

Municipal challenges in managing a building with noted health symptoms

Municipal
challenges

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Abstract

Purpose – This study aims to present property management challenges that municipalities have encountered regarding a public building with noted building-related symptoms. The study goes on to provide reasons for the failure of attempts to manage the symptoms and discusses the current challenges concerning the process.

Design/methodology/approach – A participatory case study was used as the research methodology to identify the current challenges concerning a municipal approach to managing the building-related symptoms in a case-study building. The researchers scrutinised the history of the health symptom management process and attended the project planning meetings focused on the investigation of the condition of the building.

Findings – Multiple challenges concerning maintenance and omitted or postponed repair actions, as well as vagueness in the management process were found. In addition to this, it was noted that the complexity of the initial design of the building and vandalism have resulted in challenges for the maintenance and moisture performance of the building structures. According to the study, more orderliness and a more systematic process is needed when managing a municipal property.

Practical implications – The identified property management challenges may be of practical value for the facility managers and the property owners, especially when managing the building-related symptoms and a damaged building.

Originality/value – This study highlights the importance of having an in-depth understanding of condition assessments as well as proper maintenance and timely repairs for the successful management of the building-related symptoms in a municipal building. This is a pilot project in a larger project of management of building refurbishment.

Keywords School, Condition assessment, Management, Health effects, Building-related symptoms, Moisture damage, Mould, Case study

Paper type Case study

Introduction

In many countries, municipalities own a substantial amount of building stock, including public buildings, schools and day nurseries. In all respect, management of extensive building stock is challenging, as in recent years, serious and widespread problems concerning municipal properties have arisen. In several countries, building-related symptoms, indoor air problems, mould and water leaks are considered common problems in public buildings such as schools and day nurseries (Borràs-Santos *et al.*, 2013; Cai *et al.*,



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2011; Dangman *et al.*, 2005; Ebbenhøj *et al.*, 2005; Jurelionis and Seduikyte, 2008; Kielb *et al.*, 2015; Meyer *et al.*, 2004; Park *et al.*, 2004; Saijo *et al.*, 2010; Savilahti, 2009; Taskinen *et al.*, 1997; Zhang *et al.*, 2013, 2011).

A substantial amount of a municipal building stock is damaged, and refurbishment is typically delayed, with only minor renovations carried out to repair damage observed. As a result, the damage increases in scale and may spread to other structures, resulting in a need for large-scale and expensive replacement or refurbishment work later. In addition to this, the refurbishment process is challenging and identification of building-related symptoms, pinpointing of the sources and management of the damage elimination process require wide-ranging expertise.

The building-related health problems may be divided in two classes: building-related illnesses and sick building syndrome. Building-related illnesses are health effects, which have well-defined link between environmental agent such as chemicals, gases, volatile organic compounds (VOCs), fibres and bacteria (Seltzer, 1994; Tong, 1991). The sick building syndrome is a complex problem with variety of factors resulting in a typical set of symptoms, including eye irritation, blocked, stuffy or runny nose, dry throat, headache, lethargy and dry skin (Tong, 1991). Those symptoms have linked to reduced effect on performance and sick leaves (Niemelä *et al.*, 2006; Tong, 1991). This study focus on the managing of the symptoms related to sick building syndrome.

This study examines the building-related symptom management practices in a municipality-run school with a day nursery. The municipalities have taken action to find and minimise sources of the symptoms multiple times, but the results have not been satisfactory. Thus, this case study will identify the current challenges faced in relation to the process and aims to establish the reasons for the failure.

Challenges in managing building-related symptoms in a school and day nursery environment

In Finland, municipal building stock covers about 35 million sq. m, which is over 7 per cent of the country's entire building stock. Most of those buildings require refurbishment because the majority of the stock was built before the early 1990s, and health complaints are relatively common, especially in school buildings (Korhonen *et al.*, 2018). Overall, the prevalence of building-related symptoms in municipal buildings has increased in recent years, and the condition of the buildings is deteriorating (Korhonen *et al.*, 2018).

