

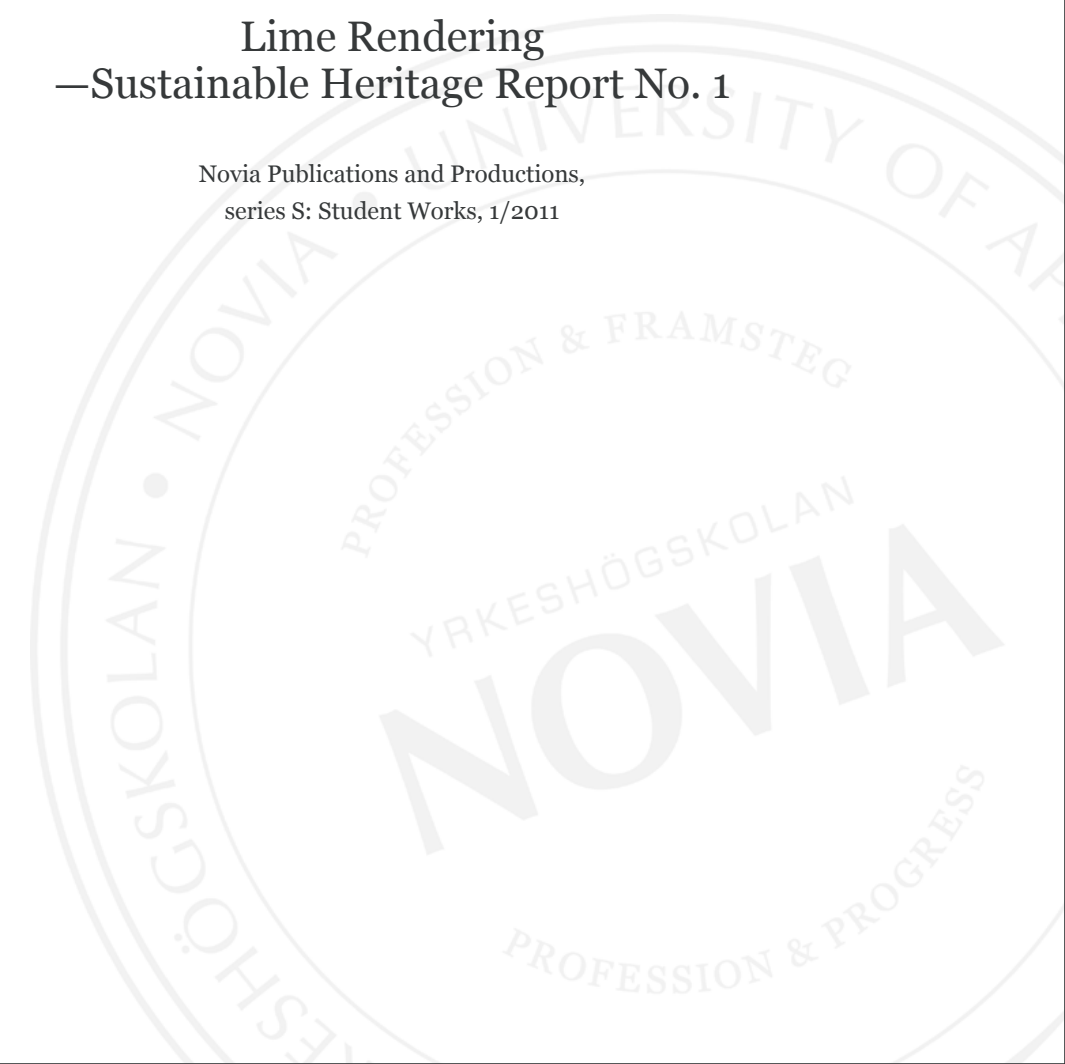


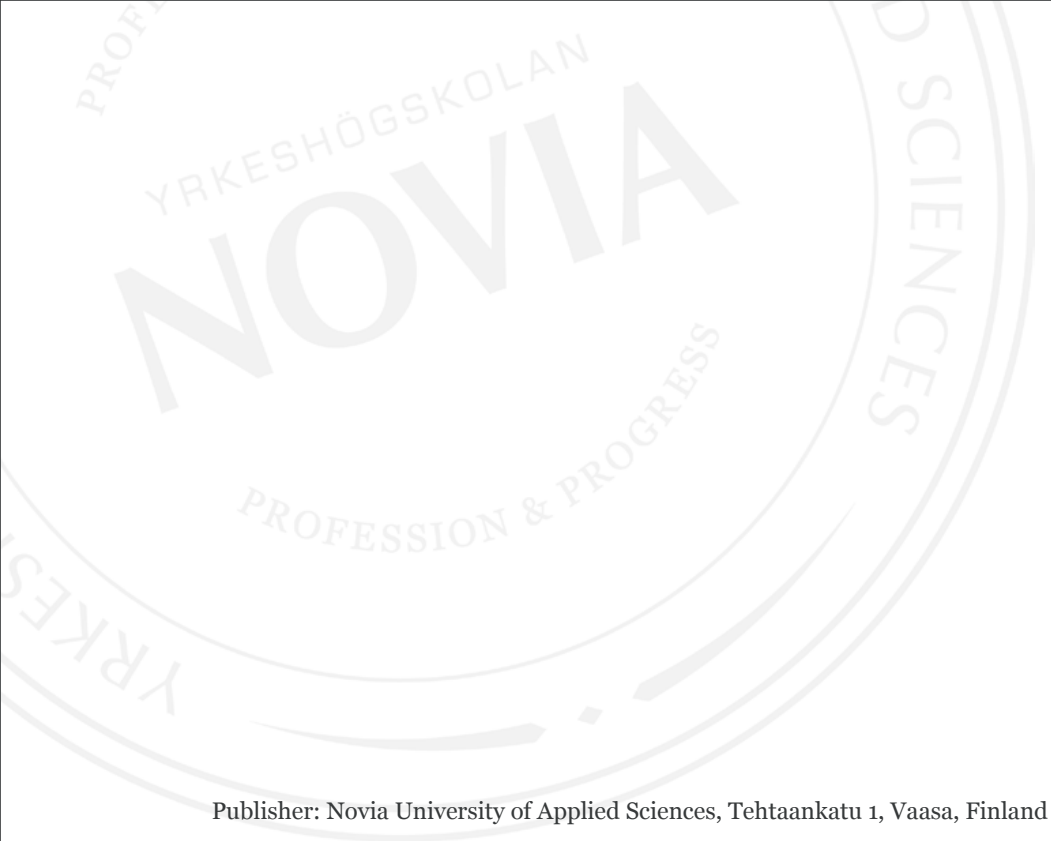
Lime Rendering —Sustainable Heritage Report No. 1

