Application and quality requirements for (tropical) hardwoods

A. Wesselink[1], G.J.P. Ravenshorst[2]

[1] Wijma Kampen, Kampen, The Netherlands, [2] Delft University of Technology, Delft, The Netherlands
[1] A.Wesselink@wijma.com, [2] G.J.P.Ravenshorst@tudelft.nl

INTRODUCTION

In the Netherlands tropical hardwoods are used for several applications, the use in road- and waterworks being the most important structural application. To be able to build these structures the following aspects have to be considered:

- To determine the requirements for the structural elements (e.g. beams) of the different products/applications.
- To obtain the raw material
- To determine the physical and mechanical properties of the material.

For hardwood these steps require different knowledge and actions in comparison to the application chain of softwood. The Dutch timber traders are specialized in working with those conditions. This paper provides an insight how these aspects, mentioned above, are considered and put into practise by both the knowledge of the Dutch timber trader in hardwoods and scientific research.

PRODUCTS FOR ROAD, WATERWORKS AND BUILDINGS.

The Netherlands is a country with a large number of big and small waterways (canals and rivers). This requires a number of constructions where tropical hardwoods are used for. These are lock gates, sheet pile walls, (pedestrian) bridges, mooring posts etc. Meanwhile, for same reasons as strength, fire resistance and life span same species are often used in buildings for galleries, columns and decking.

Figure 1: Manufacturing and stepping in of hardwood lock gate


Figure 2: Use of hardwoods in buildings (left) and pedestrian bridges (right)

RETRIEVING OF HARDWOODS

History

The use of tropical hardwood in Holland increased a lot after the war for rebuilding purposes, because timber was being asked for more and more. The Delta Works in the Netherlands made the use of several hardwood species with a natural high durability and strength even more popular throughout the whole of Europe and even beyond.

Until after WW II Wijma has been working with horses to drag the trees from the forest to the mill. At first Wijma, like many others, concentrates on the purchase and machining of oak, beech and other native species which are bought in the Netherlands and for instance in France. The trade in soft wood was also not avoided. Later the industry aimed on the importing and machining of tropical timber. New sawing skills and adjusting the machinery are necessary. The availability and knowledge of tropical timber leads to a range of new initiatives and products. Bridges, pontoons and lock gates are manufactured for civil engineering projects. Meanwhile a lot of products and projects for building purposes are realised. Knowledge about and working with these hardwood species and their machining and usage is essential.

This is why the Dutch hardwood industry – united within the Dutch Timber Federation VVNH - is involved in carrying out projects throughout the entire world using today many precious and durable hardwood species from Africa, Asia and Latin America.

For Wijma it is ranging from a piece of Art in Amsterdam to the Queen Emma pontoon bridge in Willemstad (Curaçao), from Disneyworld in Orlando to Huis ten Bosch in Nagasaki and the new Olympiahafen at Rostock; from the Seebrücke pier in Kellenhusen (Germany) to boardwalks in Dublin and Ostend in Belgium.

Figure 3: Pontoon bridge in Willemstad (Curaçao)

The origin of timber

In Table 1 origins of hardwoods species that are imported by Wijma is listed. Each species of timber has its own unique mix of mechanical and physical characteristics.

Table 1: Origin of wood species

Wood species	Origin	Wood species	Origin
Acajou	Central Africa	Afzelia	Central Africa
Angelim Vermelho	Latin America	Azobé	Central Africa
Bangkirai	Asia	Basralocus	Surinam /Guyana
Bilinga	Africa	Cloeziana	South Africa
Cumaru	Latin America	Dabema	Central Africa
Demerara Greenheart	Guyana	Framiré	Central Africa
Ipé	Latin America	Iroko	Central Africa
Jatoba	Latin America	Makoré	Central Africa
Massaranduba	Latin America	Merbau	Asia
Movingui	Central Africa	Mukulungu	Central Africa
Oak	Europe	Okan	Central Africa
Padouk	Central Africa	Piquia	Latin America
Sapelli	Central Africa	Sipo	Central Africa
Tali	Central Africa	Tatajuba	Latin America

Basics of sustainable forest management (SFM).

For the life span of the structure the circumstances under which the timber is retrieved is not relevant, but with respect of legally and / or sustainable produced timber at the source it is important to specify requirements on this issue as well.

A natural forest in Africa has 100 different trees per hectare of various ages and sizes. The top layer of the canopy by mature trees creates a shadow which temporises the vitality of other

plants and trees considerately. Only dead trees can be replaced by others to fill the caps in the canopy.
Prior to start working in the area a complete inventory of the concession identifies which trees are to be harvested or which are to be protected like for example endangered species or seed trees as they will provide seed for new seedlings. Working trails are set out carefully to avoid as much possible damage to the forest and sensitive areas are well identified to avoid at all. In the next sections different certifications for sustainable forestry are discussed.

