Handbook for Building and Repair of Stone Walls

—Sustainable Heritage Report No. 4

Kirsti Horn, editor

Traditional Wooden and Masonry Structures
in the Baltic Sea Region

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A joint project between Campus Gotland at Uppsala University,
Estonian Academy of Arts and Novia University of Applied Sciences

Contents

Summary

This report is about the dry laid stone walls in the Gotlandic landscape; it is also about what an international group of students learned through lectures, excursions and their working experience in the fields of Fide in the southern part of the island of Gotland. The introduction to what can be characterized as a hand book for building stone walls is formed through short articles about the most common types of stone and stone walls that are found in Estonia, Finland and Gotland.

The craft of stone masonry seems to be dying since there is little demand for traditional handicrafts in the modern building industry. Yet, the historic walls that crisscross the landscape in Gotland, Western Estonia and many other stony regions of the world are an important part of our heritage and certainly worth maintaining. Some of them are declared historic monuments, others not—but they all need looking after. This handbook should guide the reader on the way. All rocks are, however, different and therefore all walls are different. It is essential to start by studying the local technique of laying stone upon stone and then to reserve a lot of time for the actual construction work.

All participating students from the Estonian Academy of Arts, Estonia, Novia University of Applied Sciences, Finland, and Campus Gotland at Uppsala University, Sweden, have contributed to this report with text, drawings and photographs.

Preface

In September 2012 students and teachers from Estonian Academy of Arts in Estonia, Novia University of Applied Sciences in Finland and Campus Gotland at Uppsala University gathered in Visby for the first of ten intensive courses within the project *Traditional Wooden and Masonry Structures in the Baltic Sea Region*. This was a good start to the series of intensive courses that have been planned in cooperation between the staff of the named universities. For more details about the project and past and future courses, please visit its site on the Internet at the address www.sustainableheritage.fi.

The international cooperation within the field of building conservation was established many years ago and has already resulted in half a dozen successful intensive weeks during the past years thanks to the Nordic Council of Ministers who have supported this Nordplus project financially and thanks to a motivated group of teachers. Every course has a different theme and they are hosted by the three universities in turns. Students are taught by expert craftsmen and given an academic theoretical background to each topic by teachers of the involved institutions. In addition to the pedagogical goals we cherish an idealistic wish that the performed hands–on work should contribute to the rescue and maintenance of our built heritage. This time over 300 meters of stone walls were restored.

Many thanks to Joakim Hansson, who organised the course, and master masons Tage Wickström and Nils–Erik Hallbom, who lead the hands–on work.

Kirsti Horn

Senior lecturer, Architect SAFA, AA Dipl.

1. Dry laid stone walls in the Baltic Sea region

1.1 INTRODUCTION

Historic stone walls are found in many places around the Baltic Sea. They are an integral part of their surroundings and therefore they should be restored and maintained together with the cultural landscape. They also contribute to the variations in the terrain, create habitats and increase biological diversity. Stone walls have a natural connection with the landscape because the construction technique depends entirely on the quality and shape of the available stone. The wishes and achievements of the previous generations and the history of centuries of farming and husbandry are all reflected in the landscape (see figure 1). [Rennu 2007: 15]

Figure 1. A view of the landscape in Fide, Gotland, with crumbling stone walls. Photograph by Sille Siidirätsep.

Estonian ethnographer Madis Rennu claims that stone walls, as all other tangible cultural artefacts, have their cultural value, which is descriptive and analysable. He believes that through observing any wall building technique, it is possible to find

references for the pursuit of keeping the living environment structured, organized and localized. [Rennu 2007: 5–6] But have these three aspects been main reasons for wall construction? Have stone walls had other functions?

The principal functions of field boundaries are to mark a piece of land and indicate land ownership. Oskar Loorits has pointed out the importance of border: „The Finno–Ugric concept of private property begins with the allocation of a restricted area and the marking of an object with a set of sticks. In the mind of the Finno–Ugric peoples a marked object or an isolated area is sacred and should not be disturbed by others.“ [Loorits 2000: 320]

In addition to functioning as a border, Rennu gives the walls three practical functions. The primary practical functions of walls are to clear the land for cultivation, to limit movement of livestock as well as wildlife, to give protection from wind and snow and to act as a balancing moisture barrier. The secondary practical functions are to store structural stones or household objects (e.g. firewood, agricultural implements), to enhance security, to give hiding places for objects (e.g. money, weapons and documents). Finally as the third function, Rennu mentions the aesthetic function. [Rennu 2007: 89–91]

1.2 DRY LAID STONE WALLS IN ESTONIA

Fences and stone walls together with gates play an important role in the appearance of individual farmyards and of Estonian villages overall.

1.2.1 DIFFERENT TYPES OF STONE WALLS IN ESTONIA

In terms of building material, fences fall into three categories: dry stone walls, wooden fences and so–called mixed fences of stone and wood. Of these, dry stone walls are the oldest, most widely used and of most varying appearances depending on the kind of stone the ground yielded. In terms of material, dry stone walls can be divided into three main categories: granite, limestone and the combination of the two. Dry stone walling techniques can be divided into 13 different types. [Lukas; Rennu 2010]

Here are some examples:

