

## ASSESSING PROTECTING EFFICIENCY OF SOME SURFACE TREATMENTS ON FIR WOOD AFTER 7 YEARS OUTDOOR EXPOSURE

**Emanuela BELDEAN**

Transilvania University of Brasov- Faculty of Wood Engineering  
Address: Str. Universitatii nr. 1, 500068 Brasov, Romania  
E-mail: [ebeldean@unitbv.ro](mailto:ebeldean@unitbv.ro)

**Maria Cristina TIMAR**

TRANSILVANIA University of Brasov – Faculty of Wood Engineering  
Address: Str. Universitatii nr. 1, 500068 Brasov, Romania  
E-mail: [cristinatimar@unitbv.ro](mailto:cristinatimar@unitbv.ro)

**Anca Maria VARODI**

TRANSILVANIA University of Brasov – Faculty of Wood Engineering  
Address: Str. Universitatii nr. 1, 500068 Brasov, Romania  
E-mail: [anca.varodi@unitbv.ro](mailto:anca.varodi@unitbv.ro)

### **Abstract**

*Performance of wood preservatives or coatings as surface treatments products is closely connected to different needs and requirements. This paper investigated the protective efficiency of such products, on fir wood exposed outdoors for 7 years, in a modified L-joint test. The evaluation refers to degradation as result of the combined action of the biotic and non-biotic factors, active in use class 3. Two common non-destructive methods were used to evaluate the wood exposed outdoors: visual assessment and microscopic evaluation. Rating of the exposed faces showed that untreated control samples presented the most severe biological degradation and cracking. Surface bio-protection minimised discolouration and was generally a beneficial treatment prior coating. The surface treatments investigated in this paper generally delayed the degradation phenomena but could not provide an efficient protection over a long exposure period.*

**Key words:** fir wood; outdoor exposure; L-joint; protection efficiency.

### **INTRODUCTION**

The revival of softwood Romanian timber sector in the last years, starting with 2011-2013, led to extensive utilisation of softwoods in construction industry (<http://www.asociatiaforestierilor.ro/meridiane-forestiere/147-revista-meridiane-forestiere-nr-3-iunie-2014>).

Therefore, availability and economical aspects are considered alongside wood properties in the utilisation of wood species. Moreover, Romanian species as spruce and fir are well known as traditional construction materials. It is known that fir has a low natural durability and in most outdoor items wood must be protected. Unfortunately, many homeowners use untreated wood in many applications, while others consider coating of wood with different finishes as sufficient.

However, coating may not provide sufficient protection of wood against bio deterioration in outdoors application. In order to minimise the decay risk, wood can be treated with preservatives before finishing. Pre-treatment of wood may have though not only positive effects, but also influence performance of surface coatings: drying characteristics, adhesion and permeability (Pavlic *et al.* 2005).

To test the efficiency of the protective treatments field test have been developed (Miller and Boxal 1987, Alblas and Kettenis 2002, Van Acker and Stevens 2003 a, b, Cookson 2010). The use of field tests to evaluate protective performance of treatments in outdoor situations, out of ground contact, is the only way in which service conditions can be accurately duplicated (Carey 1982). The most-currently used methods to evaluate durability include visual evaluation, image analysis, microscopic evaluation, pick or splinter test, density and mass loss, and various strength tests. All these methods detect the extent of decay, but only the visual and microscopic evaluation may consider which fungi might be responsible for decay (Raberg *et al.* 2005)

Previous papers from an extensive study of the authors investigated beech and fir wood degradation after 7 years exposure in outdoors, revealed by nondestructive and destructive evaluation (Timar *et al.* 2012, Timar and Beldean 2013, Beldean 2009). The results demonstrated the utility of the employed modified L-joint test for a realistic evaluation of the potential of different treatments in improving wood performance (Timar *et al.* 2012).

