The Making of a Traffic Timber Bridge of Acetylated Radiata Pine

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INTRODUCTION

Two years ago at the Third European Conference on Wood Modification the initiative of the timber traffic bridges made of acetylated radiata pine was presented. In Cardiff (Tjeerdsma *et al*. 2007) the results were showed of the technical research following the development of the planned bridges. In 2009 the first timber traffic bridge of Accoya® wood has been built, placed at this location and intensively being used by the (heavy) traffic to cross the high way A7, connecting an industrial area with the rest of the city Sneek in the Netherlands. Negotiations are going on to build a second bridge.

In this up-date we will evaluate this unique bridge project within the context of the development of modified wood. What can the impact be of such a break through application of modified wood? What can we learn from this project? The whole process of design until making of and the first monitoring inspections are handled. The influence of the different decision makers on the course of action is described. The experiences of introducing a new type of wooden material in a chancy application could act as an example and inspire future decision makers and end users, such as architects, designers, constructors and building companies.

Figure 1: The timber traffic bridge made of Accoya® wood

Modification of wood opens a whole new and broad range of innovative or renewed applications for timber. Applications of which until now architects and designers only considered using steel, synthetic materials or concrete are now coming accessible. The

initiative and implementation by the province of Fryslân in the Netherlands to build heavy load-bearing traffic bridges of timber offers a unique chance for modified timber to demonstrate what will be possible using this innovative material. From an early stage on it was clear that this specific design of the traffic bridges, chosen by the local inhabitants in a contest, could not be build by the known natural wood species.

Wood modification industrialisation and market introduction of a new material

Before innovative developments reach maturity normally a number of critical phases have to be passed. It starts with an idea or philosophy. Fundamental study and research further expand the idea. A phase of lab trials and testing will be performed before pilot scale trials and demonstration projects are performed. Once investors have become interested the industrial development and market introduction of the products can commence. In this last critical phase it becomes clear whether it will be build-up to a stable branch of industry or it will slowly disappear through the backdoor.