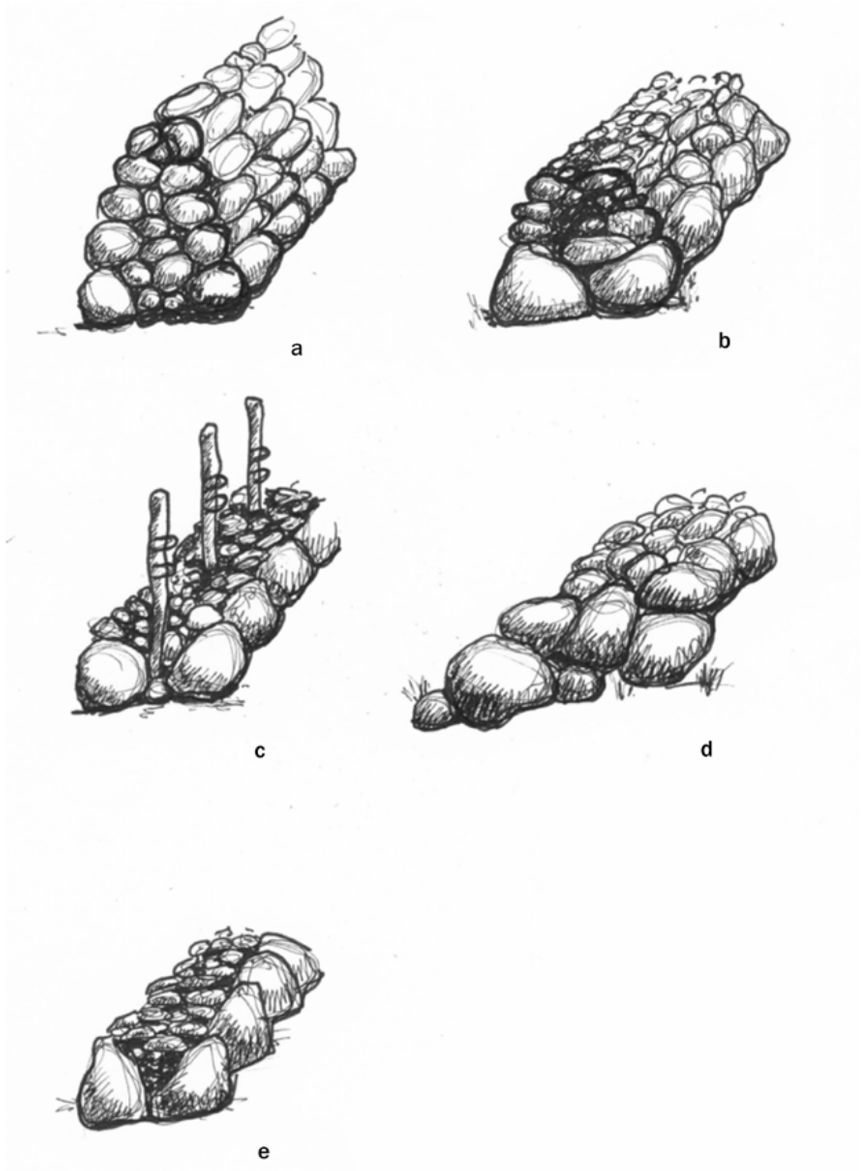

Figure 2. Five of many Estonian types of dry laid stone: *(a)* woods fence, meadow fence; *(b)* field fence, village fence; *(c)* sheep fence; *(d)* berm fence; *(e)* split granite fence.

Woods fence, meadow fence (Puisaed, metsaaed, niiduaed)

The meadow fences are made of round granite fieldstones with a diameter between 15 and 40cm in 4 to 6 rows. The walls are approximately as wide as they are high. The section shows how the construction tapers towards the top.

Field fence, village fence (Põlluaed, külavaheaed)

This type of stone wall is built between different fields and along village roads. The material is granite boulders of various sizes: bigger at the bottom and smaller towards the top. There can also be some split granite and limestone. This is one of the most common types of stone walls in Estonia.

Sheep fence (Lambaaed, lambaladu)

Sheep fences, which are a combination of stone wall and wooden fencing, were built around pastures. The low foundation is granite and limestone of random sizes.

Berm fence (Vallaed)

These lines of big granite boulders that are not arranged to form a wall, but rather look like a long mound of fieldstones, can be found along fields, meadows, forests and pasturelands.

Wall of split granite boulders (Ühekordne lõhatud aed)

These walls can be found around all kinds of fields. The cavity between the one stone high double line of split granite boulders is filled with limestone pebbles.

1.2.2 DRY STONE WALL TRADITIONS IN DIFFERENT PARTS OF ESTONIA

As archaeological investigations have proved, dry laid stone walling techniques go back three thousand years in Estonia. [Lang 1992: 53–54; 1996: 249–258]

The Estonian system of numerous dry laid stone walls, so conspicuous in the landscape, had largely been established by the end of the 17th century. This provided a firm and changeless framework to the use of land and population pattern. The appearance of stone walls varies a lot from one village to the next; from one spot even, to the next. The main reason for such diversity is the diversity of the material.

Dry stone walls in Northern Estonia

Stone walls were most common in North– and West–Estonia (granite and limestone) and on the islands of Saaremaa and Muhu. Limestone was the material in Northern Saaremaa while granite was used in Southern Saaremaa and Muhu. Usually a dry laid stone wall was built by a single man, often an senior versed person. No masters were hired, there were no building bees and it was not considered a ritual or did not depend on the farm calendar.

In the north of Estonia the principal function of stone walls was to limit the movement of animals. It was essential to guard the gardens, fields, meadows and pastures with solid materials to protect them against roaming animals and livestock. Therefore, the only serious criteria when laying a stone wall was its durability while decorative appearance was of no concern. Certain places were arranged so that people could climb over the walls and sometimes stone steps were built for this purpose. Gates were made of horizontal wooden bars. From time to time, the walls needed repairs and adjustments as the stones tend to move or fall due to frost action or to e.g. animals leaning or rubbing against the wall.

Dry stone walls in Western Estonia

All stones were cleared out of the Western Estonian farming land and used for either constructing houses or walls around the farm. To get smaller and regular shaped stones, large boulders were split with the help of fire and shims. Many of the free standing walls were primarily built to mark a piece of land and indicate land ownership in the fields. They were not well laid and did not keep animals off the fields. Because of the rocky landscape these walls can be about 1,3–1,5 meters high. It was women´s work to clean the fields from stones after the spring ploughing. They used their aprons or a sledge for the transportation of stones and built the stone walls higher each year. Stone walls had gates of wood.

Dry stone walls surrounding pastures, meadows, fields and numerous farmyards on the islands of Saaremaa and Muhu were more prominent than on the mainland and are so up to the present day. This can be explained by the very stony soil combined with the lack of timber. Stone walls of various heights were built for the same purposes as elsewhere—to protect a property and keep animals away from crops. On Saaremaa a

lot of effort was put into building handsome gates. These were the fanciest gates in all Estonia.

Stone walls and fences were built by joint efforts around common fields and pastures. The stretch that each farm had to build depended on the size of the farm. As a general rule, the owner of good land built a wall around it to separate it from poor land. Communal surveys of the boundary walls were carried out about every ten years and they had to be mended by St. George's Day (April 23). [Saron 2007]

Saaremaa differs from the mainland because until the late 19th century the procedure of building walls was regulated by ancient traditions (Saron 2007). The parish court settled all disputes pertaining to the erecting of walls. The height of the walls had to be at least 4 feet (122 cm). [Rennu 2007: 67] On the island of Muhu no height and width measures were fixed (see figure 3).