The principal purpose of this paper is to investigate the protective efficiency of some surface preservation and coating treatments, on fir wood exposed outdoors for 7 years, in a modified L-joint test. A biocide impregnation base coat and a reference biocide product were employed as wood preservatives, while an alkyd white paint was used for finishing. Degradation as result of the combined action of the biotic and non-biotic factors, active in use class 3, was evaluated by non-destructive methods.

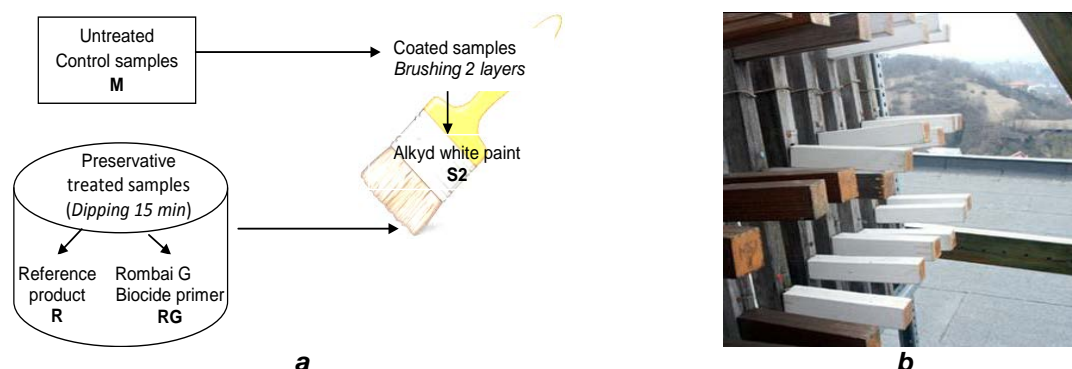
## METHODOLOGY

L-joint test is mainly a method for testing the efficacy of preservatives to be used under a protective coating (Van Acker and Stevens 2003). Accordingly, preservative treated samples were tested alongside with untreated units and reference preservative treated pieces, all the samples being over-painted using a standard alkyd finishing system S2, commonly used for outdoor applications.

The preservatives used in a complex treating schedule (Fig. 1a) were: an alkyd impregnation biocide base coat Rombai G (RG) and a reference waterborne product R ( $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ -50% (m/m),  $\text{K}_2\text{Cr}_2\text{O}_7$  – 48% (m/m),  $\text{CrO}_3$ - 2% (m/m), as aqueous solution of 1% concentration).

The test samples were the tenon members of modified L joints (see Fig. 1b). These were processed from fir (*Abies alba*) wood having perfectly radial and tangential faces, as detailed in previous publications (Timar 2008, Timar *et al.* 2012). For preservation these were treated by dipping in Rombai G and the reference product R for 15 min. at 20°C, ensuring an average spreading rate of about 140g/m<sup>2</sup>. The finishing was applied by brushing (except the joining region) in two layers on the lateral exterior surfaces, at a spreading rate of 150g/m<sup>2</sup>. Three replicates were used for each variant of treatment. The codes of treatments were: M-untreated control samples, R- treated with reference product, RG- treated with Rombai G biocide base coat and the corresponding variants coated with alkyd paint: M-S2, R-S2,-RG-S2.

The L-joints were exposed in Brasov on special racks, under the conditions of UC 3, where a complex of biotic and non-biotic factors action as in real service-life.



**Fig. 1.**  
**Treating procedure (a) and outdoor exposure stand (b)**

Two usual methods were employed to evaluate the extent of decay and other degradations occurred due to long time exposure in outdoors, above ground conditions:

- *visual evaluation* which is a fast, qualitative method, to assess extent of decay / degradation based on specific rating scheme, but still subjective. Factors like experience of the performer, structure of wood, number of replicates can influence the results. Visual assessment considered surface development of mould or sap stain fungi, degradable decay due to wood rotting fungi, as well as other phenomena such as general aspect changes, weathering effects, coatings performance and wood cracking. The outer surfaces and the joint area were examined
- *microscopic analysis* which is also a qualitative method, but has the potential to improve the accuracy and reliability of results. This requires longer investigation times to bring more in detail results, though some relativity and even subjectivity should be considered related to the small areas investigated and their selection.

