used in different industrial applications, for instance to predict ice loads due to a moving ridge against an offshore wind turbine and to predict ice loads against Azipod-propulsion and a ship body due to ridge interaction.

INTRODUCTION

Ridges are common ice features in Northern seas. They are formed when sea ice is compressed or sheared under the action of wind and currents. Ridges are constantly shifting due to wind and sea currents, causing remarkable loads against off-shore structures during interaction. A ridge contains a large number of ice pieces of varying sizes and shapes that are piled arbitrarily (Figure 1). First-year ridges play an important role in many ice-related processes.

In the previous EU-projects LOLEIF (1998-2000) and STRICE (2001-2003) the mechanical properties of ice ridge were studied by full-scale experimental tests. The tests were carried out in the Gulf of Bothnia close to the Finnish coast near Hailuoto island. According to the experimental observations, a material model for ice rubble was developed and verified to describe the failure of ice rubble [1].

METHODS

The objectives were to experimentally develop verified numerical model for ridge loads including:

- Shear and compaction failure (3D-model)
- Pore pressure and loading rate effects
- Relocation of broken ice during interaction
- Combining models for the ice rubble and consolidated layer.

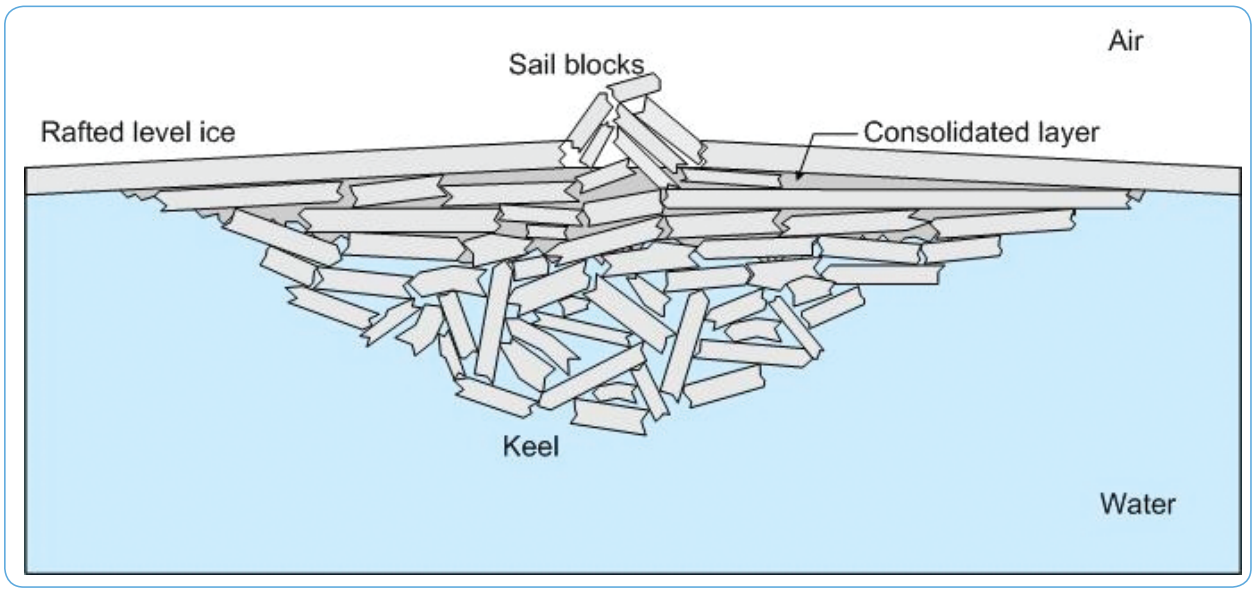


Figure 1. Schematic cross-section picture of an ice ridge.

The previously developed axisymmetric 2D-model for ice rubble has been expanded to the 3-dimensional case. The model has been implemented both for the implicit solver (ABAQUS/Standard) and for the explicit solver (ABAQUS/Explicit). To take into account the loading rate dependency, new features have been implemented into the model. By applying pore pressure elements together with ice rubble material model, one is able to combine the effects of water flow, pressure between the ice blocks and stress analysis. The modeling of pore pressure allows accounting for how the shear strength decreases while the pressure between the ice-blocks increases. The development regarding relocation of broken ice during the ridge-structure interaction was also made.

A model for the consolidated layer is developed based on the fictitious crack model [2]. The model takes into account the significant variation of mechanical properties both in the vertical and horizontal direction due to for instance the pores and boundaries of refrozen blocks. The material model takes into account the size effect of semi-brittle material and eliminates the mesh dependency due to softening during material failure.

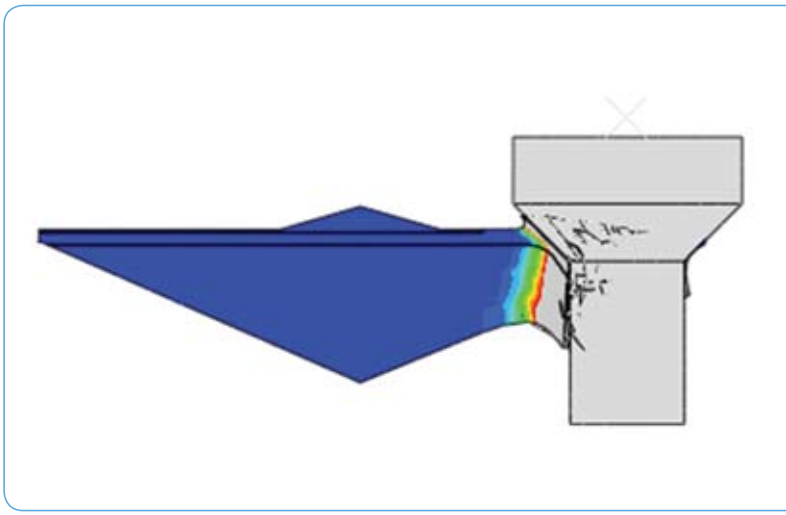


Figure 2. Snap-shot of the simulation of ice ridge interaction with a conical type of foundation for an offshore structure (for instance a wind turbine foundation). A contour plot introduces the distribution of shear failure.

RESULTS AND EXPLOITATION POTENTIAL

A numerical model has been developed to simulate ridge loads against 3-dimensional offshore structure (Figure 2). In the next phase, the model will be verified by utilizing the full-scale data. The numerical model will then be used in different industrial applications: at first to predict ice loads due to moving ridge against offshore wind turbine and second to predict ice loads against Azipod-propulsion and ship bodies due to ridge interaction. The phenomenological FE-model provides a basic understanding of the ridge loads against various structures in different ice conditions, how the loads are created during ridge-structure interaction and the contribution of loads (for instance consolidated layer vs. rubble). The numerical model can be utilized to optimize the structure for minimizing the ridge loads, to find the optimal failure mode for the whole ridge or part of it, and to determine realistic load predictions to avoid over-dimensioning of structures. The potential exploiters of results are the manufacturers of offshore structures, such as wind power plants and of oil platforms, and industries including shipbuilding, winter navigation and energy production.

ACKNOWLEDGEMENTS

The author wish to thank the following colleagues for their contribution to this work: Kari Kolari, Maria Tikanmäki and Juha Kurkela of VTT and Janne Ranta, Jukka Tuhkuri and Kari Santaoja of TKK with the Laboratory for Mechanics of Materials. The research has been funded by Tekes, four industry partners and VTT.

REFERENCES

[1] Heinonen, J. 2004. Constitutive Modeling of Ice Rubble in First-Year Ridge Keel. Doctoral Thesis. VTT Publications 536.

[2] Kolari, K. 2007. Damage mechanics model for brittle failure of transversely isotropic solids Finite element implementation. Doctoral Thesis. VTT Publications 628.

CONTACT

Jaakko Heinonen
Senior Research Scientist
jaakko.heinonen@vtt.fi
Tel. +358 20 722 6907

EXPERIMENTAL AND NUMERICAL STUDIES ON IMPACT LOADED STRUCTURES

Arja Saarenheimo , Ilkka Hakola, Kim Calonius, Simo Hostikka, Auli Lastunen, Ari Silde

An aircraft impact on safety related structures, in spite of its low probability, has been for a long time recognized as a relevant loading case in designing modern nuclear power plants. Protective concrete barrier walls of nuclear power plants are required to withstand the effects of impacts by projectiles, e.g. an aircraft crash or accidental missiles. The main concern in many cases is the fate of fuel.

INTRODUCTION

Nonlinear analysis of reinforced impact loaded concrete structures is a challenging task. In order to get reliable calculation results numerical methods and models need to be verified against experimental data when simulating full scale applications. Very little experimental information can be found in public literature. The IMPACT test facility has been developed starting in 2003 and has now reached a mature phase where well repeatable tests can be conducted and a broad range of dynamic data acquired reliably.

METHODS

The test facility is shown in Figure 1. The test apparatus consists of two main parts. First, a 13.5 m long pressure accumulator is used to provide the required initial energy for the test. Second, a 12 m long acceleration tube is used to accelerate test missiles to a final velocity of 100 m/s to 200 m/s. The mass of the missile can be up to 100 kg. When considering the verification of numerical results the most important measurements are the force-time function of impact (including effects of liquid possibly contained in the missile) and dynamic displacement of walls (at selected locations) and strains in wall reinforcement.

Reinforced concrete is a challenging material from the numerical simulation point of view. Different kinds of methods for predicting the response of reinforced concrete structures subjected to impact loads caused by deformable missiles that may contain liquid have been studied and assessed. Simplified models are very valuable when judging the reliability of both the test results and the extensive numerical simulations. Also materially non-linear analyses using Finite Element Method (FEM) has been carried out. Nonlinear analyses of reinforced structures are quite sensitive for material parameters.

Simulation of liquid fuel dispersal and burning has been performed using Fire Dynamics Simulator (FDS) software in the geometry of laboratory impact tests. The purpose of the work was to study the feasibility of the FDS code for the simultaneous simulation of extremely fast fluid release, flame formation and progress of heat and combustion products.

Figure 1. Impact test facility (pressure pipe, acceleration tube, piston catcher and force plate or impact wall).

RESULTS

One of the main aims in verifying the numerical methods and models was to assess the maximum deflection and associated strains of an impact loaded reinforced concrete wall. Calculated and measure displacement values are presented in Figure 2.

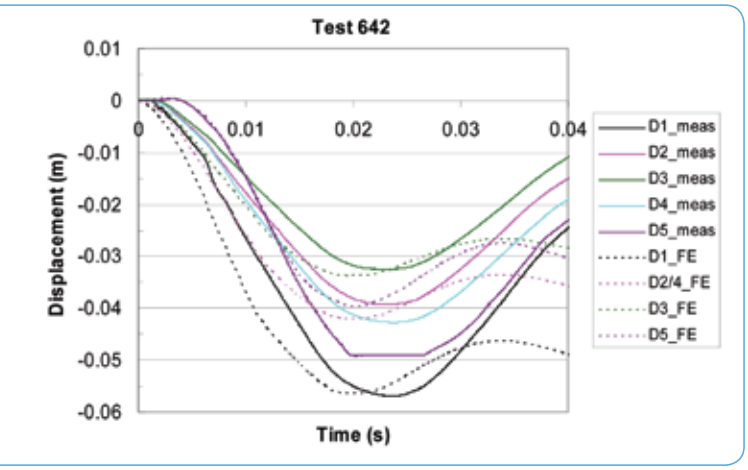


Figure. 2. Calculated and measured displacements.

The results on fuel dispersal simulations showed that sufficiently accurate predictions of spray propagation can be achieved, at least in the scale of the impact tests within the IMPACT project. The fire simulation results were both qualitatively and quantitatively plausible, although some uncertainties existed and are difficult to estimate.

A feasibility study of the FDS for the simulation of impact fire was carried out by modifying the previously studied scenario. The purpose of the work was to find out whether FDS can be used for the simulation of such a rapid fire resulting from a sudden release of small, fast moving fuel droplets. The simulations were made in the scale of Impact tests.

DISCUSSION AND CONCLUSIONS

Bending or shear failure of a reinforced concrete slab subjected to a projectile impact can be simply modeled with a two mass system. The two mass system is, however, sensitive to the assumed angle of shear failure cone and 3D finite element solutions are needed for comparison. Experimental findings can be used in defining the shear angle for different kind of slabs. Also the determination of proper damping requires carefully conducted experiments.

Based on these studies it can be concluded that four noded shell element models where the transverse nonlinear shear deformation is not considered are capable of calculating the deflection behavior of a reinforced concrete wall loaded by a deformable missile. Nonlinear analyses of reinforced structures are quite sensitive to material parameters. Especially in the case where the wall is rather weakly reinforced the tensile cracking properties of concrete dominate the nonlinear bending behavior of the wall.

The results of the preliminary simulations with FDS code show that it is a usable tool is simulating the two-phase flows involving high-speed droplets provided that initial conditions (angle and velocity of liquid release, droplet size distribution and air speed) can be specified. Given that, the formation of the water cloud and final water distribution is predicted by FDS reasonably well.

EXPLOITATION POTENTIAL

Verified numerical methods and models can be applied in designing structures to resist low velocity impact loads as well as in assessing the robustness and safety margins of existing buildings.

ACKNOWLEDGEMENTS

These projects have been funded by the State Nuclear Waste Management Fund and VTT. The authors wish to thank Prof. Markku Tuomala at Tampere University of Technology and Mr. Ari Kankkunen at HUT for their contributions to the work. The contribution of the ad_hoc group is greatly acknowledged.

REFERENCES

[1] Saarenheimo, A., Tuomala, M., Calonius, K., Lastunen, A., Hyvärinen, J. & Myllymäki, J. 2007. Numerical Studies on Impact Loaded Reinforced Concrete Walls. Proceedings of the 19th International Conference on Structural Mechanics in Reactor Technology. SMiRT 19. Toronto, Canada. 2007.

[2] Silde, A., Hostikka, S., Kankkunen, A., Hyvärinen, J. & Hakola, I. 2007. Experimental and Numerical Studies of Liquid Dispersal from a Soft Projectile Impacting a Wall. Proceedings of the 19th International Conference on Structural Mechanics in Reactor Technology. SMiRT 19. Toronto, Canada. 2007.

[3] Lastunen, A., Hakola, I., Järvinen, E., Calonius K. & Hyvärinen, J. 2007. Impact Test Facility. Proceedings of the 19th International Conference on Structural Mechanics in Reactor Technology. SMiRT 19. Toronto, Canada. 2007.

CONTACTS

Arja Saarenheimo
Senior Research Scientist
arja.saarenheimo@vtt.fi
Tel. +358 20 722 4156

Ilkka Hakola
Senior Research Scientist
ilkka.hakola@vtt.fi
Tel. +358 20 722 6685

FIRE SAFE BUILDING WITH WOOD

Esko Mikkola, Tuula Hakkarainen, Jukka Hietaniemi, Tuuli Oksanen

Use of Fire Safety Engineering (FSE) methods and product performance knowledge have been applied to show increased possibilities for use of wood (beams in large halls and wood in facades) and reduced minimum distances between low rise buildings. Also tools to predict fire performance of new products have been developed.

INTRODUCTION

Fire safety is the essential obstacle when considering an increase of wood use in building. Wood as a combustible material is often considered dangerous and difficult to manage as a building material. In the past this has caused regulations and interpretations to develop unreasonably restrictions for building with wood.

METHODS

Application of performance based design methods enable judgment of fire safety without prescriptive material-dependent engagements. These methods can be used for reviewing norms and for comparisons of fire safety levels by showing significance and magnitude of different safety measures. For development of new products with improved fire performance, physical relationships of effecting parameters are used in predicting needed modifications.

RESULTS

Analysis of wooden beams in large hall buildings has shown that wood structures are not usually critical to fire safety. If fire safety is to be improved, investments to e.g. faster detection or suppression systems would be much more efficient than investments to structural fire protection.

Wooden facades in concrete framed buildings (4 floors) cause only a limited increase in the probability of fire spread to apartments above the origin of fire. This increase is well within the limits also caused by variation in other parameters (distance to fire brigade, room shape,

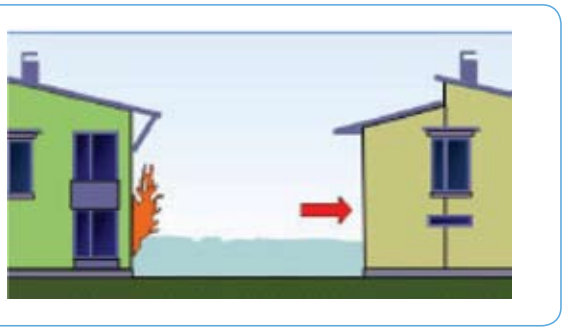


Figure 1. a) Flashover in a room scenario.

