Department of Wood & Furniture Design and Technology

[redacted]

Evaluation report (24-month report)

Testing of [redacted] products in a 3-year outdoor exposure in Greece using cladding- and block- tests

Research Committee, TEI of Thessaly *(former Larissa)*
Project no. 3749

Coordinator:

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KARDITSA, GREECE (June 2013)

1. INTRODUCTION

This technical 24-month report contains the results of: a) an outdoor test of [redacted] and control materials (originating from the [redacted]), and b) an outdoor so named *"block test"* for [redacted] stakes (called [redacted]) and untreated materials. This cooperation is done through official agreement signed between TEI of Thessaly (f. Larissa), GR, and the industry [redacted] (**project no. 3749, Research Committee, TEI of Thessaly**).

The project is being carried out in the facilities of the *Department of Wood and Furniture Design & Technology* (WFDT), Technological Education Institution (TEI) of Thessaly, at Karditsa, Greece, and the project coordinator is Prof. George Mantanis (mantanis@teilar.gr).

For the completion of the project, the following scientists have being working in this project: Dr. George Mantanis, Professor (TEI of Thessaly), Dr. Stergios Adamopoulos (TEI of Thessaly) and Dr. Dimitrios Birbilis, *wood scientist.*

2. MATERIALS AND METHODS

For the conduction of the project, the following *materials & methods* have being used.

2.1 Description of materials

Cladding test

In the first test, the following XXX wood testing & control materials are being used:

- **01** XXX Poplar Black
- **02** XXX Frake White
- **03** XXX Spruce *(unpainted)*
- **04** XXX Poplar White
- **05** XXX Frake *(unpainted)*
- **06** XXX Spruce Black
- **07** XXX Poplar *(unpainted)*
- **08** XXX Frake Black
- **09** XXX Spruce White
- **10** Control Spruce wood *(untreated wood)*
- **11** Control Western Red Cedar wood *(untreated wood)*

All XXX technology produced claddings *(Spruce, Frake, Poplar*) are tested in 2 colours, black and white, as prepared and *finished* by [redacted] and delivered to TEI of Thessaly; also one XXX wood cladding from these 3 species, without finishing, is tested.

All cladding samples are measuring 60cm x 60cm in dimensions and are exposed outdoors in the terrace of the WFDT main building, in a north-west side. They are covered from the upper side in their edges, and each cladding panel has been inserted into a specially made frame. Only the lower edge is free *(open)* (see Fig. 1). Excellent ventilation is possible

around the claddings; the whole frames are "open", and the *cladding test* looks to be very well established.

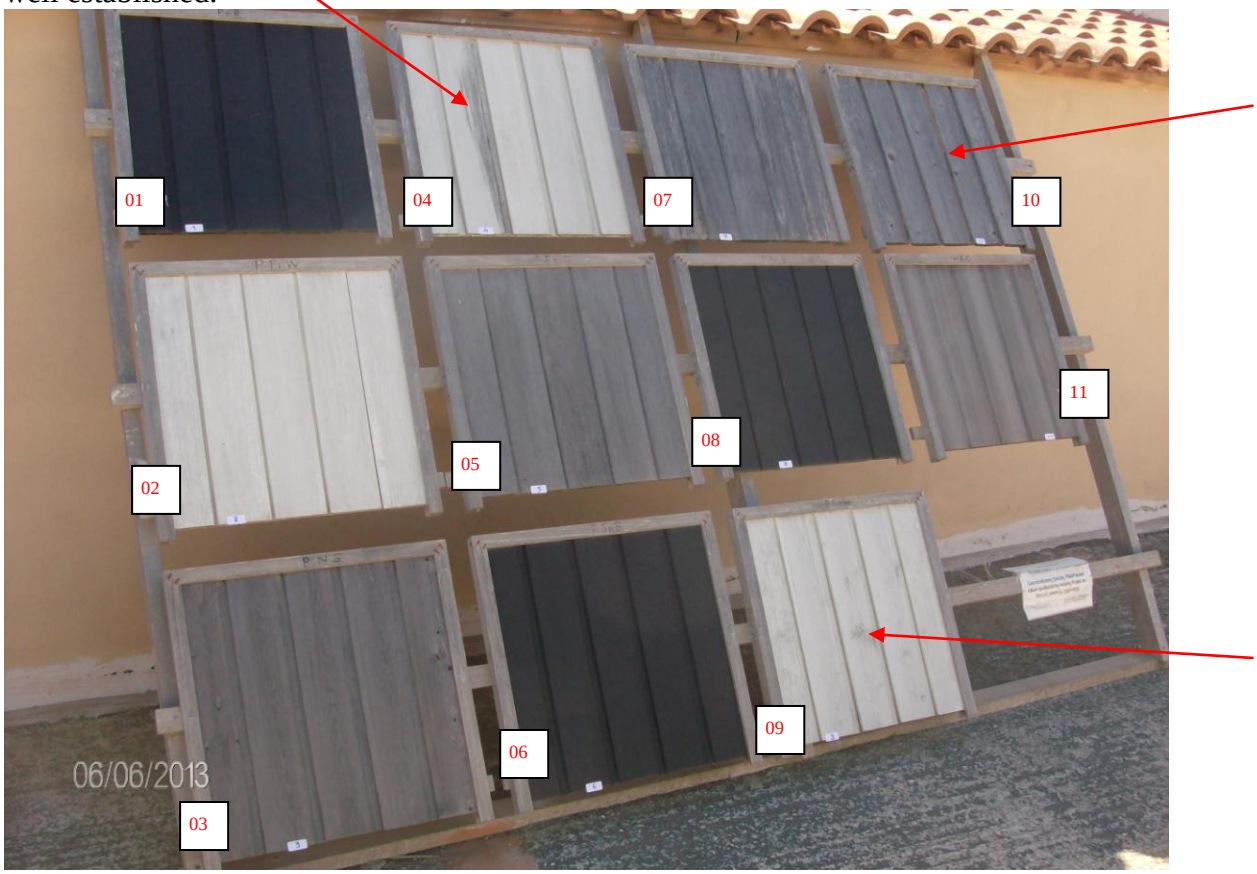


Fig. 1. *Cladding test area of the testing materials (as in* ***June 2013****); white-painted XXX samples having some discolouration (no. 04, 09), especially no. 04, while the control sample no. 10 looks very weathered and is highly distorted. The black-coloured claddings, no. 08, 01, 06 behave the best so far in the experiment, as well as the control WRC (no. 11).*

Block test

In the second test, which is called "block-test", it is being applied in order to check the *durability* of XXX materials in *use Class 3* (EN 335-2) conditions, by the same way as used by *Krause, Pfeffer and Militz (2010).* In this, the following wood testing & control materials (see Fig. 2a) have being used:

- **Block "A"**: XXX Spruce *(testing)*, Untreated Pine *(control)*, Untr. Spruce *(feeder)*
- **Block "B"**: XXX Frake *(testing)*, Untreated Frake *(control)*, Untr. Spruce *(feeder)*
- **Block "C"**: XXX Poplar *(testing)*, Untr. Poplar *(control)*, Untr. Spruce *(feeder)*

The wood stakes are measuring 20 x 30 x 300 mm^3 in dimensions; 40 stakes in each "block", i.e. 20 *testing samples*, 10 *untreated controls* and 10 *feeder stakes*. The materials are tested for 3 years under the guidelines of so called "block-test" (see Fig. 2, as in June 2013). Fungal decay on samples was assessed visually and also a determination of the dynamic modulus of elasticity *(MOE)* was made at 21-06-2013 *(24-month report).* In this report, the measurements of 2nd full year are made. The dyn. MOE measurements were made possible with a modern *Grindosonic* type equipment (Fig. 3).

Wood stakes in this test are set in *"blocks"* (as set-up in Table 1), and exposed outdoors covered also properly, in close but not in contact with the ground. Blocks placed in the terrace

of WFDT building; the environment there is close to high humidity and high biological activity.

2.2 Measurements

Cladding test

In the cladding test, all the wood claddings have been undergone several measurements, that is:

- evaluation of the general surface appearance of the claddings by visual examination (i.e. analytical photos have been taken)
- colour measurements using the standard CIELAB colour system (L*, a*, b*)
- evaluation of cupping/warping and possible distortions in the claddings
- evaluation of cracks and end-splitting.

Thus, by applying the CIELAB colour system, the colour parameters: L* (lightness), a* (redness) and b* (yellowness) have been determined using a *BYK Gardner* type colourimeter (Fig. 4). For each of the measurement points, and for each weathering sub-period, the total colour changes (ΔE*) were calculated using the equation:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

where:

ΔL, Δa* and Δb*: the changes of the colour coordinates L*, a* and b**

Block test

In the block test, all of the stakes underwent several measurements in **June 2013**, that is:

- evaluation of the general surface appearance of the wood stakes by *visual examination*,
- evaluation of possible fungal decay by application of the so-called "pick-test" by a knife,
- evaluation of dynamic MOE properties using a *Grindosonic* type equipment.

The outdoor block-test began on 29.06.2011 at the terrace of the WFDT Department, at Karditsa, GR. The outdoor cladding test began on 29.11.2011 (due to an unforeseen delay) at the terrace of the WFDT Department, at Karditsa, GR. This report, called *2nd evaluation report*, was written on 30.06.2013 by Prof. George Mantanis.

The climatic data at *Karditsa city* during that period can be seen *online* at the website: http://www.meteokar.gr/wxhistory.php?date=201306 (as of 06/2013), etc. In Karditsa, this past 2012-2013 winter was rather "mild", with slight wet conditions; followed by a rather wet spring 2012, with a long dry- May period and rather high temperatures in between.