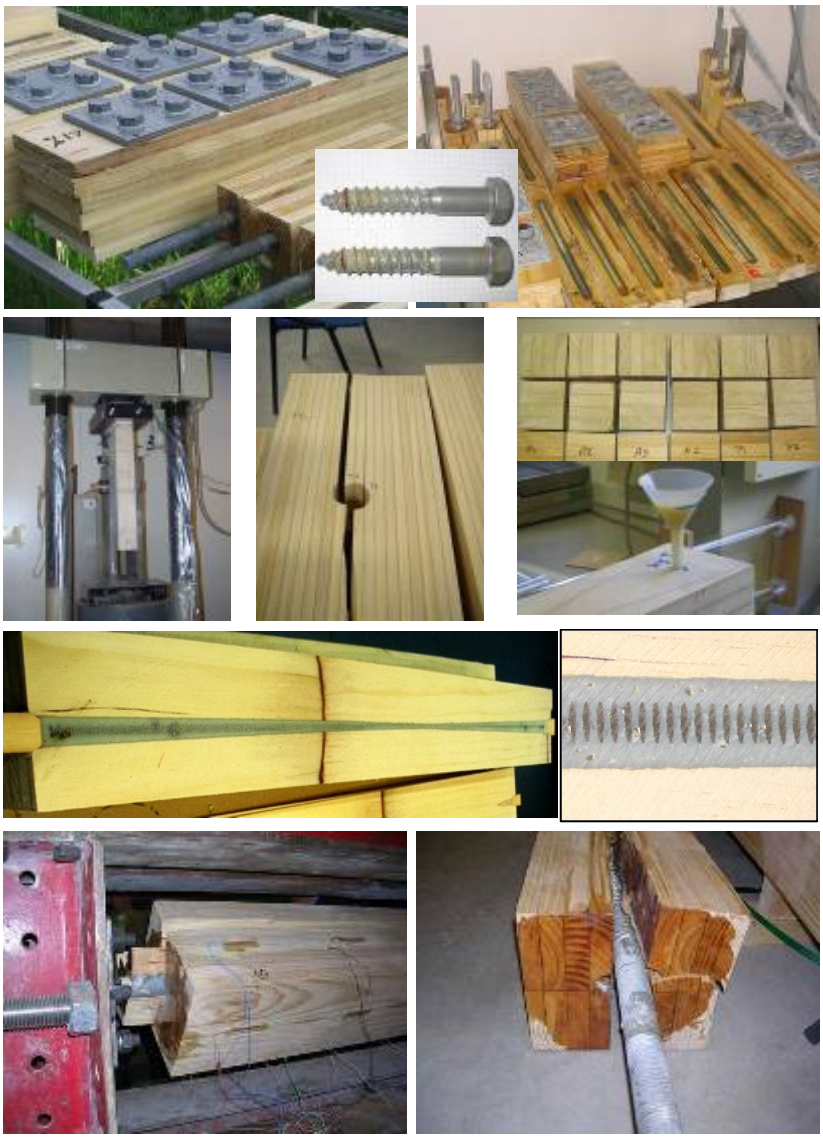

Figure2: Some of the test samples used in the extensive research and test program; corrosion test, mechanical testing of the wood, lamination and in-glued rod connections, resin injection trials.

Wood modification is a relative young and new twig on the tree of industry. Although some of the original ideas date back as far as the beginning of the previous century, only in recent years we are now witnessing the first industrial developments. Of the two main groups, thermal and chemical wood modification, the industrial development of the first had started earlier and this group has grown in the last decade to a considerable number of industrial production sites. In more recent years also the first industrial production sites of chemical wood modification plants have seen the light of day. Other types of wood modification methods or in the phase of pilot plant scale development and many others are being developed in research labs all over the world. But considering the actual production quantities, modified wood still engages only a small fraction of the total wood production and consumption numbers. We could question why wood modification still did not reach a higher level of industrial development or higher production numbers. At this moment it is crucial to consider what important steps have to be taken to bring it to the next level of maturity. What obstacles are on our way and what hurdles need to be taken to make this development besides a scientific also to an economical success?

The call on radical change towards a more sustainable society becomes louder and louder. More and more important and influential players become convinced that they have to act now. Within this transition towards a more sustainable economy, wood modification can be one of the constructive contributions. If we believe that wood modification offers a sustainable answer to our growing needs for sustainable materials we should find ways to give it also a solid economic base. For the development of acetylated wood as one of the promising examples of modified wood this unique bridge project could mean a break through in market acceptance of this new type of material into a growing market pull and increased production potential. Sometimes an unconventional and high risk step needs to be taken to open up a new possibility. Making a traffic bridge for the heaviest traffic class in an avant-garde design with a new type of material, is such an unconventional and high risk step. What can we learn from this project and what aspects are interesting to evaluate with respect to positioning and marketing of modified wood.

Why wood?

First of all we could ask ourselves the question why is this traffic bridge made of wood and not of the usually used material; concrete. This design with wooden traffic bridges as flyovers over the high way was one of three competing plans send in for a new to build high way near the city of Sneek. Although it was controversial, eventually the jury chose the design with the wooden traffic bridges because it was special, unlike others, unique architecture and above all the warm appearance and feeling of the material wood. Again this underlines that *one of* and in many cases *the* most important criteria for decision makers to chose for the material wood in comparison to other potential materials like concrete, steel, aluminium or plastics is the highly appreciated aesthetic value of the material wood. This is reason number one to consider when we position modified wood; *emphasize the aesthetic value of wood*.

Why modified wood?