On Saaremaa it was common to make low stone walls higher by adding wooden fences on top of them. The fences were made of planks fixed to wooden posts which were fitted between the stones of the wall. Juniper twigs were often used to keep animals away. A later development has been to replace the boarding with wire.

Figure 3. People of the island of Muhu used to pile their firewood on top of the stone walls as they split it during the winter months. After the summer it was dry enough to be stored in a shed. In addition to the practical value, piles of firewood gave added privacy and extra protection against wind. Photograph by Sille Siidirätsep.

It was common knowledge on the island of Saaremaa that stone walls were good caches. Almost every household had their own indigenous tale to tell of how weapons, money and documents were hidden between the stones of the garden walls during the wars in the 20th century.

Also it was common to throw garbage and leftovers in the backyard, which was surrounded with a stone wall. Semiotician Riste Keskpaik described the places where people throw their garbage as a borderland, which expresses changeovers — me vs. not–me, culture vs. not–culture, culture vs. nature etc. Garbage is used to distance the unfitting elements from the culture. [Keskpaik 2004: 69]

Dry stone walls in Southern Estonia

In the mind of the Southern Estonian peasant a stone wall was something expensive and associated with manor houses, churches and cemeteries. Stone walls were rare on farms. Yet, there were boundaries marking farmland and pastures and indicating borderlines between farms. Granite boulders were laid randomly in rows heap by heap, and it was common to dig a ditch next to these mounds to indicate the borders clearly.

People from Saaremaa, who came over to the southern parts of the mainland for seasonal summertime work in the end of the 19th century, spread the technique of building dry stone walls even here. [Rennu 2007: 86–88]

1.3 STONE WALLS ON GOTLAND [1]

The first fences and walls on Gotland were constructed 4000–5000 years ago when fishermen, collectors and hunters started cultivating the land. The small fields were surrounded by fences and contrary to present day arrangements, animals used to be outside the fence.

On Gotland you can find two kinds of boundaries: wooden fences and stone walls. The fact that wood was scarce in the 18th century lead to the building of a rising number of solid stone walls or low stone walls topped by wooden fences all over Gotland. In many places wooden fences have disappeared today and only stone walls remain as relics from land reforms of the 18th and 19th centuries.[2]

The use of mixed material in stone walls was common all over Gotland, yet variations in building tradition in different parts of the island are clear. As the material for the stone walls was mostly taken from fields, the type of the local stone determined the result. In eastern parts of the island the stones are small and irregular, in the South and South–East the material consists of random sized boulders of granite. Both materials demand high skills of the builder. In other parts of Gotland different shades of limestone and sandstone are more common.

Masters all over the island used a range of ways to combine various types of stone: big and small boulders were laid alternating in order to support each other; limestone slabs were erected in two parallel rows and the core was filled with smaller stones; or flat pieces of limestone and random boulders were laid in layers or patches (see figures 4, 5).

Usually the walls of a front yard were laid with more care than the others. Around the dwelling house rendering was sometimes applied on the stone walls to advert the owner's wealth.

1 This article is based on the lecture Historical stone walls on Gotland by Stefan Haase at Campus Gotland, Uppsala University, Sept. 11th, 2012.

2 Land reforms in Sweden: 1749 Storskifte, 1802 Enskifte and 1827 Laga Skifte - the latter of which continued until the 1920s and affected the current landscape most of all reforms. Lecture by Petra Eriksson, Reading the landscape through its borders at Campus Gotland, Uppsala University, Sept. 11th, 2012.

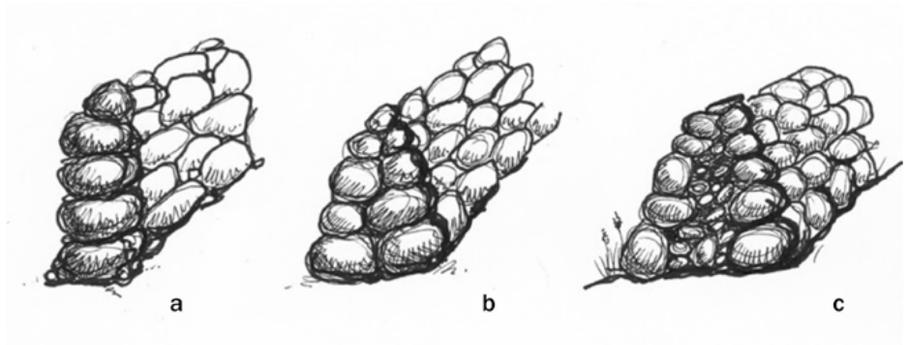

Figure 4. Most common stone walls in mainland Sweden: *(a)* single wall, *(b)* double wall, *(c)* double wall with filling. Drawings by Elle Lepik.

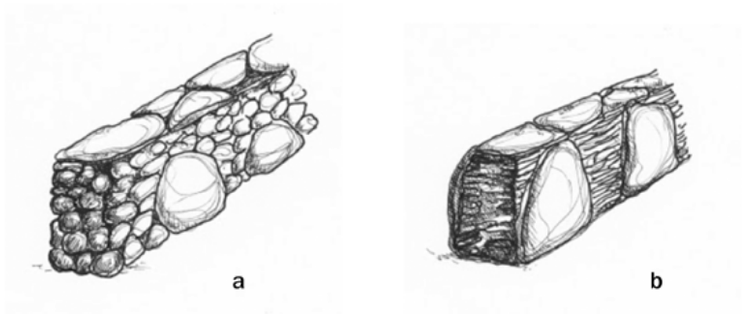

Figure 5. Mixed material walls on Gotland: *(a)* placing big rocks in between small ones; *(b)* rearing up stone slabs next to each other in two parallel rows and filling the core with smaller stones. Drawings by Elle Lepik.

Building stone walls was a winter season occupation for Gotlanders and every year a new part of wall was completed. The standard height of a traditional stone wall was 137.5 cm which was stipulated by the 13th century law. The idea was to avert horses from trying to reach over the wall for the greener grass on the other side. Every spring the farmers had to repair their stone walls—remove the bushes and restore collapsed sections.

In many places walls along the seashore are still visible. These walls were built to keep animals off sea the weed, which was left on the shore to compost for 2–3 years before being used as a fertilizer on the fields. The coastline walls are laid with heavy boulders on the top in order to resist the devastation of high winds.