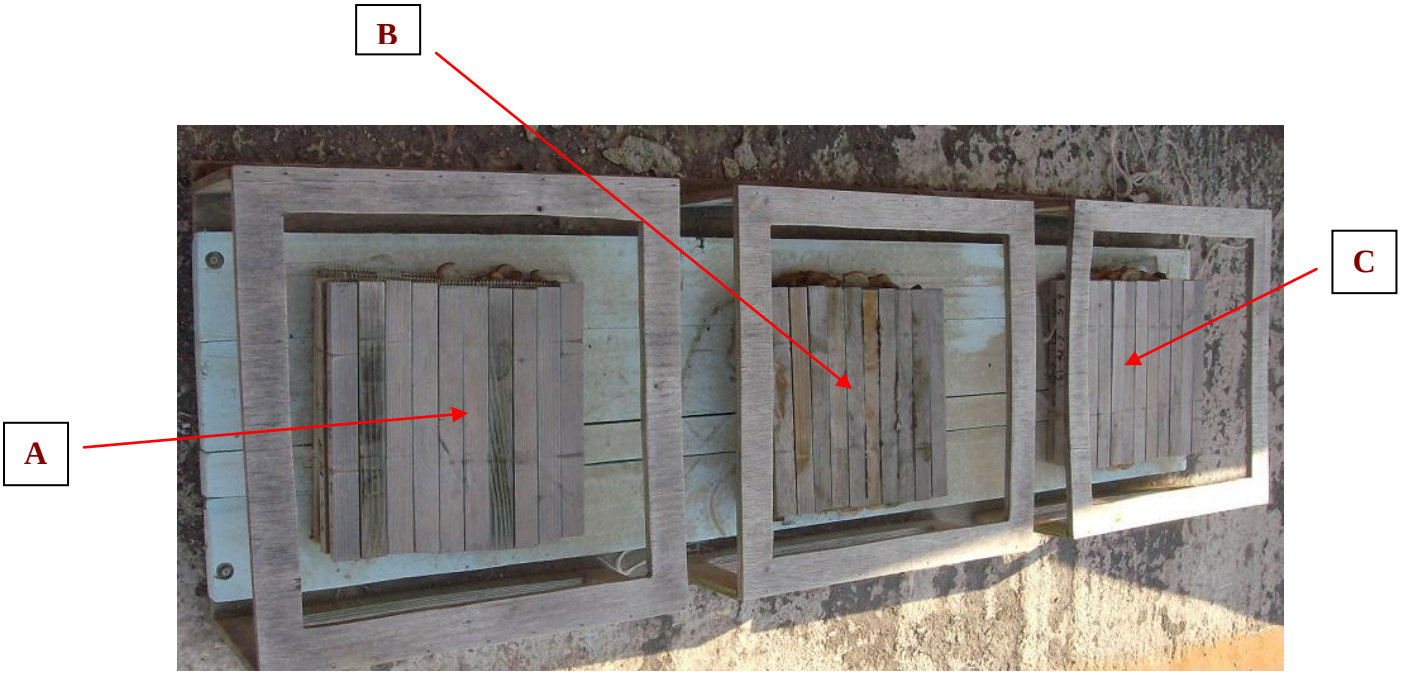


Fig. 2. *"Block-test" area of the testing materials (as in* ***June 2013****).*

Block A

A-0-01	A-Sp-04	A-Pi-03	A-Sp-08	A-0-05	A-Sp-12	A-Pi-07	A-Sp-16	A-0-09	A-Sp-20
A-Sp-02	A-Pi-02	A-Sp-06	A-0-04	A-Sp-10	A-Pi-06	A-Sp-14	A-0-08	A-Sp-18	A-Pi-10
A-Pi-01	A-Sp-03	A-0-03	A-Sp-07	A-Pi-05	A-Sp-11	A-0-07	A-Sp-15	A-Pi-09	A-Sp-19
A-Sp-01	A-0-02	A-Sp-05	A-Pi-04	A-Sp-09	A-0-06	A-Sp-13	A-Pi-08	A-Sp-17	A-0-10

Block B

B-0-01	B-Fr-04	B-UFr-03	B-Fr-08	B-0-05	B-Fr-12	B-UFr-07	B-Fr-16	B-0-09	B-Fr-20
B-Fr-02	B-UFr-02	B-Fr-06	B-0-04	B-Fr-10	B-UFr-06	B-Fr-14	B-0-08	B-Fr-18	B-UFr-10
B-UFr-01	B-Fr-03	B-0-03	B-Fr-07	B-UFr-05	B-Fr-11	B-0-07	B-Fr-15	B-UFr-09	B-Fr-19
B-Fr-01	B-0-02	B-Fr-05	B-UFr-04	B-Fr-09	B-0-06	B-Fr-13	B-UFr-08	B-Fr-17	B-0-10

Block C

C-0-01	C-Pp-04	C-UPp-03	C-Pp-08	C-0-05	C-Pp-12	C-UPp-07	C-Pp-16	C-0-09	C-Pp-20
C-Pp-02	C-UPp-02	C-Pp-06	C-0-04	C-Pp-10	C-UPp-06	C-Pp-14	C-0-08	C-Pp-18	C-UPp-10
C-UPp-01	C-Pp-03	C-0-03	C-Pp-07	C-UPp-05	C-Pp-11	C-0-07	C-Pp-15	C-UPp-09	C-Pp-19
C-Pp-01	C-0-02	C-Pp-05	C-UPp-04	C-Pp-09	C-0-06	C-Pp-13	C-UPp-08	C-Pp-17	C-0-10

Table 1. *The set-up of the three blocks A, B, C, used in the project (note: Sp stands for Spruce; Fr stands for Frake; Pp stands for Poplar; U means untreated; 0 means Sp feeder)*

Fig. 3. *Grindosonic type equipment used in the project.*

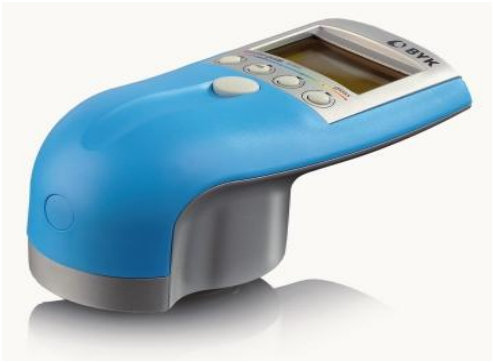


Fig. 4. *BYK Gardner colourimeter used in the project*

3. RESULTS

3.1 Results of the cladding test

The results of the cladding test in this project are summarised below.

3.1.1 Evaluation of the general *surface appearance* of claddings

It appears that all Black-varnished claddings do behave so far *better* than the other claddings. Especially, the cladding no. 08 *(XXX Frake Black)* is the best of all.

Similarly, the control WRC (no. 11) cladding, although looks *weathered severely* in the last 12 months, it is very stable dimensionally, in a very good condition having also *no structural* defects.

The White-coloured claddings are facing some problems; as easily can be seen by naked eye. Actually, in all three of them (namely, no. 02, 04, 09), there appears to be *"small checks"* in many spots in the surfaces, like *"openings"* in the white varnish itself. Notably, the no. 04 cladding *(XXX Poplar White)* appears to have a severe, large *black-coloured* staining area in its surface.

The rest of the unpainted claddings look quite deteriorated, and with more structural defects and have obtained a *"weathering colour"* appearance.

Note that cladding no. 10, which is the *straight control cladding* is by far the most weathered and structurally deteriorated.

Analytical description of the general *surface appearance* and *characteristics* of each single cladding can be read in the following lines of this report:

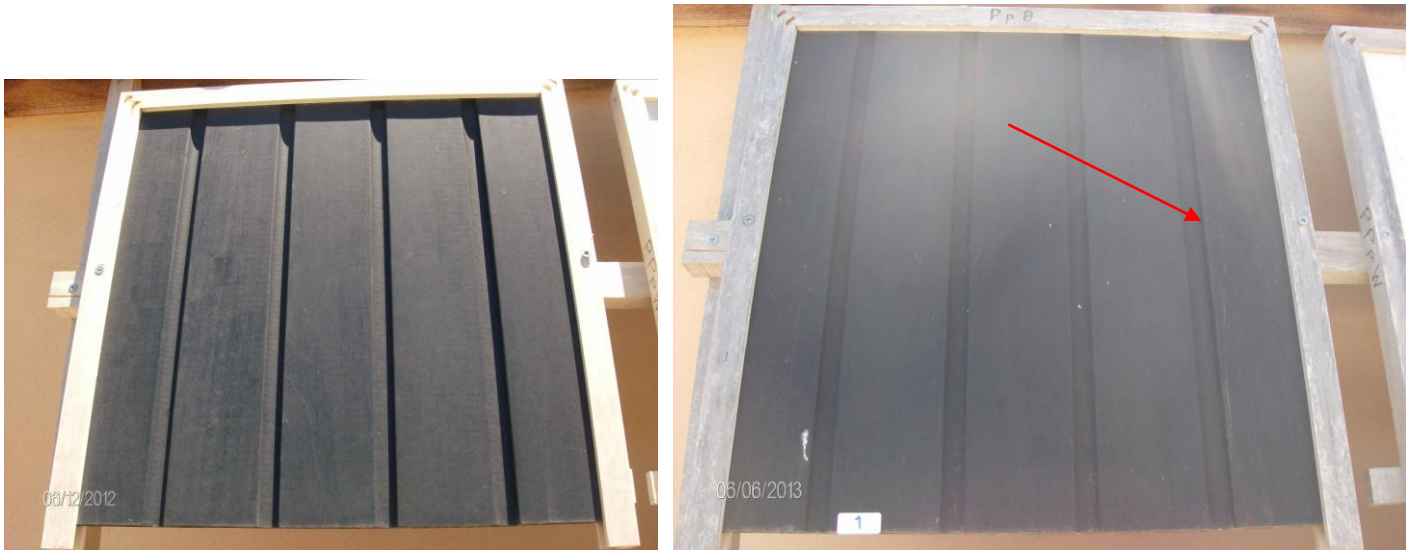


Fig. 5. *Cladding 01: XXX Poplar Black, as in June 2012; The same 01 as in* ***June 2013****; looks good in colour stability.*

Cladding 01 is in a *very good* condition, with a stable colour; a slight uprising in a plank of the cladding *(red arrow)* appears to happen. The edges of cladding 01 are quite *closed.*

Fig. 6. *Cladding 02: XXX Frake White, as in June 2012; The same cladding 02 as in* ***June 2013***

Cladding 02 is in a *relatively good* condition, with a slightly stable colour; the smooth and shiny surface appearance is not there as one year ago; some type of colour fading *(red arrows)* appeared. The edges of the cladding are *quite closed*. Locally in the surface of cladding no. 02, a number of *small checks* has appeared on it. It is the *best cladding* of the 3 White-painted XXX claddings used in the project.

Fig. 7. *Cladding 03: XXX Spruce, as in June 2012; The same cladding 03 as in* ***June 2013****.*

Cladding 03 is in a *not good* condition; small checks appearing locally in the surface, while the whole cladding is *very weathered*; extensive *uprising of fibres* exists in the surfaces. Five or six *end checks* have appeared.

Fig. 8. *Cladding 04: XXX Poplar White, as in June 2012; The same 04 as in* ***June 2013****.*

Cladding 04 is aesthetically in *not good* condition; there is a big area (see *red arrows*) with black staining; the white colour is in a *rather good* condition in the rest of the surface; the surface overall is not shiny, as it used to be one year ago *(left photo).* The edges of the cladding no. 04 are *closed* well.

Fig. 9. *Cladding 05: XXX Frake, as in June 2012; The same cladding 05 as in* ***June 2013****.*

Cladding 05 is in a *relatively good* condition and is well weathered; the colour is *grey* throughout the surface; some type of *black staining* exists around the surface. Also, 2-3 checks *(blue arrow)* are appearing in it.

Fig. 10. *Cladding 06: XXX Spruce Black, as in June 2012; (right) The same 06 as in* ***June 2013****.*

Cladding 06 is in a *rather good* condition; the surface looks shiny and clear; 7-8 minor small cracks appearing; an uprising of a plank is happening. The black colour is all *very stable* throughout and the cladding edges are closed. Possibly this cladding is in the 3rd best condition following no. 08 *(XXX Frake Black)* and no. 01. The existing *(initial)* few Spruce knots *(blue arrow)* in the cladding appearing to be *unchanged*.

Fig. 11. *Cladding 07: XXX Poplar, as in June 2012; (right) The same 07 as in* ***June 2013****.*

Cladding 07 is in a *bad* condition; the *weathering appearance* is problematic, with many colour fading and surface deterioration; the down edges are quite open and several relatively medium checks are obvious. Several *dark stains* along with some *yellow stains* have appeared locally in the cladding surface.