Figure 4: Selective logging with reduced impact on the forest

FSC certificate- Inspecting the chain of custody

Wijma Kampen B.V. has been approved by SGS Qualifor to supply several timber species with the FSC trademark. The Chain-of-Custody number for Wijma Kampen B.V. is SGS-COC-0790. The Forest Stewardship Council is an international non-profit network for promoting responsible stewardship of the world's forests. Forest owners, members of the timber trade, environmental groups and representatives of the local population work together to improve forestry management over the whole world. One of the main objectives is to see the production of timber take place in an economically viable manner which is also ecologically and socially responsible and beneficial.
The FSC does not inspect forest operations or manufacturers itself; this is carried out by accredited certification bodies under the auspices of the FSC. Certification goes beyond mere forest management: every link in the chain of custody is inspected.
For more information see the references.

Keurhout-Sustainable

Timber carrying the Keurhout-Sustainable hall mark comes from certified sustainable-managed forests. Keurhout's Board of Experts reviews certificates for sustainable forest management in the light of the minimum requirements for certification and sustainable forest management as set down by the government of the Netherlans. Wijma Kampen B.V. cuts azobé (Ekki) in Kampen the Netherlands with Keurhout-Sustainable from logs out of Gabon. Keurhout participant number of Wijma is KH 0141.

OLB quality mark -Proven origin and legality

The OLB certification and control system (Origine et Légalité des Bois ©, Eurocertifor-BVQi 2004) specifies all the requirements which forestry operators need to meet in order to receive a certificate of guarantee for the origin and legality of their timber. This standard also covers the entire Chain of Custody from forest to finished product.

Wijma Kampen B.V. is able to supply timber species as Azobé (Ekki), Bilinga (Opepe), Iroko, Khaya, Okan (Denya), Sapeli and Sipo carrying an OLB declaration, under Certificate number OLB-CERT-040701.

THE ROLE OF THE TIMBER TRADER AS ADVISOR FOR HARDWOOD TIMBER TO BE USED IN STRUCTURES

Because of this expertise and ability to come up with a specific answers to any practically-oriented question regarding timber and its use, the timber producer or trader is often consulted by wood-processing companies, architects, engineers, contractors and governments.

A good detailed design is essential for the life span of a construction. Timber being a natural material can be different regarding their characteristics each piece. Usually every construction is different as well and will suffer from various loads. In order to work with these variables several standards are applicable in the Netherlands for all load bearing structure members.

Standards are changing in time and for each species additional requirements may be applicable.

Following physical and mechanical properties will have an influence on a solid and good construction:

- Natural durability (class I - IV);
- Strength - softwood (C classes) and hardwood (in several D classes).
- Cross grain related to size and construction. Much cross grain in combination with sizes < 40 mm may cause unwanted deformation);
- Easy to work with or not (planing, cutting, gluing);
- Fixations (type of fixations and distances).

Hardwood and hardwood construction suppliers are always interested to provide a part of the solution, be it advice (in a building team), preparing drawings, supplying responsible produced timber or prefabricated constructions, assembly, fitting...

The timber traders are naturally focussed on solutions, experience, with a high level of expertise and practically oriented: the hardwood timber industry is the logical partner for every customer who needs to use timber structures in a civil engineering project or in a building project.

PHYSICAL AND MECHANICAL PROPERTIES OF HARDWOODS

Collection of the properties of a wood species

To use hardwoods in waterwork structures different properties of the timber have to be known. The determination of these properties is gained by different parties:

- The supplier gains information about the processing abilities during manufacturing: the wear of tools, if the wood is easy or difficult to process, the warping of the wood.
- The end-user (the owner of the structure): for instance the resistance of the wood surface to scouring of ships.
- By researchers: the mechanical properties and durability by testing.

The wood trader and manufacturer of waterworks gathers information on all these aspects to be able to give a specific advice for wood species choice for a specific structure to the end-user. The next sections will outline the approach in hardwood research in the Netherlands.

History in hardwood research

In the Netherlands there is a long history in hardwood research. The reason for this lies partly in the colonial history (Suriname, Indonesia) and in the spirit of commerce that has always been present. This research is mainly performed in Delft at the TNO Wood Institute and the Delft University. The result of this many years' research is the "Houtvademecum"; in English "The Wood Manual". This manual is in possession of almost everyone involved in the Dutch Timber Industry. In this book for a large number of species an indication of the properties are given. These properties are based on tests on a limited number of small sizes of mostly clear wood. That means that for instance the listed mechanical properties of a wood species can not be used immediately for calculations, but are a good starting point to judge the potential of a wood species.

