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Short communication. Natural durability of reed (*Phragmites australis*) against wood decay organisms: relation to other forest species

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Abstract

This work presents the research carried out to determine the natural durability of reed (*Phragmites communis)* from the Fertö region of Hungary against wood decay organisms, with the objective of obtaininig information to be used as a constituent element in outdoor use, and in particular, in a viable and sustainable motorway noise barrier.

Phragmites communis is a large perennial grass of considerable size which grows in temperate and tropical wetland zones throughout the world. Its growth is expansive and it frequently invades wetlands where it competes with the native species and therefore requires regular removal so that an excess of organic material is not produced in the habitat. In addition, the invasion by this plant of polluted waters also appears to have a beneficial effect, so it can be used as a natural water purifier and thus has a potential use as a purification method for wetlands contaminated by agricultural practices. Due to the need for its periodic extraction, its possible use as a construction material, although in a secondary role, gives it an added value for which further scientific study is required. In the absence of a reference Standard and being reed a lignocellulose material, the study of its natural durability has been based on the existing Standards for wood. The tests show that Hungarian reed has a high level of durability against some fungi and other wood decay organisms.

Key words: Reed, sustainable noise barrier, durability, wood decay organisms.

Resumen

Durabilidad natural del carrizo (*Phragmites australis*) frente a organismos xilófagos: relación con otras especies forestales

Este trabajo presenta las investigaciones llevadas a cabo para determinar la durabilidad natural de *Phragmites communis* procedente de la región de Fertö, Hungría, frente a organismos xilófagos, con el objetivo de ser utilizado en el exterior, y en particular, como parte fundamental de una barrera acústica sostenible para carretera.

Phragmites communis es una gramínea de gran tamaño que se desarrolla en humedales de zonas templadas y tropicales de todo el mundo. Suele utilizarse como herramienta natural para la depuración de aguas, y es especialmente relevante su uso potencial como depurador de humedales contaminados por las prácticas agrícolas. Debido a la necesidad de extraerlo periódicamente, las investigaciones que se realicen para su posible uso como material de construcción ofrecerían un valor añadido.

Dada la ausencia de una normativa de referencia, y dado que el carrizo es un material lignocelulósico, el estudio de su durabilidad natural se ha enfocado a partir de las normas existentes para madera. Los ensayos demuestran que la durabilidad del carrizo húngaro es alta frente a algunos hongos y organismos xilófagos.

Palabras clave: Carrizo, barrera acústica sostenible, durabilidad natural, organismos xilófagos.

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Introduction

The use of the reed in highway noise barriers is the short term reference point of this work. The outcomes are more general, and so the case study must be seen as a mean for more general goal related with the possible outdoor use of reed. Nevertheless, the durability data to be obtained from the case study in the next years will be crucial for further steps.

The high cost involved in the construction and renovation of noise barriers makes the development of sustainable barriers necessary. In order to evaluate the foresaid barriers, it is necessary to make a Life Cycle Analysis (LCA). The LCA provides important information for the selection of noise barriers as there is no reliable long term field data in existence available concerning the repositioning and maintenance of the aforementioned barriers (Morgan and Kay, 2001; Ekici and Bougdah, 2003). In any case, it is clear that the reed has the initial advantage in that it contains biogenic CO_2.

Wood has been used in various ways in the existing barriers, even to the extent of being the only material used (Boothby *et al.,* 2001; Grgurevich *et al.,* 2002). The most common methods reduce its use to a structural one, other materials being added to provide the sound absorption. However**,** as wood is a biodegradable material, it requires treatment with various chemicals in order to lengthen its life in service and, due to the restrictions imposed by the European Directive on Biocides, this has resulted in wood being replaced by other materials.

The barrier designed as case study (Fig. 1) uses thermotreated timber (TMT), hardwood and softwood, as its structural support, therefore dispensing with the otherwise necessary chemical treatment. At present, there are no European Standards regarding TMT, although one is in the process of being devised (CEN/TC 175, TC 175 WI 00175118, 2006).