Usually, the health symptoms in a school environment are related to structures damaged by moisture and mould (Annala *et al.*, 2017; Handal *et al.*, 2004; Haverinen-Shaughnessy, 2012; Koivisto *et al.*, 2002; Lignell *et al.*, 2007; Meklin *et al.*, 2005; Patovirta, 2005; Patovirta *et al.*, 2004; Sahakian *et al.*, 2008; Savilahti *et al.*, 2000; Taskinen *et al.*, 1997). The damage may be caused by several factors, including water leaks, the moisture load from outdoors, failures in structures and a technical ageing of materials (Koivisto *et al.*, 2002; Meklin *et al.*, 2002; Täubel and Leppänen, 2017). However, other factors, such as dust mites (Kielb *et al.*, 2015), volatile organic compounds (Åhman *et al.*, 2000; Norbäck *et al.*, 1990) and a lack of ventilation (Simoni *et al.*, 2010) are also strongly associated with the health symptoms. Typically, Finnish municipalities organise facility management by taking integrated responsibility for administration, operation and maintenance of the public building stock and the executive financial decisions are usually made by the municipal council.

Method and material

A participatory case study approach was adopted to identify the current challenges related to the municipal management practices of the building-related symptoms in a municipality-run school and a day nursery. The data used for the analysis was based on documents

including reports from investigations, surveys and questionnaires as well as building documentation. In addition to this, the authors of this article attended project meetings with municipal authors and condition assessment consultants, as the municipal authors were purchasing a new condition assessment.

The municipalities undertook measures eliminate the symptoms in the case study building for several years, but the results had been unsatisfactory. In 2018, the municipalities started project planning for refurbishment and an extension of the case study building, as the number of pupils in the school and children in the day nursery will increase in coming years. At the beginning of the project planning phase, in April and May 2018, the municipalities purchased a condition assessment, and the investigations were carried out during summer and autumn 2018. From March to November 2018, 14 project meetings were held, focused on the content and results of the new condition assessment, the content and results of the investigations carried out and the repair actions implemented. The authors of this article actively attended the project planning meetings, with the number of participants at the meetings ranging from 6 to 18. The participants of the meetings are listed in [Table I](#).

The nature of the case study gave the authors an opportunity to study the organisation in practice and build understanding of the phenomenon and the process.

This research is part of the “Management of Complex Building Refurbishment” project, which aims to develop tools and practices for improving the management of complex building refurbishment projects. The project team selected the case study school as a pilot project.

Case study building

The case study building is a primary school with a day nursery located in a metropolitan area of Southern Finland. The two-storey building was built in 1997, and the total floor area is 5,223 m². Currently, approximately 400 children attend in the primary school and just over 40 children attend the day nursery. In addition to this, 50 faculty and 14 staff members work in the building. Furthermore, a secondary school building and a building for pupils with special needs are located on the same campus, but all the pupils use each of the buildings. In total, almost 800 pupils attend one of the facilities on the campus.

The building has a pier foundation with ground-supported footing units and concrete plinth panels. The frame is plastered brickwork and combined with sheet iron caisson. The load-bearing external walls are concrete elements with mineral wool insulation installed during the construction phase. A flat roof covers a number of different levels and has

Stakeholder	Participant
Authors of this article	Three university researchers
Condition assessment consultants	Five condition assessment consultant the building developing department purchased in May 2018
Municipal authors	Representatives of the building developing department The chief of the maintenance department The representative of a renovation contractor The representative of a school committee Kitchen expert Cleaning expert
Users	The chief of early childhood education The head teacher and the deputy head teacher

Table I.
The participants of the meetings

hollow-core concrete slabs as its load-bearing structure. The roof was repaired during 2015-2017. The building has a mechanical supply and exhaust ventilation ([Plate 1](#)).

Health symptoms

The staff has complained for several years about an unpleasant smell and health symptoms when using the building. Usually, a person who suffer from such symptoms contacts an occupational health centre, where the staff then inspect the symptoms and gives a diagnosis. In addition to this, some wider health questionnaires have also been conducted. In a health questionnaire survey implemented in spring 2017, 41 per cent of the staff reported health symptoms, such as repeated and persistent respiratory disorders, eye irritation, headache, allergic symptoms, coughs and fatigue. The staff pointed out that the pupils also suffer from symptoms. In a health questionnaire survey implemented between November 2018 and January 2019, directed at all users of the building, over 60 per cent of the respondents reported having symptoms when using the building.