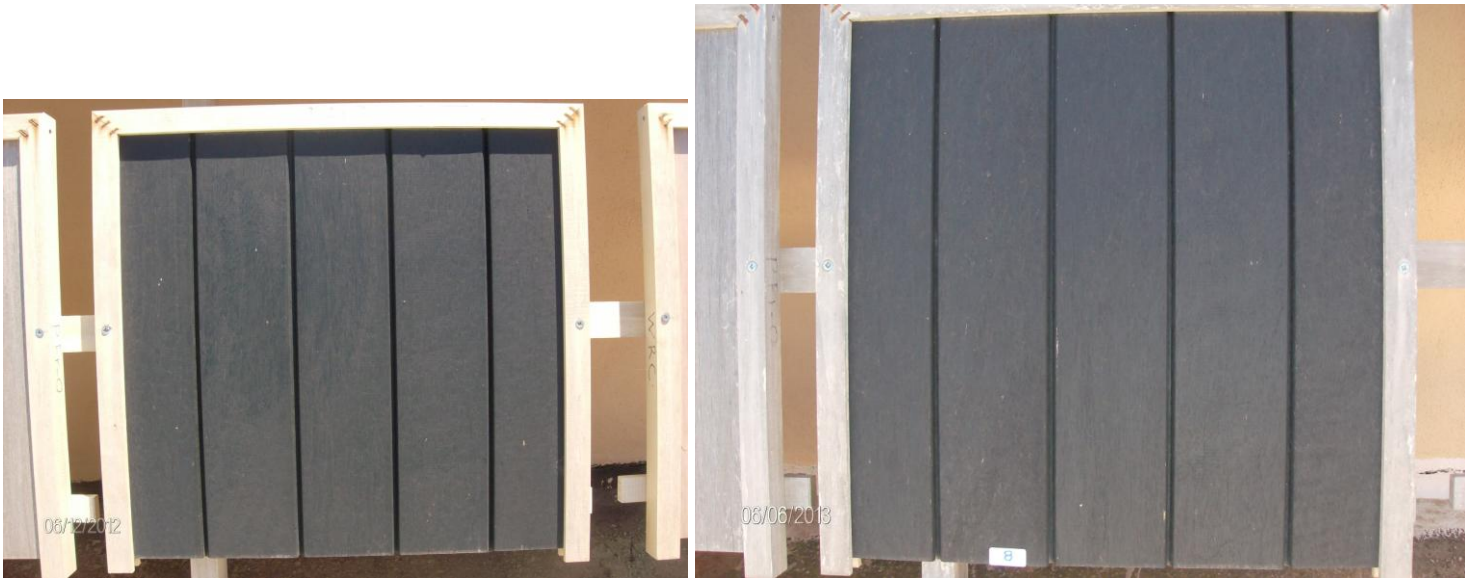


Fig. 12. *Cladding 08: XXX Frake Black, as in June 2012; the same (right) no 08 as in* ***June 2013****.*

Cladding 08 is in an *excellent condition* with a very stable colour after 2 years; obviously no checks, very closed edges. The shiny surface appearance is there! Also, cladding no. 08 is *very stable* in dimensions; with *almost no distortions* along the planks. By naked eye, the best cladding of all so far!

Fig. 13. *Cladding 09: XXX Spruce White, as in June 2012; the same no. 09 as in* ***June 2013****.*

Cladding 09 is in a *rather medium* condition, with a *slightly stable* white colour. The smooth and shiny surface appearance is not as one year ago; some type of colour fading *(red arrows)* locally has appeared. The edges of the cladding are quite *closed*. In no. 09, some *small checks* start appearing in the surface; with *openings* in the varnish.

Fig. 14. *Cladding 10: Control Spruce, as in June 2012; the same no. 10 as in* ***June 2013***

Cladding 10 is in the *worst condition* of all; extensive dark weathering, several *large checks (red arrow)*, big degree of plank distortions *(blue arrows)*, dark stains locally in the surface of this cladding; edge checks are large in 3-4 points; high roughness in the surface. This *control cladding* looks *extremely weathered*, and is *highly* deteriorated.

a 

2012

b 

2013

Figs. 15. *Cladding 11: Western red cedar (WRC) as in June 2012 (Fig. 15a); (below) The same cladding no. 11, as in* ***June 2013*** *(Fig. 15b)*

Cladding 11 is in a *good* condition, with a stable, *light-weathering* colour. Obviously it has lost its characteristic *cedar colour*, as one year ago, having a degree of *graying*. There are *no stains* or *darkening* in the surface; the edges are *quite closed* and its surface is very smooth! Only, one small *edge check* has appeared *(red arrow).*

3.1.2. Colour measurements

The colour measurements have been undertaken at the beginning of the *cladding test* (Nov. 2011), in June 2012 (7th month) and in **June 2013** (19th month). The *colour parameters* estimated are shown in full detail in the below Table 2.

Table 2. *Mean values of colour coordinates (L*, a*, b*) and total colour changes (ΔE*) of XXX wood testing & control claddings throughout the 19-month weathering period*

		Weathering months				
	Materials	**0**	**7**	**19**	***ΔL**** *(19-0)*	***ΔE**** *(19-0)*
Mean L* values	01 XXX Poplar Black	19,22	22,64	22,07	***2,85***	***11,64***
	02 XXX Frake White	82,22	81,86	81,11	***-1,11***	***3,52***
	03 XXX Spruce	47,07	62,59	43,77	***-3,30***	***26,67***
	04 XXX Poplar White	81,22	82,75	80,06	***-1,16***	***4,61***
	05 XXX Frake	46,98	60,69	47,10	***0,12***	***21,40***
	06 XXX Spruce Black	18,27	22,83	21,72	***3,45***	***10,71***
	07 XXX Poplar	48,33	60,18	43,62	***-4,71***	***24,96***
	08 XXX Frake Black	16,99	22,42	22,33	***5,34***	***6,61***
	09 XXX Spruce White	82,70	82,22	78,56	***-4,14***	***6,16***
	10 Control Spruce	84,19	65,26	47,24	***-36,95***	***41,03***
	11 Control WRC	66,05	67,01	49,54	***-16,51***	***25,32***
Mean a* values					***Δa**** *(19-0)*	
	01 XXX Poplar Black	-8,98	-2,71	-0,62	***8,36***	
	02 XXX Frake White	-1,37	-1,33	-1,46	***-0,09***	
	03 XXX Spruce	1,98	-8,22	-4,28	***-6,26***	
	04 XXX Poplar White	-1,11	-1,13	-1,60	***-0,49***	
	05 XXX Frake	4,66	-7,85	-3,14	***-7,80***	
	06 XXX Spruce Black	-8,06	-2,16	-0,72	***7,34***	
	07 XXX Poplar	6,68	-6,60	-3,68	***-10,36***	
	08 XXX Frake Black	-3,30	-1,58	-0,40	***2,90***	
	09 XXX Spruce White	-0,75	-0,84	-1,77	***-1,02***	
	10 Control Spruce	-1,65	-6,93	-5,31	***-3,66***	
	11 Control WRC	7,54	-3,03	-2,87	***-10,41***	
Mean b* values					***Δb**** *(19-0)*	
	01 XXX Poplar Black	8,51	1,81	0,93	***-7,58***	
	02 XXX Frake White	10,10	9,21	6,76	***-3,34***	
	03 XXX Spruce	34,95	21,71	9,24	***-25,71***	
	04 XXX Poplar White	11,16	10,07	6,73	***-4,43***	
	05 XXX Frake	28,36	15,38	8,43	***-19,93***	
	06 XXX Spruce Black	7,93	1,07	0,94	***-6,99***	
	07 XXX Poplar	30,35	12,04	8,14	***-22,21***	
	08 XXX Frake Black	2,95	0,80	0,34	***-2,61***	
	09 XXX Spruce White	10,07	10,54	5,63	***-4,44***	
	10 Control Spruce	26,23	17,54	8,78	***-17,45***	
	11 Control WRC	27,07	17,13	10,94	***-16,13***	

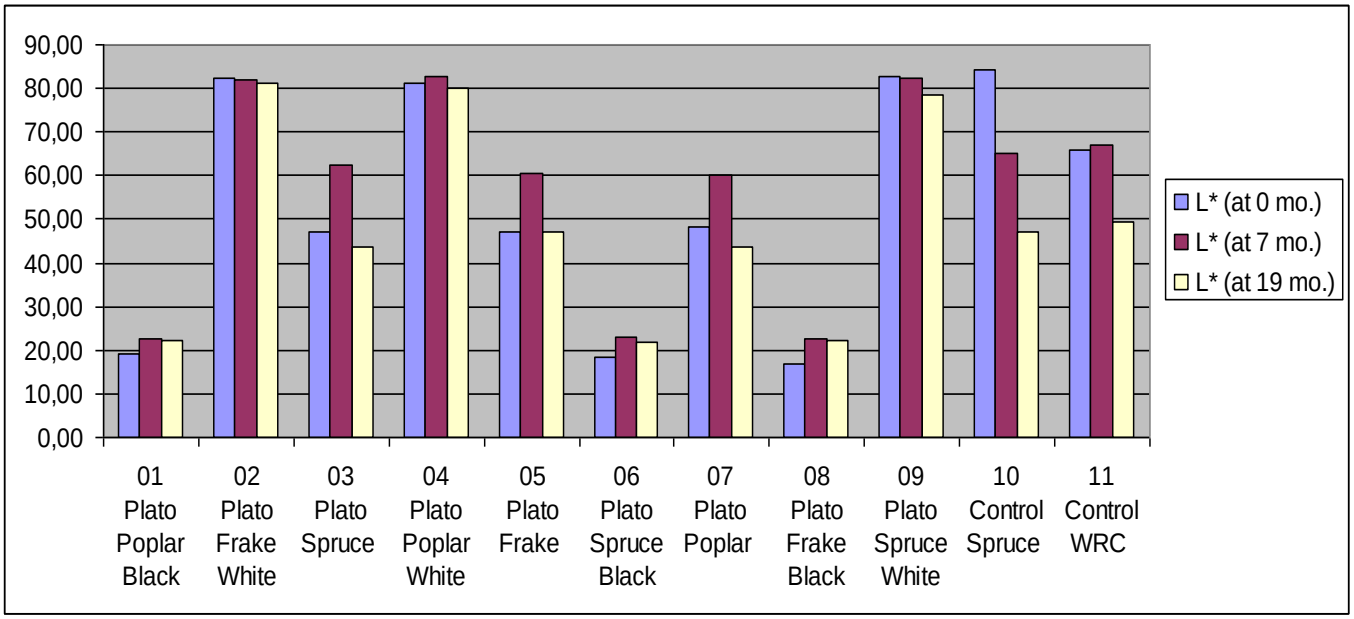
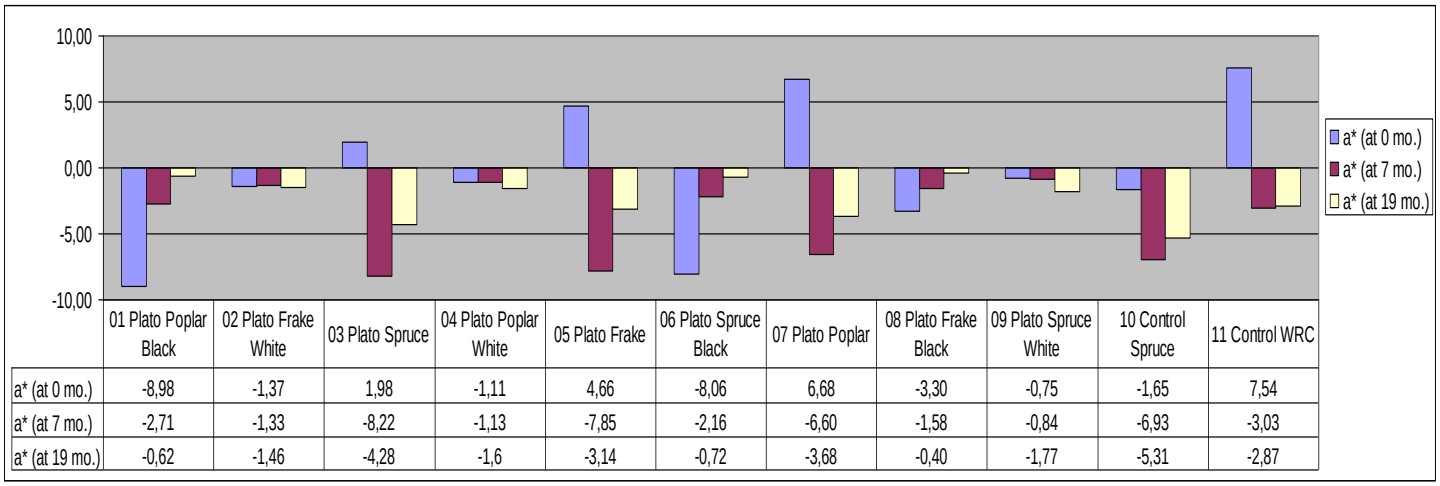


