SQUARE - A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

WP6 –National pilot project in Finland

Final report

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SQUARE

SQUARE - A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings

Final report from the Finnish pilot project Pohjankaleva student house in Oulu

Internal report

Work Package 6. Application of the QA-system in pilot projects

Deliverable D6:1. Report on the results and experiences from pilot project

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Preface

This report is part of the work carried out within the SQUARE project (EIE/07/093/SI2.466701), which stands for A System for Quality Assurance when Retrofitting Existing Buildings to Energy Efficient Buildings. The project is co-funded by the European Commission, supported by its Programme Intelligent Energy Europe (IEE). The SQUARE project aims to assure energy efficient retrofitting of social housing with good indoor environment, in a systematic and controlled way.

The partners of the SQUARE project are:

- AEE Institute for Sustainable Technologies, Austria
- EAP Energy Agency of Plovdiv, Bulgaria
- TKK Helsinki University of Technology, Finland
- Trecodome, Netherlands
- TTA Trama Tecno Ambiental S.L, Spain
- Poma Arquitectura S.L., Spain
- SP Technical Research Institute of Sweden, Sweden
- AB Alingsåshem, Sweden

The report has been prepared by TKK in Finland
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1 Introduction

1.1 Objectives and target buildings

The aim of the Finnish pilot project is make total internal renovation of student house combined with passive house external renovation together with energy efficient new ventilation system.

1.2 Scope and limits

The renovation of the selected building included the following aspects:

- structural: floors, roof, internal divisions
- building shell: insulation, air tightness, windows, new façade material
- sound proofing (increasingly important as the building shell becomes air tight and heavily insulated)
- services: all building services with a particular focus on ventilation heat recovery

The target requirements for energy use after renovation are very demanding, it is not possible to build passive house in Oulu (outdoor design temperature -32 oC) but heating energy demand can be depressed at low level. The indoor environment requirements are equally demanding, in accordance with Class C in the Finnish Indoor Air Classification 2008. Even in cold climate too high indoor air temperatures will be expected if no external solar shading is not used.

2 Background

The first pilot project is a renovation of an entire student housing complex. The developer and owner is PSOAS. The main contractor is the multinational construction company NCC and there will be several sub contractors working on design and construction in different sub works.

The project started in 2007. The main construction work will start in August 2010 and the renovation will be finalized during summer 2011. The building will be available for new students in August 2011.

Table 1 Initial state

Pilot Project Building Blocks	Initial state
Address	Tirolintie 2, Oulu
Number of apartments	No apartments (student house)
Year of construction	1970
Materials	Aerated concrete, concrete floor structure, concrete roof. No balconies.
General systems	District heating (incl. domestic hot water), electricity, water and sewer
Ownership	Public student housing company (PSOAS North Finland Student Home Foundation))

Figure 1. Location of Pohjankaleva student house.

Figure 2. West façade of Pohjankaleva.

The location of the building is 2 km north from the centre of Oulu. The population rate of Oulu is 140 000. Oulu is commercial, educational and governmental centre of northern Finland which covers half of Finland. The building has been built in 1970. Windows were replaced with triple pane windows in 1993. The new windows were equipped with fresh air vents (narrow horizontal slots which can be open and closed).

Since 2007 the proportion of unoccupied floor area has been increased from 10 to 20%. During the summertime 50% of the rooms are empty. The main reason for renovation is the modernization of the building.

3 Methods and accomplishment

Because the of renovation of the Pohjankaleva first stage of the project began one year before the SQUARE WP6, the Quality Assurance tools used were existing tools already in use in Finland. Several similar tools and procedure described in SQUARE QA-system have been in use several yers in Finland. The most used ones are FEA and TPI. Both one's are supported by Ministry of Environment wit subsides.

The main focus of the SQUARE activities in Pohjankaleva is the assessment of a QA tools already in operation and how they can be integrated with the new essential SQUARE procedures.

3.1 Establishing pre-renovation conditions

Technical evaluation of the building

The house was partially renovated in 1993. The windows were replaced by three pane windows with fresh air slot vents, and now have a U-value of 1.7 W/m^2,K. The external walls are made from aerated concreted with an U-value of 0.55 W/m^2,K. The technical condition of the building is still relatively good. The estimated urgent renovation costs (without uncertain costs associated with outdoor walls) during the coming years up to 2017 are 120 €/m^2. During the last years there have been increasing problems to occupy all rooms. During summertime half of the rooms have been empty and during semesters still 20 % of the rooms are empty.

The following tables summarize the pre-renovation situation and the targets.

Table 2. Initial and target U values.

Envelope	***U before retrofit (W/m^2 °C)***	***U after retrofit (W/m^2 °C)***
External walls	*0,55*	*0,10*
Windows	*1,7*	*0,6*
Roof	*0,35*	*0,08*
Air tightness (1/h)	*6.*	*0,5*

First energy analysis

The building is connected to district heating systems where heat is co-generated with electricity. The main fuel is peat. The heating energy consumption 140 kWh/m^2 (+domestic hot water 30 kWh/m^2, domestic + facility electricity 50 kWh/m^2) was lower than average value in buildings built at the same time in Oulu area (210 kWh/m^2)

Table 3. Initial and target Energy demand.

