UDC 620.1:630*811.17/812.7

DURABILITY OF THE SIBERIAN LARCH HEARTWOOD TIMBER OF DIFFERENT ORIGIN: THE RESULTS OF 11-YEAR GROUND CONTACT TEST IN FINLAND

M. Venäläinen[1], S. Heikkonen[2] , N. Terziev[3], P. Torniainen[4]

[1] *Natural Resources Institute Finland (Luke)*
Vipusenkuja 5, Savonlinna, 57200 Finland

[2] *Metsä Wood*
P. O. Box 50, Metsä, 02020 Finland

[3] *Swedish University of Agricultural Sciences*
P. O. Box 7070, Uppsala, 75007 Sweden

[4] *Luleå University of Technology in Skellefteå*
Forskargatan, 1, Skellefteå, 93187 Sweden

E-mail: martti.venalainen@luke.fi, samuli.heikkonen@metsagroup.com, nasko.terziev@slu.se, petteri.torniainen@finotrol.fi

Received 09.01.2019

The study describes a ground contact test on natural durability of the Siberian larch heartwood timber. The test has been conducted in Finland according to the European norm EN 252 since the year 2006. The material is timber imported from natural larch stands in Ust-Ilimsk, Russia, and cultivated larch stand in Punkaharju, Finland. The Finnish stand is growing outside the natural range of distribution of Siberian larch. Untreated Scots pine heartwood and impregnated Scots pine sapwood were used as reference materials. The results after 11 years showed that there was remarkable variation in the durability between the larch heartwood samples. Nevertheless, the most durable timber lots on average were the Siberian larch heartwoods harvested from the Russian native stands and the Finnish cultivated stand. It is predicted that it will take another 10 years or more until the failure of the most durable larch stakes.

Keywords: *Larix sibirica, heartwood, bioresistance, European norm EN 252, ground contact, testing, Ust-Ilimsk, Punkaharju.*

How to cite: *Venäläinen M., Heikkonen S., Terziev N., Torniainen P.* Durability of the Siberian larch heartwood timber of different origin: the results of 11-year ground contact test in Finland // *Sibirskij Lesnoj Zurnal* (Sib. J. For. Sci.). 2019. N. 3: 14–19 (in English with Russian abstract).

DOI: 10.15372/SJFS20190302

INTRODUCTION

The natural durability of the Siberian larch *Larix sibirica* Ledeb. heartwood is a well-known feature from the past history and a great number of studies. The rehabilitated interest in the use of larch timber in Europe results from the need to find environmentally benign alternatives to timber protected with possibly harmful chemicals, e. g. copper-based preservatives. Consumers need durable timber for out-of-doors applications, such as deckings and garden constructions that are prone to wetting and decay. The naturally durable heartwood of larch is an economically viable option to substitute for chemically impregnated timber.

Natural durability of heartwood depends on the species-wise extractive composition (Zabel and Morrell, 1992). In the case of larch, studies have illustrated the role of phenolic taxifolin in providing the decay resistance of heartwood while the most abundant extractives, water-soluble arabinogalactans, have no effect on durability (Venäläinen et al., 2006). There is a wide variation in the decay resistance between individual trees similar to many other growth and quality traits. The variation rises partly from the genetic differences (Venäläinen et al., 2001) and partly from the effect of the growing environment. There is also a common speculation that trees growing within their natural distribution area would be better from the viewpoint of quality characteristics, including decay resistance, than trees introduced and cultivated outside the natural range.

The Siberian larch has been cultivated in the Northern Europe, i. e. outside its natural range of distribution, since 1738 (Redko and Mälkönen, 2001). Currently, there are large areas of planted Siberian larch stands in Finland, Sweden and even in Iceland. This introduced species has proved to be well adapting and promising with regard to the production of good quality timber. Most of these cultivated stands are still young, and so, sawn larch timber is imported from Russia for building purposes.

The aim of this study was to compare the durability of the Siberian larch heartwood timber imported from natural stands from Siberia and timber harvested from a cultivated stand in Finland. The comparison was carried out as a long-term ground contact test according to the European standard EN 252 (1989).