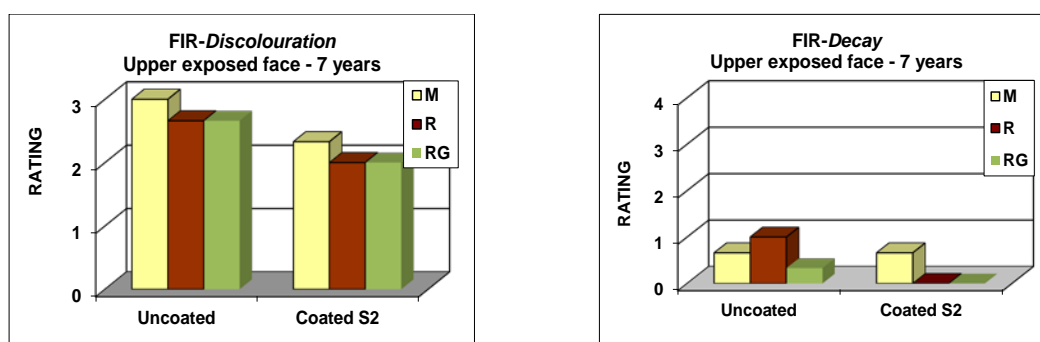
Discolouration due to mold and/or staining fungi was rated between 0 to 3, 0 means no discolouration and 3 means very abundant discolouration / growth, dark in colour, with a coverage of entire surface. Decay was rated from 0 to 4, 0 means no visible signs of decay and 4- very severe and extensive decay, according to prCEN/TS 12037:2002(E). Cracks in wood were also rated between 0-4 (0-no cracks, 4-big and/or many small cracks).

Microscopic images, captured by a stereomicroscope type Optika ZSM 2 with a digital video camera, focused on complex surface degradation: aspect and extent of fungal degradation, cracks in wood and coating, roughness of surface, defibration, adherence of coating, etc. Investigation has the advantage to highlight several types of defects on the same image, without affect the integrity of the samples.

**RESULTS AND DISCUSSION**

After 7 years exposure complex degradation occurred and differences in relation to the type of treatment were evident, as well as influence of the actual exposure situation (external faces and tenon). Generally, uncoated samples turned to grey, presented roughened surfaces, cracks and spots of discolouration more or less evident, while for the coated ones degradation of the coating film and loss of adherence, strongly linked to the above mentioned degradation phenomena, were visible. Decay was also present. Rating of these degradations resulted in the graphs from Fig. 2 and 3.

The most susceptible to degradation are upper faces of the external area and tenons. Rating of the upper exposed faces showed that untreated control samples M presented the most severe biological discolouration (Fig. 2).



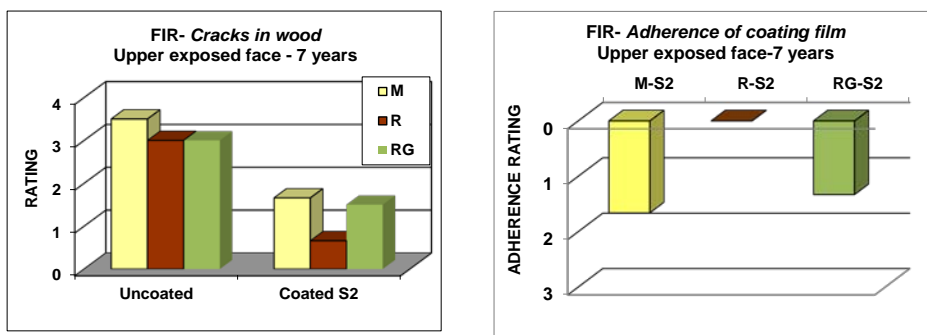
**Fig. 2.**

**Biological discolouration of the upper surfaces of fir wood after 7 years of exposure**

Surface bio-protection with both the reference product (R) and the biocide base coat (RG) reduced discolouration, highlighting the importance of preservation treatment on wood exposed outdoors. Moreover, a better protection was provided when wood was further coated with S2 paint. Decay assessment indicated a non-expectable bigger rate for biocide treated R sample than control M sample, probably due to the wood structure (possibly derived from sapwood which is more susceptible to biodegradation) or insufficient chemical fixation of preservative into the wood. Therefore, the biocide could be easily leached when the surface was not further coated.

