Plank Roof and Traditional Paintwork
—Sustainable Heritage Report No. 5

Kirsti Horn, editor

Traditional Wooden and Masonry Structures in the Baltic Sea Region
Sustainable Heritage reports, 1/2014

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A joint project between Campus Gotland at Uppsala University,
Estonian Academy of Arts, Novia University of Applied Sciences and supported
by the Nordic Council of Ministers through Nordplus funds.

Contents

Summary

This report is about the rescuing of a listed, historic storage building from ruin. It is also about traditional surface treatment of wooden facades. And above all, it is a document by enthusiastic students of a successful international intensive course in Ekenäs, Finland in April 2013.

The two fine results of the hands–on work during the intensive week are: a handsome slender roof in 18th century style, made entirely of wooden boards, and a newly painted façade supporting it. This report describes the materials for the roof—timber, nails and tar—and the building of it in great detail, not forgetting security aspects on a building site of this kind. The cooking of rye flour paint was another new but truly traditional experience for the participants of the course. In addition, many other traditional surface treatments and pigments for wood are delved into in detail.

The focus of this report lies in what was learnt by doing: how a roof of planks should be executed and how traditional paint is made. All participating students from Campus Gotland at Uppsala University, Sweden, Estonian Academy of Arts, Estonia, and Novia University of Applied Sciences, Finland, have contributed to this report with text and photographs.

Preface

The *Wooden Roof* project spanned over three years starting from first negotiations in 2011. Many people were involved in it: first of all the teachers and students of building technique at Novia UAS, but also specialists of timber harvesting, sawing, traditional building technique, traditional materials, wood boring insects, financing and supervising. The report at hand concentrates on the last stage of the whole project, i.e. the work that was performed during the intensive course in April 2013. The story begins with a short review of the preparatory activities—background and rescue operation.

The project **Traditional Wooden and Masonry Structures in the Baltic Sea Region** is supported by the Nordic Council of Ministers through **Nordplus** funds. It is designed for students of building conservation, conservation of artefacts, structural engineering and site management from the named universities in Sweden, Estonia and Finland. The idea is to give them the opportunity to learn about the traditional materials in different parts of buildings. From the conservation point of view they learn how constructions and surfaces made of these materials are to be preserved in the best manner. The extra bonus is that when students of different disciplines meet, they naturally exchange ideas and experiences and they develop contacts across cultural, national, professional and language barriers.

The following persons contributed to making the *Wooden Roof* project come true. Their expertise and enthusiasm helped keep the project going and completed and made it a most memorable experience for all those who were involved.

- **Niklas Nyman,** lecturer, organizer, teacher and site manager, Novia UAS, Degree programme in Construction Engineering and Construction Management
- **Joakim von Bergmann,** MD, Kustregionens utbildningsfastigheter
- **Robert Lindholm,** lecturer and Sune Forsström, lecturer, Novia UAS, Degree programme in Forestry
- **Engelbert Engblom,** lecturer, Novia UAS, Degree programme in Agriculture
- **Hans Dahlberg,** building entrepreneur with his team

- **Svante Andström,** MD, S–Trä sawmill
- **Siim Otsa,** smith, Estonia, manufacturer of nails
- **Jani Puhakka,** building conservator together with his team, Seurasaari Open Air Museum in Helsinki, Finnish National Board of Antiquities and Historic Monuments
- **Klaus Hansen,** lecturer, with student film team—**Benjamin Duncker, Conny Holmberg, Robert Lönnberg, Cedric Rantanen, Pengchinda Sureerat,** Novia UAS Degree programme in Information Technology
- **Simon Store,** architect, SAFA, town architect, Town planning dpt, Raseborg
- **Tellervo Saukoniemi,** researcher, Raseborg museum
- **Joosep Metslang,** lecturer, building researcher, author, and **Aune Mark,** architect, Fabbi project / Rocca al Mare Open Air Museum, Tallinn
- **Uwe Noldt,** dr. rer. nat., and **Guna Noldt,** dr. biol., Fabbi project / Johann Heinrich von Thünen–Institut, Hamburg

Thank you!

Kirsti Horn

Senior lecturer, Architect SAFA, AA Dipl.

Background to the project, the site and the preparations for the intensive course

Wooden roofs in the Baltic Sea region today

Thick wooden shingles are traditional on the medieval stone churches and some later wooden churches of Finland and Sweden while Gotlandic churches and belfries often have plank roofs. Thin shingles of various kinds can be found on historic buildings in Estonia, Sweden and Finland. Yet, today wooden roofs are rarely found outside open air museums.

Thin shingles can last some decades, while planks and thick shingles are known to last centuries provided they are treated with pine tar and maintained regularly. A plank roof which is described here, can be made only if there are planes available for the processing of timber. In 17th and early 18th century Finland this would therefore have been a rich man's roof. Tarred and sanded felt and steel sheet roofing replaced the laborious and fire hazardous wooden roofing techniques in Finnish towns during the first decades of the 19th century. A similar development took place in the neighbouring countries where also roofing tiles were a most popular alternative.

Project idea

On the grounds of Novia UAS, Ekenäs Finland, there are a number of buildings that date back to the 19th century. One of these is a vernacular storage building that sticks out from its surroundings not only because of its colour and shape but also because of the state of it. Having watched the decay accelerate over the past 15 years it was decided to save the building before it would be too late. First on the list was a new roof. It was decided that a plank roof would give the local students of construction engineering and construction management a great opportunity to learn in detail about the processing of timber all the way from the forest to a finished component in a building. The international intensive week was designed with focus on historic roofing techniques and surface treatment of wood. This report delves into both matters in great detail.

All building materials for the project were paid by its owners, *Kustregionens utbildningsfastigheter,* while The Nordic Council of Ministers sponsored the intensive course that is described in this report.

The site

Figure P1. The broken roof of the historic *loft* was the starting point for the *Wooden Roof* project. Photograph by Niklas Nyman.

