Educating European professionals and the general public on the virtues of modified wood in a modern sustainable society

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ABSTRACT

In order for modified wood to become a mainstream material in construction, design and architecture, it will be necessary to expand upon several of the key features that make modified wood attractive. It has been well documented during the previous European Conferences on Wood Modification that treatments can affect physical and chemical properties of a range of timber species. Work has also shown that similar benefits can be achieved when treating lignocellulosic fibres that can be subsequently used in composite manufacture. Some previous papers (Jones et al. 2009, 2010) considered marketing aspects of modified wood in some of the smaller peripheral regions in Europe. Though for modified wood to make a significant breakthrough, some of the concepts outlined in these earlier works needs to be exploited in multi-national markets and into mainstream product manufacturing. However, to make these quantum leaps in supply and demand goes beyond the traditional science-based assessment. The general public are, in principle, willing to accept modified wood, provided the price is commensurate with the enhanced performances claimed. Therein lies a potential shortfall, do designers really know how to use modified wood, which can differ from traditional untreated (or preservative treated) wood. Without the correct detailing, failure can still ensue. To overcome this, there needs to be a development of training and education towards the professional users of timber. Similarly, the general public may in principle accept the virtues of modified wood, but not fully understand the implications, not only on performance, but societal and environmental aspects. In short, there needs to be a better defined role for modified wood in a modern sustainable society. This paper will address some of the issues surrounding this subject and suggest ways forward to help overcome some of the problems that currently exist.

INTRODUCTION

Education of the next generations has to be improved to prevent further degradation of our planet and to create a new generation of responsible citizens truly concerned with our planet resources and that promotes a clear sustainable development. Furthermore, educating professionals and general public on the virtues of wood in general and
modified wood in particular is essential to improve the quality of construction, design and architecture and promote the development of a modern and sustainable society

**Wood as a sustainable material**

Wood is a natural renewable resource considered neutral in terms of CO₂. This is not necessarily true since all the operations of harvesting, collecting, transporting and transforming wood release CO₂. Nevertheless it is well known that wood products transformation require significantly less energy than other construction materials. In accordance with Carduban et al (2012) the amount of emitted carbon in the production of one ton of concrete is about eight times the carbon emitted in the production of one ton of framing lumber. In relation to the production of steel this value rises to about 21 times. Moreover, if the kilns use waste wood to produce the heat necessary for the drying of wood which is considered the most energy consumptive process of lumber manufacturing then it would result in a carbon neutral energy use.

Carbon dioxide is considered as one of the greenhouse gases more responsible for global warming. Trees absorb CO₂ and transform it in biomass that, if is used to produce wood products, will store carbon while in use, for the entire life of the wood. After the end life of the wood products wood can still be recycled to produce for instance particleboards and even then can be used to produce heat, ultimately releasing the carbon in the atmosphere. Additionally, trees not only absorb CO₂ but also some common pollutant gases like nitrogen oxides, sulphur dioxide, ammonia, or ozone and release oxygen into the air. Other advantages of trees is that they cool the environment, slow down the evaporation, help prevent water pollution and soil erosion, reduce UV-B exposure by about 50 percent, and provide food, among others. The utilization of wood from trees allows forests to be regenerated since in accordance to Hill (2006) as the forest matures carbon inventory reaches a plateau and the harvesting lets natural regeneration or replantation. These facts are usually unknown by the general public that tends to associate wood use to deforestation and consequently to being responsible for negative environmental impacts. Wood modification extends the life of timber products which makes carbon being stored for longer times before being return to the atmosphere.

In recent years, according to Puttmann et al. (2009), the market share of wood products in windows construction significantly decreased in Europe having been replaced by plastic and aluminum. Maintenance costs, the products service life and the reducing use of tropical hardwoods have been mentioned as the main reasons for this change. Modified wood can be a valuable alternative to these materials and reintroduce wood in a leading position in this market.

Acetylated wood, due to its high resistance to ultraviolet radiation, its excellent dimensional stability and durability is nowadays a competitive material for these uses. Despite high price of this material, since window frames do not take significant amounts of material, this wood becomes competitive with plastic or aluminum. The great advantage of the use of modified wood in relation to other materials is its sustainability because it is a renewable material with a small carbon footprint when compared the others. In addition, no less important, are the aesthetic aspects, since wood gives a natural look to structures.
**Educating for sustainability**

The use of wood is closely linked to a society with a sustainable growth; therefore the need to educate the population starts in childhood. We are talking about wood and sustainable development. How the use of one helps the other. How it should be driven into peoples’ minds from early childhood.

