

Project : PD 56/99 Rev. 1 (I)  
Promotion of the Utilization of Bamboo  
from Sustainable Sources in Thailand

## Bamboo Utilization and Protection



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Royal Forest Department, Bangkok, Thailand

and

International Tropical Timber Organization (ITTO)





Internal Technical Report No. 2

## **Bamboo Utilization and Protection**

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## BAMBOO UTILIZATION AND PROTECTION

The first employment of the project consultant for the ITTO project on "Promotion of the utilization of bamboo from sustainable resources in Thailand" was undertaken from March 31 until April 10, with an interruption of 3-4 April for field work on an EC Project in Malaysia. The EC project took care of the international flight expense for working on the ITTO project in Thailand.

The Interims Report was submitted according to the employment contract, dated 20 March 2001, and the Terms of Reference by the Project Leader Mrs. Wanida Subansenee on 10 April 2001.

During the first part of the consultancy information was obtained on the project planning and activities, research proposals were discussed with the project members and field visits undertaken according to the program, attached as Annex 1. The pre-review by the Management Consultant Mr. Kowitz Sombun was obtained from the Project Leader.

The second part of the consultancy was undertaken from 12-16 July 2001 with the same terms of reference according to the timetable in Annex 2. In the period between these two employments the consultant collected and supplied further information required by the project members, especially on the "International Testing Standards for Wood Preservatives and Determination of Toxic Values in Laboratory Tests". An ongoing communication on the project activities and needs was done.

According to the Terms of Reference the following activities were undertaken:

### 1. Review of bamboo utilization regarding its protection

Bamboo has been utilized in Thailand intensively since ages for countless uses. The following elaboration will concentrate on those fields where a protection is required for longer uses. The information was obtained from various resources.

At the Fifth FAO Conference on Wood Technology Sept. 1963 in Madison, USA Mr. Thanom Premrasmi, then Director Forest Products Research Division, Royal Forest Department, (RFD) presented a background paper "Bamboo Preservation in Thailand" with a description of the main species in use, methods of treatment and preservatives applied with results obtained. The hardly known report was given to the project. It is apparently the first record of preservation work in Thailand.

During earlier work of the consultant in 1974 at the Institute for Wood Research, RFD, on timber preservation also aspects of bamboo

preservation were included, but the results obtained are not anymore available.

At the 4<sup>th</sup> International Bamboo Congress in Chiang Mai, Nov. 1991, the consultant encouraged members of the Rajamangala Institute of Technology (RIT), Chiang Mai, to perform a study on Bamboo Preservation. In the years 1995-1997 an intensive investigation was undertaken under the direction of Mr. Jan van Lint, a consultant from the Netherlands. A report of 32 pages describes in detail the work with four bamboo species using two preservatives and various treatment methods. The aim of the project was outlined as "to provide some simple and cheap methods to treat poles for building purposes in Thailand and to disseminate this information throughout Thailand and stimulate the use of it". This valuable report of three years experimental work is widely unknown. Inquiries at RIT during a visit to Chiang Mai resulted in the information, that an application of the results was not undertaken and the work has not been continued, the more as Mr. Van Lint has left the country. The report was given to the project for information and use of the results for the ongoing working programs. At earlier times (1995, 1998, 2000) the consultant could visit a private bamboo preservation unit at Kanchanaburi and obtained some practical information.

During the first consultancy bamboo preservation was seen at three places:

---**Wood Preservation Industry** at Amphur Mae-Rim, Chiang Mai Province, with a pressure Cylinder for the treatment of timber as well as bamboo. The bamboo is treated partly as culm, partly split with a Copper-Chromium-Arsenic (CCA)- type preservative. The method for culms was described as vacuum- pressure (2 hrs)- vacuum treatment. The additional costs were indicated as 20-25% for the product resulting in an expected service life of at least 10 years. Information on the concentration of the solution, its checking, the intended uptake of preservative and its measurement was vague.

Furthermore, bamboo mats were soaked in a CCA solution for 2 days, the concentration and its checking were not clear. The expected service life is about 10 years, in comparison with untreated mats of 1-2 years. The additional costs were indicated as 25% of the product. Examples for the use of treated bamboo mats for pavilions were shown at a recreation site, they looked impressive and convincing.

