# EFFECTS OF WOOD PROPERTIES ON SURFACEMOULD GROWTH ON COATED CLADDINGS OF NORWAY SPRUCE

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## ABSTRACT

Development of surface moulds and staining fungi on painted spruce panels with known origin and wood properties was investigated over a period of 4 years. Materials of Norway spruce (*Picea abies*) were sampled from two sites with high-productive forest on lowland in South-eastern Norway and two low-productive sites at higher altitudes and somewhat farther north. Claddings were processed from inner centreboards (mainly heartwood) and outer centerboards of both butt logs and second logs. A sub-sample of radially sawn claddings was compared with corresponding tangentially sawn claddings. Heartwood proportion, density, annual ring width, knot diameters and knot area were measured. All panels were coated with the same water-borne alkyd modified acrylic paint system. Most of the tangentially sawn claddings were coated on the side facing pith, but a sub-sample was coated on the opposite side for comparison. The specimens were exposed with 45˚ angle of inclination facing south in a field trial in Oslo from 2007 to 2011, and mould growth was evaluated visually according to EN 927-3. 7.7% of the specimens were rated as 2, 71.4% were rated as 3, 19.4% were rated as 4, and 1.5% were rated as 5. Outer boards were rated significantly higher than inner boards, while differences between origins were not significant. There was a tendency of decreased rating with increasing heartwood proportion, but the relationship was not significant. Nor was there any significant effect of annual ring with, density or knot properties. Neither the difference between radially and tangentially sawn claddings, nor the difference between specimens coated on the side facing pith was significant.

Key words: coated cladding, moulds, Norway spruce, staining fungi, wood properties.

## INTRODUCTION

Wooden façades have traditionally been used in family houses in Norway and are increasingly applied also in multi storage and non-residential buildings. Norway spruce (*Picea abies*) is the most common wood species used for cladding material in façades. The house owners and other end-user demand cladding material with long maintenance

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intervals and long service life. Growth of mould fungi with dark coloured hyphea and spores are a common phenomenon on both painted and unpainted wooden façades, and will reduce the aesthetical service life of the façade. UV-radiation, rain, temperature, condensation, wind and high relative humidity degrade the surface of both painted and unpainted cladding and makes it more susceptible to fungal attack (de Meijer 2001). The chemical composition and the physical condition of the paint, together with the underlying wood substrate, are important factors for how the cladding performs (Ahola 1991, Richter et al. 1995, Williams et al. 2000). The overall effect will vary depending on the end-use of the material and the local climate (Brischke et al. 2006, Gobakken et al. 2008). Numerous studies have been performed on wooden claddings, and some have taken wood quality into consideration. Studies have been performed on the influence of surface roughness and porosity on coating adhesion (Nussbaum et al. 1998, Williams and Feist 1994), the influence of annual ring width on water sorption properties of wood (Flæte and Alfredsen 2004), and the influence of heartwood content on water sorption properties and fungal growth (Bergström and Blom 2005). In a study by Gobakken & Lebow (2010) it was found clear differences in degree of mould growth between various wood species when coated, and that there were indications that coated sapwood had more surface mould growth than coated heartwood. The degree of natural resistance to fungal growth in wood may vary considerably between species and stem positions. Heartwood in several species contains extractives with antifungal properties (Zabel and Morrell 1992).

The influence of wood-coating interactions on the growth of moulds and staining fungi is still not well enough known. In many studies of coated wood, the description of the wood is sparse, and the variation within the wood specimens seems to be of less interest. The objective of this study was therefore to analyze the effects of selected wood properties of Norway spruce on surface moulds and staining fungi when cladding panels were exposed outdoors.

