# Some specific Dutch wood end use problems and chances

R.K.W.M. Klaassen

SHR Timber Research, PO box 497 NL-6700 AL
Wageningen, The Netherlands
r.klaassen@shr.nl

## ABSTRACT

In this paper three situations specific for the Netherlands are explained.
First: In the Netherlands there is an increasing attention for the use of claddings made of planed softwood without or with a semi transparent coating. Because of our way of building and our climatical circumstances, frequently loosening grain and raising grain appear. The paper summarises the causes of both phenomenons as distinguished by a national research group.
Second: Large quantities of single timber species for the use in water building constructions and joinery are no longer available and alternatives have to be found. In the Netherlands the number of timber species used did and will increase. The Dutch experience dealing with the introduction of relatively unknown species like tropical hardwoods is discussed.
Third: The Netherlands is famous because of all the buildings standing on wooden foundation piles and during the last decade new knowledge was gathered on the processes of decay specific for this type of constructions. The paper will summarise these new achievements which enable us to predict more specific the degradation velocities in relation to location. This information was an important stimulant to increase the production and use of wooden foundation piles in the Netherlands, as wooden foundation piles are a good carbon dioxide sink. An estimation is given on the size of this sink for the Dutch situation as well as for the European situation.

## DUTCH CLADDINGS

The last years an increasing number of problems appeared with massive softwood claddings. Most Dutch cladding are made of softwood (Western Red Cedar, preserved European softwood). Raising grain, loosening grain, large cracks, large shrinkage and cupped boards are the main problems and were most obvious in flat sawn so called sideboards which are smoothly planed and exposed on the south-west and without or with an impregnating coating system.
A Dutch working group, with national experts (Mooiman et al 2007), investigated and analysed the problem.
Because of the natural behaviour of wood, sideboards are exposed on their heart side and therefore susceptible to loosening grain. Under the extreme exposure prevalent on the south west side the moisture content of the sideboards can change between < 8 % to > 20% resulting in a large shrinkage and swelling and therefore in large dimensional variations of the not or only slightly protected timber. A cladding construction will lose its coherency and on the yearring boundary cracks and differences in water uptake will appear resulting in loosening and raising grain.
Cladding is produced 'shipping dry' meaning a moisture content of 17-21% and after impregnation is dried to 14-18%.

At a south-west exposure the moisture content in the wooden claddings will be decreasing in dry periods until 6% resulting in a high shrinkage which is responsible for the introduction of the enlargement of failures in wood. It became obvious that before the placement of the claddings cell deformations and micro-cracks were already present in a part of the timber as a result of the process of planing, drying and sawing.
The working Group advised that the durable use of softwood in cladding with direct weathering exposure in the Netherlands can only be done when the following aspects are considered. Do not use flat sawn timber; use sawn timber instead of planed timber, which decreases the risks of failure (cracks, cell deformation); dry carefully, saw carefully (avoid crack and cell deformation); heart-side of the boards should be at outside exposed side of the construction in order to avoid the development of cupped boards and severe cracks; use timber with a moisture content of 10 -14%. Take measures to decrease or stop the water uptake but enable moisture dynamics (e.g. use a coating with high resistance to water transport); avoid at the sun side high temperature on the cladding surface (avoid strong decrease of the wood surface moisture contents) by using light colours of the coating; use small boards in order to reduce the shrinkage; seal the cross surfaces of the boards in order to avoid water uptake; a good ventilation behind the cladding construction is essential to avoid accumulation of moisture in the boards.
The working Group realises that because of esthetical reasons in building plans architect chooses claddings types which do lead to problems within one or two years. Therefore the architect should be actively informed about the behaviour of wooden claddings in strongly exposed constructions and about the guidelines given.

