Can we learn from the heritage lost in a fire?

Experiences and practises on the fire protection of historic buildings in Finland, Norway and Sweden

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NATIONAL BOARD OF ANTIQUITIES

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Editor: *Anu Laurila*

Working group:
Museovirasto (Finland): *Martti Jokinen, Anu Laurila, Seija Linnanmäki*
Riksantikvaren (Norway): *Einar Karlsen, Oddbjørn Sørmoen*
Riksantikvarieämbetet (Sweden): *Kerstin Alexandersson, Thomas Erenmalm, Sune Lindkvist*

Graphic design and layout *Maikki Rantala, Praxis Oy*

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Contents

1. Foreword

This publication is the result of the "Can we learn from the heritage lost in a fire?" project in which Finland, Norway and Sweden consulted about their experiences and knowledge of fires and the fire protection in historic buildings.

We hope the information and knowledge gathered during the project will help other people working with fire safety or historic buildings to find new ways of approaching the question. Here, we attempt to present our discussions and examples so that they are easy to read but at the same time, we give all necessary information. Our aim is to show that there are an infinite variety of measures and combinations for the fire protection of historic buildings. When planning fire safety, all aspects have to be considered carefully to find the most suitable one for each case.

This publication consists of three main themes: *case studies, fire protection* and *actions after a fire.* In addition, we present general information and some aspects of preventing a fire in historic wooden towns. Finally, we present an essay concerning the problem of rebuilding after a fire.

The Appendices include a checklist on the contents of a rescue plan and summaries (in Finnish, Norwegian and Swedish).

We have added a list of publications from our countries concerning the fire protection of historic buildings to the end of this publication. We have also listed some useful Internet addresses concerning these matters.

We warmly thank the Nordic Museums Committee who kindly financed our seminars and met some of the costs for this publication. We would also like to thank the Finnish Fire Protection Fund, which subsidised this publication.

Locations of case studies and wooden towns discussed in this publication.


NORWAY
SWEDEN
FINLAND
SAVUKOSKI
TRONDHEIM
INNSET
RØROS
MAALAHTI
LILLEHAMMER
RAUMA
TYRVÄÄ
EIDSVOLL
HELSINKI
OSLO
SÖDRA RÅDA
STOCKHOLM
(KATARINA CHURCH)
JÖNKÖPING
EKSJÖ

Wooden towns are typical in all three countries (Rauma, Finland).

2. Introduction

2.1 The project

The risk of fire is a serious concern especially in the Nordic countries, where the majority of historic buildings are made of wood. The laws and practices for fire protection are well developed but the legislation does not usually specify the practices concerning historic buildings, so there is need for cooperation to promote this point of view.

As we have unfortunately had some serious fires in historic buildings in the Nordic countries, we thought that it might be possible to learn something from them, such as how the fire started and how could it have been avoided. Another question was whether fire fighting caused any additional damage to the buildings and if it could have been avoided.

There are some instructions on how to protect the ruins of a building after a fire and there are international manuals for risk preparedness that deal with highly theoretical approaches to the measures to be taken after the fire. However, there is still a need for philosophical evaluation and discussion on "what to do after the fire". In addition, there is a need for practical instructions on what to do after a fire has taken place.

The outcome of fires may vary a lot, from partial damage to total devastation. Partial destruction raises difficult practical and ideological questions concerning documentation, restoration and financing. Even in the more serious cases of destruction, there may be methods of documentation that can secure at least some knowledge.

The above formed the background for the project, which consisted of three seminars during 2003. The first seminar took place in Finland in May, the second in Norway in September, and the last one was held in Sweden in November.

The participants in the seminars had the opportunity to discuss the practices of fire protection and the actions following fires in all the participating countries and they were able to learn from each other's experiences. We did not have sufficient time to go very deeply into the details of fire protection but we did learn that there are many ways to prevent a fire and to protect buildings against fire. The important aspects are that each historic building is unique and has to be treated accordingly and that fire protection is a continuous activity that should be considered part of the normal maintenance of buildings. Another

A stave church is a medieval type of building that is mainly preserved in Norway (28 churches). One stave church is also preserved in Sweden.

Large wooden farmhouses are found in all three countries (Ringnes, Norway).

conclusion we reached during the discussions is that low cost preventative measures, such as good organisation, are mostly efficient.

We also discussed the actions to take after a fire and the main thing that came up was that a surprising amount of information could be gained from the remains of a seriously destroyed building. The question of rebuilding after a fire is very difficult; we did discuss some examples of this during our project and these are introduced in this publication.

2.2 General features of the fire protection of historic buildings in the Nordic countries

A large proportion of historic buildings in the Nordic countries are made of wood. We also have densely packed historic wooden towns and their structure makes it difficult for fire brigades to act effectively. Fire can spread rapidly in dense town structure made of wood. In the past, town fires partially or completely destroyed many wooden towns.

Some of the historic buildings in the Nordic countries are located in remote places where there is no electricity, proper supply of water, fire brigade or people living nearby.

The climate in all our countries is cold in winter and warm in summer, so there is a danger of fire during long dry seasons: fire fighting can be difficult and there can be extra damage to remains when the temperature is below zero. Moreover, some technical equipment has limitations during cold temperatures. These facts create problems for the fire protection of historic buildings.

2.3 Participants and the organisation of government agencies for cultural heritage

Finland,
National Board of Antiquities (Museovirasto):
Martti Jokinen, architect;
Anu Laurila, architect;
Seija Linnanmäki, conservation officer

Norway,
Directorate for Cultural Heritage (Riksantikvaren):
Einar Karlsen, architect;
Oddbjørn Sørmoen, art historian

Sweden,
National Heritage Board (Riksantikvarieämbetet):
Kerstin Alexandersson, architect;
Thomas Erenmalm, M.Sc.;
Sune Lindkvist, architect

The authorities in Finland and Sweden act more like advisors, sharing information and making statements. Due to special projects, their role in Norway also includes planning and choosing the technical equipment.

Finland

The Museovirasto (the National Board of Antiquities) in Finland has six units. Two units have staff working on the fire protection of historic buildings. The Department of Administration employs one person who works on the fire protection of the buildings owned by the Museovirasto. The Restoration Section, part of the Department of Monuments and Sites, gives advice and information and makes statements concerning the fire protection of historic buildings.

Norway

There are five departments in the Riksantikvaren (The Directorate for Cultural Heritage). The Department for Conservation works on matters concerning fire protection. The department has even planned fire protection systems for such places as stave churches. The Department for Buildings, Monuments and Sites assists in this work.

The fire protection of Norwegian stave churches was carried out mainly in the 1980s and 1990s.

The directorate gives advice to regional and local conservation authorities, owners and others involved in fire protection.

Sweden

There are five departments in the Riksantikvarieämbetet (The National Heritage Board), two of which work on matters related to fire protection. The Heritage Department gives information, supervises and grants permission for restoration in accordance with legislation and the Conservation Department gives technical advice and information on fire protection.

2.4 Special projects on fire safety in each country

Finland

The Museovirasto started to prepare instructions for the fire protection of churches after the fire at the Tyrvää medieval church in 1997. The instructions will be published in 2004.

The city Rauma carried out a fire protection project after a fire threatened the wooden town of Old Rauma (which is also a World Heritage Site) in 1997. The project report was published in Finnish in 1998.

Norway

The Riksantikvaren in Norway has been systematically working with fire protection since the 1980s when sprinklers and fire detection systems were installed in some stave churches. The work intensified at the beginning of the 1990s because of the threat of arson. Extensive measures were carried out in the 28 surviving stave churches during a period of less than five years. In addition to the stave churches, there has been a program to protect a number of the other 400 most valuable churches built before 1800.

There was some work done during the early 1990s on the fire protection of the historic wooden towns in Norway. A pilot project in the fortified town of Fredrikstad was carried out to test external fire detection systems. The world heritage town Røros installed technical fire protection in one block in 2003. The project for the fire protection of Røros will continue in 2004.

Fire protection projects have also been carried out in industrial buildings, large farms and manor houses, and houses belonging to famous artists etc. These projects have been possible due to the financial support granted by an insurance company (Stiftelsen UNI).

Sweden

The Riksantikvarieämbetet has, in cooperation with the Statens Räddningsverk (the Swedish Rescue Agency), published the handbook "*Brandskydd i kulturbyggnader*" on fire protection in heritage buildings. The Riksantikvarieämbetet has also published a leaflet called "*Att skydda kyrkan mot stöld och brand*" that deals with fire protection in churches.

There was a project in Sweden on fire protection in the historic wooden town of Eksjö and the results of that project were published in 1999 as a book titled "*Brandskydd i trästäder – Strategi för skydd av centrala Eksjö*"; a state-of-the-art-report will be published in 2004.

In 2003, the Riksantikvarieämbetet made a special study of churches destroyed by fire, "*Kyrkan brinner – vad händer sedan?*" The study focused on the discussions after the fire (these discussions dealt with the arguments and the results of the fire).

Licence for hot works

One instrument that has decreased the number of fires at sites (also at restoration sites) has been *"the licence for hot works"*. The system was created by insurance companies but it has almost become the standard in all our countries. The number of fires at sites has declined by 50% over the past ten years (Finnish figures). The training takes one day and besides the theory, there is a practical exercise on different ways to extinguish a fire. The licence is valid for five years.

Sometimes the intention is good but something is missing.

2.5 Fire protection of historic buildings

Let us define what the fire protection of historic buildings means.

The main aim of ordinary fire protection is to safeguard human life; the fire protection of historic buildings also aims to safeguard the building and its cultural heritage. This must be born in mind when choosing the most suitable fire protection measures for historic buildings because certain equipment can sometimes destroy fabric or false releases in sprinklers can damage sensitive materials. Consequently, the aim of fire protection in historic buildings is to gain "maximum safety with minimum damage" in every phase of a project.

2.6 Legislation on fire protection in each country and the way it deals with historic buildings

Acts concerning fire protection

In Sweden, a new Act (Lag 2003:778 om skydd mot olyckor; Civil Protection Act) came in January 2004. The new Act and its regulations, including ordinances and general advice, gives some rules to be applied in the fire protection of heritage buildings.

In Finland the Act (Pelastuslaki 468/2003; Rescue Act), as well as the organisation of rescue services, also changed at the beginning of 2004. The new Act makes no mention of heritage buildings.

There is a rather new Act (Lov om brann- og eksplosjonsvern av 14. Juni 2002, nr. 20; Fire and Explosion Prevention Act) in Norway.

According to the Acts in each country, the owner of a (heritage property) building bears re-

sponsibility for fire protection and the local authorities bear the responsibility for the rescue service.

The primary interest in all these Acts is always to safeguard human life and secondly to safeguard property. There is no mention of historic buildings in the Finnish Act but in Sweden, according to the new Act, the owner of a protected heritage building has to report how the fire protection for the building has been arranged to the local fire authorities. If necessary, the fire authorities can carry out an inspection. In Norway, the Act states that the local fire authorities are to inspect all registered cultural heritage properties every four years. Unfortunately, the registers on cultural heritage properties are very often unavailable to the fire authorities. Another problem is that if an inspection is carried out, the officers very often only give priority to the measures to safeguard human life and they do not take into consideration the cultural value of a building. In order to change this practice, the Direktoratet for brann- og eksplosjonsvern, now Direktoratet for samfunnssikkerhet og beredskap (Directorate for Civil Defence and Emergency Planning), in cooperation with the Riksantikvaren, issued a booklet in 1997 that included a checklist for fire inspectors.

Laws on cultural heritage

This law in Finland and Norway states that the cultural heritage authorities should always be contacted if a protected building is destroyed by fire. The authorities will then decide on the necessary measures.

The cultural heritage laws of each country contain nothing else concerning fire protection. The only point that can be applied is to the installation of fire protection technology; all alterations and installations should be carried out in such a way that they do not affect the value of the heritage building. The legislation in all the countries stipulates that the permission of the heritage authorities is needed for all alterations and technical installations.

Other regulations

In Finland, the Maankäyttö- ja rakennuslaki (the Land Use and Building Act) defines the essential technical requirements for all buildings, including fire safety. Implementation of this Act is defined in the National Building Code of Finland, part E of which deals with fire safety. The regulations in the Building Code are binding, but they concern the construction of a new building. They are applied case by case for existing buildings if larger repairs or alterations are carried out or if there are serious shortcomings in fire safety. In all other cases, old buildings are treated in accordance with the safety regulations as applied at the time of their construction.

The Plan- och bygglagen in Sweden and the Plan- og bygningsloven in Norway (the Planning and Building Act) also include regulations concerning cultural heritage buildings, but there are no special instructions for the fire protection of these buildings.

2.7 Cooperation with other authorities dealing with fire protection matters

The heritage authorities in Sweden and Norway are in close contact with the rescue services. The Statens Räddningsverk (the Swedish Rescue Agency) and the Riksantikvarieämbetet in Sweden have jointly published a handbook titled "*Brandskydd i kulturbyggnader*". The book is directed at local officials, heritage inspectors at the municipal level, property owners and managers, architects and other relevant bodies. The book has received a good reception and the heritage authorities are even asked to give lectures on the subject to the rescue service authorities around Sweden.

In Norway, the Direktoratet for samfunnssikkerhet og beredskap (Directorate for Civil Defence and Emergency Planning) has established a national goal that no irreplaceable cultural values should be lost in fire. The Directorate, in cooperation with the Riksantikvaren, is planning to carry out a survey on the fire protection in Norwegian cultural heritage properties in the near future.

The contact between the heritage and fire protection authorities in Finland is not so close. There is a special need for instructions directed at the local fire and building inspectors who bear the main responsibility for supervising application of the Building Code.

Aerial view of Old Rauma.

3. Fire protection in wooden towns

3.1 Old Rauma, Finland, fire protection project

Old Rauma covers an area of 28 hectares and there are 600 buildings, most of which are privately owned. It has a population of 800. Old Rauma was added to the UNESCO World Heritage list in 1991. Some buildings have preserved their characteristics from the 1700s, but the majority of the buildings received their current neo-Renaissance exteriors during the active period of renovation in the 1890s.

There was a threatening fire in Old Rauma in the summer 1997. A girl was sunbathing and smoking on the roof of an outbuilding. The cigarette ash set some old dry leaves on fire in between two outbuildings and the fire spread rapidly, totally destroying one outbuilding and damaging two others.

It was after this incident that the fire protection project for Old Rauma was launched. Statis-

tics were collected and analysed. These statistics indicated that the most common cause of fire was a drunken person smoking. The number of fires caused by electricity was reduced because during repairs, all the electrical installations in the old buildings were changed. Even if fireplaces are in use in most of the buildings, they cause few fires. In addition, the number of fires during the repairs was low.

The Problem in Old Rauma is that some of the commercial buildings are only used during the day, so there is no one guarding them during the night. Furthermore, the courtyards of commercial premises are often used to store many combustible materials.

The buildings were inventoried in order to collect the basic information needed for the project. The condition of the buildings was assessed, the risks in every building were written down and information concerning their occupants was recorded. In this way, the fire authorities became familiar with which properties were more susceptible to fire. They also learnt that old people were living on some properties and that in the case of a fire they might be unable to escape without help.

The actions needed to improve the fire protection of the area were discussed after all the above-mentioned information. The aim was to find an easy, cheap and effective means to improve fire safety. The best result so far has been regular fire inspections every three years. All buildings are checked during these inspections, and instructions are given if some properties need cleaning in order to get rid of combustible material. In addition, these inspections serve as a means to update the information concerning the buildings collected during the first inventory.

The most important buildings, such as the museum, are now fitted with automatic fire alarms and there have been proposals to install some kind of simple version of this alarm system in the commercial blocks. There is a proposal to install sprinklers between tightly packed buildings but so far, no property owner has wanted to install (and pay for) this system.

An essential part of the fire protection is to affect the common opinions and attitudes of inhabitants. In Rauma, they have issued a leaflet telling about the normal maintenance of the buildings and giving instructions on simple measures for fire prevention. Some training has also been organised to teach people how to use fire extinguishers and what to do in the event of a fire.

The project has raised the awareness of the inhabitants and the Rauma fire authorities are of the opinion that if there is a fire simultaneously in Old Rauma and in the local paper mill, they will go to Old Rauma because that is irreplaceable and the mill only has “money that burns”.

Many buildings in Old Rauma have the neo-Renaissance look.

3.2 Lillehammer, Norway, fire protection project

A project involving the fire protection of a street lined with old wooden buildings (Storgata) has been carried out in Lillehammer. A project group was established with representatives from local fire authorities, the district cultural heritage authorities and property owners.

At first an inventory and a fire protection plan was ordered from a fire-engineering consultant. The result was a plan and recommendation for the fire protection for each building. The basic idea was to install the automatic fire alarm system in most of the buildings and to make fireproof walls between the attics of adjoining buildings.

After the plan was ready, the project group encouraged the owners to implement it. They

Storgata in Lillehammer is a busy shopping street.

even requested tenders for the installation of the fire alarm systems and construction of the fire-proof walls to make it easier for the owners to implement the plans.

The final decision and the costs for improving fire protection were left to the owners. The majority accepted to install the alarm systems and to improve the fire resistance of attic walls. The local fire authority is in charge of supervising the improvement. It has also made an action plan for the area.

3.3 Røros, Norway, fire protection project

Røros was founded in the 17th Century as a copper mining town and it has preserved its 17th century layout. Most of the buildings are from the early 19th Century. Both the wood-built centre and a larger area around the town, with traces of 300 years of mining history, are on The World Heritage List.

Some work with fire protection was carried out in the 1980s. There was a plan for the fire protection of one block and a new fire engine was partly financed by the Riksantikvaren. Fire detection equipment was installed in some of the buildings belonging to a museum in the 1990s. Fire detection had not been introduced into the whole town because of problems with false alarms from the then existing systems.

The Riksantikvaren gained experience with systems for fire protection that overcome these problems when working with fire protection for the stave churches. The systems for exterior fire-detection were tested during a project in the old fortified town of Fredrikstad where also sprinklers

were installed in lofts with difficult access for the fire brigade. It was no longer impossible to find relevant technical solutions for the fire protection of Røros.

In 2001, the Riksantikvaren paid for a preliminary plan for the fire protection of Røros. The plan was carried out by Interconsult in Trondheim. In April 2002, there was a conference in Røros to focus on the fire protection of wooden towns. In 2002, Stiftelsen UNI made 1.5 million NOK available for the fire protection of Røros. In 2003, The Department of the Environment granted a further 1.5 million NOK. The available funding was used for the following fire protection measures that were carried out for one block in 2003:

- a high pressure water mist system in all lofts and outbuildings (dry, manual system supplied with water by the fire brigade),
- high pressure water mist equipment fitted onto an existing fire engine
- fire hoses for the use during the initial stages of a fire (standard fire hoses in heated, isolated cabinets),
- fire detection on the outside of buildings and inside outbuildings (metal thread melting at a certain temperature),
- a truck with a lift for use by the fire brigade.

The national fire authorities granted 1 million NOK for a research project headed by the SINTEF fire laboratory and Interconsult. The project served the main project in that it made sure the know-how obtained is made available for other wooden towns.

The project for the fire protection of Røros will continue in 2004 after the installations carried out in 2003 have been evaluated. It is possible that the number of installations will be reduced in the next stage of the project.

View of Røros.

3.4 Eksjö, Sweden, fire protection project

A fire protection project is still underway in the old part of Eksjö, which is a wooden town from the 17th century. Lennart Grandelius, the former city architect, is the man behind this project.

The main idea and goal of the project is to prevent a town fire, not single fires in particular. The project started by studying the buildings and their building techniques, materials and fire risks based on information found in the archives. This information was checked in situ. The risks for fire spreading were mapped and all other risks not found in the archived information were written down during the visits to the buildings.

A fire protection strategy was made in accordance with the inventory and analysis of fire risks. It consists of two aspects: how to prevent a fire and how to limit a fire.

There were some special risks in Eksjö:

- there is a small river, Eksjöån, in the middle of the town but if the summer is dry there is insufficient water,
- it is difficult to approach many places because of the way the town is built (narrow streets etc),
- there is a serious risk of fire spreading because there are very narrow and high spaces between buildings,
- there is a risk of fire spreading through timber walls that are in bad shape,
- there are ventilation holes etc. in the walls between properties,
- there are windows in the walls towards and above the neighbours' roofs and walls,
- there are wooden ventilation channels,
- there are buildings of different heights in the same block,
- sometimes, old wooden roofing is found under the existing roof,
- apartments are small so many people live in a small area,
- the first strength for rescue service is too low.

