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Title:

The Nordic Principles for a sustainable restoration and transformation of existing buildings - as well as integrating of new houses into existing building environments.

1. Introduction, questions and abstract

A wooden building is normally regarded as a building, where the outer surfaces are of wood in the form of massive timber or wooden boards, rarer shingles. But in a broader historic, technically and architectonic view, and also geographically, a wooden building must be defined as a building with a *construction of wood*, and before about year 1900, this 'wood' was *timber*. We therefore can, historically, before about 1960, identify five different types of wooden buildings and corresponding wooden constructions in Europe. Among these are timber frame buildings with a visible timber construction, as occurring in among others Denmark, Germany, England, France and Poland.

In the Nordic countries, we have a lot, calculated in 1972 to as much as 155 *wooden towns*, with wholeness's characterized by wooden buildings, either complete or the half or approximate a quarter part, where the outer surfaces are of wood. In 2018, with a broader definition of a wooden building, are these supplemented with 10 Danish towns, and an unknown number of villages, but probably also about 10, villages characterized by timber frame buildings.

In Denmark we have very long experiences with maintenance and also repair of timber frame buildings, both filled between the timber, with wooden planks, so called bole buildings, clay, so called wattle and daub, and brigs. Especially the wooden fittings of the timber construction are very sophisticated, durable and specialized – but also very simple. We can therefore say, that most of the about 70.000 Danish timber frame buildings are very sustainable, as they now has last for 160 – 360 years, until now, and probably can last further more just as long. Regrettably about 60% of the maintenance, refurbishment and repair work on Danish timber frame buildings are done with wrong and not appropriate materials, especially plastic paint and mineral wool, causing that the life span will be much shorter and less sustainable.

It is therefore necessary to setup standards for the right and durable materials and methods for maintenance and repair – and also the principles for this work, in the 'Nordic Network for Wooden Town' called *The Nordic Principles*, because the spread of this knowledge and principles are very important for a qualified survival and protection of the Nordic wooden buildings and the Nordic wooden towns and villages.

At the end of this Article, I will suggest how we today can build new sustainable wooden buildings, based on the mentioned long traditions, and new experiments. Many so called 'sustainable' modern wooden houses, are not very durable, and therefore not sustainable, because they are built with unsuitable and new and completely untried and undocumented materials and constructions.

2. What is a wooden building?

A wooden building is as mentioned normally regarded as a building, where the outer surfaces are of wood in the form of massive timber or wooden boards, rarer shingles. But in a broader historic, technically and architectonic view, and also geographically, a wooden building must be defined as a building with a *construction of wood*, and before about year 1900, this wood was *timber*.

Historically (construction) timber has a minimum dimension of 5 x 5 Inches = 12,5 x 12,5 cm in sawn or hewn timber, not planed, but they can also be 15 x 15 cm (6 x 6") or 20 x 20 cm (8 x 8") or more. Minor dimensions as 10 x 10 cm (4 x 4"), 7,5 x 10 cm (3 x 4"), 5 x 10 cm (2 x 4") or even 7,5 x 5 cm (3" x 2") or 6,3 cm x 3,8 cm ($2^1/_2$" x $1^1/_2$") and 9,4 cm x 3,8 cm ($3^1/_2$" x $2^1/_2$") are called *scants, laths or battens*. I is first *after* about year 1900 you will find constructions with scants and battens in the outer wall constructions of wooden buildings.

This paper will only deal with wooden buildings and wooden constructions, known and build before 1960. As shown in **FIG 1**, we here have 5 different constructions of the outer walls:

1. Log construction – build of long horizontal timber logs interlocked at the corners by notching. Known archeologically and in standing buildings since the middle ages.

2. Stave construction – build of vertical wooden planks with a groove and tongue fitting. Known archeologically and in standing buildings since the middle ages.

3. Bole construction – a timber frame building with thick horizontal planks between the timber frames. Known archeologically and in standing buildings since the middle ages.

4. Timber Frame construction - a structural construction of timber posts and beams, jointed together with various wooden joints, mostly lap joints, and pegged mortise and tenon joints forming equally sized frames in the outer walls. Diagonal bracing is used to prevent "racking", or movement of structural vertical beams or posts. These can be cladded with clay, brigs or wooden boards. Known archeologically and in standing buildings since the middle ages.

5. Post and beam construction made of *scants, laths or battens,* with bearing vertical posts alternating with horizontal laths, and mostly joint together with screwed metal joints. The outside is cladded with wooden boards in various variations. Known since about year 1900. English names; Balloon frame and platform frame.

It is also interesting to see, where these wood constructions occurs, geographically in Europe. This is shown in **FIG 2.**

In many descriptions of wooden architecture, timber frame buildings are strange enough *not* regarded as genuine wooden buildings, as their outer surface are not *totally* of wood. But timber frame buildings are as mentioned constructed entirely of wood (timber), fabricated by carpenters and has many quite specialized wooden joints.

They can very often be cladded with wooden boards, but the exact same timber construction can be 'filled out' with clay or brigs – why the elsewhere hidden timber construction are therefore visible for the eye.

In fact most of the wooden buildings in the Nordic wooden towns, built after about 1860, are constructed with timber frames, and cladded with boards, and after about year 1900 furthermore constructed with scants of laths and battens, cladded with wooden boards, but with a quite small amount of solid wood in the construction.

So, at lot of, what you don't see in the Nordic Wooden Towns, because it is hidden in the construction, under the cladding boards, is timber frame. Often quite like the Danish timber frame buildings, which normally is not regarded as a wooden building.

