Sunshine - the worst enemy of wooden facades

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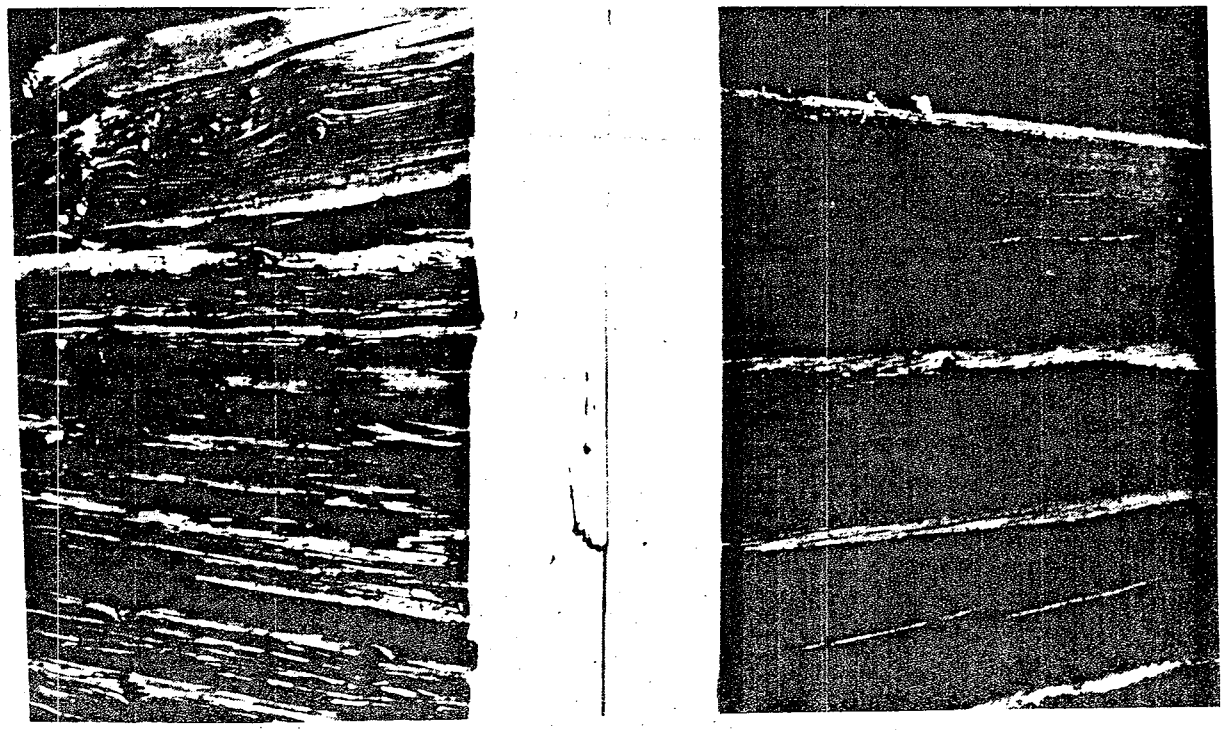
The sunny side

Everyone working with wooden buildings has noticed the apparent difference of the state of preservation with facades facing opposite points of the compass. While the southern side (in the northern hemisphere) is already full of deep cracks and splitting flakes, the northern facade can still look just grey but be otherwise virtually in perfect condition. The colour of the south side is dark brown, but the north side is grey, with some lichens or, in the deepest shadows, green algae growing on it. If the site of the building is somewhat humid, there tends to be some insect damage in the boards or logs where sapwood is visible, but this time only on the northern side. The south and the north sides are the two opposites, the facades facing into other points of the compass follow the same rules according to the amount of sunshine they are receiving.

Fig.1. It is hard to believe that the walls on the sunny and shadowy sides are of the same date. On the sunny side the surface is frail and full of deep cracks. In the shadow the logs have only the normal cracks (along the middle) caused by drying. The amount of rain is the same on both sides. A wooden facade ought to be protected first of all against solar radiation.



The type of weathering of wooden facades described above is especially obvious in the northernmost (and the southernmost) parts of the world, where the low sun during the winter and the early springtime is shining at right angles to the walls, and where the reflection of the light from the white snow still adds to its intensity.

The effect of light: discolouration

The energy of the sunshine falls to the facades in two forms: as light and as heat. The first effect, which is very soon visible, is the change of the colour of wood. The lignin decomposed by photo-oxidation (which will be discussed later) turn the surface of wood at first yellow and then brown. This change is often very quick. In light coloured wood, like the sapwood of pine, the light brown toning is clearly seen after one day of direct sunshine. The same phenomenon appears on the type of paper where there is still much lignin left: it will turn yellow if left into the sunshine.