The present old Eksjö is the northern part of the town that survived the fire of 1568.

Plan of the old part of Eksjö.

What has been done?

The strategy for Eksjö was made in 1999. In 2003, the Riksantikvarieämbetet asked Lennart Grandelius to make a report on what actions have been implemented in Eksjö.

The municipality of Eksjö has taken an active role in implementing the strategy. First, it was thought that the municipality would only pay for measures that dealt with joint fire safety and the building owners would pay for the measures concerning their properties. There are some exceptions as some sprinklers have been installed on facades and some automatic fire alarms will be installed in certain places at the expense of municipality.

There was discussion about combining the rescue services from Eksjö and a few other municipalities but in the end, it was decided that Eksjö would have to have its own fire brigade for the old town. If there is a fire alarm, the cultural heritage authority will also be at the site.

Here is a list of some of the measures that have already been implemented:

- After the buildings were checked when making the strategy, those building owners who had something to do on their buildings (such as closing or tightening openings, installing fireproof glass etc.) received a letter telling what they should do. Many of these measures have been implemented.

- After the fire in Jönköping, the safety of electrical installations was checked in four selected properties. Some notes were given concerning "everyday" (portable units) installations, but fixed installations were mostly safe. It was recommended that all electrical installations be checked.

- Households received a fire safety checklist and regular checks are made to ensure that these easy, low cost measures (such as the storage of waste, removing combustible material, tidiness, etc.) are implemented, and they mostly are.

- Manual sprinkler systems have been installed in one narrow space between two buildings and on two facades opposite each other in one alley in order to provide a "wet fire wall" in the event of a fire.

- Eksjö was granted a subsidy in 2003 to carry out the TUB (Tidig Upptäckt av Brand) project that deals with the early detection of fire. The project will study the early detection of fire by using existing technology. The results will hopefully be cost efficiency, reliability, the suitability of solutions for different circumstances, etc. One city quarter has been chosen as a test place because there are all kinds of problems there (it is very tightly packed, lots of tenants, difficult for the rescue service to reach, waste is stored in gateways, birch bark and boards under present roofing, etc.)

They have understood the meaning of tidiness in courtyards in Eksjö.

3.5 Aspects on improving fire protection in historic wooden towns

When preparing the fire protection project in a historic wooden town, it is first necessary to make the aims of the project clear. Is the main aim to prevent single fires in single houses or is the goal to prevent a town fire? This helps to find the correct measures to be taken and prevents the project from become too overwhelming.

Usually the initiative for fire protection projects that concern towns or large areas with wooden buildings comes from the municipality. It is recommended that the municipality at first makes an inventory of the fire protection aspects in the area (using either their own staff or a hired consultant). Information concerning fire risks (both in single buildings and in the town structure) and existing fire protection measures is collected during the inventory. A proposal is then made on how to improve fire protection in order to achieve the set goal.

The actions can be divided into two categories: administrative measures that municipality and authorities must implement and the technical measures that can be carried out by the municipality or property owners. It often seems that the responsibility for implementing these actions in the houses and town structure is left to the owners and property users. The authorities only carry out administrative measures such as action plans for the fire brigade, frequent fire drills and fire inspections. The municipality of Eksjö had also installed some sprinklers between buildings in order to make a wet firewall in the event of fire. The goal of the

project was to prevent a town fire, so this was regarded as an effective measure. It is always important to assess which actions should be left to owners and which the authorities should carry out to reach the project goal.

A common feature for all the projects that we studied was that the training of property owners and users was one of the most fruitful ways to work. It is important that the owners and users begin to understand that it is not only their problem if a fire breaks out in a single building located in a tightly packed wooden town structure.

This training can be carried out in many ways. Articles in the local newspapers, informative meetings, information leaflets and letters addressed to the owners can all be used. Practical training on how to use fire extinguishers or fire hoses is a very easy way to improve fire safety and to add to the knowledge among owners and users.

After looking at the examples, we propose that following matters should be considered when starting a fire protection project in a historic wooden town:

1. What is the goal of the project (prevention of single fires or prevention of a town fire)?
2. What kinds of risks are there on single properties and in the town structure and how they can be minimized?
3. What are the risks of a fire spreading from one estate to a neighbouring one and how can these be minimized? How can the fire be limited to a restricted area?
4. What can be done to detect fire as early as possible?
5. What kinds of problems does the fire brigade face when acting in a town structure or on single buildings?
6. Is there enough water to extinguish the fire?
7. How joint training in fire protection can be arranged for owners and inhabitants (it is important to make them aware of the fact that a fire in a neighbour's house is a threat to their own house too)?
8. What measures does the municipality (or other authority) take and which are left to house owners?

Small administrative measures can be taken as in this example from Lillehammer. ("Remember to check the toilets before you close the café. Check that there are no paper towels near the heaters.")

There is still too much combustible material in some of the courtyards in Rauma.

Åminneborg after the fire.

4. Case studies

1. Åminneborg, Maalahti, Finland

This is a wooden mansion with a cellar, two living floors and an unheated attic totalling 500 square meters. It was built in 1792. The construction is made of logs. Most of the original interiors were destroyed between 1936 and 1964. The oldest wallpapers still existing are probably from the 1820s (but are covered with later layers).

Fire alarms were only installed on the living floors and not in the attic, which was used as storage.

The fire

The roof and the attic were destroyed by fire in January 2003. (The temperature was –22°C).

The fire broke out in the floor between the second living floor and the attic. The cause of the fire was a short circuit in an old electric wire, which resulted from condensation in the metal coating around the electric wires. It is interesting to note that the second living floor had been heated for only a few years.

The fire was detected by the owner at 7.40 am. He noticed that there was no electricity in the building and smoke was coming from the attic, which was already on fire. The fire spread rapidly.

The first fire brigade was on the site in about ten minutes. They did not have a fire engine with a ladder so they had to call for one and it arrived about twenty minutes later. The fire fighters also had some problems with the water supply. For the short time, they had no water at all.

During the extinction of the smouldering structures after the main fire had been put out, the fire fighters used so much water that some of it spilt into the cellar.

After the fire

The result of the fire was that all the roof structures and the attic were badly charred and the attic floor support beams were badly damaged. The ceiling, walls and the floor of the second living floor were badly damaged because of the amount of water used by fire fighters and there was also damage to the first floor.

The first actions after the fire were to cover

the attic with tarpaulin and to remove all waste from the attic and the second living floor. Drying the west structures then got underway.

There was no real documentation of the remaining structures of the roof. The only documentation was a series of photos showing the situation after the fire.

The building was not insured properly but the owner wants to build the roof anew. He has asked the Museovirasto for help and hired an engineer to make the plans for rebuilding. The idea is to keep the old shape of the roof using a new structure. The new attic will also be heated and not a cold attic as it used to be. Another addition will be two new attic windows.

What can be learnt?

It is important to check old electrical installations regularly and to consider the effects of heating previously unheated spaces. In addition, it is important to have fire detectors in all spaces, particularly in the attic. Fire brigades should have information concerning historic buildings in order to act correctly. Remaining structures should be documented as this might have revealed something interesting about the wood joints or other details in the roof construction. A fire can provide a researcher with an opportunity to find something that is normally invisible and unobtainable.

2. Kotaselkä, Savukoski, Finland

This was the site of a simple logging hut about 30 km from the centre of Savukoski in Lapland. It was made of logs and had a shingle roof. The building had a floor area of about 250 square meters. It was built in the 1950s and fully renovated at the very beginning of 1990s. The first building on the site was from the 1930s and it was burnt during the war in the 1940s. The building from 1950s was not an exact copy of the old one but an "improved" version.

The building was not regularly heated but there were stoves and fireplaces for heating. There was no kind of fire alarm system in the building and no electricity. The building was protected by the act concerning buildings owned by the State.

The fire

The building was totally destroyed by fire in June 2001. The weather was very warm at that time of the year. Two fishermen were staying in the hut and they had had a fire in a stove. They did not put out the fire properly before they went fishing. The fire probably started from a sparkle that set the dry shingle roof on fire.

There was no fire fighting. When the local fire brigade arrived, the building was already lost.

The hut is next to a small river so there would have been an ample and easy water supply. Only some charred floor beams and the lowest logs remained and there were some remains of the fireplaces and stoves.

After the fire

There was no documentation of the remains after the fire. A few people from the Museovirasto visited the site soon afterwards and they took some photos. It would have been possible to document the location of floor beams and the system for the foundation as well as the types of ovens using drawings and to document the dimensions and type of the wood material used in the lowest logs.

After the fire, it was checked if there was any material (drawings, photos etc) on the building in the archives of the Museovirasto. Only one drawing (a plan), a few photos and some written documents of the renovations in 1990s were found and it was decided that rebuilding the hut was out of the question. A year later, the archives were searched again and some twenty good quality photos were found. There were pictures of the interior and facades. Also found were drawings to

Kotaselkä before the fire, just after its restoration in 1990s.

a scale 1:50 showing the plan, facade and one section of the hut.

There was lot of discussion between the owner (the Museovirasto) and the user (the Savukoski municipality) about whether should the building be rebuilt. The insurance would have covered the cost of rebuilding, but the idea of reconstructing a lost building is unpopular in the Museovirasto. Finally, it was decided that the logging site hut would not be rebuilt but the money from the insurance would be used to restore other historic buildings owned by the State in the municipality of Savukoski.

What can be learnt?

The fire might have been avoided if there had been a dense net in the chimney to prevent sparks from flying onto the roof. A very loud fire alarm might have made the fishermen notice that the hut was on fire and they might have been able to fight the fire.

Good documentation after the fire should have been made to document the remains. In addition, a thorough examination of the archived material should have been carried out immediately after the fire in order to give proper bases for the decision of whether to rebuild the property.

3. Tyrvää Church, Vammala, Finland

The church in Tyrvää was built in 1490–1530. It burned in the 17th century but it was rebuilt again in a slightly different form. Its interior was renewed in the 18th century. The old church was discarded 1855 when a new bigger church was completed – it was even used as a hay barn until its value was rediscovered by one of the Art-Historic Expeditions made by the Finnish Archaeological Society at the end of 19th century. The church has stonewalls made of natural stone and bricks and the roof and the interior are made of wood.

The maintenance of the wooden shingle roof was neglected because there was no use for the church, which is why more than half the roof had to be renewed in 1995–1997. The old shingle roof was made in 1748 by Antti Piimänen, a famous master builder. Thirteen thousand shingles were needed, which was an immense task for the volunteers who did the job. The congregation celebrated the finished roof at the beginning of September 1997.

The fire

Three weeks later on the 21 September, the church was set on fire by an arsonist, who was finally

Interior of Tyrvää Church with its characteristic paintings before the fire.

caught in 2003. A local middle-aged man burgled the church, but he could not find anything valuable to steal. After leaving the church he realised that he may have left his fingerprints there so he went back to set the church on fire in order to cover his crime. The fire was detected by neighbours early in the morning by which time the church was in full flame and nothing could be done.

All wooden parts (roof, ceiling, doors, interior) burned down almost totally. Only one door remained, but it was badly charred. Some of the floor planks remained badly charred. The floor joists were still in good condition. Some other wooden parts survived. The walls, which were made of natural stones and bricks, remained but they had suffered from the heat. The plaster contained so much clay that it was fired and fell down during the next winter.

After the fire

Because it was autumn and there was a danger of rain, work started by temporarily protecting the ruins with tarpaulin. Soon the congregation decided to build temporary scaffolding to protect the remaining walls. The scaffolding was made of corrugated steel plates. The door and window openings were sealed with boarding.

Interior of Tyrvää after rebuilding, without any paintings.

A survey of the walls was carried out very soon after the fire. The work was done by the Museovirasto with the help of one crafts school. The remains were examined when the ruins were cleaned up and all useful material was collected. All wooden parts with profiles or marks or some traces were stored. All wrought iron nails were also collected. All damage to the stonewalls was marked on existing drawings and the details and traces found in the remains were documented at least by making sketches and taking photos.

The decision to rebuild the burned church was made very soon after the fire. The Museovirasto promised to help the congregation by providing its expertise.

Two open discussions were arranged to get as many views as possible concerning the difficult question of rebuilding. The main question during the first discussion was how to approach the whole issue: should the walls be left as a ruin, should the roof be rebuilt and how and what should be done with the interior and windows, doors etc? There was a consensus that the roof must be rebuilt because it was well documented and it forms a dominant feature in the cultural landscape.

Despite difficulties, the roof was subsequently rebuilt as a training exercise and in accordance with the old model. The documentation was rather good but some details and dimensions were missing. The shingles were made by volunteers.

Then second open discussion was arranged to discuss the interior. An interior working group was set up with members from the congregation, the Museovirasto, and one famous modern architect. The group proposed that the interior should be rebuilt so that the walls (remaining) were from 1500s, the floor (partly remained) from the 1600s, the roof, ceiling, doors and windows from the 1700s and the benches and the interior painting should be modern.

During the discussion, it was pointed out that whatever is done it is a construction of this day. The old one is lost and we cannot get it back.

It was decided that the exterior was to be rebuilt as it had been. Invisible structures were made partly using contemporary technology and some reinforcement was added as demanded by the structural engineers. The doors and windows were reconstructed to represent the 1700s.

Work on the interior started by appointing an architect who first made the layout design. The benches were sized to fit to modern people and some fire safety issues were taken into consideration in the layout. The ceiling was made to imitate the old one and the walls are treated with lime wash as also in the original building. The floor was made of planks in the same way as the old one as it was well documented.

When making the plans for the interior, the architect decided to follow the original design but to simplify the detailing and show that the interior was not from 1700s. The final surfaces of the wooden fittings were planed by hand.

The question of painting the interior is still open. A few modern artists have now been invited to make proposals and then the final decision will be made.

What can be learnt from the actions after the fire?

The cooperation between the rescue and heritage authorities should be closer. There should be instructions on how and what to look for from the remaining but charred material. The heritage authorities should carry out a thorough investigation of the remaining material as soon as possible after the fire, and all findings should be documented carefully. There is plenty of information to be found even in charred pieces of wood.

After this kind of almost total destruction, the value of good, advance, documentation cannot be stressed enough. It also means that details and structures as well as materials should be documented alongside the "normal" drawings.

What can be learnt from the rebuilding process?

Before any decision is made, the situation and the existing documents and knowledge on the burned building should be thoroughly analysed. A checklist for analysing the situation is needed.

If the building is to be totally or even partly reconstructed, decisions should be made concerning whether any research or tests are needed before putting construction, materials or work methods into practice.

Rebuilding provides an opportunity to learn about old techniques and materials, but this kind of work needs more time than normal. In the Tyrvää case, some things such as roof construction or the clay plaster inside would have required detailed research.

4. City block in Trondheim, Norway

Trondheim is a medieval city. It was re-planned in 1681 with a Renaissance town plan with broad streets to prevent the spread of fire. The block damaged in 2001 had buildings dating from the 1840s. The block includes some stone cellars from the Middle Ages. The buildings were primarily used as restaurants, bars and shops. Most of the buildings had walls of wooden log construction, wooden cladding, wooden floors and roof constructions on basements of brick. The area was not a conservation area but the buildings had been defined as worth preserving by the municipality.

The fire on 7 December 2001

The fire started in a pan with hot cooking oil in a restaurant kitchen. Cooking oil is a frequent cause of fires. A couple of days before the fire, there were some indications of problems with the electrical installations in the restaurant. Fluctuations in the power supply might have caused a failure in the pan thermostat. The fire was reported to the fire brigade at 10.45. The cook had been trying to extinguish the fire without success. All available personnel from the fire brigade were on site before 11 o'clock. The Trondheim fire brigade also got assistance from fire brigades in the neighbouring municipalities and from the military.

There was an automatic fire detection system in the restaurant. According to the fire instructions, this was only in operation between 04.00 and 08.00 when there was nobody in the restaurant. There was also an automatic sprinkler system in the restaurant kitchen. The fire brigade turned off the sprinklers as they thought the fire was extinguished. The fire, however, had spread to the ventilation room in the floor above the restaurant. The fire spread from the ventilation room along the facades and through the lofts. There was a shared ventilation system with ventilation ducts in several of the buildings. Many of these buildings lacked firewalls between the lofts.

The fire in Trondheim.

It took the fire brigade hours to stop the fire spreading to the remaining part of the block. A wall of solid wood construction in one of the buildings stopped the spread of the fire. A large concrete building was also seriously damaged but the fire brigade managed to stop the fire there.

After the fire

As Trondheim is a medieval city, archaeological excavations have to be carried out before rebuilding can start. The extent of archaeological excavations was limited and areas in the interior of the block were left untouched. The authorities have not required the block to be reconstructed with copies of the damaged buildings.

What can be learnt?

What went wrong?

- The fire brigade lacked knowledge of the properties.
- The available fire fighting personnel was not used effectively.
- The fire brigade lacked modern fire fighting equipment.
- The fire brigade lacked safe access to back yards.
- There was insufficient fire insulation, particularly in the lofts.
- A sprinkler valve in one of the buildings was turned off.
- The building authorities lacked an overview of the fire safety of the properties.
- The building authorities had not used their authority to make sure the reported lack of fire protection was improved.

How will fire protection be improved after the fire?

- The local authorities will carry out a risk analysis for fire protection.
- The fire brigade will be strengthened, particularly the department working with prevention.
- There will be improved routines for fire protection during the building planning process.
- There will be improved cooperation between fire-fighting personnel and fire officers.
- There will be improved routines for fire inspections.
- There will be a project for the fire protection of the historic centre of Trondheim, including a survey of all the properties.

Interior of the Innset Church before the fire.

5. Innset Church, Norway

The parish church of Innset in the county of Sør-Trøndelag was built in 1642. It was the oldest existing timber church in Norway originally built in a cruciform plan. It was a valued sight on a hillside in a small community of 400–500 people. The church could hold 300 people. The church burnt down on the night of 3 November 1995.

The church was a log construction painted with tar. It did not have any sort of fire protection, but this was being planned. At the time of the fire, water was scarce and had to be taken from a stream nearby.

The fire

There are farms in the neighbourhood, as close as 200 meters from the building, but nobody woke up early enough to prevent the fire from spreading to the whole church, nor were they in any way able to take control of the situation. When a timber construction of this size burns, the first minutes are crucial. It is typical for a fire in a wooden church to spread rapidly to the loft and tower, where it gets out of control. Nobody knows exactly when the fire started. A neighbour living 200 meters from the church was woken up by a telephone call 3.30 am from a person who had seen the fire from the valley. It took 20 minutes for the fire brigade to arrive at the site. Then there was really nothing that could be done except prevent the fire from spreading. The church burnt down completely, except for one corner of the sacristy.

The actual cause of the fire is still unknown, but the church burnt down when Satanist arsonists were active and fresh footprints near the church could indicate that this church was set on fire. There was a case of attempted arson on 25 April 1995. The investigation after the fire concluded that the electrical installations were sound and no possible reason for the disaster was found. When the fire occurred, the church was about to install an automatic fire detection system with a grant from the Riksantikvaren.

After the fire

Two days after the fire, the remains were searched for possible items of historic value and measured

by NIKU (the Norwegian Institute for Cultural Heritage Research). But there was really not much information to find in the remains.

The first reactions of the local community were the desire to rebuild the church. In this rural area, the church was the oldest and most visible public symbol. Therefore, the loss of the church and its tower up on the hillside evoked strong feelings.

The present church is not an exact copy of the lost one but at first sight, the exterior bears a strong resemblance to it. The liturgy had changed since the last restoration in the 1930s, and the laws concerning public buildings, accessibility, and safety has also changed. The architect also had a desire to put his creative imprint on the new building and building technology combined with economics are also partly responsible for the changes made.

What can be learnt?

What is probably most important from the heritage point of view is the fact that the old church was not properly documented or measured. A feasible rebuilding of the church was simply not possible. The Riksantikvaren was not involved in the process of rebuilding.

In this fire, almost all the things that could go wrong went wrong: a long distance for the fire brigade, no early warning systems, a lack of water, and insufficient documentation.

6. Eidsvoll Church, Norway

The Church of Eidsvoll dates back to the Middle Ages. Through the centuries the church has been changed and enlarged several times to its present size and shape – which has given it a 19th century appearance. The church is a big construction of different stones and bricks. The roof, however, is of wood.

The fire

The fire alarm went off at about 6 pm on the evening of 21 August 2000. The fire brigade was at the site within minutes but due to earlier false alarms, they waited for the churchwarden, who had a key to the church, to open the front door. As the churchwarden entered the church through the sacristy, he immediately saw that the choir organ was on fire. The organ was positioned close to the crossing in the southern arm of the cruciform church.