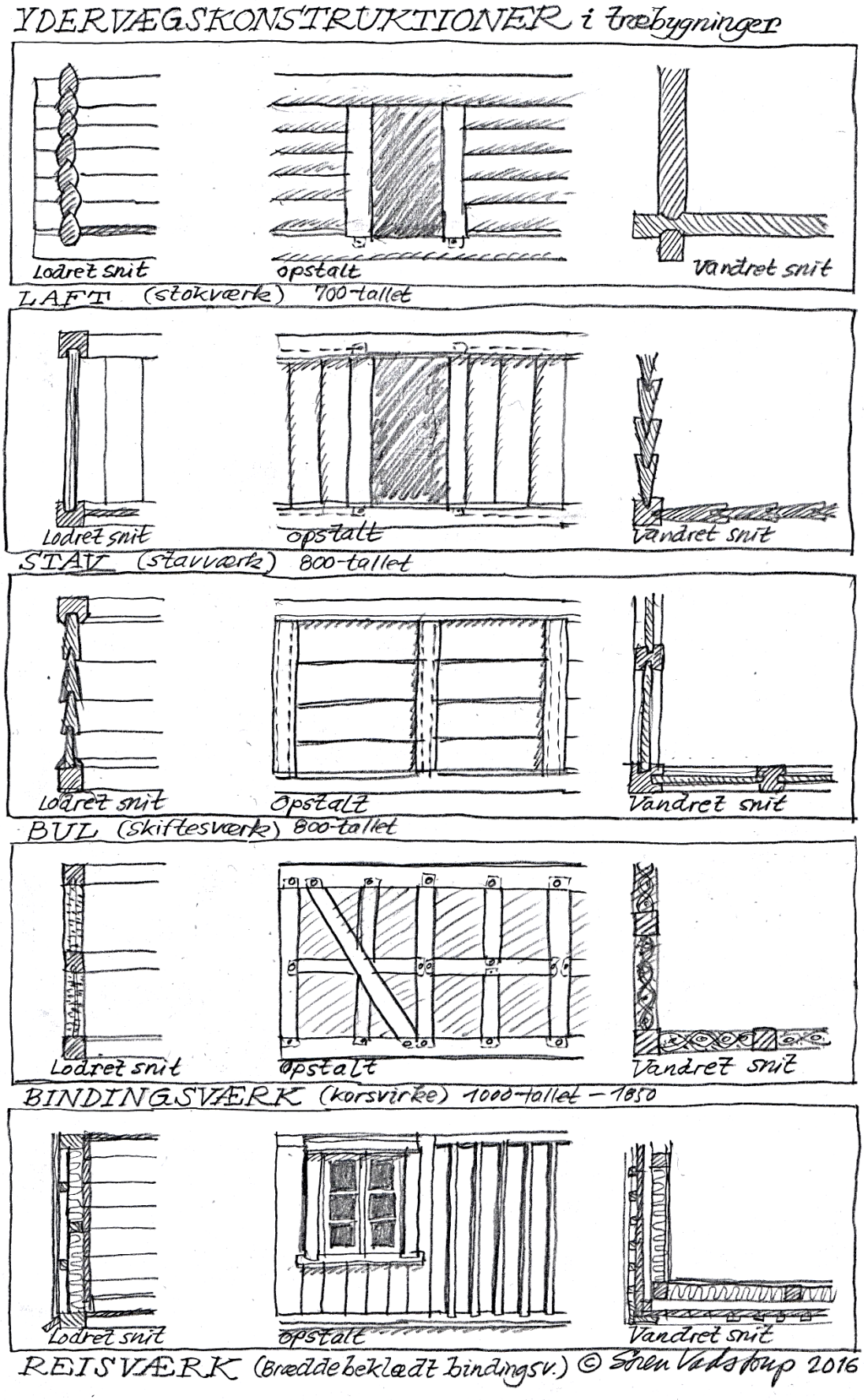


FIG 1: *The five historic constructions of the outer walls in wooden building in the Nordic countries 800 – 1960: Log construction, Stave construction, Bole construction, Timber frame construction and Laths and batten construction. Drawing: Søren Vadstrup*