Results

The surveys implemented

The municipality authors have sought the reason for the building-related symptoms for several years by purchasing multiple investigations. The reports considering the condition of the building are presented in [Table II](#).

The reports were scrutinised and the analysis shows that the investigations covered all the structural parts of the building as well as a yard, the ventilation ducts and installations and a sewer system. Several techniques and methods were used for surveying work: structural openings were made in the external and partition walls, the roof, the false ceiling and the floors. Surface moisture from the floors and the walls and the air pressure of the rooms were measured several times and a tracer gas was used to study a local air leakage. Additionally, temperature, relative humidity and carbon dioxide levels in the classrooms were measured for several weeks. Volatile organic compound were also detected, and samples from the air and various materials were taken and analysed. Twice mould was detected using a trained dog.

The results of the reports presented multiple factors that might have affected the development of the building-related symptoms. The sources and findings presented are collected and categorised in [Table III](#).

The majority of the investigations led to suggestions for repair and maintenance actions, such as regulation of the ventilation, repair of a skylight window, sealing repairs and an



Plate 1.
Aerial view of the
building (feasibility
analysis)

Table II.
The reports of
investigations,
inspections and
renovations between
2003 and 2019

Date	Type of the survey
August 2003	Inspection of kitchen by environmental centre
June 2008	Microbial survey of eight rooms
September 2008	Health-related inspection of working conditions
January 2009	Moisture survey in rooms complaints have been received about
February 2009	Condition survey of a ventilation system
September 2009	Inspection by labour protection district
March 2011	Indoor environmental survey in one class room
March 2011	Survey of water leakage from the roof
June 2011	Mould survey using trained dog
August 2011	Indoor environmental survey in three class rooms
October 2011	Quality assurance of sealing work
February 2012	Indoor environmental survey of the kitchen
June 2013	Survey of water leakage from the roof
March 2014	Indoor environmental survey
July 2014	Survey of water leakage
July 2014	Survey of water leakage
August 2014	Survey of water leakage
September 2015	VOC survey
September 2015	Microbial survey of indoor air
May 2016	Indoor air environmental and moisture performance survey
January 2017	Inspection by environmental centre
April 2017	Condition survey of pipes
May 2017	Indoor air environmental and moisture performance survey
August 2017 (26.7.2017)	Leakage test of sewers
October 2017	Building condition evaluation and long-term plan
February 2018	Ventilation assessment, research memo
February 2018	Renovation action plan
February 2018	Indoor environmental condition survey, research memo
October 2018	Microbial survey
October 2018	Condition survey

upgraded standard of cleaning, as well as more additional investigations, including a greater amount of microbe samples.

In the initial years, microbial surveys of material samples were relative random; therefore, the comprehensive overview of the microbial situation of the structures was insufficient. In the most recent microbial studies, in summer 2019, samples were collected from several locations. High concentrations of fungi genera, which are often associated with mould, were found in several locations in the partition walls, external walls and insulation of a skylight base, especially in the area where the users have complained about the symptoms. Therefore, it can be concluded that the microbes found in the partition walls are one of the main reasons for the symptoms. The damaged materials were concentrated in the area where several water leakages have occurred. Some materials in an area that was covered with water in 2014 were replaced after the water leakage. However, it seems that the water ended up in a wider area that previously assumed, or that not all the moisture-damaged materials were replaced.

In several reports, vandalism to the roof was detected, and it was suggested that further such actions should be prevented. During a roof repair, it was suggested that a plywood board be installed on the wall of a store area to prevent access; however, that has not had the desired effect.

