RESEARCHES CONCERNING THE CHEMICAL PRESERVATION OF WOOD USED IN CONDITIONS OF HAZARD CLASS 4

Octavia ZELENIUC, Luminița ENESCU, Mariana PRUNĂ
National Institute of Wood - I.N.L., Bucharest, Romania

Abstract

Depending on the forest exploitation, utilization and not in the last, on the climate conditions, the wood is subjected to biodeterioration.

The wood infection with biological agents, can start from the forest, at living trees, extending it on the sawn timber stored, processed and even on the wood in service.

Taking into account the whole variety of biotic and abiotic factors that act upon the wood species, it has been standardized at European level, five hazard classes of biological attack.

The paper deals with researches concerning the chemical preservation of wood intended for applications specific to hazard class 4.

There are presented the field test results after 24 months of exposure in the test site, of beech, spruce and pine sapwood samples, treated with CCA product type, comparing them with untreated samples.

The test was carried out in accordance with SR EN 252-1995 for determining the relative protective effectiveness of wood preservatives in ground contact.

Keywords: Biotic, abiotic factors, biological attack, wood preservation, field test.

Introduction

Wood is a biological material composed of cellulose, lignin and hemicellulose. These three structural polymers make up 90 to 99 percent of the wood mass and give wood its unique properties that make it an excellent structural material.

The wood contains also other chemical compounds such as, sugars, starches, proteins, lipids and fatty acids. These compounds exist in the storage tissues of the living

tree and even after trees is harvested, they can provide the initial food source for fungi and insects.

The fungal are rarely present inside the living trees, the bark being a true barrier against fungal and insects attack. Once the tree is harvested this protective effect diminishes and many spores present in the air can come in contact with the surface, and colonize the wood.

The wood infection with biological agents can begin even from the forest in living trees, continuing during processing, merchandising and use.

Consequently, it is of great importance to know the biological agents, their biology and also, the wood natural durability against biodeteriogens in order to take adequate preservation measures and increase the service life and performance of wood.

It is well known that the service life of wood is influenced not only by natural durability but also by the service conditions the wood elements are used in, especially temperature, relative humidity and risk of wetting.

Taking into account the whole diversity of abiotic and biotic agents that act upon the wood, it has been standardized at European level, five hazard classes of biological attack, defined by SR EN 335-1, 2 -1996 as follow:

-Class 1: the wood is under shelter, it is not exposed to humidity;

-Class 2: the wood is under shelter but the high relative humidity of the environment can lead to on accidental non-persistent wetting;

-Class 3: the wood it is not under shelter, above ground and can be exposed to a frequent wetting;

-Class 4: the wood is in contact with ground, or fresh water and is permanently exposed to humidity;

-Class 5: the wood is exposed permanently to salt water (sea water).

In practice there are different situation:

In some utilization (in interior, under roof, covered from rain and larges relative humidity and temperature variations), the wood can be utilized untreated;

In other conditions, (outdoors, uncovered, in contact with ground and water), the wood natural durability cannot assure o good resistance in time, so it is necessary chemical preservation.

The knowledge of wood species performance in contact with ground, has become imperative due to the necessity of developing practical solutions for preservation of wood used in special applications as: telecommunications, hydroenergetical constructions, naval constructions, civil buildings, etc.

In this context the paper presents some data concerning the efficiency of CCA type product in preventing the biological attack on wood used in ground contact.

Methods and Materials

The work method was in accordance with the provisions stipulated in SR EN 252-1995. The standard settles a field test method for determining the relative effectiveness

of wood preservatives in ground contact.

Wood species

There have been selected three wood species (depending on permeability and natural durability):

a) Pine - sapwood (*Pinus sylvestris L*), - reference species with the volume mass at 12 % moisture content (MC) between 412-695 kg/m3;

b) Beech (*Fagus sylvatica L*), with the volume mass at 12 % MC between 583-817 kg/m3;

c) Spruce (*Picea excelsa L*) with the volume mass at 12 % MC, between 321-509 kg/m3.

There have been used square timber pieces with following characteristics:

-size: 500 x 50 x 25 mm;

-moisture content: 14 ± 2 %;

-volume: 0.000625 m3;

-nr. of pieces: 85 (10 samples for each species, preservatives and concentration of preservative solution).

Preservation product

Taking into account the specific condition for wood uses, the samples were treated with CCA type product, having the following composition:

-chromium trioxide: 30.2 %
-copper oxide: 11.2 %
-arsen pentoxide: 17.3%.

The concentration of treatment solution was 1.5%; 3.0%; 5.0%.

For the reference product the concentration was 1.0 % and 4.25 % and chemical composition was:

-copper sulphate: 50.0 %
-potassium bychromate: 48.0 %
-chromium trioxide: 2.0 %.

Treatment

The samples treatment was accomplished by vacuum - pressure-impregnating method (0.75 at - 30 min.; pressure 5 at - 90 min.). Before treatment the samples were weighed, determining the initial mass.

After treatment the samples have been wiped off to remove the solution in excess and then re-weighed to determine the absorbed solution.