The object of the intensive course (figure P1) is located on the Campus of Novia UAS next to the old manor house of *Ekenäs Ladugård*. Its origin is unknown, but according to some local historians it was moved to its present location in the 1950's together with another similar building in the hopes of establishing an open air museum on the historic site of the manor. It is a rather modest version of a vernacular two storey storage building type of massive log construction. The kind of building can be found on old farmsteads in Sweden and Finland and is called *loft* in Swedish[1] referring to the second storey and the balcony or corridor on the front which is accessed from one end and leads to the rooms on the top floor. *Lofts* of three units often formed a decorative gateway into the farmyard. Both storeys were generally used for storage purposes, but quite often the young people would move out of the crowded farmhouse in the summer and sleep in the top rooms of such storage buildings instead.

The site of the *loft, Seminarieparken,* with its mighty trees and handsome old buildings is classed as a *nationally significant cultural environment* by the National Board of Antiquities and Historic Monuments. Consequently, every one of the historic buildings on the grounds is listed. *Seminarieparken* refers to the first seminary for Swedish speaking female primary school teachers in Finland which was built next to the manor house in 1871. By this time farming was laid down and a park planted instead. The place was thus turned into a school campus and at least three more buildings were built to support this activity (figure P2). In addition, the 19th C manor was turned into a students' dormitory (!) and what is now the oldest building in Ekenäs was turned into a centre for musical education. The functions have been changed even since and lately it has been difficult to find good use for the buildings.

1 *Luhti* in Finnish.

Figure P2. Old buildings on the Novia Campus: (a) The Seminary building (1871) is the historic centre of the campus. (b) manor of Ekenäs Ladugård (late 18th C), (c) catering building, (d) headmaster's residence, (e) the oldest building in Ekenäs (late 18th C). Photographs by Triin Jänes.

While the grand and fine school buildings have been fairly well looked after, the two *lofts* that had been brought to the site were silently forsaken. The planned open air museum came to nothing. One of the *lofts* was pulled down, presumably at some point in the 60's while the other one was left to decay. Due to a leak in its roof and lack of general maintenance fungi and insects attacked its ancient constructions until a rescue operation was carried out by staff and students of the Degree Programmes in Construction Engineering and Construction Management of Novia UAS in the spring of 2012. A lot had been done before this to make the *Wooden Roof* project that is presented in this report real—and a lot lay ahead.

The rescue operation

The practical work was planned and led by Niklas Nyman, lecturer of construction technique at Novia UAS. Many discussions were held with the proprietors, authorities, representatives of the National Board of Antiquities, colleagues and suppliers of building material before students could be involved.

From the pedagogical point of view the project was a success. Such theories as CDIO[2], learning by doing and project based teaching could all be applied to any of the courses in the **Traditional Wooden and Masonry Structures in the Baltic Sea Region** project. This particular course combined the standard curriculum with the international project. One group of students was engaged over a span of two years and the experience gave them a lot of theoretical knowledge concerning timber and wooden constructions besides the practical work. The intensive course together with students from abroad was the icing on the cake.

Building permission

Novia students made measured drawings of the *loft* and applied for building permission which was necessary because a change of roofing material was planned on a listed building. Permission was granted.

Timber

In cooperation with teachers and students of the Degree Programme in Forestry at Novia good timber for the roofing was selected from the forests, felled and transported to a local saw mill where it was sawn to planks, planed down and dried. Then the planks were tarred for the first time. Links to films of the whole process can be found at http://www.sustainableheritage.fi/courses/index.php/2012-16

2 CDIO: conceive—design—implement—operate.

Figure P3. Vertical logs were installed at strategic points on each side of the walls to give the building extra stability. This is a standard procedure where ever a log construction is subjected to loads or damage that make it bulge or lean. Photograph by Kirsti Horn.

Figure P4. New purlins were installed by a construction company to carry the new roofing. Photograph by Kirsti Horn.

Clearing the site, i.e. the building

Students of Novia UAS cleaned the rooms of the *loft* and together with a construction company removed the old roofing and its constructions. The scene was truly discouraging when the building was empty from all the rubbish and dirt that had been gathered there over the years: the decay was far worse than expected. The roof construction was a mish mash of earlier desperate attempts to give the building a cover from the elements. Logs were missing from the walls due to decay, others were soft from fungi and insects. The whole structure seemed to be held together mainly by the sturdy planks on the façade. The surrounding ground had risen above the foundation stones. Trees and bushes were destroying the south gable. The logs that support the *loft* corridor seemed to give way any minute. Floor boards were slowly turning into earth. It is clear that the building must have been in a bad shape already when it was brought to its present position and that whoever put it together had little feeling for traditional building technique.

As a result to discussions with building conservators from the Seurasaari open air museum in Helsinki, the walls of the *loft* were strengthened by vertical logs (figure P3) and later additions to the roof construction were replaced by sturdy purlins that form the support for the new roofing (figure P4). Valuable help was also obtained as to the actual roofing technique, suppliers of tar and handmade nails.

A short introduction to all traditional Finnish wooden roofing technique is presented at http://www.sustainableheritage.fi/courses/index.php/2012-16

Figure P5. Everything ready for the intensive course together with Estonian and Swedish students: tarred roofing planks were piled in the open to avoid cracking. Photograph by Kirsti Horn.

1. Plank Roof

1.1 ARRANGEMENTS ON THE SITE

The site around the *loft* had minimal maneuvering space and the scaffolding stood partly on a public walk way. So, caution and discipline was needed at every stage. Each working shift consisted of 15 students and 1–2 teachers. It was important that everyone kept to his or her place and task and respected the site security measures.

1.1.1 SITE SECURITY

The site security aspect of the project was managed in a similar way as on a big construction site. The leading teacher acted as supervising construction manager on the site at all times and made sure that all security aspects were fulfilled.

Every worker on the site was provided with personal safety gear. This consisted of a safety vest and a helmet, both of which were to be used when working or being on the building site.