## INCREASING NUMBER OF TIMBER SPECIES

For centuries the Netherlands built with oak and softwoods and only after WO II tropical timbers were used on a large scale. With the increasing attention for the conservation of the tropical forest, the use of timber species changed. As in the seventies only a few species were used (e.g. azobe for water building constructions; meranti in joinery), at the moment many different species are used in wooden construction, from the tropics, from plantations but also softwood from the temperate zone and modified woods. None of these species can replace meranti or azobe in quantities and therefore the Dutch wood industry is forced to change their production process from a situation where a single or limited number of species is used towards a process where any species can be used.
From the tropics relative unknown species are introduced on the Dutch market together with European grown species from production areas which were not used before. In order to get an impression on building possibilities at lot of research was done in the Netherlands. For example, table 1 shows those timber species for which SHR determined durability and physical properties (SHR 1993 – 2008).

After the research phase timber species were selected for specific building purposes. It became clear that it is important to get experiences with these species before they can be used in large scale projects.

***Table 1: Overview of the test results from the SHR laboratory of the last decade on timber species. Legend DF: durability against fungi according to EN 113; DS: durability in soil contact according to ENV 807, PH: physical properties according to national standards SKH publication 97-04***

| ***Botanical name*** | **DF** | **DS** | **PH** | ***Botanical name*** | **DF** | **DS** | **PH** |
|---|---|---|---|---|---|---|---|
| *Aldina heterophylla* | | 1 | | *Manilkara spec* | | 2 | |
| *Alexa grandiflora* | 2 | 3 | | *Manilkara spec* | | 2 | |
| *Andira spec* | | 3 | | *Mezilaurus itauba* | | 2 | |
| *Aspidosperma desmathum* | 1 | 3 | x | *Micropholis guianensis* | 4 | | x |
| *Astronium lecointei* | | 2 | | *Milicia excelsa* | | | x |
| *Astronium spec* | | 2 | | *Ocotea costulata* | | 1 | |
| *Bagassa guianensis* | 1 | 1 | x | *Ocotea rubra* | 2 | | x |
| *bambusa* | 4 | | | *Ormosia spec* | 1 | | |
| *bambusa* treated | 1 | | | *Peltogyne catingae* | 1 | 2 | x |
| *Bucida buceros* | | 3 | | *Picea abies* | 5 | 3 | |
| *Calophyllum spec* | 1 | | x | *Picea abies* treated | | 1 | |
| *Calopyllum brasiliensis* | 3 | | x | *Pinus radiata* | 5 | | |
| *Carapa guianensis* | 4 | | | *Pinus siberica* | | | x |