MATERIALS AND METHODS

Siberian larch heartwood material consisted of two timber lots: commercial timber imported from Ust-Ilimsk (58°15′ N, 102°75′ E), Russia, and timber harvested from a 84-year-old cultivated stand in Punkaharju (61°81′ N, 29°32′ E), Finland (Fig. 1).

Detailed information on the wood material properties as well as the results of kiln drying experiments are given by S. Heikkonen et al. (2007), K. Luostarinen and S. Heikkonen (2010), and

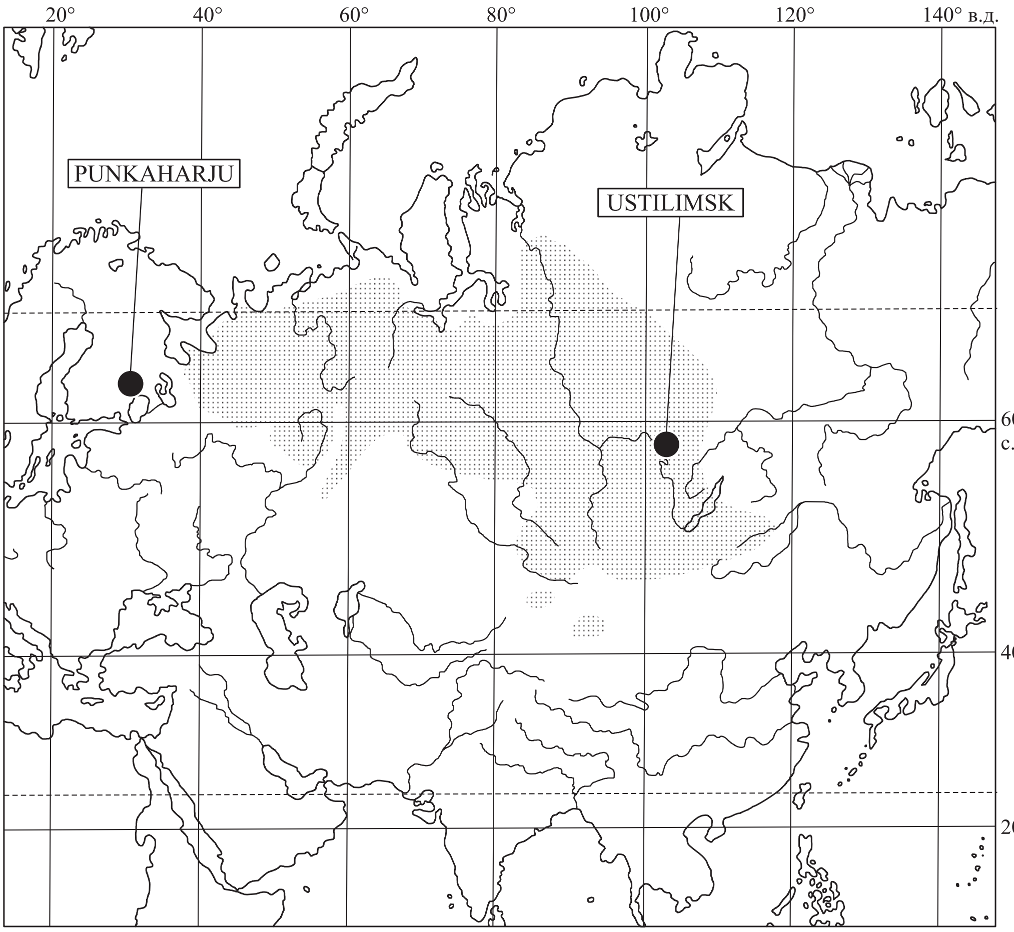

Fig. 1. The natural distribution of the Siberian larch according to R. Sarvas (1964), the locations from which the test materials were harvested (Ust-Ilimsk and Punkaharju) and the test location (Punkaharju).