However, the rational use of TMT requires the help of other materials, due as much to the need to improve the acoustic absorption qualities as to its cost. In the case of the barrier which has been designed, reed was selected as the complementary material. The barrier is basically formed with thermo-treated wood as the external structure -joists- with reed panels between them, which also improve the acoustic qualities. As an auxiliary material for the sound absorption requirement, 5cm thick bands of recycled rubber were added to the barrier in other prototype (Fig. 1).

The acoustic barriers are required for a life in service of around 25 years and this requires the study of the natural durability of reed in the aforementioned project. There are few studies of the natural durability of this material (Bosman, 1985; Haslam, 1989ab, 1995). The results obtained in these investigations can not be extrapolated when the habitat changes because there is a large genetic variation and consequently their properties vary depending on the environment where the variety of reed grows (Haslam, 1969, 1970; Massacci *et al*., 2001; Zhu *et al.,* 2003; Chen *et al.,* 2006; Healy *et al*., 2007). Reeds originating from Hungary were specifically studied in this project, in particular those from the Fertö lake region (Fertö Reed Co.).

At a general level, information on humidity must be taken into account as the existence and retention of humidity is fundamental for the durability of the reed, because the way in which water is repelled or evaporated determines the life in service of the constructions and reed structures. Moreover, recent investigations based

Figure 1. Picture of the noise barrier in construction for the A22 motorway near Vienna.

on the samples of 20 north facing and 20 south facing roofs in Denmark have improved our knowledge about long term vulnerability of the reed used as a roofing material (Anthony, 1999). It has been observed that the deterioration of the aforementioned roofs begins at the exposed surface and progressively affects the interior parts. Areas representative of the different states of decay are developed on the external reed covering**.** These areas move towards the interior as the roof deteriorates. It has been noted that the velocity at which deterioration occurs depends on the pitches of the roof, the deterioration being much greater in roofs with lower pitches. This issue has already been considered in the design process of the barrier, and the drainage of rainwater is immediate as there are no places where it can accumulate.

All this considered, the aim of this work has been to study the durability of this reed type against the action of wood decay organisms (fungi and insects).

Material and Methods

Natural durability of reed against wood decay fungi

Materials

In order to evaluate the natural durability of the reed, two types of test were carried out, one accelerated and another applying the corresponding European Standard against destroying Basidiomycetes and Ascomycetes, producers of white, brown and soft rots.

As test fungi has been used: *Coniophora puteana* (Shumecher ex Fries) Korsten, *Postia placenta* (Fries) Cooke Sensu J, Eriksson and *Gloeophyllum trabeum* (Persoon ex Fries) Murril for brown rot; *Trametes versicolor* (Linnaeus) Chalet for white rot and *Chaetomium globosum* Kunze, as representative of the fungi which produce soft rot.

The wood reference species used were: *Pinus sylvestris* L. for the fungi which cause the brown rot and *Fagus sylvatica* L. for those causing white and soft rot.

In the accelerated tests, 9 reeds (30 mm long by 6mm in diameter), were used as specimen for each test fungus. Block tests (15 x 10 x 5 mm) of *P. sylvestris* were used as the reference species for the brown rot fungi, and *F. sylvatica* as the reference species for the white rot and soft rot fungi.

In the test applying the current European Standard EN-350-1 (1995), groups of reeds of varying numbers and sizes were used depending on the type of rot:

- For tests of brown and white rots were used four bundles of reeds simulating woodblocks (50 x 25 x 15 mm) with 10 reeds per specimen for each test fungi, and as control block tests *P. sylvestris* (50 x 25 x 15 mm) as reference species for the fungi which cause brown rot and *F. sylvatica* as reference species for the fungi which cause white rot.
- For tests of the soil inhabiting microorganisms which cause soft rot bundles of 6 reeds 100 mm long were used, and control block tests (100 x 10 x 5 mm) of *F. sylvatica* as reference species.

Methods

The specimens used in the tests were placed in an oven at 103ºC to obtain an initial dry mass. They were subsequently sterilized and exposed to the corresponding fungi.

Accelerated Tests

In the case of the Basidiomycetes, Petri dishes with pure cultures of test fungi which had previously been grown in a malt agar medium (1,5%, malt 3,0%) were used. Three pieces of reed and two control block tests of the reference woods were placed in each dish. The dishes were incubated in a culture chamber at 22ºC and with 75% relative humidity for 45 days.