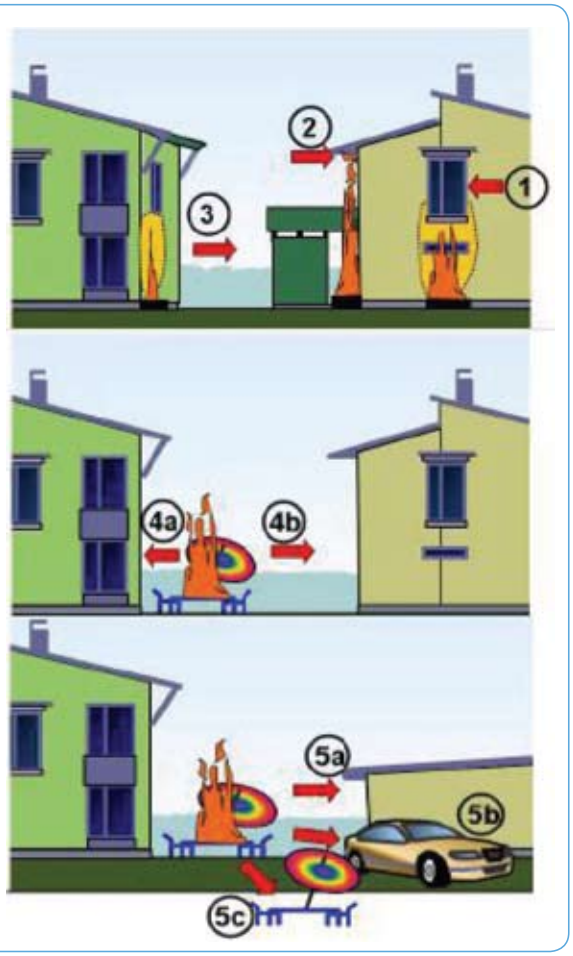


Figure 1. b) External fire exposure scenarios.

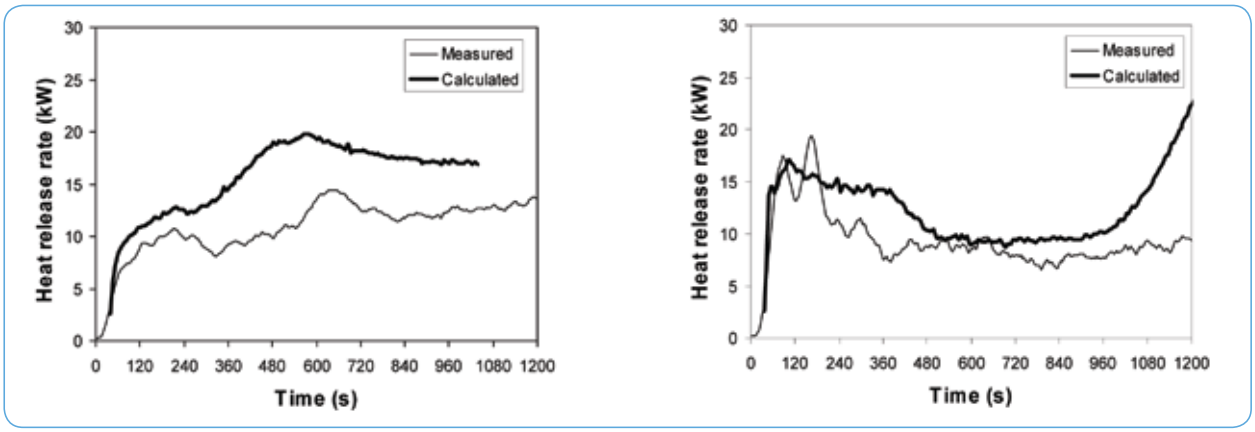


Figure 2. Comparison of measured and calculated HRR curves in SBI tests: a board with a FR treatment (left) and a special FR treated plywood (right).

window dimensions, etc.). Thus, a wooden facade does not practically increase the number of fire fatalities, and property losses can be restricted by proper construction of ventilation cavities as well as eaves and roof structures.

Based on studies of several fire scenarios (see Figure 1) in dense and low-rise buildings it was concluded that for P3 fire class buildings (detached and semi-detached houses) the minimum distance between buildings could be reduced from 8 m to 6 m [1].

Also assessment tools to estimate improvements in reaction-to-fire properties have been developed resulting in simple rules-of-thumb and a more detailed tool based on a one-dimensional thermal flame spread model. Examples of predicted and measured heat release rate curves of the European classification test (SBI) are given in Figure 2. These tools have been applied in development of plywood in co-operation with industry. A thin aluminum foil under the surface layer effectively reduces heat release making the product suitable for demanding applications [2].

DISCUSSION AND CONCLUSIONS

Results based on fire safety engineering ensure that required safety levels are reached with the proposed solutions without prescribing which materials can or cannot be used. The developed tools provide practical methods for product development of wood products with improved fire performance.

Further work is on-going in a new project entitled “Fire Resistance of Innovative Timber Structures (FireInTimber)”. Key topics of this project are fire design concepts for structures, calculation methods for structures and new products.

EXPLOITATION POTENTIAL

The results provide background data for proposals of changes in regulations enabling wider use of wood in structures and in facades as well as reducing minimum distances between low-rise buildings. Testing needs are reduced with the help of tools for product development. All of these factors result in an increased market share of buildings with wood while ensuring continued or improved fire safety.

ACKNOWLEDGEMENTS

The research has been funded by Tekes, five industry partners and VTT.

REFERENCES

[1] Hietaniemi, J. 2007. Fire safety of low-rise and dense built residential areas. (In Finnish). VTT Research Notes 2415.

[2] Östman, B., Tsantaridis, L., Mikkola, E., Hakkarainen, T., Belloni, K., Brumer, H. & Piispanen P. 2006. Innovative eco-efficient high fire performance wood products for demanding applications. Project Report 94. www.vtt.fi/proj/innofirewood/

CONTACT

Esko Mikkola
Chief Research Scientist
esko.mikkola@vtt.fi
Tel. +358 20 722 4825

RESIDENTIAL SPRINKLER SYSTEMS IN FINLAND

Jukka Vaari, Kati Tillander, Tuomo Rinne, Kaisa Belloni, Tuomas Paloposki

This project was an evaluation review of experiences on the effects of using residential sprinkler systems to prevent the loss of life.

INTRODUCTION

In 2003 the Finnish government adopted an intersectoral program concerning internal security. The main objective of the program is that, by 2015, Finland shall be the safest country in Europe. The number of annual fire related deaths in Finland (about 20 per million residents) is one of the highest in the world [1]. The introduction of compulsory smoke alarms in 1999 has not had a significant effect on this number. The primary objective of this study was to determine whether the loss of life due to fire could be reduced by the use of residential sprinkler systems.

METHODS

The objectives are achieved by analyzing existing residential sprinkler installations in Finland and abroad. In Finland, the number of residential sprinkler system installations is small, denying a statistical analysis. Selected residential sprinkler installations were examined, and available technical solutions for residential sprinkler systems were mapped. The bulk of statistical information on the effectiveness of residential sprinkler systems was found in the USA through the databases maintained by the National Fire Protection Association (NFPA).

RESULTS

The principal reason for the small number of residential sprinkler system installations in Finland is that these systems are not required by law. The only exceptions to this are wooden apartments of 3 to 4 floors high. Otherwise, the law may indirectly require the installation of a residential sprinkler system where a fire risk assessment indicates that an installation of a residential sprinkler system is the only way residents can safely exit the building [2]. This situation is most often encountered in care homes and similar facilities where the residents or patients have a limited ability to act in case of fire.

Voluntary installations of residential sprinkler systems are often rejected due to the cost involved. The cost of a residential sprinkler system is, however, dependent of the design and dimensioning of the system. In the USA, the NFPA 13D standard for domestic sprinkler systems was developed from a need to address the American fire problem in a cost-effective way. Usually the sprinkler system designed according to NFPA 13D represents about 1 % of the total building costs. Until recently, similar design guidelines have been missing from Finland. However, in 2007, the national Annex O to the CEA4001 sprinkler rules was added to provide guidance on the design and installation of relatively lightweight residential sprinkler systems. The impact of this guidance will be seen in the years to come. At the same time, the CEA4001 sprinkler rules were also amended with national Annex T containing guidelines for approving alternative water-based fire suppression systems, in particular water mist systems that represent an emerging trend in fire suppression technology.

The best available statistics concerning the effectiveness of residential sprinkler systems are available from the USA where NFPA standards for domestic and residential sprinkler systems have been available for over 20 years and where statistics on these systems have been collected for all of that time. These statistics indicate that in sprinklered residential occupancies, the probability of fire death is 50-75 % smaller compared to occupancy without a sprinkler system. In this context, occupancy without a sprinkler system means an occupancy that most likely is equipped with a smoke alarm.

DISCUSSION AND CONCLUSIONS

The study shows that residential sprinkler systems have the potential to significantly reduce loss of life due to fire. However, in the absence of legislative incentives, the cost of these systems is usually prohibitive for ordinary building owners. A large number of care homes and similar facilities are currently being equipped with sprinkler systems as a result of the mandatory fire risk assessment carried out for these occupancies. In order for residential sprinkler systems to become more commonplace, further legislative action is required. New technological developments may also provide attractive solutions at an affordable price.

EXPLOITATION POTENTIAL

This study provides the technical background to assess the current and potential impact of residential sprinkler systems on the number of annual fire related deaths in Finland. It also provides insight to the economics and cost-effectiveness of these systems. From this background, it is expected that the law enforcing agents will decide on the policies to be adopted in the future regarding the protection of residential occupancies with automatic sprinkler systems.

ACKNOWLEDGEMENTS

The research has been funded by the Ministry of the Interior, Finland's environmental administration, 10 companies from the private sector, other selected public institutes and VTT.

REFERENCES

[1] Keski-Rahkonen, O. 1997. On the risk of fire deaths in Finland and abroad. (In Finnish). Palontorjuntatekniikka 4/1997, pp. 19–25.

[2] Confederation of Fire Protection Associations Europe, Fire safety in residential homes for the elderly, Guideline 6:2004.

Figure 1. A residential sprinkler protecting the kitchen area of an apartment in a care home for the elderly.

CONTACT

Jukka Vaari
Senior Research Scientist
jukka.vaari@vtt.fi
Tel. +358 20 722 4816

INTERNET TOOL FOR CONTROLLING DOMESTIC FIRE RISKS

Tuula Hakkarainen, Hanna Hykkyrä, Kimmo Kauvo, Tuomo Rinne

An Internet tool called "Palovara" has been developed at VTT for assessing and controlling domestic fire risks. Its main purpose is to improve fire safety attitudes at homes and to support the national initiative to reduce fire risks to private citizens. "Palovara" consists of three parts: a multiple-choice questionnaire on fire risks at home, a collection of Internet links to fire safety information on various subjects, and fire simulations illustrating the development and spread of fire and smoke.

INTRODUCTION

The annual number of building fires in Finland is approximately 3500. The number of fire fatalities in Finland is about 20 incidents per million inhabitants per year, which is a relatively high number compared with many other European countries. More than 95 % of fire fatalities occur in residential buildings.

An important factor increasing the fire risks of a residential environment is the alienation from the use of fire. The utilization of fire is not a part of the everyday life of most people. As a result, for example, the insight into the ignitability of various materials becomes vague. Since not realizing fire risks at home, people may cause dangerous situations by unthoughtful action. Furthermore, knowledge on the rapid development of fire and rational action in case of fire can be inadequate.

To improve fire safety attitudes at homes and to enhance the initiative reduction of fire risks of private persons, an Internet tool for assessing and controlling domestic fire risks has been developed at VTT. The "Palovara" tool at www.palovara.fi consists of three parts: a multiple-choice questionnaire on fire risks at home, a collection of Internet links to fire safety information on various subjects, and fire simulations illustrating the development and spread of fire and smoke.

METHODS

The development of the multiple-choice questionnaire was two-phased. First, a trial version was prepared for testing and commenting by pilot users. The pilot user groups were employees of the newspaper Savon Sanomat, the City of Kuhmo and VTT, and fire officer students of the Emergency Services College. More than 300 answers and about 50 written comments were received from pilot users. On the basis of this experience, the questionnaire was revised and finalized.

The purpose of the Internet links collected to Palovara is to facilitate the information search on different topics related to the fire safety of home environment. The links arranged according to the topic lead to information on general fire safety instructions, smoke alarms and extinguishers, action in case of fire, electrical devices, smoking, candles, grilling and campfires, repair work of buildings, safety information for children, safety information in Swedish, and campaigns for safety.

Fire simulations to illustrate the development and spread of fire and smoke were performed using the Fire Dynamics Simulator (FDS) program developed at NIST [1]. The simulations describe the development of fire originating from a deep fat fryer or a sofa, scenes in a smoky staircase, and flashover of a living room. The fire load of a room and the ignitability of internal surfaces have been varied to demonstrate their effect on the fire development.

RESULTS AND DISCUSSION

The Palovara tool for assessing and controlling domestic fire risks was published in May 2008. The most important message of Palovara is that people themselves are in the key role in the improvement of fire safety at home. The front page of Palovara is shown in Figure 1.

Figure 1. Palovara front page at www.palovara.fi .

The Palovara questionnaire gives immediate feedback to the user related to each answer. At the end of the questionnaire, a report with scores on different fire safety topics is generated. The answers with voluntary background information are recorded in a database for analysis.

An extensive collection of fire safety information is provided via the Palovara Internet links. The link list can serve as a classified index when the user looks for information on a specific topic.

Fire simulation videos in Palovara provide an illustrative presentation on the development of fire. The videos help the viewer to realize that quick action and escape are important in case of fire. Furthermore, they illustrate that, unlike in disaster movies, the visibility in a fire room is very limited due to smoke.

EXPLOITATION POTENTIAL

More than 4000 people visited the Palovara site during the first month after publication. The main beneficiary of Palovara is the general public in Finland. The Palovara tool can also be used for educational purposes. By storing the answers to the questionnaire, Palovara provides future data for authorities and researchers.

ACKNOWLEDGEMENTS

This research has been funded by the Finnish Fire Protection Fund, the Department for Rescue Services of the Ministry of the Interior and VTT. The cooperation of the Finnish National Rescue Association SPEK, the Emergency Services College, and the Federation of Finnish Financial Services is gratefully acknowledged.

REFERENCES

[1] Fire Dynamics Simulator program, National Institute of Standards and Technology (NIST), 2008, http://fire.nist.gov/fds/

CONTACT

Tuula Hakkarainen
Senior Research Scientist
tuula.hakkarainen@vtt.fi
Tel. +358 20 722 4828

A NUMERICAL TOOL FOR EVACUATION SIMULATIONS

Timo Korhonen, Simo Hostikka

An evacuation simulation module has been developed at VTT for the Fire Dynamics Simulator fire model. The key features of the new computational tool are: agent-based simulation of humans as individuals, ability to simulate large and dense crowds and identification of hazardous clogging situations by the inclusion of real physical forces appearing in the egress situations, capability to consider socio-psychological effects like small-groups and exit selection, a platform for implementation of more complicated phenomena like the majority and minority effects, and interaction between fire and humans. New experimental techniques for monitoring the real-world evacuations have been developed in order to validate the developed model.

INTRODUCTION

Numerical simulation of fire and evacuation processes is an essential part of the modern, performance based building design process. In this work, a new evacuation simulation tool has been developed with three main features: i) The tool can be used to simulate large and high density crowds, where the movement dynamics is affected by the crowd pressure. ii) The interaction between the evacuees and fire can be taken into account by simultaneous simulation, thus allowing a full coupling between the fire conditions and the human behavior. iii) The decision making processes of the evacuees are modeled taking into account socio-psychological aspects like the importance of familiar people (group dynamics) and places. The simulation tool has been implemented to the Fire Dynamics Simulator (FDS) software, and is called FDS+Evac. A series of evacuation experiments has been performed to gain validation data for the model.

MODEL DEVELOPMENT

In the FDS+Evac tool, each human is followed by an equation of motion. This approach allows each human to have her/his own personal properties and escape strategies, i.e., persons are treated as auto¬nomous agents [1]-[4]. By using FDS as the platform of the evacuation calculation there is direct and easy access to all local fire related properties, like gas temperature, smoke and gas densities, and radiation levels. Fire influences evacuation conditions and humans may influence the fire. Game theoretic reaction functions and best response dynamics are applied to model the exit route selection of evacuees [5] [6]. The exit selection algorithm of the agents uses smoke density to calculate the visibility of the exit doors.

EXPERIMENTAL

Two different types of evacuation situations were studied experimentally [7]. The first type was evacuation drills which are normally carried out as part of the safety training of the staff in public buildings and workplaces. In evacuation drills, careful preparation of the observations is possible. The second type was actual evacuations, where the decision making processes are likely to be similar to what they would be in case of a real fire. The main techniques used for the observation of evacuation drills were video cameras and Radio Frequency Identification (RFID). The utilization of surveillance camera recordings was studied in the context of actual evacuations.

RESULTS

The FDS+Evac tool has been verified against the geometrical and logical test cases by IMO [8] and analytical solutions for toxicity effect (FED) and walking speed reduction due to the smoke. The tool has been validated against experimental results and other, commercial evacuation codes. The tool was made publicly available as part of FDS for the whole fire community.