The other question we could ask ourselves is; why is this traffic bridge made of *modified* wood, or more specific of the acetylated wood; Accoya® wood. This can be answered by the unique opportunities which modification of wood offers due to improved material properties. This design was not possible to be build with natural

wood species. The required combination of durability, glue-ability, dimensional stability, strength and density united in one accessible wood species could not be found. The exceptional dimensional stability in changing climatic conditions (little swelling and little shrinkage) of this durable wood makes it possible to create large constructions that are dimensionally stable and reliable. Accoya® wood weighs only 510 kg/m^3 which makes it twice as light as most of the tropical hardwood species.

It is at this point where the best opportunities are for successful introduction of modified wood. Encourage the unique selling point of modified wood. By this it can open up new application areas where specific material properties are required, so it will not have to compete directly with existing materials for price, availability or conservatism by holding on to traditional material use. Imitating existing materials and production processes is going the hard way. Finding our own way with modified wood will provide more freedom and the best chance that both technical ability and economical prospect will assemble. The best route to go is to explore applications where the special material properties of modified wood open new possibilities or provide a higher added value.

The bridge project

This bridge project has a long history and we can distinguish many stake holders who played an essential role in the realisation of this bridge. From regional and local authorities and politics, to civil engineers, architects, constructors, researchers, experts to the industry, to eventual the consortium of companies performing the job. In the course of this project a book has been made in which the whole process of realisation and the specific experiences of the many different players is described. Some particular experiences are distilled from this book and summarized below

Authorities and local politics

This project would not have been realised if the local and regional authorities did not showed their guts by supporting such a risky undertaking all the way. Even though there were many moments along the way when it appeared that the difficulties could not be solved. Many uncertainties were compensated by thorough studies and consulting different experts. At an important moment of decision making the production plant of Accoya® wood by Titanwood still had to built. The will to achieve something out of the ordinary prevailed. Modified wood offered them the opportunity to realise a unique landmark in a larger plan to promote the city as an attractive area to live in and for water tourism.

Architects and constructors

In order to realise a design both architect and constructor are needed. The architect develops the form and determines which functional demands the design should full fill. The constructor determines how this design constructively should be realised and which materials to be used. In 2004 the architect Achterbosch asked the constructor Lüning if he could help him to further structure this design. The question was can this design be realised in wood, can this bridge be constructed? Although the constructor has many experiences with constructing wooden bridges, this design was never seen and considered unique. For the architect and the constructor the Sneek wooden bridge project was a challenge to work on.

