Wood Be Better

Weathering of unpainted wooden façades - Experience and examples

NIBIO REPORT | VOL. 6 | NO 5 | 2020

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2020

Publisher
Wood Be Better, NIBIO, Norwegian Institute of Bioeconomy Research

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Front picture
Naustet in Bjørvika, designed and built by architecture students from Oslo, Bergen and Trondheim in the course of the project TreStykker 2012. Façade in furfurylated Scots pine (Kebony). Photo: NIBIO/Thomas Ekström

ISBN 978-82-17-02499-6
ISSN 2464-1162

Preface

An unpainted wooden façade tells a story – about the building it is part of and about the place where the building stands. Sun, rain, temperature and wind conditions vary with latitude, climate zone, landscape and vegetation, and will leave their mark on the façade over time. In times past, the choice of building materials said something about available local resources and building traditions and skills. Building culture and architectural strategies guide the building's orientation and the choice of cladding, roof overhangs and detailed window design. These features are decisive for how sun, rain and the growth of blue-stain fungi affect the exterior walls. The overall impact of this exposure is reflected in the colour nuances in the unpainted wooden façades. Knowledge about how these factors interact can be translated into design which serves as a script for the story about those who built and used the building and the place where it stands.

Exterior claddings of unpainted wood are becoming increasingly popular in Norway, in both private and public buildings. Wood is a sustainable and environmentally friendly material, and the exterior surface is practically maintenance-free when used correctly. Unpainted wooden façades are an attractive and cost-efficient option for exterior walls.

There have been only a few studies of the many and varied wooden buildings erected during the past 20 years. Many of these buildings have proved durable and can serve as models for future wooden building projects. At the same time, there are examples of colour changes that neither architects nor users expected or desired. In some cases, the cladding has even been replaced or treated for aesthetic reasons. It is therefore important for architects, house owners and developers to learn from the good solutions so as to avoid the poor ones. Some of the examples in this guide will show situations and details that could be the result of defects in design or execution. We stress that we have no basis for saying where responsibility for any defects should be placed. The guide focuses on the observed condition of the façade and the probable causes of its visual appearance.

It is intended as an introduction to how unpainted wooden façades change with time and how the process is affected by design and building details. We want to make colour changes more predictable by looking at different examples of designs and structures and how they affect the natural weathering of the wood. We will not go into detail about fungal decay, since our focus is on colour changes in the wood. The guide is meant to serve as an information tool for architects, craftsmen, manufacturers, house owners and others with an interest in the use of unpainted wooden claddings.

All our examples are taken from Norwegian projects. We have made a point of showing how unpainted wood acts under the diverse regional and local climate conditions that we find in Norway. Surveys were conducted and photos taken in autumn 2016 and spring 2017.

This visual guide is part of the 'Wood Be Better' research project (funded by the Research Council of Norway) and was prepared by the Norwegian Institute of Bioeconomy Research (NIBIO) and the Oslo School of Architecture and Design (AHO) and was first published in Norwegian in August 2017 (NIBIO Rapport 3(98) 2017, Fargeendring i umalte trefasader - erfaringer og eksempler).

Wood Be Better project
Ås, January 27th, 2020

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Norway has long-standing traditions in using wood as cladding on exterior walls. The natural greying of unpainted wooden façades is associated with recognisable building traditions, and is seen by many as a distinctive aesthetic and valuable feature. A politically and culturally motivated orientation towards use of wood, and increasing environmental awareness relating to use of materials in building and construction, have renewed the interest in the use of unpainted wooden façades.

What is an unpainted wooden façade?

Unpainted wooden façades are exterior claddings in wood that have neither been surface-treated before nor after installation, and where no surface treatment or significant maintenance is envisaged during the cladding's service life. This includes untreated wood species and some unpainted, modified and Royal-treated wood-based products. Modified wood and Royal-treated wood are included because they are used in unpainted wooden façades and will undergo the same ageing process as untreated wood. In the absence of a protective surface coat, unpainted wooden façades will be directly exposed to climate impacts, which will change the colour of the wood over time. The change in colour will depend on the character of the climate impacts, as well as on the anatomy and quality of the wood, cladding design and building details.

Brueland Kindergarten in Sandnes. Untreated wood shingles cladding, completed in 2012.

Why choose an unpainted wooden façade?

Given the right choice and use of materials, a wooden façade may last for more than 60 years without surface treatment and require a minimum of maintenance. Maintenance is a substantial expense, and a good reason for choosing unpainted wooden façades. An unpainted wooden façade is a 'living' façade with a natural play of colours and texture. Unpainted wooden façades are an alternative to more homogeneous and uniformly coloured painted façades and industrially manufactured materials. In a country with strong traditions in wood-based construction, unpainted wooden façades are also associated with a lasting and valuable building culture.

Unpainted wood from sustainable forestry is a renewable material that plays a key role in the bioeconomy. The use of wood as a building material means that carbon is stored in the buildings and helps to reduce the greenhouse gas emissions. However, favourable environmental effects depend on a long service life of the wooden materials and products. Furthermore, utilising the wood's intrinsic durability renders the use of superfluous chemical components for surface treatment, as well as maintenance in the form of cleaning and renewed treatment. From an environmental perspective, it is also important that unpainted wooden façades have long aesthetic durability.

Sverresborg open air folk museum in Trondheim. Photo: NIBIO/Lone Ross Gobakken

The technical and architectural role of cladding

The building envelope – i.e. the exterior walls and roof, has traditionally been the most important means of protecting a building against wind, rain and other exposure. Based on new construction principles, architectural themes and building products, the building envelope is often composed of several layers that, combined, provide adequate protection.

Timber slats may function partly as a sunscreen and partly as an exterior wall cladding, when combined with an underlying weather-tight cladding. The slats can also remove visible divisions between floors, and between the closed and open (glazed) parts of a façade. Wooden claddings play a more varied role in contemporary buildings, but their service life is still dependent on material quality and the design of building details.

The Customs Building at Gardemoen Airport. Oak timber heartwood cladding, completed in 1998. Photo: Reiulf Ramstad Architects/Roberto Di Trani.

Cladding – service life

The cladding is the outer layer of the building envelope and is intended to protect the underlying structures against the sun, rain and wind. A wooden cladding most often consists of non-loadbearing components, enabling the replacement of parts of or whole façade sections. For a façade to maintain its service life, it is important to use suitable wooden materials and timber products and assemble them in a way that prevents direct wetting and damage from wood-decay fungi.

SERVICE LIFE is defined as the time period after completion, for which the building and building components meet the functional requirements. Under ideal conditions, wood can have a service life of hundreds of years.

Cladding – aesthetic life

In addition to having a technical function, a building's cladding is also an important part of its architectural character. The cladding's appearance does not necessarily affect its technical functionality. The service life of a façade can nonetheless be reduced by its visual appearance if users and others find it unsatisfactory or are unhappy about the way it changes colour over time. The changing appearance of an unpainted wooden façade can be perceived as a pleasant architectural feature and create the impression of a 'living' façade that responds to its surroundings.

People have different expectations as to what an unpainted wooden façade will look like as it weathers. Many think that it will quickly start to turn grey and then gradually take on an even grey colour. In many cases, this is not how the colour develops, particularly not during the first years. Utilising and spreading knowledge about how the colour changes over time – depending on choice of materials, detailed design and climate impacts – makes it possible to extend the aesthetic lifetime of unpainted wooden façades. This will give the building's architects and users a more nuanced understanding of the colour changes.

Berg student village, Trondheim. Royal-treated Scots pine cladding, completed in 2010.

The student village at Berg is clad in Royal-treated Scots pine. The upper floor has horizontal cladding in the style common in Western Norway, with the overlying boards protecting the underlying boards against the rain and the sun. This has a shadow effect and creates characteristic colour patterns in the façade.

The student village was completed in 2010. Six years later, the façade had undergone a natural colour change. The façade had not suffered any fungal decay and its technical function was intact. The building was nonetheless painted in 2016. This shows the need for information about how unpainted wooden façades change colour.

Wood species, manufacturing and types of cladding

2

The weathering of a façade depends on the materials used, exposure to climate loads and the detailed design. Possible reactions between fasteners, such as screws and nails, and the wood also play a role. Even if the correct wood species is chosen, the type and quality of the boards can have a decisive effect on the appearance of the wall. Variations in the quality and surface texture tend to produce greater variation in the wall, while a uniform quality and surface texture produces a more even and uniform colour.

2.1 Durability

Durability is a term that describes the wood's intrinsic resistance to decay, i.e. the wood's capability of resisting attacks by wood-decay fungi. Wood species and wood preservatives are divided into different durability classes based on tests using wood samples in contact with soil. The classification reflects the time it takes before a fungal attack is observed and the speed at which the wood decays. Placing wood samples in soil contact represent a challenge use condition and the test gives a good indication of the wood's durability (see Table 1). Wooden materials will have a shorter service life in contact with soil and in marine environments than in structures above ground.

Field test (EN 252) of the durability of different wood species and preservatives, Ås.
Photo: NIBIO/Gry Alfredsen

DURABILITY CLASSES AND USE CLASSES say little about future weathering and colour changes, but they provide important guidelines for deciding what wooden materials to choose in order to meet technical service life requirements.

Decay in untreated aspen wood.

WATER AND MOISTURE can be trapped as a result of failure in the detailed design, construction or craftsmanship. Undrained water or inadequate ventilation can lead to situations of frequent wetting and constantly high wood moisture content. Such situations correspond to use class 4 and require highly durable wooden materials.

Table1, Durability of wood against wood-decay fungi is classified in five classes (EN 350):

Durability class	Describtion	Wood species, examples
DC1	very durable	Afzelia, Ipé
DC2	durable	Yew tree, Western Red Cedar, Oak (2-4)
DC3	moderately durable	larch (3-4), Scots pine (3-4)
DC4	slightly durable	Spruce, Sitka spruce (4-5), Radiata pine (4-5)
DC5	not durable	sapwood of all wood species, aspen, birch, ash, beech, elder, maple, elm

The most durable Norwegian wood species are oak and Scots pine. The most durable wood species are tropical species.

2.2 Use classes

The durability of a wooden material is highly dependent on the situation in which it is used. The level and duration of exposure to moisture loads are decisive factors for when fungal decay starts and how quickly it develops. The longer the wood moisture content of the wooden material exceeds 20 %, the greater the probability that fungal decay will occur. According to the condition and situation of use, wooden materials are broken down into five use classes based on exposure to moisture.

Table 2, Use classes for wood in different applications (EN 335):

Use classes	General use situation	Moisture content	Critical moisture load
1	interior, dry	Maximum 20% MC	none
2	interior or under cover, water condensation possible	Temporarily >20% MC	every once in a while
3.1	exterior, above ground, exposed to the weather. limited wetting conditions	Temporarily >20% MC	every once in a while
3.2	exterior, above ground, exposed to the weather. prolonged wetting conditions	Frequently >20% MC	frequently
4	exterior in ground contact and/or fresh water	Permanently >20% MC	permanantly
5	permanently or regularly submerged in salt water	Permanently >20% MC	permanently

According to Table 2, façades belong to use classes 2, 3.1 and 3.2. This means that the wooden material can be exposed to very different moisture loads depending on the façade structure and detailed design. That is why it is important to take account of the use situation of the different façade components, and choose materials of sufficient durability already in the design phase.