| *Cariniana brasiliensis* | | | x | *Pinus sylvestris* | 4 | 2 | x |
| *Caryocar villosum* | 1 | 3 | | *Pinus sylvestris* treated | | 2 | |
| *Castanea sativa* | | 3 | | *Piptadenia macrocarpa* | | 2 | |
| *Cedrela odorata* | | | x | *Piptadeniastrum africanum* | 2 | | x |
| *Cedrelinga catenaeformis* | 1 | | x | *Pometia pinnatum* | 3 | | x |
| *Chrysophylum cainito* | | 2 | | *Populus spec* | | 2 | |
| *Clarisia racemosa* | 1 | 1 | x | *Populus spec* | | 5 | |
| *Copaifera spec* | 1 | | | *Pouteria guianensis* | 2 | | |
| *Cordia gladrata* | | 1 | x | *Protium altsonii* | 3 | | |
| *Couratari spec.* | 4 | | x | *Pseudopiptadenia psilostachya* | | 2 | |
| *Dillenia spec.* | 3 | | x | *Pseudotsuga menzenii* sapwood | 4 | 1 | |
| *Dinizia excelsa* | | x | | *Pseudotsuga menzenii* treated | | 1 | |
| *Dipteryx odorata* | | | x | *Pterocarpus spp.* | 1 | | x |
| *Dipteryx odorata* | | | x | *Qualea paraensis* | 1 | | x |
| *Entandrophragma angolense* | | | x | *Robinia pseudoacacia* | | 2-3 | x |
| *Enterolobium maximum* | 1 | | | *Roupala montana* | | 1 | |
| *Enterolobium schomburghi* | 1 | 2 | x | *Scleronema micranthum* | 2 | | |
| *Enthandrophragma candollei* | 3 | | x | *Shorea leavis* | | | x |
| *Enthandrophragma cylindricum* | 4 | 3 | x | *Shorea spec* | | | x |
| *Erisma uncinatum* | | | x | *Shorea spec* red | 3 | 1 | x |
| *Eucalyptus globulus* | | | x | *Shorea spec* white | 2 | | |
| *Euxylphora paraensis* | 1 | 2 | x | *Simarouba amara* | 4 | | |
| *Fagus sylvatica* | 5 | 5 | | *Sindora cochinchinensis* | | | x |
| *Fagus sylvatica treated* | | 2 | | *Stryphnodendron paniculatum* | 1 | | |
| *Goupia glabra* | 3 | 3 | x | *Tachigalia spec* | 1 | | |
| *Guarea cedrata* | | | x | *Tamarix aphylla* | | 5 | x |
| *Holopyxidium jarana* | | 2 | | *Tectona grandis* from several plantations | 1 | | x |
| *Hymenaea courbaril* | 1 | | x | *Tectona grandis* plantation sapwood | 3 | | x |
| *Hymenolobium spec* | | | x | *Thuja plicata* | 1 | | |
| *Intsia bijuga* | 1 | | x | *Toona sureni* | | | x |
| *Iryanthera grandis* | 4 | 2 | x | *Trattinickia burserifolia* | 5 | | |
| *Iryanthera lancifolia* | | 3 | | *Triplochiton scleroxylon* | | 1 | |
| *Khaya ivorensis* | 3 | | | *Triplochiton scleroxylon* | | 2 | |
| *Larix spec* sapwood | 4 | 2 | x | *Tsuga heterophylla* | | | x |
| *Larix spec.* treated | | 1 | | *Vataira spec* | 1 | 3 | x |
| *Lecythis usilata* | | 2 | | *Vatairea guianensis* | | 2 | |
| *Lonchocaprus hondurensis* | | 3 | | *Vataireopsis spec* | 1 | | x |
| *Lophira alata* | | 1 | | *Vitex spec* | 1 | | x |
| *Manilkara huberi* | | 2 | | *Vouacapoua americana* | | 2 | |