Education for sustainability is crucial in our time and has an important role in the efforts to bring about sustainable development. This education should begin in childhood because it is, in accordance with Samuelsson and Kaga (2008) “in the early childhood period that children develop their basic values, attitudes, skills, behaviours and habits, which may be long lasting”. The education for sustainability is nowadays much more than only environmental education. In the International Conference of UNESCO in Salonika in 1997, recommendations were made in order to substitute the term “Environmental Education” with a broader term “Education for Sustainability” or “Education for Sustainable Development” which has, according to Spiropoulou et al. (2007) raised intense discussions within the educational community. These authors mention that children should be involved in the discussion of sustainability referring the 7Rs for education of sustainable development (reduce, reuse, recycle, respect, repair, reflect and refuse).

According to UNESCO (2005) the actual decade 2005–2014 was entitled “the Decade for Education for Sustainable Development”. The objectives of UNESCO for the Education for Sustainable Development are focused on the incorporation of Sustainable Development into common educational activities and in reorienting curricula. Moreover according to Spiropoulou et al. (2007) “the increasing awareness of the Sustainable Development concept will allow the development and enlightenment of active and responsible citizenship locally, nationally and internationally, providing continuing education to teacher trainers, pre-service and in-service teachers in making Sustainable Development a reality”. In accordance with Flogaiti (2006) and Spiropoulou et al. (2007) currently, education systems in Europe are concentrated on the development of environmental literacy, attitudes and values that exceed a simple understanding of environmental problems. Spiropoulou et al. (2007) mention that “environmental principles and issues are diffused in several curriculum subjects and that schools are supplied with appropriate educational material, teachers are offered the opportunity to attend in-service training programs on environmental issues and students are engaged in classroom and field-work activities”. In Portugal the program Eco-Escolas (Eco-Schools) addresses some of these questions. This program is an international program that seeks to encourage actions and acknowledge quality work developed by the school, in the framework of environmental education. This program intends to stimulate interest and creativity in the search for more sustainable solutions through the active participation of young people, supporting technically and financially some of the proposed projects (Figure 1). A similar program directed towards the use of wood could help to improve the utilization of wood by the next generations.
Even though it is important to promote wood use by the general public the starting point has to come from professionals. The company Carmo® has been implementing a series of actions aiming to educate people in general and trade professionals in the use of wood. One of these actions is the Carmo Deck Award. This action was geared to university students of architecture. The purpose was to reward the best project for a timber structure designed by the students. It linked owners of land wanting to build a timber structure with university students, encouraging them to design a well-suited structure for the contest. Carmo Deck Award was a great success awarding the student Ricardo Pereira from Beira Interior University and José Pereira (owner of the land where the construction was built). In fact, Carmo® developed a number of actions targeted to architects, construction industry, timber industry, big hotel chains and municipalities seeking to make aware the professionals of the wood sectors of the great potential possessed by Carmo® and the great know-how of its architects and timber engineers at the disposition of all professionals who need to design timber structures with the purpose of helping them to design better structures and interpret their reality. Always with the same purpose Carmo® organised a set of conferences both in Lisbon and Oporto, with international speakers such as Prof. Jean Luc Sandoz, Professor at the Lausanne University in Switzerland and CEO of CGTETT; Architect Carlos Lemonde Macedo from the Technical Architecture Faculty of Lisbon; Edo Kegel, at that time Managing Director of Plato International Wood; Dr. Jorge Milhe e Carmo, CEO of Carmo wooden structures and Silvia Fernandes, responsible of Technical department of Carmo wooden structures.

The presentations focused new building techniques and once more drove home the message about the virtues of wood and building with wood. Throughout all these actions the purpose of proving to all sectors of society the essentiality of using wood to promote the sustainable development of our society remained a constant.

In the UK, there has been a concerted effort in promoting wooden products, as demonstrated with the Wood Window Alliance. In their publication (Wood Window Alliance 2014), they indicated the possibility of service lives of 60 years provided basic criteria were followed in areas such as sustainability, performance, service life, whole life costs, design, durability and maintenance. These factors are borne out when assessing to ISO 15686:8 (2008), which states that the relative service life can be determined according to Table 1.
Table 1: Factors and factor categories of the factor method (ISO 15686:8 (2008))

<table>
<thead>
<tr>
<th>Factor</th>
<th>Factor category</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Inherent performance level</td>
</tr>
<tr>
<td>B</td>
<td>Design level</td>
</tr>
<tr>
<td>C</td>
<td>Work execution level</td>
</tr>
<tr>
<td>D</td>
<td>Indoor environment</td>
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<tr>
<td>E</td>
<td>Outdoor environment</td>
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<tr>
<td>F</td>
<td>Usage conditions</td>
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<tr>
<td>G</td>
<td>Maintenance levels</td>
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</tbody>
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Through the application of many of the factors within this guide, Accoya-based window frames are currently marketed with up to a 68-80-year guarantee (Menzies 2013).