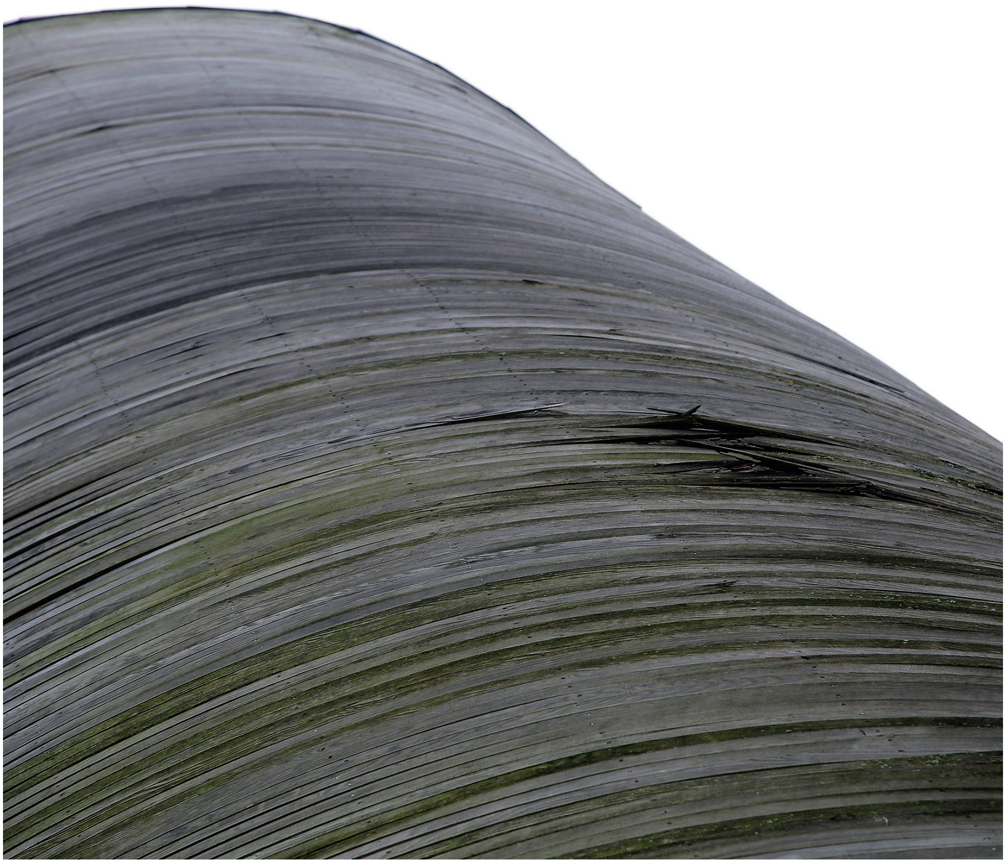
Table 3 shows choice of materials based on correct durability in relation to use class and situation of use. The table specifies minimum requirements for durability class when wood is applied in different use classes.

WOOD MODIFICATION is defined as non-toxic chemical, physical and thermal processes that change and improve the properties of wood. Properties that are improved by modification include the wood's dimensional stability and resistance to wood-decay fungi.

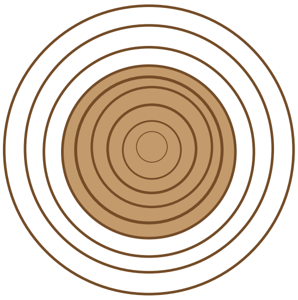
Table 3, Durability requirements for wood to be used in different use classes (EN 460):

Use class	Durability class				
	DC1	DC2	DC3	DC4	DC5
1	o	o	o	o	o
2	o	o	o	(o)	(o)
3	o	o	(o)	(o)-(x)	(o)-(x)
4	o	(o)	(x)	x	x
5	o	(x)	(x)	x	x

o – natural durability sufficient; (o) – natural durability is normally sufficient, but for certain end uses treatment may be advisable; (o)-(x) – natural durability may be sufficient, but depending on the wood species, its permeability and end use, wood protection treatment may be necessary; (x) – wood protection treatment is normally advisable, but for certain end uses natural durability may be sufficient; x – wood protection treatment is necessary.



Untreated larch wood cladding with rot damage.

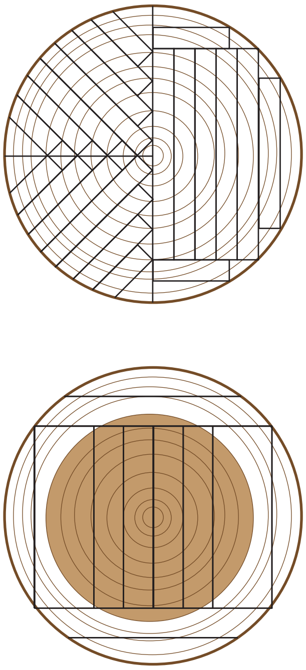


SCOTS PINE HEARTWOOD is more durable than the sapwood.

2.3 The durability of wooden materials

Many unpainted wooden façades in Norway are made of Nordic wood species such as spruce, pine and aspen, but also larch, western red cedar and oak are used as cladding materials. Of the wood species classified as 'durable' in Table 1, only oak is present in limited amounts in Norwegian forests. Durability varies, not only between different wood species, but also within each species. In most wood species, the heartwood, which is the inner part of a log, is naturally more durable than the sapwood, the outer layers of the log. The heartwood can have a different colour from the sapwood. This can be clearly observed in Scots pine. The heartwood of pine, larch and oak is often less permeable to water. This is because of the mechanical density and content of water-repellent extractives in the heartwood. These extractives increase the heartwood's capacity for resisting fungal attacks, and the quantity of active extractives can vary from one species of wood to another. The natural durability of sapwood is usually limited; it is more permeable to water and thus absorbs more moisture than the heartwood.

Scots pine log. Different durability of sapwood and heartwood.



The TYPE OF SAWING PATTERN can affect the quality of the different cladding boards.

Vertical Scots pine cladding. The cladding boards have a high proportion of heartwood, but some sapwood is present at the edges.

In addition to untreated wooden claddings, claddings of preserved or modified wood are also used.

Impregnation of wood with copper and other substances increases its resistance to wood-decay fungi and insects. By impregnation or modification, the sapwood of conifers can be upgraded from 'non-durable' to 'very durable' (Table 1). In traditional impregnation, copper compounds are often used as the active ingredient to prevent the growth of wood-decay fungi. Royal-treated wood (Royal Scots pine) is impregnated with copper and treated with linseed oil for extra water repellence.

Most impregnation agents contain toxic active ingredients against fungi, for example copper. Growing awareness of the impact of toxic and hazardous substances on human health and the environment has led to the development of biocide-free (non-toxic) wood protection systems. These systems are referred to as wood modification systems. Wood modification is defined as a process that changes and improves the properties of wood without being toxic to people, animals or plants.

Some examples of modified wood materials are: thermally treated wood (Durability Class (DC) 1-5), acetylated wood (Accoya®, DC 1-2) and furfurylated wood (Kebony RAP Clear® DC 1; Kebony Character® DC 1-2; Kebony SYP Clear® DC 2). These materials have a enhanced resistance to water and wood-decay fungi, and greater dimensional stability than untreated wood.

IMPREGNATED WOOD: The Nordic Wood Preservation Council (NTR) coordinates provisions on impregnation in the Nordic countries. The Nordic countries operate with four classes of impregnated wood in accordance to NS-EN 351-1: Durability of wood and wood-based products – Preservative-treated solid wood – Part 1: Classification of preservative penetration and retention.

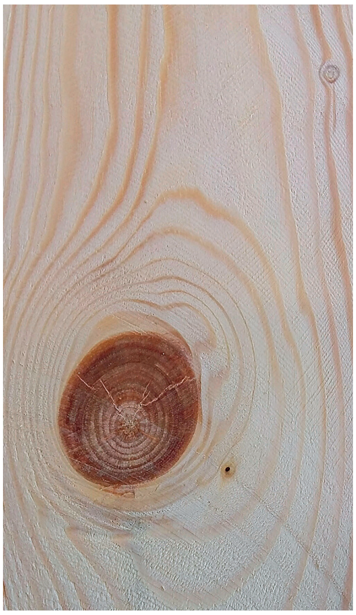
M: wood used in marine environments
A: wood used in contact with soil and freshwater
AB: wood used above ground
B: wood used in windows and doors

2.4 Service life

The service life of wooden claddings varies considerably, depending on material quality, climatic loads, workmanship and detailed design. If the structure and detailed design of the cladding are executed so that water does not get trapped and the cladding dries out quickly, a spruce cladding can have a service life of 60 years or more. If the same material is used in a façade where the detailed design is flawed, so that water is trapped and does not dry out, the service life can be significantly reduced, to less than 10 years in a worst-case scenario.

Table 4, expected service life for selected wood species in a wooden cladding with good (expected) and insufficient (worst case) detailed design

Wood species	Worst case (years)	Expected (years)
Scots pine heartwood *(Pinus sylvestris)*	< 15	60
Scots pine sapwood *(Pinus sylvestris)*	< 10	> 15
Spruce *(Picea abies)*	< 10	60
Larch heartwood *(Larix sibirica)*	< 15	60
Western Red Cedar *(Thuja plicata)*	< 10	60
Aspen *(Populus tremula)*	< 5	>15
Oak *(Quercus robur, Q. petrea)*	< 10	60
Furfurylated wood (WPG 30)	< 30	60
Acetylated wood (WPG 25)	< 30	60
Thermally treated wood (212 °C)	< 10	60



Fibre distortion around a knot.

2.5 Preparation, grading and mode of production

The properties of wood as a material can vary significantly between species, between individual trees of same species and even between different parts of a single tree.

In order to ensure that wooden materials are fit for purpose, it is necessary to specify product quality requirements. The technical specification SN/ TS 3186 sets out requirements for exterior cladding boards of coniferous wood in Norway. It contains requirements for initial wood moisture content in claddings and describes two classes of cladding. Class 1 cladding is intended for façades, while there are lower requirements for technical quality and appearance in Class 2 cladding.

Homogeneous quality and uniform preparation of the cladding boards will give the façade a more uniform appearance. Factors that affect the properties and appearance of cladding include:

- the number and size of knots
- fibre orientation
- annual ring widths
- orientation of the annual rings and type of sawing pattern
- surface processing

FIBRE DISTORTION refers to the fibres' (wood cells') distortion and orientation towards the tree's growth axis. During normal growth, the orientation of the fibres is parallel to the surface of the log. Knots can distort fibre orientation, as the fibres follow the contours of the knots.

Knots and fibre orientation

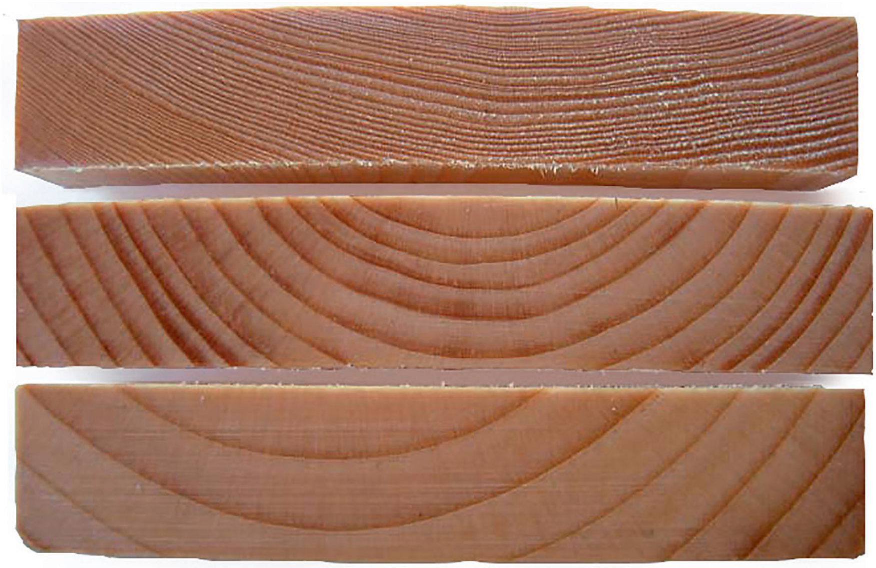
Knots in the cladding boards will affect the façade's aesthetic character. Few and small knots tend to create a calm impression, while many large knots are highly visible and give more life to the façade. Extractives and resins also contribute to a variation of the appearance and colour changes in and around the knots.

The number and size of knots in the cladding boards affect their mechanical properties. Wood from straight-growing trees has little fibre distortion and high strength. Fibre distortion increases with the number and size of knots in the cladding board. It increases the risk that the board will break when exposed to a load. Shrinking and swelling will also increase with fibre distortion and can cause deformation of the board.

Horizontal, open aspen cladding including a great amount of warped boards.

Annual ring width

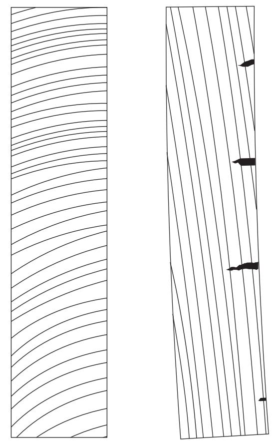
Annual ring width can affect the durability of coniferous wood. Studies using spruce have shown that wood with less than one millimetre wide growth rings absorbs less moisture than wood with wider growth rings.



