Development of an application and climatic condition based wood modification portfolio

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ABSTRACT

The purpose of this paper is to present an alternative view and approach to developing wood modification solutions to different applications and climatic conditions. Traditionally softwoods have been preserved using a relatively simple and broad brush processes such as CCA or other metal containing impregnations with a very general end use in mind and little or no climatic condition differentiation. This paper builds on the very good outcomes from the Woodwisdom project "WoodExter" where factors such as macro, meso and micro climatic conditions where closely studied and modeled to create a tool to determine guidance for designers and industry professionals. When considering the very large variations in risk levels facing wood products in different applications and regions it becomes clear that the development of a far more fit for purpose portfolio of modification products is needed. Through extensive research and development and greater market insight Stora Enso aims to develop its portfolio further. The evolution has moved from the basic preservative treatments to thermal modification and the most recent solution being a hybrid between impregnation and thermal modification. In certain regions of Europe the natural resistance of untreated spruce or pine heartwood provide excellent "fit for purpose" performance in applications such as exterior cladding and joinery especially when a suitable coating system are applied. However in other regions of Europe, where the relative humidity and conditions conducive to mould and fungal decay are higher, alternatives are clearly needed. Understanding the macro, meso and micro conditions our products will be exposed too helps us to target our products to ensure best possible performance and customer satisfaction. The paper will present Stora Enso's view of segmentation by climatic condition classes and applications and present how we then see a future wood modification portfolio.

INTRODUCTION

Understanding the conditions of use "Macro, Meso and micro climate"

One of the most significant outcomes of the Woodwisdom "WoodExter Project" which ran from 2008-2011 was a far greater understanding and subsequent description of the conditions which wood products in external above ground contact applications are exposed to. The impacts of the wider climatic conditions of the region (Macro), the local conditions such as shading, trees, close surroundings (Meso) and the actual point where the wood product is used such as joints, contacts with other materials and exposure to water traps (Micro). Wood has been used for thousands of years as an excellent building material but over the years the understanding of how and where it should be used has

been lost and as a result of global trade different species and wood products has been taken to areas where conditions are more severe in end use (Macro conditions). Another significant finding in WoodExter was the intrinsic link between Macro, Meso and Micro climatic conditions and the performance and expected service life of the wood product. With this greater understanding performance based design (PBD) modeling is now possible to develop. During the project four primary Macro climatic exposure regions were defined, as listed below.

- **Continental Europe**
- **Nordic Climate Zone**
- **Atlantic Climate Zones** (Coastal regions higher risk in southern parts than Northern parts)
    - South of latitude 50
    - Latitude 50-55
    - North of Latitude 55
- **Mediterranean climate zone** (South of Alps)

These exposure regions were then assigned a numerical figure based on the level of severity of conditions, such as annual rainfall, exposure to sea salt laden rain and wind, ultra violet radiation etc. Conditions which support rapid growth of molds and decay fungi where considered the highest risk regions. Atlantic climate zones generally getting the highest numeric classification.
The following definitions were made in relation to the Meso climate that the wood product is exposed to.

Rating	Description
Light	Local conditions have little impact on performance as the three features all offer sheltering (i) land topography (ii) local buildings (iii) >5km from the sea (no maritime effect)
Medium	Local conditions have some impact on performance as one of the three features does not offer sheltering (i) land topography (ii) local buildings (iii) >5km from the sea (no maritime effect)
Heavy	Local conditions have impact on performance as two of the three features do not offer sheltering (i) land topography (ii) local buildings (iii) >5km from the sea (no maritime effect)
Severe	Local conditions have significant impact on performance as none of the three features offer sheltering (i) land topography (ii) local buildings (iii) >5km from the sea (no maritime effect)

Finally some specific detailing condition classes were created to enable numerical classification of the Micro Climatic conditions that the wood product could be exposed too, the following tables outline the micro climatic design example conditions for timber decking and cladding products. The Excellent rating assigns the lowest numeric value and the poorest the highest.