Fig. 16. *Changes in* ***lightness*** *(L* value) of claddings in the period of* ***11/2011 – 06/2013***



	01 Plato Poplar Black	02 Plato Frake White	03 Plato Spruce	04 Plato Poplar White	05 Plato Frake	06 Plato Spruce Black	07 Plato Poplar	08 Plato Frake Black	09 Plato Spruce White	10 Control Spruce	11 Control WRC
a* (at 0 mo.)	-8,98	-1,37	1,98	-1,11	4,66	-8,06	6,68	-3,30	-0,75	-1,65	7,54
a* (at 7 mo.)	-2,71	-1,33	-8,22	-1,13	-7,85	-2,16	-6,60	-1,58	-0,84	-6,93	-3,03
a* (at 19 mo.)	-0,62	-1,46	-4,28	-1,6	-3,14	-0,72	-3,68	-0,40	-1,77	-5,31	-2,87

Fig. 17. *Changes in* ***redness*** *(a* value) of claddings in the period of* ***11/2011 – 06/2013***

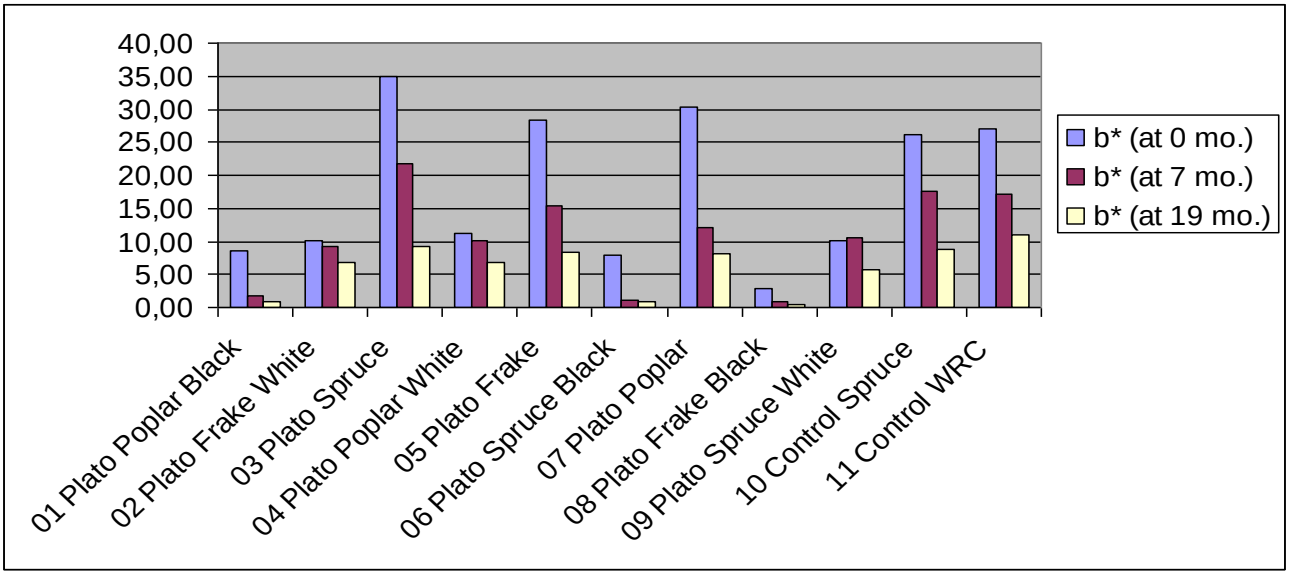


Fig. 18. *Changes in* ***yellowness*** *(b* value) of claddings in the period of* ***11/2011 – 06/2013***

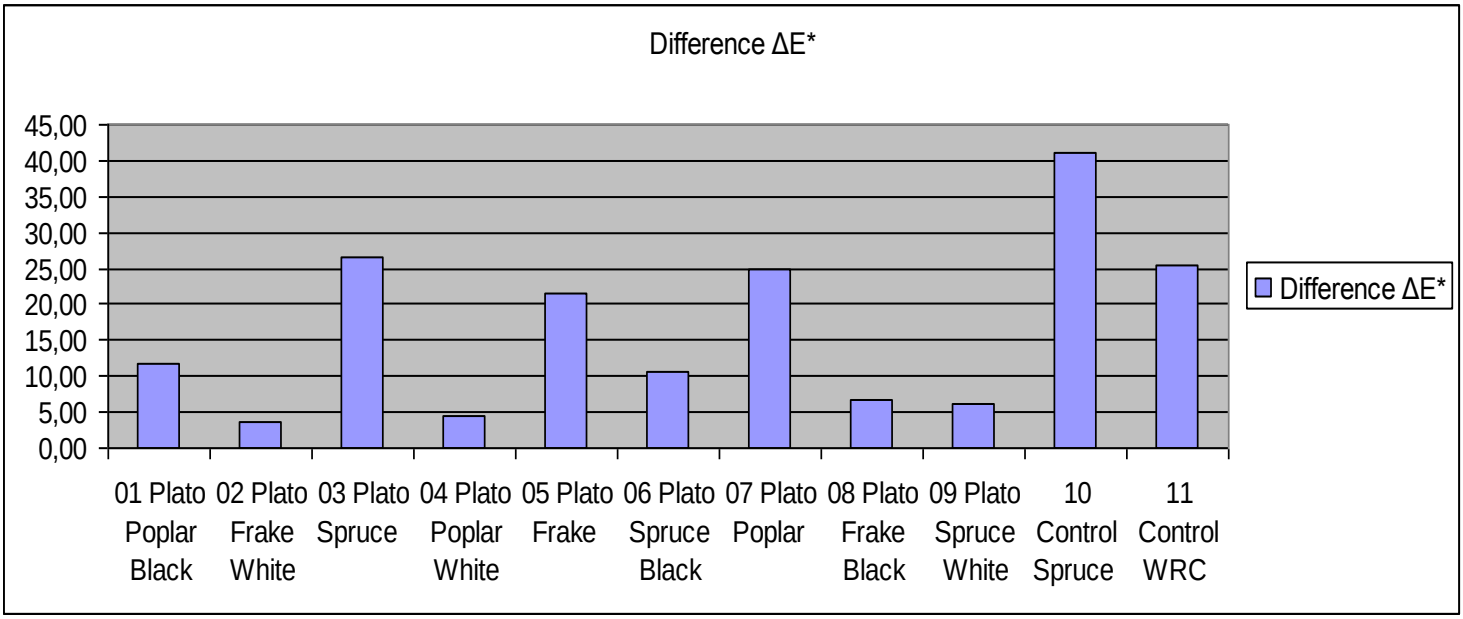


Fig. 19. *Colour changes (**ΔE*** values) of claddings in the period of **11/2011 – 06/2013***

The conclusions of the colour measurements can be summarised as follows:

- The largest ΔE* change took place for the no. 10, Control Spruce cladding; while very large ΔE* overall changes (between 06/2011 to 06/2013) happened for claddings no. 03, 05, 07 (XXX Controls), and no. 11 (control WRC).
- The largest change in *redness*, obviously happened in no. 11, Western red cedar cladding, which lost its *natural reddish* colour. Almost unchanged were the white-coloured claddings regarding redness property.
- Regarding the important parameter of *lightness* (ΔL*), the largest reduction took place for claddings no. 10, no. 11 and no. 07 (XXX Poplar).
- Regarding *yellowness*, the largest reductions happened in the claddings no. 03 (XXX Spruce), no. 07 (XXX Poplar), no. 10 (Control Spruce) and no. 05 (XXX Frake).

3.1.3. Evaluation of distortions

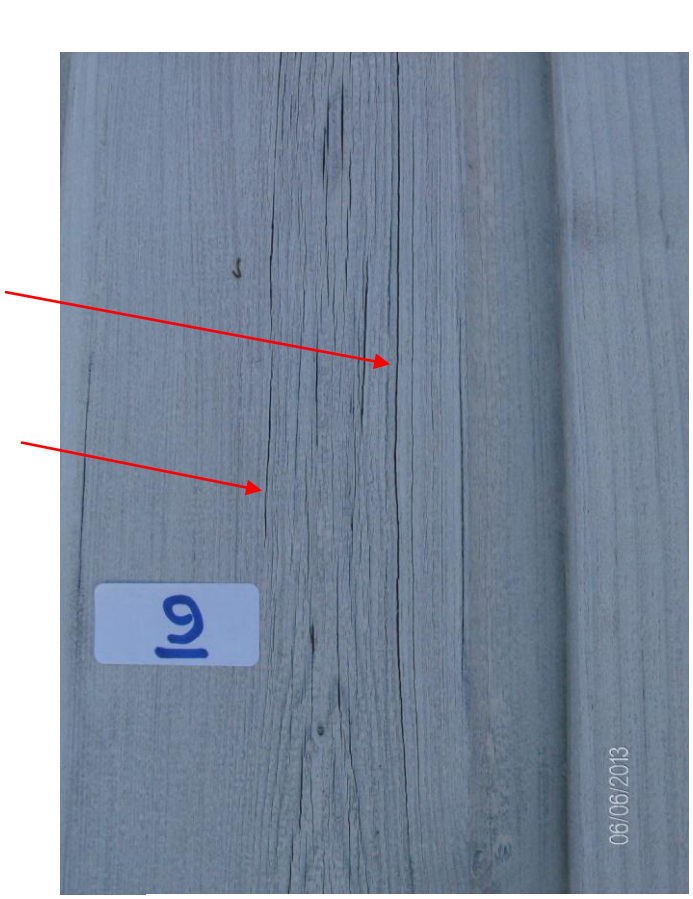
The general conclusions that can be drawn after the first 19 months:

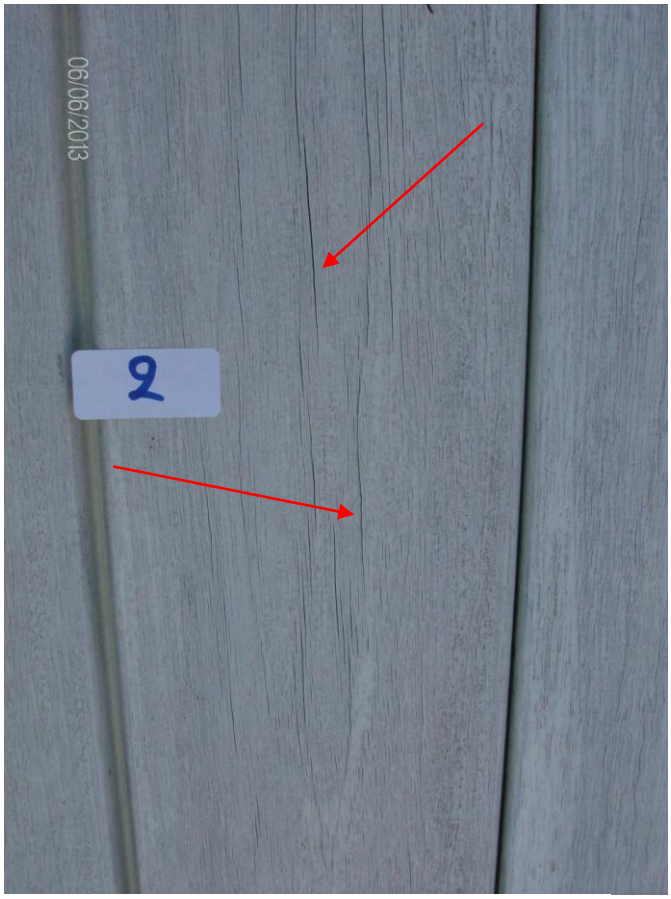
- Most distorted cladding is the control no. 10 (Control Spruce).
- Some *local distortions* appear actually in the control XXX claddings (no. 03, 05, 07). Very stable and without defects is the control WRC no. 11 cladding.
- *Insignificant* or *no distortions* observed in the rest of the black- and white-coloured claddings of XXX wood. A slight uprising appears in a plank in no. 01.