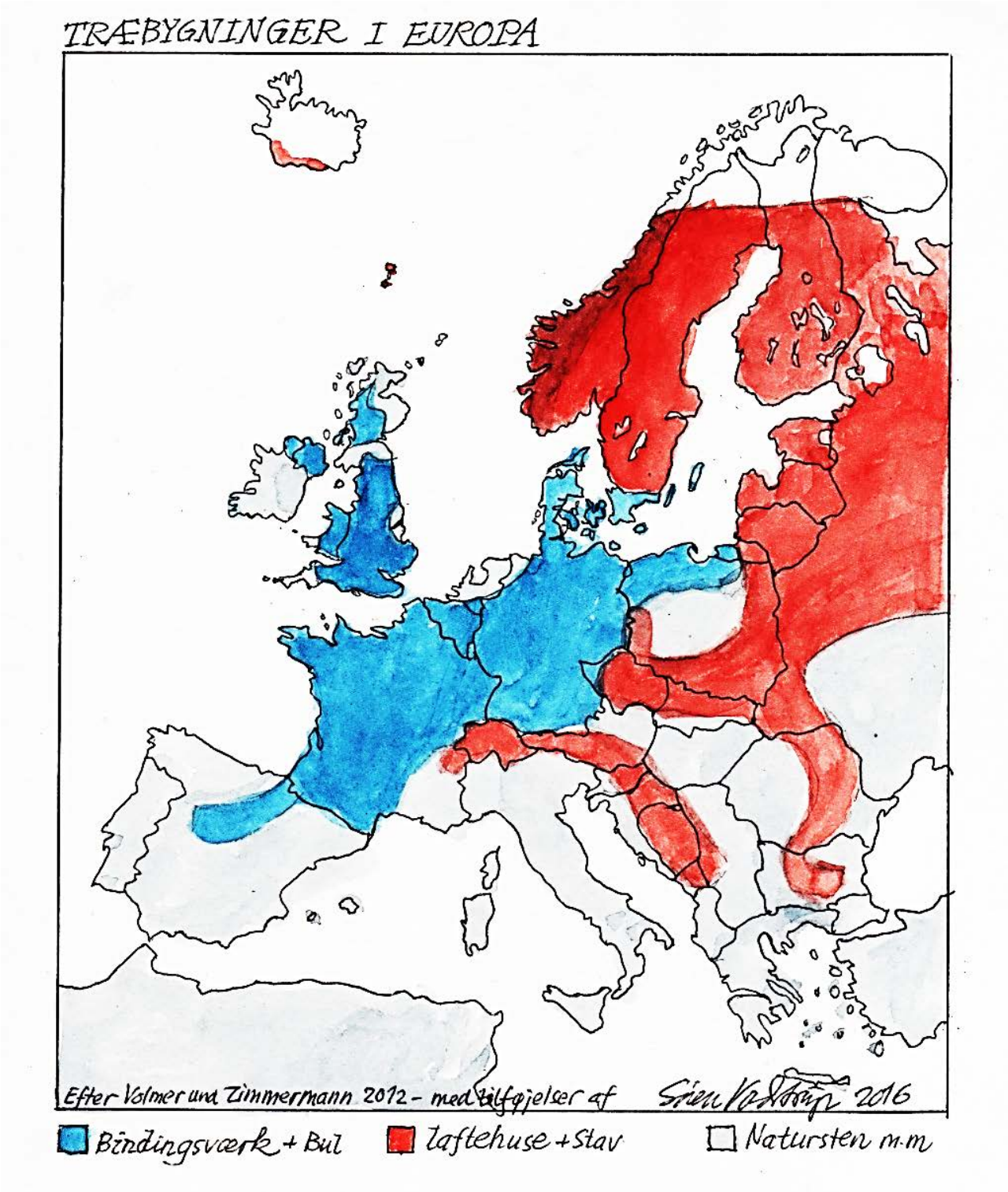


FIG 2: *Timber constructions in Europe. Drawing: Søren Vadstrup.*

Log buildings (red) and stave buildings (dark red)

Timber frame buildings.
Bole buildings are only situated in Denmark, southern Sweden and on Gotland

If you compare this to a map showing the wood species in Europe, the log and stave buildings occurs where the forests of pine and spruce are dominant and the timber frame, where oak forests and also pine forests are dominant.

*At the 'boarders' between these constructions, some buildings comprise both constructions (**FIG 3**)*

FIG 3: *Building in Switzerland comprising both log construction and timber frame, both constructions are obvious of wood. (Photo: Søren Vadstrup)*

Cladded Timber Frame

Danish timber frame buildings can in many cases be cladded with wooden boards – occurring both in dwelling houses, work shops, boat houses, store houses and factories. During the years these claddings has developed some special expressions, details

FIG 4: *Also a kind of border area construction, between Denmark and Sweden: Cladded Timber Frame Building. Denmark 1890.*

TYPICAL WOODEN CLADDINGS OF TIMBER FRAME BUILDINGS IN DENMARK

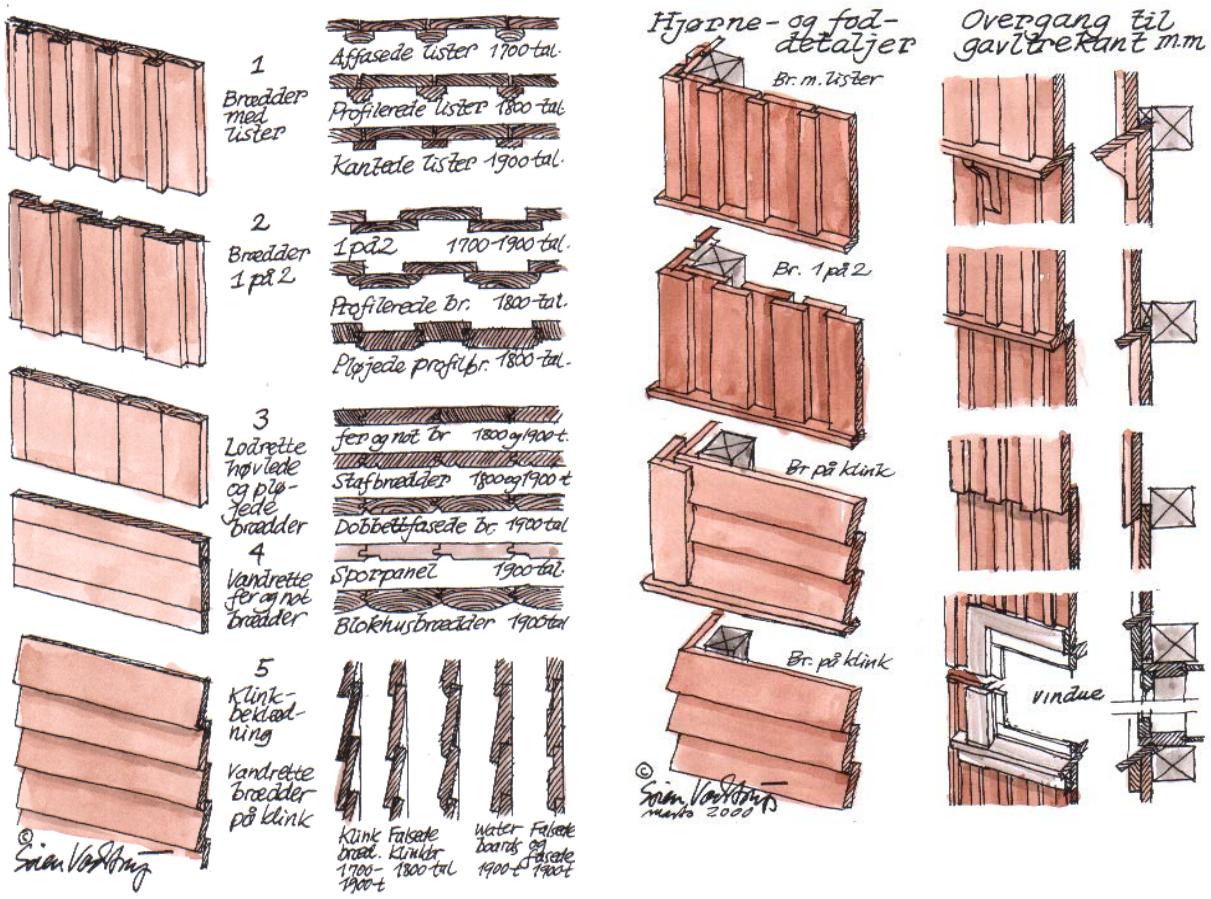
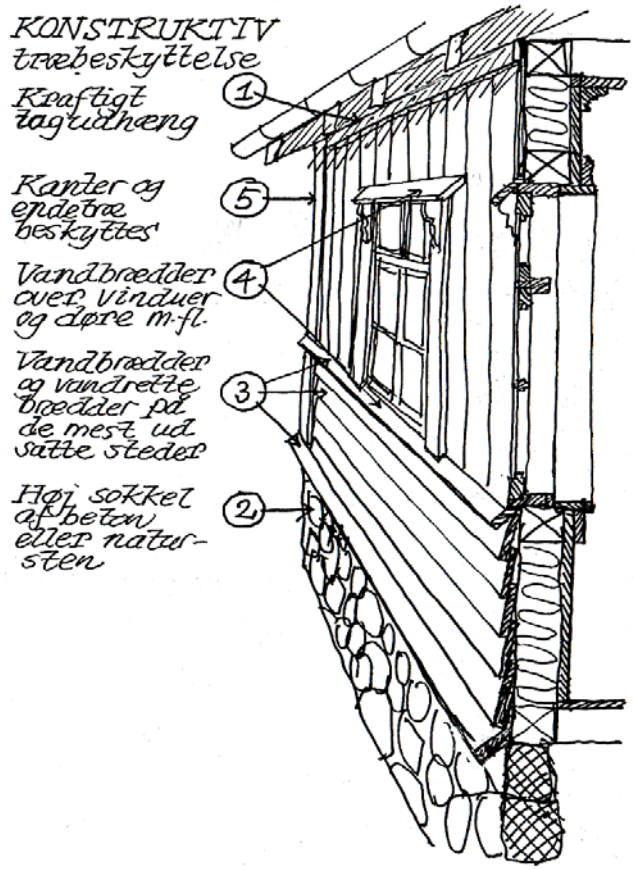