Rating	Example details (Timber Decking)
Excellent	Vertical element free to dry on all sides
Good	Horizontal board free to dry on all sides (e.g. with sufficient gaps between boards in a decking)
Medium	Larger contact area side grain to side grain with sufficient gap if clean from dirt
Fair	Horizontal and vertical contact area side grain to side grain without designed gap or with too narrow gap
Poor	Horizontal and vertical contact area side grain to side grain and end grain to end grain with no drying gaps

Rating	Example details (Timber cladding)	Coating effect not guaranteed	Coating effect very well maintained
Excellent	Cladding board profiles sloped to shed water, and with a designed ventilated cavity behind the boards	0.8	0.5
Good	Boards with ventilated cavity behind	0.9	0.6
Medium	Vertical end to end grain joint, or end to side grain joint sealed	1.1	0.9
Fair	Vertical end to end grain joint, or end to side grain joint, unsealed Horizontal end to end grain joint, or end to side grain joint, sealed	1.3	1.0
Poor	Cladding board profiles hold standing water and are mounted directly onto render. Horizontal end to end grain joint, or end to side grain joint, unsealed.	1.5	1.2

With the numerical data from each condition of exposure it was possible to formulate a combined figure for the specific product in its point of use. With this figure a simple service life calculation was possible when introducing other factors such as natural durability of the substrate and intended application.
The work carried out in the WoodExter project provided the basis for a valuable tool to be developed. As an industrial partner in the project we found the process of both giving guidance to the research and also learning from experts in the field extremely useful and it enabled us to apply a lot the findings to our own wood modification development and strategy formulation.

RESULTS

Applying the findings of WoodExter and past wood modification experience in product and portfolio development

Stora Enso has been involved in either wood preservation or modification for many decades. The origins of our involvement were based on utilization of pine sapwood for impregnation with traditional preservatives such as CCA or creosote. In the Nordic region also Norway spruce (*Picea Abies*) has been a mainstay building material as a cladding board in the majority of single family homes and continues today to be the most commonly used material, with a good price to performance ratio. To a certain extent as a result of some of the broad brush wood preservations, understanding of where and how to use certain wood species has been lost due to the high effectiveness of the chemicals to resist decay and this subsequently influenced on inappropriate design and installation. In many cases today the technical performance of wood products in externally exposed conditions remains good, but often replacement or maintenance is carried out due to the aesthetics. During the early 2000s Stora Enso embarked on a new

era of wood treatment as a strategic development area to value add and improve the overall position of softwood as a building material. We were one of the pioneering producers of the ThermoWood (Thermally Modified Timber) material and at the same time developed processes to grade logs and extract pine heartwood material to utilise in the production of engineered window components which are produced to ensure that the most critical parts of the windows have the heartwood material exposed. We have continued to invest significantly in Research & Development in the area of wood modification and it remains a key strategic cornerstone in our business. We have seen increasing control and regulations impacting on the utilisation of the traditional wood preservatives and at the same time a reduction in the availability of high quality hardwoods. The potential risk is that applications which have traditionally been using wood are turning to non-wood products which in many cases have a poorer environmental position due to the energy intensity in manufacturing and possible end of life disposal issues. Rather than take a general approach to wood modification we chose to adopt the learning of the past and combine this with the very valuable data from WoodExter. When considering the different Macro, Meso and Micro climates in relation to specific applications and expected performance it has helped us to carry out multi-dimensional segmentation of the market and to then position specific materials, products and even tailor processes dependent on the needs of the market. The following chart describes an example of the top tier of segmentation based on the Macro climatic conditions, applications and some specific Micro climatic conditions. We then segment further to specific properties and functions and this helps us to further develop our products, knowhow and tailored portfolio.