Table III.
Findings of the
surveys

Structure/feature	Findings
<i>Microbes</i>	High concentrations of different bacteria, fungi and microbes have been detected in several air and material samples
<i>Roof and skylights</i>	Water leakages occurred several times from roof and skylights Failures in structures due to vandalism Construction errors
<i>Walls</i>	Indication of water damage and microbes in partition walls External walls not studied on a large scale Construction errors in external walls
<i>Windows</i>	Recurring water leakages from windows in two classrooms
<i>Floor</i>	High relative humidity in several areas of the base floor Unpleasant smell from the base floor Material emissions from glue on the concrete floor
<i>Sewers</i>	Smell from sewers Corrosion in some sewers Accumulation of debris and dents in rainwater drains
<i>Ventilation and air pressure</i>	Air flow in many rooms lower than planned High negative, 25-30 Pa, air pressure in some rooms compared to outdoors Blocked ventilating pipes
<i>Indoor environment</i>	Carbon dioxide levels in classrooms were reported to be generally at a normal level Temperatures in classrooms generally at a normal level Relative humidity has been occasionally slightly below normal level, relative humidity 20-30%, resulting in a feeling of dry air
<i>Yard</i>	Pooled water close to the building Plants growing close to the building Minor slanting of the yard away from the building No underdrain system
<i>Other</i>	Dust, poor standard of cleaning Cracks in joints of several structures, leaking structures

Repair actions

Over the years, several repair and replacements actions have been implemented in the building. However, not all the actions have been documented or reported systematically, and thus, a complete overview of the repairs carried out is lacking. The chief of maintenance and the existing reports substantiate that the following repair actions are executed:

- The roof was completely renovated during the summers 2015-2017. The original roof structure was stripped back to the concrete slabs, and the new structure was built on the top of the cleaned slabs. Some levels of the roof were lifted to the same level as the other parts of the roof.
- Multiple small-scale repairs after water leakages between 2006 and 2014.
- Drying of some of the rooms after a water leak and replacement of some of the materials in 2011.
- A bottle was removed from a sewer in summer 2017, and the functionality of the sewer system was examined using a smoke test. No leakages were observed.

Between May 2018 and February 2019, multiple rooms were repaired extensively with the aim of decreasing the prevalence of the symptoms. The repair actions included sealing the rooms to make them airtight, putting an epoxy membrane coating on a concrete floor and replacement of a floor coating. The actions were based on a repair suggestion given in a condition assessment implemented in 2017 and early 2018. In addition to this, some actions

were taken on the basis of the most recent condition assessment carried out in summer 2018. During the demolition work in June 2018, mould was spotted across a wide area of the partition wall between a corridor and a classroom; in addition to this, staining from prior water damage was observed on the partition wall behind cupboards in another classroom.

The purchase of the condition assessment

In April and May 2018, the municipalities purchased a condition assessment. Two separate consultant companies were selected to carry out the surveys: one of the companies was commissioned to survey the technical building services and carry out microbe explorations and the other was commissioned to investigate the structural physics of the building and to make structural openings. The content of the surveys, the progress and the findings were discussed in the project meetings between May and November 2018. The municipalities also purchased some additional surveys as suggested by the consultants. However, some of the additional investigations the consultants suggested, including the additional microbial sampling of the external walls, were not purchased, even though the parties were unanimous as to the need for the investigation in the project meetings.

In addition, as there were refurbishment actions in progress during summer and autumn 2018, the content of those actions was also discussed in the meetings. Different perspectives on the renovation actions and the elimination of the symptoms emerged in the meetings. The chief of maintenance stated that the purpose of those renovation actions was to respond quickly to the symptoms exhibited by users. Whereas the condition assessment consultants, on the other hand, drew attention to the elimination of the sources of the symptoms and the long-term perspective. For this reason, they did not consider the sealing of the external wall to be the most appropriate renovation method, as the potential microbes in the external wall had not been investigated and their presence established.

The persons in the meetings had also different impressions of the prevalence of the symptoms and of the success of the renovations carried out in previous years. According to the building development department, users have had symptoms for several years, but the chef of maintenance stated that the symptoms significantly decreased occasionally over the years. Different impressions were also presented regarding the functionality of the repaired roof and the ventilation equipment. The building development department pointed out that the sources of the symptoms had not been determined, whereas the maintenance department claimed that the sources were stated in the condition assessments carried out in 2017 and early 2018. The diversity of views indicates that different persons have interpreted the results of the condition assessments in different ways.