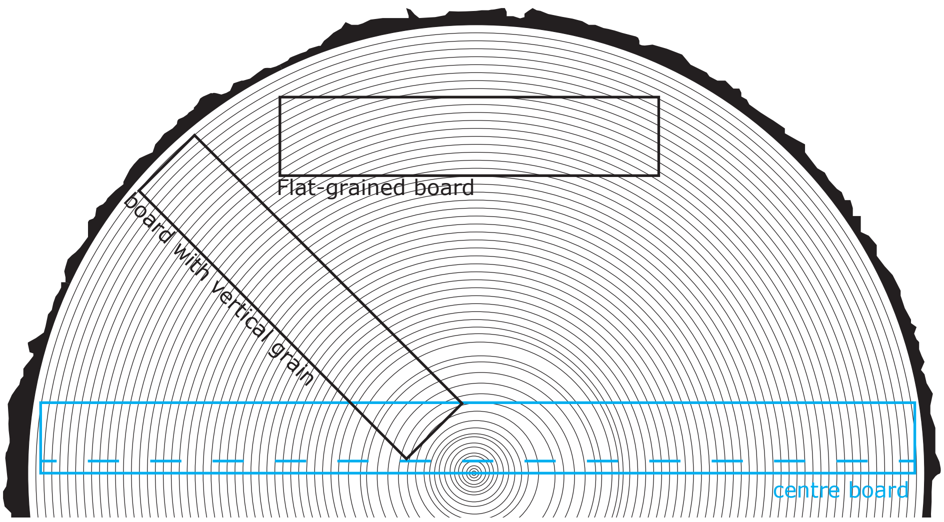
Spruce samples with different annual ring widths. Photo: Per Otto Flæte

Annual ring orientation

Annual ring orientation will affect the dimensional stability of wooden claddings during use. Vertical grain boards (growth rings perpendicular to the surface) will shrink and swell much less than flat grain boards (growth rings parallel to the surface). Vertical grain claddings develop fewer cracks. Claddings with perpendicular growth rings and a high proportion of heartwood are considered to be of good quality. That is why the centre board (centre part of the log) is often used for cladding. Flat grain boards are also available and used for claddings. Quarter sawn boards are special quality boards requiring advanced saw-mill technology, but can be delivered on order by some saw mills.



ANNUAL RING ORIENTATION: Vertical grain cladding boards will have greater dimensional stability and be less likely to develop cracks than flat-grain cladding boards.



Scots pine log showing the centre board, vertical grain, and an illustration of a vertical grain and a flat grain board

Surface processing

Cladding board surfaces are either sawn, planed, grooved or split. Splitting is primarily used for wood shingles. How the boards are produced affects how water acts on the surface. When the wood is split, it is divided along the wood fibres, which leaves few open fibres that can absorb water.

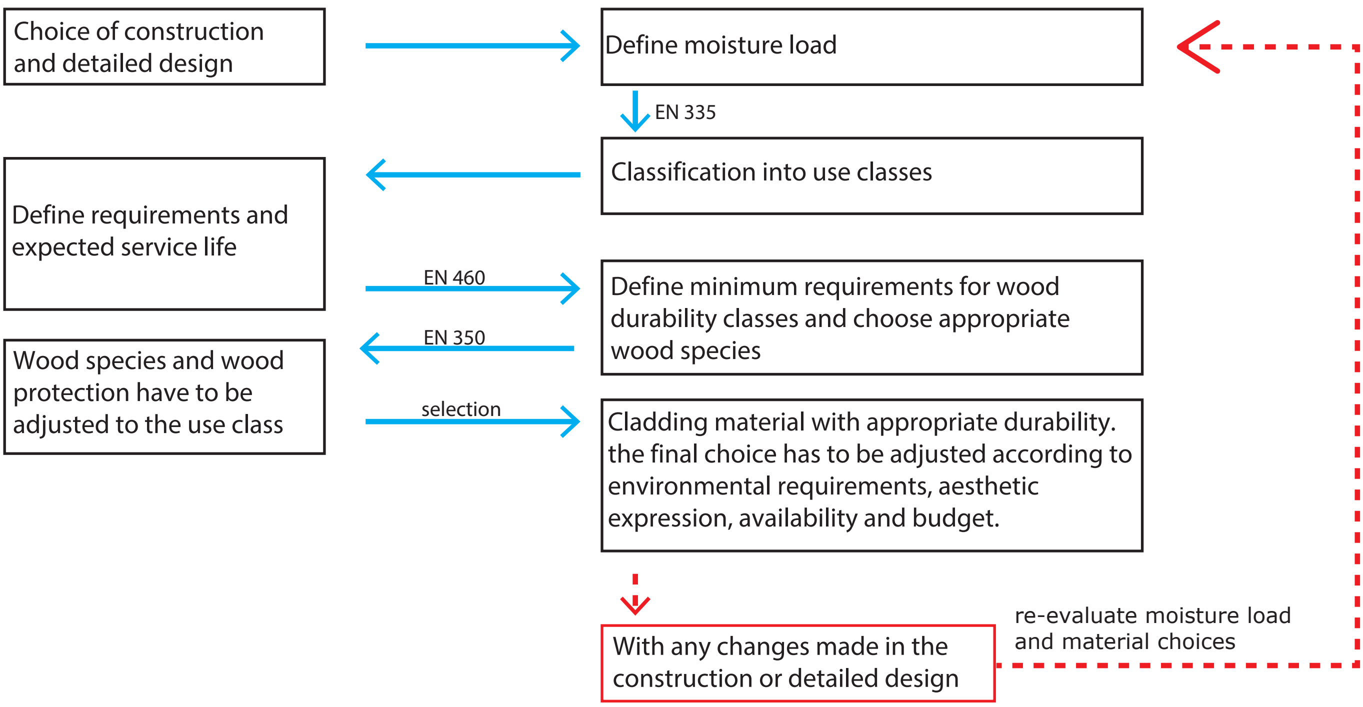
Sawing entails cutting across some of the fibres on the surface. This leaves exposed open fibres that absorb water. On planed boards, a thin layer of wood has been shaved off with very sharp knives. These boards have therefore a more even surface texture.

Different surface structures in a single plank that has been sawn-cut (on the left) and planed.

2.6 The road to choosing the right cladding material

In addition to expectations regarding the appearance of a façade, architects and contracting clients tend to prefer a wooden façade that is durable, environmentally friendly, climate friendly, maintenance-free, locally sourced and inexpensive. None of the wooden materials that are available today meet all these requirements. It is therefore important to consider what is most important in each individual project, and then choose the most suitable material and wood protection method. Wood with sufficient natural durability can be a good choice in projects where the detailed solutions are robust and there is little risk of persistent wetting. Traditional impregnated or modified wood can be used where a long service life is important and the risk of wetting is considerable. The environmental properties must be documented for all products. In order to satisfy service life expectations in the best possible manner, it is important to be familiar with wood protection methods and different use conditions.

Decision diagram for the choice of the fit for purpose cladding material

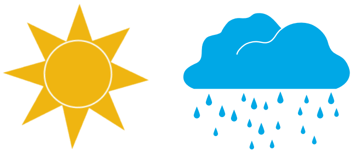


Colour changes

3

Regardless of wood species, all unpainted surfaces will undergo an ageing process that is determined by the design of the building and the climate loads to which the building is exposed. Colour changes are normally of no consequence to the technical service life or functionality of a façade, but they will give character to the building's appearance. The examples presented in this guide show that colour changes on façades are not haphazard, but follow predictable patterns and a natural logic.

Different colours in a furfurylated cladding.



SOLAR RADIATION AND PRECIPITATION are the main factors that cause colour changes in wood.

3.1 Factors

When exposed to climate loads, new and freshly cut wood will develop yellowish brown or grey colour tones. The speed and character of the colour change will depend on a number of factors:

- Place: Geographic location and climate zone
- Orientation: Which way the façade faces and the local climate conditions
- Architecture: Façade architecture and technical design details
- Sun loads: Hours of sunshine, the intensity of the sunshine and façade temperature
- Moisture: Wood moisture content as a consequence of precipitation and ambient relative air humidity
- Wind loads: Wind directions and wind speeds
- Time: Duration of different weather conditions.

3.2 The structure of the wood

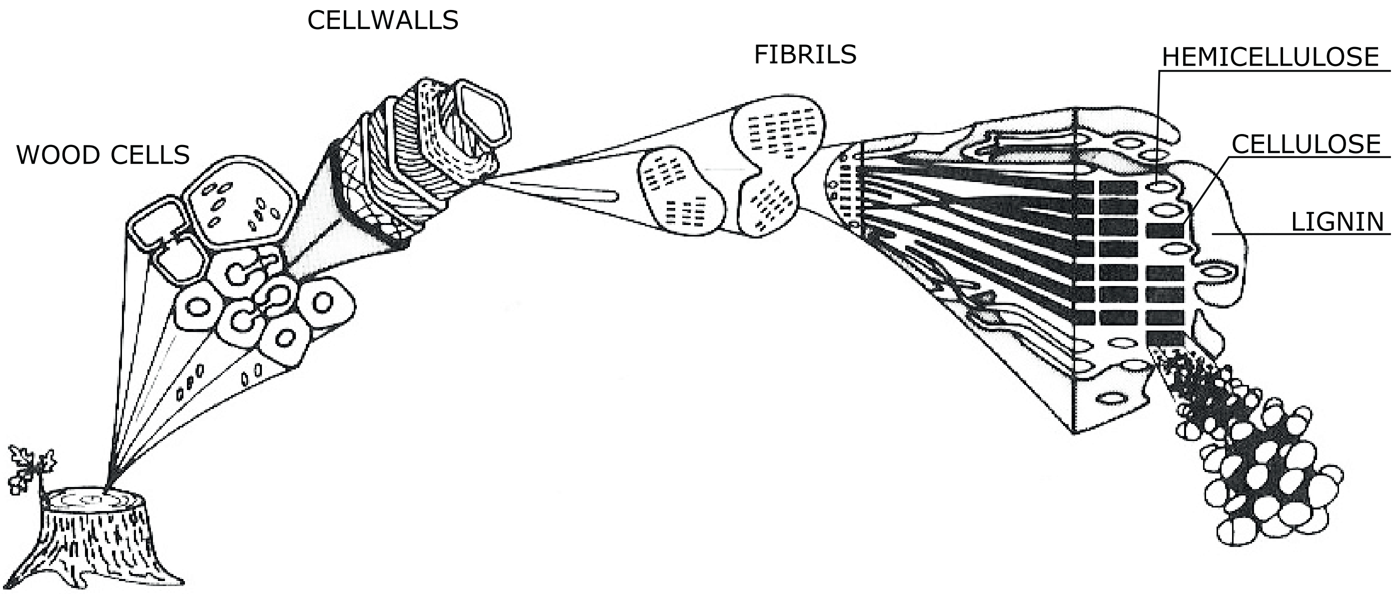
The internal structure of the wood must serve a number of functions. The most important are water transport, mechanical stability and resistance to insect attacks and wood-decay fungi.

The wood consists of many specialised cells. All the cells in the wood make up a system that gives strength and enables water to be transported upwards through the trunk and outwards through the branches.

The cell walls are made up of cellulose, hemicellulose and lignin. Together they create what can be seen as a reinforced structure. Cellulose tolerates much stretching and bending, while the lignin that surrounds it tolerates pressure loads and gives stiffness to the cell walls. The hemicellulose binds them together. The mechanical stability of the wood depends on the specific structure of the cell walls and the bond between the cells.

Many wood species contain extractives consisting of different chemical compounds. These substances are found in different combinations in different species.

The extractives help to make the wood less permeable to water, and can act as a defence mechanism against wood-decay fungi and insect attacks.



