Tracing the Historical Indoor Climate of a Swedish Church, c. 1800-2000

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Archival sources can often provide valuable information on the past indoor climate of a historical building.

Introduction

Indoor climate is a serious concern regarding the preservation of the approximately 1,380 extant historic churches in Sweden. The management of the indoor climate of these buildings has been heavily debated, since they house vulnerable polychrome wooden interior features of significant historical value, such as painted wooden pulpits from the seventeenth and eighteenth centuries, medieval wooden crucifixes, painted benches, bishop’s chairs, and other rare antiquities. When considering the indoor climate in historic buildings, not only should the current situation be examined but also the past climate. However, what is known about historical climate in churches is mostly based on assumptions.¹

Little is known about how maintenance and repairs in churches were funded and carried out in the nineteenth century. There are anecdotal clues showing that stone churches erected in the diocese of Skåne in the nineteenth century were damp and smelly, with wooden floors regularly attacked by rot and with walls and ceilings covered with patches of mold. The tradition of burials beneath the church continued well into the nineteenth century, despite bishops’ increasingly speaking against it.² When floors collapsed or sank, the reason was usually a crypt or hollow grave beneath the floor. Additionally, these graves often gave off a foul smell, making it necessary to constantly ventilate the church in the summer. Fresh spruce was used to combat the air coming from corpses, as well as mold and other odors from the congregation, but the presence of such fresh organic materials also contributed to the damp climate in many churches.³

Records made from rag paper or parchment; textiles such as cushions, altar cloths, and priests’ robes; and metal surfaces suffered from the humidity and were sometimes in poor condition in these newly built churches. Insects attacked the altarpiece, the pulpit, benches, and other wooden objects or textiles in the church. The choir especially were often dusty and dirty, as were the windows, despite the fact that the premises were supposed to be kept clean and tidy.⁴

The aim of this paper is to demonstrate the usefulness of archival sources in tracing the climate history of an old church. References to past indoor climate, often without any document-based support, have been used either to defend the status quo or to motivate radical changes in climate control. With the help of archives, an empirically based knowledge of the history of indoor climate can be developed.⁵ This knowledge may then add to other information that is collected, such as monitoring data and examination of materials.

To exemplify the usefulness of a historical perspective, a medieval stone church at Levåge on the island of Gotland in the Baltic Sea, one of 92 on the island, will be used here. Stone churches in Sweden were built and furnished for a cold climate. Their thick stone walls buffer both moisture and heat well in spring and autumn. Furthermore, they have interiors and objects made of a number of materials, often with sensitive surfaces, such as wood panels painted in elaborate patterns.⁶

Records and Archives for Research

In year 2000 the Swedish Church was finally separated from government administration, after almost five centuries of coexistence; however, the church continues to enjoy a privileged position, receiving, for example, gener-
The indoor environment of older churches in Sweden can be researched
by using a fairly wide range of written sources. By combining information from
a number of sources, a more complete picture of the historical development of
an indoor environment should appear. The documented history of climate-
related problems will also shed light on shifts in conservation ideologies and
also show what effects different corrective measures have had on the building
and its interiors.

The archival materials utilized here can be divided into two groups of sources:
theses emanating from the Swedish Church itself and those produced by
preservation authorities, such as RAA and the Board of Public Works and
Buildings, Överintendentsämnet (OIA), which was reorganized into the National
Board of Building and Planning, Kungliga Byggnadstyrelsen (KBS), after 1918
(Table 1). From 1918 to 1969 permissions for restorations and installations in
churches were issued by KBS and after that by RAA. The modern organization
of RAA developed in the 1930s, allowing it to become more influential in the
preservation of churches and their artwork. Before 1969 RAA operated as an
advisor for KBS, mainly regarding the preservation of the interiors and objects
in churches. Copies of documents produced by these authorities are preserved in
the topographical files of the Antiquarian Topographical Archive (ATA),
which is part of RAA. All these documents are public and available upon request.

The ATA files often provide a good understanding of damage, repairs, and
installations in the twentieth century, whereas church records give an understand-
ing of how the building has been used over a longer period of time. In
many parishes records such as inventories, protocols, and accounts are preserved
at least from the early nineteenth century forward, and in some parishes
there are records going back as far as the seventeenth century. Many of the
older church records have been digitized and made available online by the Na-
tional Archive, Riksarkivet (RA). Twenty-first-century records are so far available
almost exclusively on paper and may be found either at the regional archive or at
the parish office (pastorsexpedition). In protocols from bishops' visitations there
are descriptions of the state of the building, its interiors and objects, and in-
structions to the priest about improvements to be made. These records are
often useful when investigating the indoor climate history. In the case of
Levide Church, these different groups of records have been used and proven to be
valuable when tracing the history of the indoor climate.