EXPLOITATION

The FDS+Evac tool can be used to perform evacuation simulations in a wide range of different applications. So far, in Finland it has been used in the analysis of e.g. a historical museum, large shopping center, concert hall and a railway station. Applications in other countries are numerous.

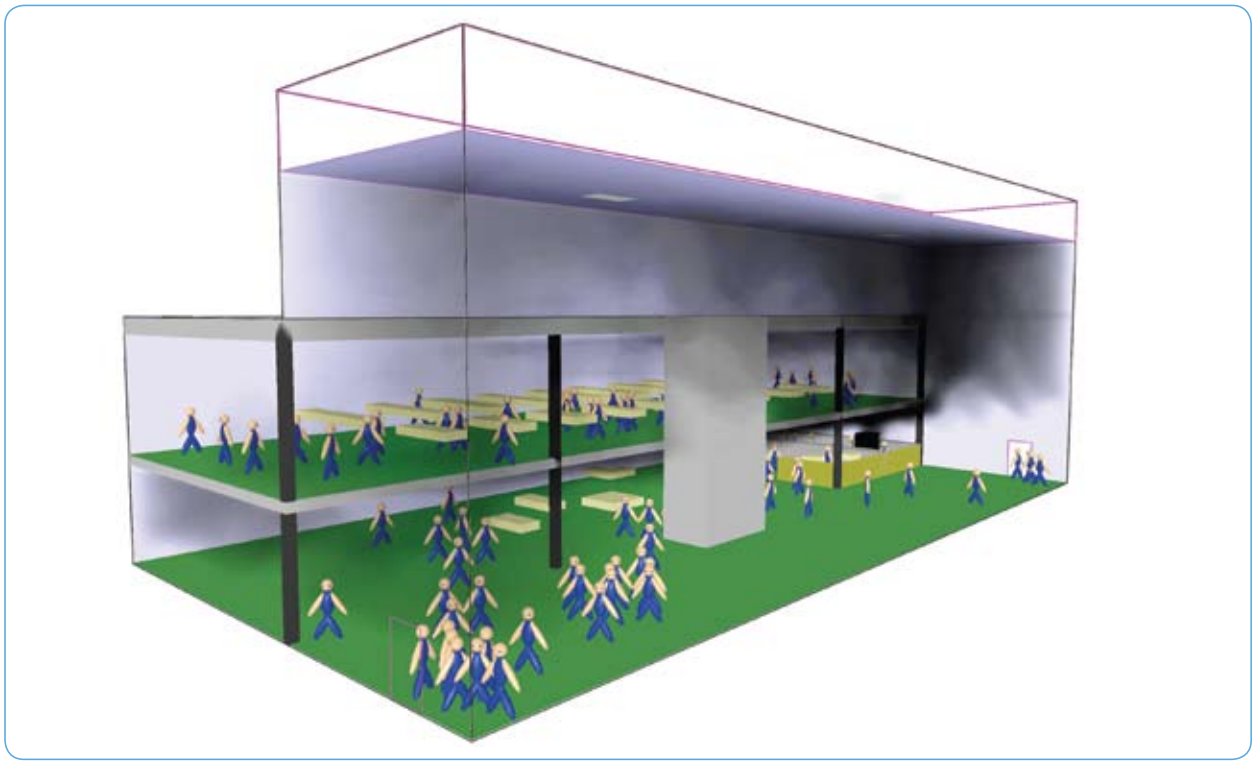


Figure 1. An example of evacuation simulation using FDS+EVAC.

ACKNOWLEDGEMENTS

The research has been funded by Tekes, the Finnish Fire Protection Fund, the Ministry of the Environment, the Academy of Finland and VTT.

REFERENCES

[1] Korhonen, T., Hostikka, S. & Keski-Rahkonen, O. 2005. A proposal for the goals and new techniques of modelling pedestrian evacuation in fires. In Gottuk, D. & Lattimer, B. (eds.), 8th Int. Symp. Fire Safety Science. International Association of Fire Safety Science, 2005. pp. 557–569.

[2] Korhonen, T., Hostikka, S., Heliövaara, S., Ehtamo, H. & Matikainen, K. 2007. Integration of an Agent Based Evacuation Simulation and the State-of-the-Art Fire Simulation. 7th Asia-Oceania Symposium on Fire Science & Technology, Hong Kong, 20–22 September 2007.

[3] Korhonen, T., Hostikka, S., Heliövaara, S., Ehtamo, H. & Matikainen, K. 2007. FDS+Evac: Evacuation Module for Fire Dynamics Simulator. Interflam2007: 11th International Conference on Fire Science and Engineering, Interscience Communications Ltd., London, UK, 2007. pp. 1443–1448.

[4] Korhonen, T., Hostikka, S., Heliövaara, S. & Ehtamo, H. 2008. An Agent Based Fire Evacuation Model. 4th International Conference on Pedestrian and Evacuation Dynamics, Wuppertal, Germany, 27–29 February 2008.

[5] Heliövaara, S. Ehtamo, H. Korhonen, T. & Hostikka, S. 2008. Modeling Evacuees' Exit Selection with Best-Response Dynamics. 4th International Conference on Pedestrian and Evacuation Dynamics, Wuppertal, Germany, 27–29 February 2008.

[6] Korhonen, T., Hostikka, S., Heliövaara, S. & Ehtamo, H. 2008. FDS+Evac: Modelling Social Interactions in Fire Evacuation. Proceedings of the 7th International Conference on Performance-Based Codes and Fire Safety Design Methods, SFPE, Bethesda, MD, 2008. pp. 241–250.

[7] Rinne, T., Hostikka, S., Paloposki, T., Korhonen, T., Saari, J.-M. & Heliövaara, S. 2008. Application of RFID and Video Imaging on Evacuation Observations in Offices and Public Buildings. To appear in 9th Int. Symp. Fire Safety Science. Karlsruhe, Germany, International Association of Fire Safety Science. 22–26 September 2008.

[8] Interim guidelines for evacuation analyses for new and existing passenger ships. 2002. MSC/Circ.1033. London: International Maritime Organization.

CONTACT

Timo Korhonen
Research Scientist
timo.korhonen@vtt.fi
Tel. +358 20 722 4945

RESEARCH ROADMAP FOR ICT ENABLED ENERGY-EFFICIENT BUILDINGS

Matti Hannus, Abdul Samad (Sami) Kazi

The European project "Research Roadmap for ICT Enabled Energy-Efficient Buildings," REEB [1], defines a research roadmap in the field of Information and Communications Technology (ICT) support for energy efficiency in the built environment.

The project aims at coordinating, at the EU-wide level, research and technology development (RTD) in the field of ICT support to energy-efficiency in the built environment. The project's main objectives cover:

- Development of a Strategic Research Agenda and supporting detailed Implementation Activity Plans for R&D and innovation in ICT supporting energy-efficient smart facilities with a focus on ICT supporting roadmaps for energy efficiency measures/policies and strategies for improving energy-efficiency both in new and renovated buildings.
- A comprehensive coordination of information exchange and dissemination between energy related ICT projects; organization of events and communication channels for promoting and stimulating the innovative use of ICT in the sustainability area and bring together all stakeholders from the enlarged EU.

These are to be achieved by:

- Setting up a community dedicated to innovative use of ICT supporting energy efficiency in construction, bringing together key actors from ICT, built environment and energy business sectors.
- Coordinating information exchange between RTD initiatives and stakeholders.
- Identifying best practices in the use of ICT, standardization and regulations.
- Establishing an inventory of RTD initiatives and results.
- Developing a vision, a research roadmap and recommendations for implementation actions, including training and education.

The main result of the project will be a proposed research strategy in the field of ICT support for energy efficiency in the built environment. Implementations are expected in European and national research programs, ICT applications, building automation and control, business models, standards and regulations, public procurement and education & training, etc.

It is expected that the project will be a key contributor to the EU world-leadership in ICT enabled energy efficiency through intelligent solutions. In addition, it will support the achievement of Europe's objective to save 20% of energy consumption by 2020 by widening take up of ICT-based energy systems and services for the future energy neutral and energy positive buildings.

ACKNOWLEDGEMENTS

The research is funded by the European Commission and VTT and will be completed in spring 2010. The project consortium includes eight partners from six countries.

REFERENCES

[1] Public web site of REEB project, 2008, http://ict-reeb.eu/

CONTACT

Matti Hannus
Chief Research Scientist
matti.hannus@vtt.fi
Tel. +358 20 722 6948

INTELLIGENT USE OF BUILDINGS' ENERGY INFORMATION

Mia Ala-Juusela, Matti Hannus, Krzysztof Klobut, Janne Peltonen, Teemu Vesanen

The energy consumption in the operational phase of buildings is one of the major contributions to energy use in Europe. The improvement of energy efficiency in the renewed stock is too slow considering the ambitious goal to improve the energy efficiency by 20 % before 2020. By using the existing building stock more efficiently with the help of the new tools and business models developed in the IntUBE project, the potential to reach the goal is considerably increased.

The project "Intelligent Use of Buildings' Energy Information (IntUBE)" [1] began in 2008. The participants will develop tools for measuring and analyzing building energy profiles based on user comfort needs. These tools will offer efficient solutions for better use and management of energy use within buildings over their life-cycles. Intelligent Building Management Systems will be developed to enable real-time monitoring of energy use and optimization. They will, through interactive visualization of energy use, offer solutions for user comfort maximization and energy use optimization.

Neighborhood Management Systems will be developed to support efficient energy distribution across groups of buildings. These will support timely and optimal energy transfers from building to building based on user needs and requirements. New Business Models to make the best use of the developed Management Systems will be created.

These results will be demonstrated in several pilot cases: social housing in Spain, office buildings in Finland and in a further case to be defined during the project.

In addition, other results will include: simulation and monitoring tools with visual user interfaces and ICT platform for service provision. The results of the project are expected to enhance the comfort levels of building users, as well as reducing overall energy costs through better energy efficiency.

The results of the project will benefit many actors in the building sector, including owners, users, energy service providers, maintenance service providers etc. in the form of well-performing buildings that optimize use of the natural resources (especially energy), resulting in less environmental effects and reduced life-cycle costs of energy use. The SMEs of the consortium will be able to extensively exploit the results in their business.

ACKNOWLEDGEMENTS

The research is funded by the European Commission, VTT and all participants, and will be completed in spring 2011. The project consortium consists of 12 partners from nine countries.

REFERENCES

[1] Public web site of IntUBE project, 2008, www.intube.eu.

CONTACT

Mia Ala-Juusela
Senior Research Scientist
mia.ala-juusela@vtt.fi
Tel. +358 20 722 6947

NEW INDUSTRIALIZATION IN SUPPLY

Kalle Kähkönen, Kaisa Belloni

The main objective of this international joint research effort is to develop a better understanding of the challenges in new industrialized supply, focusing on management, governance and organization of integrated supply, and, potentials and barriers for system concepts in the supply chain. Industrialized supply refers here to "packaged" complex deliveries that often comprise design, manufacturing, transportation and the required in situ installations. It has been a general trend also in construction to move this direction but the practical evidence and experience shows that the current supply management models and practice based on those is inadequately tackling all problems and challenges faced by companies.

In order to realize a delivery of a high quality cost efficient complex built product in an industrialized manner, three basic elements need to be aligned; i) a supply of subsystems and components, ii) a design synthesizing customer demands and recurring element and iii) a production, mixing on site production processes with assembly of sub-systems.

Quite a lot of focus in the trend of industrialized construction has been on design. However, it can be argued that advances in design need to be merged and balanced with new concepts of supply and production planning and execution.

This research project called SUPPLY is an example of concept development and early field testing of those results with company representatives. The main objective of the Finnish portion of this project is to present stochastic process modeling as an approach in the development of industrialized supply services. It is considered that such services have usually a repetitive nature and thus it is valuable to understand the statistical reliability of the process. The widely used traditional business process modeling approaches produce passive models that shall not change or react in any case. On the contrary, an active model acts by itself or reacts when the user interacts with it. This is seen as a way to understand the behavioral aspects of the processes that seem to be omitted in traditional business process models. Key elements of stochastic process modeling have been developed that form a basis for practical implementations of stochastic modeling in a company environment.

The project's modeling study uses Microsoft Project and @Risk for Project Professional software packages. The first software is a well-know tool for project management and for preparing models of projects for this purpose. The second software is an add-on tool for the first software for providing a stochastic dimension for a standard project management package. It can be used for demonstrating the appearance of the stochastic modeling key elements presented earlier. From a research viewpoint, the main interests in the case studies are the lessons to be learned from presenting the stochastic objects alongside the deterministic ones.

ACKNOWLEDGEMENTS

The SUPPLY project includes six partners from 4 countries, with the Finnish part of the research financed by Tekes and VTT. The project will be completed in autumn 2009.

REFERENCES

[1] Kähkönen, K. & Kazi, A.S. 2007. Stochastic processes modelling in the development of standardised services, in Kazi, A.S., Hannus, M., Boudjabeur, S. & Malone, A. (Ed) Open Building Manufacturing, Finland, pp. 171-188.

CONTACT

Kalle Kähkönen
Chief Research Scientist
kalle.kahkonen@vtt.fi
Tel. +358 20 722 4560

PLUG & PLAY INDUSTRIALIZATION OF BUILDING COMPONENTS

Esa Nykänen, Jyri Nieminen, Abdul Samad (Sami) Kazi

European countries are slowly transforming the building construction sector into an industrialized sector while the building component sector has succeeded decades ago. The "Plug & Play" project proposes to build on the success of the building component industry as well as from the machining and automotive industries, instead of correcting the failure of the construction sector. The industrialization affects all the current players and business models as well as it creates new e-business models, and open up for new players in the building sector.

The Plug & Play project is a feasibility study proposing extension of the successful industrialization of building components to building a complete house from components. The aim is to transform the intelligence, competences and skills of the construction process into intelligently designed components of the self assembly kind, just as IKEA did with furniture.

The projects technical focus is on a USB-inspired interface between physical building components. An open source physical standard interface makes it possible to assemble components from different industries. It also allows disassembling components, moving them and reassembling them differently just like a LEGO building. Similar to the real hardware components, related engineering software components shall be plugged together in order to build simulation and assessment models. This will be the first ever attempt to fully industrialize maintenance, remodeling and reconstruction of building, a sector of the same magnitude as the new buildings sector.

VTT's responsibility in this work includes defining drivers, barriers and potential markets for plug and play houses. The work had already resulted in a roadmap supporting the connection all the way from products and technologies to user needs and behavior (drivers, barriers, enablers, etc.). The project will also result in information regarding topics such as interoperability of design data, parametric design and a market study for plug and play housing.

Research has shown that the technology alone is not the primary key for new innovations to succeed. There are lots of variables effecting customer decisions and there are also many phases in the continuous innovation of which none should be neglected. It has been concluded that a product has to fulfill many needs in totally different areas in order to "sell" for instance sustainability.

ACKNOWLEDGEMENTS

The authors wish to thank all five project participants from four countries as well as the Finnish steering group members from three companies and Tekes. This project will be completed in 2009.

REFERENCES

[1] Halme, M., Nieminen, J., Nykänen, E., Sarvaranta, L. & Savonen, A. 2005. Business from Sustainability. VTT Research Notes 2310.

[2] Sami Kazi et.al. 2007. Stratcon –FIATEC workshop report, http://cic.vtt.fi/projects/stratcon/const_IT_ws_22_24082007_report.pdf

CONTACT

Esa Nykänen
Senior Research Scientist
esa.nykanen@vtt.fi
Tel. +358 20 722 6914

REAL-TIME COMMUNICATION OF SKILL KNOWLEDGE WITHOUT HUMAN INSTRUCTOR

Stephen Fox

Currently, manual skills are often communicated through one-to-one interaction between a person with manual skills (e.g. a craftsperson) and a person lacking manual skills (e.g. an apprentice). The shortage of skilled people means that there is a shortage of people to communicate manual skills. Moreover, those people who are available may have limited aptitude, motivation and/or time to communicate those skills. Accordingly, real-time communication of manual skills without dependence on human instructors has the potential to reduce skill shortages. However, the real-time communication of manual skills without human instructors is a formidable challenge because manual skills involve tacit, procedural (how-to) knowledge that is difficult to verbalize. Accordingly, manual skills are often communicated through repeated task-specific physical demonstrations by an instructor. Moreover, initial physical demonstrations are followed by trainee-specific demonstrations as part of instructor's feedback following instructor's observation and evaluation of trainees' practice.

The research project "Real-time Communication of Skill Knowledge without Human Instructor" has investigated the need for, and feasibility of, real-time communication of manual skills without human instructors. The research to date has involved organizations investing in technological advances in order to survive and prosper in the face of intense international competition. Also, professionals in the training of manual skills were consulted in order to explore the need for real-time communication without human instructors. Subsequently, methods and technologies which have potential to enable the real-time communication of skill knowledge without human instructors were investigated. This part of the research involved the development of ontology with experts in computer vision, and experts in computational semantics and pragmatics.

This project is still in progress. Findings to date suggest that there will continue to be a need for manual skills in many occupations. Further, findings suggest that there is a pressing need for real-time communication of manual skills without human instructors. Moreover, the use of natural language was found to be a barrier to the communication of manual skills. Assessment of feasibility led to the identification of several methods and technologies that have the potential to enable the real-time communication of manual skills without human instructors.