In the case of the soil inhabiting microorganisms causing soft rot, the specimens were buried in horticultural soil following European Standard ENV-807 (1993), and incubated at 28ºC with 80 % relative humidity for 16 weeks.

Tests applying the European Standards

For these tests the methodologies described in the European Standard EN-350 (1995) "Durability of wood and wood based products. Natural durability of solid wood" was applied. This means to follow the Standard EN-113 (1996) for white and brown rot fungi, and the ENV-807 (1993) for the soil inhabiting microorganisms producing soft rot.

After the corresponding incubation periods (16 weeks for EN-113 and 32 weeks for ENV-807) the block tests were removed and placed again in an oven at 103ºC to obtain the final dry mass, and their weight losses.

Natural durability of reed against wood decay insects

Materials

The subterranean termite species used in the test was *Reticulitermes grassei* Clément, while that of house longhorn beetle was *Hyloptrupes bajulus* L.

Specimens of reeds similar to those described for the fungi tests, and *P. sylvestris* L. (50 x 25 x 5 mm) as reference species, were used.

Methods

Durability against termites

To evaluate the durability of the reed against termites, an accelerated test was used applying the methodology described by Nunes (1997) although slightly modified, using Petri dishes 60 mm in diameter. In each dish the reed specimens were added as cellulose material. As control Filter-Lab 12502 filter paper 42.5 mm in diameter was used as cellulose substrate. Fifteen termites were added to each dish, and then they were placed on the culture chamber at 28ºC and 80% relative humidity during 4 weeks. The number of replicates was three.

Durability against house longhorn beetle

To determine this durability, 17 bundles made with 10 reeds each simulating block tests (50 x 25 x 15mm) were prepared. For the control, 6 Scots pine block tests were used. In three of them a hole to the middle of the block was perforated in the transversal section, and the remaining specimens a hole was drilled through all the length of the block in order to simulate the reed structure. Larvae in category two (masses in the range 50 to 150 mg) was placed in each block test, in accordance to the Standard EN-47 (2005). All the specimens were placed in the culturing chamber at 28ºC with 80% relative humidity for 20 weeks. After this period the number of live larvae was counted.

The test can be considered valid if at least 70% of the larvae inserted into all the control test specimens survive.

Results

Regarding the decay fungi, the results obtained from the accelerated test are shown in Table 1. Those corresponding to the application of Standard EN-113 in Table 2, and those obtained for soft rot in Table 3. In these tables the weight loss of reed compared with the reference wood species can be seen.

Table 1. Mean weight losses suffered by the studied materials in accelerated laboratory tests

	Weight Loss (%)		
Fungi	**Reed**	***P. sylvestris***	***F. sylvatica***
C. puteana	0,87	30,34	-
P. placenta	3,66	11,52	-
G. trabeum	3,69	22,07	-
T. versicolor	5,90	-	34,40
Ch. globosum	15,31	-	18,46

Regarding durability against termites, the results obtained are shown in Table 4 where the number of surviving termites and the percentage weight loss incurred in each type of material are shown.

The results obtained in relation to the durability of reed against *Hylotrupes bajulus* are shown in Table 5, where the number of surviving larvae, their percentage and the amount of sawdust in comparison with the Scots pine are shown. The appearance of the wood and of the reeds can be seen in Fig. 2.

As can be observed in Table 1, it appears that reed was durable against the brown and white rot fungi in the accelerated tests, but does not have the same resistance against soft rot fungi. When the corresponding European Standard was applied (Table 2), it is seen that reed exhibited a natural durability class 3 "moderately durable" against the species of brown rot (*C. puteana* and *G. trabeum*), and against the species of white rot (*T.*