## MATERIAL AND METHODS

In order to have different levels of annual ring width, materials of Norway spruce (*Picea abies*) were sampled from two fertile sites and two poor sites in South-eastern Norway. Sites were classified as poor if the site index, defined as dominant height at 40 years age, was 14 m or lower and as fertile if the site index was 20 m or higher. While the trees at the fertile sites (Larvik) were about 50 years old, had large annual ring width and small taper, the trees from the poor sites (Toten) were about 150 years old, had small annual ring width and larger taper. Five trees with breast height diameter between 27 and 30 cm and five trees with breast height diameter between 32 and 35 cm were sampled from each site. This sampling also represents some difference in wood density since it is negatively correlated to annual ring width within a site index and a geographical area (Klem 1934). Butt logs and second logs were processed to claddings with dimensions 19 x 98 $mm^2$. While butt logs contain wood with small and dry knots, second logs usually contain wood with larger and often sound knots. The claddings to be tested were chosen from both inner centreboards and outer centreboards. The sawing pattern is presented in Fig. 1. Inner centreboards are mainly heartwood and contain some proportion of juvenile wood. Outer centreboards contain mature wood with longer fibres and smaller variation in wood density, and they may have some proportion of sapwood. A part of the material was produced as radially sawn claddings as seen in Fig. 1 (3), and those were compared to a corresponding part of tangentially sawn claddings.

A sub-sample of the panels was painted on the external face (the side facing the bark) to be compared to panels painted on the internal face (the side facing the pith). The samples represent a wide range of wood properties. Since the number of samples was limited, many properties were measured but not stratified in the sample such as heartwood proportion, annual ring width, density and knot size. Heartwood content was measures from CT-images of the timber scanned before drying. Knots were measured on the samples before painting. Annual ring width and density were measured from small pieces of clear wood.

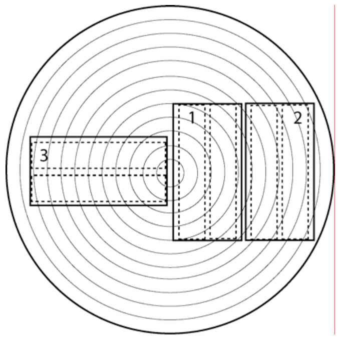


**Fig. 1.** Claddings were produced from (1) inner centreboards, (2) outer centreboards, and from (3) radially sawn boards.

The samples were applied with one layer of a fully pigmented waterborne alkyd emulsion primer and two layers of a waterborne acrylic topcoat on the top face and the sides. The primer and the topcoat were applied by spraying in an automatic industrially setup. The panels were installed vertically at an angle of 45° in rigs facing south in Sørkedalen, Norway and were exposed from June 2007 until June 2011. During that period the panels were evaluated 7 times and the evaluations were performed in May/June and September each year. The mould coverage was evaluated according to EN 927-3 (2000). The assessment was made visually and by the use of a stereo microscope (x10 magnification) following a rating system with a range from 0 (no growth) to 5 (heavy growth) given by the pictorial rating scale in the EN 927-3 standard (2000). The rating is based on a step-wise increase in mould growth coverage, but the shape and the pattern of the mould growth are also of importance to the determination. The statistical calculations were performed in JMP (SAS Institute Inc 2010).

## RESULTS

In June 2011 the specimens had mould ratings between 2 and 5, with a majority of rating 3. 7.7% of the specimens were rated as 2, 71.4% were rated as 3, 19.4% were rated as 4, and 1.5% were rated as 5. As the exposure time progressed, an effect within the test site was detected. All specimens with rating 5 and 42% of those with rating 4 were located on a rack standing close to the edge of a forest. It was apparent that this location had an effect on the growth of fungi. If specimens on this rack were excluded, 8.6% of those remaining were rated as 2, 78.7% were rated as 3, and 12.7 were rated as 4. There also seemed to be an effect of location on the specimens with rating 2, of which 52% were located on a rack at the highest elevation of the test site. If also specimens located on this rack were excluded, 4.4% of those remaining were rated as 2, 81.9% were rated as 3, and 13.7% were rated as 4.