Training and education towards the professional users of timber

A potential shortfall might be the lack of knowledge of how to deal with modified wood. Do designers really know how to use modified wood, which can differ from traditional untreated or preservative treated wood?

Any incorrect recommendation on how to use wood can lead to failure and consequently to a bad name being attributed by the general public to this material. This has led to design specification manuals, as exemplified with cladding design (Davies and Wood 2010). The issues of correct use can be amplified with modified wood with the known changes in selected performance categories. To overcome this, there needs to be a development of training and education towards the professional users of timber.

Designers must be taught the best ways to work with each kind of modified wood and they should know that it is a mistake to consider all modified wood equal and as a substitute of traditionally treated wood for all applications. For example, the loss of mechanical strength of thermally modified wood put serious restrictions on the use of this material in applications for structural purposes.

Widmann (2009) and Widmann and Beikircher (2010) studied structural behavior of thermally treated wood and the possibility to use the resistance classes system implemented in EN 338 to this kind of wood. The authors conclude that the values of the modulus of elasticity are similar or slightly higher than those of untreated beech, though bending strength values are quite lower which would put this wood in the resistance class D30. Another limitation of the use of heat treated wood as a structural material is also their greatest weakness in face of dynamic efforts, in particular due to its more crumbly behavior than solid wood (Almudena et al. 2010). Another problem might be the incorrect determination of some wood properties. Widmann and Beikircher (2010) reported that some of the procedures in European standard EN 384, to determine some mechanical properties of solid wood, could not be applied to the modified wood. If an incorrect classification of this wood is made problems will certainly arise. Once acetylation or furfurylation of wood does not decrease significantly the mechanical properties, they can be used for structural purposes depending on the original wood. The only problem is the final cost of treated wood that makes it unfeasible for this kind of use.

The use of wrong adhesives created for untreated wood might also lead to failure. Most commercially available glues, used in the manufacture of glued laminated timber for structural purposes are not suitable for Acetylated wood. However in accordance to Bongers et al. (2010) glue systems can be adapted to obtain good results.

Modified wood has hydrophobic surface and so normal waterborne adhesives perform worse than on untreated wood. In accordance to Mayes and Oksanen (2002) the absorption rate of adhesive and water into the wood is decreases and so when working
with PVAc adhesives and heat treated wood, longer pressing times than normal are needed. If MUF or RF adhesives are used, the normal production parameters (pressing time, pressure, etc.) can be used. In accordance to Sernek et al. (2007) the shear strength of the glue line decreases with increased treatment temperatures but high wood failure percentages (90–100%) occur in the wood rather than in the glue line. Jonnes and Hill (2007) stated that phenol resorcinol formaldehyde (PRF) and polyurethane adhesive (PU) are adequate for acetylated wood, and that delamination tests were successfully carried out by Tjeerdsma et al. (2007) meeting criteria for exterior use in Climate Class III scenarios. Moreover these authors reported that furfurated products are described as behaving in similar ways to tropical timbers. Wepner and Militz (2005) stated that timber treated using the Belmadur process is suited for bonding. The correct adhesives have to be used in order to obtain the best of modified wood and to induce a high confidence on the performance of modified wood.

Furthermore wood connections have to be adjusted to treated wood and the correct accessories must be used. Heat Treated wood is considerably more brittle than untreated wood and so nailing and screwing has to be done carefully. In accordance to Mayes and Oksanen (2002) splitting of the material can be avoided by using self-tapping and countersinking screws or by pre-drilling the holes. Although for Thermowood galvanised steel nails are considered suitable, for Accoya, they are not recommended.

CONCLUSIONS

Modified wood is now a commercial reality, but its correct use still limits its potential as a viable manufacturing material. Whilst the understanding of its properties is increasing, there needs to be a transfer of correct, pertinent information to designers and end-users. Educational methods need to be addressed throughout the education system to increase the understanding of modern materials such as modified wood and how they can contribute to a more sustainable society.

Increasing the promotion of good design through specific awards, establishing specialist training of professionals with experts in modified wood and collaborating the writers of design manuals will help define the uptake of modified wood as the material of choice for many uses where stability and durability are key factors. The provision of information linking the service life, whole life costs and life cycle assessments is critical to this promotion.

REFERENCES