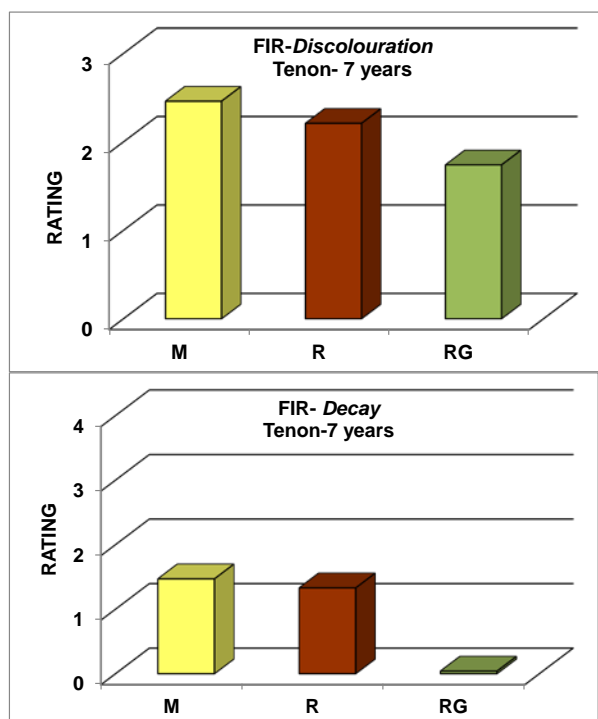
The most efficient treatment seems to be RG treatment. In fact, the biocide base coat RG is formulated to be used in UC 3, but combined with adequate finishing. Generally, a preservative treatment before coating improves the resistance to biodegradation.

The cracking phenomenon developed more extensively on uncoated samples (Fig. 3). The samples bio-protected and coated R-S2 and RG-S2 revealed a minimum wood cracking. The same samples presented a still good adherence of the film, in correlation with wood cracking, but this situation could be changed due to the fungi development under the paint film. After 7 years of outdoor exposure a slight minor film disruption by fungi causing blue stain was observed. Furthermore, the pre-treated samples with reference product and coated R-S2 have no signs of film exfoliation (rate 0).



**Fig. 3.**  
**Influence of treatment on wood cracking and coating adherence after 7 years outdoor exposure – upper faces**

When referring to the tenon area the biodegradation results were somewhat comparable with uncoated surface areas, with the same evolution, as resulted from Fig 4. The most efficient treatment was again that with RG base coat. It proved a long time resistance to discolouration and decay.