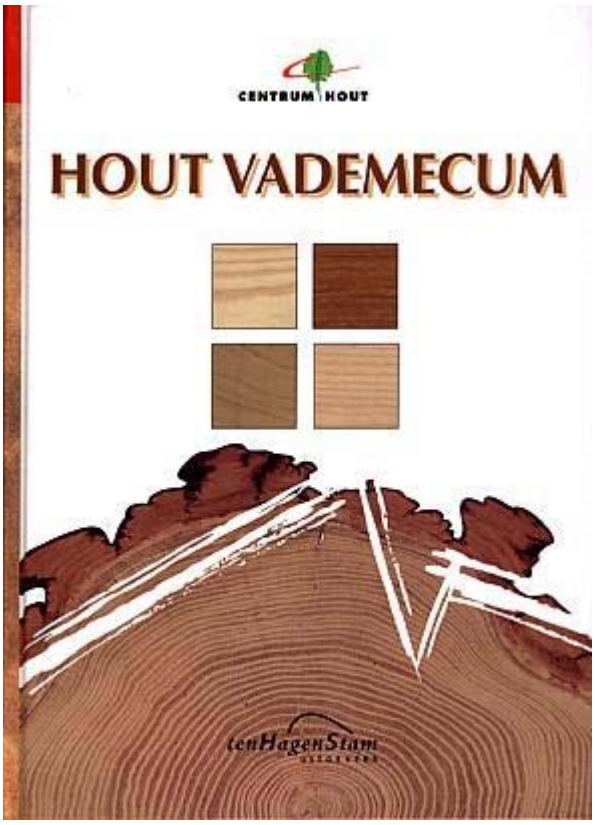

Figure 5: Front page of the "Houtvademecum"

Approach in hardwood research in the Netherlands.

Due to the demand to timber from forests that are environmentally friendly managed a large amount of so-called "lesser known" species are introduced to the Dutch market. These species are called "lesser known" because only the information from the "Houtvademecum" is known and not in practical use and for structural sizes. At the time of the introduction of a lesser known wood species only small amounts are traded. The effort in research has to be in relation to the amount of timber brought on the market.

For the strength properties the following strategy is followed:

- In waterworks timber with high strength is necessary. First the "new" wood species is scanned on its potential by literature like the "Houtvademecum"
- Then small amounts on structural sizes (a minimum of 40 beams is necessary to assign a species to a strength class) are tested. A penalty factor of 22% on the characteristic bending strength has to be applied because of the small sample size. See Fig. 2 for a typical failure for hardwoods in a bending test.
- When the wood species shows potential for a higher strength class and more timber of the species is traded then more tests are performed. Then there is no penalty factor is necessary and the wood species can be applied to be listed in EN 1912. This was done for the species azobé (ekki), which is now listed to EN 1912 as strength class D70.

Figure 6: Typical failure of a tropical hardwood beam in a bending test

Unlike for softwood, for hardwood species mostly only one visual grade in combination the assigned grade class can be used. For this reason visual grading rules for specific products like sheet pile planks, bridge decks etc. for waterworks were developed, but independent of the species. When used for structural uses, one set of basic visual grading rules (the most important are the limitations of knots and grain angle) always has to be fulfilled.
Table 2 shows strength classes that are derived for a species for one visual grade. The limitations for this grade are the same for every species.

Table 2: Strength classes of hardwood species used in the Netherlands

Wood species	**Strength class**	**Wood species**	**Strength Class**
Azobé	D70	Massaranduba	D60
Angelim Vermelho	D50	Karri (SA)	D35
Bangkirai	D50	Tali	D60
Bilinga	D35	Okan	D50
Cumaru	D60	Piquia	D40
Cupiuba	D35		

The species independent approach was also applied on strength models. It shows that there is a clear correlation between non-destructive measurements and the bending strength. See Fig. 7. With this information methods can be developed for evaluation of the strength of "new" hardwood species and for machine grading of hardwoods. It would also solve another problem,

the difficulty to recognize the botanical species to which to strength class is assigned to in practice.