Certain stages of the work had to be done using power tools such as chainsaws and circular saws. Only people who had earlier experience with such tools, and were comfortable to use them, were allowed to do so. Personal safety gear for the workers with power tools consisted of helmet, hearing protection, gloves and safety goggles.

Scaffoldings were built on the sides of the *loft* because the building of the roofing took place 3–5 meters in the air. The scaffoldings acted as a working platform and also as a fall protection for the workers on the sloping roof. They were built of tubular steel elements and crossbars and the working platforms on the scaffolding were made of wood. Steel railings were installed on the top level so that no one could fall off. Ladders of steel were fixed to the structure. Additional platforms were made between the purlins so that most of the work on the roof was done standing on a horizontal base instead of balancing on the slope (figure 1.1).

Figure 1.1. The security on the site was of obvious concern. Good scaffolding of steel bars and wooden platforms made it easy to move about on the roof. Helmets and safety vests are obligatory on a building site like this. Photograph by Kirsti Horn.

1.1.2 TIMETABLE

There was time from Monday to Friday to finish the project. This included installing the roof, painting the façades with rye flour paint and finally removing the scaffoldings around the *loft*. The foreign students arrived in Finland on Sunday and straight away we started to prepare ourselves to meet the deadline. Each day began with a lecture from 8:30 to 10, and then the group was split into two. One half worked at the *loft* the whole day, while the others cooked rye flour paint and learnt to make other traditional paints (see appendix).

Good preparations before the intensive week minimized the risk of anything going wrong. Novia students had made the roofing material ready before the guests arrived, and this saved a lot of time on the roof. The time between the first nail and the last nail took about 4 days. This means 2 days, or 10 working hours per person; in other words 30 x 10 = 300 working hours altogether (some of this time was spent on repairing the boarding on the façade). On Thursday the roof was finished, and in the afternoon of the same day we started to paint the walls and clean the site. This together with dismantling of the scaffolding took the whole group about 2 days, also known as 10 work hours per person, or 300 hours altogether.

The project kept to its schedule just perfect and everything went according to plans and without injuries.

1.2 BUILDING MATERIAL

1.2.1 IRON NAILS

Figure 1.2. Siim Otsa, the Estonian black smith who made the nails for the roof, delivered them in a nice box. Photograph by Sille Sombri.

Some 650 iron nails made by Siim Otsa, Estonian blacksmith, were used to attach the wooden planks onto the roof structure. They are about 150 mm long and made of square 6x6 mm iron bar. The nails were treated with linseed oil to make them weatherproof (figure 1.2).

1.2.2 (PINE) TAR

Tar is a very good wood preservative and has a long history as a water–repellent coating for boats, ships and roofs. The first written data of using tar as a preservative is by Plinius, the Roman historian, from some 2000 years ago but it was used already long before his times. Tar is the oily substance obtained from wood through destructive (dry) distillation (i.e. heating of timber in an environment of little oxygen). Usually it is derived from the trunk and roots of pine, but rarely also from spruce, juniper, ash tree or birch. The tighter the growth rings of a pine tree and the more heartwood *(duramen)* there is, the more tar is derived. Best materials for producing tar are stumps and roots. Traditionally the bark of living trees was partly peeled to make the trees produce extra amounts of resins over a couple of years before they were felled.

To produce tar the wood must be dry and split into thin pieces. There are many different methods of distillation. One of the oldest methods is making tar in a kiln or pit but it can be also be made in a pot or a tar oven.

Regular tarring of outdoor wooden surfaces, such as roofs walls and structures that are in contact with the ground, can significantly prolong the lifetime of the material. It is recommendable to treat wooden roofs when the weather is dry and cool. The best times are in spring or early summer and in early August. A wooden roof should be treated several times during the first years and then on average every 7 years. South facing parts need to be treated more often (every 5 years) than northern (every 10 years). The aim is to create a water–repellent coat at first, then to maintain it.

The history of producing tar from pine goes back centuries in the Nordic countries. Tar was generally produced only for domestic use in Estonia but in Finland and Sweden it was very important business since the 16th century. Tar was exported in large quantities to the seafaring countries of Central Europe as long as ships were made of wood, but during the second half of the 19th century the export slowly

decreased. Today the production is minimal, yet just enough for the maintenance of historic buildings and boats. Surprisingly, Chinese tar has gained market lately.

1.2.3 HOW TO CHOOSE GOOD TIMBER

The Nordic coniferous trees pine and spruce have been used as construction material for thousands of years. Over the last 50 years or so there has been a discussion about the decreasing quality of the material. Commercial fast growing forests give good material for the paper industry but this is no good for building purposes.

When you choose good timber you need to think about the quality of the tree and which sort of tree it is. The quality is generally good when it has grown slowly and when the heartwood forms a large part of its section. The trunk has to be straight and should have as few branches as possible. If there are knots they have to be from growing branches, because knots from dead branches will fall off when the wood dries. Timber is classified according to is appearance and load–bearing capacity. 90% of the quality criteria are connected to its knots.

The appearance of timber depends on the way it has been sawn and the amount of knots and other visible disfiguration in it. The classes are A, B, C and D, where A is best and D substandard. Classes A and B are suitable for a plank roof. This means a maximum of 6 or 8 knots respectively on the very worst one meter stretch of the material. Naturally, the material has to be sorted also in situ before use.

The loadbearing capacity of a piece of timber depends on its elasticity, stiffness and density. This can be graded either visually or mechanically and classified accordingly into strength classes (eg. C24) which are specified in the European standard EN 338. All construction timbers must be CE–marked.

Pine (Pinus sylvestris)

Pine trees can grow up to 600 years old, but normally around 250 years. A mature tree is 15–30 m high depending on the conditions of its growth place.

Good pine trees can best be found on northern slopes in relatively poor soil and fairly dry conditions. The slower they grow, the denser the material. The density of a Finnish pine tree varies between 370 and 550kg/m^3. Pine is a good tree to make planks of because the bottom half—or more—of a mature tree is without branches. It grows more slowly than spruce and there are fewer branches than in spruce but they are generally thicker and bigger.