It has to be mentioned that CCA is highly effective, but also a highly poisonous preservative, mainly due to its arsenic content. The penetration under pressure treatment is rather limited and with soaking only minimal. CCA-salts have a very good chemical fixation in wood as well as in bamboo after a certain fixation period. However, the treated culms and mats showed residues on the surface, which can lead to poisoning. Also the obvious

environmental spillage must be reduced. Safety instructions have to be placed at the plant for proper handling.

The possible use of a Copper-Chromium-Boron type (CCB) preservative should be inquired by the project. This type was also used by the preservation work at RIT, see above. As it was shown at the second consultancy, this type of preservative is on the market.

**---Visit to the Northern Enterprise Bamboo Panel Industry at Lamphoon Province.** The factory has been installed 1979 apparently as the still only bamboo plywood factory in Thailand (according to the manager). The bamboo mats are produced locally at the villages as single sheaths and brought to the factory. They are compressed with formaldehyde-glue into boards of various thickness (up to 4 cm) for different purposes. Apparently no chemical treatment for protection is applied. Details about the production could not be obtained.

Also bamboo culms are processed at this factory. As a kind of treatment they are soaked in an unspecified solution for 1 week with holes made into the internodes for an expected better uptake from the inner side of the culm. As solution NaOH was indicated, but not confirmed. No information about uptake, use and service records was obtained.

It might be mentioned, that a pre-treatment of culms with KOH by soaking is known to remove effectively the waxes and capes of silica cells of the culm epidermis and increase wet ability. It also results in a better penetration of green colour protectors.

**---Cottage Industry at Amphur Panus Nikom, Chonburi Province.** To protect the bamboo material for weaving against beetle attack the slivers are dipped into a solution of commercially available Neem seed for about three days. The slivers were dried in the sun and used for weaving. In the continuous process of the soaking operation the upper portion of the storage solution in the tank will be let off in the normal drainage system. This may cause environmental pollution, but an improvement could not be discussed. The Project members should be aware of such dangers and investigate details if possible. If in the stored products once in a while insect attack becomes obvious, this special part will be replaced. It has to be noted, that such a partial replacement will only remove the obvious attack, which will spread further in the unseen parts.

On the second part of the consultancy the Non-Wood Forest Research Experimental Station at Nakhon Ratchasima could be visited on 15 July 2001. The spacing trials with the 5 species were demonstrated, and the treatment experiments could be discussed. Later the day the integrated bamboo industry at Moo 6, Baan Kum, Bang Baan District, Ayutthaya province could be visited with an interesting demonstration of the production

of holy joss sticks and charcoal making from residues and weaving work at Angthong province.

It was agreed at the first consultancy, that the project will collect during the coming months information about the practical application of protection/preservation for bamboo in the industry, the preservatives available on the market and their price and the possibility to obtain the CCB-type preservative. During the second consultancy a list was provided by Mrs. Mayuree Jitkaew obtained from the Hazardous Substance Control Bureau, Ministry of Industry on the amount of imported wood preservatives in the year 2000 and the corresponding trade names. Although almost all of these preservatives will be used for wood preservation, the list is a valuable source of information on the available preservatives in Thailand for their possible use for bamboo preservation.

## **2. Review the existing commercial grading system in national and international market.**

Grading rules are important for the trade. In Thailand such rules do officially not exist so far for bamboo. Also in other countries grading rules for bamboo culms are not common, quite in contrary to rattan, where an extensive grading system is applied with certain differences between countries. For the export of bamboo culms some grading systems have been developed by the trade, mainly according to the buyers needs. They specify length and diameter, but may also include colour and free of defects. Wall thickness is not considered.