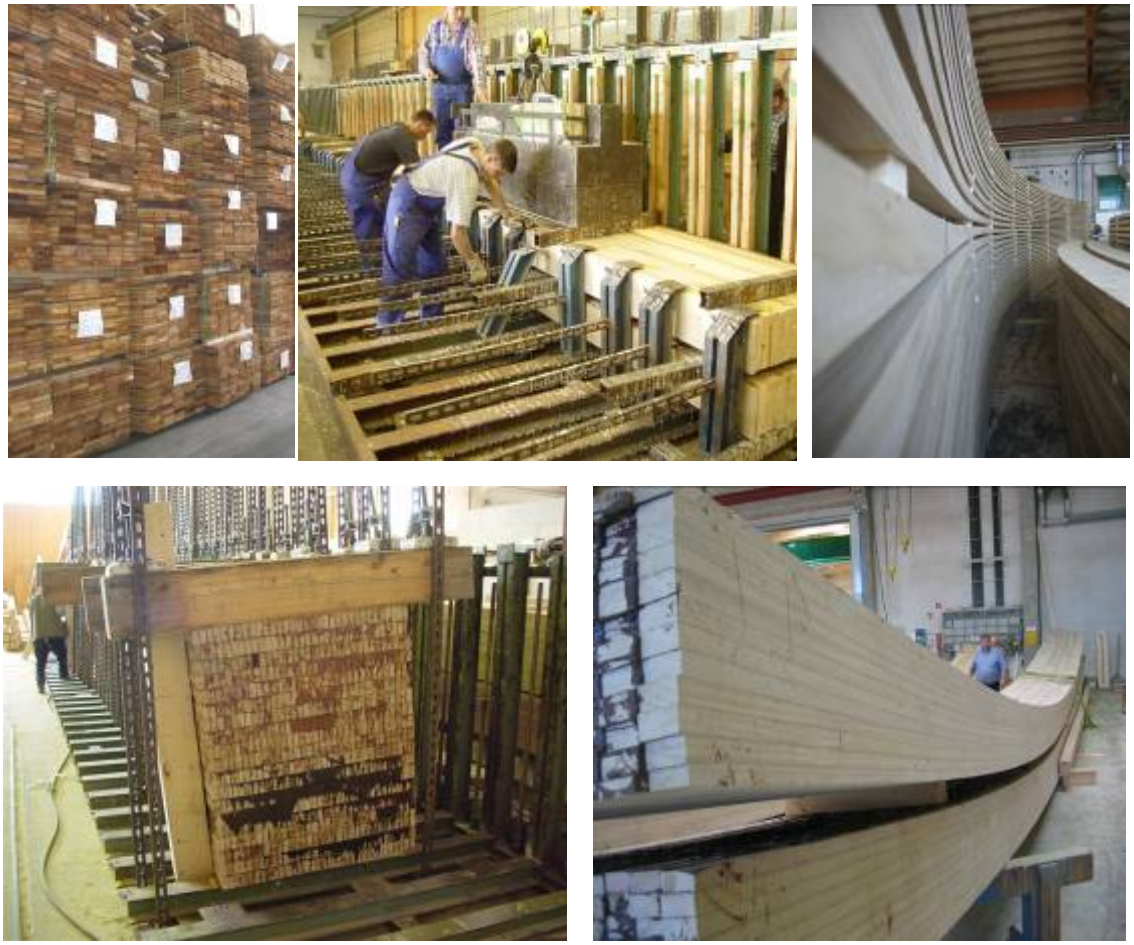

Figure 3: Two step lamination at Schaffitzel; For constructional reasons the wood is laminated in two phases. The acetylated planks are first machined into beams of 1.08m height(photo's above) which are rip-sawed into 60mm thick planks with a width of 1.08 metres. Then they are glued in another direction and formed into straight, curved and twisted beams measuring 1.08 by 1.40 metres (photo's below)

Research and technical team

The expected life span of the bridge was required to be 80 years. Research revealed that these life expectancies of that order are possible and were shown in practice. However that degree of durability only could be reached by chemical (toxic) preservation or constructive adaptation by covering the bridge, in order to prevent wetting of the wood. Criteria with respect to sustainability were dominant in the process of decision making. Chemical wood preservation was not considered as an acceptable option. Covering of the bridge would mean an unacceptable change of the original design. In the search for an alternative, acetylated wood appeared to be a comprehensive solution. SHR Timber Research could provide convincing confirmation by complete test and demonstration results achieved over the last 15 years. Titan Wood had just achieved a break through by successful re-engineering of the acetylation process to an industrial scale with good economical prospects (Kattenbroek 2005, 2007). The building of the industrial plant had commenced and acetylated Radiata pine under the brand name Accoya® wood was launched.