**Heating in Stone Churches**

Old stone churches in Sweden were, despite the cold winters of the region,
evidently not intended to be heated. Before the nineteenth century the use of
heating stoves was generally confined to residences, whereas buildings that were
little used were left cold. Heating for personal comfort, as opposed to cooking
or washing, was considered a luxury, since fuel was expensive. The atti-
itude of the church has historically been that some heat was necessary for the
preservation of valuables in the church and to protect the well-being of the
priest. In general it was considered sufficient to heat only the vestry, not the
whole building, since valuable materials were stored in the vestry, if there was
one. A shift in attitude came in the late nineteenth century, as a debate on the
need for public hygiene with cleaner air, water, and living quarters arose. Cold
churches, it was said, made individuals more susceptible to disease and would
promote epidemics. During the twentieth-century attitudes toward the need of
thermal comfort in churches shifted even more in favor of comfort heating.

There have been periods of discontinuity and hesitation on the suitability of installing permanent heating. A directive for managing churches issued by ÖA in 1887 said that the heat should be kept to a minimum and be provided only during services. Stoves were deplored for their unattractive appearance and inefficiency; instead, centrally heated air or water was recommended. However, a tile stove was thought suitable for the vestry. Apparently there was some knowledge among art conservators of the dangers of submitting painted wooden panels to strong heat.

Beginning in the 1920s, authorities encouraged churches to install central heating, since it would improve the indoor climate. After World War II installation of permanent heating systems became more common. In the 1960s there was a growing concern among antiquarians and architects that medieval stone churches were suffering seriously from overheating. Heating was said to contribute significantly to particle deposition on walls and vaults and to a dry climate, which was damaging wooden interiors and objects.

There were conflicting views on the need for heating in the 1960s and 1970s. In 1967 the National Institute of Building Research concluded that stone churches that had not been intended to be heated should remain unheated. However, this advice does not seem to have had a noticeable influence on the management of churches. On the contrary, the 1960s seems to have been a time when many churches were permanently heated for the first time. A manual issued by the company ECS-teknik in 1976, in the wake of the global energy crisis, stressed the importance of heating with care and only intermittently. A transition to intermittent heating rather than a complete shutdown of heating was seen as a solution: “Despite the fact that intermittent heating can lead to condensation and problems with contamination, the method is a clear improvement compared to previous systems of permanent heating with regards to dehydration and energy use.” Another manual, which was issued by RAA in 1979, gave advice on energy conservation in churches and emphasized that heating should be intermittent, not exceeding 60 to 64 degrees Fahrenheit in winter. There was still no mention of target ranges for interval relative humidity (RH). “The church will not suffer from being unheated,” the authors said. Another manual issued by RAA in 1982 stated that when not in use, the church should be minimally heated and that RH should not drop below 40 percent. The manual also advised that objects sensitive to very high RH should be moved to a heated space, such as the vestry, as had been the practice earlier.

By the end of the twentieth century RAA recommended permanent heating for conservation purposes, without specifying any temperature or RH interval. A stable RH and temperature was recommended, like that for museum storage. To keep a church unheated would be “a technically risky solution.” Since the early 1980s RAA no longer recommended completely shutting down heating in a church but wanted decisions regarding heating to be well thought out.

When comparing recommendations issued by RAA with actual management, it seems as if national authorities have had a limited influence on indoor climate in old churches. Then again, the Swedish Church has viewed its buildings not as museums but as functional spaces that should meet the demands of their users. It is, however, interesting that whereas authorities were skeptical about permanent heating in the 1960s and 1970s, by the end of the century RAA was approving the provision of some basic heating. In reality, many churches had already been permanently heated for quite some time, without RAA challenging the practice of heating for thermal comfort. In this sense Levie Church is an exception, since it does not seem to have been heated permanently.