As an example the following grading for the European market was obtained from exporters:

Length (cm)	Diameter (mm)
150	18-22
180	20-22; 22-24
240	20-22; 22-24
300	24-26; 26-28; 30-35; 35-40; 40-45; 55-60; 65-70; 80-90; 100-120; 120-150; 150-180
600	100-120
800-900	100-120

One company has developed a butt treatment of fresh culms to protect the most endangered base of the poles in the soil. This improvement appears most promising, if properly undertaken, and might be later incorporated in a grading system

The Project members may inquire, if national statistics about export of bamboo culms exist, where length and diameter classes are specified. Trade organizations may be approached regarding the chances and

constraints for a general grading of bamboo culms and other bamboo products.

In contrast to the international trade, some sorting systems exist for the local market. Examples were seen at Amphur Mae-Rim and Amphur Muang, Chiang Mai Province, and Lamphoon Province where culms were sold from Lampang Province for scaffolding according to length (6 m) without diameter consideration and at Pai kao -Lam for roof support of 5-6 m length. Shorter lengths (1.50-2.00 m) were bundled and sold for plant support or in split form for fences. No treatment was applied for the local market neither is it suggested.

### **3. Design a research methodology to develop sustainable utilization of bamboo.**

The Project members have prepared research programs for the various areas to be investigated. As a basis a memo on "*Species Selection*" was given to the consultant at the first visit with a description of the five main bamboo species used in out of the about 160 growing in Thailand.

For specific fields the following working programs were discussed with the respective scientists:

- *Testing of physical and mechanical properties of the bamboo species* with Mr. Suchart Thaipetch (density, bending strength, compression strength, tension strength, shear strength) The data for five main Thai bamboos should be compared with the results for bamboos of neighbouring countries to evaluate consequences for their use and processing. Also the report by Wiraj Chunwarin "Physical Properties of three Thai Bamboos", For. Res. Bull 48, 1977 will be considered. The fourth draft by INBAR (2000), written by Dr. J.J. Janssen, on the determination of physical and mechanical properties of bamboo was provided as a basis for a comparative testing. During the second consultancy the work progress demonstrated by Mr. Suchart. It is in accordance with the program and appears convincing. A recent paper by Abd. Latif and W. Liese (2001) was provided, where the anatomical characteristics of two bamboo species from Malaysia from four sites were investigated with the result, that the characters appeared rather stable, independent from the site. This conclusion strengthens the results obtained by the project, providing a broader basis for other bamboo sites in Thailand.
- *Chemical Composition of Five Bamboo Species* and comparison with the data of other species, with Ms. Pannee Denrungruang. The results will provide valuable data for the main Thai species. The investigations on the starch content in relation to the season and the influence of water storage are of practical value. Again a comparison with the results for other bamboo



from the region has to be done, and some information about literature was provided. The report by Wiraj Chunwarin "Culm structure and composition of three Thai Bamboos" For. Res. Bull. 47, 1976 contains also some relevant data. During the second visit the results of the work program were discussed. Certain restrictions in the equipment available will influence the scope of chemical analyses to be undertaken, but will not limit the value of the total work. The main importance lies upon the starch content and its variation according to the test program.

- *Bamboo Protection by various methods* with Ms. Paiwan Lek-u-thai, Mrs. Arunee Veenin, Mrs. Mayuree Jitkaew. The aim is to investigate possibilities for bamboo protection in rural areas by simple methods. Emphasis is given on alternative natural chemicals for the protection of bamboo, like Neem-seed-solution. Beside bamboo culms also bamboo slivers for handicraft will be used. At the second visit considerable progress was demonstrated for the bamboo protection work. The bamboo culm parts for furniture components have been soaked in stagnant water and also immersed in commercial chemicals, according to the program. The first evaluation was done after one month exposure under natural conditions, with controls. The results obtained were tabled and the observations analysed regarding their value. The work will be continued.

It was agreed at the first visit, to exclude from the proposal of work the pressure method, since it is hardly to be applied for bamboo in Thailand and also to exclude the CCA Type preservative because of its high toxicity and danger of pollution, especially in a rural environment. Both topics are undertaken in bigger treatment units and the Project would have only limited technical possibilities for such work. Consequently an earlier proposal by the Project leader on green colour conservation of bamboo culms by Chromate-Copper-Phosphate (CCP), Chromated-Phosphate (CP) or Copper-Chromium-Arsenic (CCA) developed in Taiwan was also not included in the program of work.