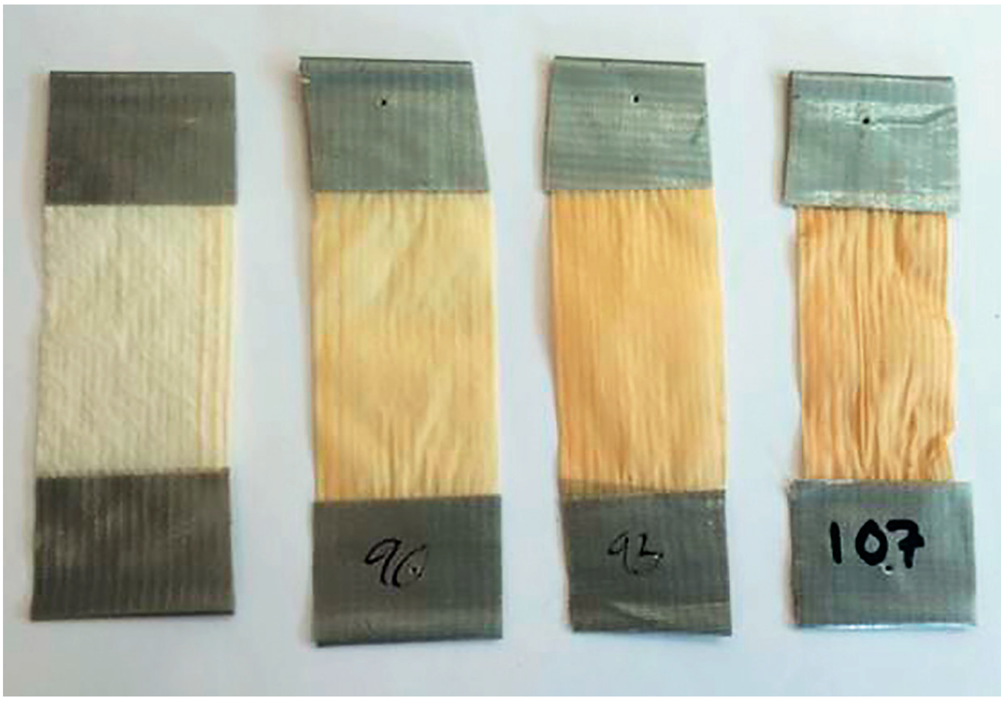
Systematic structure of wood and cell walls (Hoffmann and Jones 1989)

3.3 Process

The weathering and greying of exterior wooden surfaces is a result of several factors and the interaction between them.

Lignin degradation

As a first sign of weathering, new and lightly coloured wood of, for example, pine and spruce, tends to turn yellowish brown. This is particularly so where the wooden surface is exposed to a lot of sunlight. This is because the lignin in the wood's surface is decomposed by UV radiation. At the same time the extractives migrate towards the surface and oxidise due to repeated wetting and drying out. With time, the yellowish brown colour becomes darker. Also indoor wood panelling and furniture are known to yellow as they age.



Thin spruce veneer (100 micrometres thick) exposed to sunlight for 0, 1, 5 and 20 days. Photo: NMBU/Ingunn Burud

The image on the left shows a brownish cladding, where the whole façade has a warm dark brown appearance. Extractive migration leaves a lighter yellow colour around the knots. Façades not directly exposed to rain tend to develop a brownish rather than a grey colour.

Cladding of Scots pine heartwood, with areas of higher extractive concentration around the pitch and knots.

Blue-stain fungi

Blue-stain fungi is the common name for mould fungi with darkly coloured hyphae and spores that cause blue to black colour changes on wooden claddings. Mould and blue-stain fungi do not break down the wood. The intensity and quantity of blue-stain fungi depend on the microclimate and on the amount of time for which the surface remains moist. Façades and façade areas that are less exposed to moisture, where the ambient air humidity is low, have less growth of blue-stain fungi than those exposed to high moisture loads. Areas with much growth of blue-stain fungi can appear to be almost black after prolonged or heavy periods of rain, because the wood, the spores and the hyphae are saturated with water. When the wooden surface dries out, it appears much lighter.

Façade section between two rows of cantilevered windows in the same section of façade. Ås High School. Photo: NIBIO/Lone Ross Gobakken

Growth of blue-stain fungi on one façade area can be very variant due to the variation in the ambient climatic conditions. An example of this is found in the façade cladding at Ås High School.

The photo series on the right shows three enlarged sections of the façade with increasing amount of blue-stain fungi growth from the top to the bottom.

NIBIO/Lone Ross Gobakken

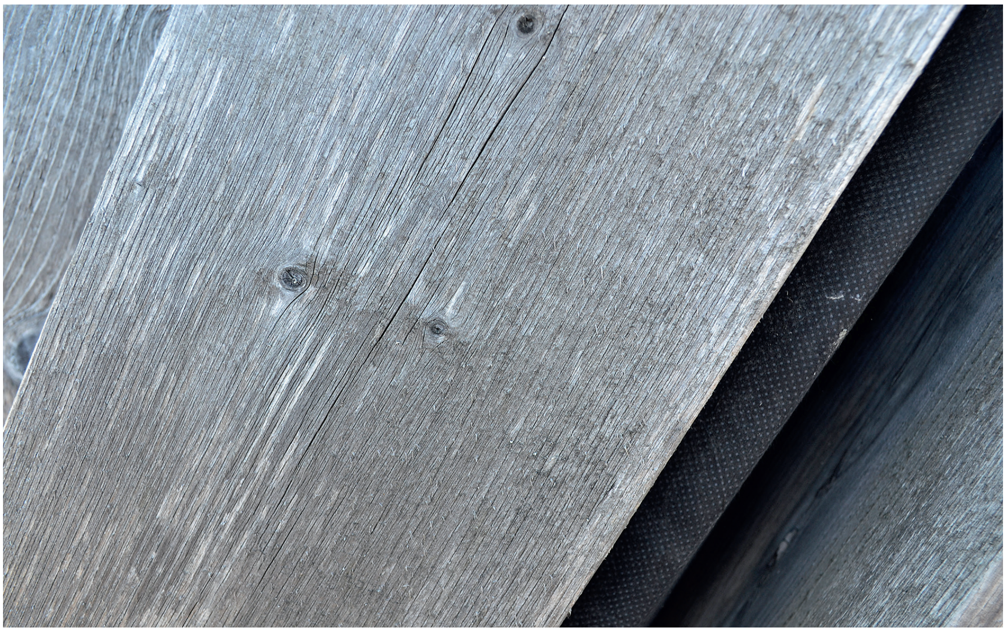
Wet south-facing façade. Lecture building, Sessvollmoen Military Camp.

Dry east-facing façade. Lecture building, Sessvollmoen Military Camp.

The two photos are of the same building and taken on the same day at Sessvollmoen Military Camp. Photo 1 shows the façade when it is soaked and dark, while the façade in Photo 2 is dryer and has a much lighter appearance.

Façade leaching

Rain on the façade causes leaching of degraded lignin components and oxidized extractives from the surface. As a result, the cellulose in the fibres become more apparent. Pure cellulose is almost white and where there is little growth of blue-stain fungi, the façade turns light grey or silvery in colour. The parts of the cell walls that hold the wood cells together have the highest lignin content. The degradation of the lignin weakens the bonding between the cells. Recurrent rainfall and leaching of degraded lignin leaves behind fibres that are rich in cellulose. These can protrude and produce a fibrous surface (see photo).



Fibrous surface of a cladding board

Mechanical erosion

In windy areas, we normally see little visible growth of blue-stain fungi, algae, moss and lichens on the cladding. Where there is a lot of wind, the cladding dries quickly. The wind can also carry ice crystals and particles of sand, causing erosion of the cladding surface. Ice and sand can 'scrub' the surface, thereby preventing fungal spores from colonizing the surface.

EROSION: It is assumed that, over a period of 100 years, approx. 3-5 mm of board thickness is lost through façade erosion.

An old façade characterized by mechanical erosion. Vigdalen, Luster. Photo: NIBIO/Lone Ross Gobakken

Biological surface growth

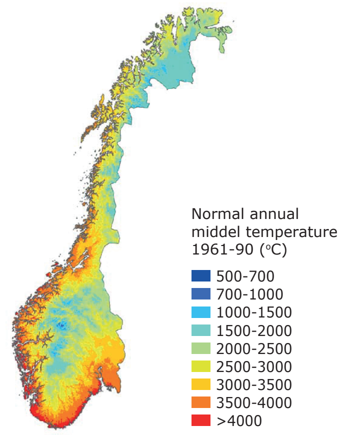
Moss, algae and lichens can grow on wooden façades. Common to these species is that they prefer environments of high relative humidity, little airflow, low temperatures and limited exposure to direct sunlight. Examples are the north wall of a building, surfaces shielded by vegetation or other areas in the shade. Algae and lichens are indicators of a moist microclimate entailing a risk of wood-decay fungi growth. Growth of moss, algae and lichens will also retain the moisture on the surface of the cladding and thereby increase the risk of growth of wood-decay fungi.

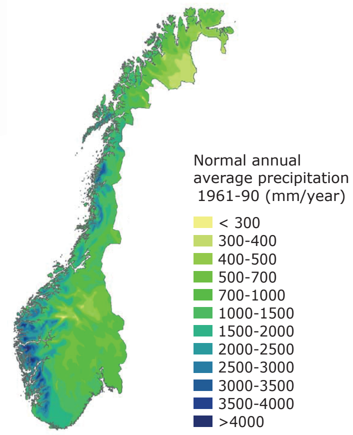
Lichens on horizontal, tilted cladding boards.

Algae growth on the lower part of a vertical cladding.

3.5 Regional climate differences

Extending 1,750 km, from 58° to 71° N, Norway has a long coastline, deep fjords, a varied topography and large variations in climate. Maps 1 and 2 show average precipitation and temperatures in Norway. Mean annual temperatures are higher along the coast than inland and in the eastern parts of the country. The coastal areas in the north, and particularly in the west, suffer high winds and much precipitation.





Normal annual average temperature and annual average precipitation (met.no)

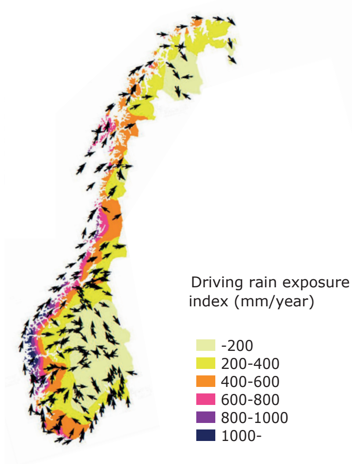
West-facing cladding of Scots pine heartwood. 4 years after installation. Stavanger.

Regional climate differences can also be reflected in unpainted wooden façades. The photo above shows a west-facing Scots pine clad façade in Stavanger, four years after installation. The façade is moist and has turned dark grey all over, an indication of strong growth of blue-stain fungi. This is a reflection of the Stavanger climate with high rainfalls and little possibility of drying out the cladding.

A 19-year old west-facing Scots pine cladding in Rena has a completely different appearance (see photo below). The climate in Rena is relatively dry. Wind-driven rain generally comes from one direction. South-, east- and west-facing walls are exposed to minor rain loads and are dark brown in appearance, with less leaching and fungal growth.

West-facing cladding of Scots pine heartwood. 19 years after installation. Rena.

Even if the walls of a building are of the same material and age, the colour can develop differently because of exposure to different climate loads. The photo below shows the northeast-facing corner of a building in Rena. One wall is grey and has been exposed to wind-driven rain, subsequent leaching and growth of blue-stain fungi. The other wall is more brown after exposure to sunlight and shows only some few traces of moisture loads. The above examples illustrate the importance of taking local climate conditions into account when designing a façade.



Driving rain map for Norway [mm/year] (Lisø K.R., 2006)

Northeast-facing building corner. The eastern-facing wall with roof-overhang. Rena.