Two examples:
*Hymenolobium spec* (trade name: Angelim pedra)
This is a heavy tropical hardwood from South America including several *Hymenolobium* species. Typical are the gum areas which vary in size and number. Because of these gum areas, after the drying process the wood included wet areas. Although moisture content measurements are part of the intern control of the Dutch certified timber company, the wet areas are variable and the installation of the electrical moisture meter in this heavy wood is difficult and therefore wood with too high moisture content was used in joinery, resulting in problems with the coating system and severe cracks. Furthermore it became clear that this species has a lower equilibrium moisture content with 8-14% than other timber species used in Dutch joinery. The timber dried in the construction resulting in cracks. Over time extractives may leach out, so a sealing coating system is required. After a short period of introduction problems, this species is finally well accepted on our national market as a species which is hard, durable and available from sustainable forests. It is therefore a welcome addition to the list of timber species which can be used in certified Dutch joinery. It is dried with more attention and to lower moisture contents, one of the smelling species is not allowed on the Dutch market and a coating system is developed against leaching (e.g. Klaassen & Bongers 2005).

Dutch larch.
The forest area in the Netherlands is limited (app. 10% of the total land area) and has a yearly wood production of app. 1 million m³. Although this amount is app. 6% of the Dutch wood consumption, almost no Dutch timber can be found in building constructions. This is caused by the bad image of the Dutch timber. The Dutch forests are young, fast growing and the Dutch forestry management systems focus more on recreation and biodiversity rather than on production and therefore the confidence in the quality of Dutch timber is low. In order to find new timber sources for building activities in this time were bulk timber species are under pressure, and to prove the building suitability of Dutch timbers, there was a need for a large scale example project were Dutch timber could be used. The restoration of a monumental governmental building (ministry of agricultur) in The Hague offered a unique chance. The ministry themselves stimulated the use of Dutch timber as promotion of the national forest and the project was large because within a limited amount of time app. 2000 window frames would have to produced. Dutch larch was chosen as main species in addition with robinia from Hungary for the production of the strongly exposed (horizontal) elements. The size of the window frames was about 1 x 2 m and because the new window frame should be similar to the original one (spruce), the timber dimensions were quite large (100 x 150 mm). Together with the national forestry service and a specialised round wood saw mill (Assink from Neede), all necessary larch (app. 1600 m³ long round wood, originated from the province Drenthe and from the forests around the city of Dieren) was brought together, sawn and dried. The larch stem sizes made it imperative to optimise the timber by fingerjointing and lamination. In order to reach acceptable yields all the lamella were shortened to a length of 50 cm and each of these lamella were divided over 4 quality classes. The highest quality class was used in the outside exposed layer of the window frame and from the lowest quality class built-in window frames were made.
Technical research on the quality of Dutch timber showed that the physical properties and its natural resistance against fungi was similar or even better than well known sentiments from east and middle Europe and Siberia. However the resin content in Dutch larch is high and the coating system was adapted to it. In the end a special window frame was developed together with the

industry (joinery producer Doornenbal from Veenendaal) with a high quality that fulfilled all requirements and with a long guarantee period. Nevertheless, it took at lot of effort to convince the architect and especially the building company that the Dutch window frames were from a high quality, the timber for production was available and the costs were similar to that of more common species like meranti. The renovation started in 2006, the production of the window frames is on schedule and at the moment more than 600 window frames have already been produced and placed in the building. Because of the successful progression of the restoration and the trust in the quality of the window frame, on a special occasion two Dutch ministers (agriculture and national building service) presented a national quality certificate to the window producer (Klaassen & Creemers 2008).

Both examples show that there are many initiatives in the Netherlands to find durable replacements for large quantities of single timber which were used in the seventies of last century. This change requires more expertise of all people involved in the wood chain and well prepared time schedules while it is sure that more time is needed to organise and manage the timber. In the Netherland more and more companies are adapting to this new situation.

## DUTCH FOUNDATION PILES

Due to the Dutch soft soil conditions wooden foundations are used since the 11th century. Due to the Industrialisation a rapid expansion of the cities started at approx. 1875. From that year on to 1960 large volumes of wooden piles were used. The length and bearing capacity of the piles were based on engineering judgement and trial and error methods, as systematic soil investigations and geotechnical engineers did not exist yet.
In many cities, buildings with foundation problems are located in the quarters built from 1875 up to 1940. Most times foundation problems are recognised by the settlement behaviour of the buildings. Prior to buying or renovating one of these buildings the question rises, what the quality of the foundation is. Foundation replacement or -repair is very expensive. Costs involved can be up to 50% of the total renovation costs. Therefore it is recommended to inspect foundations in order to make a sound judgement on buying, renovating or demolishing a building. Main causes of foundation problems are: a) Bearing capacity foundation is too low (piles too short or discontinuity in soil conditions); b) Loads and/or negative skin friction are too high; c) Mistakes in foundation construction design; d) Decay of piles due to softrot when the groundwater table is below top of piles; e) bacterial degradation active under the ground water table. Submerged wood was previously considered safe from decay (Björdal & Nilsson 2008, Klaassen et al 2008). Therefore extensive investigations are carried out nowadays to determine the quality of foundation piles at many residential areas and a database was built containing more than 4000 wood samples originating from foundation piles from different cities in the Netherlands (Klaassen 2008, Kretschmar et al. 2008). Spruce and Pine were the most common species that were used; in addition some Alder and Fir piles were found.
The type of decay differs between cities. Wooden piles in Haarlem mainly suffer from bacterial decay, whereas many problems in Dordrecht also occur due to changes in ground-water level with the consequence of decay by soft-rot fungi. Amsterdam is dealing with both problems.
The velocity of bacterial decay is variable and ranges between almost 0 to > 1mm/year. High velocities are found in poplar, alder and pine sapwood. Low velocities are found in heartwood of oak, pine, douglas and larch.