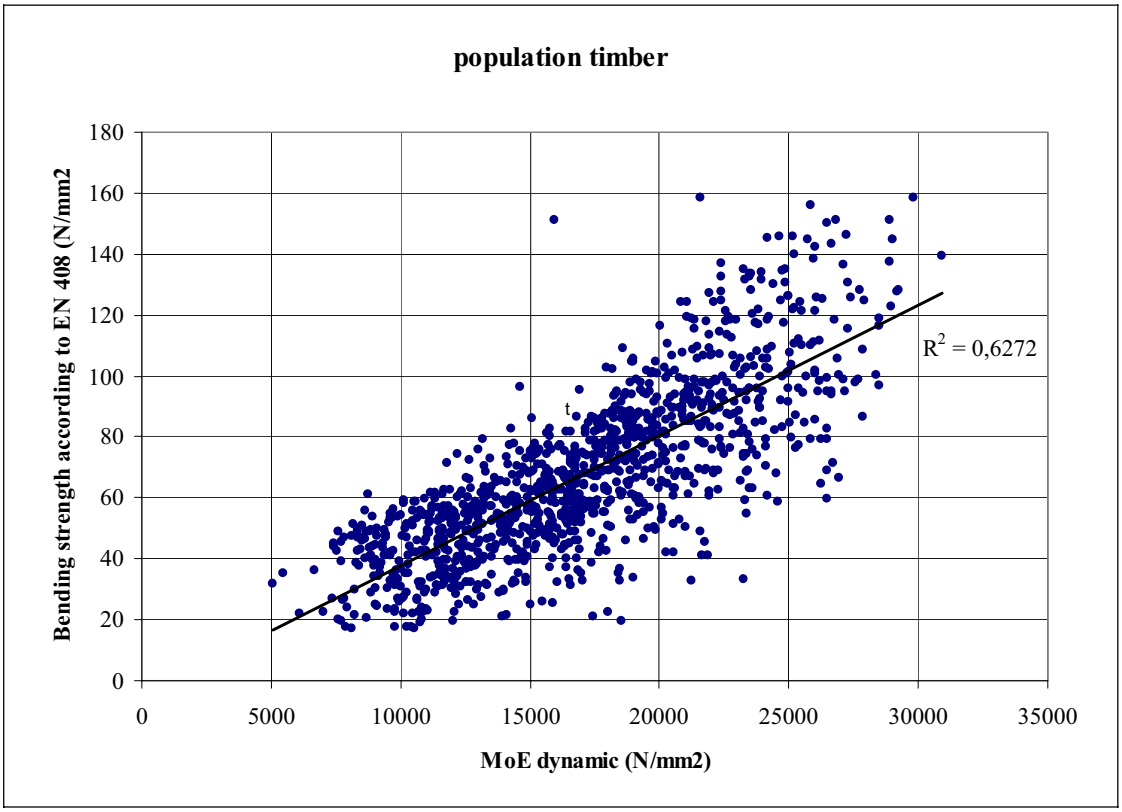

Figure 7: Relationship between non-destructive measurements and the bending strength with combined test results of a number of species

For waterworks a high durability is necessary, so when a wood species shows potential the standardised durability tests are carried out. For window frames the required durability depends on the manner the window is placed in the façade. Depending on the risk the cheaper and quicker mini-block test can be carried out. When the application is extended the testing can also be expanded.

A case study: the shear strength of hardwood species in bridge deck.

When this is required for the Dutch situation specific research is initiated to expand the industrial application of hardwoods. In the Netherlands hardwood timber is used where the beams are placed side to side with a span of approximately of 700 mm. For this situation the shear strength is the design criterion, instead of bending strength or bending stiffness, as in most structures. The shear strength according to the strength classes of EN 338 is derived from the bending strength. In this case arch action could increase the shear strength significantly. To study this 7 wood species were incorporated in a test program. The test set-up was a 5 –point bending test, with I-shaped beams to ensure shear failure. See Fig. 8. The general result of the study was that for this case the shear strength of the tested hardwood species was a factor 2 higher than according to the strength class they were assigned to. This result is only to be used for the specific situation of bridge decks. With this result hardwood species can be more economic used in bridges and also remain competitive with other materials.

Figure 8: Test set-up I-beams for determination of the shear strength

REFERENCES

Wijma: www.wijma.com

S.I. Wiselius, *Houtvademecum*, 2005, Centrum Hout, 9th edition

Ravenshorst,G.J.P. Van de Kuilen, J-W.G. Van der Linden, M.L.R.,Vrouwenvelder, A.C.W.M., 2004. An economic method to determine the strength class of wood species. *HERON.* Vol. 49. no.4. pp.297-326.

Van de Kuilen, J-W.G., Leijten,A.J.M., 2002, Determination of the shear strength of seven wood species for use in traffic bridges. *Report Delft University of Technology* (in Dutch)

Information on FSC: For more information please visit the website of *FSC International*: www.fsc.org, FSC Nederland: www.fscnl.org or www.wijma.com

Information on Keurhout: For more information please visit the website of *Keurhout*: www.keurhout.nl

Information on OLB quality mark :For more information, see the *Eurocertifor* website - BVQi: www.bvqi.fr or www.wijmadouala.com.