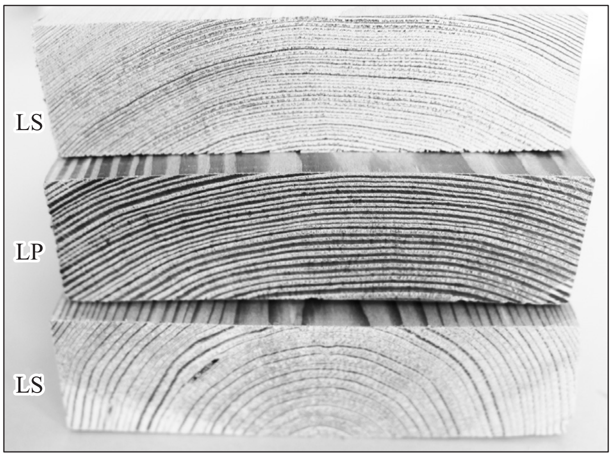

Fig. 2. The Siberian larch timber from which the 25 × 50 × × 500 mm sized test specimens were produced. LS = Siberian larch heartwood (mature wood on top, juvenile wood at bottom) grown in Ust-Ilimsk, Russia, LP = Siberian larch heartwood grown in Punkaharju, Finland.

K. Luostarinen et al. (2010). From the Finnish logs, both mature heartwood from the outer part of the log and juvenile heartwood from the center of the log were exposed in ground contact durability test (Fig. 2).

Reference specimens impregnated with chromated copper arsenate CCA (two concentrations) and copper-based preservative Celcure 800 AC were used in parallel with non-impregnated Scots pine *Pinus sylvestris* L. sapwood and heartwood stakes (acquired from two different growing locations) (Table 1).

The standardized field test EN 252 has been developed to determine the relative protective effectiveness of a wood preservative in ground contact (European Standard, 1989). Also, it has been widely used to determine the natural decay resistance of wood species. In this test, half of a 25 × 50 × 500 mm sized wooden stake is buried in the soil for 5–10 years (Fig. 3) and thus exposed to soil-inhabiting biomass degrading microorganisms. The deterioration of each stake is evaluated annually according to specific instructions of the standard (Borsholt, Henriksen, 1992). At late stages of degradation, the strength of the stake is tested with a bending apparatus using static pressing force of 1240 N (Fig. 3).

The test field is located at Punkaharju, Finland, on fertile former garden soil (pH 7.5). It is expected that the degradation in soil contact occurs during the months when the mean air temperature is above 0 °C, i.e. from April to October. The annual mean temperature during that period was 10.7 °C and the precipitation 370 mm.

The field experiment was started on the 21st of June in 2006, and the first evaluation was made after the first active degradation period in October 2006. The evaluation of the stakes was carried out by VTT Technical Research Centre of Finland annually until 2011. The bending test was carried out only in 2013 while in 2016 both the evaluation and bending test were carried out. In the last evaluation the decay rate classes were carefully adjusted to find out more clearly the differences between the test series: if the performance of a stake was worse than that of a typical 2 or 3 it was given rate value 2– or 3–. Similarly stakes better than 3 were given rate value 3+.

According to the standard EN 252 and the evaluation guideline, the decay rate classes assigned to individual stakes are treated in the data analysis as integral natural numbers (0, 1, 2, 3, 4). Thus, the average decay rate for a test series can be calculated as the arithmetic mean of the single decay rates. Furthermore, in our analysis the decay rates were given a negative value to illustrate the deterioration of the condition of the stakes. According to the instructions, when all the stakes in the test series reach the decay rate 4, i. e. are broken, the average service lifetime is calculated as a mean of the lifetime of every single stake.

Table 1. Summary of wood materials used in the EN 252 ground contact test.
The impregnated timber was Scots pine sapwood

Material code	Material description
C	Impregnation with Cu preservative (Celcure 800 AC, 3.2 %, 19 kg/m^3)
CCA (0.3 %)	Impregnation with CCA preservative (0.3 %, 2 kg/m^3)
CCA (1.3 %)	Impregnation with CCA preservative (1.3 %, 9 kg/m^3)
LP	Siberian larch heartwood grown in Punkaharju, Finland
LPN	Siberian larch juvenile heartwood grown in Punkaharju, Finland
LS	Siberian larch heartwood grown in Ust-Ilimsk, Russia
MS	Scots pine heartwood grown in South Finland
PM	Scots pine heartwood grown in North Finland
VM	Scots pine sapwood grown in South Finland

Fig. 3. Overall view of EN 252 decay field test at Punkaharju in summer and winter time, grass maintenance, Scots pine stake in close view and strength measuring with a bending apparatus.