Kirsti Horn, editor

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A joint project between Gotland University, Estonian Academy of Arts and
Novia University of Applied Sciences. Report by Finnish students.



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Summary

This report is a description of lime rendering, lime wash and the intensive course ***Lime Rendering*** in Visby, Sweden, which was attended by students from Gotland University in Sweden, University of Applied Sciences Novia in Finland and Estonian Academy of Arts in Estonia during a mild week in September of 2009. This was the first intensive course within the joint project Sustainable Heritage, which is financed by the Nordic Council through Nordplus stipends.

While rendering old buildings it is important to choose such new materials that work together with the original surface and structure. It is always safer to use soft materials, like pure lime renders, but this puts higher demands on the workmanship. In new buildings, mixtures of lime and cement might be the best solution.

Both cement and lime have good and less good qualities and they work in different ways. This is why more research is needed and information must be spread so that we can profit from the best qualities in each of them. The report deals with the subject from the point of building physics as well as from a practical perspective.

Introduction

In September 2009, students and teachers from Sweden, Estonia and Finland gathered in Visby for an intensive course with the theme lime rendering. The programme was organized and run by Kristin Balksten, doctor of Technology, from Gotland University. She was assisted by Sivert Cederlund, master mason of true Gotlandic tradition.

This was the fourth international course organized in cooperation by Novia University of Applied Sciences, Finland, and Gotland University, Sweden, and for the first time we were also joined by The Estonian Academy of Arts. SUSTAINABLE HERITAGE is a joint Nordplus project between the three schools and it is financed by The Nordic Council. Know-how in the field of conservation is spread through hands-on exercises which are backed by expert lectures, excursions and other activities designed to promote cooperation and exchange of ideas between the participating students. The schools take turns in organizing and hosting these annual intensive courses.

Hereby we proudly present the Finnish report about what we learned during the stimulating and enjoyable week in wonderful Visby. With thanks to Kristin Balksten for a most inspiring course,

Kirsti Horn, Senior lecturer, Architect SAFA, AA Dipl., together with students from Novia University of Applied Sciences.



Authors from top left: Max Levander, Rasmus Fredriksson, Mårten Sjöström, Andreas Salonen, Max Lyly, Miika Koljonen, Isa Melander, Annika Grahn.

1. Short history of lime and the use of lime as a binder in renders¹

Around the Baltic Sea, limestone suitable for burning can be found on Gotland, Öland, in the Baltic countries and in Southern Finland (Parainen, Lohja and Lappeenranta). Limestone consists of compressed lime shelled maritime animal and vegetable fossils. The chemical formula for lime is CaCO_3 , calcium carbonate.

Burned and slaked limestone has been used as a binder in mortars for thousands of years worldwide. Masons from Balticum, Central Europe and Sweden brought the knowledge to Finland in the 12th century. Lime was used as the main binder in mortars and renders until the 20th century, when craftsmen started to add more and more cement. (BY46 Rappauskirja 2005) The use of lime alone as a binder was soon forgotten as the use of cement increased.

“In literature written after World War II the relation to lime changed drastically. It is no longer presented as an independent material but a reference material, a weak version of lime–cement mortar not to be used.” (Balksten 2007)

In the 1970's the use of lime as a binder was revived. By then, the knowledge of working the material had been forgotten and thus lime mortars and renders where worked in the same way as those that have a combination of lime and cement as binder. Kristin Balksten (2007) proved through her microscopic studies that this is wrong. Lime renders have to be allowed to set before the final smoothing of the surface can be performed.

¹ The words render, plaster and mortar have many meanings. In literature, even in expert articles, encyclopedias and dictionaries they are used in a confusing manner, which makes it difficult to grasp the precise meaning of matters. This article deals mainly with exteriors of masonry buildings. The following interpretations for render, plaster and mortar are used:

render: the mixture of sand, water and lime or sand, water, lime and cement which is used for evening out and decorating masonry facades (lime render also on wood)

plaster: a similar mixture used indoors, often including gypsum

rendering: the finished surface of one or more layers of render

mortar: the mixture of sand, water and lime or sand, water, lime and cement which is used as bond between bricks or stones

In Finland, consequences of the forgotten craftsmanship and knowledge can be found at Suomenlinna fortress. Wrong methods and materials were used in repairs in the 70's and 80's. Luckily the errors were acknowledged and Thorborg von Konow, Ph.D. among others set out to correct these misjudgments. von Konow and Suomenlinna Service Committee also published a book, *Laastit vanhoissa rakenteissa*, based on their conclusions of how to repair renders and plasters in old buildings. (Mölsä 2007)

2. Understanding the lime cycle and lime as a binder

The lime cycle is a way of explaining the chemical process of how lime is produced and how it changes after it has been applied to the wall. The cycle has three main steps; burning, slaking and carbonation. Control of each step of the process is of crucial importance in order to gain the most suitable properties for the application in mind.