Discussion

The investigations purchased show that municipalities have tended to respond to failures and observations actively. However, because the failures have been repeated and the symptoms have persisted, the responses have been relatively ineffective. The study found several challenges in the management process for building-related symptoms, as well as multiple factors that have caused the indoor air problems and complicated the management of the building. The findings can be summarised as follows:

- (1) failures:
 - breakdowns of the devices and the structures.
- (2) characteristics of the building:
 - at-risk structures.
- (3) procurement of the investigations:

- limited content of the study: structures, rooms; and
 - limited survey methods and amount of samplings:
- (4) lack of competence in the evaluation of the investigations
 - lack of procurement of additional surveys; and
 - lack of implementation of the suggested repair actions.
 - (5) repair actions:
 - delayed actions;
 - only partial actions;
 - small-scale and temporary repairs instead of replacement; and
 - failed actions.
 - (6) poor standard of cleaning.
 - (7) poor standard of maintenance:
 - difficulties in maintenance because of building characteristics.
 - (8) lack of documentation.
 - (9) vandalism.
 - (10) lack of communication between the users, the maintenance department and the building developer.

Attempts were made to manage the building-related symptoms in the case study school for several years, and accordingly, multiple studies and repair actions were implemented. The explanation given in the investigations showed that the sources of the symptoms were usually studied on a small scale and the investigations were limited to only some rooms. In addition to this, the investigation techniques were limited, for example only few or no material samples were gathered from the structures, with most of the samples were gathered from air and dust from the floor. The findings of these deficient and limited condition assessments are in accordance with previous findings (Marttila *et al.*, 2015). Additionally, some of the investigations presented requirements for further research, for example, it was suggested more material samples from the partition wall structures be gathered, but those needs were not systematically responded to. Therefore, the content of the investigations remained limited. Perhaps, a more extensive study and varied techniques would have produced more reliable results and indicated more potential sources of the symptoms earlier on.

The interpretation of the investigation results and content may have been limited or the previous investigations may not have been processed well or trusted, as multiple studies overlapped and presented similar results. In addition, the repair actions suggested in the condition assessments were often implemented only partially and after a delay. Therefore, even though some of the noted failures were repaired, the damage might have expanded in some structures, and therefore, the symptoms did not decrease markedly. Furthermore, Marttila *et al.* (2017) stated that condition assessment observations are not always considered in the execution of a renovation.

Some actions might have been postponed because of a lack of funding or because of awareness that larger building refurbishment projects were being planned for the future. Other studies have also reported that a lack of funding for refurbishment and maintenance impaired the condition of the municipal property (Kero, 2011; Korhonen *et al.*, 2018; Lewis *et al.*, 2000).

Both the maintenance department and the building development department purchased condition surveys. This explains the overlapping of the content of the surveys but also

indicates a breakdown in communications between the departments. The challenges in communications and information flow may have partly originated from a high turnover of municipal workers: during the project planning phase of the case study school, the project manager changed twice.

Many of the investigations claimed that there was no need for further research even if the reason for the health symptoms had not been established. In addition to this, condition assessment observations were somewhat inconsistent with each other. For example, some assessments stated that a new, replaced roof worked correctly and had no faults, whilst another one discovered several defects in the structure and functionality of the roof. Because the level of the condition assessments varies greatly, the municipalities require comprehensive understanding when it comes to purchasing the investigations, and they also need competence in interpreting and evaluating the investigation results.

Many of the investigations highlighted deficiencies in maintenance and cleaning. The standard of the cleaning level was noted as being relatively poor in several condition assessment reports, for example, microbes growing in toilets and high amount of dust and dirt on the floors were detected. It was suggested that it be improved, as some reports indicated that a poor level of cleaning might be one reason for the health symptoms. However, it can be assumed that there has not been any improvement as this is mentioned in five reports. Perhaps, the cleaners were not notified for the required level of cleaning, the cleaning is done indifferently or the result of the work is not briefed or supervised. In other study, a poor level of cleaning was linked to building-related symptoms in schools (Wälinder *et al.*, 1999). Additionally, defects in a ventilation system have been ongoing for a long time because failures in the system, complications with operating times and a recommendation for more accurate maintenance of the devices were pointed out in several condition assessments reports. The faults with the ventilation system caused a pressure difference in the rooms, and that might have brought microbes from the structures into the indoor air. In addition, the records concerning air regulation and servicing of the machines were vague and incomplete. Therefore, it has been challenging to establish which actions have been implemented and what effect they have had. The results of the reports imply that a lack of a proper maintenance played a role in the damage the school has incurred, and other authors have reported similar results in different buildings (Chehelgo *et al.*, 2001; Kero, 2011; Lavy and Bilbo, 2009).