FIG 5: *Typical Wooden Claddings of Timber Frame Buildings in Denmark, and the affiliated details in corners and around windows etc. (Drawing: Søren Vadstrup). The technical names are in Danish, but both in English and Russian the names of similar constructions and details can be find.*



Constructive wood protection of Nordic Wooden Buildings

In the construction of the outer cladding, the Danish and Nordic wooden buildings are very thought out, with the purpose to obtain long durability with less maintenance. It is called *constructive wood protection*. It implies:

1. A large roof overhang
2. A high plinth of concrete or natural stone
3. Water boards or horizontal boards at the most vulnerable places – especially at the parts, nearest to the soil.
4. Water boards over windows and doors to lead out the rain water
5. Board edges and wood ends are further protected with tight boards

FIG 6: *Constructive Wood Protection Drawing: Søren Vadstrup*

3. Timber Frame and Bole Buildings in Denmark

The timber frame building is an important characteristic of the Danish landscape, many villages and about very old 10 towns. Timber frame is especially a prime example of Danish vernacular architecture, affected by regional traditions in their building development. In the cities, the timber frame buildings are built to portray wealth, power and status, and they are therefore influenced by architectural styles from the neighboring countries. In Denmark from the Baltic and Germany.

The timber frame construction is a post and beam construction made of timber. In the corners are placed leaning struts in order to brace the structure.

The walls infilling are made of five different materials:
1: Board horizontal wood planks, inserted in a vertical groove in the timber posts. Called *Bole wall*
2: Clay, thrown on a wattle and daub. Plastered with lime plaster and lime washed.
3: Unburnt bricks of sun dried clay. Plastered with lime plaster and lime washed.
4: Burnt brigs, laid in lime mortar and either plastered and lime washed or with visible brigs
5: Cladded with wooden boards

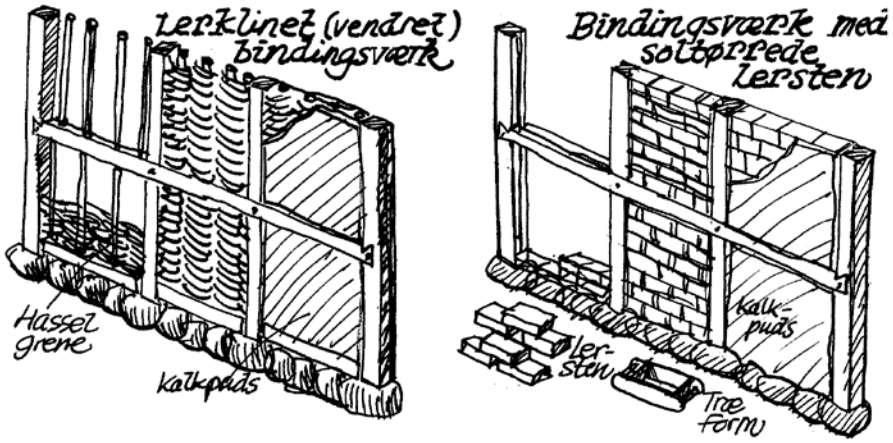
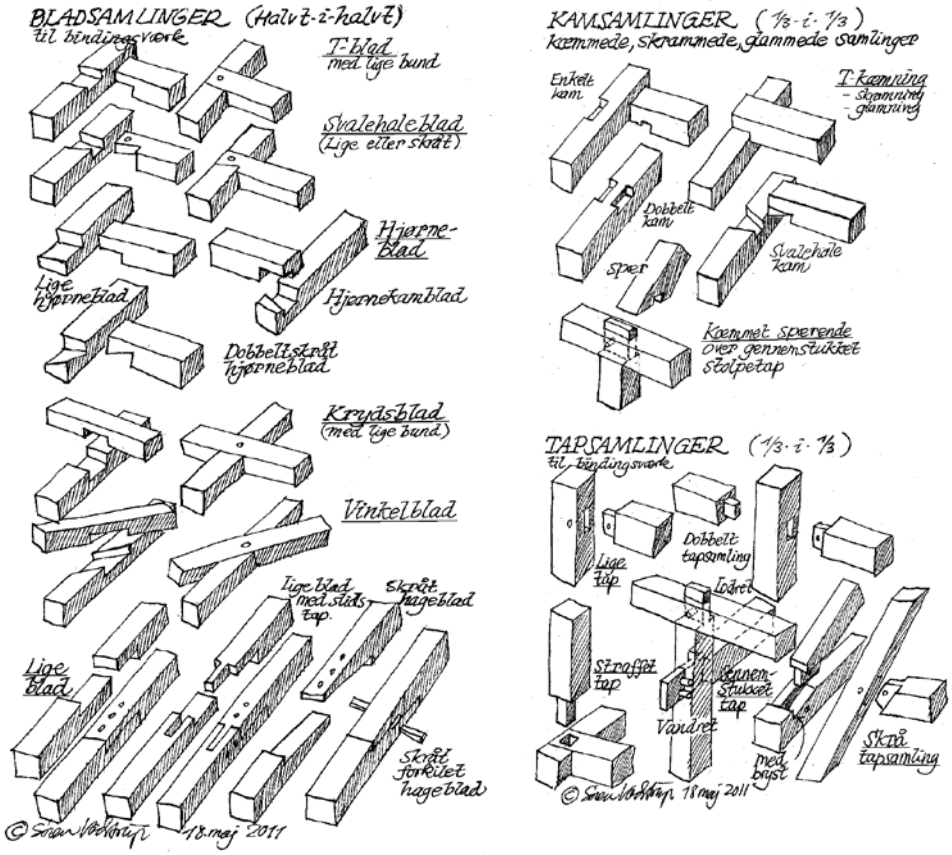