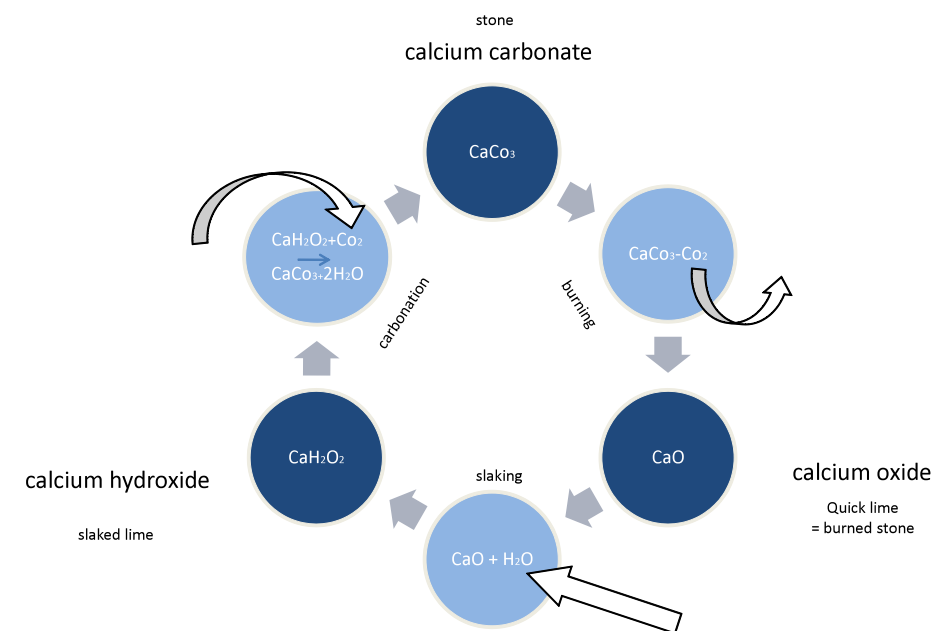


Figure 1. The lime cycle.

2.1 BURNING

Limestone is collected from quarries and the pieces are sorted according to size and quality. The pure limestone, calcium carbonate (CaCO_3), can be burned at a temperature of 700–1200°C, but a slow burning at 900°C has proven to give the best properties. When the limestone is burned it is transformed into calcium oxide (CaO) as carbon dioxide (CO_2) is released into the air (figures 6, 7).

Depending on the burning time, burning temperature and the burning process the crystal structure of the burned lime will be very different. The slaking process will also be affected by the way the lime has been burned. Therefore it is quite important that the burning process is carefully controlled by craftsmen who know how this should be done in order to obtain certain properties. As mentioned earlier the optimal burning temperature is 700–1200°C and it is very important that the temperature is no higher than 1400°C as such high temperatures might melt the lime stone making it impossible to slake in the next process. (Balksten 2007)

2.2 SLAKING AND STORING

Before calcium oxide can be used as a binder, it must be slaked, i.e. the lime must be allowed to react with water. When adding water to burned lime you create slaked lime, calcium hydroxide $\text{Ca}(\text{OH})_2$. There are four ways of slaking the lime; wet slaking, dry slaking, hot lime and earth slaking.

In both wet and dry slaking only pure water is added. **Dry slaking** is done by adding an exact amount of water. The result is a dry powder. In **wet slaking**, a surplus of water results in lime putty (figure 11).

Earth slaking is a traditional method. It is done by filling a pit in the ground with lime and then covering it with soil for a long period of time, usually several years. The moisture in the ground causes the lime to be slaked. When the lime has been slaked you have to whip it, and the result will be a smooth lime putty.

To make **hot lime** you cover the burned lime stones with sand and add some water. When the lime–sand pile starts to crack, the chemical process has begun. The volume of the lime will increase by approximately 100%. At this time you should

start to mix sand and lime to make render (hot lime). The mixture is ready to be used straight away. The making of hot lime is illustrated in chapter 8 (figures 8–10).

Storing the slaked lime is an important part of the slaking process since it affects the properties of the end product. There are different ways of storing slaked lime depending on which one of the first three methods for slaking has been used. The length of storage time also affects the properties of lime. The wet slaking method seems to have very different storing times depending on the manufacturer. One year is considered good enough, but some manufacturers keep it several years in the pit or grave². Earth slaked lime is stored for even a longer time, 5–10 years or more. Dry slaked lime must be kept from CO_2 if it should be stored for a long time. (Balksten 2007)

2.3 CARBONATION

When slaked lime reacts with CO_2 in the air the process is called carbonation. It is important that this reaction takes place throughout the render so that it gains a durable structure. For a complete carbonation it is required that water is available on top of the lime. CO_2 is dissolved in the water layer and transported into the lime together with the water. The carbonation process can be chemically described as following:



The level of carbonation can be measured as a rate that depends on the crystal structure of the lime and its permeability. Other variables that affect the carbonation rate are temperature and relative humidity, as well as the thickness of the render layers. (Balksten 2007)

2.4 MIXING RENDER

When mixing render there are two factors to be considered; the first thing is the ratio between lime, sand and water. The second thing is choosing the mixing technique.

² The slaked lime is stored in a wooden box which is buried in the ground below frost level.

The binder (lime) works as glue that binds the sand grits together. The ratio between the ingredients can be presented by weight relations e.g. 150/175/700, where 150 stand for lime, 175 for cement and 700 for sand. Typical ratios, based on volume, for pure lime render vary between 1:1 and 1:4, where the first figure stands for lime and the second for sand. A render with a mixing ratio greater than 1:2 is referred to as a fat render. Fat renders are more durable and have a greater frost resistance due to a more compact structure. (von Konow 1997)

You can mix the render using two types of machines: roller pan mortar mill or tombola. The roller pan mortar mill is suitable for mixing both dry and wet slaked lime. When mixing fat renders and lime putty the roller pan mortar mill is an excellent choice, due to its ability to mix very homogeneous mortars or renders. Dry slaked lime can be mixed with a tombola. The workability of the render depends on the mixing time.



