Bamboo Product Processing

Level-I

Based on November, 2021, version Occupational Standard (OS)

Module Title: - Carrying out treatment and Drying

LG Code: IND BPP1M2 LO (1-6) LG (4-9)

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This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Following OHS plan and policies
- Material selection
- Identifying tools and equipment
- Planning dry process
- Designing stockyard
- Selecting oven section, sample bamboo culms and cutting
- Identifying treatment method
- Chemical formulation
- Identifying drying techniques

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- OHS are follow in accordance with safety plans and policies
- select materials are according to work specifications
- Identify and prepare tools and equipment are for work
- Plan drying process accordance with site procedures
- Design stockyard according to bamboo specifications
- select oven sections and cut in accordance with standard operating procedures
- identify treatment method and confirm with supervisor
- Acquire and confirm chemical formulations with a supervisor.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 1- Following OHS plan and policies

1.1 Definition

Occupational health and safety (OHA) is a discipline with a broad scope involving many specialized fields. It encompasses the social, mental and physical well-being of workers that is the "whole person".

1.2 Safety in bamboo treatment

Safety - is a precaution to avoid accident and care is a proper handling of material, tool and equipment

We may use various types of chemicals to treat / preservatives bamboo materials. Thus most of preservatives are toxic. Thus, the following precaution should be taken.

- Avoid contact with your skin.
- Wear gloves for handling the preservatives and treated bamboos, as long as they are wet.
- Anyone who drinks CCA or Octabor should drink a lot of water (milk is even better) and be forced to vomit (put your fingers down his or her throat) at least three times
- Consult a doctor as quickly as possible; take a package of the preservative with you and show it to the doctor.

When storing hazardous chemicals in your workplace, take the following steps:

- Read the safety data sheet (SDS) or label carefully, and follow any storagerecommendati ons.
- Secure the chemicals against unauthorized access or use.
- Only keep minimal amounts of chemicals onsite. Ensure that all chemicals are clearly andc orrectly labeled, and that the labels are intact and legible.
- Do not allow chemicals to be exposed to the sun, excessive heat or sources of ignitio
- Provide adequate ventilation.
- Label shelves and cupboards so that chemicals can be stored in the right place.
- Use placarding where required.
- Ensure clear segregation schemes are maintained.
- Chemicals must be separated wheBeing stored to ensure that incompatible chemicals and not mix if there is a spill.

- Keep the outside of containers clean and the storage area tidy.
- Do not store liquids above solids to avoid contamination in the event of a leak.
- Always store corrosives on spill trays.
- Ensure shelves are not overloaded.
- Never store flammable

1.3 Personal Protective Equipment (PPE)

Before commencing operation, employers or persons in control must assess conditions likely to affect the health and safety of the employees or themselves, as identified during the risk assessment procedure, and arrange for the provision and use of appropriate Personal Protective Equipment (PPE). All PPE must be regularly inspected and replaced as necessary. The following PPE must be provided and used where necessary:

- Helmet
- Eye protection
- Glove
- Safety cloth
- Safety shoes
- Mask

Figure1: Safety clothing

Self check 1	Written test

Name…… ID…… Date……

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Define safety (2points)
2. Explain occupational health and safety(OHS) (2points)
3. List at least three precautions that the person should do during bamboo treatment (3points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 7points ***Unsatisfactory – 7 below 10 points***

Information Sheet 2- Material selection

2.1 Types of materials

- **Materials for stockyard preparation**
  - ✓ Sand cement and stone - to construct yard foundation.
  - ✓ Roofing material -, is used to cover the upper parts of the yard.
  - ✓ Gravel – construction gravel, which comes from crushed lime stone ,it utilize to make foundation
  - ✓ Poles – is like pillar used to support roof and walls.

- **Materials for treatments**
  - ✓ Mixing & boiling tanks/containers
  - ✓ Chemicals – to preserve bamboo plies
  - ✓ Labeling materials- to mark the bamboo culms
- **Cleaning materials include**

Figure: 2: Cleaning materials include

- **Bamboo Culm/splits** - bamboo materials to be treated. The bamboo culms to be treated should be matured (over3 years)

Self check	Written test

Name……ID…… Date…….