At the second visit of the consultancy also the sap-replacement treatment for bamboo culms should have been considered, which is presently tried by the Forest Products Research and Development Division for tree stems and successfully applied for bamboo culms in a number of countries, it yields a good protection with a minimal environmental danger. However, no practical treatment was undertaken at this time and the installations were not in place.

When discussing the lay-out of the three programs mentioned above the great number of samples to be used became obvious. The simple handling of this great amount may hinder its proper execution. It was recommended to consider again the amount of replicas and controls at least

for some of the analyses respective treatments, which was taken then into account.

#### **4. Design practical procedures on**

##### **4.1 Harvesting**

Bamboos in Thailand belong mainly to the pachymorph, clum forming type. The culms of one clump are of different age, whereby often the younger ones are growing up at the outside, with the older ones more inside. During the first two years the new culms undergo a maturation process due to additional wall thickening of fibre cells and also parenchyma, resulting in higher density and strength in the mature culms. Consequently the younger culms are weaker and more liable to shrinkage and cracks when un-properly seasoned. In praxis, however, also immature culms are often harvested, since they are easier to retrieve from a congested clump. Also the payment of the worker by piece or truck load contributes to this pattern.

Beside these physical-technological aspects the biological consequences are even more important. A young bamboo shoot often contains a large amount of biomass, which, however, is not self-produced by photosynthesis but entirely provided by the stored starch in the one to two years old culms and rhizome in the previous time. By cutting these younger culms the assimilation and storage will be considerably reduced, resulting in a downgrading vitality of the clump.

These aspects have to be observed when considering the strengthening or establishment of new bamboo processing units. There are many examples of a consequent depletion of the bamboo resource base leading even to the closure of production units.

All bamboo culms for the project are required to be at least three years old. No younger culms should be used, not even for experimental purpose, giving an unwanted example.

It is noteworthy, that inquiries at bamboo enterprises during the field visits about the harvesting age resulted mostly in observing the proper age for harvesting, although some examples for immature culms were to be seen. This applies mainly to the handicraft work at Amphur Panus Nikom, where the weaver prefer an only one year old culm of "Pai Nong", which is easier to split and bend (due to the smaller fibre walls and its lower lignification).

Another important aspect relates to the time of harvesting. It is common experience, that culms are easier attacked by beetles and also by fungi when cut before the rainy season than when cut afterwards. This relates to the amount of starch, which is stored at its maximum before the shooting and depleted after the young culms have been grown up. These

important aspects will be investigated in detail for the five bamboo species by the chemical and the preservation research programs.

#### 4.2 Storage and post harvest treatment

Storage is an important factor for the final utilization of bamboo culms. Its purpose is to keep larger quantities for later usage or to provide material for ongoing processes, like in pulp mills. Therefore bamboo should be free from any incipient biological attack to avoid a secondary infestation.

Wherever the bamboo is stored, the main principle should be to reduce the moisture content and to avoid any uptake of additional moisture, either by rain or by ground contact. At the felling site the culms should be left at places without overhead shade so that the moisture is reduced fast. Often the culms are laying directly on the ground accessible to rain and with no drainage facility. Infections by fungi and beetles can easily occur. The culms should be transported soonest to a storage yard, or preserved fresh by water-storage. At the storage yard, single culms should be kept in upright position, leaning against support, since water loss is faster than by horizontal drying. The storage yard should be clean and free of refuses. To reduce the possibility of fungal attack, and avoid cracking the culms should be placed preferably under cover for a period of six to twelve weeks, depending on the season. Storage on raised platforms above specially prepared ground (about 10 cm of boiler ash, powdered lime sludge) reduces the danger of termite attack. If the area is infested with termites a soil poisoning might be considered, depending on the national/regional regulations. Good ventilation and frequent inspection are important. Culms with signs of attack should be immediately burned, or depending in the situation soaked in a preservative.