Overall, it was concluded that the principal barrier to the real-time communication of manual skills by computer system is the difficulty of modeling and evaluating human motion. Until evaluation using computer vision is feasible in on-the-job training situations, the real-time communication of manual skills without human instructors will only be feasible in controlled environments such as training centers.

There is an on-going skill shortage in many occupations. Accordingly, there is a global market for methods and technologies that can enable the real-time communication of skill knowledge without human instructors.

ACKNOWLEDGEMENTS

The research has been funded by Tekes and VTT.

REFERENCES

[1] Fox, S., Ehlen, P., Purver, M., Bratt, E., Frampton, M., Kobayashi, I., Jones, B., Monroe, R. & Peters, S. 2008. Applying computational semantics to the real-time communication of skill knowledge. VTT Working Paper 101.

CONTACT

Stephen Fox
Senior Research Scientist
stephen.fox@vtt.fi
Tel. +358 20 747 4948

RAPID ECONOMIC PRODUCTION OF SPECIAL PRODUCTS

Stephen Fox, Petri Honkamaa, Niklas Lindfors, Jouko Virta

Throughout the world, and across industries, there is a fundamental trade-off between individual customer authority and production times, cost, and quality. In simple terms, the more authority individual customers have over design and/or production - the more they have to pay and/or the longer they have to wait to get what they want. This project addresses that fundamental trade-off through action research.

Products can be called special when individual customers are given authority over their design and/or production. Smaller special products, such as jewelry and clothes, are made using bespoke processes. Larger special products, such as industrial engines and ships, are made using engineer-to-order processes. Often, the production times and costs of special products are much higher than the production times and costs of mass custom products. This is because mass customizers do NOT offer authority to individual customers. Rather, mass customizers offer choices from their pre-determined list of options. Companies that make special products continue to be reliant upon subtractive manufacturing processes, such as cutting and drilling, and upon the manual skills of human operatives. Moreover, the planning and costing of special production is extremely challenging because each product has to be engineered individually. This means that standard bills of materials and process routes can not be developed once and used repeatedly.

Five Finnish companies that offer special products and face global competition are participating in the project "Rapid Economic Production of Special Products", SPECIAL. Through action research where the focus subject is influenced or changed, experts are contributing to a range of process improvements within these companies. In particular, dynamic systems modeling and activity based costing exercises have been carried out to improve planning and costing. Foreign collaboration has focused on developing innovative solutions to companies' reliance on the manual skill of human operatives.

This project is still in progress. Companies have achieved improvements to various aspects of their operations including order processing, design development, factory layout, machine use, and product costing.

The fundamental trade-off between individual customer authority and production times, cost, and quality can be managed through combinations of innovations with origins in different disciplines and industries.

The emerging market-pull paradigm of user-centered business relies upon giving individual customers more authority than can be offered through mass customization. Accordingly, there is global exploitation potential for the types of solutions developed in this project.

ACKNOWLEDGEMENTS

The research has been funded by Tekes, VTT and 5 participating companies. The research and development has been carried out with Fraunhofer Institute in Germany and Stanford University in the USA.

REFERENCES

[1] Remes, P. 2008. Individual products have selling power for Finland in the future. (In Finnish). Kauppalehti 28.03.2008.

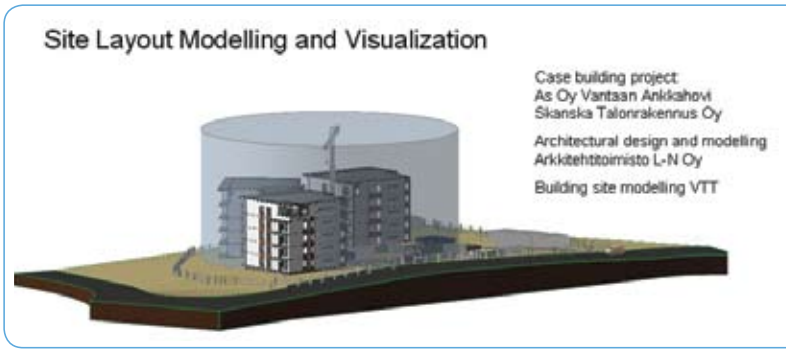
[2] Fox, S. 2007. User-centred products: a review of fundamental challenges. Engineering Management, Vol. 17, No 3, pp. 32–36.

CONTACT

Stephen Fox
Senior Research Scientist
stephen.fox@vtt.fi
Tel. +358 20 747 4948

BUILDING INFORMATION MODEL PROMOTING SAFETY IN THE CONSTRUCTION SITE PROCESS

Tarja Mäkelä, Kristiina Sulankivi



Building information modeling (BIM) has become more common in the construction sector in recent years. It started in architectural design but today BIM has been also used in structural design and production planning phase. There has been research in that area but the research demand is large. BIM offer a new kind of possibility to connect safety more closely to the planning and construction phases. This is the right moment to improve the safety management as a part of BIM process when we are creating a systematic mode of BIM operation. When using BIM in the planning phase it means that all the planning has to be done earlier than usual. Early planning promotes safety and risk management, because the basis is to foresee things. BIM technology and applications for the construction site process are just now being developed and there should be strong investment to safety as a part of that development. It is much harder to address safety matters afterwards. A 3D site plan is remarkable more illustrative than traditional 2D site plan. It offers totally new possibilities e.g. free choice of views and perspective to a plan and supports effectively all communication.

The main objective of the "Safety Building Information Model (BIM)" research project is to encourage and develop utilization of BIM technology in construction planning and management - from the viewpoint of occupational safety. In the project, the potential of BIM in safety management is studied, 3D site planning objects are collected and created, and 3D building site modeling and visualization tests are done. As a result, there will be an object library suitable to re-use in coming building projects and demonstrations of possibilities of BIM technology in safety management as well. In addition, the needs, ideas and possibilities of BIM based safety management are reported.

The first aim in this project is to find the potential of BIM technology to promote occupational safety in the construction sector and the possibilities of a 3D site layout planning. The Safety BIM project started by studying the present know-how of the research area and the information technology and applications. The research methods include literature study, interviews and workshops to innovate new applications, needs and possibilities by using BIM to promote safety now and in the future. The next step is to demonstrate the 3D site plan using a real case project and its data. The base was the original 2D site plan and the architectural model of the building. The 3D site plan objects are modeled using ArchiCAD software. As a result there are construction machines and equipments, material storing and transportation areas in the model. Good examples of risk management matters are the 3D visualization of crane reach, pedestrian and vehicular traffic zones and fall protection in construction with prefabricated units. The second aim is to research and find ideas for the safety related activities planning and management by means of 4D modeling. One method is to test different ways to visualize safety tasks in a 4D site plan.

The research project is funded by VTT, The Finnish Work Environment Fund and Skanska. The work will be completed at the end of 2008.

CONTACT

Tarja Mäkelä
Research Scientist
tarja.makela@vtt.fi
Tel. +358 20 722 3308

SUPPORT ACTION FOR INNOVATION DRIVEN CLUSTERS IN CONSTRUCTION

Abdul Samad (Sami) Kazi, Esa Nykänen

The project "Support Action for Innovation Driven Clusters in Construction", REGCON [1], is a support action project focusing on using a mentoring model to develop, maintain, and sustain innovation driven clusters in five European countries.

The driving idea of the project is the advancement of the concept of "clustering" across regions of Europe with a thematic focus on construction. The construction sector is both dynamic in creation of growth and employment (with 11.8 million operatives directly employed in the sector, it is Europe's largest industrial employer accounting for 7% total employment and 28% of industrial employment in the EU-15) but relatively backward in absorbing innovation. The Strategic Research Agenda prepared by the European Construction Technology Platform sets up ambitious but realistic goals to transform this traditional sector into being knowledge driven and R&D based. The REGCON project activates those goals from regional level.

This project relies extensively on stakeholder participation through different types of cluster development, maintenance, and sustenance workshops and meetings. It has four main strategic objectives:

- Methodology development – designing a common methodological framework especially adapted for construction cluster development in the EU,
- R&D based cluster formation – implementing the above construction cluster model in pilot cases in the EU regions,
- Mentoring – developing and exploiting a mentoring model,
- Cluster sustainability – securing the sustainability of the clustering exercise by linking it to public and private funds and by designing the appropriate organizational structure to host the cluster, following the project end.

Key results expected from the project include:

- Robust methodology and framework for cluster development and management with the European construction industry.
- Advancement of existing construction clusters in Finland and Slovenia, and their mentoring towards new construction clusters in Greece, Poland, and Spain.
- Strategic research agendas and implementation action plans for each of the clusters

These results are expected to serve as a possible basis for the formation of other regional/national construction clusters in different European countries. The strategic research agendas and implementation action plans will serve as a basis for research, development, and take-up activities in a concerted and coherent form for cluster members, and will furthermore support regional, national, and European funding agencies to provide innovation financing to key topics of interest within respective clusters.

This project is funded by the European Commission and VTT The project consortium includes 15 partners from five countries. The project will be completed in January 2010.

REFERENCES

[1] Public web site of the REGCON project, 2008, www.regcon.org.

CONTACT

Abdul Samad (Sami) Kazi
Chief Research Scientist
sami.kazi@vtt.fi
Tel. +358 20 722 6666

CONSTRUCTION AND REAL ESTATE - DEVELOPING INDICATORS FOR TRANSPARENCY

Pekka Huovila, Tarja Häkkinen, Veijo Nykänen, Jorma Pietiläinen

The project entitled "Construction and Real Estate – Developing Indicators for Transparency (CREDIT)" delivers indicators and tools for assessing and benchmarking building performance.

The goals of this project are to develop methods and tools for

- capturing end user requirements, identification and quantification of value creation in real estate and construction
- compliance assessment and verification methods
- defining and developing benchmarking methods and building performance
- benchmarking internationally key building performance indicators.

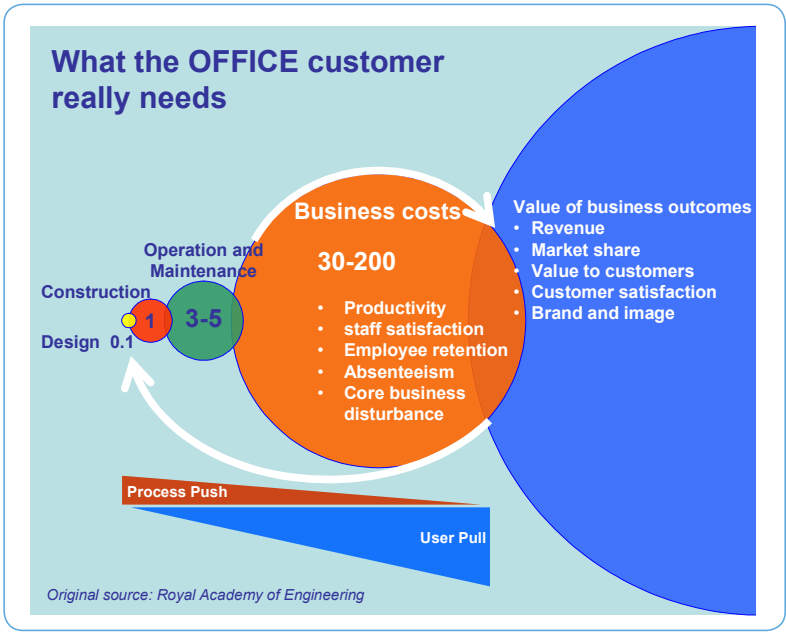
The selected approach is action research on case studies combined with development of the core research topics. The pilot cases are clustered based on building types and information about findings is exchanged between participating Nordic and Baltic countries (Finland, Denmark, Norway, Sweden, Iceland, Lithuania, Estonia).

The project will result in methods and tools for

- capturing end user needs
- building performance indicators and value creation
- life-cycle commissioning processes
- benchmarking procedures and tools.

These results will be validated in practice by the participating industrial partners. In addition, recommendations are drawn for cross-border benchmarking of core performance indicators.

Traditionally key performance indicators have focused on production and delivery process. The metrics in this project emphasize end user satisfaction and value creation.



Each participating industrial partner will exploit selected indicators and tools in their pilot projects. The results are thereby brought into their business practice. The Finnish Ministry of the Environment actively participates in the project's Reference Group, and thus considers how to exploit the results in development of regulative guidance and incentives.

ACKNOWLEDGEMENTS

The VTT portion of this international research is funded by Tekes, six Finnish industrial partners, and VTT. The project will be completed in autumn 2009.

CONTACT

Pekka Huovila
Chief Research Scientist
pekka.huovila@vtt.fi
Tel. +358 20 722 5903

CHINESE-FINNISH COLLABORATION ON SUSTAINABLE COMMUNITY RESEARCH

Pekka Huovila, Miimu Airaksinen, Ulla-Maija Mroueh, Jyri Nieminen

A framework and collaboration platform was created for joint Chinese-Finnish research on sustainable communities. The overall objective is to support sustainable development in the built environment with the help of new technologies, processes and collaboration models. The ambitious long term objective is to deliver, renovate, operate and maintain zero emission cities with energy positive buildings that support individual well-being.

This study was initiated by Tekes, the Finnish Funding Agency for Technology and Innovation, to address sustainable community technology research. The coordinating research partners are Tongji University in Shanghai and VTT in Finland. The planned research activities are to be financed both in China and in Finland. Future research collaboration plans include expert workshops and research exchange.

The study was carried out by visiting the Tongji University and exchanging information via email with Tongji professors. An ambitious research framework was created, and Chinese proposals as interesting sustainable community research projects were adjusted to fit with the created framework that meets the objectives of the Tekes technology program. Also support to obtain Chinese funding for Tongji was given during the preparation.

The biggest challenges in this project and future cooperation lie in adopting new procedures and solutions in the Chinese culture, tradition and building practice in a rapidly changing market environment.

The proposed research has significant potential for positive environmental impacts even at a global scale. Finnish industrial partners are invited to join the collaboration. Education is one of the means to support the sustainable process of successful implementation of new technologies.

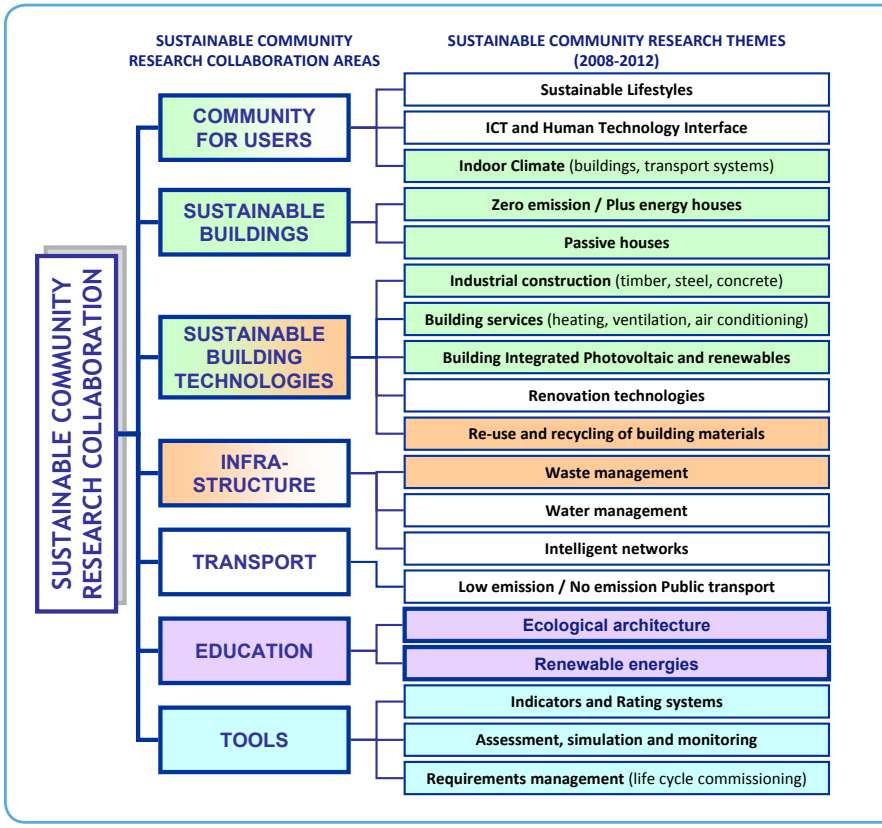


Figure 1. Framework for sustainable community research collaboration.

ACKNOWLEDGEMENTS

The research is co-funded by Tekes and VTT.

CONTACT

Pekka Huovila
Chief Research Scientist
pekka.huovila@vtt.fi
Tel. +358 20 722 5903

INNOVATIVE SERVICE SOLUTIONS FOR THE REFURBISHMENT OF TECHNICAL INSTALLATIONS

Satu Paiho

In 2006 the Finnish renovation construction market was about 7500 M€. The volume of the renovation building services was about 1500 M€, of which the share of networks (water supply, plumbing, sewage water, ventilation etc.) was about 800 M€.