Test I. writes short answer for the following questions

1. List materials used to construct stock yard (4 points)
2. What is gravel? Explain (2points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 6 points ***Unsatisfactory - below 6 points***

Information Sheet 3- Selecting tools and equipment

3.1 Tool, equipment and their uses

A. Machete or bolo

Abroad blade used either as an implement like an axe, is used to removing branches and splitting bamboo culms

Figure 3: Bolo

B. Cutting tools

- Hack saw is used to cutting bamboo Culm

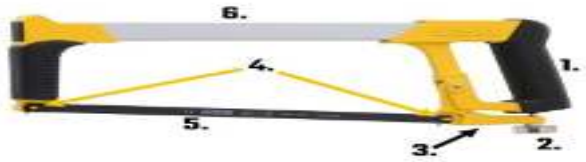


Figure 4: Hack saw

- Bow saw is a woodworking and bamboo tool used for straight or curved cuts.

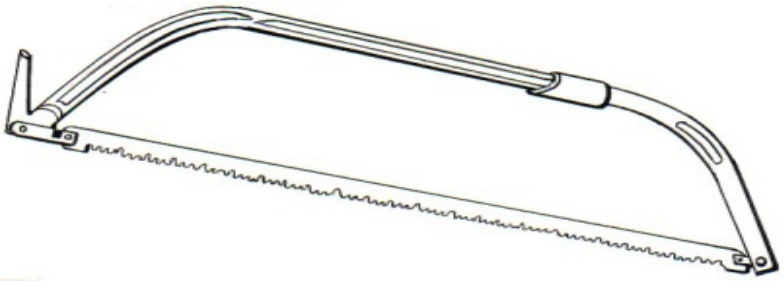


Figure 5: Bow saw

C. Oilstone: - It makes a great surface for sharpening knives and tools.

Figure 6: Oilstone

D. Mixing ladles: - Used to mix chemicals

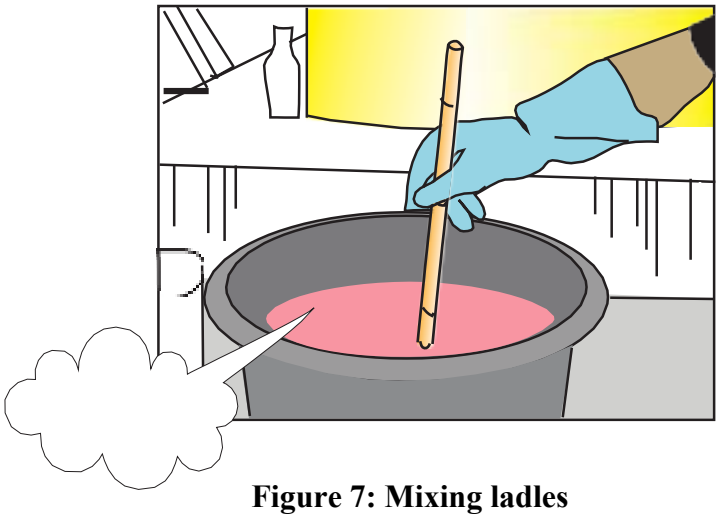


Figure 7: Mixing ladles

E. Treatment chamber: - used to treat bamboo with steam.

Figure 8: Treatment chamber

F. Treatment vat: - is used to mixing and hold chemicals for preserving of bamboo.

Figure 9: Treatment vat

- Round bamboo, slats, and slivers can be treated by keeping them submerged in water borne preservative solution.
- The preservative moves into the material due to concentration gradient and cellsap moves oves out due to osmotic pressure.

G. Tong: - Is used to holding bamboo from chemical treatment.

Figure 10: Tong

H. Stove: - is used to boiling treatment water or chemical.

I. Moisture meter: - It is used to measure moisture content of bamboo.

Figure 11: Moisture meter

J. Weighing balance /scale:- to measure chemicals

Figure 12: Weighing balance /scale

K. Measuring tape: - Diameter gauge: -Used to measure the inner and outer dimensions of various materials and pipes

Figure 13: Tape rule

L. Diameter gauge: -Used to measure the inner and outer dimensions of various materials and pipes

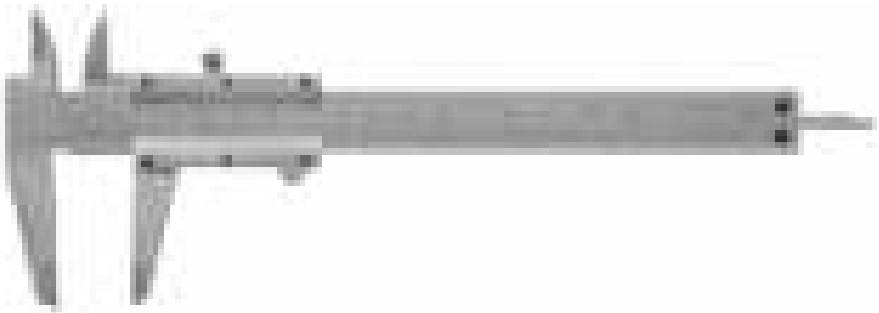


Figure14. Diameter gauge (caliper)

Self check 3	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: Choose the best answer (1) point each

1. A tool used to removing branches and splitting bamboo culms-------
   A. Machete C. Bolo
   B. Hack saw D. A&C E. none
2. ----------is a measuring tool used to measure the inner and outer dimensions of various materials.
   A. Measuring tape C. Moisture meter
   B. measuring gauge D. Weighing balance /scale

Test II: write short answer for the following questions (2 points) each.