The fire spread from the organ up to the roof of the nave, where the ceiling and roof construction were damaged. The organ in the west gallery, far from the choir organ, was also ruined. Since the fire started rather close to the choir, the baptismal font and the several-storied altarpiece were partially ruined. The painted canvas panels of the altarpiece were damaged by the heat of the fire.

The short time between the alarm and the arrival of the fire brigade saved the church but still left the building with costly damage.

The most likely cause for the fire was the bad condition of the electrical connection to the choir organ. The fire did not have time to spread up-

The interior of Eidsvoll Church reconstructed.

wards to the church tower just above. If that had, the church bells would easily have fallen in and the wood construction in the tower would have fed the fire.

After the fire

The damaged construction had much left of the original material that could be feasibly reconstructed with traditional methods. The Riksantikvaren contributed its know-how and the insurance covered the costs. The altarpiece was restored but the choir organ was totally destroyed. The main organ was technically badly damaged and was rebuilt but the facade was reused.

What can be learnt?

Several things are to be learnt from this fire. The fire brigade hesitated while approaching the church because they suspected a false alarm. If they had had the key to the main door, in a key box at the entrance, they would have entered more quickly. The churchyard was soft and the gate narrow for the fire engines. This caused problems and took time. The main reason for the fire was the electrical installations. Proper maintenance of the installations could have prevented the fire from starting.

7. Ringnes farm, Norway

Ringnes Farm is on the eastern shore of Lake Mjøsa. The land is very fertile and has been one of the best farming districts in the country for hundreds of years. The farm dates back to before 1000 AD but the present main building, completely built in wood, was built just after 1700. The building is 30 meters long and consists of 600 m^2 on two floors. The building is listed.

The fire

On 10 September 1996 at 09.20 am, the owner, who was working elsewhere on the farm, saw smoke coming out of the main building. Nobody was inside. He immediately phoned the fire brigade, which, despite the 9 km distance, was at the site in less than 15 minutes.

The fire started in an office on the ground floor at one end of the building. The most probable cause of the fire was a malfunction in the fuse box. The fire was under control after 4 hours. The greatest problem was that the fire got spread through hidden spaces and holes formed during the many changes through the ages in the walls, rooms and floors.

The fire was restricted to the part of the building used for living and more or less stayed out of

Interior of Ringnes just after the fire.

the section used for parties. Most of the doors inside where closed, which slowed down the spread of the fire. The fire was restricted to half of the first floor. Except for a few rooms that were completely destroyed, the largest damage was from smoke, soot and water. The house was filled with old pieces of furniture, paintings, decorated walls and ceilings, and valuable old items.

The house had no alarm system connected to the fire brigade. When the fire brigade arrived, they soon found that the connections between the farm's water system and the fire brigade's hoses were different. This caused a costly time delay.

After the fire

The restoration of the building was undertaken in cooperation between the owners, Riksantikvaren, and the insurance company. The fact that the building was legally listed made its restoration more complex, but it also made it possible to have the restoration carried out according to antiquarian principles. The insurance covered the extra costs.

The decision was made to return to the original room plan, enfilade, which meant changes in some walls and doors, and the building was divided into two sections according to use – living and entertainment. The wall surfaces in some of the rooms were restored to the original, with the original painted decorations. Since the house is not a museum but a home for a modern family with children, some of the changes in the living section were made to fit these demands.

An automatic fire detection system has been installed in the house. There is also portable water mist fire fighting equipment (IFEX).

What can be learnt?

Good insurance is naturally important. The value of a protected heritage building, i.e. a listed building, is often different from other buildings. In addition to functional value, a building literally has different layers of history, all the storytelling historic odd pieces and irregularities. A partial rebuilding of these traces in credible traditional methods may be costly, important and "incomprehensible" to modern insurance companies.

Dividing a building into different fire cells is important in order to prevent a fire from spreading. Even closed doors can effectively prevent a fire from spreading. An automatic fire alarm system connected to fire brigade saves lot of time and it also works when there is nobody in the building. The early detection of a fire can substantially reduce the damage.

Reconstructed interior of Ringnes after the fire.

The lost interior of Södra Råda with valuable paintings.

8. The Södra Råda medieval Church, Sweden

The old church of Södra Råda was situated in the county of Västra Götaland in Sweden near the Lake Vänern. The church was owned by the Government and managed by the Riksantikvarieämbetet. The old timber frame from the 14th century was extremely well preserved, and had been changed only slightly during the 17th century. The interior had unique paintings on the walls and ceilings, and particularly those in the chancel, from 1323, were of highest artistic quality. The enclosing churchyard wall was also made of timber.

The building in the landscape, a witness of historical continuity at this place of early Christianity, with strong links to religion and current artistic influences in Europe, was an important part of local identity.

Before 1995, the fire protection of Södra Råda was modest. A pond was constructed near the church during the 1950s to provide the water supply in case of a fire. A fire hydrant was installed and a lightning conductor was installed to the church. In order to increase the awareness of the fire risks and to prevent fire damage in the building, the property manager from the Riks-

antikvarieämbetet initiated a number of seminars and workshops in 1995 with the aim of identifying the optimal level of fire protection whilst balancing costs and security.

Experts from the Fire Defence Agency, the Riksantikvaren, alarm system producers and the Riksantikvarieämbetet took part in these meetings. The Riksantikvarieämbetet then engaged a Norwegian company to produce a fire protection plan. Their decision was to install a sampling system that sucks air from inside the church into an analysing unit outside the church. The system sounded an alarm if there was fire or smoke in the air from inside the church.

This was the level of protection chosen for the church and it was 95% installed. Due to problems with the alarm system contractor and some technical problems with the installation, the system was not fully functional at the time of the fire.

The fire – 12 November 2001

The fire alarm went off at 01.53 am, both in the chancel and the porch. The fire was discovered by a neighbour at 02.18 am and he immediately notified the central alarm service. The local fire brigade arrived at 02.40 am. The police arrived at 02.57 am.

The fire spread very rapidly and it was not possible for the fire fighters to save any interior objects in the church.

The police closed off the area around the church immediately after the fire and Hemvärnet (the Voluntary Defence Organisation) protected the area 24 hours a day for the first 5 days after the fire. Thereafter, a fence and a powerful lighting were installed around the building. Some weeks later, a construction was built over the former church to cover and protect the remains so they could later be investigated. This "tent"-like construction is still (2004) in use.

The investigation of possible causes involved technicians and fire specialists. Police technicians started a possible arson investigation the day after the fire. They could neither verify nor exclude arson. Other possible causes were an electric fault in the alarm system connection box in the churchyard approximately 8 metres from the northern facade inside the wall. This box was checked but no conclusions were reached.

The cause of the fire was unknown until the autumn 2003, when a man voluntarily confessed to arson during interrogation concerning the murder of a child. The arsonist, who was mentally disturbed, was convicted for arson in January 2004. He had the inspiration to set the church on fire from a TV-programme presenting old wooden churches in Sweden.

It was not possible to save any interior objects during the fire. Chandeliers, locks and other metal objects as well as the baptismal font were all taken care of immediately after the fire was extinguished. Like everything else in the building, these objects were badly damaged by the fire.

The remaining pieces of timber were numbered and stored. Experts on timbering techniques carried out an antiquarian documentation.

An inventory was made of written sources and drawings concerning the old church and the results were put together. It was clear that this unique church was relatively well documented, although there were gaps. For example, no documentation was found about some of the paintings in the aisle.

Almost immediately after the fire, the municipality and the local people started to demand the church be rebuilt in the same place and with the same appearance as the old one.

In February 2002, the Riksantikvarieämbetet arranged the first meeting in Södra Råda, which brought together more than one hundred people, where the Director General of the Riksantikvarieämbetet promised to reconstruct the church.

After these events, the Riksantikvarieämbetet started the Södra Råda Project in collaboration with the municipality, the inhabitants of the region, the county council and the county museum. The project initially focussed only on rebuilding the church. Now it has developed to an expanding long-term project, aiming at

- capacity building in cultural history and regional growth,
- increased commitment and interest for our cultural heritage and
- strengthening collaboration between the national, regional and local levels.

Another objective is to create a centre for the different building techniques used in medieval churches.

Many difficult decisions and adjustments are yet to be made with respect to ethics, antiquarian, technical and regional culture tourism. Seminars and workshops have been arranged and they will continue throughout the whole process.

The project is planned to end in 2008. After the rebuilding and after the project is finished, the church will be owned and managed by a foundation called "Stiftelsen Södra Råda gamla kyrkplats".

What can be learnt?

One important aim for those preserving cultural heritage is the learning process concerning craft skills. Restoring a building in the same skilled manner it was once built adds invaluable knowledge to the techniques of today. Another aim is learning how best to make use of the strong media interest for the benefit of the process itself as well as for the public.

Of course, this accident also shed light on the awareness of fire risks, especially in this type of wooden building, and the prevention of damage caused by fire. For example, the Riksantikvarieämbetet is working on a handbook showing how to make good photographic documentation of a cultural heritage such as medieval timber churches.

9. City block in Jönköping, Sweden

The block and the buildings

A block named Arkadien in Jönköping began to burn the 11 February 2001. The oldest parts of the block were put up in 1630 as a courtyard surrounded by wooden buildings near Lake Munksjön. They were built for living and handcrafts and nowadays they also house small boutiques, barbershops and institutions. Three properties in the block were more or less damaged by fire or by the water used for extinguishing the fire. All the buildings on one property were destroyed while a big stone building in the same place was only slightly affected. At least one of the buildings in the block had a fire alarm. There was no automatic fire-extinguishing equipment in the damaged or threatened buildings.

The fire and fire fighting

After the fire brigade had evacuated people they drew the lines from which they would fight the fire. They had good experience from fire drills in the very same buildings and they succeeded in keeping the fire within the limitation lines they had set. The firemen had a good water supply

The block in Jönköping before the fire.

from fire hydrants and the nearby lake. The action that gave "fog spikes" in the attics was the most effective, at least as long as the roofs were intact.

Though there were fourteen flats and six commercial apartments that were totally destroyed, the fire brigade was rather satisfied; they succeeded in saving three-quarters of the block, both in area and in approximate value.

In at least one case, the rescue of valuables succeeded well; the extinguishing water from above threatened a glue-paint covered ceiling in a café on the entrance floor. The firemen covered the floor immediately with tight sheets and pumped the water outside. As soon as they could, the conservators got access to the ceiling to protect it from further damage.

Advice: A good knowledge of a building by both the rescue service and the heritage authority will increase the possibilities of a good result; an operational rescue and salvage plan are good instruments.

Problems in fire fighting

1. There were narrow, 0.2–0.5 m "passages" between some of the buildings that were originally built as fire limitation space probably to be sprayed with water. They were up to 40 m long and went from the ground to the eaves and they were often used as storerooms for combustible materials. They were sometimes blocked with boards or growing plants at one or both ends. The walls in these passages were often covered with board or other wood-based materials.

Consequence: These passages gave no protection against fire spreading from one house to another. In some cases, they even acted as a chimney. They were often too long to be effectively sprayed with water. Their length and narrowness also made it difficult to enter them. The flames from the fire went up to the eaves and into the attic.

Advice: Sprinklers under the eaves would probably have limited or even stopped the fire. Alarm threads on the walls may have given early warning of fire in the spaces. A better possibility to access the spaces would have achieved their original purpose of fire limitation. Spreading fire could have been limited if the passage walls had been covered with non-combustible materials and the spaces were tidy.

2. There were just a few fire-limiting walls in the attics and between buildings.

Consequence: It was impossible for the firemen to

The block in Jönköping after the fire.

limit the fire to a smaller part of the block.
Advice: Build fire-resistant walls (the heavier the better) from base to roof and in the same section. Doors in the walls should be made of non-combustible material and be closed. A sprinkler in the attic would have limited the fire.

3. One roof was (probably) covered with shingles under sheet-iron.
*Consequence:*There was a shower of sparks over the town.
Advice: Sprinkle the ridge and the roof if this kind of structure exists.

4. The houses across the street (and even the burning houses) had advertisement boards made of combustible plastic on the walls.
Consequence: The firemen had some problems getting the boards under control so that they would not extend the fire.
Advice: Make advertisement boards of non-combustible materials.

5. Some of the houses were painted in different colours on the street side and courtyard side.
Consequence: The firemen found it difficult to orient themselves. If they enter the wrong yard, a two-side attack could fail.
Advice: Provide information on these conditions in the action plan.

6. One apartment in the attic in one house only had access from the attic. Neither the fire brigade nor the police knew about this apartment.
Consequence: The apartment was checked late by the police. (Fortunately, it was empty.)
Advice: A comprehensive and updated action plan tells the rescue staff about such things. Do not have just one access to such an apartment.

The investigations

The investigations began the day after the fire. The fire investigators interviewed some witnesses and they got one photo from the early phase of the fire from a private individual. They also got some photos showing the situation before the fire and up-to-date drawings of the block. These drew suspicion to a certain part, a staircase in one building. The first thing they concentrated on was the electrical installations. There were some signs indicating that the fire had occurred on the ground floor and they found some electrical equipment in these rooms, including a freezer and a heating fan. These were connected to the electrical circuit over a multiple portable outlet. The heating fan was installed to protect a water pipe from freezing. The investigators found a short circuit and a loose connection in the extension cables and plugs. This was probably the cause of the fire.
Consequence: Some experts say that a loose connection can develop great heat energy (up to 25% of the connected power). One freezer would not give more than about 50 W but a heating fan or heating unit whatsoever (2 kW) gives up to 500 W of heat, which is dangerous when it develops in a small area with combustible materials surrounding it, e.g. plastics, paper and so on.
Advice: Always connect heating and other high-effect units directly to a fixed electrical system. Always check loose connections inside high-effect and extension cord units.

After investigating the direct cause of the fire, the fire and rescue authority analysed how the building construction and the technical fire protection system affected the development of the fire.

Repair and rebuilding

Some of the houses from 19th and 20th centuries were destroyed and some remained. The half-burned houses were retained and repaired and they were given an authentic shape.

What can be learnt?

Where such units were installed, the automatic alarm systems worked as expected. After several exercises in the block, the fire brigade was familiar with the buildings. The brigades from the outer parts of the municipality and from other parts of the county had exercised with each other and the rescue leader, so cooperation between the actors worked very well during and after the fire.

The fire brigades have now increased their efforts to make operational plans for the wooden blocks in the town.

It is a good idea to carry out fire supervisory duty in restaurants, shops and other commercial places. Now all newly built living and commercial apartments are fitted with sprinklers.

Katarina Church
interior just after the fire.

10. Katarina Church, Stockholm, Sweden

Katarina Church was built 1656–1695. The architect was Jean de la Vallée. The church was damaged by fire and rebuilt again in 1723, but it was not an exact copy. The magnificent tower was new and was finished in 1739. The architect then was Göran Adelcrantz.

The church is on a hill in the south of Stockholm, Södermalm, and you can see it from a long way away. It is a very important part of the Stockholm skyline. The organ façade, which is from 1763, was by Jean Erik Rehn. The altarpiece from 1732 and the pulpit from 1753 were by Göran Adelcrantz's son Carl Fredrik Adelcrantz. The altar painting from 1735 was by Lorenz Gottman.

The fire

The church was destroyed by fire in May 1990. This is one of the most notorious fires in a cultural heritage building in Sweden. Only the outer walls made of stone (or bricks) survived. The

cause of the fire was most probably an electric fault in the cable of the great hoist chandelier. The church had no smoke detectors. Had there been detectors, the fire would have been discovered at an early stage and probably been put out. The fire brigade was located next door to the church. But when the fire brigade came to the church, there was already a big fire and they had no possibility to save the church. The church had an old sprinkler system in the tower but it could not be used because there was not enough water in the municipal water pipes.

After the fire

Only the walls, some vaulted ceilings and the ground floor remained after the fire. All other things, the furniture, the altarpiece, the pulpit, the roof construction, the bells and so on were lying on the floor. The conservators carried out an archaeological excavation in the remains of the building and found out the type of timber joints used and other knowledge. They also saved pieces of ironwork, nails, mounts and so on, that were later reused in the new construction. Even an original water-coloured de la Vallée-drawing was saved. They also found the former cast iron bell clappers that had been missing for decades.

The actors, the parish, the authorities, the church board and the newspapers immediately discussed what to do with the ruin. The proposals were many, from total rebuilding to a different shaped youth centre. In the end, rather early (within a week), the almost total rebuilding line had won. The church had been a well-known landmark for both citizens and sailors for almost 300 years.

The church board engaged, after advice from the Riksantikvarieämbetet, a skilled architect and a skilled constructor.

The project team agreed along with the church board to give the building its shape from the early 18th century (after the former fire), both in its interior and exterior. Some traces from the restoration in the 50s would be erased. The Riksantikvarieämbetet actively participated in this discussion and through argument and permission drove the design towards being more acceptable from the antiquarian point of view.

The church board wanted non-combustible roofing but the constructor said that a concrete construction would be far too rigid for the fire-affected and sensible walls. They ended up choosing a timber structure for the building. Here, the team had great help from the pieces found in the fire remains.

The project team designed public facilities in a new basement under the western cross-arm, which led to an interesting archaeological excavation.

The former altarpiece was rebuilt except from some sculptures, which was impossible to do, and the central painting, which would have been morally wrong due the artistic aspect. The former baroque organ from the 18th century, which was taken down in 1870s was not reconstructed. The organist wanted a more modern one. The contracted architect gave the benches a new, functional design.

What can be learnt?

You can never trust installations, neither electrical nor the fire-protecting ones. They always have to be checked regularly.

The roof construction was a very interesting aspect in rebuilding. The architect proposed a traditional wooden construction while the church board wanted to use concrete. The matter was studied carefully by evaluating the use of laminated timber and steel structures but finally it was noted that the old technique with wood would be the quickest, easiest and cheapest way to rebuild the roof. So skilful carpenters were employed and all parts were made on the site in order to adjust them to the existing wall structures.

Detail of the new roof construction made of timber with wooden joints.

Pyhämaa Church.

5. Fire prevention and protection

5.1 Introduction

Fire needs three things to get started: combustible material, heat and oxygen. If one of these can be eliminated, then fire is eliminated. With the need or will to protect an old building and its unique character, many of these eliminating actions can be contradictory. To reduce the amount of combustible material (the fire load) without taking it away, it could be stored behind plasterboard or fire-protecting paint. This would give a new character to surfaces, which is not recommended. Even heat-limiting installations such as inside or outside sprinklers and smoke lids in the roof (to eliminate flashover) could reduce the historic value of a building. To hinder oxygen from reaching the building during a fire is technically difficult because of doors, windows and other natural holes in houses are not airtight.

This chapter discusses these problems and the way to deal with them in old buildings.

5.2 Some examples

Conflict with construction and installations

Pyhämaan uhrikirkko (the Pyhämaa Old Church) in Finland was built before 1667 and its interior was totally decorated with water-soluble glue paint. The congregation was going to install an internal water mist system that contains more

than 20 chemicals, which might damage the sensitive paintings. The Museovirasto did not allow this; rather, it insisted that a mist system using pure water should be used. As this system is more expensive than the chemical one, the congregation did not accept the idea. Consequently, there is no fire extinguishing system inside the church, only fire alarms.

The existing wooden exterior boarding on the timber walls is from 1960s. The logs in the walls were soft and they were no longer able to bear the load well; a new supporting frame was needed all over the church. This was made of 4" x 4" wooden beams. This causes a serious risk of fire because there is a gap between the log wall and the boarding. The roof is also of double construction. A shingle roof visible but underneath there is an older roof made of smaller and thinner shingles. There is also 10-cm wide gap that forms a flue in case of a fire.

The windows were situated in the surface of the wooden boarding. There were no windows at all in the timber frame. This meant that the gap between the boarding and the frame was directly connected to the interior. This was again a serious fire risk. To prevent an arsonist from throwing something like a "Molotov Cocktail" through openings the existing glass windows were changed to a shockproof material. New glass windows were made for the timber frame. In addition, a sprinkler system was installed outside the church, under the eaves and on the ridge. This sprinkler system may be too visible.

The gap between the log wall and the exterior boarding.

The water mist cannon in the vicinity of Gol stave church.

Technique also needs human beings

There is a stave church in the Norsk folkemuseum (open-air museum in Oslo). It was moved there from Gol. Many different systems have been used to protect the church against fire.