3.1.4. Evaluation of cracks, end splitting etc.

The conclusions in regard to cracks & end-splitting are written below:

- Appearance of small cracks and a type of *splitting-up* the *white varnish* did appear in claddings no. 02 and 09 (Figs. 20 & 21). This *cracking* effect will deteriorate, in our opinion. It is like small *openings*.





***Figs. 20 & 21**. In claddings no. 02 (XXX Frake White) and 09 (XXX Spruce White), small cracks like openings are appearing (in red arrows).*

***Fig. 22.** In cladding no. 08 (XXX Frake Black), no obvious defects appearing in the surface. This cladding surface looks shiny and in an excellent condition.*

- Some minor *cracks* have appeared in cladding no. 06 (see Fig. 23). These cracks seem that will be *developed* further as they are like *openings* in the surface.
- In cladding no. 04 (XXX Poplar White), an extended *black stain* appeared on the surface (see Figs. 24-25). This maybe a *blue stain*.

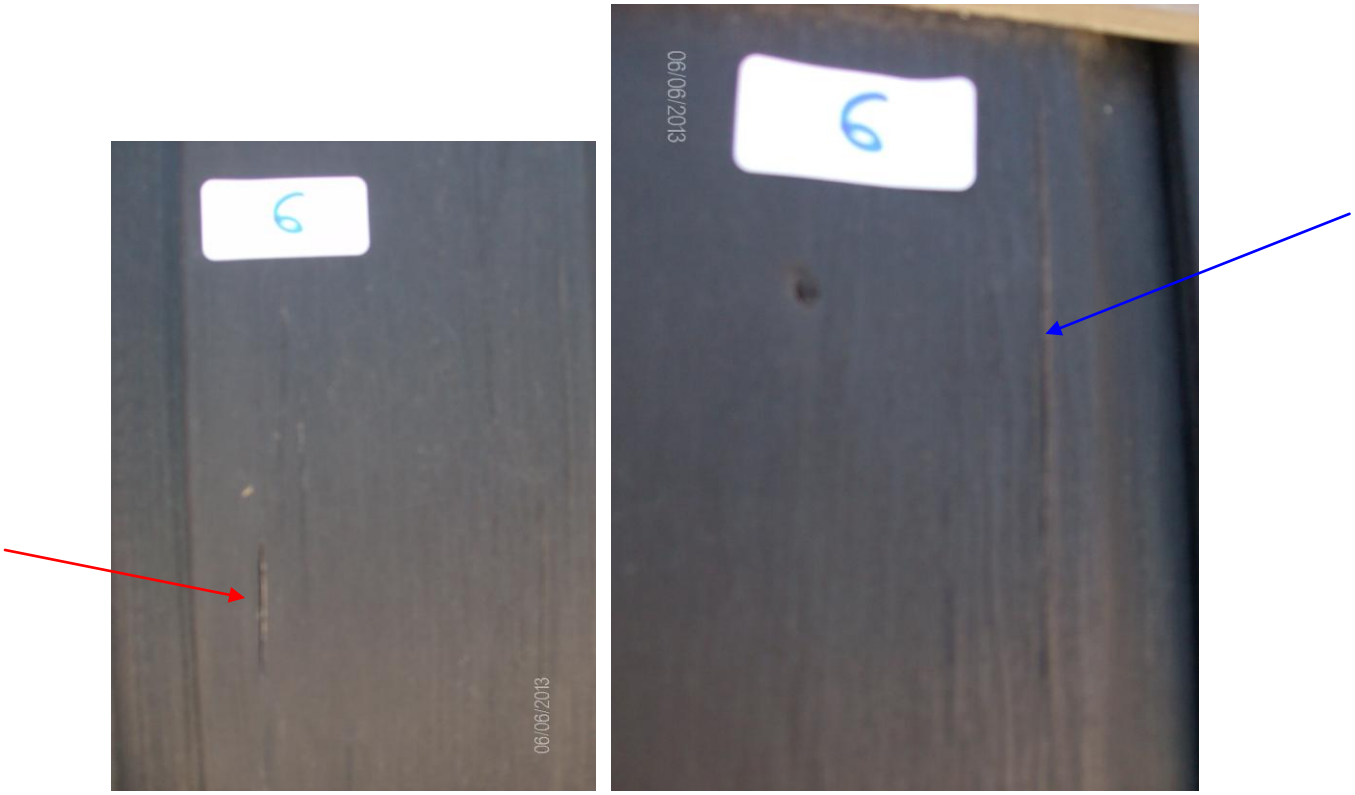
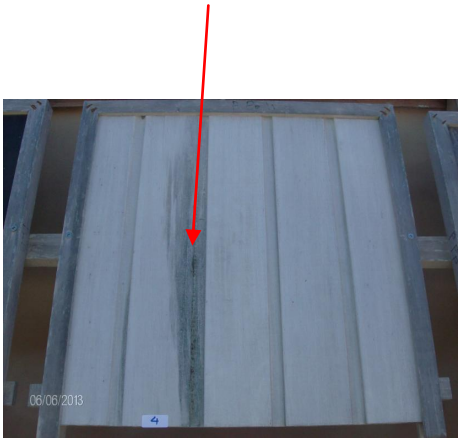


Fig. 23. *In cladding no. 06 (XXX Spruce Black), some cracks were seen (see arrows).*

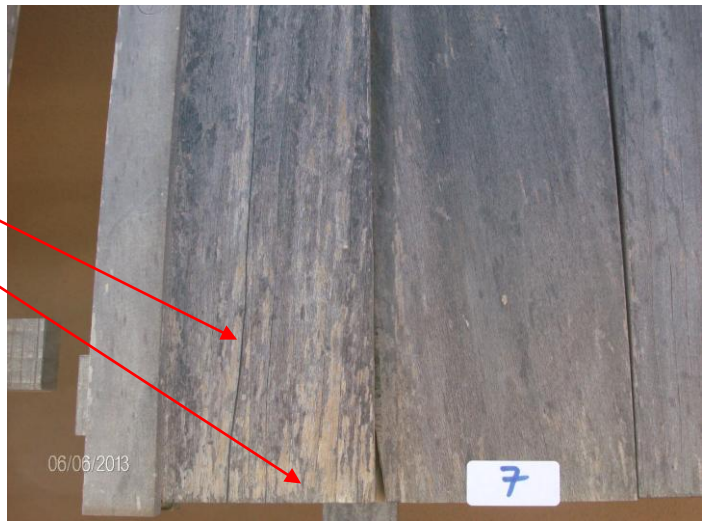
24. 

25. 

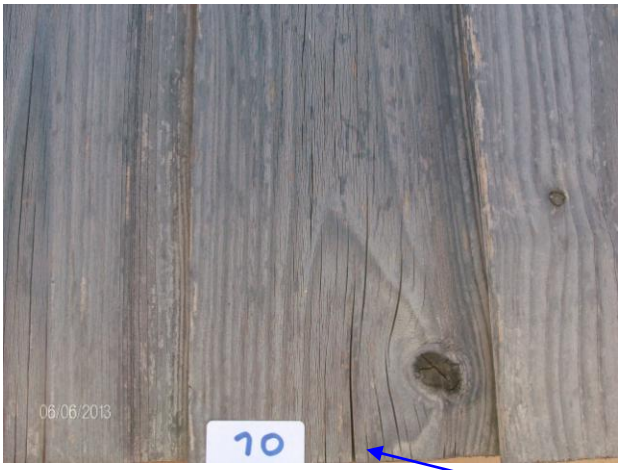
Figs. 24 & 25. *In cladding no. 04 (XXX Poplar White), a type of black or blue stain has appeared locally in the surface (in red arrows).*

Fig. 26. *In cladding no. 11 (Control Western Red Cedar), one small end-splitting was seen.*

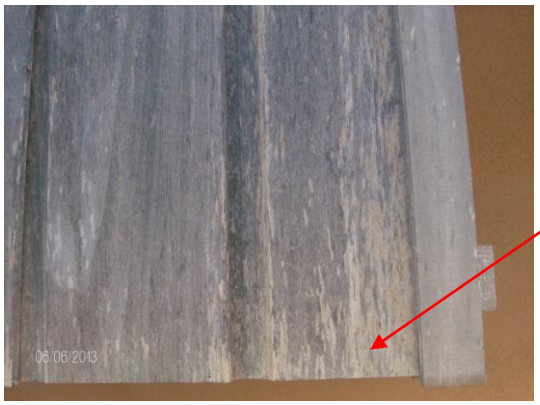
27a



28a



27b



28b

Figs. 27-28. *The claddings, no. 07 (XXX Poplar), at left side, and no. 10 (Control Spruce), at right side. In no. 07, an extended weathering appearance and dark & yellow stains. In control no. 10 cladding, the appearance is the worst of all, with lots of defects: cracks, openings, dark stains, extended weathering colour, etc.*

3.2 Results of the "block-test"

The results of the *block-test* in this project are summarised as follows.

3.2.1. Evaluation of the general appearance by visual examination

The three blocks were opened by scientists GM and SA on 19.06.2013 and separated apart. It was obvious that *significant changes* had been taken place during the last 12 months of exposure.

First, the general appearance of ***Block A*** (Fig. 29a) looked ***rather good***. The testing stakes, namely *A-Sp*, looked *slightly attacked* with visible signs of decay but still solid. The *Spruce feeders* namely *A-0* (Fig. 29b) had a larger fungal attack. The batch of control *Pine sapwood* (*A-Pi*) had been suffered a *severe attack* in overall. Some *A-Pi* stakes were close to the point of *total failure*.

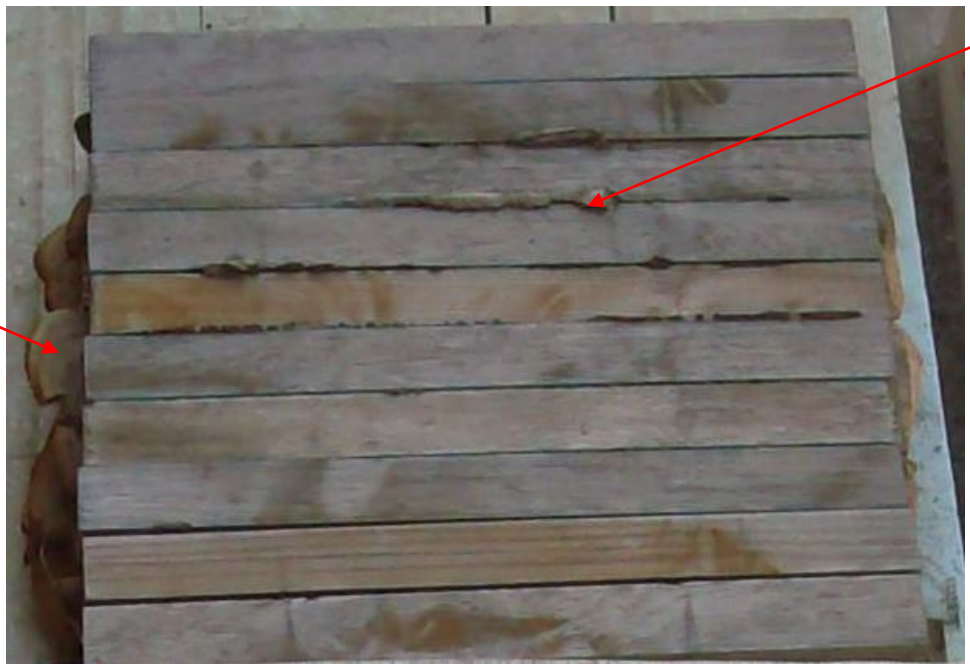
29a.

