Structural Failures of the Timber Structures in Arctic Climate

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Introduction

The wooden buildings at Svalbard were erected in order to stand for a short period. The constructions were made by simple wooden materials and constructions.

Due to the hard climatic conditions, the buildings got as airtight walls as possibly. Furthermore, the buildings were placed directly on the soil and occasionally even with soil placed up against the wall.

The climatic exposure at Svalbard is a limited amount of precipitation and a very low temperature during most part of the year. By that reason, the risk of biodeterioration in the wooden materials is supposed to be very low.

Nevertheless, after field examination in several protected hunting cabins at Svalbard, widely distributed damages caused by mould fungi and wood-decaying fungi were found.

More thoroughly investigations were carried out in order to clarify the mechanisms and consequences for the fungal activity.

Material and methods

Five buildings were investigated, four of them were cabins scattered around the western part of Svalbard, while one was a former office building in Longyearbyen.

The temperature and relative humidity were recorded in the buildings for selected periods.

A total of 113 wooden samples and tape lifts were taken for microscopically analysis.

Results

Observations

Constructions

The traditional cabins at Svalbard were constructed by simple materials. The walls are normally without insulation, either by timber or a wooden frame. It is often an external bitumen layer in order to achieve an air tight construction. Some cases, where soil was shovelled up against the lower part of the walls were observed.

Roof construction was constructed in a similar way as the walls.

The floor is placed directly on the ground without any preparation. This is possible because a combination of relative stable ground conditions due to permafrost and a light, flexible building “floating” on the surface.

Climatic conditions

Svalbard has a very cold and dry climate, which is defined as an arctic dessert. Longyearbyen has for example an average temperature of -6 °C and precipitation of 210 mm/year (www.met.no).

The climatic conditions where the buildings are standing have some local variations, but this is regarded to have minor influence of the results.

Even if the outdoor air temperature is relatively low, materials which are exposed to sun radiation can reach a surprisingly high surface temperature. Measurements at the hunting hut at Laksebu when the sun was shining from south, showed that even if the air temperature was 1,4 ºC, the building had a surface temperature of up to 45,9 ºC (table 1).

	Place	**Temperature**
Air temperature	In the shadow on the north side of the building.	1,4 ºC
North wall	I. Between snow front	5,6 ºC
	II. Upper left corner	6,8 ºC
	III.Upper right corner	7,4 ºC
	IV. Upper part, in the middle	10,1 ºC
East wall	V. Behind the snow front	3,2 ºC
	VI. Middle of the wall	6,8 ºC
	VII. Close to the roof, in the middle	8,2 ºC
	VIII. Close to the roof, upper left corner	9,7 ºC
	IX. Air temperature at point VIII.	5,8 ºC
South wall	X. Close to the roof, right corner	29,3 ºC
	XI. Close to the roof, at the door	29,7 ºC
West wall	XII Behind snow	5,2 ºC
	XIII. Abov snow layer	13,5 ºC
	XIV. Left side of the wall	23,4 ºC
	XV. Close to the roof, upper left corner	30,2 ºC
	XVI. Upper SW-corner	43,3 ºC
	XVII. Upper SW-corner, behind the bitumen layer	45,9 ºC

Table 1. Temperature measurements on external walls at Laxebu, Svalbard

Decay

Decay fungi were found in general found along the floor construction and lower part of external walls. Furthermore, all external wood had a grey discoloration, mainly caused by the blue-stain fungi *Aurobasidium pullulans*. External wood with horizontal exposure were also in several cases attacked by wood-decaying fungi, mainly *Leucogyrophana mollis*, but also occurring was *Gloeophyllum sepiarium*.

In totally 54 wooden samples, *Leucogyrophana mollis* was found in 34 samples, while softrot-damages were found in 29 of the cases. *Coniophora puteana* was found in two samples and an unidentified species in the family *Corticiacea* in one sample.

Several of the decayed materials were seriously damaged. The results of this were a severe technical failure of the timber structure. Due to continued climatic and humidity exposure, the rate of decay will increase in the future.

Discussion

Wooden constructions in old buildings in arctic areas were constructed for a planned short service life. The materials and constructions are simple and with poor protection against moisture problems. The needs for air tight constructions increase the moisture problem, with a considerable problem with both decay and negative influence on the indoor air.

If the air tightness fails, mainly snow, but also some rain, easily enters into the building. This can cause a significant problem with water from the melting snow. The effect of this problem is increased due to the almost air tight construction so the relative humidity gets very high during some periods.

Water intrusion during the summer is also to a great extent caused by the thaw of the surface layer of permafrost. The water can not penetrate deeper into the ground, and runs easily into the floor constructions where it causes decay problems.

Despite extremely tough climatic conditions for fungal growth, biodeterioration has been shown to be more extensive than expected. The investigations have shown that the reason for this is favourable growth conditions in the very narrow microclimate (i.e. “mycoclimate”) of the materials during summer time. The reasons for these conditions in the unheated buildings are mainly caused by the heating from the natural solar radiation – which due to midnight sun, can be of considerable importance. Water has an origin from local moisture sources, i.e. melting snow and local thaw of permafrost.

The growth of mould fungi causes discoloration of surfaces and a negative indoor air quality in the cabins. Wood-decaying fungi cause severe decay during the summer, and the rate of decay is shown to be relatively similar to damages in the temperate climate in for example southern Scandinavia.

Since the constructions are made in a high risk solution, the decay has caused serious deterioration of wooden materials. The decay leads to a clear need for repair in order to maintain the technical function of the constructions. Since the buildings are at extreme remote locations, the cost for repair work is extraordinary high and the practical problems enormously.

Even if it is a fundamental refusal to changing constructions and materials in old, protected buildings, minor but important measurements should be done on order to prevent against the increased risk of biodeterioration due to predicted global warming.

Our suggestion it therefore that during the repair work, the buildings should be permanently lifted somewhat up from the ground in order to ensure a better future service life of the building. This remedial action is of extra importance in case of a future global warming because such change could prolong the periods of favourable growth conditions due to increased temperature and access of water from the thawing permafrost.