Today, the stone wall patterns are less visible in the landscape than fifty or a hundred years ago. The scenery is overgrown with bushes and trees and, although good stone walls can last for about 150 years, a lot of them have perished. This is evident when we compare historic photos with present day views. Especially along the roads, stone walls were replaced by electric wires or chain–link fencing during the second half of the 20th century. Removed stones found a new purpose in road and harbour construction. Farmers have often demolished walls to enlarge their fields. All that is left of old stone walls on Gotland is protected as cultural relics by law, i.e. *Lag (1988:950) om kulturminnen m.m.* (often shortened as KML or kulturminneslagen) and the Swedish government provides some subsidies to maintain the traditional stone walls. Courses are organized to school a new generation of local masons who can look after the heritage.

Modern masonry walls are often made of concrete with a limestone facing and topping. These are sad monuments of a dying tradition and bear nothing in common with the beautiful handicraft of the old dry laid walls.

1.4 STONE WALLS IN FINLAND

Old stone walls are not as common in Finland as they are on Gotland and in Estonia. They are mostly associated with fortifications, church yards and cemeteries and would therefore be parts of rather urban than rural environments (see figure 6). Yet, there are stone walls in the countryside too, mainly in the eastern parts of the country where the

landscape is the rockiest—in the Karjala and Savo provinces.

Since half the soil consists of moraine in Finland, the stony ground has created obstacles for farmers from the beginning of agriculture. The stones have been thrown into a pile in the middle of the field or used to create a wall around it. But it is rare to find stone walls that have been used as field boundaries or for cattle breeding. Traditionally it was more popular to build fences of wood. As we know, the material comes in abundance — 86 % of Finland's area is covered by forests. Systems of agriculture have changed over time, and people found no practical use for the old stone walls, or for the wooden fences. Consequently, this kind of heritage has disappeared from the Finnish landscape.

Nevertheless, some special kinds of walls have survived in Lapland. They have been used for reindeer herding still some 50 years ago. They have a great cultural value as being a representation of the main source of livelihood of the Sami people since the 15th century. The National Board of Antiquities in Finland has restored a few examples of these fences in the 1980s and 90s. Some of these are at least partly made of stone. One example is the Ertiqvarri fence in Utsjoki that was built in the beginning of the 19th century and was in use until the 1950s. It was restored in 1991 and serves as a tourist attraction nowadays.

Figure 6. Stone wall around Hattula Holy Cross church in Häme province, Finland. Photograph by Elle Lepik.

2. Rolling stones and others

2.1 THE MOST TYPICAL STONES IN THE BALTIC SEA REGION

2.1.1 GRANITE

Granite is one of the first rock types that evolved in the earliest stages of the forming of Planet Earth. It is common around the world but is particularly significant in the Scandinavian bedrock. [Lundegårdh p. 45] It is an igneous rock that is formed by heavy pressure and cooling of magma or lava close to the crust of the earth. Depending on pressure, temperature and minerals the igneous rock varies in composition and has a variety of qualities. If subjected to a higher degree of pressure and heat, so called metamorphose the granite will become striped in appearance and get the qualities and structure of stronger stone such as gneiss.

The main minerals in granite are quartz, feldspar and mica. These three make bedrock that has a granular unaligned structure hard and resilient. On Mohs hardness scale (1–10) quartz is the strongest of the granite minerals being silica with irregular crystal structure and a value of 7. Feldspar with its value of 6 and with its angular surface structure acts as a binder. The same goes for mica, which with its smaller crystalline structure creates packs of bendable layers, and despite a hardness value of only 2–2,5 adds to the solid quality of the stone. [Lundegårdh p. 45–47] This massive hard and tough substance has an average density of 2,65– 2,75 g/cm^3 which can withstand forces above 200 MPa (megapascal). The melting temperature is around 1215–1260 °C. The mineral feldspar also gives granite its typical red colour. A large variation of colours exists depending on the composition of minerals.

The high concentration of granite boulders on the west coast of Gotland has its origin on the Swedish mainland. Thousands of years ago these have traveled on the Baltic Ice Lake with the glacier that covered most of the landmass of Scandinavia. The stones were shaven off the bedrock on the mainland, then they were trapped in the bottom layer of the ice and finally, when the glacier slowly began to melt over 10 000

years ago, they were released in this new locale together with a mass of moraine. [Lindström et al. p. 397–398] These granite boulders, which are rounded by their long traveling, are easily available in the topsoil. They were used for building purposes already by the early settlers of Gotland. Later the material was mostly used for rune stones, as heavy ballast in medieval masonry, and of course, for dry laid stone walls. Elsewhere in Scandinavia the material is so common that the bedrock was exploited as soon as stone tools and techniques were efficient enough for quarrying on a large scale, i.e. some 100 years ago. [Sundnér et al. p. 115]

2.1.2 SANDSTONE

Mudstone or sandstone is a sedimentary rock which is formed of clay or sand that has been deposited on the seabed. As time passes, these sediments get more and more compact to eventually form a rock. [Sundnér et al. p. 54] When a rock is formed by sedimentation, this means that the space between the grits of sand is filled out. [Sundnér et al. p. 19]

Sandstone grains can be cemented together either by silicate, calcite or clay minerals. The older Swedish sandstone is silica bonded while the younger is calcite bonded. [Sundnér et al. p. 54] Gotlandic sandstone is held together by silica, clays and calcite. [Sundnér et al. p. 19]

The Gotlandic sandstone, which is found in the southern part of the island around Burgsvik, is a fine–grained rock with a more or less homogeneous structure. It is composed of feldspar, quartz and clay minerals of 5–10 % calcite cement. It has a very high capillary suction and its porosity is about 20 % i.e. percentage of bulk volume / volume of cavities in the structure of a stone. When the stone is fresh, it has a saturated grey colour, which often turns brown as it ages.