The yellow–red sapwood of pine is prone to swelling and shrinking and consequent decay from dampness, while the darker resinous heartwood is water–repellent and also naturally resistant to fungi and insects thanks to pinosylvin, a natural fungitoxin in it. From this we can conclude that only the heartwood of pine is good as roofing material.

Spruce (Picea abies)

Spruce is a fast growing pyramidal conifer. It can grow up to 20–30 m tall and usually around 250–350 years old but it can live up to 500 years.

The material is lighter and softer than pine, but it is also tough and its fibres are straight. The tree has many branches, but they are thin compared to pine. The spruce dries faster than pine because of its lower density, i.e. 300–470 kg/m^3. The timber is yellowish white throughout, hence the commercial name whitewood.

The heartwood of spruce does not contain *pinosylvin* and has less resin than the pine but its cell structure is superior. Both heartwood and sapwood of spruce will stay dry after it has been dried. The conclusion is that spruce is the safer choice for a plank roof.

Both species were chosen for the plank roof on the *loft* on Campus Ekenäs in order to be able to monitor the durability of the two.

1.3 BUILDING A PLANK ROOF STEP BY STEP

1. Make sure the supporting roof structure is straight in all directions.
2. Choose a sufficient amount of good timber and plane it with one or two grooves along each side.
3. Build scaffolds around the roof.
4. Sort roofing planks into piles by quality and wood species.
5. Start at the middle of one side of the roof and work towards the gables.
6. Lay one plank after the other, 2–3 at a time, on the purlins with the top end over the ridge beam, measuring the distance between the planks and nailing them into position
7. Tar the planks.
8. Place a second layer of planks with equal spacing as the first to cover the gaps between the bottom planks: 2–3 at a time.
9. Nail the upper planks with handmade hot–forged nails through bottom planks and into the purlins.
10. Tar the top planks as the work goes on.
11. Trim the edges and seal the ridge.
12. Take down the scaffolding and clean the site.

Figure 1.3. Smooth cooperation between the three nationalities. Photograph by Kaisa–Piia Pedajas.

Figure 1.4. Banging the big nails into the purlins was hard work. Photograph by Siim Raie.

Once on the roof students from UU, Campus Gotland, Estonian Academy of Arts and Novia took turns to help each other with nailing roofing planks onto the purlins (figure 1.3).

A first layer of roofing planks was placed and secured with standard three inch nails. The boards were laid at intervals of about 1, 5 cm to allow for the natural movement of the material that will be caused by rain and varying humidity in the air.

After 3–4 boards were mounted and tarred, a new layer was produced. This upper layer, which is to withstand the worst strain from the elements, is laid with boards of best available quality while the quality of the bottom layer could be slightly less. The top boards were fastened with black hand–forged nails in an overlapping pattern (figures 1.4, 1.5).

At first, each top board was nailed down with a couple standard nails to hold them in position. To avoid splitting the planks, holes for the hand–forged nails were made with a battery screwdriver. The nails which are about 15 cm long were placed in pairs near the edge of the top plank and then driven through the bottom planks and into the purlins.

Figure 1.5. The bottom planks were tarred for the second time as the work went on. Photograph by Kaisa–Piia Pedajas.

Boards of different wood went on each side of the roof so that one half was with pine and the other with spruce. The idea is to be able to monitor which boards fare better than others, and thus to prove which type of wood is best for plank roofs. The top layer of boards was not tarred until the next summer.

A groove acting as a runoff for water, about 2 cm wide, had been milled along the outer edge of each plank. The planks were planed with the heartwood downwards so that they will form a slightly concave section as they will dry over the years. The material had been tarred once already before it went up. Students sorted it according to quality and species (figure 1.4).

Figure 1.6. Niklas Nyman (on top) kept a watchful eye on everybody.

Figure 1.7. Drilling and nailing, drilling and nailing 650 times over.

The students who worked on the ground passed on the boards to the team on the roof. The boards were placed so that rainwater on the roof would not stagnate and cause decay. The important point here was that the fibres that had been cut by the saw were directed downward. This is why the logs had been painted at the bottom end already in the forest. Hence, with the heartwood inwards, the root end of the planks must point down (figure 1.6).

When all planks were fixed, protruding purlins and ends of planks were sawn off with a chainsaw to form straight eaves. The ridge of the roof was sealed with two planks nailed tightly together and onto the new roofing (figure 1.8).

Figure 1.8. By lunch break on the fifth day the roof was complete while the paintwork on the façade still needed some finishing touches. The badly decayed front corner was secured at a later date. Photograph by Kirsti Horn.

Figure 1.9. Detail of the eaves. Photograph by Michael Diedrichs.

2. Traditional Paintwork on Wood

2.1 INTRODUCTION: TRADITIONAL PAINTS FOR WOODEN FAÇADES

There is a lot to be learned from traditional paintwork. The first and foremost aspect is that it mainly consists of non–toxic ingredients that go well with the underlying material. They follow rule number one for all paintwork which is that it should never be tougher or more impermeable than the surface it is applied on. When paints from different times are compared, the difference lies in the qualities of the binders. Traditional binders are natural oils and glues, while modern binders are mainly based on plastics.

There are two reasons for applying paint on a surface: to decorate and to protect from decay caused by dampness, UV radiation or destruction by fire. Pigments that play an essential part in the decoration business have changed over the times from natural products that can be dug from the ground, or extracted from plants, to artificial chemical compounds. This results in variations in the hues and colour schemes of different periods of architectural history.

Paints always consist of pigments and binders, but can also contain all kinds of additives such as drying agents, solvents, biocides and fungicides. Many additives are toxic as they give paints all kinds of extra qualities: protection against rot, rust and fire, shelf life, workability, fast drying etc.

A paint studio was set up during the intensive course in order to illustrate the alternatives we have to the modern, commercial, plastic–based, artificially tinted concoctions that can be bought at every ironmonger's.

Figure 2.1. View from the paint studio. Colour charts are being made. Photograph by Frida Nordström.