Levide Church on Gotland
The Romanesque Levide Church, built in the first half of the thirteenth century,
has a wooden triumph crucifix made in the fourteenth century, \textit{al secco} wall paintings from the fifteenth century, and an altarpiece of polychromed wood and a sandstone baptismal font from the sixteenth century (Fig. 1). Very few changes have been made to the building since medieval times.\textsuperscript{19} Major interior restorations were carried out in 1827, 1902-1903, 1956-1957, 1973, and 2007. Additional repairs were carried out between these restorations. Central heating was never installed. Heating was first introduced with a coal-fuelled stove in 1903.\textsuperscript{20} Electric space heaters replaced the stove in the 1950s, and in 2007 the space heaters were replaced by new ones. These heaters have, as far as we know, have been used only for heating the church for sermons.

There are some early indications of high humidity inside the church and its consequences for the building. In 1803 the church was described as being in "good condition," but it was suggested that a fireplace should be built in the vestry in order to preserve the health of the priest and to make the school children more comfortable.\textsuperscript{21} At that time the parish could not afford this improvement. In subsequent years the condition of the building deteriorated: in 1816 the roof was said to be in "poor condition," and in 1825 the wooden floor was in need of immediate repair. Most of the wood components inside the church, including the floor, floor beams, and pews, were completely replaced in 1827.\textsuperscript{22} The most probable reason is roach, although there may have also been insect damage.

The concern of the diocese regarding the insufficient storage of valuables is also telling of climate problems in the church. In 1833 the bishop repeated his wish that heating should be introduced in order to preserve the textiles, valuables, and documents.\textsuperscript{23} At this time the interior of the church was repaired, but the roof was not replaced until 1837.\textsuperscript{24} Due to the cost heating was not installed at this time.

In the late nineteenth century the documentary sources became less descriptive, often just stating that the church was in "good condition."\textsuperscript{25} Judging from accounts from this time, money was being spent on the maintenance of the church building. In the 1865 financial plan for Levde there was no entry for maintenance, except for a small payment to the bell ringer for washing and cleaning the church.\textsuperscript{26} In 1886 funding was secured for the purchase of an additional wooden cabinet for church records, of which a large part had been stored directly on the floor in the vestry. The rest of the records were apparently stored in the rectory.\textsuperscript{27} In 1897 the bishop decided that Levde needed heating. Architect Nils Petersson, who worked on restoring and making modifications on Gotland churches, made a proposal for installing a cast-iron stove and a chimney in Levde Church.\textsuperscript{28} The proposal was approved by BPWB in 1899 (Figs. 2 and 3).\textsuperscript{29} Wood panels were installed along the north and south walls during the restoration (Fig. 4). Most of the floor was still wood at this time, as was the roof covering, which was replaced in 1902-1903.

After just a few years, however, there were complaints that the stove did not deliver thermal comfort to the degree that had been expected. Analysis was done in 1915, showing that the stove managed to raise the indoor temperature 11 to 12 degrees Fahrenheit above outdoor temperature. After having heard this report, the congregation said it was satisfied with the capacity of the stove. Apparently, this was the kind of thermal comfort to be expected at the time.\textsuperscript{30}

By 1922 the church was in immediate need of restoration. The interior painting and plaster were heavily damaged. Plaster fell to the ground upon touch. Capillary uptake from the ground into the walls was eliminated as a possible cause, because of the perceived excellent draining qualities of the soil (primarily gravel).\textsuperscript{31} Henrik Kreüger, professor at the Royal Institute of Technology, and Anders Roland of KBS believed that damage was the result of interior condensation caused by poor ventilation. The north and south walls had been clad in wooden panels that were now rotting and further damaging the plaster immediately behind them (Fig. 5). Fungi were growing between the panels and the wall paintings, some of which dated from the fifteenth century and had been retouched in 1903, causing severe damage. The plaster itself was also of poor quality, probably cement from the 1902-1903 restoration, and it was recommended that it be replaced with lime plaster.\textsuperscript{32}

Kreüger suggested improved ventilation to reduce the damaging effects of condensation and recommended against the use of wooden panels placed directly on the walls.\textsuperscript{33} What made this damage...
even more alarming was that the wall paintings had been restored in the beginning of the twentieth century, and the work had to be done again. A. Edle of RAA criticized the parishioners for not making the board aware of the situation earlier, when it would have been possible to limit damage. 34 RAA urged the parish to take action immediately in order to avoid further deterioration. 35