The sandstone will easily absorb water through capillary action. This can give the effect that the dampness in the stone freezes or causes salt precipitations. Weathering by rain and wind is a type of damage that can easily occur in sedimentary rocks such as sandstone. This will result in exfoliation and sanding. The natural degradation can be biological, physical or chemical. Also air pollution (sulphuric rain) or other environmental damage can be a contributing factor to weathering particularly in urban

areas. If the rock is made up of composite materials, the degradation of one or several components results in major damage. [Sundnér et al. p. 54]

Alongside the Gotlandic stone Swedish sandstones also include the Scanian Öved and Höör sandstone, the Lingulidsandstone from Närke and Västergötland, the Mälardalen/Gävle/Roslag sandstone and the Dala sandstone (Älvdalquartzite). These are the most common types of sandstone used for building purposes. The Gotlandic sandstone has been the most popular of them all. The days of glory for the Gotland sandstone were during the early Middle Ages (from late 1000s to mid–1200s). In addition to being used as building material for the southern Gotlandic churches it was also successfully used as the material for baptismal fonts that became so popular that they were exported all around the Baltic Sea region. It should also be mentioned that the most important use of the Gotlandic sandstone has been as grindstone. Locally it can be found in masonry and even as roofing material.

The greatest period for quarrying of the stone for buildings occurred from late 16th century through the whole of the 17th century. The stone is found in buildings in both the northern part of Germany and in Poland, in cities such as Lübeck, Wismar and Gdansk. In Sweden, it was mainly used during this period for portals and sculptures. During the period 1890–1920 the stone became popular again and today it is used for both adornment and as facing on exterior walls of high class buildings. [Sundnér et al. p. 22]

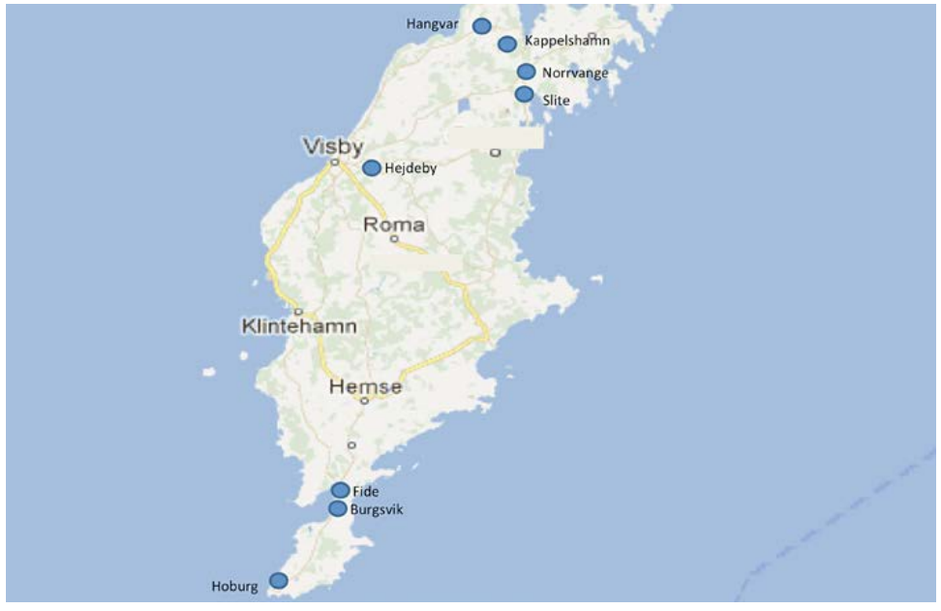

Figure 7. Map of Gotland showing the special sand– and limestone findings.

Figure 8. The excavation at a lime stone quarry reveals the layered structure of the bedrock. Photograph by Kirsti Horn.

2.1.3 LIMESTONE

The limestone is a sedimentary rock that mainly consists of calcium carbonate ($CaCO_3$). Limestone is formed when dead organisms that are made up of calcium are sedimented on the sea bed. The Gotland limestone dates back to the Silurian period some 443–419 million years ago and can be divided into two main types: layered and fragmented limestone. The layered limestone (see figure 8) lies in horizontal layers in the bedrock and the fragmented limestone contains a lot of fossils or sediment. [Sundnér et al. p. 33] The Gotland limestone has a porosity of 1–5 % which is ideal for a building stone. The colour of the Gotlandic limestone varies depending on its location (see figure 7).

The so–called Hobursstenen, a reddish limestone, can be found in Southern Gotland.

In Hangvar, located in the far north of the island, the Hangvar–stone is gray to reddish–gray.

In Hejdeby, which is about 10 km east of Visby, there is a limestone with shades from gray to yellowish.

In Kappelshamn, up north, near Hangvar there is a limestone quarry where the limestone is slightly yellowish.

In Norrvange, Lärbro, about 40 km north east of Visby there is a gray and a reddish–gray, limestone without fossils. [Sundnér et al. p. 34]

Two types of reef lime stones (also known as coral rock) can be found in När–Bursburgen and Hoburgen Marbadshuvud. These limestone types are composed of the remains of sedentary organisms such as sponges, and of sediment–binding organic constituents such as calcareous algae.

There are many different types and qualities of limestone on Gotland depending on the minerals, fossils and several other compounds in the rock. Limestone is used in many different ways. In the building industry it plays an important role as the raw material to binders of mortars and concrete; in agriculture it is needed for the preparing of the soil; it is used for the neutralization of polluted water; and many industries rely on it as an additive in their processes. Cement is produced on a large

scale in Slite, by the Nordkalk industries.

Among all stones on Gotland, the limestone is dominant, especially the sedimentary layered stone. There have been a lot of small quarries on the island but most of them are now closed. The stone varies in size and shape, it is easy to break and shape, it is also possible to split it into thin slabs for floors and walls, always elegant and fashionable (see figure 9). The layered limestone is the one that has been used mostly for masonry constructions, but also for baptismal fonts, stairs, quoins, plinths, tracery and vaulting.

Walls of limestone can be built in different ways. Today, the buildings and walls are made mostly with mortar, but you can still find some new buildings and garden walls that are built with dry laid stone walls i.e. without mortar (see figures 10, 11).

Figure 9. Floor of very big flagstones of Gotlandic limestone. Photograph by Anna Plahn.

Figure 10. The interior of a new two–storey house which is being built without mortar. Its builder, master mason Erik Larsson to the left. Photograph by Anna Plahn.

Figure 11. Perfect craftsmanship by Helen Wahlström, Lau, Gotland. Photograph by Anna Plahn.

3. Repair and building of stone walls

3.1 INTRODUCTION

This section of the report is composed of observations and personal experiences from all three nationalities of students on the intensive course about stone walls on Gotland in September 2012.

The subject of historic stone walls was introduced on an excursion during which various kinds of walls and landscapes were seen and analysed.