In earlier times stored bamboos were sprayed with a preservative for short-term protection. Since the chemical drips from the smooth culm surface into the soil, environmental damage piles up. Under no circumstances spraying with Sodium PCP can be tolerated because of its poisonous effects. For pulp bamboos a prophylactic treatment with borax-boric acid may be considered. Alternately, bamboo stacks may be sprayed with pulp mill black liquor containing 5-6% solids. Black liquor being alkaline delays fungal attack and improves chipping properties by rupturing the epidermal layers. Storage yards at preservation plants should be sealed to collect drippings from treated material.

#### 4.3 Cracks and weathering

Mechanical and physical damage of a culm occurs rarely because of its hard skin. Due to drying stresses mainly in young culms collapse may arise as a serious defect. Cracks and splits can take place especially, when

the culm is not properly seasoned. Especially species with thick culm walls, like *Dendrocalamus asper*, crack often at their ends when drying too fast.

Alternate wetting and drying may result in longitudinal splits. If dried too quickly, bamboo will split and shrink around its solid node. Likewise cracks can develop if the culm is exposed to intensive sun. Such cracks may not influence much the strength of a construction component, but can lead to subsequent deterioration by fungi and insects, which get easy access into the inner culm part, preferred by insects. Since the cracks often develop on the sunny side, they are equally exposed to rain, so that water gets collected inside the culm. In such a humid chamber fungi will develop and thrive resulting in a rapid deterioration. Care, therefore, must be taken to use only properly seasoned culms. To avoid cracking, an incision along the back side can be made to encourage splitting at this part, because it cannot be prevented by any economical chemical treatment.

Bamboo is also subject to mechanical wear caused by frictional forces of ropes/wires used for fastening bamboo components.

Nailing without pre-boring often leads to splits; dulling of the sharp point of the nail seems to reduce splitting. Species with thick walls appear to tolerate nailing more than other thin-walled species. However, while nailing is frequently used for fastening bamboo, nails tend to pull out with time. Nails may also get corroded and become loose.

Weathering of exposed bamboo structures is an interaction of different atmospheric conditions, like ultra-violet light and changing of surrounding temperature and moisture content. Air moisture has a very deleterious effect on bamboo as fluctuating atmospheric conditions produce cyclic moisture gradients between surface and inner layers which result in surface checks caused by repeated swelling and shrinkage. Although the ligno-cellulosic composites are very stable up-to about 100°C, higher atmospheric temperatures lead to a rapid drying of the culms which may cause severe checking. These cracks ultimately become breeding space for micro-organisms.

Direct exposure to sun also causes checks of bamboo due to unbalanced shrinkage occurring on the exposed side. Subsequently, water contributes further to cracks and splits due to expansion of water on freezing.

A major factor in weathering of bamboo in outdoor locations is damage by UV and visible light radiations, which cause photo-degradation. Such radiations breakdown bonds of the ligno-cellulosic polymer, whereby the surface of bamboo turns grey and rough. Also other biotic factors, like moisture (rain, dew) accelerate the weathering process, although damage is minimal. Strong winds, laden with dust particles can cause mechanical

abrasion (sand blasting), exposing fresh surfaces underneath and thus continue the weathering process.

#### 4.4 Production Processing

There are a number of general constraints which have to be considered when discussing the further development of bamboo in Thailand.

**Natural constraints**, like population pressure on bamboo forest, grazing, ground fire, ownership of the bamboo forest

**Improper management and over-exploitation**; to conserve the biological productivity of the bamboos only the older, "mature" culms ( above 3 years) are to be harvested, which have also better strength properties. Since the workers are often paid by volume/weight over-cutting occurs with a reduction of the growing stock and lower quality. Bamboo stands need management. Newly established bamboo industries cause an increased demand, which often leads to premature felling and the destruction of the resource.

**Low quality** of products and simple design. Mechanization at the rural craft industry may create losses of job opportunities.

**Competition** in quality and design of bamboo products from other regions or countries.

**Low durability** of bamboo houses and products in natural environment due to lack of appropriate treatment, degradation of bamboo depots at pulp mills.

**Social acceptance** of bamboo products is often limited..

**Alternative materials**, for traditional bamboo uses are increasingly applied, as " original imitation", like for fences, baskets, furniture, They are colourful, durable, with attractive designs and often more economical.