2.2 TRADITIONAL BINDERS FOR EXTERNAL WOODEN SURFACES

The binder is the film–forming component in the paint. Different types of binders possess different attributes, and have therefore been used for different purposes. In the following the qualities of five different traditional binders are discussed.

2.2.1 LINSEED OIL

The binder in linseed oil paint is, as the name implies, the oil which is pressed from the edible seeds of flax i.e. the linseed plant. Before the oil can be successfully used for painting, it has to be boiled for a couple of hours at a temperature over 200°C. Traditionally some minerals (lead oxide, umbra etc.) were added at this stage to enhance the drying process. This is done likewise today. Consequently, the commercial boiled oil is not edible or suitable for impregnating cutting boards or table tops in the kitchen.

The heating makes the oil polymerize and oxidize. This shortens its drying on the wall. The drying of linseed oil is chemically a slow process of oxidation in contrast to other traditional binders which dry through the evaporation of water or some other solvent. Instead, this binder expands as it oxidates and finds its way into the top cells of the timber and all the small cracks of the surface.

In addition to the boiled oil and pigments, siccative (a drying agent) and sometimes also solvents and other additives can be added. Solvents (turpentine) are known to make the oil weak and should therefore not be used out–of–doors.

2.2.2 TAR

Traditionally tar was used rather as a wood preservative than a binder. It can be successfully mixed with linseed oil (see chapter 2.4.1.2) and tinted with earth pigments. The processing of pine wood to tar is discussed in chapter 1.2.2.

2.2.3 PETROLEUM (LAMP OIL)

Petroleum contains some substances that can act as binders. This is why it is a better solvent for linseed oil than turpentine. Petroleum is too weak as a binder on its own and is therefore always mixed with linseed oil. Because petroleum has a very strong odour, it is suitable only for outdoor use.

2.2.4 RYE FLOUR

The binder in the rye flour paint is the starch in the flour. Through several hours of boiling with water the starch turns into glue which binds the pigments. A small amount of linseed oil is often added as well, to strengthen the binder and make the paint more resistant to water.

2.2.5 CASEIN

Casein is the name for a family of proteins, and has a long history as a binder in traditional paint. Casein can be found in milk products, and it has therefore been common to use for example milk or quark when making paint. Either lime or cement must be added to make the milk paint water–resistant. These alkaline substances make the casein harden and produce a very durable paint.

2.3 TRADITIONAL PIGMENTS FOR EXTERNAL WOODEN SURFACES

Traditional in this case means pigments that were in use in Sweden, Finland and Estonia during the 18th and 19th centuries. In the following a list of traditional inorganic weatherproof pigments is presented. All of these are known to be sustainable and suitable for the exterior of wooden buildings (figure 2.2). Most of them are manmade from various minerals, but some can be found in the earth. They can be mixed in oil and tar based paints as well as water–soluble paints. They are still available in specialized shops and used for not only restoration purposes but also for new buildings in connection with traditional binders. The choice of colours was traditionally limited to red, yellow and white and mixtures of these, while brown and black were used to heighten details or tint the primary pigments. The palette became more varied towards the end of the 19th century with the change of architectural style and thanks to the development in the paint industry.

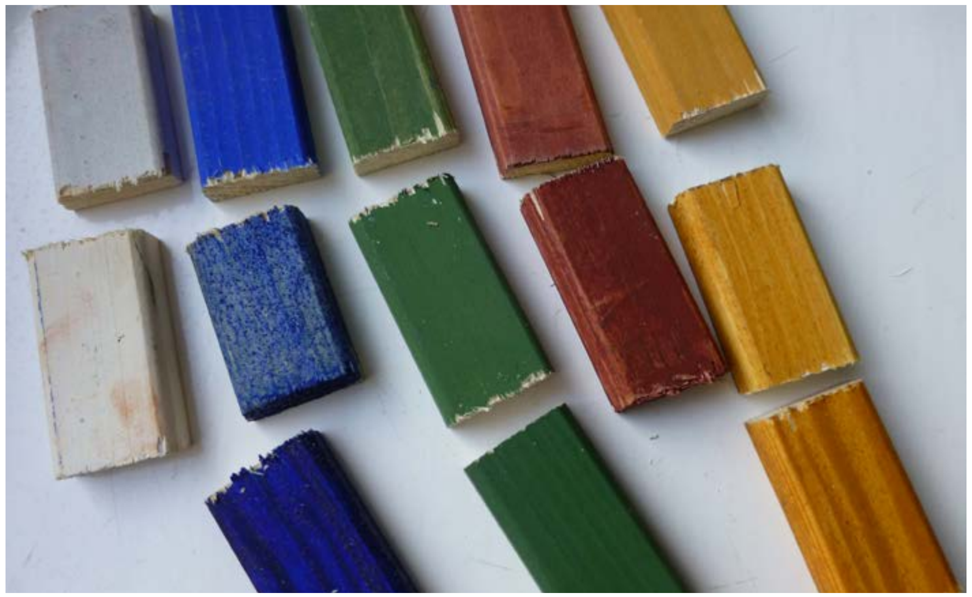

Figure 2.2. Experiments from the paint studio. Some of the samples of different pigments and binders: milk–cement in top row, petroleum in the middle, linseed oil at the bottom. Photograph by Kirsti Horn.

2.3.1 RED

Falun red (manmade)

Red pigments have good opacity and excellent light resistance and good resistance against corrosion. Falun red pigment has been widely used in the production of traditional red paint in Sweden and Finland ever since mid 18th century. The pigment is manufactured from sulphuric discarded copper ore at the copper mines in Falun, in northern Sweden. It contains copper, ferrous ochre, silicic acid and zinc.

Red earth

Red earth pigments can be found in the ground at several locations all over the world. These are usually named according to where they are found. As a rule, red is iron oxide and it can be made darker through heating (burning).

2.3.2 YELLOW

Yellow ocher

Thanks to good availability and a relatively low price, ochre is widely used on wooden façades. This pigment has very good UV resistance and opacity. Depending on content of iron compounds, ochre can be found in many different shades of yellow.