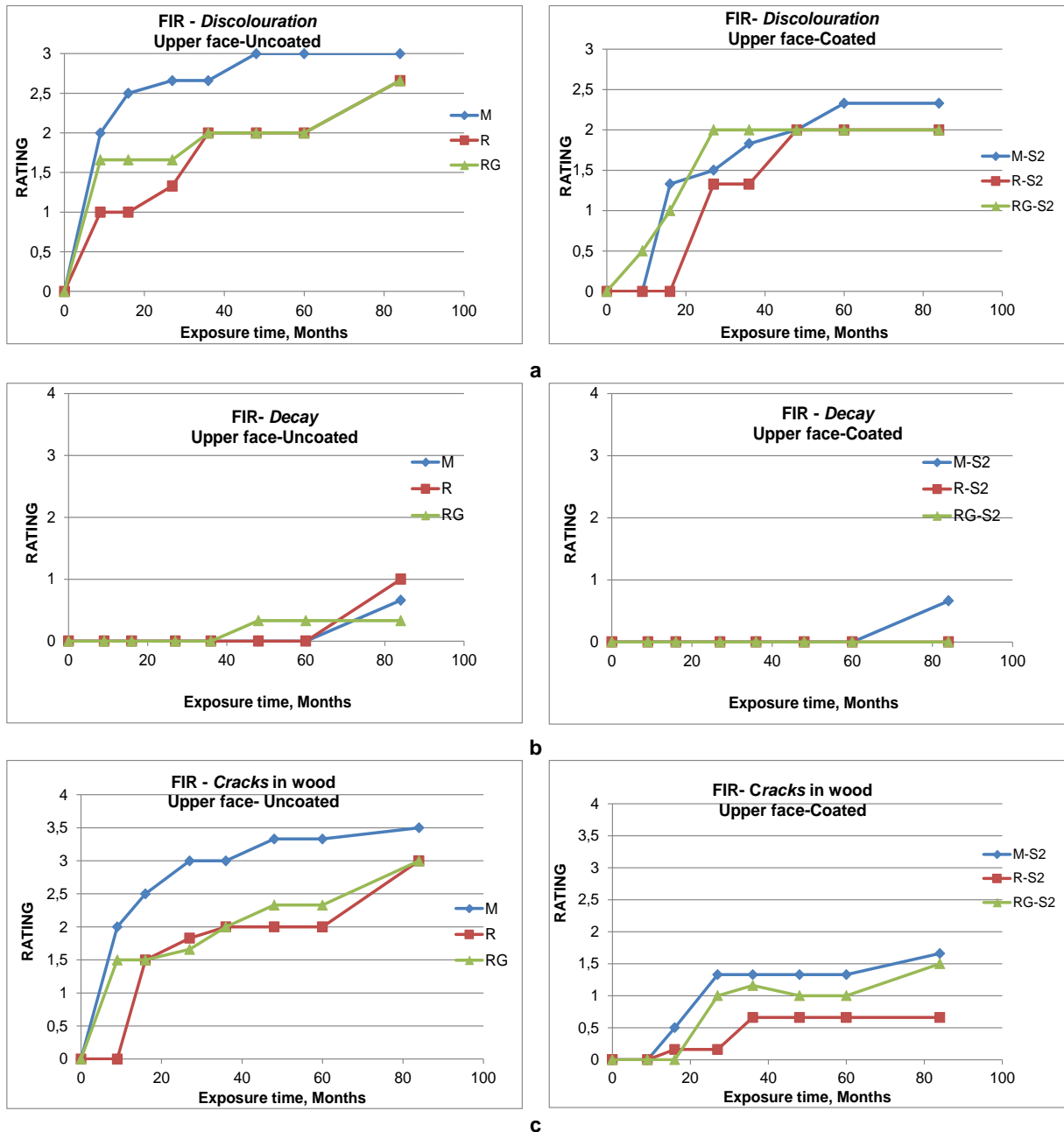
**Fig. 4.**  
**Influence of treatment on degradation phenomena after 7 years outdoor exposure- tenon area**

Degradation phenomena analysed after 7 years of exposure represent actually the result of an in time evolving process. The different types of degradation phenomena appeared in time after different periods of exposure and evolved at different rates. The effects of different treatments and the modification of their efficiency in time are illustrated in Fig. 5. Therefore, the data from evaluations after 9, 16, 27, 36, 48, 60 and 84 months allows distinguishing the sequences in the complex degradation.

Discolouration was the most rapid degradation phenomena, appearing after short exposure times as short as 3 months, so that at the first complex evaluation after 9 months of exposure rating varied from 1 to 2 for the uncoated samples. Control samples reached the maximum rating discolouration of 3 after 48 months of exposure. Discolouration of uncoated, treated RG and R samples progressed less rapidly than for control M samples up to 60 months, showing protective effects. However, after this period a more rapid increase to a rating of 2.5 was achieved (Fig. 4 a). Coating of samples delayed and reduced the intensity of discolouration. Discolouration of coated samples M-S2 appeared only after 16 months of exposure (rating 1-1.5) and thereafter a continuous increasing was observed, though after 7 years the rate was less than 2.5. For treated and coated samples R-S2 and RG-S2 discolouration was generally more reduced (maximum rating 2), though the evolution patterns were different.