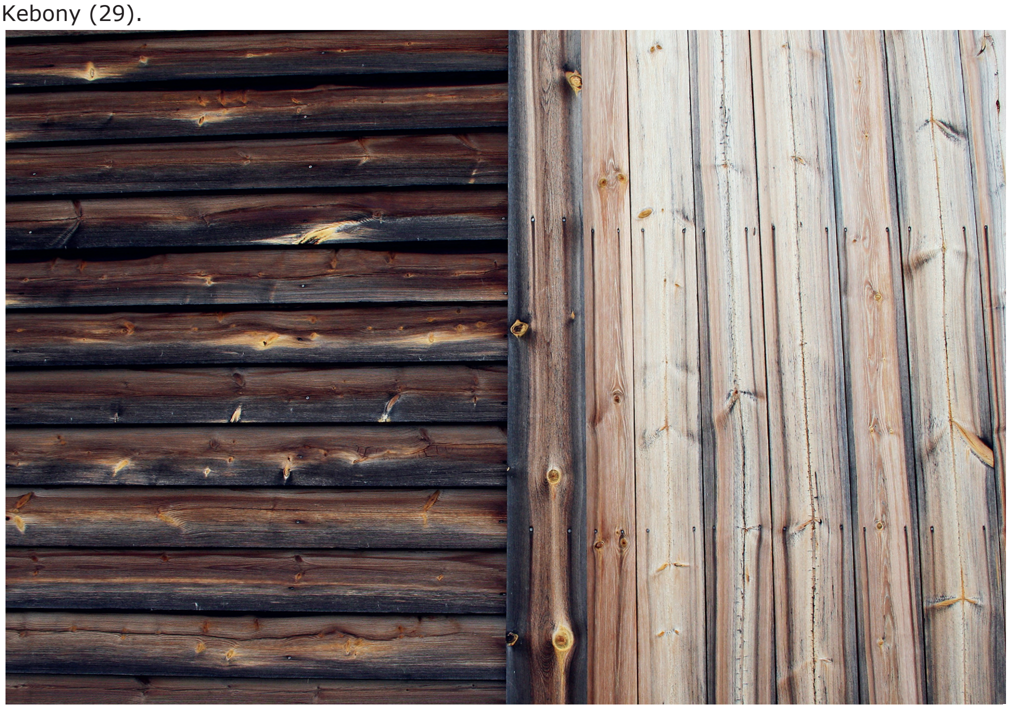
3.6 Cladding types

The choice of exterior cladding is vital to the architectural appearance of a building. Wood species, dimensions, profiles, orientation and execution are important factors. All wood species and cladding materials will undergo a colour change. The difference between wooden materials is generally relatively small if exposed to the same environmental loads. The choice of board quality and cladding type can therefore have greater consequences for the appearance of a façade than the choice of wood species.

SIMILAR COLOUR CHANGE: When exposed to the same sun and rain loads, unpainted wooden claddings will, regardless of wood species and treatment, develop similar shadings of grey.

Colour changes and weathering of different wood species and wood treatments after 3 month (upper row) and 3 years (lower row), respectively. Upper part from left: untreated spruce (35), untreated Scots pine (36), Royal Scots pine (31). Lower part from the left: acetylated Scots pine (34), thermally treated Scots pine (32), furfurylated Scots pine/ Kebony (29).

BOARD QUALITY AND CLADDING TYPE will have a greater influence for the façade's appearance than the wood species.



Vertical and horizontal installation of the same type of cladding board of Scots pine heartwood.

Horizontal cladding

Traditionally, horizontal claddings are most commonly used in Western Norway. This is because they provide good protection against wind-driven rain. A horizontal cladding of overlapping boards can vary widely in colour. Lower parts of the board can develop a clearer grey colour because they are subjected to the rain. Upper parts are protected by the overhanging board and can appear more brown. A plane vertical surface, for example a tongue and groove cladding, will have less colour variation.

Horizontal cladding of overlapping boards as used in Western Norway.

Horizontal tongue and groove cladding without overlapping boards.

Vertical cladding

Vertical claddings, for example board on board claddings, have been common in Eastern and inland areas of Norway. In vertical claddings, the area closest to the ground tends to suffer the greatest moisture loads, wetted by the rainwater that runs down the boards as well as by rain water splashes from the ground. The lower edges of the boards are often chamfered to prevent end-grain water absorption. In the event of a wood-decay fungi attack in the lower part of vertical cladding, it is necessary to replace all the boards in question. Horizontal claddings have an advantage in this respect in that only the lower boards have to be replaced in the event of decay damage close to the ground.

Vertical cladding where it meets the ground.

Wood shingles

In the Middle Ages, wood shingles were used as roof cladding, for example on stave churches. Later on, wood shingles were increasingly used also to clad façades. Shingles for cladding were traditionally made by hand by splitting knot-free pieces of wood with little or no fibre distortion. The advantage of split wood shingles is that the surface follows the grain orientation of the wood. This leaves fewer open fibres and the surface is more moisture-repellent than cut or sawn surfaces.

Overlapping shingles.

Vertical open cladding.

Open claddings and battens

Vertical and horizontal battens can be used together with straight cut or chamfered boards in façade claddings. Narrow gaps between the boards facilitate ventilation while letting in very little water. Such claddings are found in, for example, barns. Battens are also increasingly used to create an outer, 'transparent' façade layer. This requires that there is a weathertight cladding or membrane behind the battens.

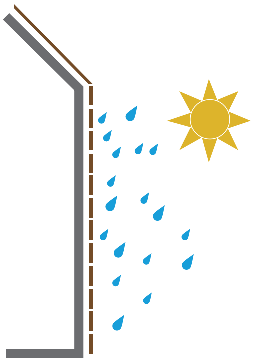
Detailed design

4

Vertical and plane sections of walls without protruding elements often develop an even colour. However, the façades of most buildings have windows, doors, overhangs, balconies etc. to meet the needs of their users. In order to accommodate these elements, the façade cladding must be disrupted, and the details of how this is done will have consequences for the impact of sun, wind and rain on the exterior wall. In this section, we will illustrate how different detailed solutions have affected the colour of the cladding in existing buildings.

The detailed façade design entails different exposure to moisture and sunshine. This can lead to very different changes in colour within the same façade.

Wood shingle cladding of Scots pine heartwood. Technical workshop, Rena Military Camp.



4.1 Vertical surfaces

A plane wall with few details is subject to homogeneous climate loads and will tend to develop an even colour. Good ventilation is important in a plane façade cladding. This is ensured by using battens behind the cladding to allow air to move behind the boards. Narrow gaps between the boards can improve the ventilation, but can also weaken the air flows that help to dry out the façade.

Military surgery course centre, Sessvollmoen Military Camp, Scots pine heartwood (Longva Architects), 2004

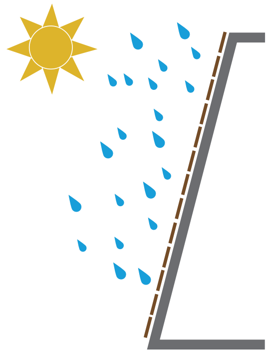
Section of an evenly coloured wooden façade. The use of battens ensures good ventilation and drying of the cladding. The upper and lower ends of the boards are chamfered.

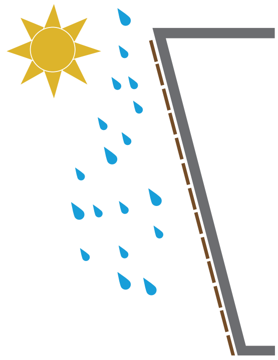
Military surgery course centre

Architect: Longva Architects
Project period: 2002-2004
Building owner: Norwegian Defence Estates Agency
Address: Sessvollmoen, Ullensaker
Cladding: Scots pine heartwood

Photo: Longva Architects/Ivan Brodey.

4.2 Tilted surfaces





On tilted walls, the slope determines the exposure to different climate loads.

Where the lower part of a wall tilts inwards, the moisture load is reduced and the wall suffers less leaching. Such walls are also shielded from the sunlight and can retain their original colour for a longer period. Specific local conditions can nevertheless produce high air humidity, and, in turn, lead to considerable growth of blue-stain fungi. Walls and surfaces with the lower part tilted outwards are more exposed to climate loads. Such surfaces can be part of a roof or the upper part of a building with a complex assembly of formative shapes, lofts and roof terraces.

The slope of a tilted façade will determine the degree of leaching and rainwater run-off, and thus how the colour changes. In principle, a wall with the lower part tilting outwards will suffer more leaching than a vertical wall. The run-off speed will also be lower on tilted surfaces. This can slow down the drying process and accelerate the growth of blue-stain fungi, algae, moss and lichens.

Camera Obscura, Trondheim, untreated spruce (Architecture students and lecturers from NTNU, with Knut Einar Larsen), 2006

The walls of Camera Obscura are tilted at different angles and with different orientation. The wall in the photo can be seen as consisting of two segments exposed to different climate loads. Half the wall tilts outwards at the lower end, exposing it to the rain (on the right), while the other half is protected from the rain by the protruding roof and cladding boards and the inward tilt of the wall below. The transition zone between the two main segments shows signs of leaching with some growth of blue-stain fungi.

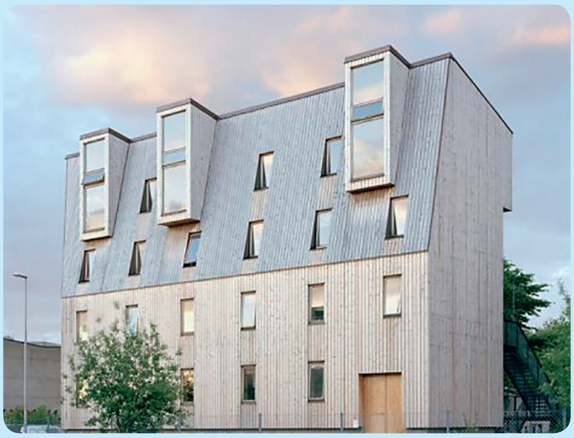
The boards that are exposed to rain have turned grey. The protected boards where the wall tilts inwards towards the bottom are brown. Some local patches, however, show signs of leaching where the water has run down from the roof. All the cladding boards have good ventilation.

Ling Ling restaurant, Oslo, furfurylated Scots pine (Alliance Architects), 2011

The wavy roof and wall design of the restaurant building Ling Ling at Aker brygge in Oslo has sloping surfaces leaning partly inwards and partly outwards. This entails uneven exposure to climate loads, causing a variegated and playful façade.

Sørhauggata 100 dormitory, Haugesund, Royal Scots pine (Helen & Hard Architects), 2015

One year after installation, the cladding boards of the slanted wall/roof face have clearly greyed more than the vertical wall cladding. Several roof boards can also be seen to have a higher moisture content than the rest, creating a play of colours on the surface.



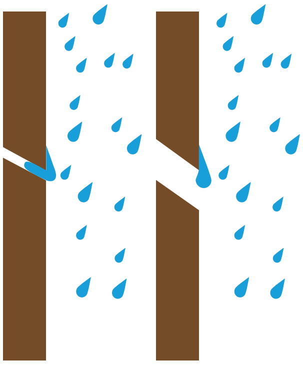
Svartlamoen sustainable apartments

Architect: Brendeland & Kristoffersen Architects
Project period: 2004-2005
Building owner: Svartlamoen foundation (boligstiftelse)
Address: Strandveien 37, Trondheim
Cladding: Scots pine heartwood

Photo: Brendeland & Kristoffersen/David Grandorge

Svartlamoen sustainable apartments, Trondheim, Scots pine heartwood (Brendeland & Kristoffersen Architects), 2004

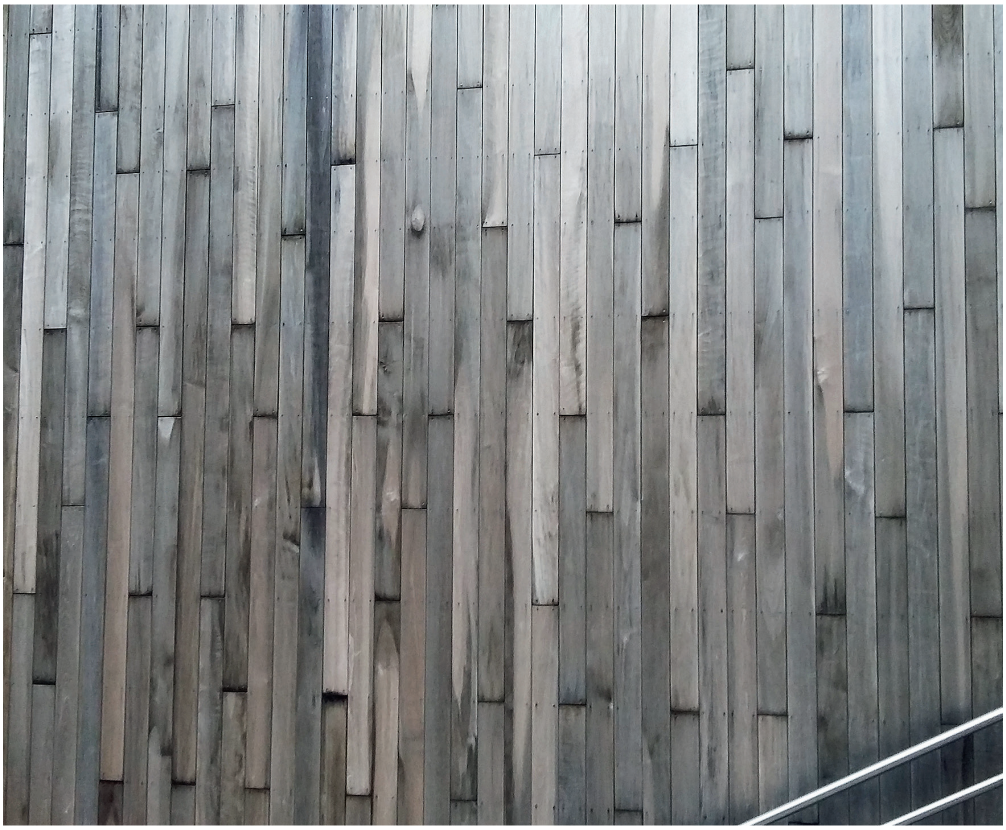
Tilted wall and roof faces often tend to support more growth of blue-stain fungi than vertical walls. Northwest- and northeast- facing walls get little direct sunlight. They therefore dry out slowly and this can lead to extensive growth of blue-stain fungi, particularly in inner corners and areas that are shielded from the wind.