For fire detection, an air sampling system is installed in the church. It is so sensitive that it will also detect external fires. Inside, there is a water mist sprinkler system. An "ordinary" sprinkler system is installed in the gallery outside, + a water mist in the apsis. Four water mist cannons are installed outside the building. Double plastic tubes (that melt in a fire) activate the canons and the water mist in the aisle; all the heads in the aisle are released simultaneously whereas in the choir and around the apsis the heads are released individually. There is a gas flask in the technical room to provide pressure for the release system in the event of a power failure. The technical room, which is needed for the equipment, is built underground. The cannons were installed first and then the sprinklers. Now, there is perhaps too much equipment.

There was a false release in the stave church in the winter 2003, when the water mist system was activated. The mist fell to the floor as snow without causing any damage. The cause for this

false release was a leakage in the detector pipe. The plastic tubes were installed too tightly so that they would not swell or shrink with fluctuations in temperature.

There are two caretakers who know how to operate the system and they check it once a week. A thorough check is carried out at least once a year.

There is also a net of fire hoses that covers the whole area of the open-air museum. These hoses have been equipped with a sabotage alarm and the water for them comes from the communal water pipe. There are fire detectors in the museum buildings. They are black because this colour merges well into the old wooden surface.

Systematic organisation is essential

Statens Fastighetsverk, (the Swedish National Property Board) has written *"Instructions on fire safety in national monuments"* (Instruktion för brandsäkerhet i statliga byggnader). Here are some excerpts from the instructions:

"There are special requirements for historic properties in terms both of how materials and design withstand fire and the possibility of matching fittings and other measures to the historic environment."

"The property manager is obliged to:

- Identify who is responsible for what in relation to the fire safety of the property.
- ...
- Carry out regular training of staff and ensure that the tenants' staff receives training.
- ...
- Maintain continual contact with the Fire Service in order to ensure that they know the property, understand its value and prepare intervention plans.
- ...
- Document incidents, analyse them and draw conclusions.
- ...
- Carry out and document a risk analysis and assessment of the cultural and economic value of the building and coordinate this with the tenant's analysis and assessment of collections and other valuable inventories.
- ...
- Draw up operating instructions and organise maintenance."

The Statens Fastighetsverk has also been working on fire safety matters during the repairs. When a building is turned into a building site, they estimate that the risk of fire increases 30 times. Fire compartments and fire safety equipment are not usually active at that time and the building activity itself increases the fire risk because of hot works and so on. Therefore, they have tried to create ways to make the sites safer. The following measures can be taken:

- Work on repairs should be carried out so that a building is divided into fire compartments.
- A portable fire alarm system called MADAMM can be used; its working range is 50m and it is a sampling system (should be used only when there is no work on in the site, such as at night and on weekends, because the dust can cause problems). The price for one unit like this is about 45 000 SEK (2003).
- All workers on the site are trained from the very beginning to consider fire safety.
- The rescue of human beings must be ensured in the event of a fire; fireproof elevators can be used (there is high pressure in the elevator well; it is normal technology for high-rise buildings). These fireproof elevators are in use not only during the building activity but they also function normally even in the event of a fire.

"MADAMM" a movable air sampling fire detector.

5.3 How to choose fire prevention and protection methods

Here are some basic recommendations for choosing the fire protection method and equipment:

- Consider each building unique. Therefore, it requires unique and creative solutions.
- What is usually needed is the combination of organisational and technical fire safety precautions. Often a good organisation can minimise the need for technical adaptations.
- First try low cost methods complete with installations.
- Good solutions need cooperation between the owner, the fire inspector and the heritage inspector.

Sprinkler heads do not disturb the space very much if installed carefully.

Some key words for fire protection:

- Maximum safety with minimum damage
- Extended cost-benefit analysis
- Fire protection strategy

Maximum safety with minimum damage:

- Choose fire protection methods that do not involve interference with the building.
- If interference is unavoidable, keep it to the minimum, and it must be reversible.
- New installations must be accessible for maintenance and removable without causing damage because they have a much shorter lifespan than the building itself.
- Technical installations and information signs must be discrete.

Extended cost-benefit analysis:

- When choosing the systems for fire protection both monetary costs should be considered as well as the reduced cultural value of the building due to damage to the fabric of the building, aesthetic interference, false releases from sprinklers etc.

Fire protection strategy:

- To minimise the interference to the building and to secure the best use of available money, a fire protection strategy should be carried out before expensive technical equipment is installed.

5.4 Low cost fire prevention

The basic idea is that fire prevention is something that needs constantly to be worked over and it has to be done systematically. Each heritage building should have a specially appointed person with the responsibility and the training for fire protection. He must carry out or order regular fire inspections according to a checklist that is specially made for each building. All observations must be well documented during in-

spections. The checklist and fire risk assessment can be made with a fire inspector. In Sweden, the new rescue law (Lag 2003:778 om skydd mot olyckor, from January 2004) gives more attention to fire safety documentation and the owners/tenants responsibility and less to the fire inspections carried out by the rescue service. The new rescue law (Pelastuslaki 468/2003) in Finland and the Norwegian law contain similar requirements.

There are some simple measures that can improve the fire protection of a building very much like caution with electric equipment and an open fire, locked storage for rubbish, the tidiness in the vicinity of buildings, in the attics etc.

Some technical installations do not cost too much but are effective, power surge protection, simple smoke detectors and fire extinguishers for instance.

The most important thing is to have trained personnel, to estimate the possible risks and to make a fire protection strategy. It is also recommended to make a rescue plan in cooperation with the local fire authorities to prevent extra damage in the event of a fire.

If a fire breaks out, the most important thing is its early detection, that the fire fighting equipment is easily within reach, and people know how to use it.

It is easy for an arsonist to set fire to an open bin full of rubbish in the vicinity of an historic building.

5.5 How to prevent arson

The most important thing is always to make it as difficult as possible for arsonist. When discussing how to prevent arson, the first things that come up are good locks and a burglar alarm. A very good system might be a combination of a light fitted with a movement detector, a video camera sending a picture to a guard company and a loudspeaker to talk to the person who is approaching the building. To give the fire brigade more time, manual fire fighting equipment, for instance fire hoses or in some cases an automatic fire suppression system for instance sprinklers or water mist is recommended.

Some experiences from Finland

A discussion between people from the Museovirasto and an insurance company in Finland shed light on some interesting aspects regarding outdoor lighting and arson. (Note: Outdoor lighting is not same as a facade floodlight). Here are some points of view:

- An illuminated building is visible to all by-passers and it adds to control.
- (Young) people avoid gathering in well-lit places.
- Lighting adds the fear of being caught because to be seen adds enormous stress (every second is long) and 80% of burglars give up after 6 minutes if they have not succeeded. (Standard: 6 minutes with a max. 60 cm long tool.)
- There is a positive connection between lighting and security: no dark corners to work in, light helps camera control. Insurance companies set lighting as second security measure after proper locks.
- According to insurance companies 70% of crimes in Finland, are committed by amateurs and to prevent them the simplest thing, a proper locking, is needed. Only 1 % of crimes are by organised criminals.

The negative aspect in some cases of outdoor lighting is that it can draw attention to a place that would otherwise be unnoticeable. It could therefore “encourage” a passer-by. In remote places, it can also help an arsonist to act because it is easier to work with the light on.

5.6 Rescue Plan

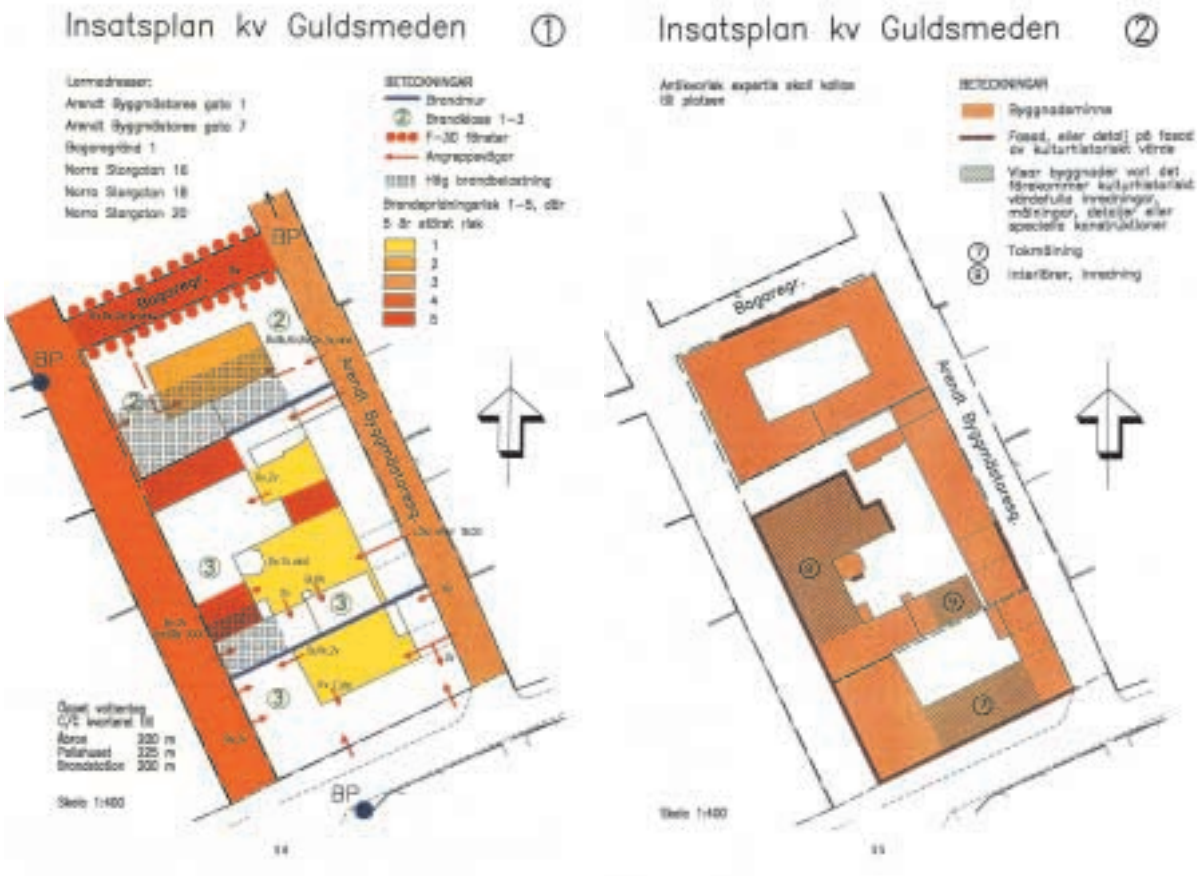
Finland

The requirements for a Rescue Plan are assessed in the Rescue Act 468/2003. According to this law, owners and occupants should independently implement fire preventive measures on their premises. The Decree on Rescue Services 787/2003 provides for standard of municipal emergency services and readiness for action.

A Rescue Plan has to be worked out for a building where the damage is assumed to be extensive, such as all buildings open to the public, hotels and other accommodation buildings, shops bigger than 500 m2, hospitals, day care centres involving more than 25 people, firms and companies involving more than 30 people and blocks with at least 5 flats etc. This means that most of the protected and historic buildings in Finland fall into categories where a rescue plan has to be prepared.

A Rescue Plan
should include the following:

1. Risk assessment and preparedness in the case of an emergency
2. Preventive measures
3. Possibilities for evacuation and protection; organisation for extinguishing and rescue
4. The appointment and training of people responsible for safety issues and the use of other personnel and inhabitants
5. Equipment required for fire extinguishing, rescue and clearance, devices for personal protection and first aid according to the assumed case of emergency
6. Instructions for accident, emergency and hazards assumed in point 1.
7. A plan on how to inform the people concerned



An example of rescue plan drawings in Eksjö.

Sweden

Rescue plans ought to be made for cultural heritage buildings and apartment blocks. These should include information about how to get into the building or courtyard. They also should contain information on the most valuable objects to be saved, where they can be found and how to handle them etc (salvage action).

In general, a salvage action includes actions that limit damage and loss during and after a fire or any other accident that the rescue service might work with. This means that during a fire (acute salvage), the participants have to make the site as dry and smoke-free as possible (primary damage). After the fire, they have to protect the site from secondary damage such as interruption in the owner's activity, corrosion, dirt and soot, water and humidity damage, temperature damage (proceeded salvage). The salvage action plan can be completed with an activity priority in which the most sensible, valuable or precious items should be saved in the first place. (In Sweden, the Larmtjänst is responsible for salvage activity and the activity priority is held and updated by the local Larmcentralen. Statens Fastighetsverk has proceeded far in this task.)

Norway

According to the Norwegian Fire Precautions Act and Norwegian fire regulations, a rescue plan is only required in buildings where there is a risk of the loss of human life. However, all building of great historic importance, according to the law, should be designated as special category buildings with the following requirements:

- The owner must appoint an individual with documented training to be responsible for the fire safety in the building.
- Fire safety must be documented: A. Plan drawings of the buildings showing the position of all fire installations. B. Descriptions of all fire prevention equipment. C. Copies of maintenance agreements for the equipment.
- There should be fire drills every other year.
- The local fire officer should carry out inspections every four years.
- In buildings of great cultural value, the owner should install permanent fire extinguishing systems, for instance sprinklers.

5.7 Fire fighting

All the following examples deal with wooden towns but the same ideas can also be implemented in single historic buildings. If the firemen are familiar with the building, it is easier for them to work effectively without causing extra damage to the building. This is the reason why a special rescue plan for historic buildings should be made in cooperation with local fire brigade.

It became obvious when looking at the case studies that the best way to ensure effective fire fighting is to make fire brigades familiar with the sites by organising fire drills. In Jönköping (Sweden), they organised fire drills in the same block where the fire occurred and this was the reason the work during the fire was effective. The fact that the fire brigade was familiar with the block saved some valuable paintings that might otherwise have suffered water damage.

An opposite example was presented from Trondheim (Norway), where the fire brigade did not know the block in advance, which caused many problems and made fire fighting very difficult.

In Eksjö (Sweden), they have not experienced any serious fires of late but the fire brigade there had made detailed plans on how to act in the event of a fire in the old town. They also organised fire drills frequently in the old town. The politicians had also discussed if neighbouring municipalities should integrate their fire brigades. This was not done as the Riksantikvarieämbetet issued a statement that there must be a local fire brigade as long as the old part of the town existed. The politicians accepted this and the fire brigade stayed in Eksjö.

5.8 Using a fire protection strategy to choose the right technical solutions for the fire protection of cultural heritage

Fire protection strategy

The basic idea in choosing the most suitable fire protection method is first to analyse the risks and to check the available/existing protection methods. Then, the remaining risks are listed and suitable prevention methods are chosen. However, a certain risk of fire always remains but a decision should be made on the acceptable level of remaining risk. The main objective is to gain "*maximum safety with minimum damage*".

Building up a fire protection strategy

Risk analysis, causes of fire

⇩

Fire preventive measures

⇩

Remaining risk

⇩

Fire limiting measures

⇩

Acceptable remaining risk

Risk analysis, causes of fire

Any fire protection strategy should start with an analysis of all potential causes of fire on the property. This will create awareness resulting in necessary fire preventive measures being carried out.

Some of the most likely causes of fire are:

- Incorrect use of electrical equipment
- Faults in electrical equipment
- Use of open fires, candles etc.
- Faults in the construction of chimneys and fireplaces
- Arson
- Lightning

It is obviously best if a fire can be prevented. Even if a fire is extinguished, it will always cause damage to a building. Fire preventive measures can be divided into administrative and technical measures.

Fire preventive administrative measures

Priority should always be given to administrative measures as they are the most cost-effective and cause little damage to the building. Most fires can be avoided through administrative measures. Some examples of these measures are presented below.

Electrical equipment

Electrical installations are a cause of fire in about 25% of cases. Therefore, all installations should be checked regularly and all faulty pieces must be replaced immediately. Electrical installations can be checked using an infrared camera to reveal points that create extra heat. If a building is not used constantly, the electricity should be turned off if possible. Moreover, all electrical equipment must be disconnected when not in use.

In Jönköping (Sweden), a loose connection inside a multiple outlet caused the fire in a wooden town block. A loose connection can develop heat up to 25% of the connected power so in case of high effect units (like heating fans); it is advisable to connect them directly to the fixed electrical system. Other examples in which a fire had started from electrical installations are Åminneborg (Finland) (short-circuit caused by condensation), Katarina Church (Sweden) (most probably an electric fault in the cable of the great hoist chandelier) and Ringnes farm (Norway) (the fire started from electrical cable near the central unit).

Open fires

An open fire is always a risk and in some churches, candleholders have caused fires. Therefore, it is good to have something on the floor to prevent a fire if a candle falls over. The protecting cover must

An open or smouldering fire is always a risk. So smoking should be forbidden near historic buildings.

be non-combustible and it should have raised edges to prevent the candles from rolling away from the cover. Even the security around bench-placed, handheld and freestanding candles should be considered.

In Norsk folkemuseum (Oslo), there are some buildings where an open fire is used. In those buildings, a dense net is installed in the chimney to prevent sparks from spreading and setting fire to the roofs.

Prohibiting smoking in and near historic buildings should always be considered.

The surroundings of buildings should be kept clean and such things as old leaves must be taken away as they easily catch fire when they are dry.

Instructions to contractors and others working in the building

Many fires occur when there is building work going on. Contractors and other people who carry out work on a site should therefore be given proper instructions on fire safety and sign a contract clearly making them responsible. Hot work should not normally take place in heritage buildings. However if such work has to be done all workers should attend a special course.

Safe storage of rubbish etc.

No combustible material should be stored in (or near) a building if this can be avoided. An attic is not usually good storage space. Sometimes it is necessary to store some building fragments in the attic but in that case, tidiness is very important.

The removal of rubbish is also a measure to prevent arson. Preventing arson can be difficult but at least it is possible to make it more difficult for the arsonist to set a fire. All combustible material should therefore be removed from the proximity of a building. No litter boxes should be near the building. The spaces for rubbish bins should be locked if they are located in the vicinity of a historic building.

Spread of fire

Fire doors should always be closed to limit a fire to only one compartment. If they happen to be open in the event of a fire, there is a serious risk for fire spreading to adjoining compartments.

Fire preventive building measures

It is important to be aware of the risk of fire spreading from buildings or activities nearby. Sometimes it is necessary to build fire barriers to prevent fire from spreading. In towns, fires can spread quickly in attics because of the lack of fire barriers. The insulation of walls between attics can be an effective measure in preventing town fires.

Fire preventive technical measures

Construction of fire barriers, new fire doors etc. can often create too much damage to a building. It is often better to consider technical equipment as this can be installed without a need for great changes to the building – for instance, alarm systems or sprinklers.

Burglar protection

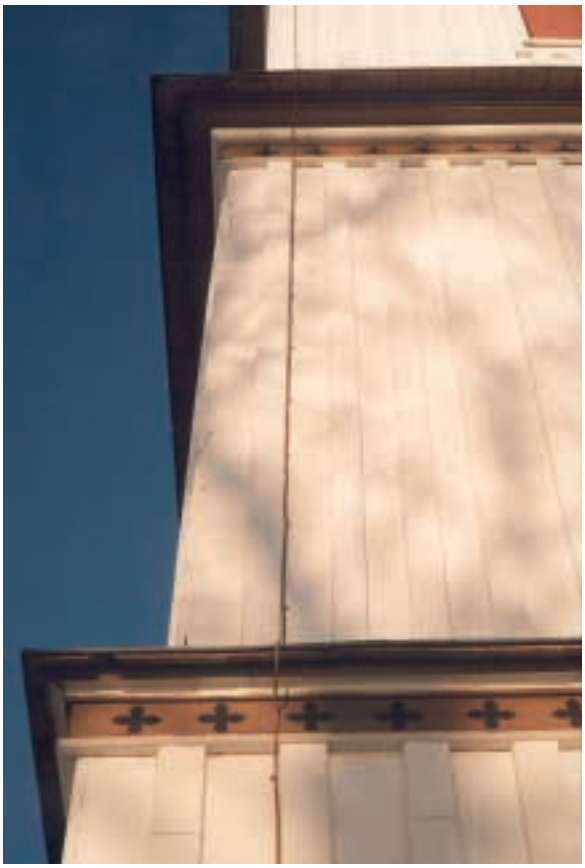
Burglar protection (locks, detectors, guarding) is equally important against the arsonists. Lamps that light up using a movement detector can prevent an arsonist. Permanent night illumination can be the wrong solution because it might give an arsonist "a working light" and it can draw undesired attention to a (remote) building.