Only incipient and limited decay was observed on the upper exposed faces (mean rating close to 1) and this appeared much slower than discolouration, being detectable only after long exposure periods of 48 and 60 (Fig. 4 b). Accordingly, it could be said that the bio- treatments applied alongside further coating improved resistance to biodegradation, though the efficiency of these protective effects tended to be somehow time-limited.

Surface cracking was registered after 9 months exposure for uncoated samples M, RG and after 16 months for R samples and it increased until 3 and 3.5 rating. The cracks of coated samples M-S2, R-S2, RG-S2 occurred after 16 months and remained below a rate of 2 until the end of evaluation (Fig. 4 c).



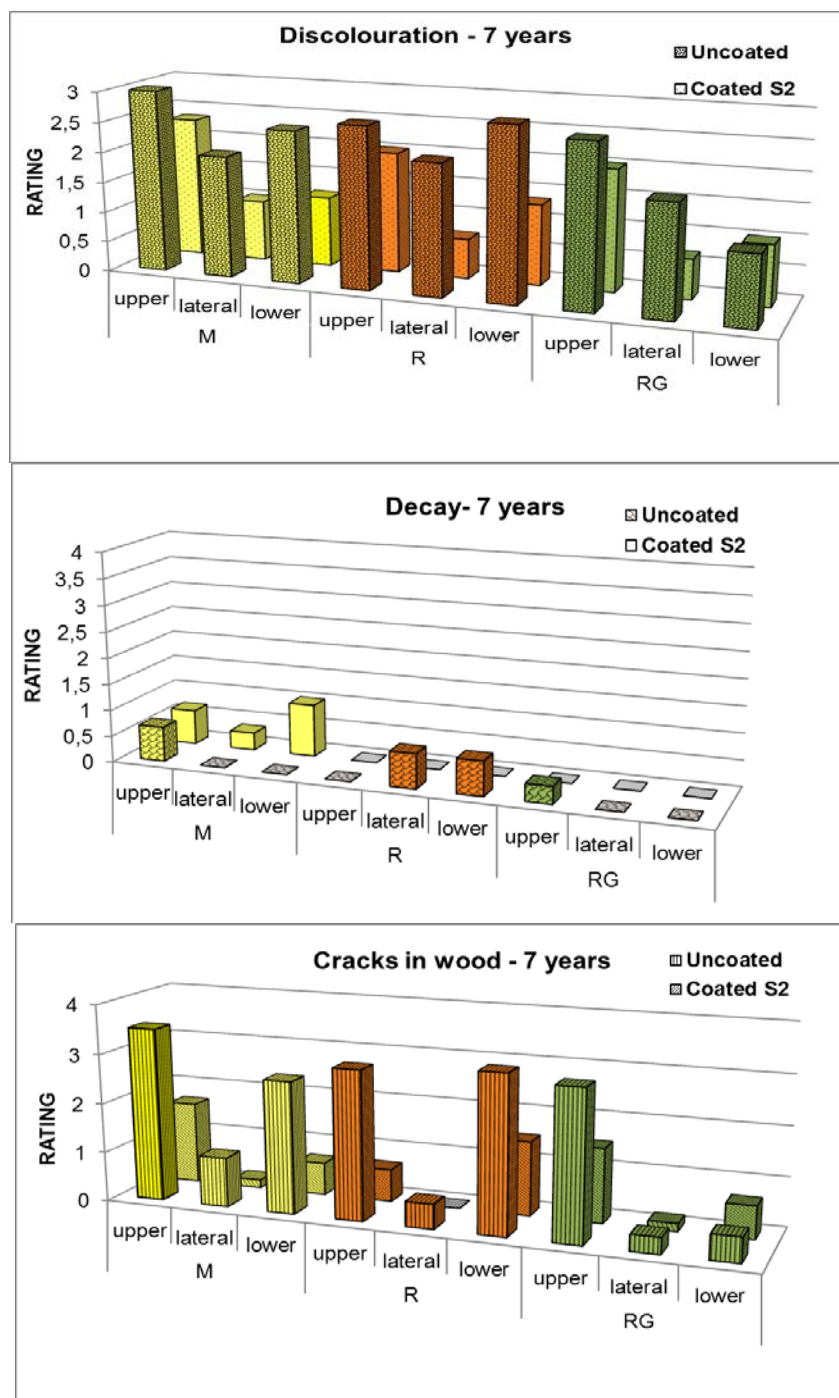
**Fig. 5.**

***In time evolution of biological degradation (discolouration, decay) and cracks in wood according to the type of treatment***

Upper horizontal exposed faces of samples were examined in comparison with lateral faces in vertical position and the lower faces opposite to the upper ones. According to the actual exposure situation the degradation differed in terms of type and severity. If upper surfaces were directly exposed to rain and sun, the lateral and lower surfaces were less exposed to weathering factors.

