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Sorption properties of historic and recent pine wood

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ABSTRACT

Restorers of historic timber structures often face the necessity of using recent timber to replace structural elements destroyed by fungi and insects. As a rule new wood is of the same species, approximately the same wood density and annual increment.

The paper presents data on differences in the sorption/desorption processes in recent and historic Scots pine (*Pinus sylvestris* L.) wood. Data loggers Materialfox (Germany) were installed in the 18th–19th cc. monuments of the Kizhi museum (Republic of Karelia, Russia). Wood moisture was measured with a 4 h interval for 150 days.

The data obtained proved the working hypothesis about differences in the sorption properties of historic and recent timber.

High wood moisture content of historic timber treated with borax chemicals increases the risk of fungi development in the joints with new insertions. It also increases the risk of infestation by borers.

Using recent timber for insertions in the historic timber structures should be limited. Special requirements to the recent wood to be used for restoration are to be set up. They should be protected from environmental impact, especially if the structure had previously been treated with chemicals.

1. Introduction

Restorers of historic timber structures often face the necessity of replacing decayed or damaged structural members or their parts. According to the "Principles for the Preservation of Historic Timber Structures" (1999) adopted by ICOMOS "New members or parts of members should be made of the same species of wood with the same, or, if appropriate, with better, grading as in the members being replaced. Where possible, this should also include similar natural characteristics. The moisture content and other physical characteristics of the replacement timber should be compatible with the existing structure".

The quality of wood is a wide characteristic that includes density, strength, chemical composition and sorption properties. The most common parameters used for the selection of timber for restoration are the density and tree-ring width (Weaver, 1993; Kaila, 1997; Larsen and Marshtein, 2000). The age of the tree at the time of felling is also important. It has been previously shown that the majority of religious buildings in the Republic of Karelia were built of 200–300 year old Scots pine (*Pinus sylvestris* L.) timber. At the same time, its density and annual ring width varied widely (400–600 kg m −3, 0.01–0.2 cm) (Kisternaya and Kozlov, 2007).

Introduction of new material reduces the aesthetic appreciation of the monument (Fig. 1). There is an opinion that new material can be easily degraded by wood-destroying fungi from infected historic timber (Gorshin et al., 1992). It can also cause additional deformation due to uneven shrinkage of fresh material.

Wood as a natural and organic material absorbs and releases moisture on a daily or annual basis. As it does so it expands and contracts in a way that is influenced by its density and other species characteristics. Sorption properties of wood are determined by sorption properties of its high-molecular components – cellulose, hemicellulose and lignin (Skaar, 1998). It is known that cellulose molecules degrade as wood ages, influencing its sorption properties (Feist and Hon, 1984; Fengel and Wegener, 1984). The rate of deterioration is determined by service conditions (Varpholomeev Yu, 1992; Shapovalova, 1994). Chemical treatment with hydroscopic salts also influence wood sorption properties (Desch and Dinwoodie, 1996).

The aim of the study was to investigate the differences in the sorption properties of historic and recent Scots pine wood.

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Fig. 1. Numerous new patches influenced the aesthetic appearance of the house of peasant Sergeev from the Village of Logmoruchei (1910), Kizhi Open-air Museum, Russia.

Fig. 2. The Kizhi Pogost. From left to right: the Church of the Transfiguration (1714), the bell-tower (1863) and the Church of the Intercession (1765).

2. Objects and methods

Sorption properties of historic and recent timber were studied at the world heritage site Kizhi Pogost (C544) located on a small island of Kizhi in the north-western part of Lake Onega (Fig. 2).

The climate in this region is temperate-continental. Average annual temperature is about 3 °C. Average maximum temperature is 33 °C and average minimum is −40 °C. Summer lasts from June to September. Average annual precipitation is 650 mm, of which 400 mm occurs from May to October. Maximum precipitation occurs during September. Relative humidity is within 75–90% during the warm period (Kisternaya and Kozlov, 2007).

Wood moisture sensors (Materialfox loggers, Scanntronik Mugrauer GmbH, Germany) were installed in the Church of the Intercession and the bell tower of the Kizhi Pogost.

The Church of the Intercession was built through several time periods, beginning at the end of the 17th century and continuing until 1750. The Church is 32 m long, 8.7 m wide and 27 m high. The structural material of the building is Scots pine logs with an average diameter of 26 cm. Onion domes are covered with aspen shingles. The structure was treated in the 1980s with PBB-211 solution (Na-pentachlorpenol + borax + boric acid 2:1:1) by

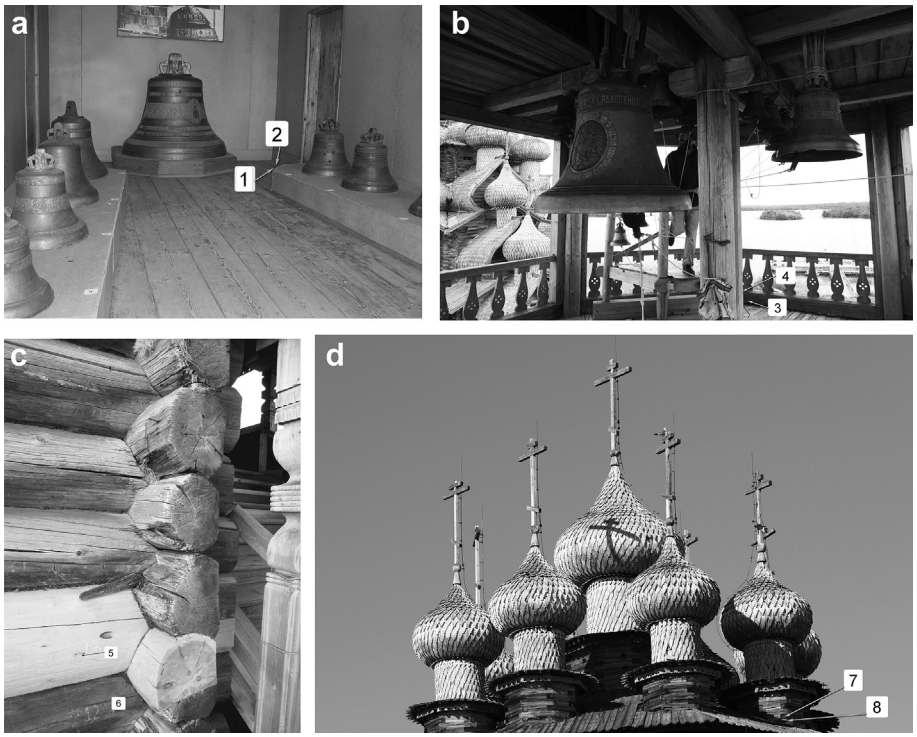

Fig. 3. Location of sensors. A – Sensors were installed in historic (#1) and recently repaired (#2) floor cross-beams in the basement of the bell-tower. B – Sensors were installed in historic (#3) and restored (#4) cross-beams on the belfry; C – Sensors were installed in a historic treated with PBB-211 log (#5) and a new member (#6) on the northern wall of the Church of the Intercession; D – Sensors were installed inside the onion dome of the Church of the Intercession on historic treated with PBB-211 cross beam (#7) and newly repaired (#8) cross-beam.