In December 1925 Roland again inspected the church and observed that there was less moisture in the plaster on the inside of the walls than there had been three years before. 36 However, mold was evidently growing on the north wall, despite attempts to improve ventilation by opening the doors in summer. Since there were only single panes of glass in the windows, there was still condensation from them running down the walls in winter, causing Roland to suggest that a second sash be installed. He further recommended that if this course of action did not improve the indoor climate, central heating using low-pressure steam be installed to reduce the humidity level. The priest replied that a second sash in the windows would diminish the light in the church, and the parish was not willing to make this change for aesthetic reasons. 37 Instead, a new stove was installed, since the old one was no longer functional. Roland hoped that a new stove would increase the temperature in the church and that ventilating in the summer would decrease condensation. RAA was hopeful that these measures would prove fruitful.

The problem with humidity in the lower parts of the north and south walls persisted. In 1946 the parish sought the approval of KBS to make small repairs to the wall paintings, since they had been damaged by moisture again. 38 The most recent major changes to the interior were made in 1956-1957 by architect N. A. Rosen (Fig. 6). Damage very similar to that detected in 1922 was described: plaster was falling off the north and south walls up to 5 feet (1.5 meters) above the floor. 39 There were also extensive attacks by "woodworm." 40 This is the first explicit mention in the sources of insect damage.

In the early 1950s the church was still heated only for sermons. Rosen suggested electrical heating using pew heaters (radiator under the pews) and wall-mounted radiators. The floor was entirely replaced with limestone resting on a 3 inch-thick layer of concrete. Rosen argued that drainage trenches dug along the south wall, along with constant heating in winter, would dry out the walls sufficiently. Until then, the source of heat had been the stove placed in the northeast corner of the nave. By adding heat in winter it was hoped that the problems with condensation and mold would be resolved, but unexpected damages occurred — soiling of walls and vaults and desiccation of wooden materials. However, it seems as if permanent heating was not applied for any long period.

When architect Gunnar Jonsson inspected the church 20 years later, in 1973, several types of humidity-related problems were detected. In the spring, water rose up into parts of the floor, just as was reported in 1922. The plaster was damp in the lower parts of the walls where the wooden panels of the benches were placed against the walls, without any air gap. Furthermore, rainwater leaked through the doors, and condensed water ran from the windows down the inside of the walls (Fig. 7). 41 By then the walls had become quite damaged by dampness, and there was also considerable soiling of the walls resulting from dust particles circulated by the heat from the radiators.

The case study suggests that the indoor environment of Levide Church was already experiencing high humidity problems in the early nineteenth century (documentation from most of the eighteenth century is missing). The earliest known sign of large-scale rot is from 1827. Appeals by the bishop to install a stove went unheeded until 1897, when the diocese forced the parish to act. Repeatedly throughout the twentieth century, condensation was reported on the floor and the lower parts of the walls. In 2008 when the altarpiece was conserved, the conservator noted that it was damaged by a fluctuating climate, causing the wood to crack and the paint to form vesicles and flake (Fig. 8). Mold growth was also observed. 42 During visual inspection carried out by the author in July 2011, damage to the plaster similar to that described in documents from 1922, 1956-1957, and 1973 was detected. The damage visible is much less severe than that documented 50 years earlier; however, the church had undergone an interior restoration in 2007, so damage should not be expected to be very great at this point. One change that might have reduced subsequent damage to the plaster was the removal in the 1950s of the tall wooden panels standing right next to the walls. The damage visible on the walls today consists of salt efflorescence caused by migration of moisture through the wall, making the plaster crack and fall off.

Conclusions

Swedish archives offer very good possibilities for those who wish to better
understand how churches have been managed and conserved in the past. The main reason for this record keeping is the historical alliance between church and state in Sweden. All of the source material is public, and some of the older materials have been digitized and made available online. By combining available information on the design and performance of heating systems, descriptions of damage, and measures of conservation and repairs, a fuller picture of the historical indoor climate of a church can be understood.

To some extent these sources are used today by architects and conservators when preparing conservation programs, but only rarely are any conclusions drawn or analysis made. Brief descriptions of the building history, including serious damage, are always included but are seldom allowed to influence decisions on what measures to take. The author suggests that primary sources always should be consulted before decisions are made, a practice that may lead to long-term adjustments in the indoor climate of a church. These sources often contain valuable information on how the building and its contents have reacted to being either completely unheated or intermittently or permanently heated. From these sources it may be possible to tell, for example, whether an identified problem seems to be a permanent feature of the building or whether it could be corrected through an intervention.