As expectable, the horizontal faces showed more defects than the vertical ones after a given time. For example, higher degradation rates of discolouration and decay, cracking and coatings flaking appeared compared to lower and lateral faces. Influence of treatments applied was observed (Fig. 6). Biodegradation rate of uncoated M and R samples on the lower face is comparable or above to those on the upper face. Water movement and its accumulation on the lower side, combined with a delayed drying and reduced light exposure induced biodegradation. As result, discolouration on the lower faces was often more clearly visible, as the black spots individualise themselves on a no or less weathered surface.

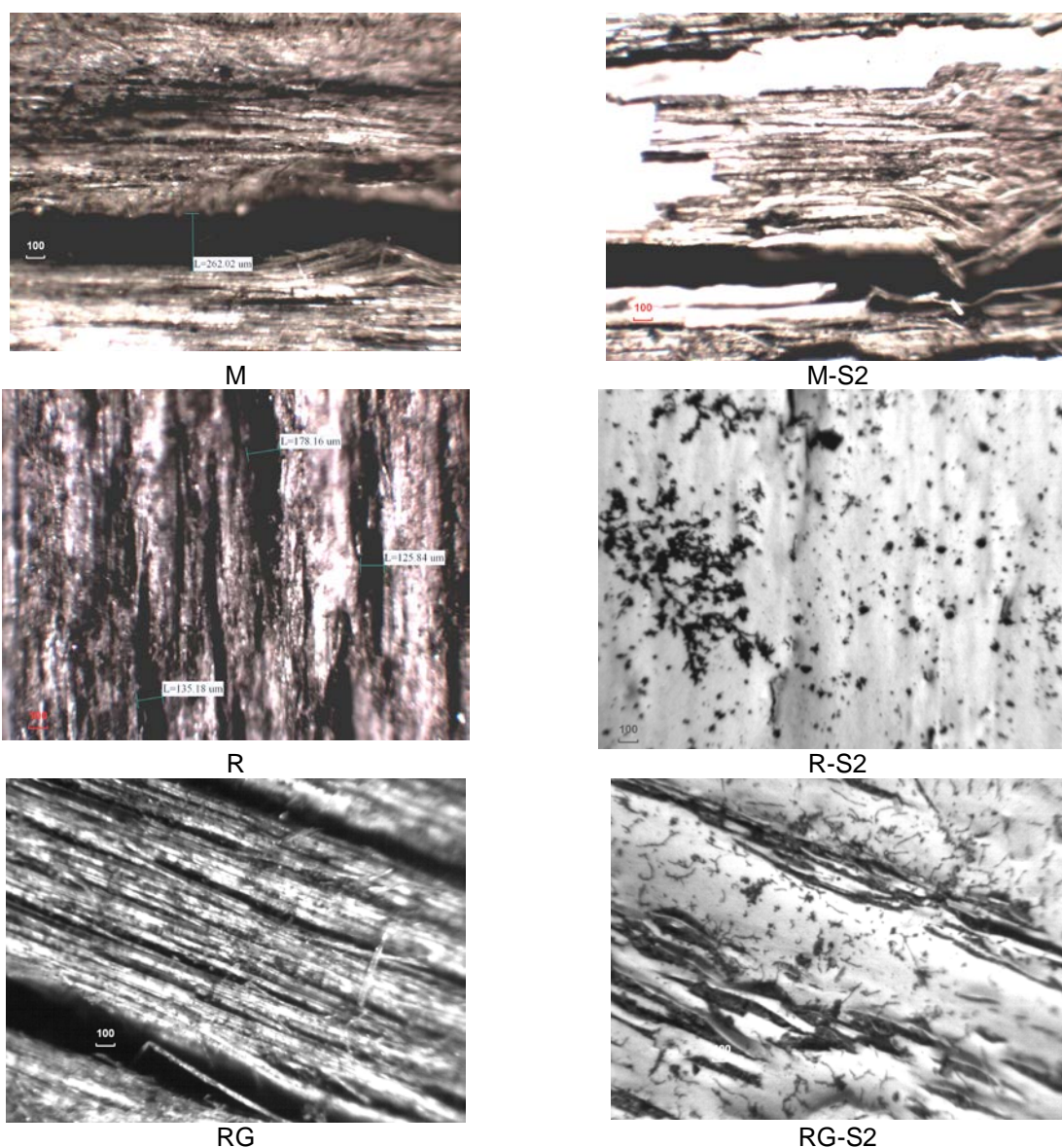
The lateral sides were generally less degraded than upper and lower faces. Exception made treated R samples for which decay started from the tenon area (see Fig. 4) end extended on the neighbouring surfaces: lateral and lower. The water in excess accumulated into the joint remained there for a longer time and allowed the installation and development of decay.