A thorough and practical introduction to the work was given by the famous conservators of Gotlandic building traditions *Helen Wahlström* and *Stefan Haase*. The theory of how the stones should be selected, the site organised and how the work should proceed became clear as the students were shown around their farm where walls in different stages of construction could be studied (see figure 12). “You must not be in a hurry when you build a stone wall”, they both said. “Take your time in order to avoid accidents. This is a healing process from everyday hustle and bustle; fitting one stone on top of the other gives peace of mind.”

Figure 12. When you take a longer brake from building you can make the working joint invisible by making it at an angle. Stefan Haase (in the middle) instructing students. Photograph by Kirsti Horn.

Later on we spent three days restoring old walls that were partly damaged. With the energy of youth more than 300 meters of wall was repaired by the group of some 20 students! The experience in the ancient fields of Fide was maybe not so philosophical but certainly most enjoyable thanks to our teachers, *Tage Wickström* and *Nils–Erik Hallbom* who shared the secrets of their trade and life long experience with us (see figures 13, 14).

Figure 13. Tage Wickström and Nils Hallbom demonstrating how big boulders could be moved into position. Photograph by Sille Siidirätsep.

Figure 14. The work looks easier than it is. It requires both patience and muscles. Photograph by Mariliis Vaks.

We learned a lot about the working methods and details of two different kinds of stone walls: those made of boulders and those made of slabs of lime stone. The major part of our energy was directed on the restoration work of some ancient walls protected by law. In Fide (see map, figure 7) most of these walls are made of round boulders in a very different way from e.g. the Estonian tradition and the lime stone walls we had seen earlier.

A short stretch of new wall was made just for fun using pieces of lime stone slabs that were found close to the building site. The experiment (see figure 15) gave us a welcome chance to use our creativity and put into practise what we had learned about foundations and other practical details from Stefan Haase.

Figure 15. Experiment by students. Photograph by Tomas Simons.

3.2 PLANNING THE RECONSTRUCTION WORK FOR AN OLD STONE WALL

When you plan to repair a wall of stone you should start by making a work and time schedule. Mainly you need to reflect on:

- the building technique of the existing wall
- the condition of the wall
- the surrounding bush vegetation and the landscape
- the slow pace of the work

3.2.1 BUILDING TECHNIQUE

Each type of stone requires a different building technique. Flat and round pieces are laid quite differently, one requires more muscle than the other, and every time the local traditions must be followed as maintenance work is performed in the landscape. It is of vital importance to know the technique for laying a specific type of wall since there are endless variations on the theme. This is why it is of great importance to analyze the surrounding local building technique before starting to build. Gravitation is the ruling force: every stone must lay securely before the next can be lifted on top of it.

The condition of an old wall determines how much work there is in restoring it and how much time it will take. Walls that are hundreds of years old can be in a bad shape due to forceful cattle, overgrown vegetation and weathering.

Thorny bushes and junipers find shelter close to stone walls. It takes a lot of effort to cut these out of the builders' way (see figure 16).

Figure 16. The cultural landscape in Fide where we worked is crisscrossed by old stone walls. Students are clearing the side of the wall from junipers. Photograph by Kirsti Horn.

3.2.2 REUSE THE OLD STONES!

The building material is most likely lying about on the ground around the wall. The goal is to get all stones back to where they fell from. Start by digging up the material and sorting different shapes and sizes of stones into heaps. A systematic approach makes rebuilding easier and faster and it will also result in a stable and good looking product (see figure 17).

Figure 17. International cooperation. Photograph by Mariliis Vaks.

3.3 PLANNING A NEW WALL OF FLAT SLABS OF LIME STONE

3.3.1 DESIGN

When designing a new wall there are two ways to go about it:

- either you copy the local traditions and do your best to fit in with surrounding walls, or
- make an entirely different design to ensure anybody can see your creation reflects the time of construction through choice of material and building technique. Still, respect local colour and scale to avoid making an eye sore!

3.3.2 STONES

If the stones are taken from a quarry then let them adjust to the climate for at least one year before using them (see figure 18).

Figure 18. Piles of stone weathering and waiting for transport at one of the many small lime stone quarries on Gotland. Photograph by Kirsti Horn.

3.3.3 CLEARING THE SITE

Before you start building the stone wall it is important to clear the area from trees and bushes so that stumps and holes in the ground do not become a hazard.

3.3.4 FOUNDATIONS

Measure and mark the area for the stone wall. It is good to use wooden sticks or string lines to help create a straight line during construction.

Remove the topsoil and roots from marked area; dig a trench some 50 cm wide and down to a depth of 20–30 cm. The ground should then be packed with a bed of rubble. When the earth is even, level and stable start by putting the biggest stones on the rubble bed. For a high wall it might be necessary to make a sturdy foundation of concrete below ground level.

3.3.5 SORTING DIFFERENT SHAPES OF STONES

Big and small stones, chips and different shapes of stones ought to be sorted out and piled in heaps to make construction work easier. The piles should be placed approximately half a meter away from the marked area, so that you can reach them easily and still move between the wall and materials.

3.3.6 THE LAYING OF A WALL

The process of laying a wall is like a giant three dimensional jig saw puzzle, where the natural shape of each stone is used to its particular advantage. The best shape is triangular or angular because it is easier to follow a straight line with these and also make a nice and straight façade. Stones with right angles should be kept aside so that they can be used at corners or ends to make a neat and straight finish or gate post. After laying the bottom course of big stones you continue by putting stone on stone so that they do not tilt but sit securely on top of each other. To check the stability push and press down each stone at the corners testing if it is secure. The work is best illustrated by a film at http://www.youtube.com/watch?v=GohedCCYkEw on the Sustainable Heritage video channel at YouTube.

Smaller stones can be used as wedges to hold the bigger ones in position. The stones should also overlap so that they are bound by friction, thus holding the construction together. Two types of materials can be alternated so that some layers are made of flat and some of round stones. Figures 19 and 20 represent the wall we built of rather small pieces. It is composed of two skins of bigger triangular pieces and a core filled with random pieces and rubble.

Big and well–shaped flagstones ought to be used to cover the top of the wall in order to protect the inside from rain and snow and consequent frost action. In windy places it might be necessary to put additional boulders on top of it all to keep the flag stones in place. If you are not a friend of snakes, make your wall without holes, because snakes like making their nests in the cavities!

Figure 19. Student experiments: lime stone wall being constructed. Photograph by Kirsti Horn.