Utility	***Energy demand before retrofit (kWh/ m²)***	***Energy demand after retrofit (kWh/ m²)***
Space heating	*140*	*25*
Water heating	*30**	*35****
Domestic electricity + Common appliances electricity	*50*	*67***
Total demand	*220*	*127*

* *Decreased number of tenants*
** *Increased number private appliances*
***Private showers instead of shared can increase use of showers

Occupant survey and performance of ventilation

Main problems related to the indoor air quality were too high room temperatures during spring and winter. The fresh air slot vents in the upper frame of the windows are also causing a lot of draught complaints. All rooms are connected to a centralized mechanical exhaust ventilation system. When the exhaust air flow rates were measured in 2009 the average exhaust air rate was reduced app. by 20%. In individual rooms exhaust air flow rates varied from 20 to 120% of the design value. The opening of windows increased the exhaust air flow rate in a single room by 40 %. The air tightness of the external walls was not bad.

3.2 Formulation of requirements and targets prior to renovation

Finnish building code, part D2 Indoor Climate and Ventilation includes minimum requirements for adequate ventilation and IAQ and thermal comfort. The significance of indoor climate for health, comfort and productivity has been well recognized in Finland over last decades. As a result of many extensive research projects on indoor climate and clean ventilation, Classification of Indoor Climate, Construction and Finishing Materials was published in 1995. This classification changed the installation work in construction sites (clean ventilation) as well as building material market (low emission building material labelling) and has systematized the design. The classification was updated in 2001 and in 2008.

Voluntary design values for the heating and cooling

- Operative temperature [°C] $t_{out} \leq 0$ °C 21-22 (normal) 20/23 (Min/Max
  $< t_{out} \leq 15$ °C 21-23 20/24
  $t_{out} > 15$ °C 23-25 22/27

- Air leakage at 50 Pa 0,6 1/h.

- Heat recovery efficiency 80-85%.

No mechanical cooling will be used. Balconies will be used as solar shades. Room temperature levels will be simulated with IDA/ICE-program by TKK and main .

The North Finland Student House Foundation , PSOAS, have established some very demanding target requirements for energy use after renovation. These are taken from a voluntary standard for passive houses recently developed in German and adopted to climate in North Finland. Pohjankaleva is the first major renovation project where they are applied. The goal is to reach passive house standard level which in northern Finland is 30 kWh/m^2 per year for heating energy (domestic hot water 25 kWh/m^2).

Co2 emissions are difficult to estimate. The building is connected to district heating network system which utilizes waste heat from Toppila electric power plant. The main<fuels are peat, wood and oil. The mixture of these fuels varies yearly. Peat is classified in EU as fossil fuel.

3.3 Energy efficiency and indoor environment

Targets are to keep total energy (heating + electricity + domestic electricity) needs at 127 kWh/m^2. The energy requirements have been verified by means of building simulations prior to renovation. Provided the energy targets are actually reached, the building will reach the top level Finnish official rating with a good margin. A certificate related to the compulsory energy declaration of buildings will be issued after the renovation is completed.

In order to guarantee a good indoor environment, thermal comfort requirements will be equally verified through building simulations and they will also be verified through detailed measurements as part of the SQUARE activities by the end of the construction project. c.

3.4 Cooperative partners for the QA system implementation

TKK coordinates the SQUARE QA system implementation at Pohjankaleva and focuses on integration of existing Finnish tools in SQUARE QA system. PSOAS is a non-profit foundation operating student houses in Oulu, Rovaniemi ja Kajaani. PSOAS with rooms for over 5000 students is a medium size operator in Finland. In their office is working 15 employees. They have managing director, five building managers, several persons for custom service, rent control and bookkeeping. In every August they need to handle 1000 new tenants starting their studies in local universities. The board of the foundation accepts major building projects. PSOAS do not any own cleaning or maintenance personnel. Cleaning and maintenance services are bought mainly two different private companies.

Other stakeholder's mentioned below are mainly addressed in joint efforts with PSOAS. The status of the main participating groups, organisations and companies with respect to QA are the following:

- PSOAS as a housing association is quite experienced with new buildings and renovation projects and management of existing building stock.

- The main contractor NCC Finland is a very large construction company with long experience from building construction and renovation. Their team at Pohjankaleva is very dedicated and interested in solving upcoming challenges related to the extraordinary requirements. They have their own QA system and own experts to consult e.g. in moisture and air tightness related issues.
- Another important stakeholder group is the subcontractors. The largest housing design consult in Finland, Optiplan, will coordinate the design process. Local consults must be used because of expensive travelling costs between Southern and Northern Finland.
- The Buildings Regulations Department of the city of Oulu will be present during design and construction meetings.
- Maintenance and cleaning companies will select in 2011.