In all piles, older than 5 years, bacterial degradation is present in the outer layers at least. A limited number of extracted piles is investigated over the whole length and here the tip and the top where both degraded by bacteria.
For the Netherlands the number of piles in service has been estimated (FUGRO 1995-2008, Veldhuyzen 1963). Until 1925 all foundations were fully made of wood (number of houses about 425.000). Between 1925 and 1950 almost all foundations were made with wooden piles, but the connecting construction to the building was made in concrete. After 1950 foundations were also made with concrete piles. Between 1925 and 1965 about 365.000 houses have wooden piles. After 1965 the use of wooden foundations under houses was strongly reduced. As most of the houses are standing on 20 wooden piles the actual number of wooden piles supporting Dutch houses is 16 million. As water constructions (quay walls, bridgeheads) are also standing on wooden piles the number of piles in service can be doubled at least. The 32 million piles in the Dutch soil are equivalent to 8 million ton $CO_2$ extraction from the atmosphere. General pile dimensions are 10 meter in length and 25 cm in diameter, weight 1 $m^3$ dry wood = 500 kg, 1 g dry wood is equivalent to 1 g $CO_2$.
If more information on the process of bacterial wood is available, the use of wooden foundation piles in the Netherlands can be done in a durable way, providing a massive carbon dioxide sink.

**REFERENCES**

Björdal, C. and Nilsson, T. (2008) Culturing wood-degrading erosion bacteria. In: *International Biodeterioration and Biodegradation* 61(1), 3-10.

Fugro (1995 – 2008) Archive on foundation inspections in the Netherlands (>3000 houses or buildings included)

Klaassen, R.K.W.M., Eaton, R.A. and Lamersdorf, N. (2008) Bacterial wood decay: survey and results of EU project BACPOLES. *International Biodeterioration and Biodegradation* 61(1).

Klaassen R.K.W.M. (2008) Bacterial decay in wooden foundation piles: patterns and causes. A study on historical pile foundations in the Netherlands. In: *International Biodeterioration and Biodegradation* 61 (1), 45-60.

Klaassen, R.K.W.M. and Bongers, H.P.M. (2005) Partijkeuring Sapupira/Angelim pedra afkomstig uit Amazonia, Bolivia, Mato Grosso en Rondonia. *SHR report* 5.299, Wageningen

Klaassen, R.K.W.M. and & Creemers, J.G.M. (2008) Nederlands Lariks. *SHR report* 6.492, Wageningen

Kretschmar, E.I., Keijer, H., Nelemans, P. and Lamersdorf, N. (2008) Investigating physico-chemical sediment conditions at decayed wooden pile foundation sites in Amsterdam. *International Biodeterioration and Biodegradation* 61 (1), 85 – 95.

Mooiman, A., Klaassen, R.K.W.M., Bouwman, G., Boon, K., Dubelaar, J., Gard, W., Huyzer, T. and de Jong, J. (2007) Optimalisatie houten gevelbekleding van naaldhout. Centrum hout, Almere.

NNI (1996) NEN–EN 113: Houtverduurzamingsmiddelen – bepaling van de giftgrenswaarde ten opzichte van houtaantastende basidiomyceten gekweekt op een agar voedingsbodem.

NNI (1993) ENV 807: Wood preservatives. Determination of the toxic effectiveness against soft rotting micro-fungi and other soil inhabiting micro-organisms.

SHR (1993 – 2008) Series of reports on properties of timber species. Wageningen

SKH (2006) Beoordelingsgrondslag "Houtsoorten voor toepassing in timmerwerk; toelatingseisen en bepalingsmethoden". SKH publicatie 97-04, Wageningen.

Veldhuyzen C.J. (1963) Het verbruik van houten heipalen in Nederland. *Landbouw Economisch Instituut*, juli 1963; Archieven Stadsdelen Amsterdam.