FIG 7: *Timber frame infillings. Left: Wattle and daub. Right: Sundried and unburnt clay brigs. Both finished with lime plaster and lime wash. Drawing: Søren Vadstrup*

FIG 8: *The joints between the timber elements are either halved and dovetailed (left) or mortice and tenon fittings (right), depending on age, region and specific us of the building.*



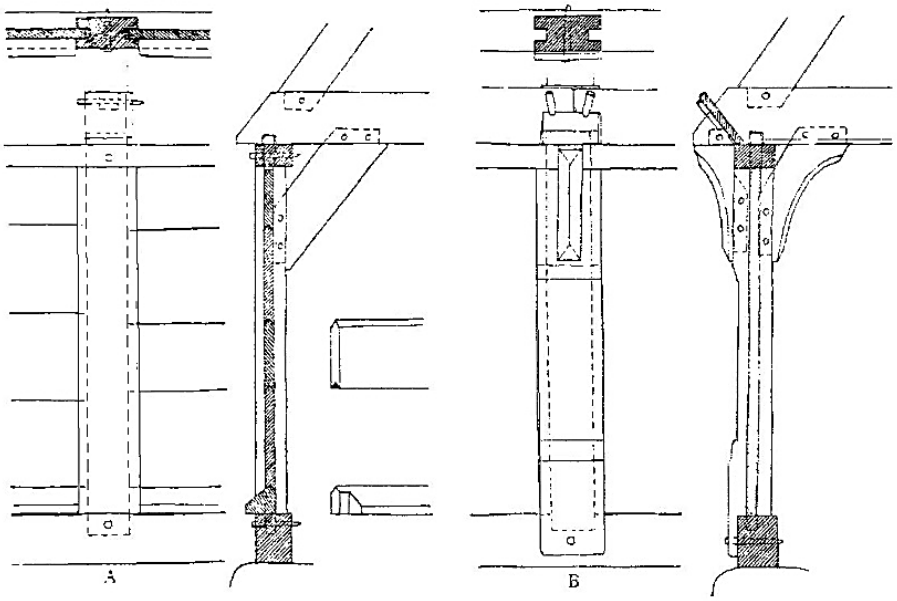
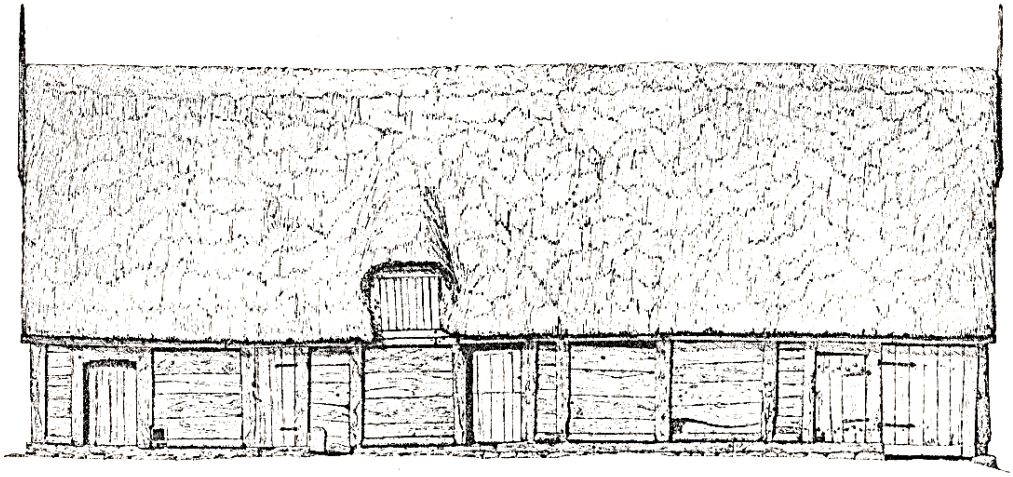
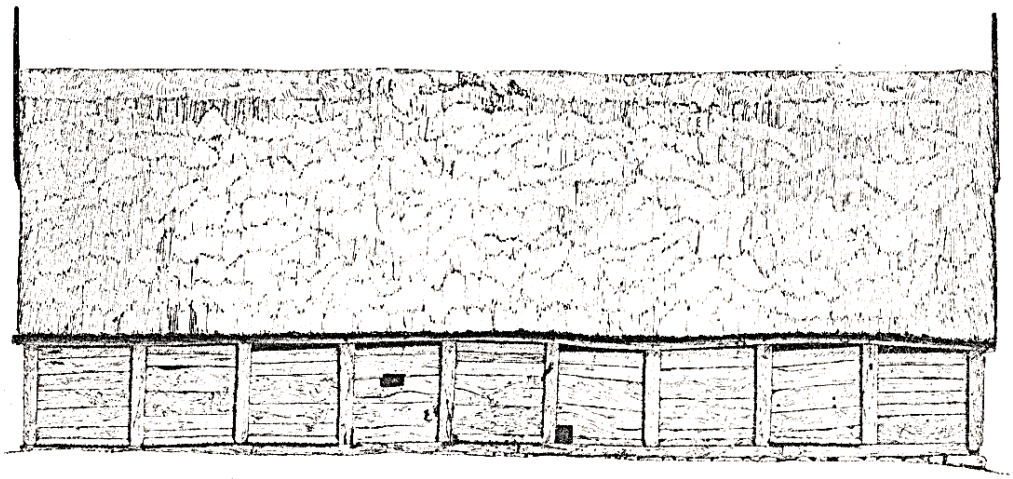