Figure 20. Student experiments with layers of stones of different shapes. Photograph by Kirsti Horn.

3.4 PLAN FOR MAINTENANCE

The maintenance of stone walls means besides rebuilding collapsed sections also clearing bush vegetation from the vicinity of the wall. If you have a maintenance plan to follow it is more likely that the stone wall will be standing longer.

The surroundings of the walls are favorable to the growth of bushes and trees. Consequently stone walls are often covered in vegetation and disturbed by growing roots and swaying branches. The clearing of the stinging bushes takes time if it is done by hand (see figure 21). To make the work faster a brush cutter is a good alternative. For keeping bush vegetation away you can also allow cattle that feed on bushes in the fields to restrict the vegetation.

Stone walls usually need some maintenance after the winter. With regular fixing of small defects you avoid a big restoration project in the future. Traditionally the walls were repaired by their owners annually because they had a practical function. Today the walls sometimes annoy their owners as they stand in the way for modern vehicles. Instead, there should be a maintenance plan for these cultural relics, not to mention funds to carry out the work.

3.5 COSTS

The cost of building a stone wall consists of two parts, the material costs and the labor costs. Traditionally the stone material was taken from the fields so as to make the land arable. Naturally, there were no costs for the material then but today when people want to build stone walls around their houses they have to buy the material. The walls in the fields are generally old and just need repair work. Usually the material lies around the site. In some cases new stretches of wall are built there too, but then of bought stone material. Perhaps searching for stone in the fields seems like too much work for the modern man?

When you buy new stone material you can choose from all kinds of stones. A uniform quality makes construction easier. The most popular stone is limestone and the material is easily found in most parts of Gotland. In certain parts of Gotland there are lots of loose granite boulders easy to dig from the ground. The limestone and

sandstone form the bed rock and therefore require more work as they are quarried.

The price of good lime stone slabs is ca. 1500 Swedish crown (SEK) = EUR 180 plus VAT per loading pallet, i.e. some 0,75 m^3. In addition to the material costs there are, of course, costs for transportation too.

There are very few companies that specialize in dry laying of stone walls on Gotland. We had the opportunity to interview master mason Erik Larsson who lays stone walls and has a life time experience of the work. He told us that per day one man can lay 2–3 meters of chest high limestone wall and 4–6 meters wall of boulders. The market for laying stone walls is limited and the money you can make is not a lot. According to Stefan Haase one meter of wall – 50 cm wide and 80–100cm high with a foundation 20cm below ground level – is worth SEK 4000–5000 or EUR 480–600 plus VAT.

Most of the stone wall projects on Gotland are paid for by the Swedish government and the main reason for repairing and laying walls is to keep the landscape as it has been for ages. Our tutor Tage Wickström has been involved in successful projects to teach drug addicts and socially excluded individuals the craft and this way, not only to restore the landscape, but also, to give the apprentices a job in the construction industry.

3.6 SITE SECURITY

3.6.1 THE MAKING OF A PLAN FOR THE SITE

When making a work plan and time schedule it will be different each time according to the nature of the stone wall project. Things that are worth keeping in mind are:

- Use the right equipment.
- From where and how do you get stones?
- Sort different shapes of stones in piles.
- Make sure there is enough space to move safely.
- Study building techniques.
- Make a plan for maintenance.

3.6.2 TRANSPORT

Nowadays, when building with stone, it pays to use the right equipment and vehicles to transport and move the material. This will save you from injury and it will also save a lot of time and trouble. Ancient fields are usually small and the gates are narrow and the cultural landscape has historic value which ought not to be disturbed by extra–large tractors and trailers.

3.6.3 RISKS

Stones are hard, they can have sharp edges and can weigh a lot depending on the size.

A builder of stone walls of granite or limestone is exposed to several risks that could lead to terrible injuries. Cutting yourself with a sharp edge, leaving your fingers between two heavy stones and dropping a heavy stone on your feet are probably the most common accidents in this type of construction work. That is why you need proper protection.

3.6.4 PERSONAL SAFETY

Good clothing

Accidents always happen, but appropriate clothing will minimize injury. It is important to wear proper and durable leather working gloves and comfortable safety footwear with toe guards. It is also advisable to have appropriate clothes like working pants with knee pads, a wind tight jacket and so on, according to the weather. Safety goggles will give protection from thorny bushes and splinters from breaking stones. Always make sure that the size of your working clothes is correct (see figure 22). E.g., too big gloves or shoes can lead to an accident.

Figure 21. Proper gloves, working pants and safety footgear. Photograph by Tomas Simons.

Good weather

It is not possible to work safely with heavy stones when they become slippery from rain, snow or frost.

Good tools

An iron bar is all you need for a wall of round boulders like the ones we worked on. Flat pieces of lime or sand stone can be shaped with a mason´s hammer if necessary. A chainsaw and bush scissors come in handy while clearing out the field around the stone wall.

Food and drink

Another way to secure your safety is eating and drinking sufficiently. Lifting stones on an empty stomach can be hazardous as consequent irritation and exhaustion can make you careless.

First aid

The first aid kit should include sterile wipes and band aid for scratches, bandages, ice pack and pain killers for bigger injuries and tweezers for removing the inevitable ticks and thorns.

3.6.5 WORK SAFETY

If you are building a stone wall of limestone the biggest risk is probably cuts from the sharp edges of the stones. At this point the thick gloves come in handy. Otherwise the risk of injury is less significant than when working with boulders, because the stones are of a manageable size and weight. The building of a limestone wall is fairly slow work and in the beginning you will probably be sitting on the ground or kneeling for long periods. A pair of knee pads and a piece of polystyrene to sit on are necessary.

When building a stone wall of round boulders, the individual stones are generally much bigger and heavier than pieces of lime stone and can therefore cause more serious injuries. To avoid the risks, you should know your limits. Always ask somebody to help you and lift heavy loads together. It is also important to watch out for your fingers when you place the stones so that they do not get pinned in between the stones.

When the time comes to put a really big and heavy stone to its place, a bar of iron or wood is a good tool to have (see figure 23). The principle of leverage can be used to lift or adjust the large stones that are too heavy to be lifted. During the hands–on exercises we used heavy iron bars. The principle is: A stone should be underneath the bar, one end of the bar is placed under the stone to be lifted and the other end is pressed downward.