The grey colour for its part is caused by water. Also sulphur dioxide and atmospheric iron have an important role in the chemical process of the greying of wood. The amount of rain and other humidity on both the north and the south facades can be the same, but the northern one remains wet for a longer time and thus turns grey a little faster.

Facades in direct sunshine and those in shadow will both turn visibly grey in about one year. The shadowy surfaces will reach a dark grey colour. There the final colour is often due also to the contamination of blue stain funghi.

On the sunny facades the decomposition of lignin, which is the first colour change, will go on continuously and the grey tone will be overstepped by a brown one which finally becomes very dark. In resinous species of wood the intense heat of sunshine on a darkened facade makes the resin flow towards the surface, where it finally oxidizes forming yellow powder. This is seen especially on knots. When a wooden surface which is getting plenty of sunshine is washed with much rain, like a shingle roofing, it will turn grey because water will take brown decomposed lignin away.

What is said here applies best on pine and also on spruce, larch and similar species of trees; some other species may have a somewhat different behaviour.

It can be added, that the patina of weathered wood is a most important feature of wooden monuments. No such preservatives that change this colour can be used. When wooden surfaces are rebuilt in open air museums, like shingle roofings or unpainted weatherboardings, no preservatives should be used, because they always cause wood to age unnaturally. When wooden houses are transported to open air museums, they should be placed in their original points of the compass.

The effect of light: defibration

The intense light of direct sunshine induces on a wooden surface a physico-chemical change which is called photodegradation - undirect light does not have enough energy for a similar effect. Especially ultraviolet light is highly active, but as a whole the effect of visible light may be about the same. Ultraviolet light is much stronger because it forms only 5% of the spectrum; but the possible closing out of only uv-light will not prevent the process but only make it last longer (Derbyshire and Miller 1981). Also water has a very important role in this process; if protected from humidity the surface will degrade much slower.

Of the two main chemical compounds of wood, cellulose and lignin, lignin is first decomposed by photo-oxidation, caused by light in the presence of water. Lignin has a brownish colour, and especially its decomposition products stain wood brown. (Those types of funghi that decompose also lignin - so called brown rots - will turn wood brown for the same reason).

In the structural model of wood lignin is acting as cement and cellulose as strength-giving reinforcement. More important than the decomposition of lignin of the cell walls, is the decomposition of the middle lamella which cements the cells together. It consists mainly of lignin (70%) and is thus rapidly destroyed. When this happens, the cells will part from each other. Wasps build their nests out of such naturally delignified wood fibres.

Also the molecules of cellulose are depolymerized by strong light in the presence of water. Because cellulose gives strength to wood, its destruction has a profound effect on surface integrity. The tensile strength is lost, and this renders wood susceptible to microcracking.

The rate of light erosion

Visible light can penetrate no more than 0,2 mm deep into wood, and uv-light only 0,08 mm. The intensity of light diminishes rapidly below the surface. Thus its real effect is restricted to a thin surface layer, a fraction of a millimetre in depth.

The rate of the loss of surface has been estimated to be 5 - 12 mm per century (Feist and Mraz 1978). Accelerated weathering tests may give a somewhat too high values, because only the beginning of the weathering phenomenon is studied. In practise, the photo-oxidated cells will remain on surface for some time, and thus form a protective light filter on it. In Japan, a value of 3 mm per century is used. According to my own observations, the loss of a surface which is well protected from rain is about 1 mm per century. At the door of Shosoin treasury (8th century) in Nara, Japan, under long eaves, the uncovered surface lies 12 mm deeper than the original surface covered by metal door hinges. The species of wood is Japanese cypress (Chamaecyparis obtusa). Another example is the southwards facing main door of Urnaes stave church (13th century) in Norway. The door is very well protected from rain and wind

by roofings, but low springtime sun reflecting from snow can easily reach it. The door has lost 7 mm of its surface, compared with the original level under the metal hinges.

The effect of heath: cracking

The most disasterous phenomenon of deterioration of wooden surfaces is surface cracking. There is also another type of cracks, shrinkage cracks, which form into new timber. They are due to the shrinking of wood when it dries from its original moisture content above fibre saturation point into air dry. This shrinking is concentrated in singular large cracks, often several mm wide. The surface of wood at the sides of a crack is untouched. Shrinkage cracks can be found as well on northern and southern facades, both inside and outside. They are seen almost always on timber with great dimensions, directing radially from surface to pith. Once formed, these cracks do not grow wider or deeper with time. They are harmful only in such species of wood which do not have a funghi resistent heart wood, by giving rise to biological attack.