Umbra

Umbra consists of clay with iron and manganese oxides. It has an earthy greenish yellow tint.

2.3.3 BROWN

Burnt ochre (manmade)

Browns and darker shades of yellow can be produced through heating the natural ochre.

Burnt umbra (manmade)

A reddish brown is attained through burning the natural umbra.

2.3.4 WHITE

Lead oxide, zinc oxide and titanium white (all manmade)

The very toxic yellowish white lead oxide and the less poisonous zinc oxide were commonly in use in paints still in the 1960's. This must be remembered when removing old layers of paint. Today lead and zinc are not used in modern paints thanks to EU regulations.

It was not until the 1920's that nontoxic titanium dioxide was developed for painting purposes. Titanium white is a most pure white pigment with very good opacity.

Lime

Lime is suitable as a pigment in water soluble paints but loses its opacity when mixed with oil.

2.3.5 BLACK

Lamp black / Chimney black (manmade)

Most black pigments are organic, i.e. they consist of carbon which is the result of burning organic materials (bone, plants, coal, gas, oil). Chimney black[3] is the best of these in terms of opacity.

Falun black (manmade)

An inorganic black pigment is made by burning the Falun red at high temperatures.

2.3.6 GREEN

Chrome oxide green (manmade)

This is one of the most used green pigments in architectural surface treatment. The pigment has very good opacity. It was invented in the early 19th century but the use as a paint coloring pigment did not start until 1892.

3 Chimney black: *kimrök* in Swedish; *kimrööki* in Finnish.

Figure 2.3. Experiments from the paint studio. Hues with various earth pigments and linseed oil: from left Kassel brown, Falun red, Terra di Siena, Terra, bright green earth, Caput Mortum, Ochre, burned Umbra, Ultramarine, burnt green earth, Terra di Pozzuoli, English red and burned Umbra. Photograph by Kirsti Horn.

2.4 EXPERIMENTS WITH BINDERS AND PIGMENTS

In the paint studio during the intensive course in Ekenäs 2013 several experiments were made with linseed oil paints and variations of it. Also milk–cement paint was experimented with while the 40 liters of rye flour gruel which was cooked with Falun red was applied on the walls of the storage building we restored.

From these exercises each participant obtained 14 colour charts and 20 different colour samples on pieces of wood.

The paint recipes for these experiments are all taken from *Kevät toi maalarin* by Panu Kaila.

2.4.1 PAINTS WITH LINSEED OIL AS BINDER

The result of the experiments with linseed oil paints were colour charts painted on cardboard. Each sheet consisted of one pigment in three different shades, e.g. terra, terra + white, terra + black. We used 14 different pigments and made a colour chart for each pigment. The following pigments were used: Terra, Terra Pozzuoli, Terra di Siena, Umbra, Burnt umbra, Green earth, Burnt green earth, Caput mortum, Ocher, Kassel brown, English red, Ultra marine, Falun red, Titanium white and Chimney black. The binder was boiled linseed oil (figure 2.3).

The next experiment was to compare linseed oil paint with petroleum + linseed oil paint and tar + linseed oil paint. In this experiment the following pigments were used: Falun red, Titanium white, Chrome oxide green, Yellow ocher and Ultramarine blue. Samples painted on wooden sticks were compared and the conclusions are as follows:

- The colour of linseed oil and petroleum + linseed oil paint was almost identical. The binder had no effect on the tone of the pigment but the amount of pigment obviously affected the opacity.
- The tar + linseed oil paint was much darker in colour than the other ones, i.e. the darkness of the tar affected the hue.
- The petroleum + linseed oil paint dried fastest, i.e. in 1–2 days.
- The linseed oil paint dried in 2–4 days.
- The tar + linseed oil paint took weeks to dry.

2.4.1.1 LINSEED OIL PAINT

Linseed oil has been used in several generations on wooden façades ever since the 18th century. Earlier it was used only on works of art, furniture, wooden details indoors and the finer details of façades: windows and doors and their planed moldings and sills. Because it was costly, only the planed façade paneling of finer buildings such as mansions and churches were painted with linseed oil paint.

It would be a waste of paint and money to apply it on rough surfaces but instead, it should be used on smooth surfaces where it sticks in any case when it is applied in thin layers on dry, untreated wood. Fresh timber should be allowed to air a year or two before it is painted with any kind of oil paint.

Traditional linseed oil paint is made of pressed and boiled linseed oil and pigments. Linseed oil paint contains neither solvents nor any plastic or alkyd binders. By using linseed oil paint you enable the wood underneath to breathe because the coat of paint crackles to minute squares as the oil matures. The underlying wood does not decay when it can dry through the microscopic cracks. With time the cracks grow wider (visible) and the oil weaker. At some point the paint then loses grip of the underlying surface and will be easy to remove. But before this it is easy to repaint an old surface of oil paint as a new coat can be applied without removing any of the old paint as long as it sticks to the underlying wood. This should be done every 15–30 years on a façade depending on weather conditions.

Conditions for successful paintwork

Temperature: above +10°C

Moisture in the wood: max 15%

RH in the air: below 80%

Drying: light and a temperature above +10°C are necessary.

Drying time: 2–3 days (20°C and RH <50%)

Primers, number of coats: according to specification by manufacturer

Note: avoid painting in direct sunlight or on warm surfaces.

Recipe for *linseed oil paint*

- Boiled linseed oil
- Pigment
- Max 2% siccative for faster drying

2.4.1.2 TAR + LINSEED OIL, OR ROSLAG'S MAHOGANY

Roslag's mahogany is a paint that consists of linseed oil, tar, pine turpentine and pigments. For a fine brown traditional impregnation no pigments are needed. Roslag's mahogany is good for outdoor surfaces, and because it contains linseed oil it can be used on all wooden surfaces regardless of structure. Roslag's mahogany has traditionally been used for boats. Its origins are in the fishing communities of Roslagen, Sweden.