Outer façade elements are design TKK, department of Architect. Such timber elements has developed in another EU-project TES (www.tesenergyfacade.com)

3.5 General strategy and overall goal for the QA system implementation

SQUARE inputs will focus on integrating existing Finnish procedures together which then can be operate with SQUARE QA systemsn assessment of the existing system and on the integration of a number of additional documents considered to be particularly relevant with respect to efficient use of energy and good indoor environment. These new documents will be taken from the SQUARE system and tailored in order to harmonise with the needs of PSOAS.

The overall goal of the activity is twofold:

1. To closely follow the main steps of the renovation process and on to building management in order to assure that requirements on indoor environment and energy use are fulfilled
2. To take active part in the development of PSOAS's QA system, thus improving its usefulness as a tool in the everyday work and for capacity building of the organisation

Procedures applied during pilot project:

-Simple energy analyse (www.motiva.fi)

-Simple condition survey

-Plumbing and water systems

-Indoor air and ventilation

Voluntary guidelines:

-Guidebook how to design healthy apartment building www.sisailmayhdistys.fi
-Guidebook how to design low energy building (2009) (Jarek Kurnitski et al) www.ril.fi
-Indoor climate classification 2008 www.sisäilmayhdistys.fi
-Over 1000 low-emitting (VOC's + odors) building materials www.rts.fi
-Design handbook for clean supply air systems www.sisailmayhdistys.fi

Procedures which will be applied during design and construction work

-Moisture control during construction work
-Dust control during construction work
-Guidelines for how to build a clean ventilation system
-How to clean building before occupancy

Procedures which will be used during maintenance period:
-Maintenance handbook
 -Mandatory in Finland
-Energy certification
 -Annual
 -Between 10 years

3.6 Focus areas for the QA system implementation

The SQUARE activities in the Finnish pilot project involve practical QA activities such as measurements, investigations, inquiries etc. as well as "simulation work dealing with energy efficiency and room temperatures" more directly related to the QA system implementation. Examples of planned practical activities are:

- measurements of air tightness , thermal bridges and thermal comfort measurements after renovation
- TES façade elements will be pressurised and tested in factory in order to ensure air tightness
- Moisture performance of TES façade element has been simulated in different European climate zones in Germany. Moisture performance in Oulu is acceptable

- Early stage idea of using TES element as a route for air supply ducts was dropped away in order to ensure the air tightness of element
- measurements of ventilation rates and carbon dioxide levels.
- questionnaires to tenants

The QA in the construction process is considered to be well managed in this project, mainly as a result of PSOAS's procedures for choosing their contractors. Therefore, the focus of the implementation will be on the preparatory and operational phases. More specifically it will focus on:

- Assessment of the existing system, using the Finnish conditions evaluation method. These methods have developed during 90's for structures, HVAC-systems, electrical installations taking into account the previous experiences of PSOAS. This is done in order to improve the usefulness and applicability of existing as well as new (SQUARE QA) procedures. This way the feed back to the SQUARE project will also be enhanced, as long term experience from the application of our QA system is very limited until date.
- Definition and integration of relevant requirements on indoor environment and energy use in the system
- Integration of procedures and templates for the conditions survey and energy analysis
- Review of procedures and templates for the building management phase, in particular with respect to follow up on energy use.

3.7 Identified success factors in the implementation work

Existing Finnish sub tools has been used successfully.

3.8 Identified barriers or difficulties in the implementation work

Start of the pilot project has been very promising. The final results wil be after SQUARE project has been closed.

3.9 Dissemination potential within the organisation

People in PSOAS have been very interesting and willing to QA-systems during design, construction and operation periods.

4 Timetable

Due to the very strict requirements, targets and improved housing quakity, the estimated renovation cost are very high. PSOAS and NCC Finland therefore also considered a budget for complete demolition and rebuilding before the decision on renovation will be taken. Final decision to renovate was made in October 2009. After that detailed cost optimazation hs been done. At the moment estimated renovation costs will be 1600 €/m2. Detailed planning is under work now. NCC Finland is ready to start in August 2010. The SQUARE project will end before construction work will be stated. In summer 2009 a national research project KIMU was started (6/2009-6/2011). KIMU is dealing with climate change in private apartment buildings. KIMU is interested to use experiences from SQUARE. So it will be possible to follow up the Pohjankaleva project until end.

Table 4. Updated time-table for Finnish pilot project.

	Year
	Month
Building selection	2008/3
Energy use and indoor environment requirements	2008/9
Thorough primary investigation - TPI	2007
First energy analysis – FEA	2008
Renovation concept development and analysis	2008(1-12)
Envelope renovation	2010/8-
General systems renovation	2010/9-
Measurements and checks during construction	2011(1-6)
Operation and maintenance	2011/8-
Monitoring, metering and measurements	201077-
Non-compliances, corrective and preventive actions Warranty period 24 months	2011-2013

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