1. ----------is a tool used to mix chemicals
2. ----------is a woodworking and bamboo tool used for straight or curved cuts.
3. A tool used to mixing and hold chemicals for preserving of bamboo is----------

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 8 points Unsatisfactory - below 8 points

Information Sheet 4- Planning dry process

4.1 Introduction

Drying of bamboo before use is necessary since dry bamboo is stronger and less susceptible to biological degradation than moist bamboo. Furthermore, shrinkage and swelling are directly related to the moisture content. Moist bamboo affects the processing, such as machining, gluing and painting. Dimensional changes would ultimately occur if bamboo has not been dried before being used. The bamboo should be dried to the equilibrium moisture content corresponding to the service conditions before the manufacturing process.

Therefore, plan a dry process play an important roles to get dry and quality bamboo that meets the purposes. Planning is a complex process that can take many forms. There are different kinds of planning and different ways of planning. In the case bamboo drying, a plan shows how, when and where the drying process is carried out. In general planning process has the following steps.

4.2 The steps in the planning process

- Develop objectives.
- Develop tasks to meet those objectives.
- Determine resources needed to implement tasks.
- Create a timeline.
- Determine tracking and assessment method.
- Finalize plan.
- Distribute to all involved in the process

In drying planning is thinking work activity.

- To find a fast and efficient drying method.
- To find a system that is cheap and easy to construct, which a poor can emulate.
- To find a system that can be developed locally.
- To develop a system that is portable, so it can be taken to the remote parts the countries which are not accessible by road?
- Ready safety equipment

- Plan material selection method with specification
- Undersatnding the characterstices of bamboo.
- Select location for stacking storing place
  - ✓ Free from insect ,termite
  - ✓ Soil contact
  - ✓ Moisture
  - ✓ Ventelation
  - ✓ Leveling
- Understand drying techniques
- How to disose chemicales
- How to reuse materials
- Understand fumigation stacking area

Self check 4	**Written test**

Name…… ID……Date……

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions (2 points) each.

1. Write the importance of drying (2points)
2. List 4 importance of planning drying process (4points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points ***Unsatisfactory - below 6 points***

Information Sheet 5- Designing stockyard

Site and layout of drying yard

The site chosen should be flat, well drained and free of debris. Furthermore the site should not be obstructed by objects such as trees and buildings which could impede air circulation through the stacks. Adequate gaps should be left between stacks to encourage air circulation and to allow access to the stacks. If possible the long axis of the yard should be orientated parallel to the prevailing wind.

Design of stacks

Stacks should be located on good foundations to prevent timer from coming in to contact with damp soil and to ensure adequate ventilation under the stacks. the design of foundations recommended for air drying stacks in the USA are as follow the bottom row of boards should be 46cm off the ground the foundations should consist of masonry or preservative treated timber blocks 15cm—15cm. these blocks should be spaced at intervals of 1.2—1.6m in rows 1.8—2.4m apart to correspond with the width of the stack.

The bamboo yard should preferably by level a direct approach to the main road and always be away from residential area the land should be at a higher level with proper drainage. It should be well fenced to prevent cattle from straying inside (so as to avoid dung which is serious source of infection)

The yard should be maintained under hygienic conditions to minimize incidents of fungal and insect attack to which the timber is exposed during long periods required for air seasoning.

It is preferable to have it surfaced with concrete or cinders, gravel, sand or same such material. The layout of the yard should be such as to enable free movement of transport from one part to another to protect the stacks from the direct sun there should be same big shady trees in the yard.