The repair actions carried out over the years were not systematically documented, and the documentation that did exist was not kept safe. Therefore, carrying out a systematic follow-up examining the success of the repairs in eliminating health symptoms has been challenging. According to one head of maintenance, occasionally, the symptoms almost disappeared. However, because the documentation of the repair actions has been sub-par, and the symptoms have not been systematically followed-up on, it is challenging to establish afterwards which of the actions have been successful.

The challenges faced at the school have been complex and varied and have covered multiple failures in several structures and systems. For example, the water leakages originated from the roof, the skylights, around the windows and the rainwater drain under the floor. The standard of construction work has been relatively poor, because the condition assessments found several errors as a result of the work, and the initial structural solution of the building is complicated. The roof initially had several levels, and the envelope of the building is structurally complex and includes multiple recesses and corners. The complexity has caused problems for maintenance because walking on and access to the roof, for example, are challenging. In addition, some unfavourable modifications were implemented during the construction phase. For example, there is no underdrain system under the

building, even though one was designed, and the building is built on a soil with high capillarity in relation to the design plan.

As the building is complex and failures have been detected in multiple structures, elimination of the symptoms is challenging. To eliminate the symptoms and prevent the new ones occurring, a comprehensive and systematic management of the building is required. Proper and systematic maintenance, quick response to hazards, timely repairs and follow-up of the symptoms seem to be important, which supports the findings of [Kero \(2011\)](#). In addition, a comprehensive investigation of a building after a hazard or symptoms arises appears to be necessary, and the repairs suggested should be carried out without delay after a failure such as a water leakage, to curtail the damage.

Consistently with past research, water leaks were one of the major reason for moisture damage in the school ([Gravesen *et al.*, 1999](#)). A blockage in the rainwater drains and the drainage pipes caused moisture damage, which is consistent with the study carried out by [Leivo and Rantala \(2005\)](#). In addition, the roof outlets were relatively small, and the maintenance was not implemented in a particularly careful or timely manner. Therefore, the outlets were blocked up, resulting in water leaks. Overall, water leaks have proven to be a very common reason for mould exposure ([Crook and Burton, 2010](#); [Haverinen-Shaughnessy, 2012](#); [Nduka *et al.*, 2018](#); [WHO, 2009](#); [Yang *et al.*, 1997](#)). A significant finding of this study was that vandalism caused the water leaks and moisture damage, which other authors have not strongly associated with the building-related symptoms.

Even though this study was limited to one public building in Finland, the authors believe that municipalities across multiple countries, whose mission is to improve the management process of a damaged building or building-related symptoms, may find the findings of this study useful. The municipal challenges reported in this study are not limited to this case as other studies present similar problems, such as challenges with maintenance and an urgent need for repairs ([Hopland, 2014](#); [Kero, 2011](#); [Lavy and Bilbo, 2009](#); [Lewis *et al.*, 2000](#); [Smith and Stewart, 2007](#)), inadequate information about the building condition ([Kero, 2011](#); [Lavy and Bilbo, 2009](#)), a lack of competence in purchasing and interpreting the condition assessments ([Kero, 2011](#); [Marttila *et al.*, 2016](#)) and similar technical challenges in school buildings ([Lewis *et al.*, 2000](#)).

Conclusions

This study highlights the importance of proper maintenance, as well as an in-depth understanding of condition assessments in the management of building-related symptoms. The research aimed to identify property management challenges that municipalities have encountered regarding a public building with noted building-related symptoms. The study revealed multiple reasons for the failure of municipal attempts to manage the building-related symptoms in the building occupied by the public school and day nursery. The main findings can be summarised as follows:

- technical challenges and failures: ignorance of the sources of the building-related symptoms;
- organisational challenges: overlapping work between the maintenance department and the developer department and ignorance of the work the departments have done;
- lack of competence in purchasing the condition assessments and interpreting the results of the surveys; and
- communicational and political challenges: public pressure for swift actions.

In addition to this, the research discovered that a lack of proper maintenance, as well as omission of repair actions, impacted the extent of the symptoms. Additionally, vandalism, the complex design solutions and defects in building work have had a partial effect on the development of the problems.

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