The project entitled "Innovative Service Solutions for the Refurbishment of Technical Installations (INSERT)" [1] aims to:

- Develop methods and operation models for purchasing plumbing renovations
- Improve productization and commercialization of different plumbing renovation services
- Examine and test new business models and service solutions
- Develop new illustrative communication solutions for sharing up-to-date information between different parties within a renovation project

The renovation process and the technical solutions in plumbing renovation are parsed in a modular way. The goal of the project is to divide the decision-making into clear phases and to describe different renovation solutions by means of content, extension and influence.

The technical solutions emphasize model solutions and prefabrication methods in order to ensure flexibility and mass customization for different purposes. Those different renovation needs in blocks of flats that have a direct link to plumbing renovation are taken into account in the project. The aim is to examine the suitability of the operation models in broader renovation actions.

In the research and testing of the new business models, the information management in the different phases of the renovation process and the new integrator role are changing the existing role towards a more knowledge-intensive service provider role.

The results of the project will have a wide range of impact areas, including the following:

- Inhabitants: influence, awareness, better operational quality, increase in the value of the dwelling
- Blocks of flats and property companies: clearer decision making, systematic customer process, product descriptions for different renovation phases, possibility to use new roles/doers
- Service providers: market image with productized services, new business opportunities
- Other actors: development bases for new products or redevelopment of existing products, methods and models for risk management, increase in the value of the business in general.

ACKNOWLEDGEMENTS

The project is funded by Tekes, VTT, and 12 other partners and will be completed in 2009.

REFERENCES

[1] Public web site of the INSERT project, 2008, http://linjasaneeraus.vtt.fi

CONTACT

Satu Paiho
Senior Research Scientist
satu.paiho@vtt.fi
Tel. +358 20 722 4908

ASSESSMENT AND IMPROVEMENT OF THE EPBD IMPACT

Jari Shemeikka

The project "Assessment and Improvement of the EPBD Impact (ASIEPI)" will give input to the envisaged update of the Energy Performance of Buildings Directive (EPBD), to the reporting of building related performances in the context of the Energy Services Directive and to the implementation of the measures foreseen in the EU Action Plan for Energy Efficiency.

The objectives of the ASIEPI project [1] are:

- To develop a concept for inter-comparison and benchmarking of EPBD requirements in the Member States (MS);
- To obtain a good overview how compliance and control of legislation is done in the individual MS with suggestions for improvement;
- To raise awareness about the difficulties and possible solutions for:
  - limiting thermal bridges
  - improvement of building airtightness and summer comfort
  - using the EPBD implementation as driving force for innovation in energy efficient technologies.

The ASIEPI project will help the envisaged update of the EPBD in 2009 and to the reporting of building related performances in the context of the Energy Services Directive. The project should provide input for several of the measures foreseen by the EC in the Action Plan for Energy Efficiency.

The main outcome is a set of instruments improving the impact of the EPBD for new constructions and renovations:

- a benchmarking method in order to compare the current EP requirement levels in the MS and to be able to follow the evolution of the requirements over time.
- information papers, internet conferences, presentations on demand, databases, reports, participation in conferences and workshops focussing on how the EPBD can be correctly implemented with emphasis on a better implementation of technical issues and on compliance and control.

This outcome should result in:

- Accelerated awareness raising on potential problems with national approaches
- Accelerated identification of appropriate solutions in order to improve national approaches;
- Accelerated increased impact of EPBD implementation.

The project results will be used by (1) the Member States and their national stakeholders responsible for the implementation and improvement of EPBD and (2) European Commission. The project results will summarize the current state of implementation, the possibilities for future development and improvements, all of which support the Action Plan of Energy Efficiency of EC

This project is funded by EU's Intelligent Energy Europe programme and several companies around Europe. The project will be completed in spring 2010. The project consortium includes 17 partners from 14 countries along with support from 11 other organizations.

REFERENCES

[1] Public web site of the ASIEPI project, 2008, www.asiepi.eu/.

CONTACT

Jari Shemeikka
Senior Research Scientist
jari.shemeikka@vtt.fi
Tel. +358 20 722 4921

APPLICATION OF ICT AND AUTOMATION IN GROUND IMPROVEMENT

Pekka Kilpeläinen

The main goal of the POHVA2 project is to develop new methods for applying automation and ICT more effectively in ground improvement. This particular project started in 2007 as a follow up to the earlier POHVA1 project [1] aimed at developing actual ground improvement processes. The focus in the new project is in ground strengthening method: deep stabilization and foundation engineering method: pile driving. In the POHVA2 project various new measuring and control methods are studied. The goal is also to develop prototypes and arrange tests at real work sites.

A common feature in both of these methods is positioning of the piles or columns as planned. A 3D model of the piles/columns is created in the design phase. This 3D model with a real time positioning system such as RTK-GPS (Real time kinematic GPS) attached to the work machine is used to improve the accuracy of the installation of piles/columns. With real time positioning, measuring and marking operations at the work site can be also reduced.

In deep stabilization, methods for more accurate and optimized addition of binder agent are investigated. The goal is to achieve more homogenous structures with calibrated relationship between soil conditions and the achieved strength of columns. This work is based on research done in the POHVA1 project (2005-07).

In pile driving, methods for measuring the bearing capacity of the pile in real time with a measuring system attached to the piling machine are studied. This will improve the quality and efficiency of the piling and reduce breakdowns of the piles. Also methods for measuring vibrations from pile driving work are studied. The vibrations from pile driving can be harmful to the structures, buildings, etc. near the work site. The goal is to develop a system that can be used for detecting harmful vibrations in real time and warn the piling operator in advance. The system consists of wireless sensor units and a display unit in the cabin of the machine that shows the vibration level to the user.

The project also includes a survey of the global markets in ground strengthening. The goal is to recognize the potential market areas for technology export of Finnish companies in ground strengthening.

In the POHVA2 project co-operation is done widely with research groups from the University of Oulu and different companies and organizations that work with ground strengthening. The project consortium consists of machine manufactures, pile manufactures, piling contractors, design and engineering companies, engineering software companies and clients.

Research partners in this project are VTT, the research unit of Construction Technology (University of Oulu) and Mechatronics and Machine Diagnostics Laboratory (University of Oulu).

The research is funded by Tekes along with 17 companies, the Finnish Road Administration, the Finnish Rail Administration, Confederation of Finnish Construction Industries (RT), City of Espoo, City of Helsinki, and VTT.

REFERENCES

[1] Korkiala-Tanttu, L., Juvankoski, M. & Valasti, P. 2008. Development of ground improvement process, Summary report VTT-R-11157-07, 19 p. www.vtt.fi/inf/julkaisut/muut/2007/VTT-R-11157-07.pdf

CONTACT

Pekka Kilpeläinen
Research Scientist
pekka.kilpelainen@vtt.fi
Tel. +358 20 722 2243

INTERNAL SURFACES OF MINERAL-BASED FUNCTIONAL MATERIALS

Markku Leivo, Anna Kronlöf, Tapio Vehmas

The project "Internal Surfaces of Mineral-Based Functional Materials (SIPI)" aims at understanding how to tailor functional properties of porous inhomogeneous mineral-based materials by using nano-particles. By improving the understanding of interactions of material internal surfaces, it is possible to tailor their functional properties. These internal surfaces determine the whole behavior and properties of these building materials.

In the research it is critical to understand the phenomena so that the physical chemistry reactions can be controlled and thus the materials achieve the desired functional properties. Modeling is used to establish the base for tailoring functional properties in different demanding conditions. For instance, in concrete early age reactions and interactions greatly define what kind of properties will result in the hardened concrete. This is why it is important to know how nano-scale internal surfaces of particles and products with different dimensions are interacting, developing and control the formation of a structure. This means evaluating characteristics such as dispersion and orientation of particles, connection with each other and end properties of a material. Understanding internal nano-scale interactions enables a totally new way to make material and create new functionality to the material.

There has already been research on using nano-particles in porous inorganic materials such as concrete. The aim of earlier work has been to improve properties and bring functionality to the material, though it has been found that there is worldwide lack of knowledge on the understanding and modeling of interaction of nano-particles and nano-size surfaces. This lack of know-how has prevented the technology leap in tailoring functional properties to building materials. For instance, introduction of TiO_2 to a cement matrix has not provided as good of self-cleaning properties as expected.

The SIPI project investigates the interactions of nano-sized internal surfaces and their implications to the functional properties of materials. The project is also generating the know-how to measure interactions in very demanding environments, like high pH and high ion-concentration. Imaging the nano-structure of materials to see how different nano-sized components are distributed is also included in the work. The final phase of the work will be modeling these interactions to establish the baseline for tailoring functional properties.

In this research the knowledge of nano-science is introduced to "common" materials, in a manner that is similar to the introduction of micro-technology during previous decades. The scientific results of the project will be used in future product development. It is anticipated that the knowledge will lead to development of new functional materials in various building sectors.

The project is a cooperation effort between Helsinki University of Technology, Åbo Academy and VTT with funding provided by Tekes and three industrial partners. The project will be completed in spring 2011.

CONTACT
Markku Leivo
Senior Research Scientist
markku.leivo@vtt.fi
Tel. +358 20 722 6933

STEEL SOLUTIONS FOR THE SEISMIC RETROFIT AND UPGRADE OF EXISTING CONSTRUCTION

Ludovic Fülöp, Merja Sippola

A large portion of the existing building stock is in need of seismic retrofitting. On one hand, in the period when these structures were designed and erected, there was very limited understanding of the effects of earthquakes on buildings. Building regulations were not adequate with respect to earthquake loads. On the other hand, with time, buildings undergo a slow deterioration of their properties. Such deterioration can lead to reduced strengths when an exceptional loading condition, like an earthquake, can not be resisted by the structure.

The rehabilitation of an existing structure is an individual task. Still, the aim of this STEELRETRO project is to set up solutions based on the use of steel for the retrofitting of existing buildings. The proposed solutions should be broad enough to cover groups of typical retrofit cases, and should provide generic design and construction methodologies as well as tools for cost estimation.

The results of this work will permit the increase of the use of steel in seismic retrofit of existing buildings. Safety of the retrofitted buildings is expected to increase, together with the quality of the intervention. A decrease of the price of the interventions is also probable because of the possibility for typification of the interventions, and for prefabrication of the used construction elements. Emphasis will also be placed on the reversibility of the intervention techniques, and their potential to be used in post-earthquake repairing of damaged structures.

At the start a comprehensive review of the existing rehabilitation techniques is undertaken, with the aim of mapping the current practice. The areas where steel can be competitive, or where it can be made more competitive, are identified. Then, several benchmark structures are proposed, where alternative rehabilitation methods can be applied. The modeling, using sophisticated FEM analysis, of these structures is underway. Several rehabilitation techniques will be implemented for each structure and the performances of these techniques are compared both in structural and economical terms.

The targeted end-users of the results are designers and contractors of rehabilitation work. The intention is not to analyze high-profile historical buildings, because they need thorough individual consideration, but to give guidelines for the more common structures which are present in the practice of an average designer. With a significant part of the construction industry now operating in the rehabilitation sector, any gain of efficiency for these structures can have a significant economic impact.

ACKNOWLEDGEMENTS

The research has been funded by the European Commission, through the Research Fund for Coal and Steel and by VTT, and will be completed in autumn 2010. The project consortium consists of 11 partners from 8 countries.

CONTACT

Ludovic Fülöp
Senior Research Scientist
ludovic.fulop@vtt.fi
Tel. +358 20 722 6924

PREFABRICATED STEEL STRUCTURES FOR LOW-RISE BUILDINGS IN SEISMIC AREAS

Ludovic Fülöp, Anna-Leena Perälä

Single-storey industrial (SSIB) and low-rise commercial (LRCB) buildings represent a significant proportion of the building market. In Northern Europe, these buildings are mostly made of steel, while in the Mediterranean area prefabricated reinforced concrete (RC) structures are predominant. Considering the high seismic risk in many of the Mediterranean countries, this situation is a kind of a paradox. Steel structures usually have good performance during earthquakes; while prefabricated concrete buildings suffer from the weakness of the connection regions (Figure 1).

The aim of the PRECASTEEL project is to develop steel and hybrid steel-RC structural configurations for the SSIB and LRCB markets in seismic areas. The proposed building configurations will have to use the advantageous properties of both materials in order to increase safety against earthquake loading. They should also allow for the possibility of standardization and prefabrication, and be cost effective.

In order to achieve the objectives several methods are used. A statistical market survey is undertaken concerning SSIB's and LRCB's in Europe; followed by experimental investigations of building components; analytical modeling of the buildings dynamic behavior and the development of a software tool for efficient comparative evaluation of the possible configurations.

Figure 1. Collapse of unfinished precast structure in the August 17, 1999, Kocaeli (Turkey) earthquake [1].

ACKNOWLEDGEMENTS

The support of Ruukki from the early phases of the project is gratefully acknowledged. The research is funded by the European Commission, through the Research Fund for Coal and Steel (RFCS) and by VTT, and will be completed in autumn 2010. The project consortium consists of 11 partners from 7 countries.

REFERENCES

[1] Saatcioglu, M, Mitchell, D, Tinawi, R, Gardner, N.J., Gillies, A,G, Ghobarah, A., Anderson, D.L., & Lau, D. 2001. The August 17, 1999, Kocaeli (Turkey) earthquake - damage to structures. Canadian Journal of Civil Engineering Vol. 28, No 4, pp. 715–737.

CONTACT

Ludovic Fülöp
Senior Research Scientist
ludovic.fulop@vtt.fi
Tel. +358 20 722 6924

VIBRATION BARRIERS FOR REDUCING TRAFFIC-INDUCED VIBRATIONS IN BUILDINGS

Asko Talja, Ludovic Fülöp, Juha Kurkela, Ari Vepsä

Vibration caused by railway or road traffic is experienced by people directly in their body or indirectly, as vibration of the building or as a tinkle of vessels and other movable objects. The inconveniences caused by traffic vibration include, among others, sleeping disturbance, fear of building damages or decrease of the value of their real-estate (Figure 1).

The objective of the TÄRE project is to develop new products and methods for reducing traffic induced vibrations. New types of vibration barriers to be installed in the soil are examined. Their performance is evaluated and the competitiveness of different solutions is examined. A vibration barrier can prevent the spreading of the vibration into the soil next to the vibration source, or it can prevent the transition of the vibration to the building. The possible new structural solutions can be vibration barriers, made of recycled materials (e.g. rubber tires, timber posts, concrete elements etc.) that have been built as pillars or walls.

An attempt is made to model several configurations (i.e. materials and geometries) of vibration barriers in different soil typologies. The attenuation of the barriers depends on the frequency content of the vibration in the soil. The frequency content, however, depends especially on the stiffness of the soil. Therefore, different vibration barriers have their best performance in different soils. The study is concentrated on soft-soil areas, which are the most sensitive in Finland.

The aims of the project are achieved by several steps. First, the functionality and performance of existing vibration barriers is summarized. Second, a parametric Finite Element Modeling (FEM) analysis is done, in order to test the efficiency of using a wide range of barriers. Third, product concepts are sketched, using recycled materials and the most efficient configurations resulting from the FEM.

Figure 1. Adverse effects of traffic induced vibrations

The know-how and research results generated by this project can be used in: (i) product development of vibration walls, (ii) planning of the use of land and (iii) decision-making concerning the development plans of both infrastructure and housing projects.

ACKNOWLEDGEMENTS

The research is funded by the Finnish Rail Administration, 6 Finnish companies and VTT, and will be completed at the end of 2009.

CONTACT

Asko Talja
Senior Research Scientist
asko.talja@vtt.fi
Tel. +358 20 722 6831

STATISTICAL BASED INFORMATION AND METHODS TO BE USED IN THE FIRE RISK ASSESSMENT

Kati Tillander, Tuuli Oksanen

The statistics system of the Finnish rescue services (PRONTO) contains accident statistics at the level of a municipality going back as far as 1996, as well as statistical data on the rescue service resources of Finnish fire departments and municipalities. The purpose of the system is to enhance the monitoring and development of rescue administration. The statistical information is also valuable for research purposes.

The database includes detailed information on different accidents to which the fire department has been alarmed and on the tasks they have performed. There are 20 given accident types, which are used to separate different tasks from each other.

This study concentrates on building fires, which is one of the accident types. After every building fire, detailed information on the fire incident and the features of the building is delivered to the database by the fire department.

A detailed compilation of statistical data in the national accident database over the years has generated a valuable source of information on fires that actually occurred and has opened up the possibility of examining the fire-risk problem in detail, in addition to basing fire-risk assessment on actual statistical data.

The problem has been studied earlier using the data available at that time. The previous studies cover the years 1996-99, partially also the years 1996-2001 [1-2]. At the present moment PRONTO includes information on in total over 42 000 building fires (during 1996-2007). The focus of this current study is to use recent data and bring the information presented in the previous studies up-to-date.

As a result of this research, information and tools based on recent statistical data is generated to be used in the quantitative assessment of the fire risk of individual buildings. Also more information related to the factors affecting the fire risk in buildings is produced. The main goal is to produce information and tools that can be utilized by fire engineers, research scientists and fire departments.