RESULTS AND DISCUSSION

The average decay rates according to the visual evaluation were calculated for the first five degradation periods (Fig. 4).

The quick degradation of Scots pine sapwood showed that the microorganisms living in the soil were aggressive against perishable wood. Only two impregnated test series (Cu and CCA 1.3 %) had kept intact while the surface of the stakes of all other materials, including the larch samples, had started to soften. The difference between Scots pine sapwood and heartwood was evident, as well as the difference between the two CCA concentrations.

Until October 2016, i. e. during eleven years (active degradation periods), Scots pine sapwood had reached the degradation phase in which the calculation of average service lifetime was relevant, i. e. all the stakes were broken. The average service life of untreated sapwood was 4.9 years. For the

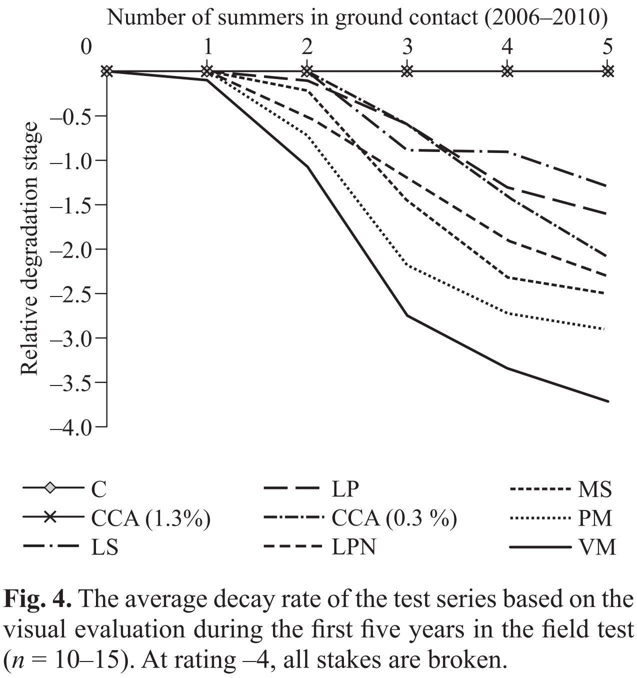

Fig. 4. The average decay rate of the test series based on the visual evaluation during the first five years in the field test (n = 10–15). At rating –4, all stakes are broken.

Table 2. Performance of the test stakes in the eleven-year ground contact test started in 2006 at Punkaharju, Finland. The number of broken stakes in the annual bending test is given until Oct. 2016. The number of stakes that passed the bending test, i. e. were still standing after Oct. 2016, is given in the visual degradation classes applying the European standard EN 252 (1989)

Materal code	N	N of broken stakes in 2007–2016							N in	Decay class for standing stakes in 10/16				
		–07	–08	–09	–10	–11	–13	–16	10/16	3–	3	3+	2–	2
C	15	–	–	–	–	–	–	–	15	–	14	1	–	–
CCA (0/3 %)	12	–	–	–	–	–	–	5	7	1	6	–	–	–
CCA (1/3 %)	10	–	–	–	–	–	–	–	10	–	6	3	1	–
LP	10	–	–	–	–	–	–	1	9	–	2	3	2	2
LPN	10	–	–	–	1	1	–	1	7	–	2	3	2	
LS	10	–	–	–	–	–	–	1	9	–	4	2	–	3
MS	14	–	–	1	–	1	2	7	3	1	2	–	–	–
PM	11	–	1	–	–	2	2	4	2	1	1	–	–	–
VM	15	1	1	3	5	3	2	–	–	–	–	–	–	–

other test series the annual number of broken stakes is given in Table 2. Furthermore, the frequency of stakes that were not broken until 2016 is given in the sharp tuned decay rate classes (Table 2).