29b.

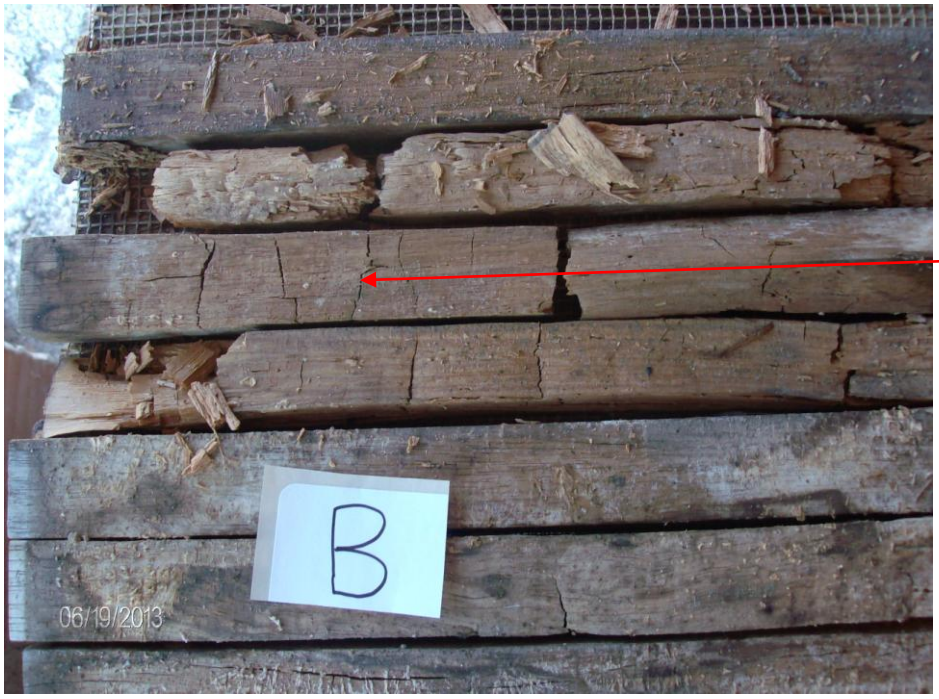
29c.

Fig. 29 a-b-c. *Appearance of block A, as seen in* ***June 2013****.*

Second, the appearance of ***Block B*** was that as seen in Figs. 30a-b-c. The general appearance of block B was ***very bad***. The testing materials (namely *B-Fr*) looked under a *moderate* fungal attack. The batch *B-0* with material of *Spruce feeders* and the batch *B-UFr* (with *untreated Frake* stakes) had suffered *very severe attack* in general. Many stakes (approx. 6 + 8, respectively) had a *total failure* and had been collapsed (see details in Figs. 30 b-c).



30a.

30b. 


30c.

Fig. 30 a-b-c. *Appearance of block B, as seen in* ***June 2013****.*

31a. 

31b.

Fig. 31 a-b. *Appearance of block C, as seen in* ***June 2013****.*

Third, the appearance of ***Block C*** was that as seen in Figs. 31a-b. Apparently, the general appearance of this block was ***rather good***. The testing materials (namely *C-Pp*) looked *good,* with a *slight* fungal attack. The *C-0* materials, *Spruce feeders*, had a *slight to moderate* attack, while the batch of *untreated Poplar* (namely *C-UPp*) had a similar *slight to moderate* attack. This was really interesting for the *untreated Poplar* stakes: we should note this result as a *rather unexpected* finding for *poplar* wood.

3.2.2. Evaluation of fungal decay of stakes by the *"pick-test"*

After the opening of all three blocks, a careful visual examination took place. The results were really interesting.

All three blocks had the appearance of fungal decay, which was *more pronounced* in the stakes of block B. The evaluation of the decay itself was carried out (for the first time) from wood scientists GM and SA by applying the well known *"pick-test"*. Relevant previous works were studied in detail in the beginning.

Then, based upon the bibliography *(Krause A., Pfeffer A., Militz H. 2010),* the surface of the specimens (stakes) was assessed with a sharp pointed knife (see Fig. 32), to reveal softened areas on all surfaces, of blocks A, B and C. The evaluation criteria of the called *"pick-test"* were adopted according to the guidelines of EN 252. The decay ratings of the pick-test carried out in 19.06.2013 are shown in the following Tables 3, 4 and 5.

The *decay rating* was made according to the following descriptions:

Rating 0*: Sound (no evidence of decay, any change of colour without softening has to be rated as 0).*

Rating 1,0*: Slight attack (visible signs of decay, but very limited in intensity or distribution: changes which only reveal themselves externally by very superficial*

degradation, softening of the wood being the most common symptom, to an apparent depth in the order of 1 millimeter).

***Rating 2,0**: Moderate attack (clear changes to a moderate extent of decay according to the apparent symptoms: changes which reveal themselves by softening of the wood to a depth of approximately 2-3 millimeters over more than 1 cm^2).*

***Rating 3,0**: Severe attack (marked decay in the wood to a depth of more than 5 millimeters or 3-5 millimeters over a wide surface, more than 20 cm^2).*

***Rating 4,0**: Failure (failure of the stake).*

***Fig. 32.** Application of the "pick-test" as in **June 2013** (WFDT, TEI of Thessaly).*

The *evaluation* made by the two scientists and the corresponding results are shown below:

Table 3.** **Block "A"** – Evaluation of fungal decay by the "pick-test" – **XXX Spruce

Stake no.	***A-0*** ***Untreated Spruce*** *(feeder)*	***A-Pi*** ***Untreated Pine sapwood*** *(control)*	***A-Sp*** ***XXX Spruce*** *(testing)*	***A-Sp*** ***XXX Spruce*** *(testing)*
01	*1,0*	*3,5*	*01.* *1,0*	*11.* *1,5*
02	*2,0*	*3,5*	*02.* *1,0*	*12.* *1,0*
03	*2,0*	*2,5*	*03.* *1,5*	*13.* *2,0*
04	*2,0*	*3,5*	*04.* *1,5*	*14.* *1,5*
05	*2,0*	*3,5*	*05.* *1,5*	*15.* *1,5*
06	*2,0*	*3,0*	*06.* *1,5*	*16.* *1,5*
07	*2,0*	*2,5*	*07.* *2,0*	*17.* *1,5*
08	*2,0*	*3,5*	*08.* *1,5*	*18.* *1,5*
09	*2,0*	*3,5*	*09.* *1,5*	*19.* *1,0*
10	*2,0*	*3,5*	*10.* *1,5*	*20.* *1,0*
AVG.	***1,9***	***3,2***	***1,4***	

Table 4. ***Block "B"*** *– Evaluation of fungal decay by the "pick-test" -* ***XXX Frake***

Stake no.	***B-0*** ***Untreated Spruce*** *(feeder)*	***B-UFr*** ***Untreated Frake*** *(control)*	***B-Fr*** ***XXX Frake*** *(testing)*	***B-Fr*** ***XXX Frake*** *(testing)*
01	*2,0*	*3,5*	*01.* *2,5*	*11.* *3,0*
02	*4,0*	*4,0*	*02.* *2,0*	*12.* *2,5*
03	*4,0*	*4,0*	*03.* *2,5*	*13.* *2,5*
04	*4,0*	*4,0*	*04.* *1,5*	*14.* *2,5*
05	*4,0*	*4,0*	*05.* *1,5*	*15.* *2,0*
06	*4,0*	*4,0*	*06.* *2,0*	*16.* *1,5*
07	*4,0*	*4,0*	*07.* *2,5*	*17.* *1,5*
08	*3,5*	*4,0*	*08.* *2,5*	*18.* *2,0*
09	*3,5*	*4,0*	*09.* *3,0*	*19.* *2,0*
10	*3,0*	*2,5*	*10.* *3,0*	*20.* *1,5*
AVG.	***3,6***	***3,8***	***2,2***	

Table 5. ***Block "C"*** *– Evaluation of fungal decay by the "pick-test" -* ***XXX Poplar***

Stake no.	***C-0*** ***Untreated Spruce*** *(feeder)*	***C-UPp*** ***Untreated Poplar*** *(control)*	***C-Pp*** ***XXX Poplar*** *(testing)*	***C-Pp*** ***XXX Poplar*** *(testing)*
01	*1,5*	*2,0*	*01.* *1,0*	*11.* *2,5*
02	*2,0*	*2,0*	*02.* *1,0*	*12.* *2,5*
03	*2,5*	*1,5*	*03.* *2,0*	*13.* *2,5*
04	*2,5*	*3,0*	*04.* *1,0*	*14.* *2,0*
05	*1,5*	*3,0*	*05.* *1,5*	*15.* *1,5*
06	*2,5*	*2,5*	*06.* *1,5*	*16.* *1,0*
07	*3,0*	*2,5*	*07.* *1,5*	*17.* *1,0*
08	*4,0*	*2,5*	*08.* *1,0*	*18.* *1,0*
09	*1,5*	*2,5*	*09.* *2,0*	*19.* *1,0*
10	*1,5*	*2,0*	*10.* *2,0*	*20.* *1,0*
AVG.	***2,2***	***2,3***	***1,5***	

From the results, it can be concluded: (a) XXX Spruce stakes averaged 1.4; XXX Frake stakes averaged 2.2 (note: they were more heavily rotted); and XXX Poplar stakes averaged approx. 1.5; Scots pine stakes in block "A" were severely attacked apparently. (b) The block "B" had undergone a very big biological decay; most of the stakes were close to 4.0 *(total failure)*, while a large number of these were not possible to be used in the MOE *Grindosonic* test due to their *disintegrated* situation. (c) Block "C" (XXX Poplar), unexpectedly, had a *much better* behaviour in overall; that is, scores 1.5, 2.2 and 2.3 were approximated for the stakes *C-Pp* (testing), *C-0* and *C-UPp*, respectively. Especially the *control untreated Poplar* stakes!

3.2.3. Evaluation of dynamic MOE properties

The results of the evaluation of the *dyn. MOE* properties using a *Grindosonic* equipment are summarised in the following Figs. 33, 34 and 35. Note that wherever in the above figs. there are *no points* of MOE values estimated, it means that is was not possible to evaluate an MOE value, for the corresponding stake, due to the *marked decay* and/or *failure* it had obviously suffered.