The final report will be public and freely downloadable from the internet (http://www.vtt.fi/publications/index.jsp).

ACKNOWLEDGEMENTS

The authors wish to thank Emergency Services College, Fire departments of Keski-Uusimaa, Länsi-Uusimaa and Tampere, and the three participating companies. The research is funded by the Finnish Fire Protection Foundation and VTT and will be completed at the end of 2008

REFERENCES

[1] Rahikainen, J. & Keski-Rahkonen, O. 1998. Determination of ignition frequency of fires in different premises in Finland. Fire Engineers Journal, Vol. 58, Issue 197, pp. 33–37.

[2] Tillander K. 2004. Utilisation of statistics to assess fire risks in buildings. VTT Publication 537.

CONTACT

Kati Tillander
Research Scientist
kati.tillander@vtt.fi
Tel. +358 20 722 4865

Acronym List

AC	Alternating Current
AMR	Automated Meter Reading
BI	Building Intelligence
BIM	Building Information Models
BS	Building Services
BTES	Borehole Thermal Energy Storage
CCA	Copper, Chromium and Arsenic
CDM	Continuum Damage Mechanics
CE	Consumer Electronics
CFD	Computational Fluid Dynamics
CM	Construction Management
DB	Design Build
DBB	Design Bid Build
DBFO	Design Build Finance Operate
DBO	Design Build Operate
EBD	Evidence Based Design
ECBCS	Energy Conservation for Buildings and Community Systems
ECTP	European Construction Technology Platform
EPBD	Energy Performance of Buildings Directive
FBF	Future Building Forum
FDS	Fire Dynamic Simulator
FE	Finite Element
FEM	Finite Element Modeling
FLEC	Field and Laboratory Emission Test Cell
FM	Facilities Management
FSE	Fire Safety Engineering
GPRS	General Packet Radio Service
HUT	Helsinki University of Technology (also abbreviated TKK)
HVAC	Heating, Ventilation and Air Conditioning
IAI	International Alliance for Interoperability
IAQ	Indoor Air Quality
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
IPCC	International Panel of Climate Change
IR	Infrared Microscopy
IRM	Interactive Risk Mapping
LC	Life Cycle
LCI	Life Cycle Inventory
LRCB	Low Rise Commercial Building
M&V	Measurement and Verification
MR&R	Maintenance, Repair and Rehabilitation
MS	Member States
MVD	Model View Definitions
NFC	Near Field Communication
NFPA	National Fire Protection Association
PBB	Performance Based Building
PFS	Probabilistic Fire Simulator
PMO	Product Modeling Ontology
PMV	Predicted Mean Values
PPD	Percentage of Dissatisfied
RC	Reinforced Concrete
R&D	Research and Development
RECC	Real Estate Construction Cluster
RFID	Radio Frequency Identification
RH	Relative Humidity
RTD	Research and Technology Development
SB	Sustainable Building
SCM	Supply Chain Management
SL	Service Life
SME	Small and Medium Enterprise
SSIB	Single Storey Industrial Building
Tekes	Finnish Funding Agency for Technology and Innovation
TMMC	Two-Model Monte Carlo
TKK	Teknillinen Korkeakoulu, Helsinki University of Technology (also abbreviated HUT)
VBE	Virtual Building Environments
VOC	Volatile Organic Compounds
VTT	VTT Technical Research Center of Finland (Valtion Teknillinen Tutkimuskeskus)
WCD	Wing Crack Damage

Listing of Scientific Journal Articles, 2006 – June 2008

ECO- AND ENERGY EFFICIENCY

Heikkinen, J. 2007. Effect of variable ambient temperature on fin efficiency in a two-dimensional flow passage. Heat and Mass Transfer, Vol. 43, No. 4, pp. 341–350.

Nystedt, Å., Shemeikka, J. & Klobut, K. 2006. Case analyses of heat trading between buildings connected by a district heating network. Energy Conversion and Management, Vol. 47, No. 20, pp. 3652–3658.

Pakanen, J. & Karjalainen, S. 2006. Estimating static heat flows in buildings for energy allocation systems. Energy and Buildings, Vol. 38, No. 9, pp. 1044–1052.

Vesanen, T., Klobut, K. & Shemeikka, J. 2007. Implementation of a fuel cell system model into building energy simulation software IDA-ICE. Journal of Fuel Cell Science and Technology, American Society of Mechanical Engineers (ASME), Vol. 4, No. 4, pp. 511–515.

INDOOR CLIMATE

Holopainen, R., Tuomaala, P. & Piippo, J. 2007. Uneven gridding of thermal nodal networks in floor heating simulations. Energy and Buildings, Vol. 39, No. 10, pp. 1107–1114.

Ilacqua, V., Hänninen, O., Saarela, K., Katsouyanni, K., Künzli, N. & Jantunen, M. 2007. Source apportionment of population representative samples of PM2.5 in three European cities using structural equation modelling. Science of the Total Environment, Vol. 384, No. 1–3, pp. 77–92.

Järnström, H., Saarela, K., Kalliokoski, P. & Pasanen, A.-L. 2006. Reference values for indoor air pollutant concentrations in new, residential buildings in Finland. Atmospheric Environment, Vol. 40, No. 37, pp. 7178–7191.

Järnström, H., Saarela, K., Kalliokoski, P. & Pasanen, A.-L. 2007. Reference values for structure emissions measured on site in new residential buildings in Finland. Atmospheric Environment, Vol. 41, No. 11, pp. 2290–2302.

Kalagasidis, A. S., Weitzmann, P., Nielsen, T. R., Peuhkuri, R., Hagentoft, C.-E. & Rode, C. 2007. The International Building Physics Toolbox in Simulink. Energy and Buildings, Vol. 39, No. 6, pp. 665–674.

Karjalainen, S. 2007. Gender differences in thermal comfort and use of thermostats in everyday thermal environments. Building and Environment, Vol. 42, No. 4, pp. 1594–1603.

Karjalainen, S. & Koistinen, O. 2007. User problems with individual temperature control in offices. Building and Environment, Vol. 42, No. 8, pp. 2880–2887.

Mortensen, L. H., Rode, C. & Peuhkuri, R. 2008. Investigation of airflow patterns in a microclimate by particle image velocimetry (PIV). Building and Environment, Vol. 43, No. 11, pp. 1929–1938.

INFORMATION MANAGEMENT AND BUILDING PROCESSES

Fox, S. 2007. User-centered products - I'll tell you how to design it for me. IET Engineering Management, Vol. 17, No. 3, pp. 32–36.

Fox, S. 2008. Evaluating potential investments in new technologies: Balancing assessments of potential benefits with assessments of potential disbenefits, reliability and utilization. Critical Perspectives on Accounting, In press.

Fox, S. & Koskela, L. 2007. Improving the reliability and validity of results from multi-national research projects. International Project Management Association Project Perspectives, Vol. 24, pp. 72–76.

Glaser, S. D. & Tolman, A. 2008. Sense of sensing: From data to informed decisions for the built environment. Journal of Infrastructure Systems, Vol. 14, No. 1, pp. 4–14.

Häkkinen, T. 2007. Sustainable building related new demands for product information and product model based design. Electronic Journal of Information Technology in Construction, Vol. 12, pp. 19–37.

Karlsson, M., Lakka, A., Sulankivi, K., Hanna, A.S. & Thompson, B.P. 2008. Best practices for integrating the concurrent engineering environment into multipartner project management. Journal of Construction Engineering and Management, Vol. 134, No. 4, pp. 289–299.

BUILDING SERVICES AND SUSTAINABILITY

Heinonen, S., Halonen, M. & Daldoss, L. 2006. Slow Housing - Competitive Edge for Innovative Living Environments. International Journal of Geography, Fennia, No. 184:1, pp. 91–104.

Häkkinen, T. 2007. Assessment of indicators for sustainable urban construction. Civil Engineering and Environmental Systems, Vol. 24, No. 4, pp. 247–259.

Häkkinen, T. & Nuutinen, M. 2007. Seeking sustainable solutions for office buildings. Facilities, Vol. 25, No. 11–12, pp. 437–451.

INFRASTRUCTURE AND GEOTECHNIQUES

Koppinen, T. & Lahdenperä, P. 2007. Realized economic efficiency of road project delivery systems. Journal of Infrastructure Systems, Vol. 13, No. 4, pp. 321–329.

Korkiala-Tanttu, L. 2007. Speed and reloading effects on pavement rutting. Geotechnical engineering, Proceedings of the Institution of Civil Engineers, Vol. 160, No. GE3, pp. 123–127.

Korkiala-Tanttu, L. & Dawson, A. 2007 Relating full-scale pavement rutting to laboratory permanent deformation testing. International Journal of Pavement Engineering, Vol. 8, No. 1, pp. 19–28.

Miyamoto, A., Konno, M. & Rissanen, T. 2006. VR-based education system for inspection of concrete bridges. Computers & Concrete, Vol. 3, No. 1, pp. 29–42.

Suksi, J., Rasilainen, K. & Pitkänen, P. 2006. Variations in 234U/238U activity ratios in groundwater - A key to flow system characterisation? Physics and Chemistry of the Earth, Parts A/B/C, Vol. 31, No. 10–14, pp. 556–571.

BUILDING MATERIALS AND PRODUCTS

Holt, E. & Raivio, P. 2006. Use of gasification residues in compacted concrete paving blocks. Cement and Concrete Research, Vol. 36, No. 3, pp. 441–448.

Kronberg, T., Ritschkoff, A.-C., Mahlberg, R., Mannila, J., Kallio, M., Vesa, A. & Hupa, L. 2006. Soil resistant surfaces for traditional ceramics. Journal of the European Ceramic Society, Vol. 27, No. 2–3, pp. 1775–1780.

Metsä-Kortelainen, S., Antikainen, T. & Viitaniemi, P. 2006. The water absorption of sapwood and heartwood of Scots pine and Norway spruce heat-treated at 170°C, 190°C, 210°C and 230°C. Holz als Roh - und Werkstoff, Vol. 64, No. 3, pp. 192–197.

Peuhkuri, R., Rode, C. & Hansen, K. 2008. Non-isothermal moisture transport through insulation materials. Building and Environment. Vol. 43, No. 5, pp. 811-822.

Pinto, I., Knapic, S., Pereira, H. & Usenius, A. 2006. Simulated and realised industrial yields in sawing of maritime pine (Pinus pinaster Ait.). Holz als Roh- und Werkstoff, Vol. 64, No. 1, pp. 30–36.

Raiskila, S., Fagerstedt, K., Laakso, T., Saranpää, P., Löija, M., Paajanen, L., Mahlberg, R. & Ritschkoff, A.-C. 2006. Polymerisation of added coniferyl alcohol by inherent xylem peroxidases and its effect on fungal decay resistance of Norway spruce. Wood Science Technology, Vol. 40, No. 8, pp. 697–707.

Raiskila, S., Pulkkinen, M., Laakso, T., Fagerstedt, K., Löija, M., Mahlberg, R., Paajanen, L., Ritschkoff, A.-C. & Saranpää, P. 2007. FTIR spectroscopic prediction of Klason and acid soluble lignin variation in Norway spruce cutting clones. Silva Fennica, Vol. 41, No. 2, pp. 351–371.

Raiskila, S., Saranpää, P., Fagerstedt, K., Laakso, T., Löija, M., Mahlberg, R., Paajanen, L. & Ritschkoff, A.-C. 2006. Growth rate and wood properties of Norway spruce cutting clones on different sites. Silva Fennica, Vol. 40, No. 2, pp. 247–256.

Tarvainen, V., Ranta-Maunus, A., Hanhijärvi, A. & Forsén, H. 2006. The Effect of Drying and Storage Conditions on Case Hardening of Scots Pine and Norway Spruce Timber. Maderas: Ciencia y tecnología, Vol. 8, No. 1, pp. 3–14.

STRUCTURAL ENGINEERING

Gardner, L., Talja, A. & Baddoo, N. R. 2006. Structural design of high-strength austenitic stainless steel. Thin-Walled Structures, Vol. 44, No. 5, pp. 517–528.

Kärnä, T., Qu, Y., Bi, X., Yue, Q. & Kuehnlein, W. 2007. A spectral model for forces due to ice crushing. Journal of Offshore Mechanics and Arctic Engineering - Transactions of the ASME, Vol. 129, No. 2, pp. 138–145.

Makkonen, L. 2006. Plotting positions in extreme value analysis. Journal of Applied Meteorology and Climatology, Vol. 45, No. 2, pp. 334–340.

Makkonen, L. 2007. Reply to a comments by L. de Haan. Journal of Applied Meteorology and Climatology, Vol. 46, No. 3, pp. 397–398.

Makkonen, L. 2008. Bringing closure to the plotting position controversy. Communications in Statistics - Theory and Methods, Vol. 37, No. 3, pp. 460–467.

Makkonen, L. 2008. Problems in the extreme value analysis. Structural Safety, Vol. 30, No. 5, pp. 405–419.

Makkonen, L., Ruokolainen, L., Räisänen, J. & Tikanmäki, M. 2007. Regional Climate model estimates for changes in Nordic extreme events. Geophysica, Vol. 43, No. 1–2, pp. 19–42.

Mróz, A., Holnicki-Szulc, J. & Kärnä, T. 2008. Mitigation of ice loading on off-shore wind turbines: Feasibility study of a semi-active solution. Computers & Structures, Vol. 86, No. 3–5, pp. 217–226.

Toratti, T. & Talja, A. 2006. Classification of human induced floor vibrations. Building Acoustics, Vol. 13, No. 3, pp. 211-221

Toratti, T., Schnabl, S. & Turk, G. 2007. Reliability analysis of a glulam beam. Structural Safety, Vol. 29, No. 4, pp. 279–293.

Qu, Y., Yue, G.J., Bi, X. & Kärnä, T. 2006. A random ice force model for narrow conical structures. Cold Regions Science and Technology, Vol. 45, No. 3, pp. 148–157.

FIRE SAFETY

Hietaniemi, J. 2007. Probabilistic simulation of fire endurance of a wooden beam. Structural Safety, Vol. 29, No. 4, pp. 322–336.

Hostikka, S. & McGrattan, K. 2006. Numerical modelling of radiative heat transfer in water sprays. Fire Safety Journal, Vol. 41, No. 1, pp. 76–86.

Keski-Rahkonen, O., Mangs, J., Hostikka, S. & Korhonen, T. 2007. Quantitative application of Monte Carlo simulation in Fire-PSA. Kerntechnik, Vol. 72, No. 3, pp. 149–155.

Uppfeldt, B., Ala-Outinen, T. & Veljkovic, M. 2008. A design model for stainless steel box columns in fire. Journal of Constructional Steel Research, Vol. 64, No. 11, pp. 1294-1301.

Östman, B. & Mikkola, E. 2006. European classes for the reaction to fire performance of wood products. Holz als Roh- und Werkstoff, Vol. 64, No. 4, pp. 327-337.

Listing of Scientific Conference Papers, 2006 – June 2008

ECO- AND ENERGY EFFICIENCY

Avdelidis, N.P. & Kauppinen, T. 2008. Thermography as a tool for building applications and diagnostics. Proceedings of Thermosense XXX, The Annual Infrared Thermography Applications Conference, SPIE the International Society for Optical Engineering. Orlando, Florida, USA, 18 March 2008. Vol. 6939, Nr. 69390U.

Braganca, L., Mateus, R. & Koukkari, H. 2007. Perspectives of building sustainability assessment. Proceedings of Portugal SB07, Sustainable Construction, Materials and Practices. University of Minho & Instituto Superior Technico, Lisbon, Portugal, 12–14 September 2007, pp. 356–365.

Hasan, A., Vuolle, M., Holopainen, R. & Tuomaala, P. 2007. Reduction of space heating energy through minimisation of life cycle cost using combined simulation and optimisation. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland 10–14 June 2007.

Hekkanen, M., Tulla, K., Mäkikyrö, T. & Seppälä, P. 2006. Assessing energy efficiency and environmental impact in private housing: the Oulu Housing Fair. Proceedings of CIB W70 2006 Trondheim International symposium, Changing User Demands on buildings - Needs for lifecycle planning and management. NTNU Norwegian University of Science and Technology, Trondheim, Norway, 12–14 June 2006.

Karjalainen, S. & Piira, K. 2007. Improving the possibilities to monitor energy consumption at home. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Kauppinen, T. 2007. Building thermography as a tool in energy audits and building commissioning procedure. Proceedings of Thermosense XXIX. The Annual Infrared Thermography Applications Conference, SPIE the International Society of Optical Engineering. Orlando, Florida, USA, 9–12 April 2007. Vol. 6541, Nr. 65410P.

Kauppinen, T., Hekkanen, M., Paloniitty, S. & Krankka, J. 2006. Certification of building thermographers: experiences after three courses. Proceedings of Thermosense XXVIII, The Annual Infrared Thermography Applications Conference, SPIE the International Society for Optical Engineering, WA, USA, 17–20 April 2006. Vol. 6205. Nr. 620511.