**Fig. 6.**  
**Comparative evaluation of exposed surfaces according to the type of treatment**

The performance of the treatments was affected by cracking phenomenon. Water accumulation on the lower side led to dimensional changes of wood substrate and therefore discolouration evolvement was more evident around or inside of cracks. The samples pre-treated with the biocide product R were more cracked on lower face than upper, which could explain the higher rate of biodegradation (discolouration and decay).

The microscopic images from Fig. 7 highlight in detail some of the discussed aspects. The presence of staining fungi is evident on all surfaces as black points or spots, regardless of the treatment considered, but obviously colonisation was different as extent. Cracks and fissures in wood, more or less deep, can be observed, as well as surface roughening and fibre detachment. Coating film degradation is also very clearly represented in images. Loss of film is visible on M-S2 sample but R-S2 and RG-S2 also revealed a complex deterioration. Often staining and mould fungi penetrated through the coating leading to spot-wise degradation, micro-fissures and exfoliation of the paint film. Therefore, the coating loosed protective function and became an accelerating factor in degradation, apart from aesthetical depreciation.



**Fig. 7.**

***Some microscopic aspects of degradation of external upper faces for control and treated samples (original magnification 40x)***

## **CONCLUSIONS**

A common practice to increase durability and to provide an acceptable service life of wood exposed outdoors, out of ground contact, should be applying treating schedules that include both bio-protection and coating. Unfortunately, it is often thought that coating itself should be enough, which is not true.

Biocide products investigated in this paper combined with coating delayed the degradation phenomena, but could not provide an efficient protection over the long exposure period of 7 years.

Therefore, maintenance operations applied before severe degradation should be considered more carefully.

Now the market offers more types of preservatives and each is more closely targeted toward specific applications. Selection of the right products for a given application is essential and expert advice should be available for the consumers. A minimum protection should be ensured by the compatible selected products, while correct application and a good maintenance is required for a better performance and longer service life of wooden products. This would bring both economic and ecological benefits.

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