The conditioning -drying of samples after treatment have taken 28 days:

-7 days for fixing of preservative, the wood being stored tightly packed in polythene bags;

-21 days for further fixing of preservative and drying, the samples being stacked with strips (at about 20 0C and 55 % relative humidity); each sample was turned

through with 180 0 daily.

The average retention in active substance is presented in table 1 and 2.

Table 1. CCA product - average dry salt retention in kg/m3 obtained with each solution concentration

Wood species	Solution concentration, %		
	1.5	3.0	5.0
Pine (sapwood)	5.66	11.74	18.20
Beech	6.24	13.40	23.03
Spruce	2.25	4.54	7.54

Table 2. Reference preservative - average dry salt retention in kg/m3, obtained with each solution concentration

Wood species	Solution concentration, %	
	1.0	4.25
Pine (sapwood)	3.51	16.73
Beech	4.15	17.55
Spruce	2.23	6.55

The test site

The test site is located in Bucharest, at the National Institute of Wood - I.N.L.

(fig. 1). The ground is of podsol type, brown -reddish, smooth and even as level, humid, well drained and with barely vegetation. The exposure duration: May 2000-May 2003. The samples are buried in the soil to half their length.

Figure 1. Field test. Samples treated with CCA type product exposed in the test site

RESULTS AND DISCUSSIONS

The test duration is of minimum five years or until sample failure. The samples are periodically examined, usually once at 12 months.

The examination is carried out at random and after observations the samples are introduced back in the same place at the same depth into the ground.

Samples were scored according the scale presented in table 3.

Table 3

Rate	Classification	Description
0	No attack (0)	No perceptible change of wood appearance and strength.
1	Slight attack	Perceptible changes but very limited as extension, location or distribution: - changes observed only at exterior by color modification or superficial decay, wood softening in 1 mm depth.
2	Moderate attack	Visible changes with moderate importance: - wood softening in 2-3 mm depth on the whole sample surface or partially upwards from the ground level.
3	Hard attack	Important changes: - significant wood decay at a depth of 3…5 mm on extended surface (ex: soft rot or other decay on the whole surface of the sample, from the ground level up wards) or wood softening in a bigger depth of 10…15 mm on a limited surface (white rot on several mm^2).
4	Failure (breaking)	Sample cracking in the ground.

At each examination has been estimated the following aspects:

- soil adherence on the samples;
- appearance and integrity of the samples;
- rate of biodegradability.

After macroscopic analysis of the samples extracted out of the ground has been observed:

a) reference samples (untreated)

The part exposed to the air presents color modifications, black spots, little splits on the transversal section exposed and wood softening at the soil - air boundary, as follows:

At soil - air boundary appears a marked wood softening at the beech samples and beginning of incipient brown rot at spruce samples; two reference samples had broken

both at beech wood (fig. 3 - pos. 5, 6) and spruce wood (fig. 4 - pos. 5, 6); the break reveals the decay extension in interior, even the surfaces does not present obvious softening traces;

The part buried in the ground, presents a superficial softening of wood and a brownishing of pine (fig. 2 - pos. 5) and beech samples; on spruce samples it is observed the appearance of some white and brown reddish rot stains.

Figure 2. Pine sapwood samples after 24 month of exposure in ground contact

b) samples treated with preservative type CCA

at low concentration (c=1.5%; fig. 2, 3, 4 - pos.4) the parts buried in the ground present a superficial softening at the zones with adherent soil and at the soil - air boundary occurs a brownishing of wood surface and a superficial softening especially at beech samples;

at a solution concentrations of 3%, is observed only isolated brown stains on the faces, without modification of wood strength (for beech, fig. 3 - pos.3); at the spruce samples appears a slight exudation of the copper on the surfaces;

there are no modifications on the parts exposed to the air at pine and spruce samples; at some beech samples (c=1.5%; 3%) is observed the appearance of mould and ends splits;

at high concentration (5%, fig. 2, 3, 4 -pos.2), the samples present only ends splits (more marked at beech wood), due to weather conditions; there are no color modification and other perceptible changes on the surfaces.

Figure 3. Beech samples after 24 month of exposure in ground contact

Figure 4. Spruce samples after 24 month of exposure in ground contact

c) samples treated with reference preservative (fig. 3 - pos. 1, 1')

a*t the concentration of 1.0%*, were observed surface discolorations, ends splits more marked at beech samples; also appear brown stains on the exterior surface of the samples; significant more marked at beech samples were was noticed also a superficial wood softening at the soil - air boundary.

a*t the concentration of 4.25%* the samples revealed no attack traces or perceptible modifications on the surfaces.