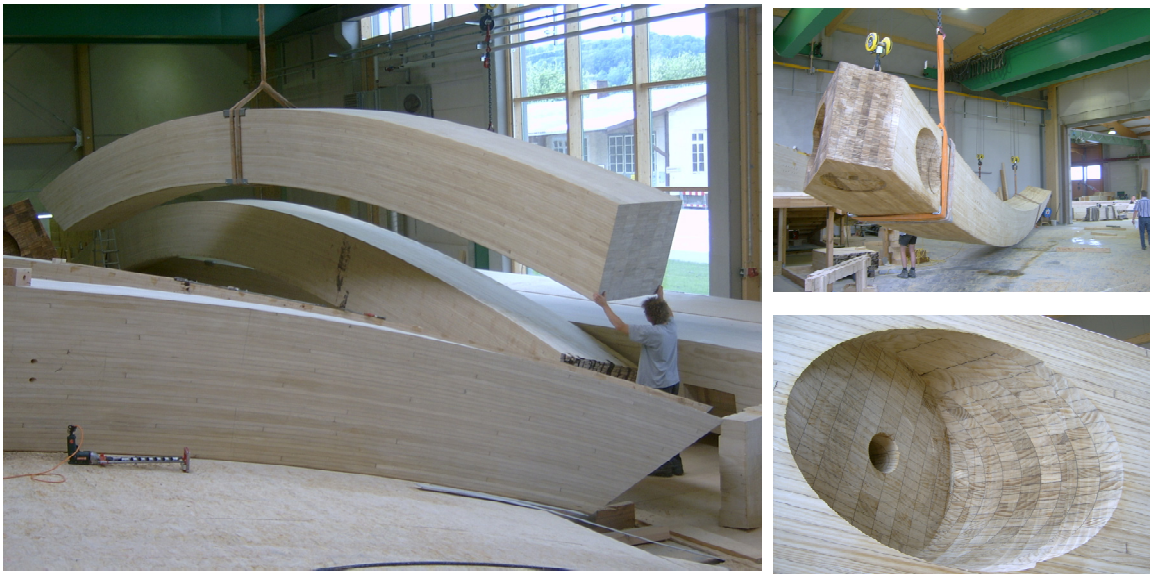

Figure 4: Elements with cross cut of 1,4 by 1,1 meter, double bended. Profiled for specific rotating connection between the horizontal carrier and the vertical pressure bow.

Accoya® was offered to the technical team of experts as alternative. Various studies and testing were performed to find out what *was* and what was *not* possible. During these studies many times the ceiling of what is technically possible was reached. Eventually it was concluded that this design could be made using Accoya® wood and by that a barrier was crossed. The main part of the performed research and testing has already been presented at the ECWM3 in Cardiff in 2007 (Tjeerdsma *et al.* 2007). Comprehensive results were achieved on the mechanical testing, industrial stress grading, glue-ability, dimensional stability and water up take, corrosion testing, testing of the specific joints of in glued rods and coatings. This valuable data was made available to the builders of the bridge, lead by the German wood constructing company Schaffitzel.

Building consortium

Although Schaffitzel has a long and extensive record of building wooden, the project was characterised as exceptional due to many reasons; on the first place the unusual design of the bridge and on the second place the new type of wood material. The practical experiences the builder has acquired with processing this new type of material is very valuable for future industrial processing in similar but also in other application areas. Never modified wood has been industrial processed on this scale. Industrial stress grading, quality control and logistics, profiling and lamination, bending and block lamination, assembling and coating. It appeared to the builder that this new type of material clearly distinguished itself compared to spruce or larch. As an example the builder mentioned the low moisture content of Accoya® wood which gave them some surprises with profiling and drilling. In stead of the normal wood shavings these operations delivered finer wood particles. Due to this reason the handling of the wood shavings was completely different. The quality of the wood surface after profiling and the almost absence of knots in the basic material were regarded as pleasant aspects to work with Accoya® wood.

Figure 5: Assembling the elements of the bridge on a location near the high way A7 in Sneek. All parts are assembled with glued-in threaded rods, which have substantial metric studs to a girth of 48 mm. An important matter was the connection of the rod ends that were finally secured into the wood by way of injection with an epoxy glue

Monitoring program

In order to observe the performance a monitoring program has been set up by SHR. Part of the monitoring program is a periodic visual inspection of the wood and coating quality, the lamination glue lines and the connections of the elements with the in-glued rods. The other important parameter on the performance of the modified wood in this bridge is the moisture content of the wood on critical positions in the wood construction. The wood moisture content is monitored by measuring the moisture content with a capacity moisture meter during the periodical inspections. On critical spots with regard to weathering and moistening of the wood and on inaccessible locations of the bridge special sensors are placed to measure the wood moisture content electrically.