Kauppinen, T., Nissinen, K., Tolman, A. & Thunshelle, K. 2006. Barriers and limitations for innovative energy saving solutions of retrofitted public buildings. Proceedings of CIB W70 2006 Trondheim International Symposium, Changing User Demands on buildings - Needs for lifecycle planning and management. NTNU Norwegian University of Science and Technology, Trondheim, Norway, 12–14 June 2006.

Klobut, K., Kiviaho, J., Rosenberg, R., Vesanen, T., Pykälä, M-L. & Laine, J. 2008. Preparation of the SOFC integration with an office building. In First International Conference and Workshop on Micro-Cogeneration Technologies and Applications. Micro-Cogen 2008. Ottawa, Canada, 29 April–1 May 2008.

Koukkari, H., Kuhnhenne, M. & Braganca, L. 2007. Energy in the sustainable European construction sector. Proceedings of the First Workshop COST C25: Sustainability of Constructions - Integrated Approach to Life-time Structural Engineering. Lisbon, Portugal, 13–15 September 2007, pp. 0.23–0.34.

Nieminen, J., Holopainen, R. & Lylykangas, K. 2008. Concepts and market acceptance of a cold climate Passive House. 1st Nordic Conference on Passive Houses. Trondheim, Norway, 2–3 April 2008, pp. 240–247.

Nykänen, V., Paiho, S., Pietiläinen, J., Peltonen, J., Kovanen, K., Kauppinen, T. & Pihala, H. 2007. Systematic process for commissioning building energy performance and indoor conditions. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Ojanen, T. 2007. Low energy log walls under cold climate conditions. Proceedings of Thermal Performance of the Exterior Envelopes of Whole Buildings X Atlanta. (CD-ROM). ASHRAE, DOE, ORNL. Clearwater Beach, USA, 2–7 December 2007.

Rosenberg, R., Valkiainen, M., Klobut, K., Kiviaho, J. & Ihonen, J. 2007. Residential fuel cell systems. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Saari, M., Laine, J., Airaksela, M., Tuomi, J. & Holopainen, R. 2008. MERA, Multi-storey building, Finnish passive house. 1st Nordic Conference on Passive Houses. Trondheim, Norway, 2–3 April 2008, pp. 28–34.

Shemeikka, J., Klobut, K., Sipilä, K. & Heikkinen, J. 2007. The challenge of coupling the building's internal and external energy systems in dynamic simulation - a distributed ICT approach. Proceedings of 7th International Conference on System Simulation in Buildings, SSB2006. (CD-ROM). University of Liège, Belgium, 11–13 December 2006.

Wahlgren, I. 2007. Eco efficiency of urban form and transportation. Proceedings of ECEEE 2007 Summer Study, Saving Energy - Just do it! La Colle sur Loup, France, 4–9 June 2007, pp. 1679–1690.

INDOOR CLIMATE

Airaksinen, M., Järnström, H., Kovanen, K., Viitanen, H. & Saarela, K. 2007. Ventilation and building related symptoms. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Airaksinen, M., Tuomaala, P. & Holopainen, R. 2007. Human thermal model and modeling thermal comfort. Proceedings of Roomvent 2007 - SCANVAC Conference. Helsinki, Finland, 13–15 June 2007.

Airaksinen, M., Tuomaala, P. & Holopainen, R. 2007. Modelling human thermal comfort. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Heimonen, I., Himanen, M., Junnonen, J-M., Kurnitski, J., Mikkola, M., Ryynänen, T. & Vuolle, M. 2007. Tools for life cycle models in building service technology. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors, Helsinki, Finland, 10–14 June 2007. Vol. 3, pp. 445–452.

Heimonen, I., Immonen, I., Kauppinen, T., Nyman, M. & Junnonen, J-M. 2007. Risk management for planning and use of building service systems. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007, Vol. 3, pp. 485–494.

Järnström, H., Saarela, K., Pasanen, A-L. & Kalliokoski, P. 2006. The usefulness of pre-collected reference values in verifying excessive VOC emission from a moisture damaged, PVC coated floor. Proceedings of Healthy Buildings 2006, Creating a healthy indoor environment for people. Lisbon, Portugal, 4–8 June 2006. pp. 139–142.

Järnström, H., Saarela, K., Pasanen, A-L. & Kalliokoski, P. 2007. Variables affecting indoor air quality in newly finished buildings - a multivariate evaluation. Proceedings of 9th REHVA World Congress, Clima 2007 Well Being Indoors. Helsinki, Finland, 10–14 June 2007.

Karjalainen, S. 2007. Why it is difficult to use a simple device: an analysis of a room thermostat. Proceedings of 12th International Conference HCI International 2007. Beijing, China, 22–27 July 2007. Berlin - Heidelberg: Springer. Lecture Notes in Computer Science. Vol. 4550. Part 1. Human-Computer Interaction. Interaction Design and Usability, pp. 544–548.

Karjalainen, S. & Vastamäki, R. 2007. Occupants have a false idea of comfortable summer season temperatures. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Kauppinen, T., Kovanen, K., Heikkinen, J., Hostikka, S. & Shemeikka, J. 2007. Thermal comfort in new buildings - experimental point of view. Proceedings of Roomvent 2007, 10th International Conference on Air Distribution in Rooms. Helsinki, Finland, 13–15 June 2007. Vol. 1, pp. 57–64.

Kovanen, K., Heimonen, I., Heikkinen, J., Ojanen, T., Laamanen, J., Lehtinen, J., Alasuutari, S., Louhelainen, K., Mäittälä, J., Kivinen, T. & Jauhiainen, P. 2008. The commissioning procedure of farm building performance in Finland. In International Conference on Agricultural Engineering. The European Society of Agricultural Engineers (EurAgEng). Hersonissos, Greece, 23–25 June 2008.

Kovanen, K., Riala, R., Tuovila, H. & Tossavainen, A. 2007. Man made mineral fiber emission from HVAC-components. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Lähdesmäki K., Vinha J., Viitanen H., Salminen K., Peuhkuri R., Ojanen T., Paajanen L., Iitti H. & Strander, T. 2008. Development of an improved model for mould growth: Laboratory and field experiments. Proceedings of 8th Nordic Symposium on Building Physics. Copenhagen, 16–18 June 2008.

Nieminen, J. & Lylykangas, K. 2006. Life-cycle optimized housing: Society of Environmental Engineering. 17th Air-Conditioning and Ventilation Conference. Prague, Czech Republic, 17–19 May 2006, pp. 237–242.

Paavilainen, J., Järnström, H., Saarela, K., Sarlin, T., Viitanen, H. & Airaksinen, M. 2007. Simulation of moisture and microbial problems in building. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Tuomaala, P., Airaksinen, M. & Holopainen, R. 2007. A concept for utilizing detailed human thermal model for evaluation of thermal comfort. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Viitanen, H. & Ojanen, T. 2007. Improved model to predict mould growth in building materials. Proceedings of Thermal Performance of the Exterior Envelopes of Whole Buildings X International Conference (CD-ROM). Clearwater Beach, USA, 2–7 December 2007.

Viitanen H., Vinha J., Peuhkuri R., Ojanen T., Lähdesmäki K. & Salminen K. 2008. Development of an improved model for mould growth: Modelling. Proceedings of 8th Nordic Symposium on Building Physics. Copenhagen, 16–18 June 2008.

CONSTRUCTION INFORMATION TECHNOLOGY

Beausoleil-Morrison, I., Griffith, B., Vesanen, T., Lerson, S. & Weber, A. 2006. A case study demonstrating the utility of inter-program comparative testing for diagnosing errors in building simulation programs. Proceedings of eSim 2006, IBPSA-Canada 4th Biennal Building Performance Simulation Conference. Toronto, Canada, 4–5 May 2006.

Kiviniemi, A. 2007. Potential obstacles to use BIM in architectural design. Proceedings of International Workshop on Collaborative Human Futures: A New Design Paradigm. The Hong Kong Polytechnic University (PolyU) Cyberport, 19–20 November 2007, pp. 53–65.

Kiviniemi, A. 2007. Integrated BIM in Finland Senate Properties' BIM requirements. Invited speaker in International building SMART Forum, Queensland Government Session. Brisbane, 12–16 November 2007.

Kiviniemi, A. 2007. Life cycle management of information from brief to commissioning and management. Invited speaker in HCMAC (Health Capital Assets Managers Consortium) Conference. Brisbane, November 2007.

Kiviniemi, A. 2007. Model-based information systems. Invited speaker in Workshop on Lean Construction & Automation in Infra Sector. Berkeley, 24–25 April 2007.

Kiviniemi, A. 2007. IDS & BIM, 10 years' perspective: dream and reality. Keynote presentation in International Symposium on Building Information Modeling "BIM: the next big change in construction". Brussels, 3 October 2007.

Kiviniemi, A. 2007. Integrated BIM: leading edge or bleeding edge? Some Finnish experiences and views. Keynote presentation in bibs IT/CAD Conference. Odense, October 2007.

Kiviniemi, A. & Fischer, M. 2007. Potential obstacles to use BIM in architectural design. Invited speaker in International Workshop on Collaborative Human Futures: A New Design Paradigm. Hong Kong Polytechnic University, November 2007.

Kähkönen, K. 2007. Quantitative risk management for construction – model of elements for workable solutions. Proceedings of 4th Nordic Conference on Construction Economics and Organization - Development Processes in Construction Management. Luleå University of Technology, Sweden, 14–15 June 2007. pp. 271–282.

Kähkönen, K., Hyväkkä, J., Porkka, J., Siltanen, S. & Woodward, C. 2007. Integrating building models with live video stream. Proceedings of CONVR 2007 - 7th International Conference on Construction Applications of Virtual Reality. Penn State University, PA, USA, 22–23 October 2007.

Leicht, R. 2007. Comparing traditional schematic design documentation to a schematic building information model. Proceedings of 24th W78 Conference Maribor 2007, Bringing ITC Knowledge to Work. CIB – International Council for Research and Innovation in Building and Construction. Maribor, Slovenia, 26–29 June 2007, pp. 39–45.

Porkka, J. & Kähkönen, K. 2007. Software development approaches and challenges of 4D product models. Proceedings of 24th W78 Conference Maribor 2007, Bringing ITC Knowledge to Work. CIB – International Council for Research and Innovation in Building and Construction. Maribor, Slovenia, 26–29 June 2007, pp. 85–90.

Zarli, A., Kazi, A. S., Hannus, M. & Bourdeau, M. 2007. Strat-CON: A strategic vision for future R&D and innovation in ICT-enhanced construction. Proceedings of the 13th International Conference on Concurrent Engineering. Sophia Antipolis, France, 4–6 June 2007, pp. 67–76.

BUILDING SERVICES AND FACILITY MANAGEMENT

Bazjanac, V. & Kiviniemi, A. 2007. Reduction, simplification, translation and interpretation in the exchange of model data. Proceedings of 24th W78 Conference Maribor 2007, Bringing ITC Knowledge to Work. CIB – International Council for Research and Innovation in Building and Construction. Maribor, Slovenia, 26–29 June 2007, pp. 163–168.

Rosqvist, T., Räikkönen, M. & Komonen, K. 2007. Investment analysis for capacity management based on real options. 2nd World Congress on Engineering Asset Management, 4th International Conference on Condition Monitoring. Harrogate, UK, 11–14 June 2007.

Tolman, A., Möttönen, V. & Tulla, K. 2006. Data management in facility management. Proceedings of the European Facility Management Conference EFCM 2006, GEFMA, EuroFM, IFMA. Masago Messe Frankfurt, Frankfurt am Main, Germany, 7–9 March 2006, pp. 181–187.

Tolman, A., Möttönen, V. & Tulla, K. 2006. Mobility in facilities services. Proceedings of CIB W70 2006 Trondheim international symposium, Changing User Demands on buildings - Needs for lifecycle planning and management. NTNU Norwegian University of Science and Technology. Trondheim, Norway, 12–14 June 2006.

INFRASTRUCTURE AND GEOTECHNIQUES

Kaitala, E. & Saarelainen, S. 2007. Improvement of the de-icing on the roads at Kittilä, Muonio, Enontekiö, Inari and Utsjoki. Proceedings of the 8th International Symposium on Cold region Development ISCORD 2007. RIL - Finnish Association of Civil Engineers, International Association for Cold Region Development Studies. Tampere, Finland, 25–27 September 2007. pp. 115–116.

Kivikoski, H. & Saarelainen, S. 2007. Testing of mineral liners for landfills in the cold climate. Proceedings of the 8th International Symposium on Cold region Development ISCORD 2007. RIL - Finnish Association of Civil Engineers, International Association for Cold Region Development Studies. Tampere, Finland, 25–27 September 2007. pp. 207–208.

Koppinen, T. & Rosqvist, T. 2007. Dynamic project portfolio selection in infrastructure sector. Proceedings of the Second World Congress on Engineering Asset Management and the Fourth International Conference on Condition Monitoring. Northampton, UK. 11–14 June 2007, pp. 1053–1065.

Koppinen, T. & Rosqvist, T. 2007. Optimal and dynamic asset management in infrastructure sector. Proceedings of CME 25 Conference - Construction Management and Economics: Past, Present and Future. University of Reading, UK, 16–18 July 2007.

Laaksoharju, M., Pitkänen, P., Selroos, J-O. & Mäntynen, M. 2007. Potentials and limitations of the use of geohistory for the understanding of current features and conditions and possible future evolutions. In Proceedings of Second AMIGO Workshop, Linkage of Geoscientific Arguments and Evidence in Supporting the Safety Case. OECD Publishing 2007. Toronto, Canada, 20–22 September 2005.

Lahdenperä, P., Kiviniemi, A. & Korkiala-Tanttu, L. 2006. A road map for the development of transport infrastructure management. In: Pietroforte, R., De Angelis, E. & Polverino, F. (eds.) Proceedings of the Joint 2006 CIB W065/W055/W086 Symposium. Construction in the XXI century: Local and global challenges. Rome, Italy, 18–20 October 2006. Edizioni Scientifiche Italiane. Ingegneria Economico-Gestionale 39, pp. 190–191.

Saarelainen, S. & Halonen, P. 2006. Long term performance of a reinforced pavement layer. Proceedings of 13th International Conference on Cold Regions Engineering. Current Practices in Cold Regions Engineering. University of Maine Orono, American Society of Civil Engineers (ASCE). Washington DC, Maine Orono, USA, 23–26 July 2006.

Saarelainen, S. & Viitala, J. 2007. Railway tunneling in frozen ground on Bothniabana. Proceedings of the 8th International Symposium on Cold region Development ISCORD 2007. RIL - Finnish Association of Civil Engineers, International Association for Cold Region Development Studies. Tampere, Finland, 25–27 September 2007. pp. 47–48.

Välisalo, T., Riihimäki, M. & Lehtinen, E. 2007. Asset Management by Water and Sewerage Works in Finland. Proceedings of 5th International Water History Association Conference IWHA 2007. Pasts and Futures of Water. University of Tampere, Finland, 13–17 June 2007. pp. 199.

BUILDING MATERIALS AND PRODUCTS

Hanhijärvi, A., Kevarinmäki, A. & Yli-Koski, R. 2006. Block shear failure at dowelled steel-to-timber connections. Proceedings of CIB-W18 Meeting 39, International Council for Research and Innovation in Building and Construction, Working Commission W18 – Timber Structures. Florence, Italy, 28 August 2006.

Hanhijärvi, A., Ranta-Maunus, A., Sarkama, H., Poussa, M., Mitsuhashi, K. & Puttonen, J. 2007. Analysis of Tension and Bending Strength of Graded Spruce Timber. In International Council for Research and Innovation in Building and Construction, Working Commission W18, Timber Structures CIB-W18. Karlsruhe: University of Karlsruhe. Bled, Slovenia, 28–31 August 2007.

Jämsä, S. & Viitaniemi, P. 2006. Influence of wood material and surface treatment on water absorption and cracking. Proceedings of Fifth International Wood coatings Congress Enhancing Service Life. Coatings Technology Centre. Prague, Czech Republic, 17–18 October 2006, pp. Paper 3: 1–7.

Knapic, S., Pinto-Seppä, I., Usenius, A. & Pereira, H. 2007. Modelling cork oak features. Proceedings of COST E44 Conference, Modelling the Wood Chain Forestry – Wood Industry – Wood Products Markets. Helsinki, Finland, 17–19 September 2007, pp. 117–124.

Ojanen, T., Ahonen, J. & Simonson, C. 2006. Moisture performance characteristics of OSB and spruce plywood exterior sheathing products. Proceedings of the 3rd International Building Physics Conference, IBPC3. Concordia University, Montreal, Canada, 27–31 August 2006, pp. 97–105.

Poussa, M., Tukiainen, P. & Ranta-Maunus, A. 2007. Experimental study of compression and shear strength of spruce timber. Proceedings of CIB W18, International Council for Research and Innovation in Building and Construction, Working Commission W18, Timber structures. Bled, Slovenia, 28–31 August 2007.

Song, T. & Usenius, A. 2007. INNOSIM – a simulation model of wood conversion chain. COST E44 Conference proceedings. Modelling the Wood Chain Forestry – Wood Industry – Wood Products Markets. Helsinki, Finland, 17–19 September 2007, pp. 95–108.