4.3 Joints

The shape of joints are important contributors to colour developments in the façade. The wood is vulnerable to wetting in the joints where the end grain is exposed. Capillary water sorption takes place through small pores in the wood. It is therefore important to design joints and details so as to limit the water uptake and facilitate the drying process. Prolonged wetting can create colour differences in a façade and accommodate the establishment and growth of wood-decay fungi.

Astrup Fearnley Museum, Oslo, aspen (Renzo Piano Building Workshop), 2012



Two differently executed joints in a façade. The photo on the left shows a wide enough gap in the joint between the cladding boards, where the wood can quickly dry out. The photo on the right shows a small gap in the joint between cladding boards, resulting in a darkly coloured area around the joint. This is the result of water trapped in the joint and being taken up by the wood though capillary sorption in the end grain. The darkly coloured areas around the joints are also clearly visible in the wider section of the façade.

Adequate distance between cladding boards.

Small distance between cladding boards.

Husabøryggen residential community, Stavanger, Scots pine heartwood (Brandberg-Dahls Architects), 2014

The boards are mounted touching the window flashing. This allows wetting of the end grain. It is important that the details around windows and other openings in the façade are arranged so as to drain the water away from the cladding.

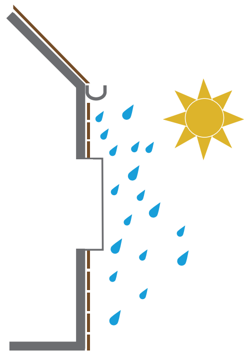
It is recommended to leave a gap of at least 6 mm in JOINTS and between cladding boards and window hardware/ flashings, to prevent the water from being trapped and absorbed by the wood.

(SINTEF Byggforsk series 542.101 2011)

Husabøryggen residential community

Architect: Brandberg-Dahls Architects
Project period: 2008-2012
Building owner: Stavanger properties
Address: Sagafjords vei 1, Stavanger
Cladding: Scots pine heartwood

Photo: Brandberg-Dahls/Johannes Marburg

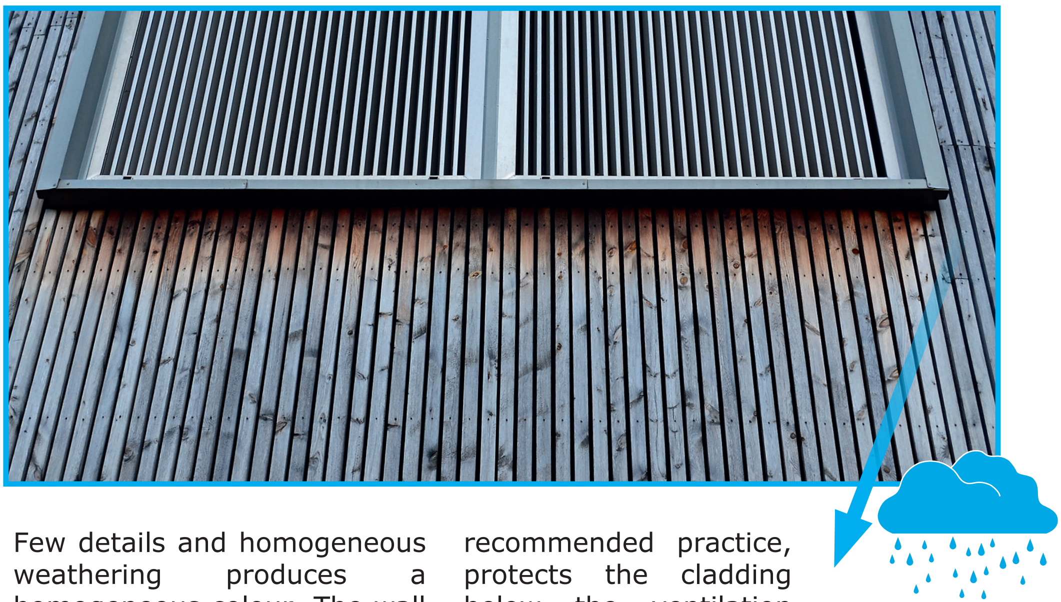


4.4 Mouldings and windows

Any discontinuity in a façade will affect the impact of sun and rain on the cladding. Even minor projections by windows and mouldings can give rise to pronounced colour differences.

Gymnasium Gløshaugen – Annex, Trondheim, Scots pine heartwood (Plan Architects), 2006

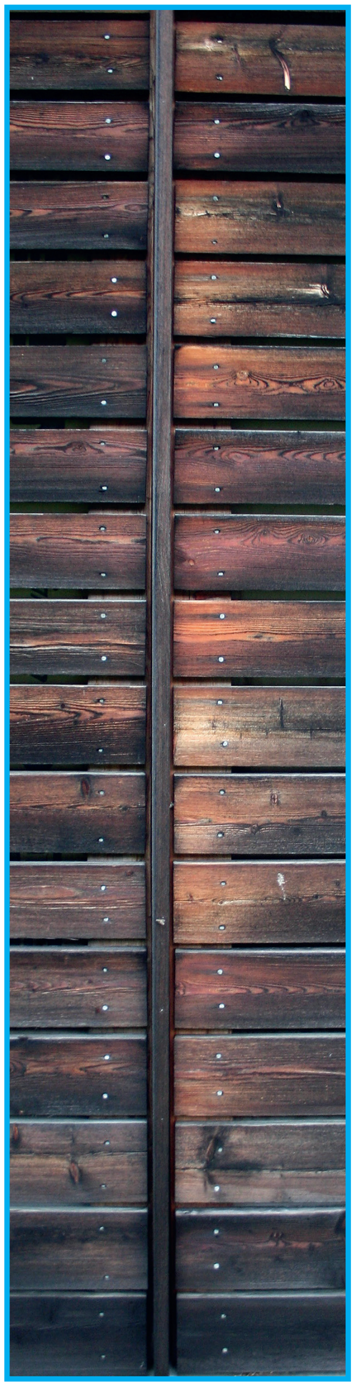
READABILITY: We can learn much about local weather conditions by 'reading' the colour changes in a façade. In this photo, leaching of the façade follows a vertical line in the façade. The predominant wind direction will affect the impact of the rain on the façade.

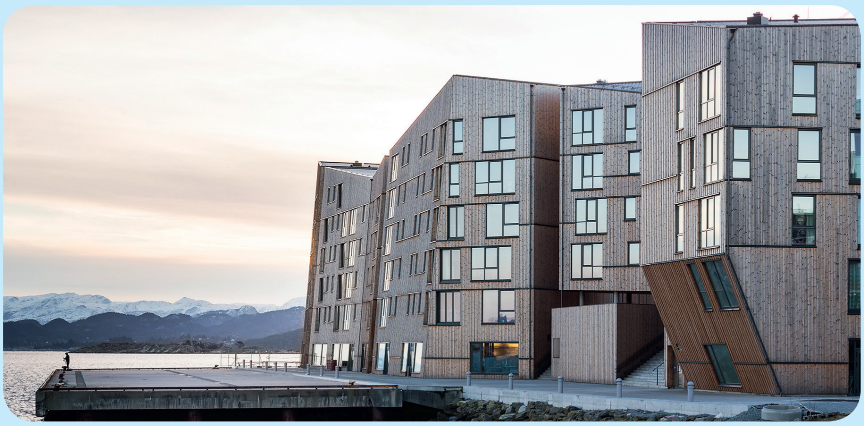


Few details and homogeneous weathering produces a homogeneous colour. The wall faces northwest. The flashing, installed in accordance with recommended practice, protects the cladding below the ventilation grate and results in local colour variation.

Infirmary – annex, Sessvollmoen Military Camp, Siberian larch (Longva Architects), 1998

Both vertical and horizontal trim boards can lead to colour variation in the cladding. The example shows how vertical and horizontal discontinuities in the façade create colour variation in the façade as a whole. There is pronounced growth of blue-stain fungi on the façade, but some cladding boards and segments have a brown colour and show less growth. The areas next to the vertical discontinuities in the façade are protected against the rain and have less blue-stain fungi growth. The colour changes could be the result of locally high air humidity and drizzle on the façade, without there being enough water to cause leaching of lignin and extractives. The façade retains a brown undertone and is covered by different degrees of blue-stain fungi growth.





Vannkanten

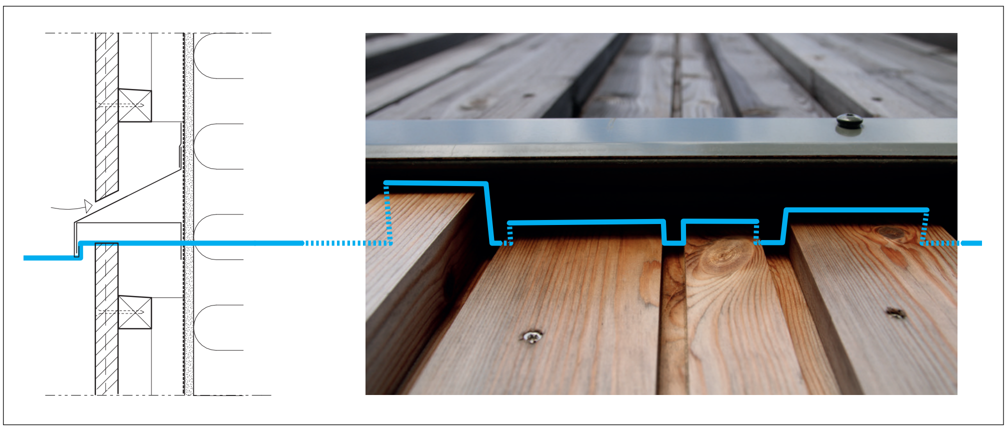
Architect: AART (Denmark) | Kraftværk (Studio Ludo AS)
Project period: 2010-2014
Building owner: Kruse Smith
Address: Siriskjær, Stavanger
Cladding: thermally treated Scots pine

Photo: AART Architects/Adam Mørk

Vannkanten, Stavanger, thermally treated Scots pine (AART and Kraftværk), 2014

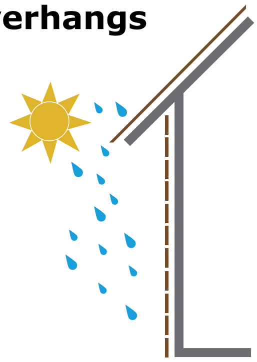
Different thicknesses of the cladding boards can create DEPTH DIFFERENCES in the façade cladding and can soften the transitions beween differently coloured segments.

At Vannkanten, narrow, horizontal metal flashings were mounted to serve as fire partitions in the façade cladding. The metal profiles shield against the rain, so that a band of reduced leaching, fungal growth and greying is formed below them. The cladding boards in the façade differ in thickness. This creates variation and shadow effects. It also creates variations in the width of the rain shield, and results in a wavy line against the grey surface below.



4.5 Cantilevered building components, balconies and roof overhangs

Cantilevered building components, balconies and roof overhangs lead to greater microclimate differences than cover-trims and flashings. These components can therefore lead to major colour differences.



Officer Candidate School, Rena Military Camp, Scots pine heartwood (LPO Architects), 1997

The photo shows colour changes in the cladding after 20 years of exposure. The façade has eaves and horizontal discontinuities in the form of flashings between the floors. The façade has a northerly orientation, but gets some evening sun from the west.

The façade had developed a relatively even grey colour, except under the eaves and horizontal partition boards in the façade. Below the eaves, where the cladding is protected from leaching and direct rain, it has a darker brown colour.

Some light grey areas can be seen below the brown areas, both under the eaves and under the façade dividers. These are the result of leaching combined with ample opportunity for drying out after periods of rain. The eaves have possibly also provided some protection against the heaviest showers.