**Market evaluation** often insufficient, thus leading to handicrafts and industrial products with low demand and low benefit.

**Economics**, bamboo is widely used because due to low wages and its availability. The improvement of the poor man's life quality will affect the affordability of bamboo. The international market demands high quality of bamboo products and constant supply. The experience and quality in bamboo processing in other bamboo regions has to be carefully evaluated for planning the increased utilization of the bamboos in Thailand.

**Socio-economic value** of bamboo is underestimated

**Low investments** for the management of natural stands and the establishment of bamboo plantations.

**Insufficient cooperation and information exchange** between producers of bamboo and their products, traders, national and regional institutions.

Among the many products to be made from bamboo in Thailand the following merit special attention from the consultants viewpoint:

- poles for export with a treatment of the basal part. Europe imports annually about 40 mill. bamboo poles from Asia mainly as supports for fruit trees and at vine-yards and the market could be extended by offering base-protected poles.

- constructions and houses with improved design
- furniture with improved design
- mats for countless uses
- mat-boards for specific purposes

The economic production of parquet appears questionable because of the high standards obtained in other countries, especially China and the consequent great competition on the market. Bamboo parquet does not require preservative treatment.

#### **5. Prepare the Technical Report at the end of the mission including recommendations and submit to Project Leader**

An Interim Report has been submitted at the 10. April 2001 on the basis of the first visit. During the following months further compilations have been made and information, Testing Standards and literature as requested by the Project members submitted.

The present Final Report includes the results of the second visit from 12-16 July 2001 and is herewith submitted. The recommendations are outlined under point 7. They were presented at the First Project Steering Committee Meeting on July 16, 2001 to the members of the Committee as part of the lecture on "Bamboo Preservation in Thailand".

#### **6. Further Items**

##### **6.1 Information supply**

On Monday 2<sup>nd</sup> April a 2hrs lecture on "Structures, utilization and protection of bamboo" was delivered to researchers of the Project, with several others from the Forest Products Research Division and the Faculty of Forestry attending, followed by an intensive discussion.

On request of the project the consultant brought along about 25 research papers on various aspects of bamboo according to a request

submitted before. This information is missing at the institutions in Bangkok and will be useful for the projects implementation.

A further list of literature on bamboo and related topics was given to the consultant and has been send, together with some other information of relevance. Further material was brought at the second consultancy. As a result of the second visit some more literature will be send to the project.

The consultant gave an overview on his general experience on bamboo protection and suggestions for the Project in a lecture on "Bamboo Preservation in Thailand1" at the First Project Steering Committee Meeting on July 16<sup>th</sup>.

## 6.2 World Bamboo Congress

The VII World Bamboo Congress originally scheduled for mid November 2001 in Dehra Dun, India. Had to be postponed to 18-23 February 2002.

It is strongly recommended, that the project Leader takes part in this important event, also with a presentation of the ITTO Bamboo Project, its goals and results obtained by then. Furthermore a researcher of the Project Team should participate, so that the active working generation gains from the information presented and can established contacts with other research units.

## 6.3 ITTO Project on Rattan Utilization

The ITTO Project on "Promotion of sustainable Utilization of Rattan from Plantation in Thailand" was given to the consultant for comments. The content was discussed with the Project Leader Ms. Pannee Denrungruang. The goals of the Project appear rather ambiguous and should integrate more the knowledge and experience available, also for Thailand. An International Congress on Rattan was held 1987 in Chiang Mai with useful contributions for the project. In the following years several other conferences on rattan took place and considerable literature of value for the intention of the ITTO Project has been published. Recently an "Expert Consultation on Rattan Development" was organized by FAO, Rome, 5-7 December 2000 with numerous presentations. Among these Prof. Dr. Isara Vongkaluang, Faculty of Forestry, reported on "Thai rattan in the early 2000" and the consultant on "Challenges and constraints in rattan processing and utilization". The material of interest for the project was made available by the consultant together with some other Congress Proceedings. The Proceedings will appear in due course.