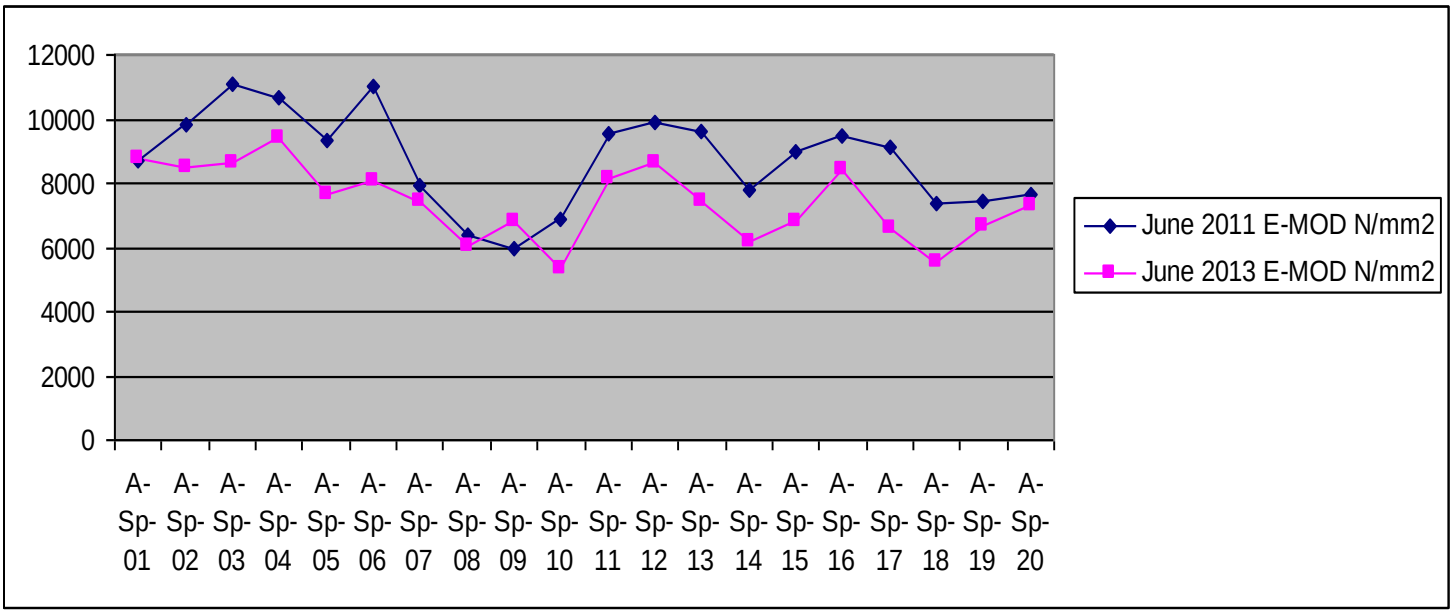


Fig. 33a. *Block A: dyn. MOE values for* ***XXX Spruce*** *stakes in the period* ***06/2011 - 06/2013***

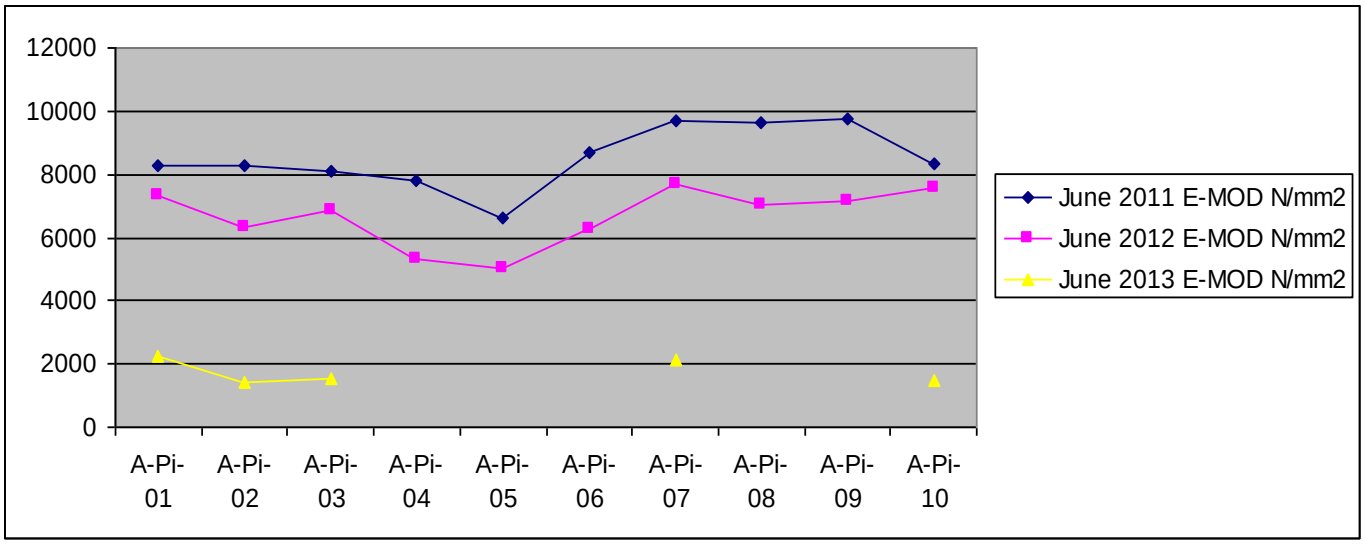


Fig. 33b. *Block A: dyn. MOE values for* ***Untreated Scots pine*** *in the period* ***06/11 - 06/12 - 06/13***

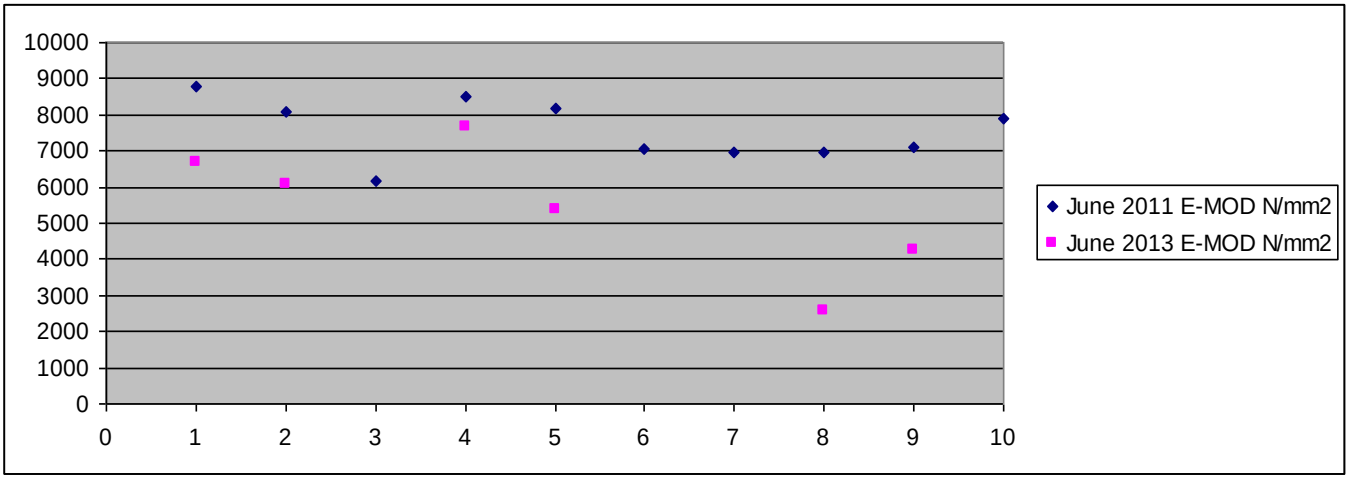


Fig. 33c. *Block A: dyn. MOE values for* ***Untreated Spruce*** *in the period* ***06/2011 - 06/2013***

Apparently in **"Block A"**, from the Figs. 33, we can conclude: a) there is a small *~15%* drop in the dynamic MOE properties in the *A-Sp* stakes *(XXX Spruce)* measured (Fig. 33a), b) there is *dramatic* decrease in MOE in the *control untreated Pine sapwood* stakes (Fig. 33b); only 5 measured, while the rest found close to zero, that is, it *was not* possible to measure, and c) for the feeder samples, *untreated Spruce*, only six (6) stakes were possible to be measured with the *Grindosonic* device, showing thus a *rather large* drop in the dynamic MOE values.

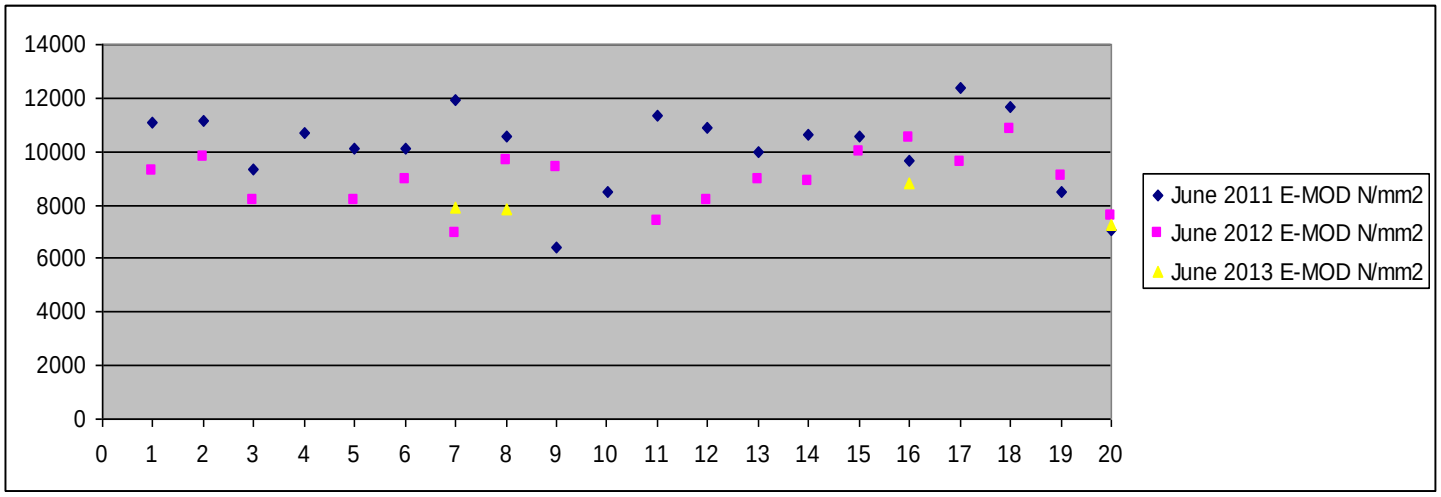


Fig. 34a. *Block B: dyn. MOE values for* ***XXX Frake*** *in the period* ***06/11 - 06/12 - 06/13***

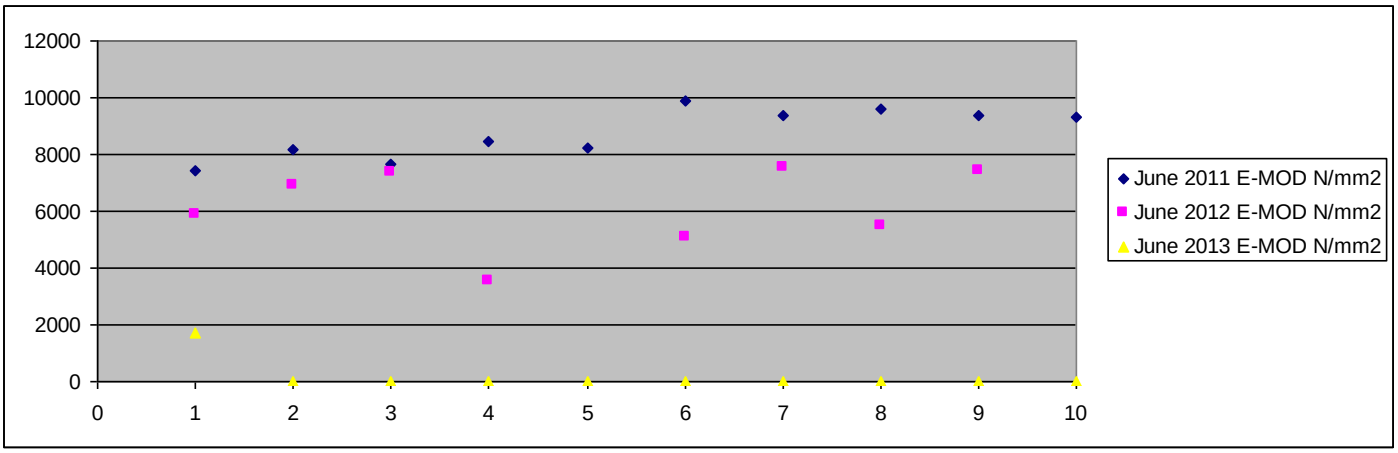


Fig. 34b. *Block B: dyn. MOE values for* ***Untreated Frake*** *in the period* ***06/11- 06/12 - 06/13***