The dark grey areas have probably taken a heavy rain load and hence supported more growth of blue-stain fungi.

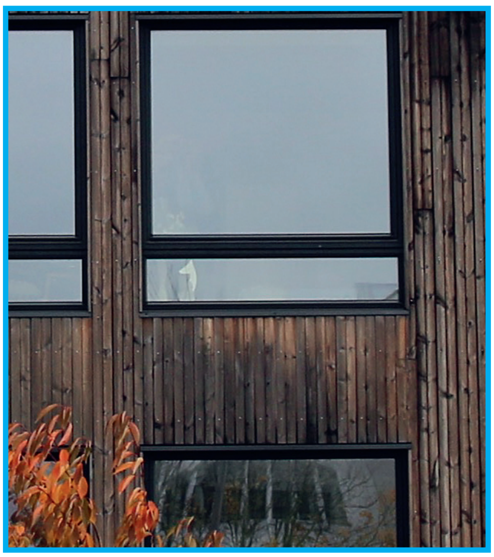
Rena Military Camp

Architect: LPO Architects
Project period: 1997-2009
Building owner: Norwegian Defence Estates Agency
Adress: Rena, Åmot
Cladding: untreated Scots pine

Photo: LPO Architects

Tou Park BT4, Stavanger, furfurylated Scots pine (Alliance Architects), 2013

The colour changes that follow vertical dividing lines indicate that the rain load has largely been vertical with some wind-driven rain from the right. The cladding on the left, under the balcony, shows marked colour differences where it is shielded from the rain.



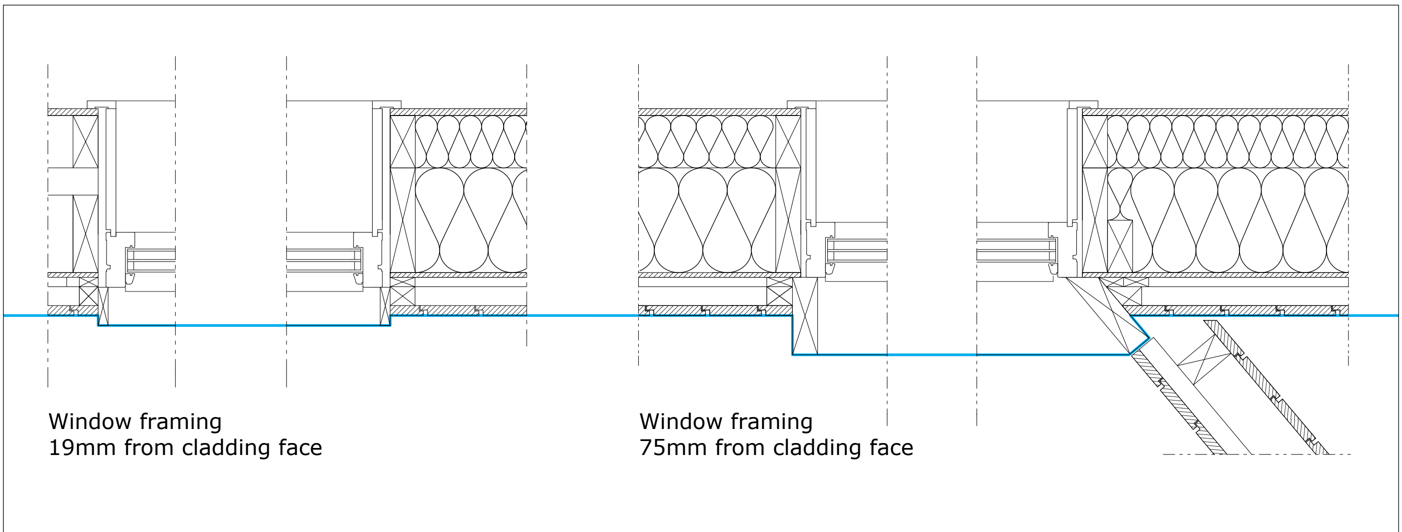
Cropped image 1. Diagonal line dividing areas of different façade colour under the window.

Consistent use of downpipes to drain the water from the balconies leaves little water running down the sides or underneath the balconies. The colour changes can therefore only be explained by the sun and rain shield provided by the balconies.

The diagonal colour change below one of the third-floor windows is an interesting detail (cropped image 1). It suggests that the window has been partly open and shielded the cladding below from wind-driven rain from the left over a prolonged period.

Cropped image 2. Window with narrow trims on the left. Projecting window trims on the right.

The windows in Tou Park were installed with different detailed designs. Some windows have narrow trims that flush with the cladding, while others are bordered by edge trims that protrude a few centimetres from the façade. This creates colour differences around the windows.



Tou Park

Architect: Alliance Architects
Project period: 2012-2014
Building owner: Tou industrial park
Adresse: Tinngata 30, Stavanger
Cladding: furfurylated Scots pine

Photo: Alliance Architects

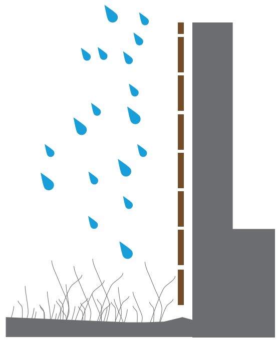
Svartlamoen sustainable apartments, Trondheim, Scots pine heartwood (Brendeland & Kristoffersen Architects), 2004

Moisture accumulation in shielded areas with very little leaching, such as under eaves and overhangs can produce special, wavy, aquarelle-like colour effects.

Visible water accumulation under an oriel.

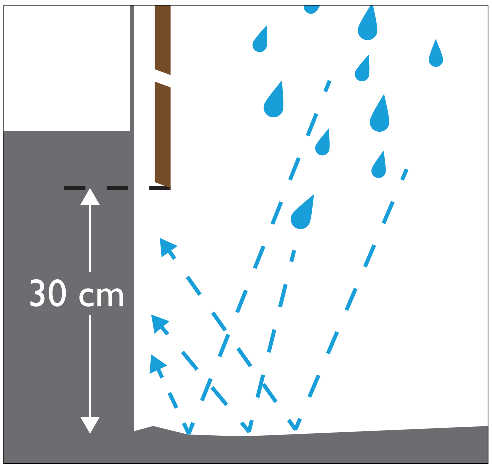
4.6 Cladding where it meets the ground

The shape and design of a cladding at ground level has a large influence on the appearance of a building. Especially the end grain in vertical claddings and the lower boards in horizontal claddings, which are close to the ground, are exposed to splashes of rain water from the ground. The distance between the cladding and ground is an important factor determining the moisture load acting on the cladding. The type of pavement or ground surface will also have an impact on the moisture load. Gravel and grass will normally give less splashing and soiling, while hard and/or non-porous ground covers can increase the moisture load. It is recommended to keep a good distance between the cladding and the ground. Requirements for accessibility and a wish for a more seamless adaptation to the surrounding terrain have led to the development of detailed solutions using gutters, surfaces and materials that allow for cutting the cladding closer to the ground. It used to be customary to mount a drip bar along the bottom of the cladding, which could be replaced when necessary.



Norwegian National Courts Administration, Trondheim, oiled oak (Arkiplan Arkitekter), 2002

The cladding on the lower part of the wall at the entrance to a building is exposed to splashing. This leads to colour changes and growth of blue-stain fungi. These colour changes can be prevented by increasing the distance between the cladding and the ground.



DISTANCE TO THE GROUND: Unless special measures are taken to protect the cladding, a distance of at least 30 cm is recommended between the bottom of the cladding and the ground. This will reduce colour changes in the cladding boards near the ground.

Lecture building, Rena Military Camp, Scots pine heartwood (LPO Architects), 1997

Splashing can also be a problem where the cladding meets the concrete foundation as in this case, where the foundation wall extends further out than the cladding. The lower part of the cladding is clearly marked by wetting and the growth of blue-stain fungi as a result of splashing and possible capillary sorption in the end grain.

Roof overhangs can protect the façade against high water loads and reduce splashing from the ground. The photo below shows the difference between a cladding protected by a wide eave overhang (on the right) and cladding under a minimal eave overhang (on the left).

Ås High School, Ås, aspen (LMR Architects), 2010

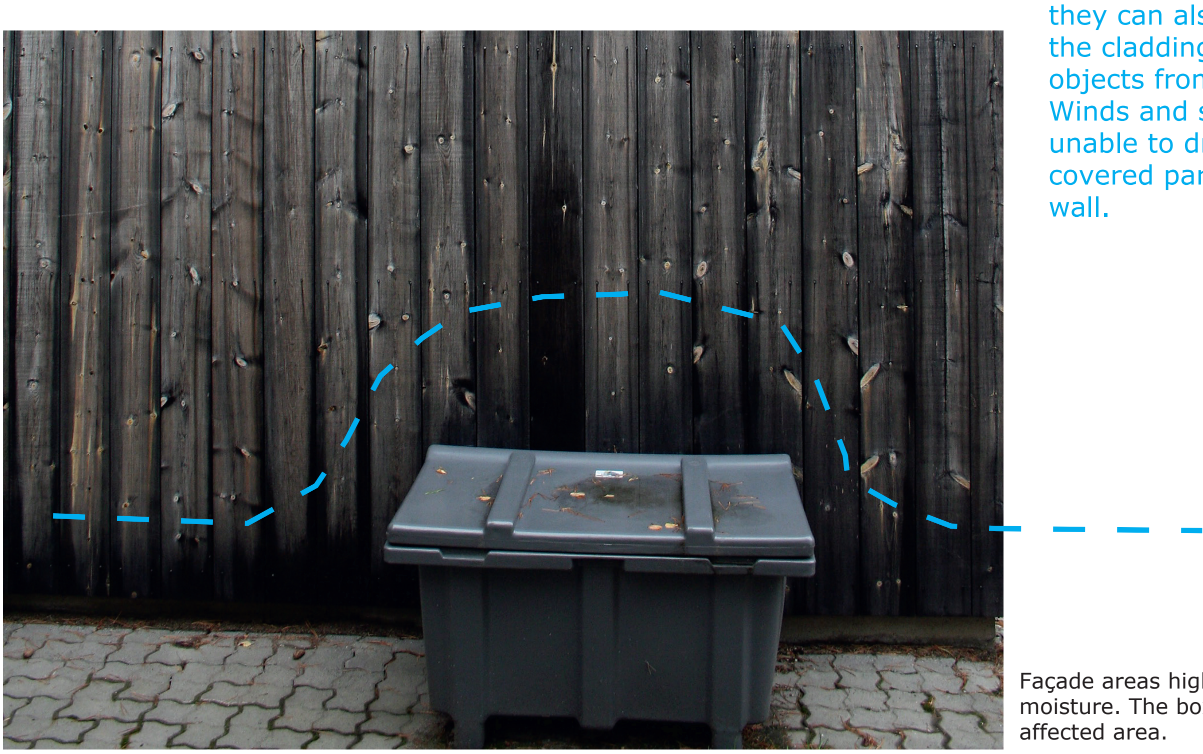
Protruding elements on the façade can also cause back-spray and capillary sorption through the end grain of the cladding boards, as here above the windows at Ås High School.

Photo: NIBIO/Lone Ross Gobakken

Officer caserns, Rena Military Camp, Scots pine heartwood (LPO Architects), 1997

The end-grain of verical claddings and the lower cladding boards in horizontal claddings can be strongly affected by snow. Mounted with only little distance to the gound, these cladding boards can be covered in snow. This entails long periods of wetting with limited chances to dry. This can lead to major colour changes. Blue-stain fungi grow on these moist surfaces as they are gradually warmed up by the sunshine in spring. The area of risk 'moves' upwards if any objects are placed against the wall.

Not only do OBJECTS raise the ground level, they can also prevent the cladding behind the objects from drying. Winds and sunshine are unable to dry the covered parts of the wall.



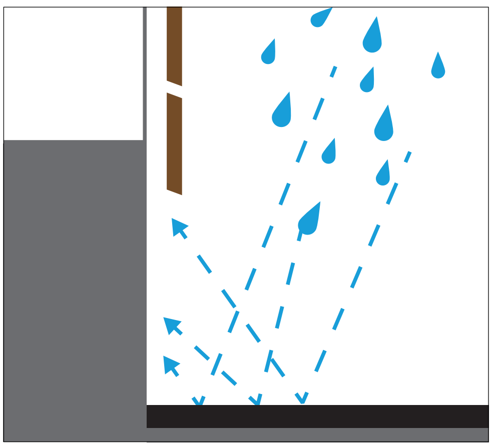
Façade areas highly affected by moisture. The box has enlarged the affected area.