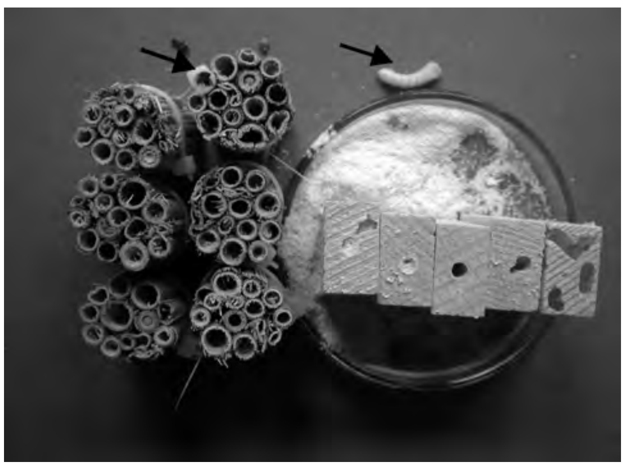

Figure 2. Percentages of number of surviving larvae of Hylotrupes, and the proportion of sawdust obtained

Table 2. Mean weight losses suffered by the studied materials in accordance with EN-113, and its corresponding durability class

	Weight Loss (%)			
Fungi	**Reed**	***P. sylvestris***	***F. sylvatica***	**Durability Class**
C. puteana	17,731	47,173	-	3 (moderately durable)
P. placenta	1,408	18,868	-	1 (very durable)
G. trabeum	14,450	41,950	-	3 (moderately durable)
T. versicolor	14,637	-	38,406	3 (moderately durable)

versicolor). However, against *P. placenta,* which produces brown rot too, reed was shown to be a very durable material (durability class 1).

With respect to the results obtained by applying ENV-807 against soft rot, reed exhibited a class 3 natural durability (moderately durable).

In both Standards, the test reference wood species used are not durable (class 5).

Considering the wood decay insects, termites and house longhorn beetle, as can be seen, reed is not completely durable against termites attack although the accelerated tests are not enough to get a final conclusion. By other hand (see Table 5), the percentage of surviving larvae of Hylotrupes in the reeds is very low (11,7%) compared with 100% in the controls. Moreover, as can be appreciated in Fig. 2, the larvae obtained from the reeds are either dead or of a comparatively smaller size than those found in the pine block tests. It must equally be noted that the amount of sawdust formed in the reeds is clearly less than in the reference specimens.

Discussion

The use of standards for determining the durability in wood, even though wood and reed are basically composed of lignin and cellulose, is clearly a limiting factor. The outcomes must be seen as a preliminary step for addressing specific European Standards for reed. By other hand, the variability of the material is a key factor, as also happens in wood, and this make even more important the development of Standards.

Consequently, the use of EN-113 and ENV-807 shows, depending on the type of fungi, durability levels which oscillate between class 3 (moderately durable) and class 1 (very durable). This confirms the previous results with accelerated tests that were somewhat better but within the same margins. Though the use of reed is not contemplated in the Standards used, the results clearly show a natural durability which is notably higher than the reference control wood species which in both cases are class 5 (not durable).

The tests against termites again show a superior performance with respect to the reference woods, but the reed was vulnerable to attack. Fortunately, this problem does not exist in cold countries such as those in northern and central Europe.

The results obtained in the trials against *Hylotrupes bajulus* are somewhat better than those against termites and again much better than the control woods.

Table 3. Durability results of the soil inhabiting microorganisms test of reed in comparison with the beech

Material	Weight Loss (g)	Weight Loss (%)	Natural Durability Class
Reed	0,306	5,273	3 (moderately durable)
F. sylvatica	0,546	17,53	5 (no durable)

Conclusions

Reed is clearly more durable than the reference softwoods, but still is moderately durable against some wood decay organisms. The line of research in a reed-concrete composite is worth of exploring, because cellulosic fibers and composites is a current and very active research topic. In fact, it has been seen

Table 4. Percentages of number of surviving termites and weight loss of materials studied

Material	Survivors (%)	Weight Loss (%)
Reed	46,6	6,47
Control (cellulose)	86,6	13,81

Table 5. Percentages of number of surviving larvae of *Hylotrupes*, and the proportion of sawdust obtained

Material	Number of Surviving Larvae	Surviving Larvae (%)	Sawdust (%)
Reed	2	11,7 %	1 %
P. sylvestris	6	100 %	100 %

that a combined use of concrete and natural fibers increases the durability of this kind of lignocellulosic material.

In conclusion, the results show a potential of the reed for exterior use when compared with the control woods. For this reason, it is planned to monitor the acoustic panels that are being installed on the A22 motorway near Vienna. The construction design is, in any case, a crucial consideration in the prevention of water retention.

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