The statistical analyses were performed only on boards from butt logs since almost all the specimens on the two racks with apparent effects of location were from second logs. There was a tendency of higher rating in specimens with smaller heartwood proportion, but the effect was not significant, neither when heartwood was calculated as proportion of cross section ($\chi^2$=2.50, p=0.11) nor when it was calculated as proportion of the surface ($\chi^2$=1.99, p=0.16). The rating was not significantly influenced by annual ring width (($\chi^2$=61, p=0.43), density (($\chi^2$=2.01, p=0.16), maximum knot diameter ($\chi^2$=1.79, p=0.18), or with knot area ($\chi^2$=0.28, p=0.59). The difference between origins was not significant ($\chi^2$=0.98, p=0.61). There was a tendency of more rating 4 in specimens from Larvik than from Toten, but the difference was counterbalanced by a slightly higher proportion of rating 2 in specimens from Larvik. There was significantly higher rating in outer boards than in inner ($\chi^2$=6.27, p=0.04). The proportions of rating 3 were similar for inner and outer boards, but none of the outer boards were rated as 2. As compared with inner boards where both rating 2 and rating 4 appeared, more of the outer boards were rated as 4. The rating was not significantly different between specimens coated on the side facing pith and corresponding specimens painted on the side facing bark ($\chi^2$=2.39, p=0.30), but the tendency was towards a higher rating on sides facing the bark. There was also a tendency of higher rating in specimens with radial surfaces than in corresponding outer boards with tangential surfaces, but the difference was not significant ($\chi^2$=1.40, p=0.24).

## DISCUSSION

Since wood is a heterogenous and non-isotropic material, variation in the wood properties will always be present. This might influence the effects of any treatments if it is not taken into consideration. According to Kollmann & Côtè (1968), the properties that influence most on sorption behavior are fibre angle, density and content of extractives, i.e. heartwood content. Williams et al. (2000) mentioned knots as an important factor for coating performance. In spruce, heartwood content has been found to influence growth of surface fungi and water affinity rather than water absorption (Bergström and Blom 2005).

In this study only centreboard selection was found to have a significant effect on surface moulds and staining fungi when Norway spruce claddings were exposed outdoors. Outer centreboards were found to have significantly higher mould rating than inner centreboards. Outer centreboards give a flat-grained cladding board. Moisture-induced deformations of wood might lead to cracks in coatings that are exposed to variations in temperature and relative humidity. Since shrinking in tangential direction is about twice as large as that in radial direction (Kollmann and Cöté 1968), one may expect more cracks in the coating and then a shorter lifetime for tangentially sawn claddings (flat-grain boards) cut from the outer centreboard than claddings from vertical- or edge-grain boards. A slightly more weathered paint film with cracks on claddings made from outer centreboard may give that extra adaption in micro climate for mould and staining fungi to grow better. In addition the outer centreboards have none or very little heartwood, and any antifungal effect from extractives was not present. The tendency of higher mould rating in specimens with smaller heartwood proportion and higher mould rating on sides facing bark support the results for the effect of centreboard selection. Radial surfaces swell and shrink less than tangential surfaces, and unexpectedly claddings with radial surfaces had the tendency of having higher mould rating than in corresponding outer boards with tangential surfaces.

The variability in rating was small apart from the specimens on the racks with apparent effects of location. Claddings with the highest mould rating were found on a rack standing close to the edge of a forest, where the trees may have caused a more sheltered environment (higher temperature, less wind and higher relative humidity). Also organic residues may have been deposited on the surface of the cladding giving enhanced growth conditions for mould and staining fungi. The elevation within the test site and the positioning of some surrounding trees may have caused a high portion of rating 2 on a rack at the highest elevation. Shorter periods of fog and more hours of direct sunlight may have resulted in less time-of-wetness and lower mould rating. Very small changes in temperature, wood moisture content and surface nutrients, which are the predominant factors for fungal growth, can have big impact on the onset fungal colonisation. The critical in-situ condition (CIC) for wooden components is exemplified by Gobakken et al. (2008) and shows the importance of parameters that serve as triggering factors for fungal growth for a specific component and how they can out rule other important properties.

Gobakken and Lebow (2010) reported from a field test of 4.5 years that wood substrate was significant but of less importance than coating and exposure time. Type, amount and composition of fungicides in the paint have a direct effect on the colonisation of mould fungi on the surface (Gobakken and Jenssen 2007, Van Acker et al. 1998, Viitanen and Ahola 1997) and may preclude any enhanced effect of the wood substrate.

More restrictions concerning the composition and the use of fungicides in coating emphasise the importance of more knowledge about how paint systems with less or without fungicide perform on different wood substrates. This study on coated claddings of Norway spruce showed that few of the studied wood properties affected the growth of moulds and staining fungi. But to be able to optimizing each step in the production of environmentally friendly, durable and aesthetical acceptable wooden façades for the future, more knowledge about wood properties in combinations with surface finishes and various climatic conditions are needed.

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