Burglar alarms

Many fires by arsonists can be avoided if there is a burglar alarm system. Infrared detectors sensing movement are commonly used. Infrared detectors with two different detection systems reduce the number of false alarms. Detectors mounted in doorframes can be another alternative if physical intrusion of the installation is acceptable. The detector is activated only when the door is opened and it is therefore only acceptable if a break-in through the windows is unlikely.

Lightning protection

Lightning is a major cause of church-fires. What seems to be a fire caused by an electric fault can in reality be caused by lightning. It is therefore important that all electric installations are given the necessary lightning protection. Buildings in positions where lightning strokes are likely, churches for instance should also have an external lightning protection system. The Riksantikvaren has developed methods for fixing external lightning conductors in harmony with old buildings. In Norway, lightning conductors can be installed straight to a surface and they do not have to be fixed with very visible fasteners.



A lightning conductor installation in Norway.

According to instructions on electrical installations in Finland, how conductors should be installed depends on the surface material. The normal distance is 50 mm but if the surface is of combustible material, conductors should be installed with a 400 mm gap. If the material is incombustible, conductors can be installed straight onto the surface.

Video surveillance

The threat of arson is usually the main reason for installing video surveillance systems to prevent a fire. Unfortunately, there have been many problems with false alarms from the video cameras at Norwegian stave churches. This is due mainly to insufficient flood lighting during the night and the incorrect positioning of lights in relation to cameras.

The only visible part in air sampling systems is the tiny end of a plastic pipe – if it is possible to hide the main pipes in such places as the attic above.

Fire limiting measures

Even if most fires can be avoided, there will always be a risk. This remaining risk has to be met by fire preventive or fire limiting measures. These measures can be administrative, such as routines for handling a fire, or technical, such as alarms or sprinklers.

Technical fire limiting measures

Technical fire limiting measures are based on the following principles:

1. Manual fire fighting
2. Automatic fire-extinction, such as sprinklers

Effective manual *fire fighting depends on:*

- Fire detection
- Fire fighting equipment, such as fire extinguishers or fire hoses
- People to carry out the fire fighting, either the fire brigade or local personnel. If the distance to the fire brigade is more than 10 minutes, it is necessary to rely on local personnel.

Internal fire detection

There are many types of automatic fire detection systems. Most of these are designed for the heated spaces. There are special challenges in unheated heritage buildings.

Ceiling-mounted detectors are the most common fire detectors. There are now sufficiently reliable detectors on the market. Optical detectors are better than ionic detectors (optical detectors effectively detect fires without smoke early). Wireless detectors are being used in Danish and Swedish royal palaces. Wireless detectors eliminate the need for visually obtrusive cables.

Air sampling systems have proved to be very reliable in stave churches and other churches in Norway. These systems are also extensively used in farm buildings (with similar difficult climatic conditions). In Sweden, air-sampling systems are even used in palaces and museums.

External fire detection

Air sampling is an alternative for external fire detection in wooden towns. Metal threads melting at a certain temperature and metal tubes reacting

Fire hose boxes should be designed to match the surroundings.

to change in temperature are other alternatives. These systems can also be used inside a building.

Infrared cameras for external fire detection have been tested at Røros in Norway.

Manual fire fighting, fire hoses

Fire hoses are more effective for fire fighting than fire extinguishers. A benefit with fire hoses is the continuous supply of water. A fire extinguisher has a limited working time. Moreover, hoses are often easier to use. Fire hoses should therefore be installed for full internal coverage of the building. These are mainly for use during the first minutes of a fire.

Special frost-proof outdoor fire hoses are designed and manufactured for use at stave churches and other churches. Similar hoses are also used in museums and wooden towns. The hoses are 50 meters long and similar to the ones used by fire brigades. They can also suppress larger fires. Neighbours and others must be trained to use these fire hoses.

When using hoses made of cloth, the pressure of water can cause a "strike". This can be reduced by using plastic hoses with a smaller diameter.

Manual fire fighting, mini fire stations

These are standard containers with a water reservoir of 6 or 10 cubic meters and a fifty-meter fire hose. They were used at stave churches in Norway until a sufficient water supply was provided. They have now been moved to museums and churches as a temporary measure.

Plastic fire hoses are easier to use than the ones made of cloth because it is not necessary to pull it out full length.

A mini fire station in Norway.

Water supply

Traditional sprinkler systems require a proper water supply. A good water supply is also necessary for manual fire fighting. The fire brigade normally carries a limited amount of water in their vehicles. To provide a reliable water supply is a problem in many locations, particularly in rural areas. If there is no public water supply, water can be supplied by:

- A reservoir with pumps
- A reservoir under pressure
- Pumps from a local lake or river

Automatic fire extinction, sprinkler systems

Traditional sprinkler systems have been used for more than one hundred years. In buildings without frost problems, wet sprinklers are recommended because they are simple, with few components, and very reliable. In unheated buildings, there has to be a dry, air-filled sprinkler system. This is more complicated as it needs a compressor to maintain air pressure in the pipes. A dry system is in most cases better than a wet system with anti-freeze. If the anti-freeze is not properly diluted, ice problems might occur in "pockets". The anti-freeze substance may also damage valuable surfaces.

Interior sprinkler systems are released by individual heads activated by temperature. When a sprinkler head in a dry system is released, the pipes (normally filled with air) are filled with water. On the outside of buildings (roofs and facades), it is normal for several sprinklers to be released by a separate release system (deluge sprinklers).

The problem with sprinkler heads is that they are sensitive and should be handled correctly at a building site in order to prevent false releases.

Loft sprinklers

It is often very difficult and hazardous for the fire brigade to gain access to lofts during a fire. In these areas of a building, a fire easily gets out of control. Priority should be given to installing fire suppression systems in lofts and towers. If there is a short distance to the fire brigade, a dry system supplied with water from the fire brigade can be an alternative.

Copper sprinkler pipes match well with aged wood.

Automatic fire extinction, water mist

The main problem with traditional sprinklers is the amount of water released. Even if a false release is very unlikely in certain buildings, such a release is unacceptable. This is particularly a problem in buildings with vulnerable interior surfaces (such as water-soluble paint) or items. In some cases, water may also cause serious damage to ceiling constructions. Water mist was intro-

If possible, it is good to use secondary spaces to install technical equipment.

duced into the stave churches because their interiors were coated with water-soluble paint. Both low impulse and high impulse water mist installations are used in stave churches. As water mist uses little water, it is an alternative in buildings with a limited water supply. There have however been more false releases of water mist systems than with traditional sprinklers in stave churches. This is due mainly to the release systems for the water mist.

The Riksantikvaren wanted a mechanical system that was independent of electricity for the release because:

1. Electric installations cause a danger of fire.
2. If there is a failure of the power supply, the sprinkler will not be released.

For these reasons, a release system with plastic tubes was developed for the stave churches. When there is a fire, the tube melts and the loss of pressure causes a release of water mist (or sprinklers). The problems with this system include:

- Leakage because the tubes have been mounted too tightly and could not move according to temperature fluctuation
- Condensation and ice in the plastic tubes causing leakage
- The tubes have been cut by animals

Many water mist installations are equipped with double plastic tubes to reduce the risk of false releases. In some churches, there are two separate systems to release the water mist, for instance plastic tubes + air sampling.

There should be more tests and research with water mist on how it affects wall paintings if used longer than 10 minutes, how it really works in high spaces etc.

Many indoor paints such as sensitive glue-based paint do not stand the amount of water that traditional sprinkler systems need, so a water mist system is more suitable for this kind of interior. (Pyhämaa Church)

A fire detector for the release of automatic fire suppression systems, for instance a water-mist that consists of two thin plastic tubes. It is discrete and functions without electricity, but there have been some problems with it, such as incidents where the tubes have been cut by animals.

Technology needs both space and human beings.

Inert extinguishing gases

These can be used in buildings with sensitive interior surfaces or items. The gases consist mostly of nitrogen. Gas systems are not normally an option in cultural heritage buildings because to function properly, they need an air-tight building and no windows.

The aesthetics of exit signs etc

The design of the exit signs and fire hoses should be such that they do not ruin the visual impression and understanding of historic buildings and sites. Ideally, they should be effective when needed but invisible at other times. In Sweden and Norway, the exit signs in sensitive interiors have been exchanged with "invisible" spotlights that turn on automatically when the alarm goes on to show escape doors and routes. Sometimes movable exit signs are used if there is no continuous need for them. Fire hoses can be hidden behind doors or their boxes can be designed to match the location.

Acceptable remaining risks

Even if comprehensive fire preventive and fire limiting measures are carried out, a certain risk of fires occurring still has to be accepted. This acceptable remaining risk must of course be as little as possible, particularly if the building is of high cultural value.

Two important aspects must be remembered when making technical installations:

1. They always need space for central units, water "tanks" etc., and this space might become surprisingly large sometimes.
2. In addition, there must always be a person or people who are responsible for technical equipment and their regular maintenance.

6. After a fire

Documentation (before the fire) examples

When a historic building is totally lost by fire, the importance of good documentation cannot be over stressed. This documentation should include plans, elevations and sections and information on the structures, materials and techniques used in the building.

In Sweden, two interesting project were presented concerning documentation as a part of fire safety measures. They were documentation of the Drottningholm Palace and the combination of cultural heritage values in the fire safety in estates of Statens Fastighetsverk (the National Property Board).

Documentation of Drottningholm Palace

The Drottningholm Palace with its garden, Chinese Pavilion and theatre was named as UNESCO World Heritage Site in 1991 and it is regarded as one of the most important sites in Sweden. That is why it was decided that the palace is documented thoroughly so that in event of damage, the current appearance can be recreated. It is interesting that in this case it was decided *in advance* that the building or parts of it would be rebuilt if they were damaged.

The work covers 387 rooms and 9336 square meters and the task was given to two architect offices, Ove Hidemark and AIX. The work started

A photographic documentation drawing showing two interior walls in Drottningholm. (By Architect office AIX)

in 2000 and it will end in 2004. The final cost for the project will be about 9 000 000 SEK.

All spaces are documented with similar accuracy. The aim is to document the "surface forms" but not what is behind the surface. No colour research is made, but the ordinary inventories of each room include records of the materials in them.

The work started by making detailed line drawings of some rooms, then taking ortho-photos (these are scale photos and do not contain any distortions) and high quality digital photos that show the 3-dimensions of the surfaces. The spaces were then measured using laser scanning to produce a "cloud of points" that are then processed into a 3D model of the space. In "simple" spaces, some 300 points were measured.

There were problems in laser scanning. Most of the new measuring techniques are created for industrial use and they do not work well in such polymorphic spaces made of so many different materials as at Drottningholm Palace.

Finally, it was decided that the best way was to use stereo- and ortho-photography combined with digital photos. The structures in the attic were measured by hand and the joints and other details were photographed. All the drawings were made with auto-cad on a scale of 1:1.

The result will be printed drawings that are saved in digital form. In addition, the stereo and digital photos will be saved. This documentation covers all the surfaces of the spaces but not the structures or materials behind the surfaces.

The project has not been continuous but it has been carried out in intensive periods. This has made it possible to develop the systems continuously, as after one period there is time to evaluate what could have been done in a different way and to find new methods to work with.

Cultural value and "replaceability"

The Statens Fastighetsverk has created a new system to combine historic value and fire safety. The first project was carried out on an old palace building in Stockholm that is now used as an office.

First, they estimated the historic values of the building space by space and made coloured plans to show the result. They had set four different levels of value, from low to very high, and they used colours to indicate these values in the plans. Then a three-level estimate was made of the "replaceability" of the spaces a:
1) if damaged by fire, possible to replace,
2) possible to replace partly,
3) impossible to replace.
This replaceability was estimated
on the assumption of two aspects:
1) The fire does not damage the building totally, but occurs only in a restricted area;
2) The building is well documented.
The results of this evaluation were marked on the plans using colours.

These two estimates (historic value and replaceability) were based on the research and evaluation on the building and on the maintenance programme. Coloured drawings have to be made so that they are readable even by colour-blind people.

After these evaluations were carried out, they were combined with the fire safety analysis to find the most suitable solutions to improve the fire safety of each space. The cost for evaluation and the proposals for what should be done came to about 300 000 SEK for 12500 m^2.

Actions after a fire, examples

Protection of ruins or remains after a fire

After the fire at the Tyrvää Church in Finland, the stonewalls remained but almost all wooden parts had burned down. Work in the site started by protecting the ruins temporarily with tarpaulin because it was autumn and there was a danger of rain. If the warm walls made of stone and bricks had become wet and then frozen, it would have caused severe damage.

Soon, the congregation decided to build temporary scaffolding to protect the remaining walls. It was made of corrugated steel plates provided by the Rautaruukki factory. The door and window openings were sealed with planks.

Immediately after the fire at Södra Råda Church in Sweden, the police closed off the area around the church and Hemvärnet (the Voluntary Defence Organisation) protected the area 24 hours a day for the first 5 days after the fire.

Protective construction was built to cover the remains of Södra Råda.

Thereafter, a fence and a powerful lighting were put up around the building. Some weeks later a construction was built over the former church to cover and protect the fire remains so they could later be investigated.

Investigation of ruins and remains

At Tyrvää Church, a survey of the remaining stonewalls was carried out very soon after the fire. The work was done by the Museovirasto with the help of a crafts school. The remains were investigated when cleaning the ruins, and all useful material was collected. All wooden parts with profiles, marks or some traces were stored. All nails made of wrought iron were collected.

The investigation of the burned material was organised so that all larger remains were checked in the place where they were found. They were measured and possible carvings and remaining details were checked and documented.

Smaller pieces were found when all the charred material was sifted before it was thrown into the skip. The Museovirasto staff organised this work but before this part of the half-burned material was already taken away, so some information was lost.

All charred material was sifted at the Tyrvää Church site after the fire.

In Södra Råda, it was not possible to save any interior objects during the fire. Chandeliers, locks and other metal objects, as well as the baptismal font were all taken care of immediately after the fire was extinguished. Like everything else in the building, these objects were badly damaged by the fire. The remaining pieces of timber were numbered and stored. Experts on timbering techniques carried out an antiquarian documentation.

Archaeological excavations were carried out at the site when it was cleared of the charred material.

Documentation of ruins and remains

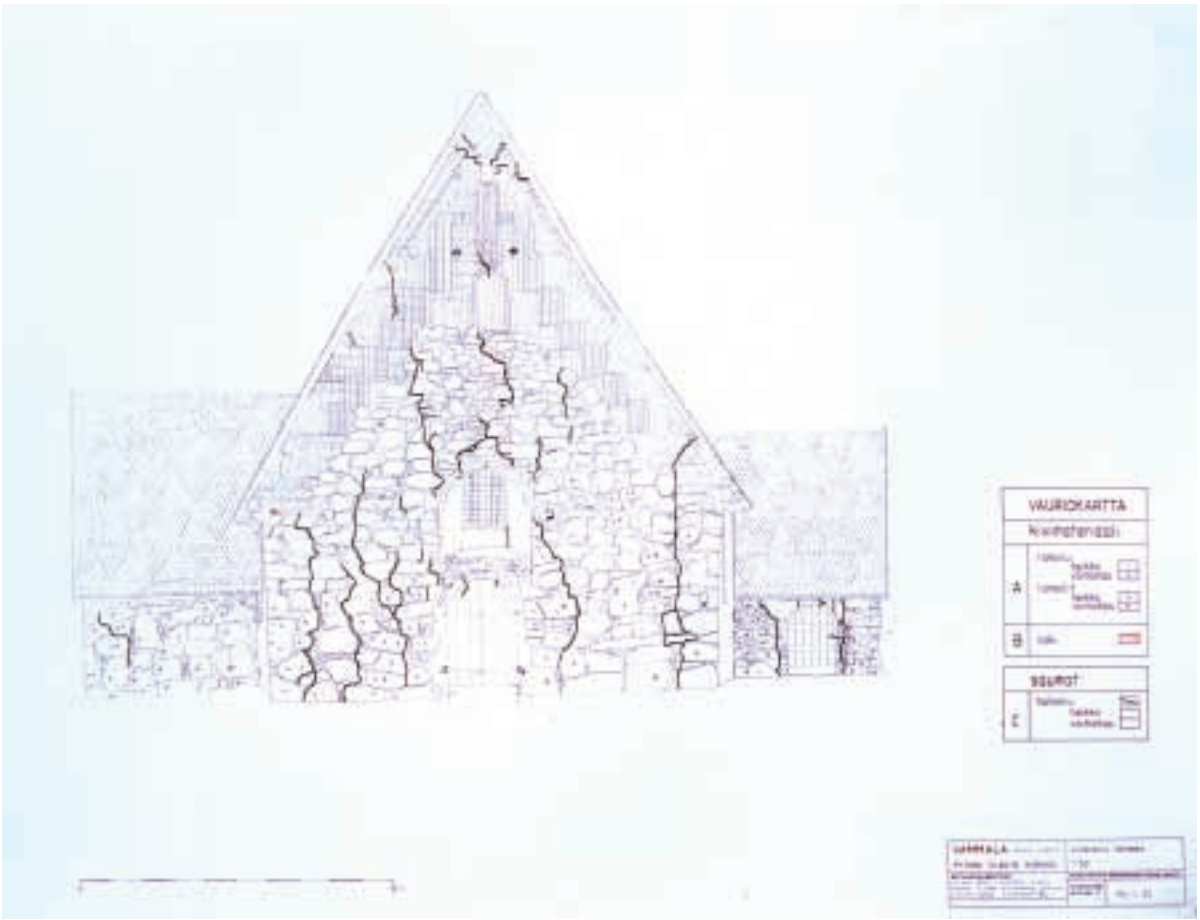
At Tyrvää Church, all the damage in the stonewalls was marked on existing drawings. In addition, the details and traces found in the remains were documented at least by making sketches and taking photos. A so-called *post documentation* of the church was made according to the photos. These drawings contained all the information found in the photos but still some information and especially the joining and other invisible details were missing.

Archive research

There were many documentation drawings (mostly from 1990s) of the Tyrvää Church in the Museovirasto archives: plans, elevations and sections, altarpiece, pews, pulpit and balcony. In the 1960s, the windows were made according to the plans made in the Museovirasto so there were many drawings of that time. In addition, the roof was well documented when the shingle roof was repaired in 1996-97.

There were documents in the archives of the local parish showing the order of the benches in 1665. Also, many photos (partly from private individuals) showed the interior and exterior of the church. However, a thorough documentation of the paintings and interior details did not exist.

In the case of Södra Råda, an inventory was made of written sources and drawings concerning the old church and the results were put together. It showed that this unique church was relatively well documented, although there were some gaps. For example, no documentation of some of the paintings in the aisle was found.



All cracks in the stonewalls were marked on the existing drawings of Tyrvää church.

Tyrvää was a dominant in landscape.

Analysis before the decision to "rebuild or not"

Before any decision is made, the situation and the existing documents and knowledge on the burned building should be thoroughly analysed. If rebuilding is chosen, there might be a need for research or experimentation before applying certain constructions, materials or techniques. Rebuilding can be seen as a possibility to learn about old techniques and materials, but this kind of work needs more time than normal.

It was interesting that both the Katarina and Tyrvää Churches were dominant in the landscape and their silhouettes were so important that this point of view was used as justification for rebuilding.

Another justification for the Katarina Church was that it was very actively used. In the Tyrvää case, the church was not used so much before the fire but it became very popular after (and during) its rebuilding.

Things that should be analysed before a decision is made:

- the meaning of the building for the surrounding area or landscape
- the value of using the building (is it still needed)
- existing knowledge on the building (level of documentation)
- the possibilities of rebuilding (economics, skills, techniques, materials)
- the effects of rebuilding (mental, economic, educational, research)
- the style of rebuilding (copy, interpretation, new design, mixture)
- the effects of not rebuilding

Insurance and reconstruction

Insuring heritage buildings is always a crucial but often a difficult matter. It should be born in mind that it might cost much more to restore a partially damaged building or piece of art than it is to rebuild or reconstruct it.

After a fire disaster, there should be immediate contact and cooperation with the insurance company. Much can be damaged and many traces can be lost the first hours of "clearing up" after a fire. This might be very costly in terms of both lost heritage and money if not treated in the right way.

Proposal for "First Aid actions"

When talking about first aid, the first questions concern the implementation of actions and organisation of them. The first heritage authority to be contacted should be the local one. Then, this person can ask the national heritage authorities for help. They should have a few people that know how to act in a case of a fire. These national authorities can develop their systems for actions after a fire, if they are always the organisation that organises the work on the site.

The following instructions are for a very valuable heritage building and they should be applied on a suitable scale case by case.