## **7. General Considerations and Recommendations**

7.1 Bamboo in Thailand is an important and contributes significantly to the component for the rural communities, regional and national welfare.

7.2 Among the many commodities made from bamboo only a few, albeit substantial ones demand protection against natural bio-degradation.

7.3 Work on bamboo protection and preservation has been done in Thailand, but the results and information vanished and is hardly available.

7.4 The ITTO Project, partly concerned with improving the service life of bamboo products, can make a significant contribution to the economy of bamboo utilisation, if properly made available to the customers.

7.5 Regarding the application of bio-toxic preservatives the chances of natural and less toxic substances should be exploited, as undertaken by the Project.

7.6 The use of toxic preservatives should be concentrated at places of competence, preferably not at smaller village level.

7.7 Safety precautions have strictly to be applied and placed at posters at any treatment installation.

7.8 Problems exist already with the disposal of residues and sludge and will increase further. Their proper handling is an urgent task.

7.9 The efficiency of so-called "Traditionally Methods" should be thoroughly exploited, as done by the Project.

7.10 A Wood/Bamboo Preservation Center for information and technical guidance has to be established to assist the treaters, the consumers and the trade/market for treated products.

7.11 A Thai Wood Preservation Association should be established for exchanging regularly information at meetings, although competition will restrict the needed communication.

7.12 An Annotated Bibliography of Bamboo Preservation should be compiled for the needs in Thailand, probably as a thesis work to register the available information and make them generally available.



## ANNEX 1

### First Visit Program of the Processing Consultant Prof. Dr. Walter Liese March 31 –April 10, 2001

Friday	March 30	09:45	leave Hamburg
Saturday	March 31	06:30	Arrive Bangkok
			Meeting at Royal Forest Department (RFD)
			Discussion with Project Leader, members and National Management Consultant.
Sunday	April 1	08:30 - 11:00	Orientation on Bamboo Project at Project Leader Office
		11:00 – 12:00	Discussion on mechanical and chemical properties of Bamboo
		13.30 – 15:00	Discussion on preservation of Bamboo with Project Leader and Project Staff.
		15:00 – 16:30	Discussion
Monday	April 2	09:00 - 12:00	Lecture on "Structures, utilization and protection of Bamboo"
		Afternoon	Discussion
		19:30	Leave for Penang, Malaysia
Thursday	April 5	09:20	Arrive Bangkok from Penang, Malaysia
		12:15	Leave for Chiang Mai Province
		13:25	Arr. Chiang Mai Discussion with Project Leader and Team members
Friday	April 6	08:00 – 16:00	Visit Project site at Baan Mae-Mae, Amphur Chiang-Dao, Chiang Mai
Saturday	April 7	09:00	Visit Bamboo Panel Industry (Northern Enterprises), Lumphoon Province.
Sunday	April 8	09:00	Visit bamboo market and bamboo cottage industry at Chonburi Province
		Afternoon	Leave for Bangkok
Monday	April 19	09:00	Discussion with Project members,
Tuesday	April 20	09:00	Visit laboratories at Forest Products Research Division
		23:55	Leave Bangkok for Frankfurt
Wednesday	April 21	09.15	Arr. Hamburg

## ANNEX 2

### Second Visit Program of the Processing Consultant Dr. Walter Liese

12-16 July 2001

Wednesday	July 11	19:10	Leave Hamburg
Thursday	July 12	13.50	Arr. Bangkok
		Afternoon	Discussion with Project Leader Mrs. Wanida Subansanee
Friday	July 13		Discussion with Project Members at Forest Research Office, RFD
Saturday	July 14		Work on Project documents
Sunday	July 15		Field Trip for Project Steering Committee Visit Bamboo Demonstration Plot, Dying and Protection Experiment at Non-Wood Forest Products Research Experimental Station, Nakhon Ratchasima Province. Visit small scale bamboo weaving industry at Anghong Province and joss stick and charcoal industry at Ayutthaya Province
Monday	July 16		Project Steering Committee Meeting with report on "Bamboo Preservation in Thailand", presentation and discussion of "Conclusions and Recommendations"
		17:10	Leave for Kuala Lumpur, Malaysia