Figure 2. Roller pan mortar mill and tombola (model: Multi-marque / Liner).
<http://www.multi-marque.co.uk/products.asp> (fetched: March 1, 2011).

2.5 ADDITIVES

Since the early use of lime renders and mortars there has been an interest to enhance certain properties in the mixture. This has been done by experimenting with additives. There are mainly three properties that you want to enhance: workability, frost resistance and water permeability. There are old stories about adding all kinds of materials in the render mix. E.g. to gain better water resistance eggs and linseed oil have been added. Animal hair, wood fiber or grass have been used as reinforcement. Even urine, dead animals, soap etc. have been found in old renders but their effect remains a mystery.

3. A comparison of lime–cement render and lime render

Until the 1950's renders were mostly made with lime alone as binder. These renders had a lime–aggregate mixing ratio of 1:1 to 1:3. (Museovirasto 2004) Such renders are referred to as fat renders, because of the high proportion of lime. (Balksten 2005) In the 21st century renders are often made thinner to enhance the workability with poor outcome. To create an outstanding result you have to know and respect the old techniques and consider every building individually. (Balksten 2005)

The cement industry did not start until the late 19th century. At first cement was used only for renderings on exposed buildings such as light houses but after World War II it has been a standard ingredient in rendering. Lime and cement have very different qualities as binder. Lime is elastic and dries slowly whereas cement rapidly creates a strong and stiff bond. (Balksten 2005) In lime–cement render, the amount of binder is usually smaller than in lime render. A typical lime–cement render consists of 1 part lime, 2 parts cement and 8 parts of aggregate. Craftsmen who are used to working with lime–cement renders, often imagine that the same small amount of binder is enough also when working with lime without the cement. Therefore they often make thin and fragile lime mixtures, that do not have the required strength, but a short lifespan instead. (Museovirasto 2004)

Another reason why modern craftsmen prefer thin renders is that fat renders shrink a lot when hardening. This can be avoided by adding water to the surface frequently after the rendering has been applied. This leads to a longer hardening process. It can take up to 2 weeks, depending on the surrounding conditions. (Balksten 2005)

Making a good quality finish with lime renders requires different work methods compared to modern lime–cement renders. But since modern craftsmen are simply not used to lime, they often fail to work it properly. If lime render is applied the same way as lime–cement render, the structure will become weak. A typical problem occurs when lime rendering is smoothed before it has hardened sufficiently. This makes the

lime rise to the surface creating a so–called lime film. This also prevents the following layers to adhere properly. (Klasén & Balksten 2005) It is of vital importance that the lime render should be allowed to firm up before it is pressed and smoothed to its final form. The process can take anything between one hour and several days depending on weather conditions and the ingredients in the render.

If an old lime render were to be repaired with a lime–cement render the outcome could be disastrous. As the cement is a stronger binder than lime, this will result in erosion of the underlying layer. This is due to the fact that the stronger layer will block moisture from exiting the construction and so the lime render is trapped in moist conditions. (Balksten 2005) Common for all repairs on renders, is that the new layer of render has to be weaker than the previous. This concludes that you can not apply lime–cement based products on lime rendering. The same applies to patches: The softer lime render will erode along the edges of a stronger patch. (Museovirasto 2004)

Even if the traditional and orthodox craftsmanship is almost forgotten, anyone who is open minded can learn the techniques. When using the correct mixing ratio and the right working techniques lime renders become as strong and durable as modern lime–cement renders. (Museovirasto 2004) Proof of this can be seen on numerous medieval churches e.g. on Gotland where the original rendering still does its job i.e. it protects the wall structure.

4. Maintenance and repair

It is important that the person who decides how to repair old rendering knows the history of lime render. An inexperienced or badly informed person often makes the wrong decisions and in the worst case he destroys the old rendering. To know what to do to a damaged surface, you need to know the following characteristics about the old render: sand curves (diagrams that depict the ratio between different sizes of grains in the sand), porosity of the sand, what binder has been used, mixing ratio, number of layers and type of lime wash. One way to find out these is by sending a lump of the old render to a specialized laboratory. But an experienced mason can easily get an overall picture of the properties of an old rendering by carving a hole through all its layers with a knife. The cavity provides information about the condition and consistence of the various layers. (Järvinen 2005)

When you know everything about the rendering and its damages, it is time to decide how to repair the damage. First of all it is important to deal with the cause to the damage before attending to the rendering. Most damages are caused by a combination of bad detailing, moisture and frost. Movements in the underlying structure cause cracking and a wrong choice of paint can be disastrous. Careless maintenance, too, can lead to expensive reparations. Depending on how extensive the damage is, there are four different ways to repair it. (BY 46 Rappauskirja 2005)

1. Repainting i.e. new lime washing.
2. Patching and new lime washing.
3. Stripping the old and making an entire new rendering and new lime washing.
4. Building an entirely new surface structure consisting of thermal insulation wire netting and rendering on the façade.

New rendering is necessary only if the old has failed altogether or if there are movements in the underlying structure that have to be dealt with. A new surface structure can be built for the same reasons but usually the bonus of extra thermal

insulation is the reason for this choice. The fact that this changes every detail on a façade is obviously a limiting factor.

5. Frost resistance of lime rendering and lime–cement rendering

Frost resistance of rendering depends on many different factors. It is impossible to use the same methods or materials in every object since no two old buildings are alike. Therefore deeper research and cooperation between engineers, architects, conservators and craftsmen is needed in every restoration project. Next, some important factors about frost resistance are presented in a comparison between renders of lime and lime–cement.