Usenius, A. 2007. Flexible and adaptive production systems for manufacturing of wooden components. Proceedings of 18th International Wood Machining Seminar. Vancouver, Canada, 7–9 May 2007. Volume 1, pp. 187–196.

Usenius, A. & Heikkilä, A. 2007. WoodCIM® - model system for optimization activities throughout supply chain. In proceedings of COST E44 Conference, Modelling the Wood Chain Forestry – Wood Industry – Wood Products Markets. Helsinki, Finland, 17–19 September 2007, pp. 173–183.

Usenius, A., Song, T. & Heikkilä, A. 2007. Optimization of activities throughout the wood supply chain. Proceedings of International Scientific Conference on Hardwood Processing. Quebec City, Canada, 24–26 September 2007, pp. 199–205.

Van Acker, J. & Usenius, A. (co-editors), Ghent University (ed.), 2007. Proceedings of COST E 44, Conference on Modelling the Wood Chain Forestry – Wood Industry – Wood Products Markets. Helsinki, Finland. 17–19 September 2007. 183 p.

STRUCTURAL ENGINEERING

Heimo, A., Tammelin, B., Fikke, S.M. & Makkonen, L. 2008. COST-727 Action: icing on structures. WMO Technical Conference on Meteorological and Environmental Instruments and Methods of Observation (TECO 2008). St. Petersburg, Russia, 27–29 November 2008, 5 p. (in press)

Kristjansson, J.E., Nygaard, B.E.N., Makkonen, L. & Berge, E. 2006. How well can icing episodes be predicted based on current NWP models? Proc. WMO TD. No. 1355. Second THORPEX International Science Symposium. Landshut, Germany, 4–8 December 2006. pp. 236–237.

Laakso, T., Makkonen, L. & Holttinen, H. 2006. Climate change impact on icing of large wind turbines. European Conference on Impacts of Climate Change on Renewable Energy Sources. Reykjavik, Iceland. 5–9 June, 2006. 4 p.

Makkonen, L. 2007. A model of hoarfrost formation. Proceedings, 12th International Workshop on Atmospheric Icing of Structures (IWAIS 2007). Yokohama, Japan, 9–13 October 2007. 4 p.

Nygaard, B.E., Kristjansson, J.E., Berge, L. & Makkonen, L. 2007. Using NWP models to simulate in-cloud atmospheric icing episodes. 12th International Workshop on Atmospheric Icing of Structures (IWAIS 2007). Yokohama, Japan, 9–13 October 2007. 4 p.

Sormunen, P., Laine, T., Laine, J. & Saari, M. 2007. The active utilisation of thermal mass of hollow-core slabs. Proceedings of 9th REHVA World Congress, Clima 2007 WellBeing Indoors. Helsinki, Finland, 10–14 June 2007.

Tammelin, B., Makkonen, L., Fikke, S. & Dobesch, H. 2006. COST 727 Action: Measuring and forecasting atmospheric icing on structures. German Wind Energy Conference, DEWEK 2006. Bremenhaven, Germany, 22–23 September, 2006. 4 p.

Toratti, T. 2006. Classification of human induced floor vibrations: In 2nd International symposium on advanced timber elements. Acoustics and low frequency vibration, Cost E29. Berne University of applied sciences, Biel, Switzerland, 27 April 2006, pp. 97–107.

Vesikari, E. 2006. Development of a life cycle design tool for concrete bridges. Proceedings of European Symposium on Service Life and Serviceability of Concrete Structures ESCS-2006. Concrete Association of Finland. Espoo, Finland. 12–14 June 2006, pp. 227–233.

Vesikari, E. 2006. Lifecycle design module for project level bridge management. Proceedings of the 3rd International Conference on Bridge Maintenance, Safety and Management. Taylor & Francis. Porto, Portugal, 16–19 July 2006.

Vesikari, E. 2008. Life cycle management tool for buildings. In proceedings of 11th International Conference on Durability of Building Materials and Components - Globality and Locality in Durability. Istanbul, Turkey, 11–14 May 2008, Vol. 4, pp. 1637–1644.

FIRE SAFETY

Ala-Outinen, T., Schaumann, P., Kaitila, O. & Kettner, F. 2006. Light weight structures exposed to fire: a stainless steel sandwich panel. 4th International Workshop Structures in Fire, SiF'06. Aveiro, Portugal, 10–12 May 2006.

Hietaniemi, J. 2007. Fire safety engineering design of densely built residential areas. Proceedings of the Interflam 2007 Conference, 11th International Conference on Fire Science and Engineering. University of London, UK, 3–5 September 2007. Interscience Communications Ltd. pp. 1243.

Joyeux, D., Sylvain Désanghère, S., Kaitila, O. & Chica, J. A. 2006. Use of simplified methods for designing external member's protection. 4th International Workshop Structures in Fire, SiF'06. Aveiro, Portugal, 10–12 May 2006.

Kaitila, O. & Korhonen, T. 2006. Simple thermal calculation methods for steel columns protected with steel casings and layered steel balcony slab structures. 4th International Workshop Structures in Fire, SiF'06. Aveiro, Portugal, 10–12 May 2006.

Korhonen, T., Hostikka, S., Heliövaara, S., Ehtamo, H. & Matikainen, K. 2007. FDS+EVAC: Evacuation module for fire dynamics simulator. Proceedings of the Interflam 2007 Conference, 11th International Conference on Fire Science and Engineering. University of London, UK, 3–5 September 2007. Interscience Communications Ltd. pp. 1443–1448.

Paloposki, T., Belloni, K., Tillander, K., Villberg, K & Saarela, K. 2007. Removal of fire odor. Proceedings of the Interflam 2007 Conference London, 11th International Conference on Fire Science and Engineering. University of London, UK, 3–5 September 2007. Interscience Communications Ltd. pp. 1071.

Rinne, T. & Hietaniemi, J. 2007. Use of fire safety engineering and fire risk analysis in heritage buildings. Proceedings of the Interflam 2007 Conference, 11th International Conference on Fire Science and Engineering. University of London, UK, 3–5 September 2007. Interscience Communications Ltd. pp. 1575.

Tsantaridis, L., Hakkarainen, T. & Mikkola, E. 2007. Tools for developing wood based products with improved fire performance. Proceedings of the Interflam 2007 Conference, 11th International Conference on Fire Science and Engineering. University of London, UK, 3–5 September 2007. Interscience Communications Ltd. pp. 745.

INTERNATIONAL LEADERSHIP ROLES

ORGANIZATIONS

American Concrete Institute (ACI)

- Erika Holt, Member of Technical Committees 209 Shrinkage and 231 Early Age Properties

European Association of Product and Process Modelling (EAPPM)

- Matti Hannus, Board Member

European Cooperation in the field of Scientific and Technical Research (COST)

- Ludovic Fulop, Management Action TU0601: Robustness of structures
- Kari Kolari, Management Action C26: Urban Habitat Constructions under Catastrophic Events
- Heli Koukkari, Vice-Chair of Action C25: Sustainability of Constructions - Integrated Approach to Life-time Structural Engineering
- Pekka Lahti, Transportation and Urban Development Domain Committee (TUD DC), National representative and member of Executive Group (EG)
- Pekka Lahti, Management Action C23: Low-Carbon Built Environment
- Pekka Lahti, Rapporteur of Action C21: Urban Ontologies for an Improved Communication in Urban Civil Engineering Projects
- Lasse Makkonen, Management Action 727: Measuring and Forecasting of Atmospheric Icing on Structures; including WG Chairman
- Antti Nurmi, Management Action E27: Sustainability through New Technologies for Enhanced Wood Durability
- Tomi Toratti, Management Action E55: Modelling the Performance of Timber Structures; including WG Leader
- Arto Usenius, Vice-Chair and Management Action E44: Wood Processing Strategy
- Arto Usenius, Management Action E53: Quality Control for Wood and Wood Products; including WG Leader
- several other researchers participate as members to the COST Action committees

European Commission Expert Group on Fire Issues

- Esko Mikkola, Invited Member

European Committee for Standardization (CEN)

- Tarja Häkkinen, Member of Technical Committee 350 and WGs1-5: Sustainability of Construction Works
- Helena Järnström, Member of Technical Committee 351: Assessment of Release of Dangerous Substances; including WG2: Emissions from Construction Products into Indoor Air
- Veijo Lappalainen, Member of Technical Committee 247: Building Automation, Controls and Building Management; including WG3: Building Automation and Control and Building Management Systems and WG4: Open System Data Transmission
- Esko Mikkola, Member of Technical Committee 127: Fire Safety in Buildings
- Hannu Viitanen, Member of Technical Committee 38, WG 21: Durability – Classification, WG 23: Fungal Testing, WG 25: External Factors and Preconditioning

European Construction Technology Platform (ECTP)

- Matti Kokkala, High-level Group Member
- Matti Hannus, Co-leader of Focus Area Processes and ICT

European Fire Sprinkler Network

- Jukka Vaari, Technical Committee Member

European Network of Building Research Institutes (ENBRI)

- Eva Häkkä-Rönnholm, Board Member

Fully Integrated and Automated Technologies (FIATECH)

- Abdul Samad (Sami) Kazi, Co-champion of Element 5: Intelligent Self-Maintaining and Repairing Operational Facilities

International Association for Hydraulic Research, Ice Research and Engineering (IAHR)
- Jaakko Heinonen, Committee Member

International Construction Research Alliance (ICALL)
- Pekka Huovila, Member

International Council for Research and Innovation in Building and Construction (CIB)
- Matti Kokkala, Board Member and Chairman of Program Committee
- Kalle Kähkönen, Joint Coordinator of W65: Organization and Management of Construction
- several other researchers participate as members of Task Groups and Working Commissions

International Energy Agency (IEA)
- Markku Virtanen, Energy Conservation in Buildings and Community Systems (ECBCS) Program, Vice Chairman of Executive Committee
- Markku Virtanen, Chairman of Future Buildings Forum
- several other researchers participate in the work of IEA Annexes

International FORUM of Fire Research Directors
- Tuula Hakkarainen, Member

International Organization for Standardization (ISO)
- Tarja Häkkinen, Coordination Group member of Technical Committee 59, Subcommittee 17: Construction works and Sustainability; WG2 Coordinator
- Veijo Lappalainen, Member of Technical Committee 205: Building environment design; including Member of WG3 Building control systems design. Member of Maintenance Agency for EN ISO16484, Part 5 and EN ISO16484, Part 6
- Hannu Viitanen, ISO Technical Committee 146: Air Quality; including Member of SC6/WG 10 Fungi

International Panel of Climate Change (IPCC)
- Lasse Makkonen, Reviewer of the IPCC Fourth Assessment Report on Climate Change

International Research Group on Wood Protection (IRG/WP)
- Anne-Christine Ritschkoff, Executive Committee Member
- two researchers participate as members

International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM)
- Markku Leivo, National Representative Member
- several researchers participate in RILEM activities as Members

International Workshop on Atmospheric Icing of Structures (IWAIS)
- Lasse Makkonen, Member of the International Advisory Committee

Nordic Facilities Management Network (NordicFM)
- Kauko Tulla, Member and Deputy Board Member of Finland

Nordic Wood Preservation Council (NWPC)
- Antti Nurmi, Member of Technical Committee

Nuclear Energy Agency (NEA), of Organisation for Economic Co-operation and Development (OECD)
- Erkki Vesikari, Member of Committee on the Safety of Nuclear Installations – Concrete

Scandinavian Committee for Computerizing in Wood Industry
- Arto Usenius, Member

Sustainable Building Alliance (SBA)
- Eva Häkkä-Rönnholm, Board Member

United Nations Environment Programme (UNEP)
- Tarja Häkkinen, Expert Member in Sustainable Buildings and Construction Initiative Think-tank.

EDITORIAL BOARD MEMBERSHIPS IN SCIENTIFIC JOURNALS

ACI Materials Journal
- Erika Holt

Cement and Concrete Research (Elsevier)
- Erika Holt

Construction Innovation (Emerald)
- Kalle Kähkönen

Fire and Materials (Johm Wiley)
- Esko Mikkola

International Journal of Construction Project Management (Nova)
- Abdul Samad (Sami) Kazi

International Journal of Fire Science and Technology (Science Univ. of Tokyo)
- Matti Kokkala

International Journal of Managing Projects in Business (Emerald)
- Abdul Samad (Sami) Kazi

International Journal of Sociotechnology and Knowledge Development (IGI Global / InfoSci-Journals)
- Abdul Samad (Sami) Kazi

Journal of Cases on Information Technology (IGI Global / InfoSci-Journals)
- Abdul Samad (Sami) Kazi

Journal of Information Technology in Construction (International)
- Matti Hannus, Abdul Samad (Sami) Kazi

Journal of Civil Engineering and Management (Lithuania)
- Kalle Kähkönen

Journal of Structural Mechanics
- Jaakko Heinonen

Project Perspectives (International Project Management Association):
- Kalle Kähkönen (Editor-in-Chief)

Wood Material Science and Engineering (Taylor and Francis)
- Anne-Christine Ritschkoff

ACADEMIC ASSIGNMENTS

Visiting/Adjunct Professorships

Hanken School of Economics
- Abdul Samad (Sami) Kazi

Helsinki University of Technology
- Matti Kokkala
- Kalle Kähkönen
- Tuomas Paloposki
- Hannu Viitanen
- Markku Virtanen

Lappeenranta University of Technology
- Anne-Christine Ritschkoff
- Arto Usenius

Loughborough University, United Kingdom
- Matti Hannus

Tampere University of Technology
- Pertti Lahdenperä

University of Salford, United Kingdom
- Pekka Huovila

University of Helsinki
- Lasse Makkonen

Advisory Board Memberships in universities, research programmes, etc.

Danish Agency for Science Technology and Innovation: Programme for Renewal of Construction Sector
- Leena Sarvaranta, Evaluator

European Commission, 7th Framework Programme
- Tarja Häkkinen, Evaluator
- Anne-Christine Ritschkoff, Evaluator
- Abdul Samad (Sami) Kazi, Evaluator
- Leena Sarvaranta, Evaluator
- Anne Tolman, Evaluator

Loughborough University, United Kingdom National Research Programme
- Pekka Huovila, Evaluator

Natural Sciences and Engineering Research Council of Canada (NSERC)
- Lasse Makkonen, Reviewer

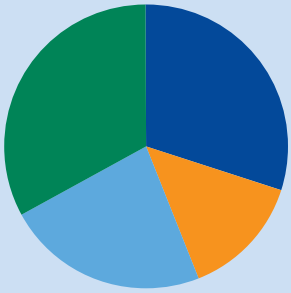
National Dutch Innovation Program for the Construction Sector (PSIBouw)
- Matti Hannus, Advisory Board Member

Nordic Innovation Centre (NICe): Programme for Innovative Building
- Leena Sarvaranta, Member of Think Tank Group and Evaluator

Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS): building and environment.
- Anne-Christine Ritschkoff, Evaluator
- Leena Sarvaranta, Evaluator

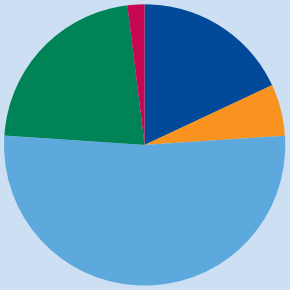
VTT INCOME AND STAFF OVERVIEW

Turnover by type of income



- Income from the private domestic sector 30%
- Income from abroad 14%
- Income from the public domestic sector 23%
- Basic governmental funding 33%

Education of VTT personnel



- Doctors 18%
- Licentiates 6%
- Other university degree 52%
- College degrees, vocational or trade school graduates 22%
- Basic education 2%

VTT's Public Building Research, 2008 Turnover

Total 12.5 Million euros

- ICT-based Systems and Services 15%
- Building Performance, incl. Energy Efficiency 13%
- Infrastructure and Environment 11%
- Fire safety 10%
- Structural Engineering 15%
- Building Materials and Products 22%
- Processes and Business Models 14%

Editorial team: Erika Holt, Matti Kokkala & Taija Vento
Graphic design: Tuija Soininen & Sari Halme
Language checking: Erika Holt
Cover photos: Jussi Tiainen, Antonin Halas, ImageMaker

This review is printed on Galerie Art Silk printing paper, which has been granted the environmental emblem of the Nordic countries.
Edita Prima Ltd

VTT Technical Research Centre of Finland is the largest multitechnological applied research organization in Northern Europe. VTT provides high-end technology solutions and innovation services. From its wide knowledge base, VTT can combine different technologies, create new innovations and a substantial range of world class technologies and applied research services thus improving its clients' competitiveness and competence. Through its international scientific and technology network, VTT can produce information, upgrade technology knowledge, create business intelligence and value added to its stakeholders. VTT is a non-profit-making research organization.

VTT TECHNICAL RESEARCH CENTRE OF FINLAND
Vuorimiehentie 5, Espoo
P.O.Box 1000, FI-02044 VTT
Tel. +358 20 722 111, Fax +358 20 722 7001
www.vtt.fi

Edita Prima Oy, 2008