Gotland churches were cool, humid environments before they began to be heated in the beginning of the twentieth century. The humidity did not necessarily constitute an obstacle in the preservation of sensitive materials. Moveable objects such as books, silver, and textiles were often stored in the vestry in specially designed coffins or cabinets. The vestries of some churches were intermittently heated with stoves in the nineteenth century.

The case of Levide Church shows that high levels of moisture in the surface of the north and south walls have been a persistent feature of the building, despite attempts to limit condensation and leakage. Leaking doors and windows, fluctuating levels of temperature and relative humidity, and possibly moisture from the ground have contributed to a humid climate inside the church. Today the church is used approximately 40 times a year, perhaps not unlike the frequency historically. The absence of permanent heating made the church a cool and humid place, and the use of a stove to heat the church for services managed only to raise the temperature and lower humidity temporarily.

Electric heating was introduced in the 1950s for the purpose of both thermal comfort and preservation of the building but not to preserve the wooden interiors. The architect intended that permanent heating would make the walls drier and thus reduce the problem of mold and salt deposition. Humidity-related problems, however, did not seem to become less noticeable, and problems with soiling of the walls and dehydration of wood were added.

To sum up, architects, engineers, and conservators involved were apparently not able to prevent the same kinds of damage from occurring time and again. The exact same problems with the interior — crumbling plaster on the long sides of the walls close to the ground, massive woodworm attacks, and rotting wood — occurred repeatedly in the twentieth century, initiating restoration projects that were carried out in 1956, 1957, 1973, and most recently in 2007.

It has not been the intention of this paper to suggest a final solution for heating Gotland churches. The purpose has rather been to demonstrate the information value of archival sources and how these can be used to acquire a fuller understanding of historical indoor climate. Archival sources can be utilized to indicate whether a problematic indoor climate is caused by wrong methods of heating or ventilation, by lack of maintenance and care, by the location of the building (such as on wet ground), its envelope, the composition of materials used, or a combination of these factors. Tracing the history of an indoor climate, combined with other methods used in conservation science, can help in assessing damages and their possible causes.

An important characteristic of these sources is that they most often only describe symptoms of the indoor climate, such as condensation, mold growth, massive rot, dehydration, or insect damage. They seldom contain any analysis or reflection on the causes of such symptoms. Is there a problem with the building construction, the site of the building, or with the heating system? Such conclusions are often not offered in
the documents, not even if they have been put together by engineers, architects, or conservators involved in interventions in the church. Therefore, there is also good reason to look critically at how interventions are documented in Sweden today. Conservation programs should include an analysis of possible alternative measures and the care of the building in the past. Description of damages and measures to be undertaken should be documented, along with conclusions on causes and the choices made between possible measures. This methodology should improve the basis for future interventions made.

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Acknowledgements
The author expresses his gratitude to the Reverend Anders Jernberg for generous access to the parish records. He can be reached at mattias.legner@hago.se.

Notes
11. Helge Zettervall, Allmänna ansökningar förändra kyrkobyggnader (Guidelines Regarding Church Buildings) (Stockholm: Överintendenteriet, 1887), 89.

Fig. 7. One of the windows on the north wall, seen from the inside. Photograph by the author, July 2011.

Fig. 8. The center of the altarpiece, most recently conserved in 2008. Photograph by the author, July 2011.
17. RAA, Värme och ventilation i äldre kyrkor (Heating and Ventilation in Older Churches) (Stockholm, RAA: 1982), 3.
22. Villa, Levede kyrkoarkiv, vol KL1, Parish meeting, June 10, 1827, pp. 149-150. RAA, ATA, Levede kyrka, inventory June 22, 1830.
27. ViLa, Levide parish, vol. ltc:1, year 1886.
29. ViLa, collection of drawings, A25 nr 163.
32. One barrel of cement was purchased in 1902 for the restoration work (Fardhem rectory, Lib:2).
33. ATA, Levide church, letter from H. Kreuger, Aug. 8, 1922.
34. ATA, Levide church, pro memoria by A. Roland, Aug. 8, 1922.
35. ATA, Levide church, letter from C. Moller to the parish, Aug. 16, 1922.
36. ATA, Levide church, pro memoria by A. Roland, Dec. 2, 1925.
37. ATA, Levide church, letter from the reverend Feb. 23, 1926.