5.1 POROSITY AND DENSITY

Lime renders are more permeable than hydraulic renders³, due to a different chemical structure. This allows the moisture to travel both ways through the structure, which is a good feature because both render and underlying structure dry up effectively. This particular quality makes it possible to use lime render even on wood. (Balksten 2007)

Air pores save the rendering from damage even if the water in it freezes. While freezing can cause a lot of damage to a dense render pores neutralize the harmful pressure of freezing water. (BY 46 Rappauskirja 1999) In addition, the open surface of a low density render allows the lime wash to stick better than on a render of a higher density.

Renders that contain cement have generally a high density. The air pores are usually well shaped, but the amount of them is usually quite low. A dense material like lime–cement render is not suitable on soft materials like wood, old lime rendering or old bricks since it does not breathe and does not let moisture from underlying materials pass through. If cement render is used on a softer or weaker background, water will be gathered behind this dense skin. This will then destroy both underlying

³ While lime hardens by a slow process of carbonation as it reacts with carbon dioxide in the atmosphere over a period of weeks, hydraulic limes and cements set rapidly by reacting with water in a matter of hours. Hydraulic lime is made of stone that contains impurities, such as clay. Pozzolana, an Italian volcanic earth was added to mortars already by the Romans because its reaction with calcium hydroxide results in a strong mortar or concrete.

material and rendering. (Balksten 2007)

The frost resistance does not depend only on which binder—cement or lime—is used. Instead, the result depends on the mixture of binder(s), sand and water as a whole. Finally, the most important aspect is the craftsmanship. Even the best materials cannot compensate bad work. (Balksten 2007)



Figure 3. Students of structural engineering are busy learning the technique with best materials on masonry to the left and on wood to the right.

5.2 WORKING METHODS

One of the most important aspects when making render is that the mixture is homogeneous and well made. The render must be well mixed for quite a long time⁴ to get air in it. The air makes bubbles that become air pores in the render. (Balksten 2007)

Usage of different types and grades of sand reduces the necessity of large amounts of binders and water. A dry render is hard to work with but not vulnerable to cracking. Mixtures of cement and lime are usually easy and fast to work with and the results are therefore often more successful in our hectic times. Pure lime renders take several weeks to harden (carbonize) and there are more stages in the working of it compared to lime–cement renders. Any short cuts in the process result in inhomogeneous rendering which is likely to be damaged by frost. In a cold climate it is also important to make sure the render has hardened before temperatures sink below zero. Builders prefer the faster lime–cement products since their season is a month or two longer.

5.3 OTHER ASPECTS TO BE CONSIDERED

Other things which must be paid attention to are the details on a facade. Roofs protect vulnerable walls while functioning and clean rain gutters, mouldings and flashings keep the walls dry. (BY46 Rappauskirja 1999)

Tall buildings with high walls put extra demands on the render, since their walls are practically unprotected from horizontal rain, wind and runoff. If such a building stands by the sea and has to go through many cycles of freezing and melting per year the stress on the surface is classified as very high. According to BY 46 Rappauskirja (2005, 3.3 and 3.9) harder mixtures are needed the higher the stress level is. Harder mixtures are also needed in lower parts of buildings and foundation walls, not only because of capillary stress but also because of mechanical stress. Yet, according to Kristin Balksten, there are bell towers on Gotland with medieval lime rendering intact!

A common mistake is the use of wrong kinds of paints. Paints which do not allow

4 20 minutes – 2 hours for lime mortar. 10 minutes for lime–cement mortar or hydraulic lime. Follow manufacturer's manual if you use ready–made mixtures!

the plaster to breathe, i.e. do not allow moisture to pass through, will sooner or later result in frost damages. In cities smog can cause similar problems as the wrong kind of paint. This makes it important to wash the walls from time to time, and particularly before they are given a new coat of lime wash. Traditional lime wash is a good choice as long as it is protected from local runoff of rain water.



Figure 4. Multiple problems on both rendering and lime wash caused by bad detailing, rain and frost.

6. Lime wash

Lime wash is a paint made of lime putty and water, and usually some pigment to add colour. Lime wash can be applied on the entire surface of a wall, or used only for decorative purposes. It can, however, only be used on pure or almost pure lime renders. Ochres and other earth pigments can be used in lime wash. These pigments do not react with the lime and are unaffected by UV radiation.

Certain additives can be used to make the lime wash stick better to the underlying surface. For example linseed oil, casein and PVA (polyvinyl acetate) enhance the adhesion but might not be successful in the long run. The properties of lime wash can also be altered using additives, e.g. methyl cellulose, a plant-based glue, which enhances water retention. This can be useful in very hot and dry or windy weather conditions to prevent the lime wash from drying too quickly.

6.1 THE UNDERLYING SURFACE

There are certain matters you have to consider before applying lime wash to a wall. First of all, the underlying material has to be known. Lime wash can be applied on bricks, natural stone and on lime render or lime plaster. If the lime rendering or plasterwork contains cement, some cement should also be added to the lime wash to ensure a strong bond between the render and the finish. When applying lime wash on a newly made surface, you have to know how it was made. For example a render that has been worked too smooth before it has been allowed to set, will develop a lime film on the surface. This will prevent the lime wash from sticking to the surface.



Figure 5. Lime wash can also be used for decorative purposes. This little experiment was made by one of the students in al secco technique on dry plaster.

6.2 MIXING AND APPLYING LIME WASH

6.2.1 LIME WASH

Lime acts as binder in lime wash. The normal ratio is one part lime and 2–6 parts water. In Finland lime water is used, according to Russian tradition (see below), while in Sweden clean water is considered good enough. It is important that the lime wash is thin enough so that it is absorbed into the rendering instead of just creating a layer on the surface. Thin lime wash sticks to the wall very well and does not crackle.