Conditions for successful paintwork

Temperature: above +5°C

Moisture in the wood: max 15%

RH in the air: below 80%

Drying time: 2–3 weeks; less in sunny places.

Recipe for *tar–oil paint*

- Tar 1/3
- Boiled linseed oil 1/3
- Pine turpentine 1/3 or less
- Pigment

2.4.1.3 PETROLEUM PAINT

Petroleum paint consists of petroleum based oil (lamp oil), boiled linseed oil and pigment. This is a paint that is sometimes used as a substitute to linseed oil paint because the lamp oil is cheaper. Since it consists of petroleum based products, it is not very environment friendly.

Conditions for successful paintwork

Temperature: above +10°C

Moisture in the wood: max 15%

RH in the air: below 80%

Drying: light and temperature above +10°C are necessary.

Drying time: 2–3 days (20°C and RH <50%)

Primers, number of coats: according to specification by manufacturer

Note: avoid painting in direct sunlight or on warm surfaces.

Recipe for *petroleum paint*

- Lamp oil 5 dl
- Boiled linseed oil 1 dl
- Pigment

2.4.2 WATER–SOLUBLE TRADITIONAL PAINTS

Inexpensive paints can be made of ingredients familiar to every DIY household. The pigments are the only part that has to be bought from a specialist supplier. Red earth and ochre give maybe the best results but many other earth pigments can be used here just as well.

2.4.2.1 PAINT WITH MILK (CASEIN) AND CEMENT AS BINDER

Milk–based paints have been in use already for centuries. Today traditional milk paints have been revived as ecological and economical alternatives to the commercial paints which usually contain plastics.

It is better to use low–fat or fat–free milk. In order to attain an opaque coating, fillers (flour of dolomite or marble) are added to the mixture. When using casein paint, it must be remembered that it is a perishable material. Therefore it would be wise to use it as quickly as possible. Preserved at cold temperature (not below zero) and in a sealed container it is usable for a week.

Milk–cement or milk–lime paint is suited for stiff nonfat surfaces and leaves a matt water–proof coating. Before using the paint, the surfaces must be clean and dry. If the surface is very smooth or shiny, it must be made coarse. It is good to let the paint set for about 15–20 minutes before starting to apply it. Yet, while painting it must be stirred constantly to avoid the setting of the cement.

Conditions for successful paintwork

Temperature: 5–20°C

Drying time: 6 h

Note: avoid painting in direct sunlight.

Recipe for *milk–cement paint*

- 9/10 fat–free milk
- 1/10 cement
- pigment

2.4.2.2 PAINT WITH RYE FLOWER AS BINDER

Rye flour paint is one of the oldest traditional paint types in Sweden and Finland. It is inexpensive and environment friendly. It has limited binding ability but is nevertheless very durable with a good lifespan. It becomes wet, and dries depending on the weather.

Generally it is applied on rough wooden surfaces. It gives a nice matt finishing and protects wood from decay. It is easy to maintain and can always be repainted. The classical warm red colour is obtained with the pigment called Falun red, but also other UV resistant pigments can be used.

Conditions for successful paintwork

Temperature: 0–20°C

RH in the air: preferably near 100%, but less is just as good

Drying time: depends on the temperature

Note: Paint with added oil should be applied when it is still warm. All rye flour paint can be used straight from the kettle.

Recipe for *rye flour paint*

- 50 l water
- 2 kg ferrous sulfate
- 4 kg rye flour
- 8 kg red earth pigment
- (for risky surfaces add boiled linseed oil 5–10% of the whole volume)

To make rye flour paint you first mix ferrous sulfate with cold water and heat it up. Stir until it dissolves. Mix flour with a small amount of cold water to get a porridge–like mixture. Add the flour mixture in the kettle. Bring it to boil and then lower the heat and let it simmer for 2–3 hours stirring it constantly. Add the pigment towards the end of the cooking time and watch out for a sudden boiling over. The aim is to create a homogeneous mixture. Remove from heat and in case of risky surfaces, add linseed oil while stirring well to create an emulsion (figures 2.4–2.7).

Figure 2.4. The cold mixture of water and rye flour is added to the boiling mixture of water and ferrous sulphate. Photograph by Triin Jänes.

Figure 2.5. Turns were taken by the kettle; here, Krista Laido is stirring the gruel for the red earth paint. Photograph by Kirsti Horn.

Figure 2.6. Finally the red earth pigment was mixed little by little with the hot gruel. Photograph by Eva Tammekivi.

Figure 2.7. Applying red earth paint can be done even in bad weather. It is advisable to heat up the paint if the temperature is low. Photograph by Kirsti Horn.

2.5 WHAT PAINT SHOULD BE USED ON WHAT KIND OF WOODEN FAÇADE?

The following table can be used as a guideline for what kind of surfaces are suitable for the different traditional paints that are discussed above.

Type of paint	Recommended surface structure (wood)
Linseed oil paint	smooth planed wooden surfaces eg. joinery and planed boards, panels and trimmings
Petroleum + linseed oil paint	smooth planed or rough planed and sawn surfaces
Tar + linseed oil paint	smooth planed or rough planed surfaces
Milk + cement paint Milk + lime paint	rough surfaces or sawn surfaces
Rye flour paint	rough surfaces or sawn surfaces

Table 2.1. Types of paint for recommended surface structures (wood).

3. Conclusions

The project **Traditional Wooden and Masonry Structures in the Baltic Sea Region** is designed for students of building conservation, conservation of artefacts, structural engineering and site management from three universities in Sweden, Estonia and Finland in order to give them the opportunity to learn about the traditional materials in different parts of buildings. From the conservation point of view they learn how constructions and surfaces made of these materials are to be preserved and maintained in the best manner. The hands–on work, which is an integral part of each course, opens eyes also to the possibilities of applying the best of traditional crafts in the modern building industry. The objective is to contribute to the preservation of some historic monument during the days of practical work (figures 3.1–3.2).