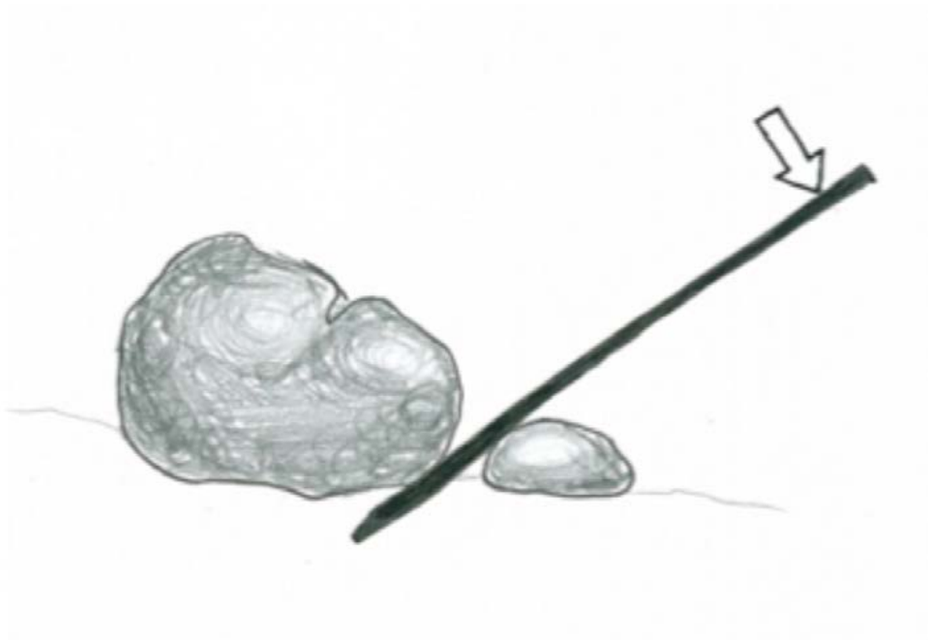

Figure 22. The leverage principle. Illustration: Maja Lofteskog.

Anyone who has been working within the construction industry knows the ergonomically correct way to lift heavy objects, i.e. to lift with your legs. The working technique affects both the outcome and your own health. Today we are more aware of lifting techniques, tools design and working hours that can facilitate the daily work than a century ago when the only restriction was the age limit of 12 years for industrial jobs and crafts. The Swedish Social Board has made a checklist that provides information on principles you are supposed to follow when lifting and carrying heavy loads. It reads as follows:

- Keep the load close to your body
- Stand with your legs wide depending on the shape and size of the burden
- Keep hips and knees bent
- Keep your back straight

- Lean your shoulders slightly backwards
- Start with straight arms
- Lift the burden by simultaneously straightening your knees, hips and back
- If the burden is lifted down, go off safely with the same procedure and foot position without jerking.
- If we apply this to lifting a stone, it may look something like figure 24.

Figure 23. How to lift according to Swedish Social Board. Illustration: Maja Lofteskog.

During our visit to Erik Larsson, the master mason, he showed another form of lifting technique abandon Social Board principles. He bent down for a stone on the ground without significantly bending the knees, as shown in figure 25. Erik claims with a smile on his face that if ever he suffered from back ache, he would simply go and find an even heavier stone and lift it a few times over and then continue with his work. This is how he has avoided arthrosis of the knees!

Figure 24. Not recommended: A lifting technique without bending the knees. Illustration by Maja Lofteskog.

3.7.6 COMMUNICATION ON THE SITE

While laying stone walls accidents cannot be completely avoided, because of gravity and the fact that we are clumsy at times. Appropriate clothing and tools are a must but not enough. An awareness of the other builders' intentions and movements is also a safety factor. It is important to communicate clearly and to make sure that no one is in the way or in a place that causes risk. You really should not work alone, at least not while laying walls of round boulders because of the high risk of injury. Never take loads that exceed what you can carry safely.

When trimming the vegetation around stone walls, the person using hedge trimmers or a chainsaw should always work at a safe distance from everybody else.

Also knowing where the others are and communicating while lifting or laying stones makes the site safer. Coworkers should be warned about tree stumps, pits and trenches. It is also important to make sure that no one is standing so that a stone could accidentally roll on him or her.

Trust between the workers comes with the years and, as we could learn by watching the stone mason pair who taught us, the communication was no longer in words. They knew exactly what was going on and what the other one was going to do next. Where to lay the next stone and when to lift which stone together just came naturally. It was remarkable how they cooperated. It looked so easy!

Figure 25. Masters and apprentice. Tage Wickström and Nils–Erik Hallbom showing the way. Photograph by Tomas Simons.

4. Conclusions

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. 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.

This report is a testimony of not only successful arrangements, inspiring teachers and highly motivated students, but also of the fact that all the mentioned goals were reached. Firstly: the intensive course on Gotland in September 2012 resulted in over 300 meters of restored stone walls. Secondly: although the work was hard it was highly rewarding and the attained knowledge became another link in the long chain of tradition.

And 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 stone walls in particular.

Group photograph of all participants and master masons Tage Wickström and Nils–Erik Hallbom (crouching). Copyright Krister Nordin.

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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.

The Estonian Academy of Arts is a leading national and international center of innovation in visual culture. In addition to active study and research, the EAA also offers lifelong learning opportunities through the Open Academy.

Currently, the 1200 students enrolled at the Estonian Academy of Arts are taught by 83 professors, associate professors, teachers and lecturers. Additionally, 38 workshop managers are on hand to assist students. The Estonian Academy of Arts prides itself on their small student to professor ratio, which allows personal and one-on-one attention for the instructor and learner. Studies take place in small groups of carefully selected students.

Many of the students participate in exchange programmes at partner international universities during their studies. The EAA cooperates with almost 100 universities abroad and belongs to several international higher education networks. Annually, students are recognized in international design competitions.

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About Campus Gotland, Uppsala University

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About Novia University of Applied Sciences

Novia University of Applied Sciences acts along the Swedish-speaking parts of the Finnish coastline. With over 4000 students and a staff of 380, Novia is the largest Swedish–speaking university of applied sciences in Finland. High–class and state-of–the–art degree programs provide students with a proper platform for their future careers. Novia University of Applied Sciences offers

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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 the dry laid stone walls in the Gotlandic landscape; it is also about what an international group of students learned through lectures, excursions and their working experience in the fields of Fide in the southern part of the island of Gotland.

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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