6.2.2 LIME WATER

To make lime water $\frac{1}{4}$ parts wet slaked lime and $\frac{3}{4}$ parts cold water are mixed thoroughly. Let the mix set for 24 hours so that the water can dissolve the lime. When 24 hours have passed, there will be a layer of lime–water on top of the lime. The lime water can be used in lime wash and also for pre–watering the wall before lime washing. Post–watering with lime water after the final coat of lime wash will give the paintwork extra durability.

6.2.3 APPLYING

The lime wash and the lime–water is traditionally applied to the wall using a big brush, spattering it onto the wall or painting it with cross or round motions. Lime wash can also be sprayed onto the wall. According to 20th century tradition in Sweden a wall should be painted 5–7 times (i.e. as many times as there are parts of water in the lime wash), but 3 coats are generally considered enough in Finland.

If the rendering has been patched, it's important to start by painting the new spots to match the color and texture of the rest of the wall before applying the lime wash to the entire surface. When lime washing, the temperature has to be over +50C.

In addition to all this, it is important to think about the weather conditions: will it rain tomorrow or will it be too stormy or too sunny? It might be necessary to protect

the whole sunny side of the building from too much heat. On cool, calm foggy summer days the conditions are optimal for lime washing.

6.3 FINNISH LIME WASHING TRADITIONS

According to the Finnish National Board of Antiquities (Museovirasto) the recommended quantity of lime in the paint depends on many different factors: the quality of the lime, the suction of the underlying surface, the number of coats of paint and the weather conditions during application. For the first coat the lime to limewater ratio can be as small as 1:10 and increase up to 1:4 – 1:3 in the top layers. It is also recommended that the maximum usage of pigments is 8 vol% of the lime putty. Furthermore, you should not use more than 3 pigments to achieve your desired colour. The pigments must be soaked in water before they are mixed with the lime wash.

7. Conclusion

It is of vital importance that we take our time to learn about a building before we start repairing it. While rendering old buildings it is important to choose such materials that work together with the original surface and structure. It is always safer to use soft materials, like pure lime renders, but this puts higher demands on the workmanship. Historic buildings have to be looked after with respect to old methods and materials. But since the traditions have been broken among the masons, this means that architects and engineers have to prepare their specifications with extra care and often with the help of true specialists in the field.

In new buildings, mixtures of lime and cement might be the best solution for rendering. Both cement and lime have good and less good qualities and they work in different ways. This is why more research is needed and information must be spread so that we can profit from the best qualities in each of them.

8. Working with lime render

We began our exercises by emptying the lime kiln which had been built and burned by the Swedish students during the previous week. We sorted out the completely burned lime stones from the ones that had not been completely burned.

It is very important to use good protection of lungs, eyes and skin because burned lime stone, or calcium oxide is highly alkaline with a pH-value =14.



Figure 6. Emptying the lime kiln and sorting out the lime.

We collected the burned lime stone into large wooden crates. Once more the stones were sorted so that those that were not completely burned were discarded.



Figure 7. Sorting out the completely burned lime stone.

When the lime was sorted, we started making hot lime. We picked out a small bucket of the purest lime stones (1/5) and sand (4/5). The sand was then piled over the stones. Finally we added slowly water on top of it all and waited for the burned stone, i.e. calcium oxide, to react.