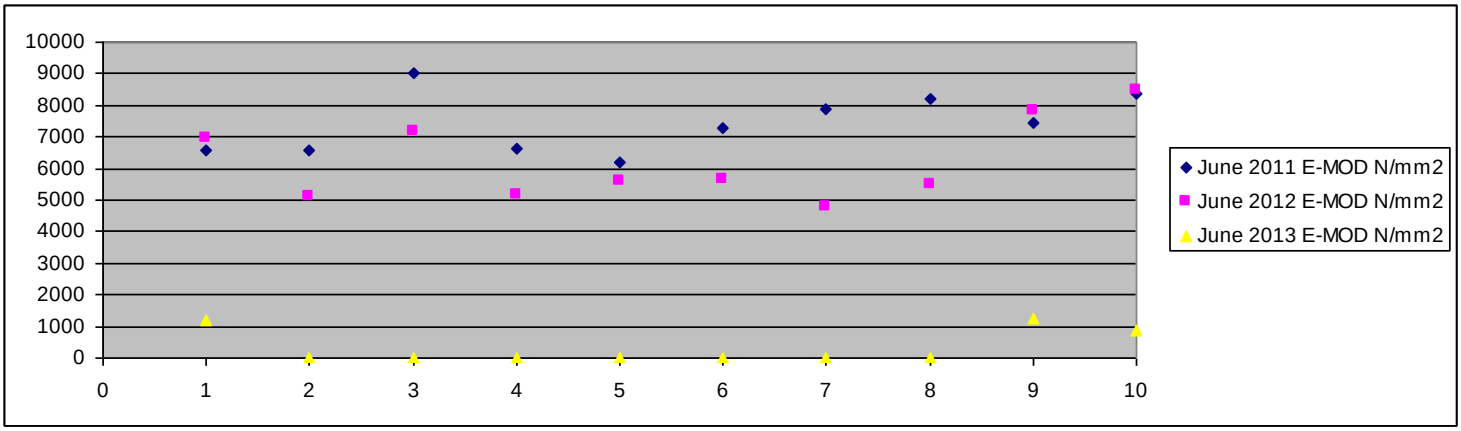


Fig. 34c. *Block B: dyn. MOE values for* ***Untreated Spruce*** *in the period* ***06/11 - 06/12 - 06/13***

Then, in **"Block B"**, from the Figs. 34, we can conclude: a) there was possible to measure dyn. MOE properties in only 4 *B-Fr* stakes *(XXX Frake)* (Fig. 34a); b) there was *very dramatic* decrease in MOE in the *control untreated Frake wood* stakes (Fig. 34b); almost all stakes had MOEs close to zero, that is, it *was not* possible to measure due to obvious *failure*, and c) for the feeder samples, *untreated Spruce*, only three (3) stakes measured close to 1.000 N/mm^2 with the *Grindosonic* device; the rest zeroed.

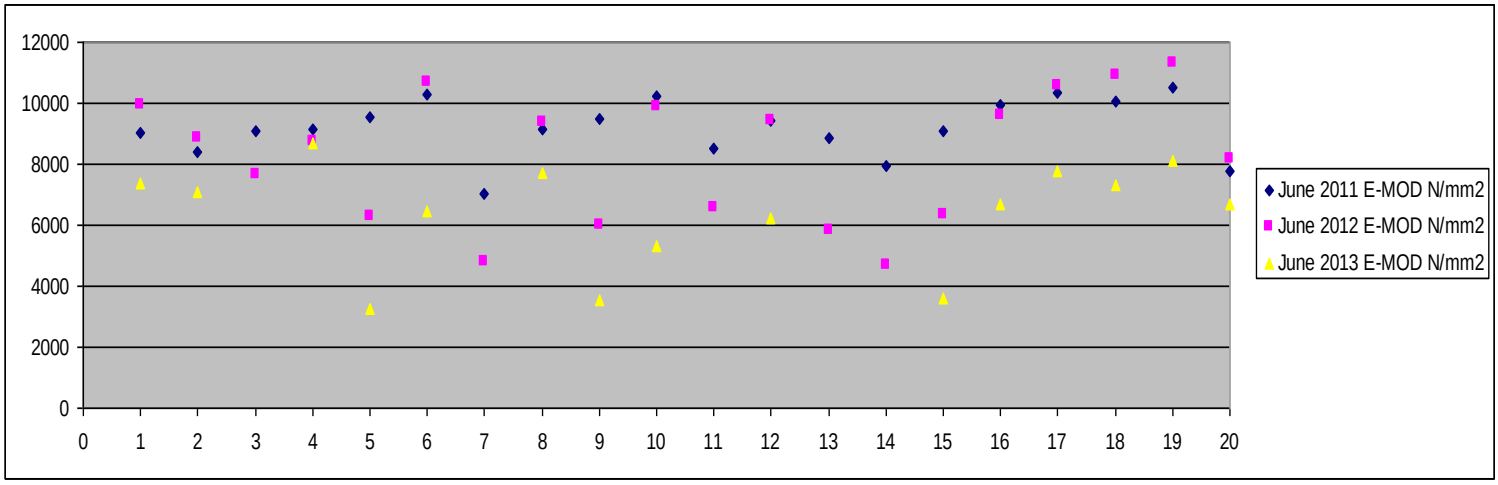


Fig. 35a. *Block C: dyn. MOE values for* ***XXX Poplar*** *in the period* ***06/11-06/12-06/13***

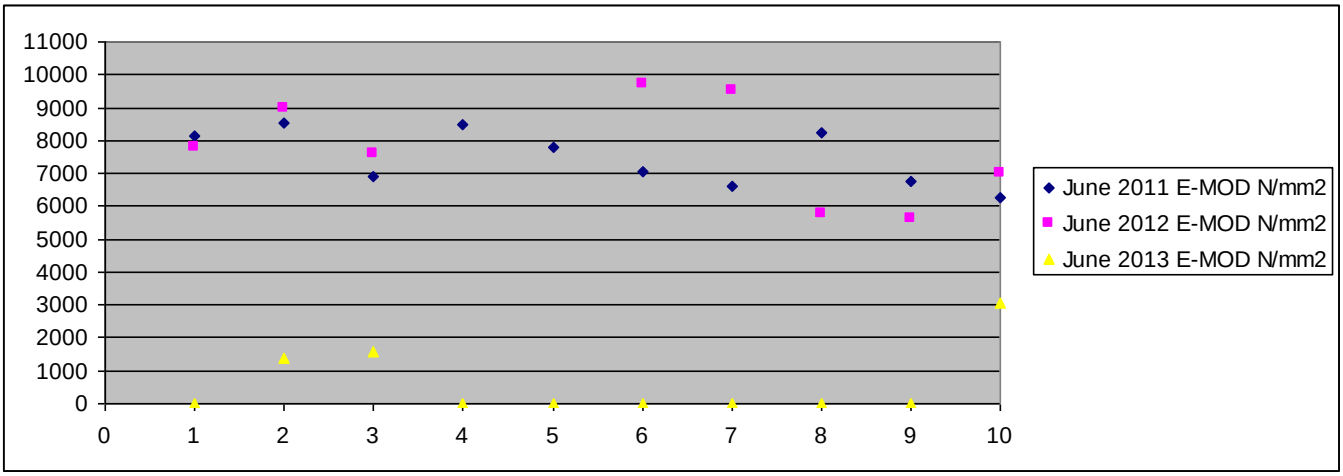


Fig. 35b. *Block C: overall MOE dyn. values for* ***untreated Poplar*** *in the period 06/11-06/12*

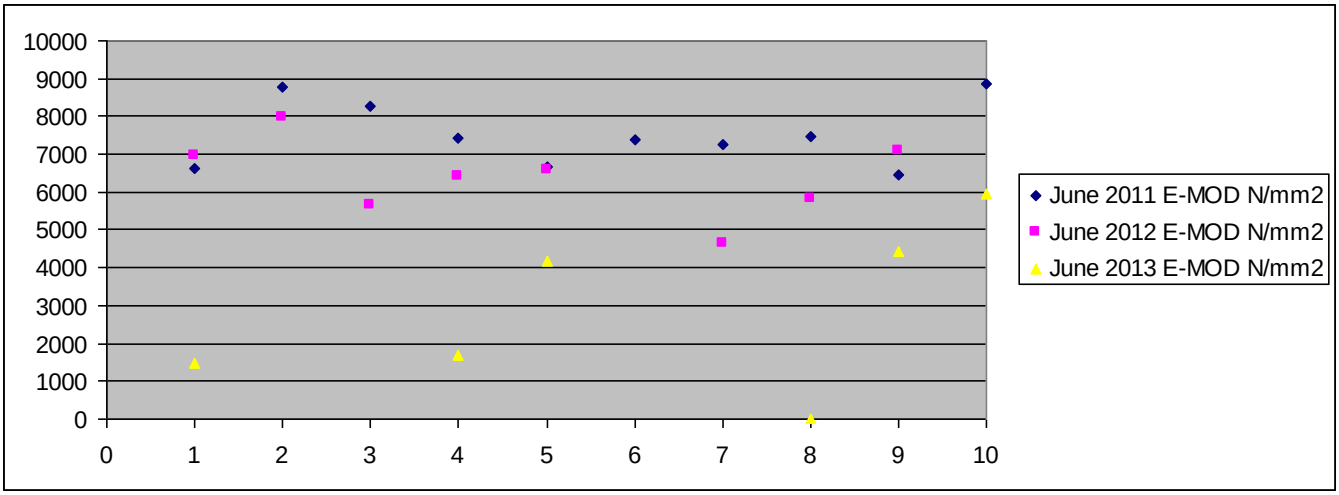


Fig. 35c. *Block C: overall MOE dyn. values for* ***Untreated Spruce*** *in this period* ***06/11-06/12-0/13***

Apparently in **"Block C"**, from the Figs. 35 above, we can conclude: a) there is a *>30%* drop in the dynamic MOE properties in the *C-Pp* samples *(XXX Poplar)* measured (Fig. 35a), b) there is *very large* decrease in MOE in the *control untreated Poplar* stakes (Fig. 35b); most measurements were close to zero, that is, it *was not* possible to measure, and c) for the feeder samples, *untreated Spruce*, only five (5) measurements were possible to realise with the *Grindosonic* device, showing thus a *very large* drop in the dynamic MOE values.

4. CONCLUSIONS

The general conclusions that can be drawn by this *2nd year report* are the following:

- In the *cladding test*, it appears that all black-painted XXX materials have a *better performance* and *clearer* surfaces as compared with the rest of the claddings.
- The largest ΔE* colour changes, in this weathering period, took place for the claddings: no. 10 *(Control Spruce)* as well as for the claddings no. 03, 05, 07 *(XXX controls)*, and no. 11 *(control WRC).*
- It seems that from the black-painted claddings, the best so far is the no. 08 (XXX Frake Black) which exhibits *very stable* performance and *the least structural* defects. This is followed by no. 01 (XXX Poplar Black) and no. 6 (XXX Spruce Black). To note: control WRC (no. 11) is also stable although is has a *weathering-type* colour.
- The white-painted claddings (no. 02, 04, 09) are facing a type of *small checks - openings* on the varnished surface; note the large *bluestain* in cladding no. 4.
- In the *block test*, the blocks A and C behaved very well thus far. Block B is in a *bad situation* suffering a *severe* fungal deterioration, with most of the feeder and control stakes to be close to *failure*. In the *testing materials*, in the so-called "pick-test", XXX Spruce stakes rated 1.4 on the average, and XXX Poplar rated 1.5, while the XXX Frake *behaved poorer* reaching ca. 2.2. This deterioration in mechanical properties and rigidity of wood stakes was obvious when the same biologically attacked stakes underwent the *dyn. MOE Grindosonic* test, in where *large decreases* in the MOE values were observed.

30-11-2013

The scientific coordinator of project no. **3749**

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