Protection of ruins and remains

No matter if a fire has destroyed a building totally or partially, the remains must be protected so that no extra damage is done. It is necessary to cover the ruins so that, for example in case of rain, they do not get wet and in the case of a heavy wind, nothing is lost. There might be archaeological material under ground that must be protected, so the use of heavy machinery or trucks when tidying up the site must always be considered carefully.

Outsiders must be kept away from the ruins and remains so that they do not mess the site or steal anything. Not a single item should be removed from the site before it is investigated. If

The starting point for investigations after a fire can be like this (Innset church, Norway).

the temperature happens to be below zero, it might be necessary to heat the remains under a tarpaulin to prevent them from freezing. However, in the case of heating, it must be remembered that a combination of high humidity and heat might also cause the rapid growth of fungi in structures. Therefore, heating must always be considered carefully and carried out in a controlled way. Sometimes, dehumidifiers can be used to reduce the humidity in the air.

1. There should be a guard on the site to prevent outsiders from entering.
2. The ruins or remains should be sheltered and covered so that frost, rain, wind, or anything else does not cause extra damage.
3. A first aid cover can be tarpaulin, canvas or something else that is quick and easy to install but does not harm the ruins (it must be installed carefully and preferably by conservation experts).
4. Later, a more construction like covering can be made and this can be used as space for researchers to investigate the ruins (like in Södra Råda).
5. Supporting structures should be made if structures in danger of collapse.
6. If some structures have to be taken down, it must be done in a controlled way.
7. Heating and drying wet structures. (A temperature few degrees above zero does not harm fungi-sensitive materials, even if they are wet. Fungi and mould only grow at certain temperatures and humidity, seldom around zero.)

The remains in Tyrvää were investigated carefully.

Investigation of ruins and remains

Much information can be found from charred remains. Sometimes a fire exposes layers and structures not previously visible. That is why remains must be investigated properly.

1. As soon as a fire is suppressed, no people other than investigators (police and conservation experts) are allowed to enter the ruins and remains.
2. Good and open cooperation and the exchange of information between police and heritage authorities should be established at the site.
2. Investigators (other than police) should be conservation experts.
3. Large remains can be checked and documented in situ, smaller remains can be taken to conservation laboratories.
4. Charred material should be sifted to find even the smallest parts carrying some information.
5. All parts that carry some information about a building should be stored in a safe place.
6. Very detailed information can be gained using microscope analyses.

Documentation of ruins and remains

Sometimes a fire is an opportunity to study layers and structures that are not usually visible. This research must also be well documented.

1. During the investigation of ruins and remains, the site must be documented properly. The remains should not be messed up before they are documented.
2. The site and details must be documented with systematic photography.
3. If proper drawings showing the building before the fire exist, they can be used as a basis for documentation.
4. If there are no drawings, the ruins should be documented as they are and in the case of partial destruction, proper drawings of the building should be made and the notes made during the investigation should be marked on them.
5. Important observations should be marked on (existing) drawings of the building (such as the places where the remains were found, constructions and layers that the fire exposed).
6. It is good to make sketches of the details and constructions etc. found.
7. Documentation of found materials and their properties (wood, plaster, paint etc) should be made.

Investigation of archives

When information about a fire reaches the heritage authorities, they should check to see what is in the archives about the building. Sometimes a piece of information can be found that tells us what to search for at the site of a fire. This can be something like if a valuable object stored in the building, whether some special building parts might have survived, if there are some structures that have not been studied but that might now be visible etc. A check should also be made to see if the site is archaeologically interesting and if excavations are needed.

1. Check the archives of the heritage authorities.
2. Check the literature.
3. Check the local archives.
4. Check other possible archives that might posses some information about the burned building.
5. Collect the information together to help the investigation on the site and future actions.

Report

It is advisable to make a report that includes the investigation and documentation of the site as well as the results of archive research. This report can assist decision-making when the question of repair, rebuilding or conserving the ruins is discussed.

The report will also serve as a final documentation of the lost building (or a part of the building).

An essay:
"Conservation, rebuilding or what?"

How to approach the question

If a building is partially or totally destroyed by fire, there is always a question of how to deal with the loss. Each loss, whether it was total or partial is unique. It may be advisable not to make premature decisions after an accident because feelings are still strong and they guide too much the decision-making. After the first shock is over, it is easier to analyse what was important or valuable in the building that is lost. Then, it might also be easier to consider the different solutions and their possibilities.

One way to approach the question is to analyse the values of the lost building. If the value was age (or authenticity), it is something that cannot be reconstructed. If the value is in its use, the building should be rebuilt but in this case, a contemporary design might be a good solution. If the value of the building was in its art, it might be possible to reconstruct it after a thorough investigation and analysis. These were just examples of values that might be related to buildings.

Tyrvää Church lost interior.

There are usually three main alternatives to built a lost heritage building:

1. Rebuilding

Often, the immediate reaction is that everything must be reconstructed. In practice, this often appears to be very difficult as there is not enough knowledge or proper documentation about the lost building. Even if it was possible to rebuild a lost building with total accuracy in every detail, it would always be a new building. The patina and the age value are lost forever.

On the other hand, rebuilding can be seen as an opportunity to study old materials, their production and construction techniques. During a rebuilding process, it is possible to train craftsmen in conservation and to study the process, materials, techniques and constructions.

2. Nearly rebuilding

If the idea of a total rebuilding is rejected, the next idea is very likely to build something reminiscent of the lost building – but more simple, more practical or made with contemporary techniques. This solution is often chosen. In this case, there are very often high hopes but the "end product" can be a disappointment as it does not sufficiently resemble the lost building but it is not really a new one either.

3. Contemporary design

The most demanding way to act is to build something totally new with a contemporary design. This option requires courage from the client and designer. If the result turns out successfully, it can be seen as a new beginning. On the other hand, if the new design is not good it might increase the feeling of loss.

Södra Råda before fire.

Attitudes in different countries towards rebuilding after a fire

Finland

In the 1970s and 1980s, rebuilding was regarded in Finland as a falsification of history. Lost is lost, it is gone and you cannot get it back. This thinking was based on quite strict adoption of the Venice Charter of 1964 (International Charter for the Conservation and Restoration of Monuments and Sites). According to Finnish way of thinking, authenticity is authenticity of materials, not only that of shape or design.

Lately, the attitude has become more tolerant and rebuilding can at least be seen as a learning process. In addition, the concept of rebuilding atmosphere has been discussed quite much lately.

The separation between total or partial rebuilding had already been made earlier. It is easy to accept rebuilding when only a part of the building is lost in a fire. Then, it is possible to think of it as a kind of recovery or a repair. The Venice Charter says that the reconstructed part must be distinguishable; you have to be able to recognise the original from later additions. The reconstructed part has usually traits of the original but its details are simpler, thus indicating the difference between the authentic and reconstructed parts. The aim is that the overall impression is harmonious, even if some details are missing.

Norway

The policy of the Riksantikvaren is to distinguish between cases where buildings have been lost completely or just partially. When a building is completely lost, rebuilding it is of no interest. The historic value lies in the authentic material. A partially lost building is a different case. To save the authenticity of the remaining parts, it is often of vital importance to reconstruct the lost parts. This could be for structural reasons, the understanding of the monument, or simply the presentation of the monument itself. Rebuilding would normally be undertaken using traditional materials and techniques.

Economically, from the insurance point of view, a partial fire is more costly than complete destruction. Partial destruction leaves a lot of traces and authentic material that will be used as a basis for rebuilding. There is also an attempt to conserve, repair and reuse as much as possible of the damaged parts – to avoid loss of authenticity.

There have been a number of fires in Norwegian churches where this policy has been applied over the past ten to fifteen years.

Sweden

On the national level, there has been no clear policy or established practise on how to handle the issue of protected buildings lost in fire. As in many other countries, the Venice Charter had an impact on the restoration policy in Sweden, especially during the late 1970s and 1980–1990. One important example of the Venice Charter is the great caution in dealing with rebuilding.

During previous decades, the practice has been to regard every new piece of damage to cultural heritage as a unique situation, with many aspects and conditions interacting. For churches lost in fire, the wish of the congregation on how to handle the loss is of utmost importance. However, the County Administrative Board has to approve the proposal from the congregation in accordance with to the Heritage Conservation Act.

Decisions concerning other protected buildings are made in dialogue between the owner of the property and the antiquarian authorities so as to ascertain a decision that is both historically credible and democratically acceptable.

During previous decades, one common solution to handle the loss of a protected building was to reconstruct its exterior using traditional materials and techniques. A more pragmatic attitude has generally been practised for the interior. The result of this has sometimes been a new layout.

Since a reconstructed building has to fulfil the regulations for a new building (according to the Planning and Building Act) this can also affect the outcome.

The attitudes mentioned above may differ to some extent from attitudes in other parts of Europe, since Sweden was not directly involved in World War 2. It seems that Sweden also focuses more on workmanship in details, such as handhewn logs, than elsewhere. This may also have something to do with the fact that Sweden was spared the devastating effects of the war.

Churches lost in fire as examples

Traditionally in the Scandinavian societies, the church has been the centre of the local community. Everybody belonged to the church and the church was not only the place where the service was held but it was also the place where the State was very much present – the place where new laws were proclaimed, news was exchanged, and people met and made business. Inside the church, everybody had his place according to rank. Even in our modern times, the majority belong to the church and most people are buried in cemeteries surrounding the churches. This makes the church building a central part of people's lives, even if the majority does not attend services regularly.

The church is also often the oldest building in the community and the building where we find the most interesting architecture – the result of craftsmen's skills, the artists' works and so on. These facts have also made church buildings the objects with the longest history in restoration and conservation. Much of the ideology of conservation and restoration has been developed in work going on in churches. Maybe they can also lead the way when discussing the question of rebuilding after a fire.

During the last century, approximately one church per year was lost in fire in Sweden. In a study in 2003, the Riksantikvarieämbetet selected

sixteen churches that had been lost in fire during the past few decades to find out how the discussions went after the fire, what the arguments were and in what they resulted.

Reactions after a fire

According to the Swedish study, the immediate reaction among people was to get the church back in the same shape as it was before the fire. This often seemed to be the only possible alternative just after the fire. When time passed, however, a more varied discussion on how to handle the damaged building usually took place.

The people working within a church or in the congregation were most often the ones who preferred changes and had no difficulties in seeing alternative solutions to restoring the church after a fire. The church building itself is often given a functional (use) value and usually a complete rebuilding is considered too costly and not resulting in the expected outcome. "What is lost can not be restored".

The people not actively involved in the church were often more negative to changes and they usually argued for a complete rebuilding of the church. The importance of the church as a landmark was argued, as was its importance for historic continuity and local identity. "We miss our church, its silhouette and the ringing bells. An important part of our cultural heritage has been damaged". It was argued that extensive changes or a new design would damage culturally historic values. Often this reflected a wish to regain what once existed, and culturally historic values are used as arguments.

There is something special about old churches, something that people long for and love. Our academic discussions should take this side of things into consideration in order to find what touches the hearts of people, even if it does not follow accepted rules and practises.

Examples

Tyrvää (Finland)

In this case, the idea was to restore the lost atmosphere and not the lost interior. In fact, the rebuilding of the interior of Tyrvää Church followed the Venice Charter by showing in some details of the wooden structures that it is not the original. It was not meant to be a copy of the burned interior, even if does look very much like it in reality.

In this particular case, it could have been possible to accept the copy because everything was burned down and thus it would have been impossible to mix the original and the rebuilding.

The boarding in the panels for paintings was made horizontal while in the old Tyrvää Church it was vertical.

Karjalohja "new" Church from 1977.

Karjalohja Church when rebuilt.

Karjalohja (Finland)

The church in Karjalohja was left as a ruin because the Museovirasto demanded so. Only the brick walls remained in 1970. They were strengthened with concrete to withstand the cold and humid Nordic climate. A box of glass and steel was built next to the church in 1977. In its leaflet, the congregation says that the new glass church has caused anxiety in people because of its modern and severe architecture. There is a story about a small boy who said to his mother "what a congregation, they even have a swimming hall here ".

Because the members of congregation missed their old church, the decision was made to rebuild it, but not to follow what it was like before the fire. This was due to the economic reasons; everything had to be low cost. The first step in 1995 was to lift the look-like prefabricated top of the tower onto the church. The next phase was a new roof in 1997, but without the wooden ceiling vault. Step by step, the church was rebuilt. Finally, old benches from the Church of Kouvola were added. They had been lying in storage for many years and they were given as a donation. The local people are now very happy about their "real church", which is used only in the summer because it is unheated. A heating system will be installed in 2004, if the congregation has money to do it.

Otaniemi Chapel (Finland)

Otaniemi Chapel is one of the most impressive examples of Finnish contemporary architecture. It was built in 1957 and designed by the architects Heikki and Kaija Sirén. It was struck by lightning and totally burned down in the 1970s. It was reconstructed in 1978 immediately after the fire without any discussion about the other options. Of course, all the drawings were at hand and the architects were able to direct the rebuilding.

Veldre before the fire.

Veldre reconstructed.

Norwegian examples

There are several cases of rebuilding lost churches. The most famous examples are probably the Holmenkollen Chapel in Oslo and the Fantoft stave church in Bergen. In these cases, the original design was far more important than the originality of methods and materials. In the case of the Innset Church, the general exterior impression is that the old church has returned, but a closer look shows that the new architecture as well as modern liturgy and regulations have changed the church and converted it into a modern church with a lot of references to the old. This applies even more to the Veldre Church where the church is a completely new and modern design with a number of references to history such as the top of the tower, the old door ring, a copy of the old Madonna in medieval colours and the altarpiece made of reused stones from the foundations of the old church.

Fantoft just after the fire.

Fantoft reconstructed.

The new church in Trönö was built inside the remains of the old church.

The modern and the old meet.

Trönö (Sweden)

Trönö Church, built of bricks in 1893–1895, burnt in 1998. It stands out from other churches in that a new church was built inside the ruin of the old one. A smaller church was built in the chancel and front part of the aisle. The new church is of a modern design. The remaining part of the aisle is now used as an open yard. The spire of the tower walls has been replaced by a construction made of glass.

After the fire, the parish discussed whether to rebuild the old church or to tear down the walls and build a completely new church. The true wish of the parish was to rebuild the old church as it was before the fire. Since the funding was insufficient for rebuilding the church and since the parish did not want to tear down the walls, this somewhat uncommon solution was chosen.

Which solutions were chosen?

A study of the 16 churches in Sweden showed that five different solutions were mostly discussed.

Initially a complete rebuilding, including both the exterior and the interior of the church was discussed and this solution was chosen in two cases. If this solution was rejected, a rebuilding of the exterior with a new interior designed for today's liturgical requirements was discussed. This was done in nine cases.

Two parishes made the choice to build a new church of contemporary design on the same site. Building a new church of contemporary design on a new site was also discussed, but not chosen, by any parish. Finally, the alternative not to rebuild the church at all was discussed. This latter decision was taken in two cases because those churches were no longer in use.

Summary

In English

Background

The project consisted of three seminars during 2003 and the participants were from the heritage boards of Finland, Norway and Sweden.

There are some common aspects in the fire protection of historic buildings in all these countries:

- A large proportion of historic buildings in Nordic countries are made of wood.
- There are historic wooden towns that are densely packed and where the threat of fire is serious risk.
- Some historic buildings are located in remote places.
- The climate in all three countries is cold in the winter and warm in the summer, so there is a danger of fire during long dry seasons and on the other hand, temperatures below zero can cause problems for fire protection and fire fighting in winter.

Whilst the main aim of ordinary fire protection is to safeguard the lives of human beings, the fire protection of historic buildings should also safeguard the building and its cultural heritage value. The aim of fire protection in historic buildings is to achieve *"the maximum safety with minimum damage"*.

Legislation and cooperation with other authorities

The legislation in all three countries is very similar. According to the Rescue Service Acts in each country, the owner of the (heritage property) building bears responsibility of its fire protection and the local authorities bear the responsibility for the rescue service.

The cultural heritage laws of each country contain nothing about fire protection measures. There is not anything in the acts that give instructions for building activity about the fire protection of historic buildings.

In Sweden and Norway, the heritage authorities are in close contact with the rescue services. In Sweden, the Swedish Rescue Agency and the National Heritage Board have together published a handbook "*Brandskydd i kulturbyggnader*".

The fire protection of historic wooden towns

Three projects concerning historic wooden towns were presented in the seminars: Rauma (Finland), Lillehammer (Norway) and Eksjö (Sweden).

After studying the examples during the project, it is possible to propose that following matters should be considered when starting a fire protection project in a historic wooden town:

1. What is the goal of the project (prevention of single fires or prevention of town fire)?
2. What kind of risks are there on single estates and in the town structure and how can they be minimized?
3. What are the risks for fire spreading from one estate to a neighbouring one and how can these be minimized?
   How a fire can be limited to a restricted area?
4. What can be done to detect a fire as early as possible?
5. What problems does the fire brigade face when acting in a town structure or on a single building?
6. Is there enough water to extinguish a fire?
7. How is the common training of owners and inhabitants in fire protection arranged (it is important to make them aware of the fact that a fire in a neighbour's house is a threat to their own house, too)?
8. Which measures are paid for by authorities and which are left to house owners?

Case studies

Some cases from each country were discussed during the seminars. These were the Tyrvää Church, Åminneborg manor and the Kotaselkä logging site hut in Finland; the Trondheim town fire, Innset Church, Eidsvoll Church and Ringnes farm in Norway; Södra Råda medieval church, Katarina Church and the Jönköping town fire in Sweden.

Choosing the fire prevention and protection methods

Here are some basic recommendations for choosing the fire protection method and equipment:

- Consider that each building is unique. Therefore, they require unique and creative solutions.
- Try low cost methods first, complete with installations.
- Choose fire protection methods that do not involve interference in the building.
- If interference is unavoidable, keep it to the minimum, and it must be reversible.
- New installations must be accessible for maintenance and removable without causing damage because they have a much shorter lifespan than the building itself.
- Technical installations and information signs must be discrete.
- Good solutions need cooperation between the owner, the fire inspector and the heritage inspector.

Before anything is done, a strategy should be made. What is usually needed is a combination of organisational and technical fire safety precautions. Often good organisation can minimise the need for technical adaptations. There should be a special person in each heritage building who is appointed to have the responsibility and training for fire protection. This person should also carry out regular fire safety inspection.

Technical installations

The basic idea in choosing the most suitable fire protection method is first to analyse the risks and to check the available and existing protection methods. Then, the remaining risks are listed and suitable prevention and protection methods are chosen. A certain risk of fire always remains but a decision should be made on the acceptable level of the remaining risk. The main objective is to gain "*maximum safety with minimum damage*".

A few points must be remembered when making technical installations. They always need space for central units such as water "tanks" etc. and this space might sometimes become surprisingly large. In addition, there must always be a person or people who are responsible for technical equipment and their regular maintenance.

After a fire

When a fire has occurred and been suppressed in a historic building, it is necessary to protect, investigate and document the remaining material. Sometimes a fire reveals structures or layers that were previously not visible. In these cases, a fire can be seen as a possibility to learn something new and this possibility should be used. It is surprising how much information can be gained from charred pieces of wood and how much material can survive a fire.

Actions after a fire

1. Protection of ruins and remains
2. Investigation of ruins and remains
3. Documentation of ruins and remains
4. Investigation of archives
5. Report on the investigations

Analyses before the question of "rebuild or not"

Before any decision is made, the situation and the existing documents and knowledge on the burned building should be thoroughly analysed. Then, decisions should be made on whether studies or experimentation are needed before applying certain constructions, materials or techniques.

Rebuilding can be seen as a possibility to learn about old techniques and materials.

"Steps" in the fire protection of historic building

1. Documentation and evaluation of the building

Thorough existing documentation of historic buildings is important in cases when a building is totally lost in fire. Then, at least the information that has been documented is saved. During the documentation, the value of the building and its parts should be estimated as well as the necessary fire safety improvements.

2. Fire preventive measures

The first and maybe the most important actions in improving the fire protection in historic buildings are to make a fire protection strategy and to create an organisation for it. Organisation means that the users of the building are trained to take fire protection into consideration in their daily work and to know how to act in the event of a fire. It is important that a special person be ap-

pointed to be responsible for fire protection in each building.

3. Fire detection measures

Early detection of a fire can considerably reduce damage. Therefore, detection should be effectively organised. Fire detection can be either by people present at the site or by an automatic fire detection system. There are many kinds of automatic detection systems available and a careful consideration must be given to the best type in each specific case.