FIG 9: *Construction of a 'Bole wall'. A: ordinary post B: Post with 'overhang' to protect the wood fitting from rainwater. Drawing: Mogens Clemmensen: Bulhuse. Copenhagen 1932*



Østside.



Vestside.

We have approximately 70.000 timber frame buildings in Denmark. Only 10 of these are in Bole construction. Further 10 are situated in southern Sweden.

4. Sustainable wood technology in Danish Half Timber Houses

Technically the wooden structures of Danish timber-framed buildings, includes a number of interesting features which today are very sophisticated and instructive and increases the durability of the house and the construction a lot:

1. The knowledge of and the use of specific wood species for special purposes: sill, roof strap, gable beam, posts, rafters, battens, nails and dowels plus wattle and daub.
2. The sawn direction of the timber, especially the beams position and orientation in the cross-section, and also the processing of the timber in the wet and dry state, followed by air-drying. (**FIG. 10**)
3. Constructive wood protection through a strong roof overhang, water boards and draining cobblestone sparkling, which reduces the up splashing. (**FIG. 6**)
4. The wooden structures in it selves, the construction principles, the wooden gatherings, the struts and the special latches, that locks the constructions together and make them stable.
5. Surface treatment of exterior wood – and masonry

Saw direction of the timber

First of all the center (heart) of the wood trunk should always be avoided in timber, used for timber frame constructions. This can be possible by sawing the trunk out as shown on **FIG. 10**, which demands a trunk, including bark at about 50 – 60 cm. at the thinnest end. The trunk is divided first in two parts, where the saw follows the center with great precision. After this, the half trunk is divided in two, again where the saw is following the center precisely. This gives four equal 'quarters' of the trunk – therefore the name 'quarter sawn'. Now the four quarters are sawn into construction timber, 12,5 x 12,5 cm. If the center/heart of the trunk is still on one or two of the quarter pieces, this is removed by a saw cut of approximately 1 cm., before the final dimension is sawn out.

There is a big difference between the various sawn directions of the timber, especially the beams position and orientation in the cross-section. They are virtually like 'day and night':

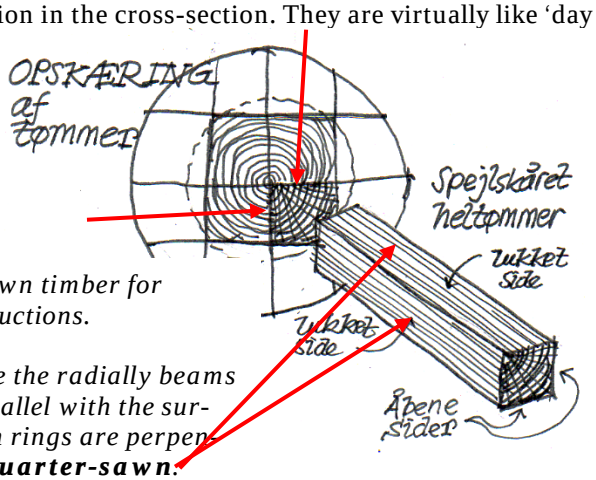


FIG 10: *Quarter-sawn timber for timber frame constructions.*

The two sides, where the radially beams in the trunk, are parallel with the surface, and the growth rings are perpendicular, are called ***quarter-sawn****.*
(Drawing: Søren Vadstrup)

In the two quarter-sawn sides of the timber (with red arrows), going radially in the trunk, and parallel to the beams, are concentrated all the best properties of the wood:

- virtually water repellent
- impossible to crack and split
- shrinks and swells (expands) hardly (stable)
- Hard in the wood and surface – because of the beams

Therefore these two sides of the timber rotten and deteriorates very slowly. They should consequently be facing outwards in the construction.

The two other sides of the quarter-sawn timber, which are not following/parallel to the beams, have virtually the opposite properties:

- Water soaking
- Prone to crack and split along the beams
- Shrinks and swells always
- Soft
- Rotten and deteriorate very fast.

Therefore these two sides must *never* be facing outwards, but should always be facing inwards in the construction. In this way the timber frame construction can easily last for 350 years – or more.

5. Wooden towns in Denmark

Wood has always been the natural building material in the Nordic countries and in the Baltic Sea region. Traditional houses were built of timber, the raw material coming from local pine and oak. Towns and villages were dominated by wooden architecture until World War II - in some regions also later.

The historic wooden towns belong to this common tradition. They also have their own identities, seen in town plans and street patterns, sometimes Medieval and organic, sometimes of Renaissance grid plan, but always in human scale and separating between public and private spaces.

We can experience the Nordic Historic Wooden Town today in small towns such as Alingsas, Eksjo, Rauma and Roros and in wooden ”suburbs” from the early industrial era, like Haga in Goteborg (Sweden) and Port Arthur in Turku (Finland). They are unique cultural heritage, attractive living environments and popular tourist destinations, each with its own unique history.

At the same time, they should serve as a source of inspiration for the town planners of today, with regards to sustainability, from both social and ecological viewpoints. They should be used as a model for circular economies, small-scale technologies and traditional materials and methods.