Meaning of marks in the figure 2, 3, 4:

1, 1'-samples treated with reference preservative, c=1.0%; 4.25%;
2 - samples treated with CCA type product, c=5.0%;
3 - samples treated with CCA type product, c=3.0%;
4 - samples treated with CCA type product, c=1.5 %;
5,6 - reference samples (untreated)

Table 4 Assessment of decay attack of the samples after 24 months exposure in the test site, in ground contact

Rate	Classification	Condition and appearance of samples:		
		Pine sapwood	Beech	Spruce
0	*No – attack*	*Treated with CCA c=3%, 5 %* Rate 0 - No evidence of perceptible attack	*Treated with CCA c=3%, 5 %* Rate 0.6 - Appearance of some superficial brown stains on the buried surface	*Treated with CCA c=3%, 5 %* Rate 0 - No evidence of perceptible attack
1	*Slight attack*	*Treated with CCA c= 1.5%* Rate 0 - No evidence of perceptible attack.	*Treated with CCA c= 1.5%* Rate 1.2 - Perceptible changes but very limited as extension, and distribution	*Treated with CCA c= 1.5%* Rate 0 - No evidence of perceptible attack
1	*Slight attack*	*Treated with reference preservative c=1.0%* Rate 0.8 - Appearance of some superficial, brown stains on the buried surface.	*Treated with reference preservative c=1.0%* Rate 1.3 - Perceptible changes, but very limited as extension, location and distribution.	*Treated with reference preservative c=1.0%* Rate 0 : - No evidence of perceptible attack
0	*No attack*	*Treated with reference preservative c=4.25%* Rate 0 - No evidence of perceptible attack	*Treated with reference preservative c=4.25%* Rate 0 - No evidence of perceptible attack	*Treated with reference preservative, c=4.25%* Rate 0 - No evidence of perceptible attack
2-3	*2 -Moderate attack* *3 -Severe attack*	*Reference Untreated samples* Rate 2.4 - Visible modifications, clear discoloration; wood softening at the air-soil boundary (more than 3 cm, surface affected).	*Reference Untreated samples* Rate 3.2 - Two samples broken: wood softening till a depth of 2-3 mm; -serious attack, dark discoloration; -significant decay at the air – soil boundary.	*Reference Untreated samples* Rate 3.0 - Two samples broken: -wood softening till a depth of 2-3 mm; -serious attack, dark discoloration; -significant decay at the air - soil boundary.

Specification (Type of sample)	Solution concentration %	Average absorbtion of solution kg / m^3	Average retention kg / m^3	Average rates	Life time
Preservative type CCA					
-Pine sapwood	1.5	377.12	5.66	0	
	3.0	391.20	11.74	0	-
	5.0	364.00	18.20	0	
-Beech	1.5	416.32	6.24	1.2	
	3.0	446.40	13.40	0.6	
	5.0	460.56	23.03	0.6	-
-Spruce	1.5	150.00	2.25	0	
	3.0	151.20	4.54	0	-
	5.0	150.72	7.54	0	
Reference preservative					
-Pine sapwood	1.0	351.20	3.51	0.8	
	4.25	393.60	1.73	0	-
-Beech	1.0	414.72	4.15	1.3	
	4.25	413.12	1.55	0	-
-Spruce	1.0	222.88	2.23	0	
	4.25	154.08	6.55	0	-
Reference samples (untreated)					
-Pine sapwood	0.0	0.0	0.0	2.4	-
-Beech	0.0	0.0	0l.0	3.2	-
-Spruce	0.0	0.0	0.0	3.0	-

The average rates obtained at the attack assessment for each sample, depend on wood species preservative concentration and the average dry salt retention and are presented in the table 5.

CONCLUSIONS

Analyzing the obtained results, can be drawn the conclusions:

After 24 months of exposure in the ground, there were no obvious decay traces and softening of wood surfaces, indifferent of preservatives concentration;

Taking into account that the exposure duration was only 24 months, it cannot be calculated the average life time; this could be estimated when all the stacks in any series have failed (ratting 4);

Untreated samples were seriously attacked by decay, which indicates that the soil at the test site is adequate in terms of biological activity.

Treated samples have however performed better than untreated samples.

It is interesting to note that there were, as yet, no significant differences in decay between spruce and pine sapwood, while there is some differences between those

species and beech. To date, the most serious attacks have been found on beech samples.

A field trial provides a more certain basis for an approval decision than a laboratory test. There are some advantages in this case: the samples are exposed to all kinds of weather conditions and also to natural contamination from bacteria and fungi; and it is possible to assess the protective effects over a long period of time.

References

Baciu G., Baciu D., Zeleniuc O. (1999-2001): Methodological and experimental research regarding the testing of wood in conditions with major biodegradability risk classes 4 and 5 - Research project, INL Bucharest.

Pernilla Johansson, Jöran Jermen, Ingrav Johansson (1992): Field trial with wood preservatives for class AB, SP Report, Sweden.

SR EN 335-1,2/ 1996: Durability of wood and wood based products. Definition of hazard classes of biological attack - Part 1: General; - Part 2: Guide to the application of hazard classes to solid wood

SR EN 252 / 1995: Field test method for determining the relative protective effectiveness of a wood preservatives in ground contact;

Zeleniuc O., (2002): Test field for determining the efficacy of wood preservatives type CCA. Test Report, INL Bucharest.