This report—no. 5 in the series—is yet another testimony of not only successful arrangements, inspiring teachers, fascinating lectures and highly motivated students, but also of the fact that all the mentioned goals were reached. Firstly: the intensive course in Ekenäs in April 2013 contributed to the rescue of a listed building. Secondly: all participants deepened their understanding for wood as a construction material and the ways its surface should be treated.

Finally, the articles in this report will certainly spread interest, knowledge and respect for historic monuments and all the various aspects these represent in general, and wooden buildings in particular.

Figure 3.1. On the back of the *loft* the weatherboarding had to be patched. Vertical supports to the structure can be seen in the middle of the gable and at the far corner.

Figure 3.2. Success! The listed building has been saved to future generations. Yet, there is more to be done in coming years… We look forward to continuing.

Figure 3.3. Student Authors (group photo): Emilia Eklund, Robert Engman, Jonas Isaksson, Jonas Lindqvist, Einar Lindroos, Gustaf Lindroos, Lucas Mondino, Andreas Pettersson, Micael Westerholm and Simon Öst *(Novia University of Applied Sciences);* Kristina Aas, Triin Jänes, Karoliine Korol, Kaisa–Piia Pedajas, Siim Raie, Sille Sombri and Eva Tammekivi *(Estonian Academy of Arts);* Anne Jeppson, Lisa Johansson, Anna Martin Bergman, Frida Nordström, Lena Pella, Robin Renman Åqvist, Elin Sahlin, Erik Slesgård and Jonas Sundvall *(Uppsala University).* Teachers in front from left: Niklas Nyman (with helmet), Towe Andersson (red cap), Joakim Hansson (in black), Kirsti Horn (in blue) and Krista Laido (in white), Joosep Metslang in the window. Photographs in figures 3.1–3 by Michael Diedrichs.

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Appendix

Programme Wooden Roofs and Traditional Surface Treatment of Wood —Intensive Course No. 2

Intensive Course No. 2: 'Wooden Roofs and Traditional Surface Treatment of Wood' in Ekenäs, Finland, 14.–20.4.2012; Nordplus Framework Programme 2012–2016, Traditional Wooden and Masonry Structures in the Baltic Sea Region—Intensive Course within the Field of Building Conservation.

Programme	Group 1+2	Group 1	Group 2	After hours
Day 1 / Sunday, April 14, 2013				
	Arrival in Helsinki Visit to open air museum Transport to Ekenäs **Introduction** to project, site and schedule Welcome dinner			
Day 2 / Monday, April 15, 2013				
	8:30–9:30 **Lecture** Joosep Metslang: 'Wooden roofs in Estonia'	**Hands–on work:** building of plank roof	**Paint workshop:** experiments with different binders and pigments	Sauna
Day 3 / Tuesday, April 16, 2013				
	8:30–10:00 **Lecture/walk** Joakim Hansson: 'Good and bad paintwork in Ekenäs'	**Paint workshop:** experiments with different binders and pigments	**Hands–on work:** building of plank roof	Sauna
Day 4 / Wednesday, April 17, 2013				
		Hands–on: building of plank roof	**Paint workshop:** (experiments continue)	Dinner for students and teachers
	Late afternoon: excursion Visit to a local saw mill; guided walk in pine forest			

Programme	Group 1+2	Group 1	Group 2	After hours
Day 5 / Thursday, April 18, 2013				
	8:30–10:00 **Lecture** Prof. Uwe Noldt: 'Structural damage by wood boring insects in the Nordic countries'	**Paint workshop:** making of red earth paint	**Hands–on:** building of plank roof	Sauna
Day 6 / Friday, April 19, 2013				
	8:30–10:00 **Lecture** Prof. Uwe Noldt: case study in situ	Finishing the roof; painting the facades; taking down the scaffolding		Sauna, taklagsöl
Day 7 / Saturday, April 20, 2013				
	Foreign students and teachers travel home			

About Estonian Academy of Arts

Estonian Academy of Arts (EAA) is the only public university in Estonia offering higher education in fine arts, design, architecture, media, visual studies, art culture, cultural heritage and conservation.

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About Traditional Wooden and Masonry Structures
in the Baltic Sea Region

The project *Traditional Wooden and Masonry Structures in the Baltic Sea Region* is a partner project in Building Conservation involving Campus Gotland at Uppsala University, Sweden, the Estonian Academy of Arts in Tallinn, Estonia, and Novia University of Applied Sciences in Ekenäs, Finland. This is a follow up of an earlier, very successful project called *Sustainable Heritage* during which both publication series and an online project site were established. The strategy is a course structure spanning over five years, 2012–2016, to cover a sufficiently wide area of valuable objects of study and thereby forming an entirety. There will be two intensive courses arranged annually with wood and masonry as themes—one every autumn and one every spring. The intensive courses are tailored for students of *Construction Engineering and Construction Management* at Novia UAS, *Building Conservation and Objects Antiquarian Programmes* at Uppsala University and *Architectural Conservation and Conservation of Artefacts* at Estonian Academy of Arts in Estonia. These courses are hosted by the three partner universities in turns and they are designed to widen the scope of the standard curriculum in each school. The Nordic–Baltic Network is financed by the *Nordic Council of Ministers* through Nordplus funds and its cooperation is run by Novia UAS. The course programme consists of a wide range of themes which concentrate on the two main building materials of our region: stone and wood. The aim is to learn how these are to be preserved in the best manner and how traditional building and decorating techniques can be applied in modern building.

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This report is about rescuing a historic building from total destruction and experiments with traditional paintwork; it is also about what an international group of students learned through lectures, excursions and their working experience in Ekenäs, Finland.

*The project **Traditional Wooden and Masonry Structures in the Baltic Sea Region** is designed for students of building conservation, conservation of artefacts, structural engineers and site management from three universities in Sweden, Estonia and Finland in order to give them the opportunity to learn about the traditional materials in different parts of buildings.*

From the conservation point of view they learn how constructions and surfaces made of these materials are to be preserved in the best manner.

Please, help yourself to more reports and views of the hands–on activities at various historic sites at www.sustainableheritage.fi.

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