The Nordic Wooden Town

In 1968-74, a number of organizations in the Nordic countries carried out a major action to save the remaining Nordic wooden towns, which are unique in their history, age, environment and architectural quality, and by this have a great impact in defining the Nordic countries. The reason was the comprehensive 'total redevelopments' in the 1960s and 70s, which would provide space for more cars in the cities with parking and broader streets, and raise the standard of living for the population.

As mentioned above, this was a great threat for Nordic building culture and had to be stopped as soon as possible. Not least because the demolitions were done completely without thought and without prior registration of the state, than to say economic calculations over alternatives (preservation and refurbishment) or the involvement of citizens.

The project 'The Nordic Wooden Towns', therefore, put in a number of registrations of the cultural heritage and the build environments throughout the Nordic countries, and the urban planning began increasingly to include the conservation and refurbishment of existing buildings and urban areas.

At the end of the project in 1974, nationwide conservation associations for building culture were established in Sweden and Denmark - in Norway, the world's oldest society, Fortidsminneforeningen, was already in 1844. These societies have professionals, authorities and politicians, but also largely homeowners and other interested members.

The 155 Nordic Wooden Towns in 1971

As part of the project, a larger survey was carried out in 1971-74 to find all the relevant wooden towns in the Nordic countries, both in terms of where they are situated and how well-preserved they are. See **FIG. 11:**

The map identifies 155 Nordic wooden towns, which are grouped into 3 categories:
1: Well preserved wooden towns
2: Wooden towns with large areas preserved
3: Wooden towns with smaller areas preserved.

These 155 Nordic wooden Cities are incl. 10 wooden towns in Iceland and the Faroe Islands, but no one in Denmark, for Danish timber-framed buildings, did not count as real wood buildings. They are doing this now in the new 'Nordic wooden town project', which the preservation associations in the now four Nordic countries have started in 2015.

Today, the Nordic wooden towns are again under pressure, but now no longer direct demolitions, but from violent modernizations, renovations and extensions, replacements of, among others, doors and windows, maintenance with wrong materials and flooding of 'tourists'.

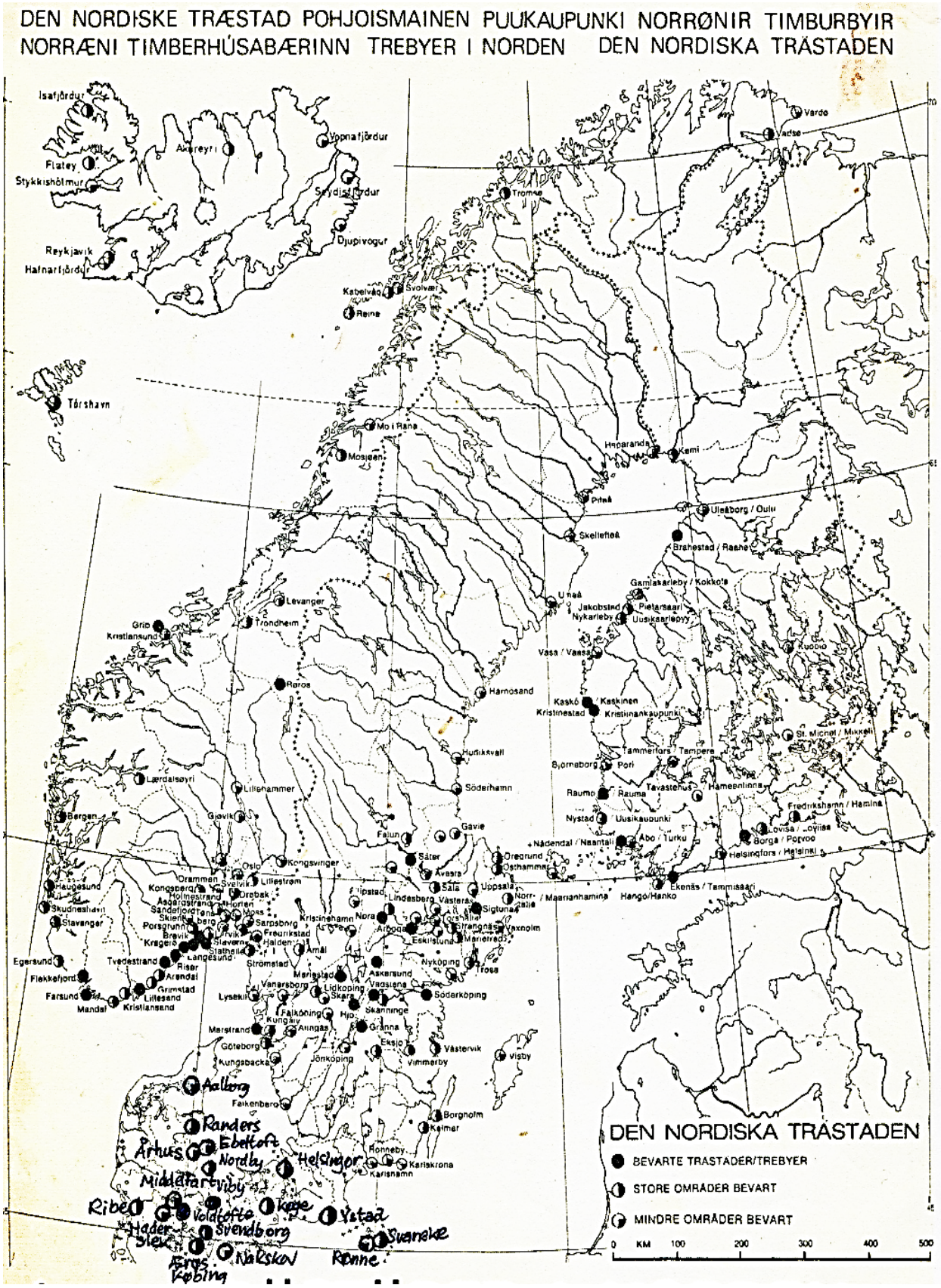


FIG 11 *the 155 Nordic Wooden Towns – plus the 16 Danish Wooden Towns*

- Well preserved wooden towns
- Wooden towns with large areas preserved
- Wooden towns with smaller areas preserved.