4. Fire fighting equipment

To prevent damage, the first fire fighting actions are important. If it is impossible to totally suppress a fire, it is necessary to limit it. The fire fighting equipment for the first action should be easily available and easy to use.

An automatic sprinkler system in some cases can be the best solution.

5. Instructions for fire fighters and fire brigades

Historic buildings might contain some extremely valuable parts or items. The fire service should be informed of these so they can prevent the fire from spreading to those parts or the items are carried out if they are threatened. There should also be instructions for which, how and where valuable items should be evacuated in the event of a fire.

6. After a fire

Protecting remains (also archaeological) is important in order to prevent further damage. In addition, outsiders must be kept away from the remains or ruins so that they do not destroy any evidence or remaining parts.

In the event of a fire in a historic building, the remains should be thoroughly investigated and documented. Sometimes a fire can reveal structures that are not normally visible, so a fire can be a chance to see and document them.

7. Repair, rebuilding of leaving as a ruin

When a building is partly or totally destroyed by fire, it is necessary to analyse the situation before the decision of repair, rebuild or leave as a ruin is made. All aspects such as the meaning of the building in the landscape, the level of documentation, the use of the building and the resources available and necessary for the work should be taken into consideration.

Yhteenveto suomeksi

Taustaa

Hanke koostuu kolmesta vuonna 2003 järjestetystä seminaarista. Osallistujat ovat Suomen, Norjan ja Ruotsin museovirastoista.

Näissä kolmessa maassa on historiallisten rakennusten paloturvallisuuden kannalta yhteisiä piirteitä:

- Suuri osa historiallisista rakennuksista on puisia.
- Joka maassa on historiallisia, tiiviitä puukaupunkeja, joissa tulipalon vaara on suuri.
- Osa historiallisista rakennuksista sijaitsee “kaukana kaikesta”.
- Ilmasto on kaikissa maissa kylmä talvella ja lämmin kesällä. Kuiva kesäaika lisää paloriskiä ja toisaalta talven pakkaset vaikeuttavat paloturvallisuusasennuksia ja sammutustyötä.

Kun tavallisesti paloturvallisuuden päätavoite on suojella ihmisiä, on historiallisten rakennusten kohdalla tavoite suojella ja säästää myös rakennus ja siihen sisältyvät arvot. Palosuojauksen tavoite historiallisissa rakennuksissa on saavuttaa ”*maksimiturvallisuus minimivahingoilla*”.

Lainsäädäntö ja yhteistyö muiden viranomaisten kanssa

Kaikkien kolmen maan lainsäädäntö on hyvin samankaltainen. Pelastuslakien mukaan joka maassa päävastuu rakennuksen paloturvallisuuden järjestämisestä kuuluu rakennuksen omistajalle ja viranomaiset kantavat vastuun pelastustoiminnasta. Kulttuuriperintöä tai rakentamista koskevassa lainsäädännössä ei puhuta historiallisten rakennusten paloturvallisuudesta mitään.

Ruotsissa ja Norjassa kulttuuriperintöviranomaiset ovat tiiviissä yhteistyössä pelastusalan viranomaisten kanssa. Ruotsissa on sikäläinen museovirasto mm. tehnyt yhdessä Pelastusviraston kanssa käsikirjan *Paloturvallisuus kulttuurirakennuksissa* (Brandskydd i kulturbyggnader).

Historiallisten puukaupunkien paloturvallisuus

Hankkeen aikana olivat esillä kolmen puukaupungin paloturvallisuushankkeet: Vanhan Rauman, Lillehammerin (Norja) ja Eksjön (Ruotsi).

Näihin tutustumisen jälkeen on mahdollista suositella, että seuraaviin asioihin kiinnitetään huomiota kun pyritään parantamaan puukaupungin paloturvallisuutta:

1. Mikä on tavoite (yksittäisten palojen vai kaupunkipalon estäminen)?
2. Yksittäisten rakennusten sekä kaupunkirakenteen paloturvallisuusriskien kartoitus.
3. Kuinka suuri riski on palon leviämiselle naapurirakennuksiin ja miten tämä voidaan estää. Miten rajata palo mahdollisimman pienelle alalle?
4. Miten palot saadaan havaittua ajoissa?
5. Millaisia ongelmia on palokunnan kannalta kaupunkirakenteessa ja yksittäisissä kiinteistöissä?
6. Onko tarpeeksi sammutusvettä saatavilla?
7. Miten asennekasvattaa asukkaita ja kiinteistöjen omistajia (on tärkeää saada heidät ymmärtämään, että palo yhdessä rakennuksessa voi olla uhka koko kaupungille)?
8. Mitkä toimenpiteet tehdään julkisella rahoituksella ja mitkä jäävät omistajien ja asukkaiden maksettaviksi?

Esimerkkitapaukset

Seminaarien aikana käsiteltiin muutamia tapahtuneita paloja, joiden avulla keskusteltiin historiallisten rakennusten paloturvallisuudesta ja toimenpiteistä palon jälkeen. Nämä esimerkit olivat: Tyrvään Kirkko, Åminneborgin kartano ja Kotaselän savottakämppä Suomesta; Trondheimin korttelipalo, Innsetin kirkko, Eidsvollin kirkko ja Ringnesin maatila Norjasta sekä Södra Rådan keskiaikainen kirkko, Katarinan kirkko ja Jönköpingin korttelipalo Ruotsista.

Miten valita sopiva tapa parantaa paloturvallisuutta

Ohessa on muutamia suosituksia miten lähestyä kysymystä paloturvallisuuden parantamisesta:

- Muista, että jokainen historiallinen rakennus on yksilö. Siksi jokainen niistä vaatii yksilöllisiä ratkaisuja.
- Aloita edullisista ja yksinkertaisista toimenpiteistä. Täydennä teknisillä asennuksilla.
- Valitse sellaisia palosuojaustoimenpiteitä, jotka eivät aiheuta vahinkoa rakennukselle.
- Jos rakenteisiin on pakko tehdä muutoksia, tee mahdollisimman vähän.
- Uusiin asennuksiin on päästävä käsiksi ja niiden on oltava poistettavissa, sillä teknisten laitteiden elinikä on lyhyempi kuin rakennuksen.
- Teknisten asennusten ja kylttien tulee olla mahdollisimman huomaamattomia.
- Hyvien ratkaisujen löytäminen vaatii omistajan, paloinsinöörin ja kulttuuriperintöviranomaisen hyvää yhteistyötä. Ennen kuin mitään tehdään, on laadittava strategia. Yleensä tarvitaan hallinnollisten toimenpiteiden ja teknisten asennusten yhdistelmää. Usein kuitenkin jo hyvä organisaatio vähentää teknisten asennusten tarvetta. Jokaisessa historiallisessa rakennuksessa tulisi olla yksi henkilö, joka vastaa paloturvallisuudesta ja suorittaa säännölliset tarkastukset.

Tekniset asennukset

Sopivimman palosuojaustavan valitsemisen perusajatus on ensin analysoida riskit ja selvittää olemassa / käytettävissä olevat suojaustavat. Sitten jäljelle jäävät riskit listataan ja sopivat toimenpiteet paloturvallisuuden parantamiseksi valitaan. Aina jää jäljelle kuitenkin jonkinasteinen riski, jolle on määriteltävä hyväksyttävä taso. Perustavoite on saavuttaa maksimiturvallisuus minimivahingoin.

Muutama seikka on muistettava, kun käytetään teknisiä laitteita. Ne tarvitsevat aina erillisen teknisen tilan keskusyksikölle, vesi- ja kaasusäiliöille ym. ja tämä tila saattaa muodostua yllättävän suureksi. Laitteet vaativat myös ihmisiä, jotka osaavat niitä käyttää ja huoltavat niitä säännöllisesti.

Palon jälkeen

Kun historiallisessa rakennuksessa ollut palo on sammutettu, on tarpeen suojata, tutkia ja dokumentoida jäänteet. Joskus palo tuo esille rakenteita tai kerrostumia, jotka eivät ole ennen olleet esillä. Näissä tilanteissa palo voidaan nähdä tilaisuutena tutkia ja oppia uutta ja tämä mahdollisuus tulee käyttää. On yllättävää kuinka paljon informaatiota voi olla jäljellä hiiltyneissä puupaloissa ja paljonko materiaalia voi palosta säilyä.

Toimenpiteet palon jälkeen

1. Jäänteiden suojaus
2. Jäänteiden tutkimus
3. Jäänteiden dokumentointi
4. Arkistotutkimus
5. Raportti

Analyysi ennen kysymystä ”rekonstruktio vai ei”

Ennen kuin päätöksiä tehdään palaneen rakennuksen rekonstruktion tai korjauksen suhteen, on koko tilanne ja olemassa olevat dokumentit sekä tiedot rakennuksesta analysoitava kunnolla. Mikäli tämän jälkeen päädytään jonkinasteiseen rekonstruktioon, on selvitettävä tarvitaanko tutkimusta tai kokeita rakenteista, tekniikoista tai materiaaleista ennen kuin aletaan rakentaa. Näille valmisteleville töille on varattava tarpeeksi aikaa.

Rekonstruktion voi nähdä mahdollisuutena oppia uutta vanhoista tekniikoista ja materiaaleista.

Historiallisen rakennuksen paloturvallisuuden parantamisen ”askeleet ”:

1. Rakennuksen dokumentointi ja arviointi etukäteen
   Jos rakennus tuhoutuu kokonaan palossa, on perusteellisen dokumentoinnin olemassaolo tärkeää. Silloin ainakin tallennettu osa informaatiosta säilyy. Dokumentointia tehtäessä on myös mahdollista arvottaa rakennusta ja sen osia sekä merkitä muistiin puutteita paloturvallisuudessa.

2. Paloa ehkäisevät toimenpiteet
   Ensimmäinen ja kenties tärkein toimenpide historiallisen rakennuksen paloturvallisuuden parantamisessa on strategian tekeminen ja paloturvallisuusasioiden organisointi. Organisointi tarkoittaa, että rakennuksen käyttäjät koulutetaan ottamaan paloturvallisuusnäkökohdat huomioon jokapäiväisessä työssään ja että he osaavat toimia palotilanteessa. On tärkeää myös nimetä yksi henkilö vastaamaan rakennuksen paloturvallisuusasioista.

3. Palon havaitseminen
   Palon aikainen havaitseminen vähentää vahinkoja huomattavasti. Siksi palon havaitseminen on tehtävä tehokkaaksi. Se voidaan järjestää joko ihmisten (esim. vartijat) tai automaattisten laitteiden avulla. Automaattisia laitteistoja on saatavilla useita erilaisia ja aina on pyrittävä löytämään juuri kyseessä olevaan kohteeseen sopivin.

4. Palon sammuttaminen
   Palon aiheuttamien vahinkojen ehkäisyssä alkusammutus on tärkeää. Jos paloa on mahdotonta saada kokonaan sammumaan, on sen leviäminen estettävä. Alkusammutuskaluston on oltava nopeasti saatavilla ja helppokäyttöinen. Joissain tapauksissa automaattinen sprinklerilaitteisto on paras ratkaisu.

5. Ohjeet sammutustyöstä
   Historiallisissa rakennuksissa saattaa olla erityisen arvokkaita osia tai esineitä. Palokunnalla ja palomiehillä on oltava tieto näistä, jotta palon leviäminen arvokkaisiin osiin voidaan estää tai esineet voidaan pelastaa palon uhatessa niitä. Näitä arvokkaita osia ja esineitä varten on laadittava ohjeet, mitä, miten ja minne ne pelastetaan.

6. Palon jälkeen
   Jäänteiden (myös arkeologisten) suojaus palon jälkeen on tärkeää, jotta estetään lisävahinkojen syntyminen. Ulkopuoliset on pidettävä poissa palopaikalta, jotteivät he tuhoa tai varasta mitään. Historiallisen rakennuksen palon jälkeen jäänteet on tutkittava ja dokumentoitava huolellisesti. Joskus palo saattaa paljastaa aiemmin piilossa olleita rakenteita, jolloin on mahdollisuus tutkia ja dokumentoida näitä.

7. Korjaus / rekonstruktio / raunio
   Kun rakennus on joko kokonaan tai osittain tuhoutunut palossa, on hyvä analysoida tilanne kunnolla ennen päätöstä korjauksesta / rekonstruktiosta / jättämisestä raunioksi. Kaikki näkökohdat, kuten rakennuksen merkitys maisemassa, dokumentoinnin taso, rakennuksen käyttöaste ja käytettävissä olevat resurssit tulee huomioida.

Sammanfattning på svenska

Bakgrund

Projektet har bestått av tre seminarier under 2003 och deltagarna representerade de centrala kulturmiljövårdande myndigheterna i Finland, Norge och Sverige.

Dessa tre länder har några gemensamma förutsättningar, vad gäller brandskydd i historiska byggnader:

- En stor andel av husen i Norden är byggda av trä.
- Det finns gamla trästäder med tät stadsmiljö där brandrisken är stor.
- En del av de historiska byggnaderna finns långt från närmaste brandstation.
- Det nordiska klimatet, med kalla vintrar och varma somrar kan medföra problem med såväl brandskydd och brandbekämpning vintertid som ökad brandrisk och vattenbrist sommartid.

Det huvudsakliga syftet med brandskydd är att rädda liv. I historiska miljöer måste man även se till att de gamla byggnaderna får ett tillräckligt brandskydd. Målet med detta brandskydd är *”maximal säkerhet med minimal skada”*.

Lagstiftning och samverkan med andra myndigheter

Lagstiftningarna i de tre länderna är mycket lika. Brandlagstiftningen säger att ägaren till en byggnad har ansvaret för brandskyddet medan de lokala myndigheterna har ansvar för räddningstjänsten.

Kulturmiljölagstiftningen i de tre länderna innehåller ingenting om brandskyddsåtgärder. Inte heller sägs något om brandskydd i kulturhistoriskt värdefulla byggnader i ländernas plan- och bygglagstiftning.

I Sverige och Norge har kulturmiljömyndigheterna mycket nära samarbete med brandmyndigheterna. Räddningstjänsten i Sverige har, tillsammans med Riksantikvarieämbetet gett ut handboken ”*Brandskydd i kulturbyggnader*”.

Brandskydd i äldre trästäder

Tre projekt om äldre trästäder studerades i seminariet; Rauma (Finland), Lillehammer (Norway) och Eksjö (Sweden).

Efter att ha genomfört dessa studier kan följande förslag ställas om saker som bör beaktas när ett brandskyddsprojekt för en trästad skall startas:

1. Vilket är målet för projektet (förebyggande skydd mot enstaka bränder eller mot en stadsbrand)?
2. Vilka brandrisker finns i enstaka byggnader och i staden som helhet? Hur kan dessa risker minimeras?
3. Vilka risker finns för brandspridning från en byggnad till en annan och kan dessa risker minimeras? Hur kan en brand begränsas till ett avgränsat område?
4. Vad kan göras för att en brand skall bli tidigt upptäckt?
5. Vilka problem, för brandkåren, utgör bebyggelsestrukturen och utformningen av enskilda byggnader vid en utryckning?
6. Finns det tillräckligt med vatten för att släcka branden?
7. Hur kan utbildning och information om brandskyddsfrågor spridas till fastighetsägare och hyresgäster? (Det är viktigt att dessa förstår att en brand hos grannen även är ett hot mot deras eget hus.)
8. Vilka åtgärder kan betalas av myndigheter och vilka måste husägaren stå för?

Fallstudier

Under seminarierna diskuterades ett antal fallstudier. Dessa utgjordes av Tyrvää kyrka, Åminneborg herrgård och Kotaselkä timmerhus i Finland, stadsbrand i Trondheim, Innset kyrka, Eidsvoll kyrka och Ringnes gård i Norge samt Södra Råda gamla kyrka, Katarina kyrka och stadsbrand i Jönköping i Sverige.

Hur väljs metoder för förebyggande brandskydd och för tekniskt brandskydd

Här följer några allmänna rekommendationer för val av brandskyddsmetoder och utrustning:

- Beakta att varje byggnad är unik och att de därför behöver unika och kreativa lösningar.
- Välj lågkostnadsmetoder i första hand och komplettera sedan med installationer.
- Välj brandskydd som inte skadar byggnaden eller påverkar den negativt.

- Om negativ påverkan är oundviklig, minimera den och gör åtgärden reversibel.
- Installationerna måste vara åtkomliga för underhåll. De måste även vara möjliga att avlägsna utan att ge skador, eftersom de har kortare livslängd än byggnaden själv.
- Installationer och informationsskyltar skall vara så diskreta som möjligt.
- Goda lösningar fordrar samarbete mellan ägare, brandingenjör och antikvarisk expert.

Innan något annat görs, bör en brandskyddsstrategi tas fram. Vad som normalt erfordras är en kombination av organisatoriskt och tekniskt brandskydd. En god organisation kan ofta minimera behovet av tekniska lösningar. En person bör vara ansvarig för brandskydd och brandövningar och denna person bör även se till att brandsyner genomförs.

Tekniska installationer

Ett grundläggande arbetssätt, när metoder för brandskydd skall väljas, är att såväl brandrisker som tillgängliga och existerande skyddsmetoder först analyseras. Därefter förtecknas de kvarstående riskerna och sedan väljs de lämpligaste förebyggande och skyddande metoderna. Det kommer emellertid alltid att återstå en viss brandrisk och man har då att avgöra vad som är en ”acceptabel kvarstående risk”. Målet bör vara att uppnå *”maximal säkerhet med minimal skada”*.

Några synpunkter bör beaktas när tekniska installationer väljs. Dessa behöver alltid utrymmen för apparatur, vattentankar med mera. Det måste även finnas en eller flera personer som är ansvariga för utrustningen och dess skötsel.

Efter en brand

När en brand har helt eller delvis förstört en historisk byggnad är det alltid viktigt att man skyddar resterna och det är även viktigt att undersöka och dokumentera lämningarna. Ibland kan en brand avslöja ytor, lager eller konstruktioner som inte var synliga före branden. Då kan branden ge en möjlighet till ökad kunskap. Det finns överraskande mycket information i förkolnat trä och det är förvånande hur mycket som faktiskt överlever en brand.

Åtgärder efter en brand

1. Skydd av ruiner och lämningar.
2. Undersökning av ruiner och lämningar.
3. Dokumentering av ruiner och lämningar.
4. Arkivsökningar.
5. Rapportering.

Analyser före frågan ”återuppbyggnad eller ej”

Innan några beslut fattas måste alla omständigheter kring den brunna byggnaden noggrant analyseras. Det kan gälla befintlig dokumentation och annan kunskap om byggnaden samt om någon forskning eller provning behövs innan några speciella konstruktioner, material eller metoder väljs. En återuppbyggande kan ses som en möjlighet att lära sig mer om äldre material och metoder.

Arbetsordning för brandskydd i historiska byggnader

1. Dokumentering och värdering av byggnaden.

En noggrann dokumentation av en historisk byggnad är viktig i de fall byggnaden blir helt förlorad vid en brand. Då är åtminstone den dokumenterade informationen sparad. I samband med dokumentationen bör en uppskattning göras av byggnadens kulturhistoriska värde såväl som erforderliga brandskyddsåtgärder.

2. Åtgärder för förebyggande brandskydd

De första och kanske viktigaste åtgärderna för att öka brandskyddet i historiska byggnader, är att skapa en strategi och en organisation för brandskyddet. Organisation innebär att de som använder byggnaden är så pass utbildade att de beaktar brandrisker i sitt dagliga arbete och att de vet hur de ska agera vid ett tillbud. Det är viktigt, i varje historisk byggnad att detta ansvar läggs på en speciell person.

3. Åtgärder för att upptäcka brand

Branddetektering bör organiseras omsorgsfullt, eftersom att tidig upptäckt av en brand kan reducera skadorna betydligt. Detekteringen kan skötas av närvarande personer eller av ett system av

branddetektorer. Det finns en stor mängd av olika automatiska detektorsystem och det är viktigt att rätt typ väljs i varje situation.

4. Utrustning för brandbekämpning
För att förebygga skador är den första släckningsinsatsen av stor vikt. Om branden inte kan släckas genast, är det nödvändigt att begränsa den och hindra den från att sprida sig. Utrustningen för den första insatsen skall därför vara lätt åtkomlig och lätt att använda. Ett automatiskt sprinklersystem kan i vissa fall vara den bästa lösningen.