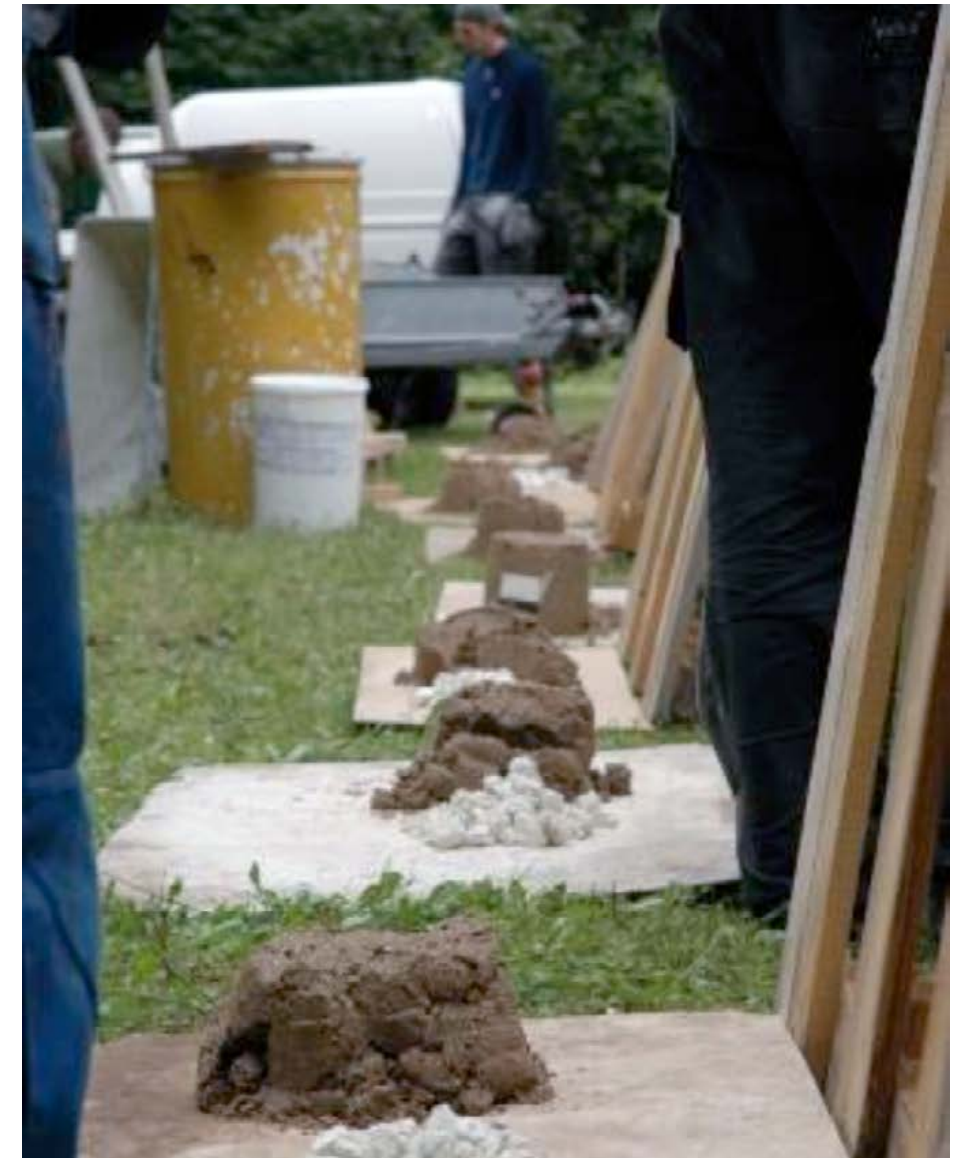


Figure 8. Hot lime ingredients: sand and lime from the lime kiln.



Figure 9. The burned lime is reacting with the added moisture. It expands to double its volume and releases heat.

When the reaction was over we started mixing. By adding some more water we made the render into an even and smooth paste.



Figure 10. Mixing hot lime by hand.

We made larger quantities of lime putty by wet slaking, in wooden crates which were built according to a 19th century model.



Figure 11. Wet slaking. Kristin Balksten in action.

The wet slaked lime paste was mixed with sand and water in a roller pan mortar mill.



Figure 12. Making bigger quantities of lime render by using a roller pan mortar mill.

When we had enough mortar we started to practice rendering. Our first assignment was to render a wooden board.



Figure 13. Rendering wooden boards.

We used two wooden strips as guides as we practiced making an even surface.



Figure 14. Creating an even surface by using two strips of wood as guide.



Figure 15. Moulding the surface by using a stencil.

One of our main assignments was to render an elevation of a stable with lime–cement–mortar.



Figure 16. The facade with patches of student work.

Our second major exercise was plastering a living room that was under renovation. This time the plaster was made with only lime as binder. We used the lime we had slaked.



Figure 17. Making the plaster attach to wire netting was hard work.

References

- Balksten, Kristin (2005). *Kalkputs: Porstrukturens betydelse för beständighet*. Göteborg: Chalmers University of Technology.
- Balksten, Kristin (2007). *Traditional lime mortar and plaster*. Göteborg: Chalmers University of Technology.
- Klasén, K.; Balksten, K. (2005). *The influence of craftsmanship on the inner structures of lime plasters*. Proceedings of the International RILEM Workshop Repair Mortars for Historic Masonry. Delft, Holland 2005.
- von Konow, Thorborg (2006). *Laastit vanhoissa rakenteissa*. Helsinki: Lönnberg print.
- von Konow, Thorborg. *BY 46 Rappauskirja (1999)*. Suomen Betoniyhdistys. Lahti: Lahden Kirjapaino ja Sanomalehti Oy.
- BY 46 Rappauskirja (2005)*. Suomen Betoniyhdistys. Helsinki: Nykypaino Oy.
- Järvinen, Kalevi (2005). *Kalkki: Muurattujen julkisivujen pintakäsittelyt*. Kustannus Oy Hakkuri, Uusimaa Oy.
- Museovirasto, korjauskortisto (2004). *F3 julkisivu, kalkkirappauksen korjaus*. Helsinki: J–Paino Oy.
- Museovirasto, korjauskortisto (2004). *F3 julkisivu, kalkkimaali*. Helsinki: J–Paino Oy.
- Mölsä, Seppo (2007). Suomenlinnassa korjataan vanhoja virheitä. *Rakennuslehti* 3/2007.

Appendices

- A. Terminology
- B. Course programme

APPENDIX A: TERMINOLOGY

English	Swedish	Finnish
Lime	Kalk	Kalkki
Limestone	Kalksten	Kalkkikivi
Mortar	Murbruk	Laasti (muurauslaasti)
Render	Puts (utomhus)	Rappaus (ulkotiloissa)
Plaster	Puts (inomhus)	Tasoite (sisätiloissa)
Binder	Bindemedel	Sideaine
Aggregate	Ballast/Sand	Runkoaine
Additives	Tillsatsämnen	Lisäaine
Slake	Släcka (kalk)	Sammuttaa (kalkkia)
Cement	Cement	Sementti
Mixing	Blanda	Sekoittaa
Quarry	Bryta, brott	Louhia, louhos, kaivos
Limewash	Avfärgning	Kalkkimaali
Linseedoil	Linolja	Pellavaöljy

APPENDIX B: COURSE PROGRAMME

Sustainable Heritage Intensive Course: Lime Render

Programme in Visby, Sweden, September 2009

Academic studies	Hands-on work	Extra activity
<i>Day 1</i>		
Introductory lectures: <ul style="list-style-type: none"> • Renderers • Techniques • Local history – lectures by Kristin Balksten and Stefan Haase	Making render – tutoring craftsman Sivert Cederlund and Kristin Balksten	<i>Welcome dinner</i>
<i>Day 2</i>		
<ul style="list-style-type: none"> • Using lime render • Different types of render and plaster – lectures by Kristin Balksten	Preparing for Making render and plaster – tutoring craftsman Sivert Cederlund and Kristin Balksten	Sightseeing in Visby – Joakim Hansson
<i>Day 3</i>		
<ul style="list-style-type: none"> • Lime render on churches – lectures by Kristin Balksten and Joakim Hansson	Working on a church / documentation – tutoring craftsman Sivert Cederlund and Kristin Balksten	Sightseeing in the countryside – Joakim Hansson