In Denmark, 16 wooden/timber frame towns now have been identified. None of these are 'well preserved', but only 'Wooden towns with smaller areas preserved'. A single town with 'Well preserved wooden areas' is located in Skåne in Sweden. However, around 10 villages in Denmark can be termed ' Well preserved timber frame villages'. But this amount has to be documented further.

The map of the 155 Nordic wooden Towns has therefore been supplemented with the 16 Danish 'timber frame towns and 3 timber frame villages. See **FIG. 11**.

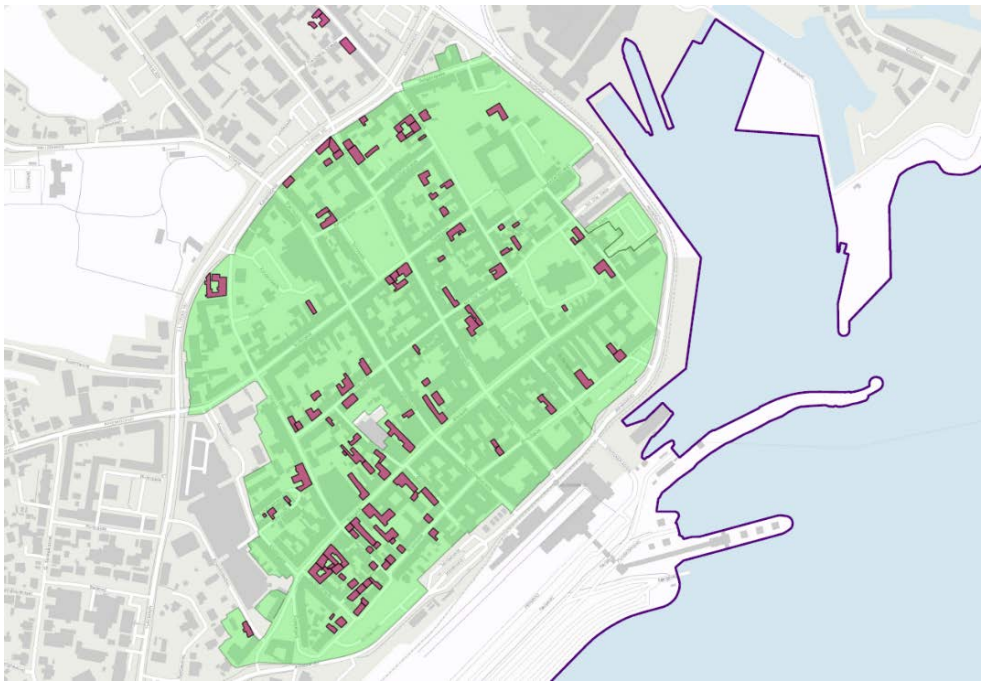


FIG 12: *The about 90 Timber Frame Buildings in the city center of Helsingor*

Helsingor

As an example of the state of the Danish wooden Towns, a record has been made of the existing timber-framed buildings - with visible timber, in the city center of Helsingor. The registered approx. 90 buildings, equivalent to about 15% of all buildings in the city center. In addition to this there are maybe the same amount of plastered timber frame buildings, where the timber therefore is not visible. They are also possible to register, but it is not the purpose of removing the overlay plaster.
See **FIG. 12.**

This building is one of the oldest timber frame houses in Helsingor. It dates from 1577.

THE NORDIC PRINCIPLES

for a sustainable transformation and refurbishment of existing buildings -
as well as integrating of new houses into existing building environments.

Manifesto

We, the four Nordic associations working for a qualified preservation and development of the Nordic building culture, hereby present five principles for the careful and sustainable transformation and refurbishment of existing buildings in the Nordic countries - as well as the integration of new houses into existing building environments.

Our concrete experience, as well as proven research, over the last 15-20 years, has shown that the most attractive, technically best, most durable and economically advantageous results can be achieved by consistently using the old and proven classical building materials - rather than modern, newly developed and insufficiently tested materials, methods and structures. These old, well known and genuine materials have been used in the Nordic region for hundreds of years, for the maintenance and refurbishment of older buildings.

The classical building materials represent simplicity, genuineness and historical authenticity that fits well with older buildings, and in addition they are environmentally friendly, sustainable and without toxic or dangerous substances that spread to the environment. Therefore, they are also suitable for use in new buildings fitted into older building environments.

This knowledge and attitudes, methods and experiences are shared and used by the antiquarian authorities in the Nordic countries, by the major state building owners, and they also form an important part of the teaching of architectural schools in the restoration and transformation of existing buildings.

Sustainability means a very long lifetime, at least 200-300 years, based on simple and systematic maintenance with classical materials, reparability and flexibility in form and function - where the buildings are refurbished and reused on the actual site - and not demolished and / or recycled as materials. We call it *real* reuse, recycling and circular economy, rather than secondary recycling and circular economy.

The practices and experiences of the Nordic countries in these areas are in many ways leading in the world, but in spite of this, we can observe that 3 out of 4 restoration, renovation or energy improvement projects or newbuilding's carried out in the Nordic countries, are based on the almost opposite principles. This leads to a critical deterioration of the Nordic building culture, historically, technically and architecturally.

The Nordic Principles
for a sustainable transformation and refurbishment of existing buildings - as well as integrating of new houses into existing building environments.

1. All interventions, small or large, on or around existing buildings, must be based on a methodical, historical, technical and architectural analysis and assessment, that is the prerequisite for a maximum knowledge of the building - and thus a qualified and respectful project.

2. Keep as much as possible of the original materials, elements and structures by repairing in order to replace - also so wear and patina can be kept. This preserves the identity, soul and atmosphere of the house and represents genuine reuse.

3. New materials and elements in existing buildings, and in new buildings in old environments, must respect and harmonize with existing materials, elements and structures. As well as the local building traditions.

4. Consistently use the classical building materials, structures and crafts techniques that older buildings are constructed with. They have proven their sustainability and represent long-term quality rather than short-term quantity.

5. Create or recreate the architectural whole of the place / building - both together and in detail. Not least through simplicity, authenticity and historical authenticity.

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