Surface cracking in its strength is seen only on southern facades. It is caused by too quick drying of wood: the heat of direct sunshine after a rain. Two mechanisms have been presented (Kärkkäinen 1985): If wood dries very quickly, the tensile stress on surface will cause compression stress inside. This can go beyond the compression strength of the cell walls, which will be crushed. On the other hand, if saturated cell walls dry quickly, the adhesion of escaping water can be so great that the cells are destroyed (Kärkkäinen 1985). Anyway the collapse of cells will cause microcracks in dry state, especially when photo-oxidation has weakened the cell walls. Microcracks add to the ventilation of the surface, and next time wood will dry even quicker, which in its turn leads to more and deeper cracks. Surface cracking is a progressive phenomenon, which will go on to a certain point. The surface is then covered by deep cracks with flakes falling off. Deep cracks also deposit moisture and thus provide favourable circumstances to funghi, which otherwise find southern side too dry.

The darker the surface the better it absorbs solar heat and the worse are the cracks. The dark brown discolouration by sunshine encourages cracking. It has been measured that in air temperature of 20°C the surface temperature of white painted wood is 40°C and dark coloured wood is 80°C. This is why dark transparent wood stains are disasterous on sunny facades. A thin weatherboarding can be virtually out of use after 10 years. In Finland the windows treated with dark stains are often renewed after 20 years.

Protection of wood against sunshine

Wood preservation industry is mainly working with toxicants against biodeterioration. Biocides are often advertised useful also for protection of facades, weatherboardings and windows, which really are in

no need of biological prevention. The main danger for wooden facades, sunshine, is not brought forth.

There has also been done some research to find treatements which protect wood from photo-oxidation. Both organic and inorganic materials and the modification of wood have been tested. The protection from uv-light, the prevention from oxidation and water repellency are the main aims. (Ahola 1986).

The effect of light can be prevented naturally by covering wood with paint or shelter. These also prevent wood from getting wet, and thus protect it from quick drying. If the surface of a historic building has been originally painted with oil paint, only regular repainting is needed. In many cases painting is however not possible. In Urnaes stave church the large decorated southern gable, which was already badly damaged, was recently protected by a wooden shelter which can be opened if needed. In Finland in the Myllymäki test project deteriorated buildings of a small farm are conserved as authentic museal objects, avoiding all intervention to the structure. The buildings will be covered by a large shelter, which will protect them from sunshine and rain. The first experimental shelter was put up over the smoke sauna of the farm in 1984. The results of the experiment look encouraging (Kaila 1984).

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Summary

The deterioration of wooden facades facing southwards is mainly due to sunshine. Intense sunlight, both the ultraviolet and the visible section of the spectrum, deteriorates wood through a physico-chemical process called photo-oxidation. The presence of humidity is also essential. Discolouration of wood is the first effect.

In wooden monuments the natural patina of weathered wood is a most important feature. It is not advisable to use any preservatives that change this colour. When a building is transported to an open air museum it ought to be re-erected in its original direction so as to retain the authentic appearance of weathering.

Breakdown of lignin in the middle lamella loosens wood cells from each other, and the degradation of cellulose destroys surface integrity. The rate of loss of material degraded by light is in the long run approximately 1 mm per century. The most disasterous phenomenon of deterioration of wooden surfaces is however surface cracking. It is caused by too quick drying of wood by the heat of direct sunshine. Dark transparent wood stains encourage cracking by absorbing heat.

The protection of wooden surfaces against solar radiation can be done by covering it with paint or shelter (weatherboarding).

Résumé

La détérioration des facades en bois donnant sur le sud est due surtout à l'éclat du soleil. Le soleil intensif, l'ultraviolet ainsi que la section visible du spectre détériorent le bois par un phénomène physico-chimique dit photo-oxydation. La présence de l'humidité est aussi essentielle. Le premier effet est la décoloration du bois.

Quant aux monuments en bois, la patine naturelle du bois créée par le climat est un trait très important. La préservation des bois qui peut changer cette couleur n'est pas recommandée. Quand un bâtiment est transporté dans un musée en plain air il devrait être érigé dans sa direction originale pour pouvoir garder son apparence authentique usée par le climat.

La dissociation de la lignine dans la lamelle centrale détache les cellules les unes des autres, et l'integrité de la surface est détruite par la dégradation de la cellulose. La quantité du matériau dégradé par la lumière, pendant une longue période, est environ 1 mm par siècle. Le phénomène de détérioration le plus destructif des surfaces en bois est pourtant le fendillement de la surface. Il est dû au séchage du bois trop rapide au soleil directe. Les traitements foncés transparents augmentent le fendillement en absorbant la chaleur.

La protection des surfaces en bois contre le rayonnement solaire peut être effectuée soit avec la peinture soit avec une construction protective (rêvetement de planches).