Academic studies	Hands-on work	Extra activity
<i>Day 4</i>		
<ul style="list-style-type: none"> • Handcraft traditions – lectures by Kristin Balksten and Stefan Haase	Working with render – tutoring craftsman Sivert Cederlund	Excursion – Joakim Hansson and Stefan Haase
<i>Day 5</i>		
<ul style="list-style-type: none"> • Plaster in Estonia – lecture by an Estonian expert	Working with render – tutoring craftsman Sivert Cederlund and Kristin Balksten	Excursion – Håkan Lindkvist and Kristin Balksten
<i>Day 6</i>		
<ul style="list-style-type: none"> • Handcraft traditions – lecture by a Finnish expert	Working with render – tutoring craftsman Sivert Cederlund and Kristin Balksten	Student activities – Students from Gotland
<i>Day 7</i>		
Evaluation, feed back	Planning of additions to web site and next course – all teachers involved in the network Completing work & Cleaning – tutoring craftsman Sivert Cederlund and Kristin Balksten	<i>Farewell party</i>

About Gotland University

Gotland University was established in 1998 and is one of the youngest universities in Sweden. It is located in the World Heritage city of Visby on the island of Gotland, a geologically and ecologically unique island that is surrounded by the Baltic Sea. Gotland's rich historical past and beautiful natural environment attracts visitors from all over the world. These features as well as the many yearly cultural manifestations that take place all over the island create and enhance a stimulating learning environment for students and teachers alike. Gotland is a very dynamic region that favours education and actively promotes national and international exchanges and collaboration.

As the first university in Sweden, Gotland University has adopted a Liberal Education philosophy. Its mission is to prepare the student for personal growth and professional success while engaging him/her in today's complex world. Multidisciplinary teaching will achieve this. It implies that besides compulsory courses, the students can select courses according to their interest. For example, a student wishing to become a designer and who has a strong interest in ecology could choose from among courses in design and construction in combination with courses in ecology and biology.

All year around, quality 'on-campus' and 'internet-based' programmes and courses are offered in Swedish and English. The choice includes a Master Programme in International Management and independent courses in Archaeology, Osteo-Archaeology, Cross Cultural Studies, IT/Business Administration, International Business Relations, European Studies, Game Design, Building Conservation, Object Antiquarian Studies, Russian, History, Human Geography, Ethnology, Ecology and Art History.

FIGURES FOR 2008:

- Number of registered students: 6.473
- Number of full-time students: 2.396 (63% of whom are 25 years or older, 53% are women).
- Number of employees: 212 of whom 90 are women. Age average 45 years old.
- Number of teachers: 110 of whom 55 hold a PhD.
- Number of professors: 10



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About Estonian Academy of Arts

The forerunner of Estonian Academy of Arts (EAA) was Tallinn Applied Art School, founded by Estonian Art Society in 1914. It was the first and for some period also the only art school in Estonia. In the very beginning the curricula based on the art school of Baron Stieglitz in St. Petersburg, which study system preferred technical and practical skills but from the end of the 1930's onwards the students could receive specialist training in fine art as well.

The present-day Estonian Academy of Arts is the only public-law university in Estonia providing higher education in six fields of study:

- Fine arts: painting, drawing, graphics, sculpture, interdisciplinary arts;
- Design: product design, textile art and design, fashion art and design, leather art; and design, ceramics, glass art, jewellery and blacksmithing, art and cultural anthropology;
- Architecture: architecture and urban planning, interior design, urban studies;
- Media: graphic design, scenography, photography, interactive multimedia;
- Art history: art history, training of art teachers;
- Conservation: conservation and protection of cultural heritage.

In EAA the field of advanced training is consolidated into the Open Academy, while research supported by Doctorial School and development by the Design Innovation Centre.

The number of students on Bachelor, Master and Doctorial level is over 1000 students. EAA is the cooperation partner of 80 universities and member of several international cooperation networks. In current academic year there study 20 full-time foreign students and 60 exchange-students in EAA.



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STUDENTS' WORK

About Novia

Novia University of Applied Sciences offers multidisciplinary higher education with a practical orientation, training professionals for expert and development posts.

There are 34 degree programmes leading to a Bachelor's Degree.

Three programmes run entirely in English:
Integrated Coastal Zone Management in Raseborg,
Nursing in Vaasa and Maritime Management in Turku.

With its approximately 3500 students and a staff of 390, Novia is the largest Swedish-speaking university of applied sciences in Finland. Novia has activities in seven different locations along the west coast.

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Kalkputs – Sustainable Heritage Rapport nr 1. Rapporten handlar om kalkputs, kalkmålning och kursen Lime Rendering i Visby, som studeranden från Högskolan på Gotland i Sverige, Yrkeshögskolan Novia i Finland och Eesti Kunstiakadeemia i Estland deltog i under en vacker vecka i september år 2009. Detta var den första av skolornas gemensamma kurs inom projektet Sustainable Heritage, vilket stöds av Nordiska rådet i form av Nordplus stipendier.

När man putsar / rappar en gammal byggnad är det mycket viktigt att välja sådana material som passar ihop med det gamla underlaget och konstruktionen. Det är alltid klokast att använda svag puts, dvs. kalkputs, men detta ställer höga krav på utförandet. På fasader av nya hus av moderna material är kalk-cement putset ett bra val.

Både cement och kalk har goda och mindre goda egenskaper. Det är viktigt att veta att de härdas på olika sätt och måste därför appliceras på olika sätt. Rapporten ger en insikt i vad detta handlar om från både ett byggnadsfysikaliskt och ett praktiskt perspektiv.

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