Table 1: Example of multi-dimensional segmentation and portfolio development

Climate Zone	Painted Cladding	Un coated cladding	Private garden decking	Public sector decking	Public sector fencing	Factory Painted Windows
Nordic	Spruce cladding WoodHeart ThermoWood D	ThermoWood D New Product A	WoodHeart D ThermoWood	Q-Treat S-Treat New Product A	S-Treat	WoodHeart Thermowood S/D
Atlantic (Maritime)	WoodHeart New Product A	ThermoWood New Product A New Product B	ThermoWood X New Product B	Q Treat S Treat	S-Treat	WoodHeart ThermoWood D
Central Continental	WoodHeart ThermoWood D	ThermoWood D New Product A	ThermoWood D New Product A	Q Treat S treat	S-Treat	WoodHeart ThermoWood D
Mediterranean	WoodHeart New Product A	New Product A New Product B	WoodHeart D New Product B	Q Treat S Treat	S treat	WoodHeart ThermoWood D

Our segmentation and product development is not just based on hypothetical assumptions but actual field test data and *in-situ* product follow ups. An example of such field data is based on ongoing tests for laminated pine heartwood cladding boards with different coating systems. The test rigs have been on site at the BRE near London for nearly 5 years and monitoring of moisture movement, dimensional stability, visual defects and coating performance has been carried out. Results are very positive and give us the confidence to develop pine heartwood for cladding applications. In addition several windows using both Pine Heartwood and ThermoWood have been installed at the same test field since 2002. Again the performance has been assessed and the data used to develop our products and provide assurances to our customers. We have similar

tests and development going on in other parts of Europe including Göttingen in Germany and commissioned an extensive survey of reference projects in Spain and Portugal recently. All this data helps us to better understand our products and the variations in conditions that they are exposed too. The following figure shows some extracts from the ongoing study at the BRE.

Material used: Woodheart (pine heartwood)
Style: Horizontal
Preservative: None
Coating: Grey
Date installed: 19 February 2009

	12 May 2010	2 March 2011	14 March 2012
Coating performance	0	0	0
Surface dirt	0	0	0
Checking	0	0	0
Raised grain	0	0	0
Erosion	0	0	0
Surface mould growth	0	0	0

Rig	Mean	Max	Min
SET1 TWTH	14.4	41.5	8.8
SET2 TWGV	16.8	48.4	8.5
SET3 WHYV	12.8	23.6	8.9
SET4 WHGH	13.9	25.3	8.8
SET5 WRC	14.1	31.9	10.1

Table 1 Moisture content (%) data summary during Jan 2009 - Mar 2012

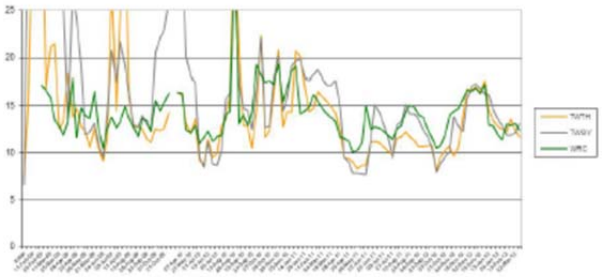

Figure 1: Extract from the Cladding field trial report from BRE, UK

CONCLUSIONS

As a conclusion we believe that by utilising the results from the Woodwisdom project WoodExter, working with leading research institutes, our customers and with our past experience and knowhow we have been able to gain a far greater understanding of the varying conditions that our wood products are exposed to in exterior applications. This has enabled us to refine or R&D focus to specific properties and conditions and for us to develop a more comprehensive and fit for purpose product portfolio. As we have learnt that in some regions such as parts of the Nordic region the conditions are less severe and this enable the use of wood species such as Norway spruce without the need for preservation systems, just a good coating system. We also learn that design and the Meso and Micro climate conditions play a very significant role in performance and service life. It is extremely important to pass on this knowledge to designers and users and to ensure that the products we provide are meeting and exceeding the desires of the final consumer. We also need to remain vigilant to the economic viability of enhancing the properties of wood so as to ensure the material remains competitive against non-wood products. Customers are also far more demanding today in relation to performance and reliability, it is very important that we know our own products and are able to guide how and where they can be used. Companies wishing to develop and promote new wood modification systems must be prepared to invest significantly into R&D and market development activities, without these two the process will be very difficult. Stora Enso remains committed to developing its range of modification solutions further enhancements of existing products and also totally new systems in the

coming years and look forward to our continued cooperation with the various research institutes around the World.

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