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Cupping of wooden cladding boards in cyclic conditions—A study of heat-treated and non-heat-treated boards

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Abstract

The aim of the study was to examine how the thickness and heat-treatment of cladding boards affects cupping during cyclic conditions. The study was conducted with heat-treated and non-heat-treated cladding boards in laboratory conditions. On the basis of the results, thickness and heat-treatment both have a significant influence on cupping of the board. The cupping of heat-treated board was considerably lower than that of non-heat-treated board.

Keywords: Cupping; Curvature; Facade; Cladding; Heat-treated

1. Introduction

Cladding board shrinks as it dries and swells as it absorbs moisture. This may lead to undesirable dimensional changes, e.g. cupping of the board. The forces exerted in cupping are great, and they have a clear effect on the permanence and serviceability of wooden claddings. Design practice should therefore require that efforts be made to minimize changes in dimensions during the life of the cladding board. Although a protective coating usually protects the outer surface of the cladding, an untreated board or permeable or semi-permeable coatings allow water to penetrate into the cladding board [1]. Without sufficient protection, transfer of moisture into and out of the cladding board can lead to undesirable dimensional changes, which may contribute to, e.g. peeling and cracking of the wood surface and of the coating [2–5] (Fig. 1).

Although cladding boards are tightly fitted at one or two edges by their fastenings, they tend to move with time. If the boards are fitted only at one edge, they have a natural tendency to cup during drying and wetting periods. If the boards are fitted from two edges, the most common loosening effect of the cladding boards is caused by the compression set and pulled nails. When a dry cladding board is fastened down with nails, absorption of moisture will cause the board to swell against the underside of the nail head. If the nail holds in the underlaying member, the board may be compressed against the nail head. If it does not hold, the nail is pulled slightly. This process, combined with the loosening effect of the joint between the nail and the board, contributes to a general loosening and pulling of nails and they tend to work out with time [1]. This loosening of the boards provides more space for the boards to cup. Recent studies have shown that even brand-new cladding boards tend to move despite their fastenings [6,7].

One reason for the decreased durability of modern claddings is assumed to be the use of deformation-sensitive cladding boards. At the end of the 18th century, cladding boards were about 40 mm thick, whereas modern instructions recommend about 20 mm thick boards for claddings.

As a result, it is assumed that dimensional changes in the surface layers caused by repeated swelling and shrinking contribute to: (1) further breakdown of the

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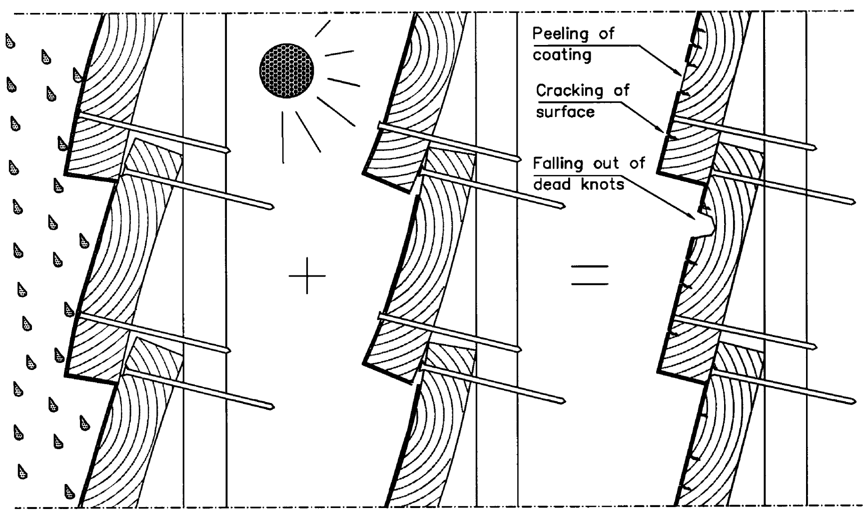

Fig. 1. Typical damage to wooden claddings due to weathering.

wood–paint-system [2,8], (2) loosening and falling out of dead knots [1], and (3) problems of an esthetic nature. These observations indicate that the thickness of the board is related to vulnerability of wooden facades. However, no comparative studies are available in the field of cupping of wooden cladding boards during weathering.

This study presents new data concerning the cupping sensitivity of non-heat-treated and heat-treated cladding boards when the surface of the board is exposed in cyclic conditions.

2. Materials and methods

The aim of the study was to examine how the thickness and heat-treatment of the board prevents cupping during cyclic conditions. The samples consisted of non-heat-treated and heat-treated boards made of Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) timber.

The restricted cupping measurements were conducted with full-scale test walls, which were 1300 mm high and 650 mm wide. The boards, which were re-sawn with a band-saw according to Nordic practice, were fitted from two edges using 75 mm nails so that the pith side of the board was exposed in cyclic conditions. The surface of the board was coated with a pigmented primer according to current instructions.

The test period consisted of 14 wetting and drying periods. In a wetting period, the surface of the element was wetted using a driving rain test apparatus, which sprayed 1.35 l/m^2/h to the surface for 3 h. After each wetting period, the element was exposed to drying at $40 \pm 5\%$ relative humidity (RH) for 21 h. The rate and extent of cupping were recorded automatically every 30 min (Figs. 2 and 3).

Fig. 2. Driving rain test apparatus and 2 test walls from the front.

This experiment simulated driving rain and microclimate exposure of the surfaces of cladding boards in south-facing facades in Finland.

The cupping results were converted into curvature results using the following equation (Fig. 4):

$$\kappa = 1/R = 2w/(w^2 + 0.25L^2), \quad (1)$$

where κ is the curvature (1/m), R the radius of curvature (m), w the cupping (m), and L the width of the board (m).

Before the test, the test walls were preconditioned in the climate room for 4 weeks to reach equilibrium moisture content (EMC) corresponding to 65% RH. This is an average RH level in Finland in summer. The EMC was assumed to have been reached when the weight of the sample was stable.