The exact moisture content of Accoya® wood cannot be measured with standard moisture meters (capacitive / electric) because the moisture content of Accoya® wood is below the measuring range. The standard wood moisture meters may be used to determine whether Accoya® wood has become wet (has an excess of “free-water”). If the moisture meter (electric or capacitive) shows a moisture content of more than 10%, than there is non-bonded water (“free-water”) present. For this measurement the precise setting of the moisture meters is not important. All moisture measures with Accoya® wood have to be considered as indicative, but for he purpose of monitoring the wooden bridge this is adequate. The purpose of measuring the moisture content in this context is to supervise if any excessive water accumulation appears in the wood as a result of failure of the coating, formation of (large) cracks, delamination or opening of the joints.

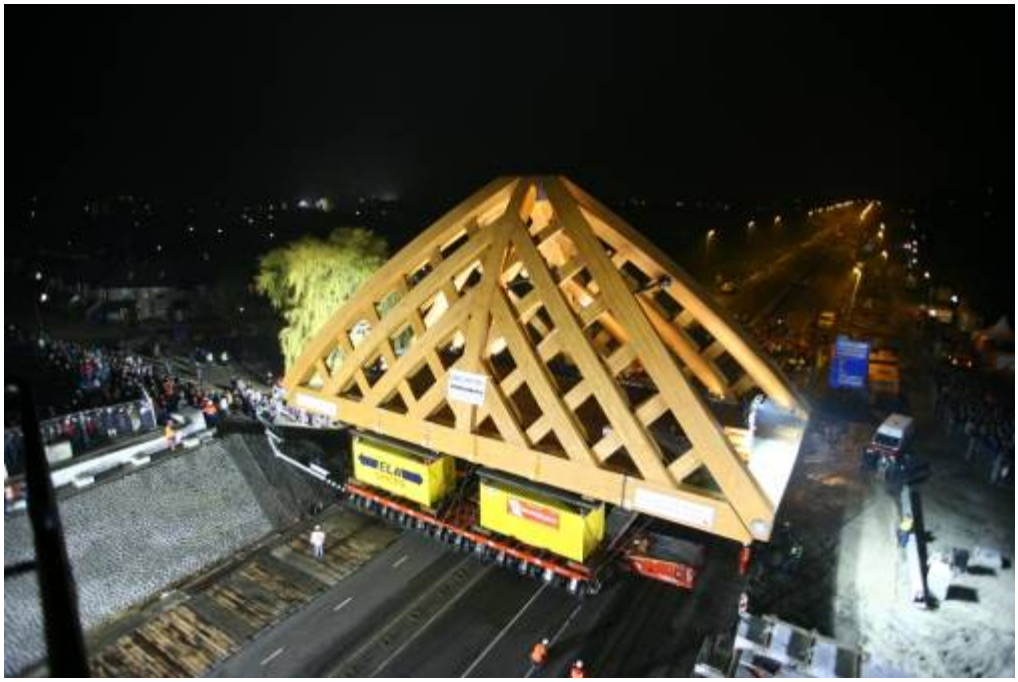

Figure 6: Transportation of the bridge to its final location over the high way A7 at Sneek

Real life experience

In November 2008 the constructive wooden elements were assembled nearby the final position to the bridge and ultimately transported to its final destination. It might be clear to anyone that these type of wooden bridges never will become a commodity product. In that sense this should not be the focus on the use and possible application areas for modified wood. However it can make a statement for future use of modified wood. Building such a bridge in this unique project does not prove that this will be a technical and economical viable application for modified wood. The building phase now has been finished and an interesting period has started in which valuable data will be delivered on the performance of Accoya® wood in such a high demanding application.

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