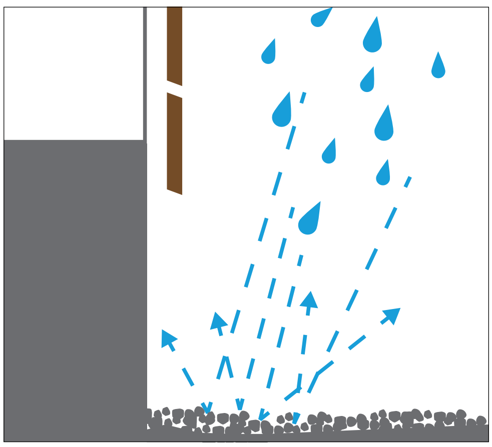
Vannkanten, Stavanger, thermally treated Scots pine (AART and Kraftværk), 2014

Cladding near the ground that meets gravel

Cladding near the ground that meets asphalt

The main photo shows cladding areas near the ground that meet gravel and areas that meet asphalt. The distance to the ground is the same, but the cladding has developed very different colours. The distance between the areas in the two cropped images is approximately four metres. Different ground covers produce different amounts of back-spray and different degrees of soiling on the lower part of the cladding.





4.7 Water run-off

Water run-off from building components such as window trims, sunscreen lamellas and balconies will have an impact on the colour variations in the façade. In horizontal claddings, the water will not just run straight down, but also sideways, because of the cladding profile and the orientation of the fibres in the boards.

Lecture building, Rena Military Camp, Scots pine heartwood (LPO Architects), 1997

The façade is characterized by the direction from which it takes most of the rain. This can be seen in particular on the rain-exposed side of the sunscreen lamellas, which are marked by leaching and growth of blue-stain fungi. The opposite sides of the lamellas show no signs of leaching. The sunscreens pool rainwater-run-offs and distribute it unevenly along the façade. These colour differences are visible in the façade segment below the row of windows. When the rain hits the lamellas, the water is channelled down and washes out the areas below. Behind the lamellas, the cladding areas are protected from the rain and have a browner tone.

NINA-building, Trondheim, furfurylated Scots pine (Pir II Architects), 2013

The façade of the NINA building has a mixture of vertical and horizontal cladding. Large run-off areas can be seen in the horizontal cladding below the windows because the water runs sideways along the grain as well as downwards.

NINA building

Architect: Pir II Architects
Project period: 2008-2013
Building owner: Norwegian Institute for Nature Research (NINA)
Adresse: Høgskoleringen, Trondheim
Cladding: furfurylated Scots pine

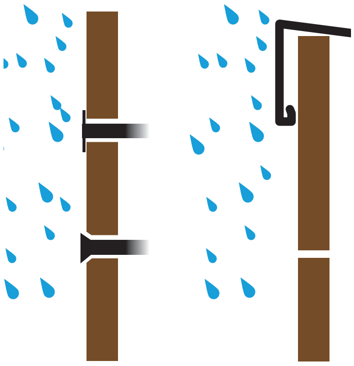
Photo: Pir II/Sindre Karlsen

5°East, Stavanger, acetylated Radiata pine (Link Architects), 2015

The cladding boards have horizontal tongue and groove joints with a narrow gap between the boards. Run-off from the window trims and flashings spreads over large areas below the windows and follows the horizontal and vertical joints.

Berg student village, Trondheim, Royal Scots pine (Skibnes Architects), 2010

The photo shows a corner of the cladding that has a markedly lighter silver colour. This is a result of large amounts of water being led towards the corner of the façade along the skew girder. This caused heavy leaching of the cladding boards.

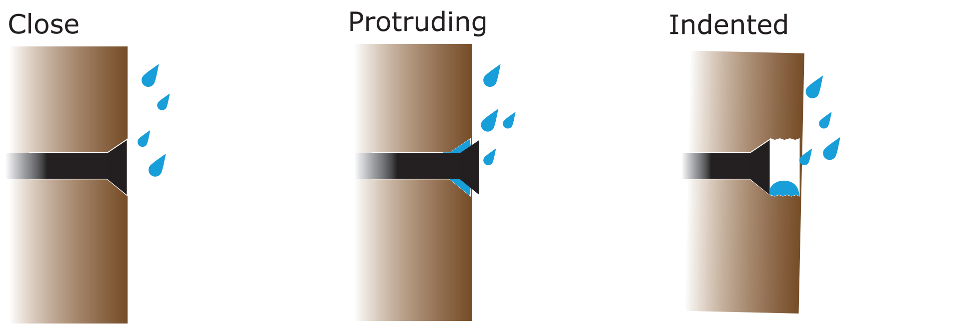


4.8 Fixings, fasteners and hardware

Wooden claddings often come into contact with metals used in fixings, gutters, downpipes and various flashings, hardware and trims used on roofs, façades and windows. Some combinations of wooden cladding and metal can produce colour changes in the wood. Common reasons for this are corrosion, chemical reactions between the metal and the wood as well as leaching and run-off from the metals. Run-off from metals can also reduce the growth of blue-stain fungi.

Hot-galvanised or galvanised nail and screw heads can be damaged as they are driven into the wood. These fine cracks in the anti-corrosion layer can cause rust formation and run-off of rusty water, which leaves grey and black stripes on the façade.

Consequences of different fixing depth of nail- and screw heads in a cladding board:



Limited moisture penetration around the fastener.

Moisture can penetrate the wood. Without drying there is a risk of development of wood decay fungi.

Moisture can penetrate the wood. Without drying there is a risk of development of wood decay fungi.

Run-off of rusty water on a Scots pine heartwood cladding.

Svartlamoen sustainable apartments, Trondheim, Scots pine heartwood Brendeland & Kristoffersen Architects), 2004

FIXINGS: Use of acid resistant, stainless steel fixings is recommended on unpainted wooden façades. This reduces the risk of colour changes arising from chemical reactions between the fixings and the wood.

Even if no colour changes occur, fixings can lend specific character to a façade. The photo shows shiny screw heads that are clearly visible against the cladding.

Reactions between tannins and ferrous metals

Tannins are chemical substances found in wood that can react with ferrous metals. Oak is rich in tannins and can be greatly discoloured in contact with ferrous metals. Walnut and chestnut are other tannin-rich species that can be similarly discoloured in contact with fixings and hardware containing ferrous metals.

Photo 1.

Photo 2.

Photo 3.

The photo series above shows the same segment of an oak panel surface. It illustrates how the wood reacts with the ferrous metal. Photo 1 shows the surface before the test. Photo 2 shows iron rings placed on the wet surface, and Photo 3 shows the colour change on the surface after half an hour under moist conditions.

Copper and zinc in flashings and trims

Copper and zinc are often used for windowsill flashings and where the walls meet the roof of a building. Both copper and zinc are toxic for various species of fungi. Water run-off from flashings onto the cladding boards below can thus reduce the growth of blue-stain fungi, algae and moss on the affected part of the cladding.

Svartlamoen sustainable apartments, Trondheim, Scots pine heartwood (Brendeland & Kristoffersen Architects), 2004

Colour differences can develop on the façade depending on the specific type of flashing that is used. Copper windowsill flashings were used in the Svartlamoen building, which reduced the growth of blue-stain fungi on the northeast-facing façade.

Signs of chemical reactions on flashings and trims

Husabøryggen residential community, Stavanger, Scots pine heartwood (Brandberg-Dahls Architects), 2014

Substances that leach from the wood can cause colour changes in adjacent metals and alloys. Among other things, acetic acid from Scots pine can lead to corrosion and rust formation on uncoated metal flashings and trims.

NINA-building, Trondheim, furfurylated Scots pine (Pir II Architects), 2013

On the west-facing façade of the NINA building, copper flashings were used in combination with cladding boards of furfurylated Scots pine. Because of leaching and run-off from the furfurylated cladding, the flashings have retained their shiny appearance rather than turning to a brownish green colour through oxidation as is usually the case with copper over time.

Colour changes and green vitriol

Treatment of unpainted wooden cladding with iron sulphate is widely used in modern wooden buildings. When treated with iron sulphate, the façade turns an even grey colour after only a short time. Iron sulphate is not a wood preservation agent – it will usually only affect the colour of the wood. Iron leaching from wooden cladding treated with iron sulphate can lead to a rusty red discolouring of, for example, brick or concrete walls below. The discolouring is difficult to wash off.

Lecture building, Sessvollmoen Military Camp, Scots pine heartwood (GASA Architects), 2004

Spills during application and iron sulphate leaching from Scots pine cladding will lead to rusty red discolouration of concrete walls in areas not protected by projections. The area of the wall that lies below the projection is protected and bears no traces of discolouration.

The interplay between architectural design and colour changes

Unpainted wooden façades are a suitable and architecturally expressive solution both for private and public buildings as well as in small and large-scale projects. The façade can reflect the building's function, the architectural strategies and the client's profile and priorities. The lecture building in Rena Military Camp (designed by LPO Architects) is a good example of this. This development was one of the major public projects in the 90s, where new uses of wood were tried out to promote Norway's expertise in architecture and structural engineering. Twenty years after its completion, the building illustrates the interplay between architectural design and the colour changes produced by the environment and climate.

West-facing façade, lecture building, Rena Military Camp. Characterized by wind-driven rain.

The roof overhang, the vertical wooden lamellas below and the plane, vertical Scots pine cladding in the lower part of the façade create separate horizontal zones with distinct architectural characteristics. The zones are exposed to different sun and rain loads. The row of lamellas at the top is gradually becoming more visible as the wood turns grey due to rain and growth of blue-stain fungi. The grey colourblends with the metal trims around the upper row of windows. The cladding below is protected by the sunscreens and retains a brownish colour tone. The lower row of windows is recessed so that the continuous plane of the cladding is not broken by trims and flashings. The vertical wood lamellas shield against direct sunlight on the upper floor of the building whilst they channel the water run-off onto the wooden cladding below. This creates secondary vertical façade segments that tally with the rhythm of the lamellas and windows.

The overall impression is of a façade that was structured in zones and layers at the time of completion. This can be clearly perceived when viewing the building from different angles and under varying conditions of sunshine and shade. The character of the façade will gradually change as it is exposed to regional, local and structurally dependent climate loads. The weathering of the building reflects how it interacts with its surroundings. The forces of the sun, rain and wind leave a readable and architecturally induced imprint in the form of colour variations in the wooden façade. Acceptance of and the ability to control this dimension could enrich Norwegian timber architecture. For this to happen, architects, developers, clients and users of wooden buildings must adopt a new attitude and acquire new expertise.

Thoughtful control or facilitation of colour changes in unpainted wooden façades requires knowledge about wooden materials, cladding types, construction and building details. Knowledge is also required of the climate zone, the landscape and how the building is situated. We must rediscover old skills and activate new knowledge acquired by wood researchers. This will create a basis for a more nuanced discussion about the use of wood as cladding material. We will also gain a better starting point for more informed architectural design of unpainted wooden façades.

This report is based on the perusal of many projects designed by a great number of skilled architects. Our focus on detail must be balanced against the overall impression that a building creates, to which we have not been able to devote as much attention. We urge everybody to visit well-designed, well-maintained and beautifully weathered examples of unpainted wooden façades.

The sunscreens protect some areas for rain-water run-off and pools run-off over other areas of the façade. Lecture building in Rena Military Camp.

Trondheim
Rena
Sessvollmoen
Oslo
Haugesund
Ås
Stavanger

The reference projects

TRONDHEIM
1. Svartlamoen sustainable apartments
2. Camera Obscura
3. Berg student village
4. NINA-building (Norwegian Institute for Nature Research)
5. Norwegian National Courts Administration
6. Gymnasium Gløshaugen - Annex

RENA
6. Technical Workshop
7. Lecture Building
8. Officer Candidate School
9. Officer Caserns

SESSVOLLMOEN
10. Military Surgery Course Centre
11. Lecture Building
12. Infirmary - Annex
13. Officer Caserns

OSLO
14. Ling Ling Restaurant
15. Astrup Fearnley Museum

ÅS
16. Ås High School

STAVANGER
17. Vannkanten
18. Husabøryggen residental community
19. 5° East
20. Tou Park BT4

HAUGESUND
23. Sørhauggata 100 dormitory

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This guide is based on information from the aforementioned literature and on practical experience.

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