The results showed that there was a remarkable variation in the durability between the heartwood stakes. The most susceptible stakes were already broken while in the most durable ones only surface softening was discovered. This finding was consistent with earlier results concerning the wide variation in natural decay resistance (Venäläinen et al., 2001). In general, Siberian larch heartwood appeared to be more durable than Scots pine heartwood.

The performance of larch timber grown in Finland and Siberia seemed to be similar. The predictable service lifetime for both materials seems to be much over 11 years. This finding differs from the earlier results that have shown superiority of Siberian-grown timber compared to timber grown in Sweden (Jebrane et al., 2014). The juvenile heartwood that is located close to the pith was somewhat less durable than mature heartwood. The softening of impregnated Scots pine sapwood stakes (Cu and CCA 1.3 %) proceeded evenly but accelerated during the last years compared to larch heartwood.

CONCLUSION

The most durable timber lots in this long-term ground contact test, carried out in Finland for 11 years, were Siberian larch heartwoods harvested from native stands from Ust-Ilimsk, Russia, and cultivated stand from Punkaharju, Finland. It is predicted that it will take another 10 years or more until the failure of the most durable larch stakes will occur. Since the results are quite unexpected, more durability tests with different methods and on different locations are needed for general conclusions.

The authors are grateful to SIBLARCH project financed by the European Union Northern Periphery Program for initiating this interesting field test.

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УДК 620.1:630*811.17/812.7

ПРОЧНОСТЬ ПИЛОМАТЕРИАЛОВ ИЗ ЯДРОВОЙ ДРЕВЕСИНЫ ЛИСТВЕННИЦЫ СИБИРСКОЙ РАЗЛИЧНОГО ПРОИСХОЖДЕНИЯ: РЕЗУЛЬТАТЫ 11-ЛЕТНЕГО ЭКСПЕРИМЕНТА ПО ЗАГЛУБЛЕНИЮ ИХ В ГРУНТ В ФИНЛЯНДИИ

М. Веняляйнен[1], С. Хейкконен[2], Н. Терзиев[3], П. Томиайнен[4]

[1] *Институт природных ресурсов Финляндии (Люк)*
Финляндия, 57200, Савонлинна, Випусенкуя, 5

[2] *Метса Вуд (Metsä Wood)*
Финляндия, 02020, Метса, а/я 50

[3] *Шведский университет сельскохозяйственных наук*
Швеция, 75007, Уппсала, а/я 7070

[4] *Технологический университет Лулео в Шеллефтео*
Швеция, 93187, Шеллефтео, Форскаргатан, 1

E-mail: martti.venalainen@luke.fi, samuli.heikkonen@metsagroup.com, nasko.terziev@slu.se, petteri.torniainen@finotrol.fi

Поступила в редакцию 09.01.2019 г.

Исследование посвящено определению изменения биостойкости древесины лиственницы в ходе 11-летней выдержки в грунте на основе европейского стандарта EN 252. Испытанию подвергались образцы древесины лиственницы сибирской, заготовленной в районе Усть-Илимска, лиственницы сибирской и сосны обыкновенной из культур, выращиваемых в Финляндии (Пункахарью). Культуры лиственницы в Финляндии произрастают в условиях, отличающихся от условий естественного распространения лиственницы сибирской. В качестве эталонных материалов использовались необработанная ядровая древесина и пропитанная биозащитными препаратами заболонь сосны обыкновенной. В результате 11-летних испытаний по определению прочности образцов древесины при статическом изгибе установлены существенные различия между образцами ядровой древесины лиственницы. Тем не менее отмечается высокая биостойкость ядровой древесины всех исследованных образцов лиственницы. Предполагается, что прочностные свойства наиболее биостойких экземпляров могут сохраняться еще в течение 10 лет и более.

Ключевые слова: *Larix sibirica, ядровая древесина, биостойкость, европейский стандарт EN 252, контакт с грунтом, тестирование, Усть-Илимск, Пункахарью.*