5. Instruktioner för räddningstjänsten
Historiska byggnader har ofta värdefulla byggnadsdelar eller kan innehålla värdefulla föremål. Av denna orsak bör brandkåren informeras om detta så att de kan hindra brandspridning till dessa delar. De bör även informeras om vilka föremål som ska evakueras samt hur och vart de skall flyttas, om de hotas av brand.

6. Efter en brand
Att skydda lämningarna, även de arkeologiska, efter en brand är viktigt för att förebygga ytterligare skador. Även obehöriga måste hindras från att beträda brandplatsen, så att de inte förstör bevismaterial eller rör om i lämningarna.

Efter brand i en historisk byggnad, måste brandresterna undersökas och dokumenteras noggrant. Branden kan i vissa fall ha blottlagt tidigare osynliga byggnadsdelar.

7. Reparation / rekonstruktion / ruin
När en byggnad har blivit helt eller delvis förstörd av en brand är det nödvändigt att noggrant utreda situationen innan beslut tas om byggnaden ska repareras, återuppbyggas eller lämnas som en ruin. Alla aspekter skall beaktas i beslutet, bland annat byggnadens betydelse i landskapet, dokumentationsnivån, byggnadens användning samt tillgängliga ekonomiska och materiella resurser.

Sammandrag på norsk

Bakgrunn

Prosjektet besto av tre seminarer gjennom år 2003, med deltakere fra i Museiverket i Finland, Riksantikvaren i Norge og Riksantikvarieämbetet i Sverige.

Disse landene har flere felles problemstillinger knyttet til brannsikring av kulturhistorisk verdifulle bygninger:

- En stor andel av bygningene er bygget i tre.
- Tette trebyer der brann er en alvorlig risiko.
- En del av de verneverdige bygningene ligger på fjerntliggende steder.
- Klimaet er kalt om vinteren og varmt om sommeren, noe som lett forårsaker fare for brann i lange, tørre perioder og temperaturer under null i andre. Dette skaper problemer for både brannsikring og brannslukning.

Det overordnede målet med ordinær brannsikring er å verne menneskeliv, mens brannsikring i kulturhistorisk verdifulle bygninger i tillegg skal sikre bygningene og deres kulturhistoriske verdier. Målet med brannsikring i verneverdige bygninger er å oppnå ”maksimum sikkerhet med minimal skade”.

Lovverk og samarbeid med andre myndigheter

Lovverket i alle tre land har mye felles. Ifølge brannvernlovene er det eieren av den verneverdige bygningen som har ansvaret for brannsikringen og de lokale myndigheter som er ansvarlig for brannvesenet.

Kulturminnelovene i disse landene inneholder ikke noe om brannsikringstiltak. Lover som regulerer bygningsvirksomheten, inneholder heller ikke noe om brannsikring av kulturhistoriske bygninger.

I Sverige og Norge samarbeider kulturminnemyndighetene nært med brannmyndighetene. I Sverige har Redningsverket og Riksantikvarieämbetet sammen utgitt håndboken ”Brannskydd i kulturbyggnader”.

Brannsikring av kulturhistoriske trebyer

I prosjektet ble det presentert tre studier av kulturhistorisk verdifulle trebyer: Rauma i Finland, Lillehammer i Norge og Eksjö i Sverige.

Erfaringer fra disse studiene viser at følgende bør vurderes når man planlegger brannsikring av verneverdige byer:

1. Er målet å forhindre enkeltbranner eller bybranner?
2. Hvilke typer risiko er det i de enkelte gårdene og i bystrukturen, og hvordan kan disse minimaliseres?
3. Hva er risikoen for at en brann skal spre seg fra en eiendom til en annen, og hvordan kan brannen begrenses til et område?
4. Hva kan gjøres for at branner skal oppdages så tidlig som mulig?
5. Hvilke problemer har brannvesenet med å operere i bystrukturen og i den enkelte bygning?
6. Er det nok vann til å slukke brannen?
7. Hvordan organisere opplæring om brannsikring for eiere og innbyggere? (Det er viktig å gjøre dem oppmerksom på at en brann hos naboen også representerer fare for brann i eget hus.)
8. Hvilke tiltak betales av myndighetene og hvilke overlates til eierne?

Hvordan velge metoder for brannsikring?

Her er noen grunnleggende anbefalinger for valg av brannsikringsmetoder og utstyr:

- Hver bygning er unik. Derfor kreves det også tilpassede og kreative løsninger.
- Forsøk først lavkostløsninger, og kompletter med installasjoner.
- Velg brannsikringsmetoder som ikke medfører inngrep i bygningen.
- Hvis inngrep ikke kan unngås, gjør dem så små som mulig og reversible.
- Nye installasjoner må være tilgjengelige for vedlikehold og kunne fjernes uten å forårsake skade, fordi de har en langt kortere levetid enn bygningen selv.
- Tekniske installasjoner og informasjonsskilt må være diskrete.
- Gode løsninger krever samarbeid mellom eier, brannmyndighet og kulturminnemyndighet. En strategi må ligge til grunn for arbeidet. Vanligvis er det behov for en kombinasjon av organisatoriske og tekniske sikringstiltak. God organisering kan minimalisere behovet for tekniske installasjoner. Det bør utpekes en person med ansvar for brannsikring og opplæring i alle kulturhistoriske bygninger.

Tekniske installasjoner

En analyse av risikoen må ligge til grunn for valg av den best egnede brannsikringsmetoden. Deretter må en velge egnede brannforebyggende og brannbegrensende tiltak for å dekke opp restrisikoen. Det er umulig å eliminere risikoen helt, og en må derfor vurdere hva som er et akseptabelt risikonivå. Hovedmålet er ”maksimum sikkerhet med minimum skade”.

Ved montering av tekniske installasjoner skal en være oppmerksom på at sentralenheter, vanntaker osv. ofte krever overraskende stor plass. Det må alltid være en eller flere ansvarlige for det tekniske utstyret og for regelmessig vedlikehold av dette.

Etter brannen

Etter brannslukningen er det viktig å beskytte, undersøke og dokumentere de igjenværende restene av den kulturhistoriske bygningen. Brannen kan avdekke strukturer og lag som aldri før har vært tilgjengelige. Man bør benytte den muligheten som brannen kan gi til å lære noe nytt om bygningen. Det er forbausende hvor mye informasjon som kan ligge i forkullede trerester og hvor mye som kan være igjen etter en brann.

Tiltak etter brannen

1. Beskyttelse av ruiner og restmateriale
2. Undersøkelse av ruiner og restmateriale
3. Dokumentasjon av ruiner og restmateriale
4. Arkivundersøkelser
5. Rapport om undersøkelsene

Analyser knyttet til spørsmålet om ”rekonstruksjon eller ikke”

Før det tas noen avgjørelser, kreves en grundig analyse av forholdene, tilgjengelig dokumentasjon og kunnskap om den brente bygningen. Deretter bør en avgjøre om det er behov for ytterligere forskning eller eksperimenter før det tas stilling til hvilke konstruksjoner, materialer og teknikker som bør benyttes. En rekonstruksjon kan være en mulighet til å få ny innsikt i gamle teknikker og materialer.

Casestudier

Under seminaret ble følgende case diskutert: Tyrväa kirke, Åminneborg herregård, og Kotiselka laftehytteområde fra Finland, Södra Råda middelalderkirke, Katarina kirke og Jönköping by fra Sverige, og Innset kirke, Eidsvoll kirke og Ringnes gård fra Norge.

Trinn i brannsikring av kulturhistorisk verdifulle bygninger:

1. Dokumentasjon og evaluering av bygningen

En grundig dokumentasjon er viktig. Ved en forhåndsdokumentasjon bør også bygningens verdi vurderes og behovet for bedret brannsikring. Når en kulturhistorisk bygning blir totalskadet i en brann, vil man i hvert fall sitte igjen med den dokumenterte kunnskapen om bygningen.

2. Brannforebyggende tiltak

Det første og trolig det viktigste man gjør i forbedringen av brannsikkerheten er å skape en organisasjon for sikring av den verneverdige bygningen. Dette innebærer at brukerne av bygningen er opplært til å ta hensyn til brannsikkerheten i deres daglige arbeid, og at de vet hva de skal gjøre hvis en brann bryter ut. Det er viktig at det utpekes en ansvarlig for brannsikringen i hver bygning. Det bør også utarbeides en strategi for brannsikringen. Innbruddsdeteksjon er også en beskyttelse mot påtenning.

3. Branndeteksjon

Tidlig deteksjon kan redusere sannsynligheten for brann betraktelig. Derfor bør deteksjonen organiseres effektivt. Dette kan enten bestå av en tilstedeværende person eller et automatisk branndeteksjonssystem. Det finnes mange forskjellige deteksjonssystemer, og man bør vurdere nøye hvilket som er best egnet i det enkelte tilfelle.

4. Brannslokningsutstyr

Den første slokningsinnsatsen er viktig i begrensning av skadene. Dersom det ikke er mulig å slokke brannen, er det viktig å begrense den og forhindre at den sprer seg. Slokkeutstyr bør være lett tilgjengelig og enkelt å bruke. Et automatisk slokkeanlegg kan i noen tilfeller være den beste løsningen.

5. Instruks for slokkepersonell og brannvesen

Kulturhistorisk verdifulle bygninger vil ofte inneholde svært verdifulle bygningsdeler. Brannvesenet bør informeres om slike for at det kan forhindre spredning av brannen til disse delene, eller at de kan tas ut av den brennende bygningen. Det bør utarbeides planer for ikke bare hva som bør evakueres, men også hvordan.

6. Etter brannen

Det er viktig å beskytte restene på branntomten for å unngå ytterligere skade. Uvedkommende må holdes borte fra brannrestene og ruinen slik at ikke spor eller bevarte deler blir ødelagt. I tilfelle brann i en kulturhistorisk bygning bør restene undersøkes og dokumenteres grundig. Noen ganger kan en brann avsløre strukturer som vanligvis ikke er synlige. En brann kan være en mulighet til å se og dokumentere disse.

7. Reparasjon/ rekonstruksjon/ ruin

Når en bygning er delvis eller fullstendig ødelagt i en brann, er det viktig å foreta en grundig analyse før man tar stilling til spørsmålet om man skal reparere, rekonstruere eller la restene forbli en ruin. Alle aspekter som f.eks. bygningens betydning i landskapet, nivået på dokumentasjonen og bygningens bruk, bør tas i betraktning.

Appendix:
Contents of a Finnish rescue plan:

1. General information
   - 1.1 Approval and upkeep of the plan
   - 1.2 Purpose
   - 1.3 Identification and general description of the monument or place
     Variety of different values of the building, materials used if they have some effect on fire safety
   - 1.4 Contacts to local rescue service

2. Risk assessment
   What are the fire risks in the particular building? Possible causes of a fire

3. Measures to prevent hazards and the possibilities for protection
   - 3.1 Fire safety
     Fire and hazard classifications; evacuation areas and exits, marking passageways and exits; the width and amount of escape routes; fire compartments, doors; safety devices, fire detectors, fire alarms, fire extinguishers, emergency lighting, function of fire doors (automatic?), smoke extraction; tidiness and order, refuse collection and disposal, smoking, the use of open fire (candles etc), attics and cellars (storage?), the use of electric equipment, fire safety of fixtures and coatings, electric heaters; prevention of arson; hot work supervision plan; instructions for daily fire protection routines; instructions for fire protection inspections; interval of inspections by authorities
   - 3.2 Toxic chemicals
     Location and behaviour in the event of a fire
   - 3.3 Other dangerous substances
     Location and behaviour in the event of a fire
   - 3.4 Work safety and first aid preparedness
   - 3.5 Crime prevention
     Burglar prevention is part of arson prevention
   - 3.6 Information security
   - 3.7 Environmental hazards
   - 3.8 Property management
   - 3.9 Civil defence (bomb shelter)

4. People responsible for safety issues; safety education and training
   - 4.1 Nomination of people in charge
     People in charge of fire protection and regular fire safety inspections
   - 4.2 Personnel initiation and training
     Instructions on how to train permanent and temporary workers to act in of the event of a fire; who organises fire drills and how often

5. Safety equipment and materials
   Description and location of fire safety equipment detectors, extinguishers, alarm systems, sprinklers etc.

6. Instructions in a case of emergency
   - 6.1 General instructions
     - 6.1.1 Internal arrangements in case of alarm
     - 6.1.2 Exit
     - 6.1.3 Giving an alarm
     - 6.1.4 Information service
     - 6.1.5 Recovering
   - 6.2 Action in special cases
     - 6.2.1 Fire
       First fire fighting devices, who guides the fire brigade, doors to be closed to prevent the fire from spreading etc.
     - 6.2.2 Medical emergency
     - 6.2.3 Criminal emergency
     - 6.2.4 Environmental hazards in the form of toxic substances
     - 6.2.5 Action during emergency alarm
     - 6.2.6 Radiation alarm
     - 6.2.7 Interruption of electricity, water or heating supply
     - 6.2.8 Damage of computer systems
     - 6.2.9 Evacuation
       Items to be saved and how and where they are taken

Appendices
Plans supplied with safety instructions:
- *Situation plan*
- *Floor plans*
- *Fragile and dangerous premises and the location of valuable items that should be saved in of the event of a fire*

List of literature and links

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- Kokkala, Matti, 2000. Rakennusten paloturvallisuussuunnittelu. Toiminnallinen lähestymistapa [*Fire Safety Design of Buildings Performance-Based Approach.*] Research Notes 2028. Technical Research Centre of Finland (VTT), Espoo.

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- VTT Technical Research Centre of Finland, Fire technology: http://www.vtt.fi/rte/firetech/indexe.html
- Central Organisation of Rescue Services in Finland: http://www.spek.fi
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- Gamlebyen i Fredrikstad. Brannsikring. Sluttrapport: Konklusjoner etter utredning tester og 9 mnd. Pilotprøving. Interconsult 2001
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- Markering av rømningsveier. Riksantikvaren 2002
- Montering av utvendig lynvernanlegg på kirker. En veiledning i estetikk. Riksantikvaren 1995
- Novel Techniques For Active Fire Protection Of Historic Towns And Buildings. Interconsult 2000
- Om bybrannsikring med Røros som eksempel. Interconsult 2002
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- Typer automatiske innvendige slokkeanlegg i fredete og verneverdige bygninger. Riksantivaren 2000
- Veiledning og sjekkliste for brannsyn i verneverdige objekter, DBE 1997

Norwegian links:

- The Directorate for Cultural Heritage (Riksantikvaren):
  www.ra.no
- Norwegian Fire Protection Association (Norsk brannvernforening):
  www.norsk-brannvern-forening.no
- Ringnes farm:
  www.ringnesgaard.no
- The Norwegian Fire Research Laboratory (SINTEF-NBL);
  www.nbl.sintef.no
- The Directorate for Civil Protection and Emergency Planning (Direktoratet for samfunnssikkerhet og beredskap):
  www.dsb.no
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  www.interconsult.com

Swedish literature:

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- Brandskydd i kulturbyggnader, Räddningsverket och Riksantikvarieämbetet, 1997
- Brandskydd i kyrkor,
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Swedish links:

- Riksantikvarieämbetet
  (National Heritage Board)
  www.raa.se
  www.raa.se/materialguiden
  (Information on fire properties of construction materials in Swedish)
- Svenska brandförsvarsföreningen
  www.svbf.se
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- Eksjö kommun (Municipality of Eksjö)
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- Branden i Jönköping den 24 februari 2004, Tillsyn och utvärdering, Räddningsverket
  http://www.srv.se/funktioner/publish/doklager/dok2A1-9.pdf
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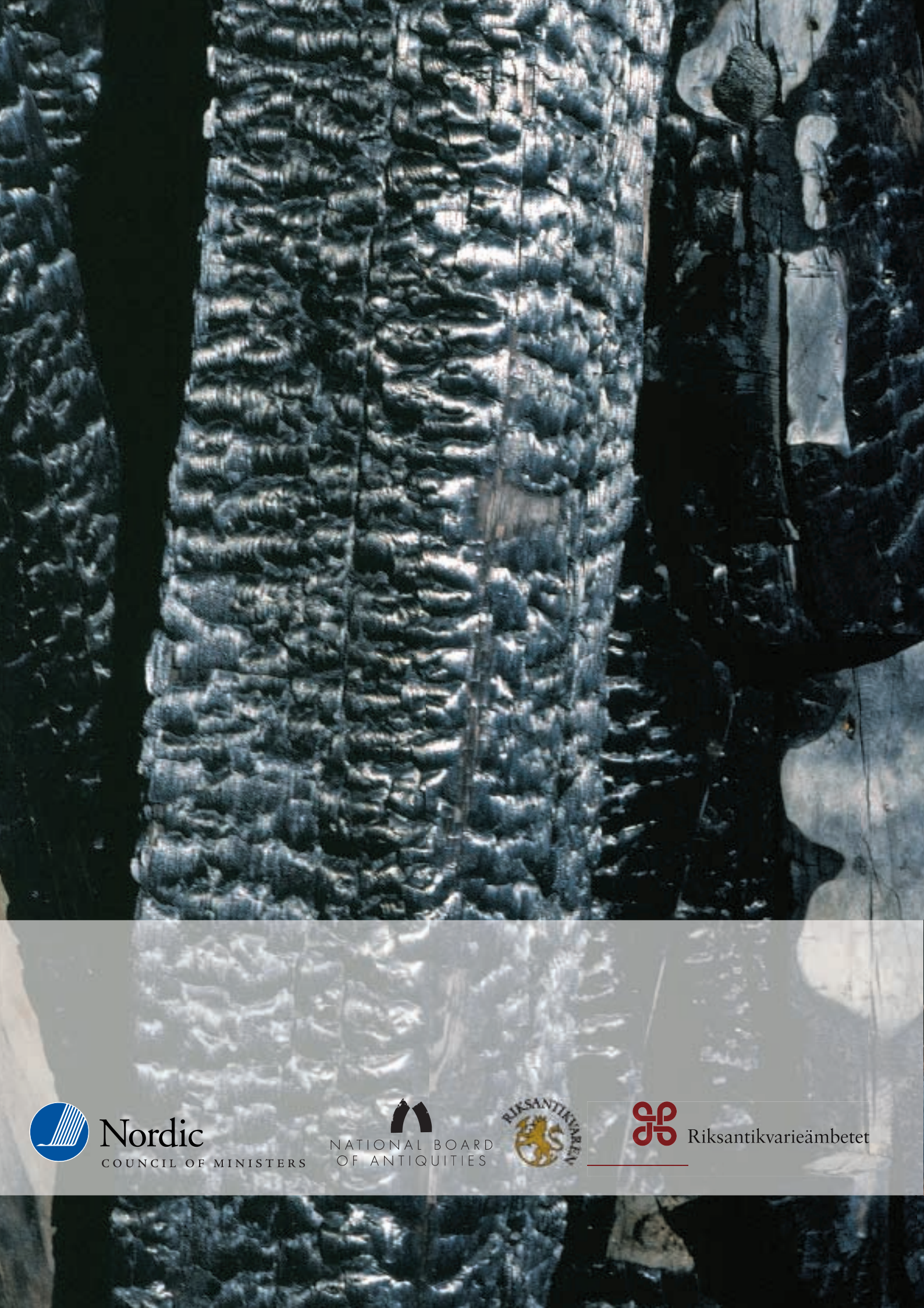
Fire drill at Petäjävesi Church

Cover pictures
The photo at the back shows charred wood remains from the Tyrvää Church fire.
Tyrvää Church (Finland) lost interior / The Södra Råda (Sweden) before the fire / Copper pipes in a Norwegian stave church.

Pictures:
Museovirasto: pages 2, 5, 7, 10, 12, 21, 36, 51, 54 (down), 55, 56, 58
Museovirasto / Soile Tirilä: cover background
Martti Jokinen: cover Tyrvää, pages 8, 16, 22, 23, 27, 29, 37, 38, 40, 47, 48 (down right), 49 (upper), 50, 60, 63, 64, 80
Jorma Lehtinen: pages 6, 9, 15, 45
Raul Pohjonen: page 20

Riksantikvaren: pages 14, 18, 26, 28, 38 (upper), 46, 48 (upper), 57, 65
Rune Petter Ness, Adresseavisen: page 25
SINTEF, Norway: page 48 (down left)

Riksantikvarieämbetet: cover Södra Råda and copper pipes, pages 13, 19, 30, 39, 41, 49 (down), 54 (upper), 61, 66
Bo E. Karlson, Jönköpings läns museum: pages 32, 33
Lena Simonsson: page 35
From Report *"Brandskydd i trästäder – Strategi för skydd av centrala Eksjö"*: pages 17, 42
AIX-architects: page 52



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