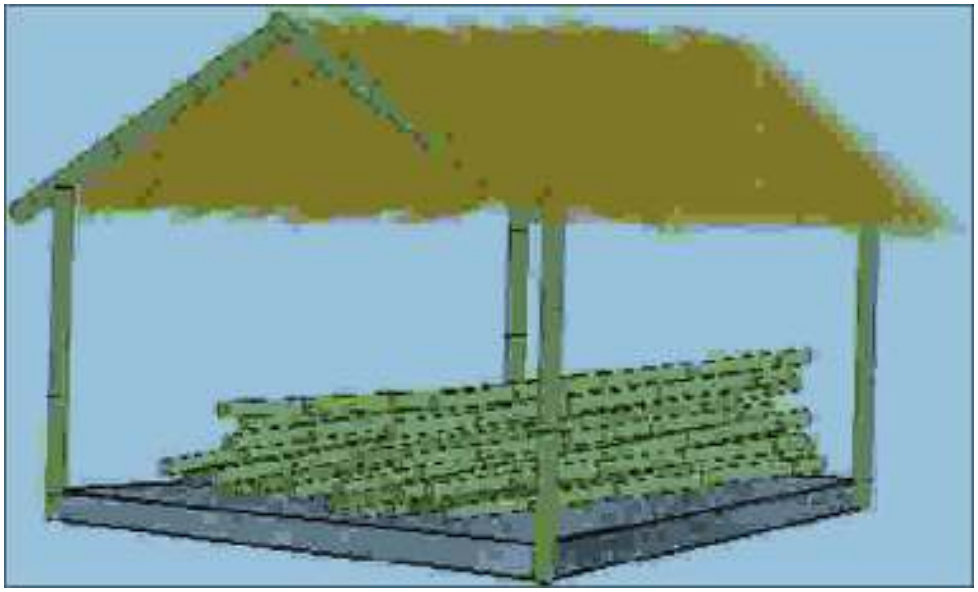


Figure 15: stockyard

Self check 5	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: Choose the best answer (1point)

1. The site for yard should not be---------

   A. slope B. well drained C. Free of debris D. B&C E. all

Test II: write short answer for the following questions

2. Write the importance of good yard foundation (2 points)

Test III: say true or false for the following questions (1 point) each

1. Long axis of the yard should be orientated parallel to the prevailing wind.
2. The site not be obstructed by objects such as trees and buildings which could impede air circulation through the stacks

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points ***Unsatisfactory - below 6 points***

Information Sheet 6- Selecting oven section and cutting sample bamboo culms

6.1 Oven selection and cutting sample bamboo

Dry kilns are classified in some different ways and often described and named according to its operational technique, type of heating or energy source. The sample Culm is cut depends on the dimension of the products. For example, for furniture the bamboo poles desired length (7 or 8 feet long), as the maximum component length of furniture is 7 feet.

Figure 16: Pilot kiln-drying and

Figure 17: Industrial kiln-drying

6.2 Kiln-Drying Schedule

Kiln schedules are used to define the temperature and relative humidity needed in the kiln to dry bamboo with a minimum occurrence of degrades and in the shortest time possible. A typical kiln schedule is a series of drying conditions, expressed as temperature and relative humidity, which is used as a directive on how to operate a kiln throughout a period of time comprising the whole drying process. A drying schedule may be designed for manual, semi-automatic or fully automatic control systems. It is usually formulated in a table-type format showing the drying conditions at different stages or periods of a drying process.

Table 6.1 Table 9.2 Three drying schedules, applying for bamboo culm parts of the three main species of Vietnam (Tang et al. 2013)

Step	Moisture content (%)	Schedule No. 1 Mild		No. 2 Severe		No. 3 Highly severe	
		T (°C)	RH (%)	T (°C)	RH (%)	T (°C)	RH (%)
1	Over 90	50	80	55	80	65	80
2	90–70	50	70	55	75	65	60
3	70–50	60	60	60	65	70	45
4	50–40	60	50	65	50	70	35
5	40–30	60	30	65	35	70	30
6	30–20	65	30	70	25	75	25
7	20–10	65	20	70	20	75	15

Self check 6	Writ written test

Name…… ID……Date……...

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test II: write short answer for the following questions

1. What is the bases to cut sample culms for kiln drying (3 points)
2. Explain the use of kiln schedules (3 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points ***Unsatisfactory - below 6 points***

Information Sheet 7- Identifying treatment method

7.1 Introduction

Bbamboo is a giant grass which contains high percentages of cellulose, which makes it a source of food for many organisms, especially fungi and insects such as borer beetles. Therefore, bamboo is prone to insect attacks. In order to prevent these kinds of attack, the Bamboo pole has to be treated to increase its durability. If the bamboo is not treated properly, the products made out of bamboo will not last long. Treatment and seasoning protects them from different kinds of insects, borers and fungal attacks.

7.3 Preservation treatment methods

Basically Preservation treatment methods of bamboo are of two types:

1. Traditional treatment (Non- chemical method)
   - Leaching
   - Lime washing
   - Smoking
2. Chemical treatment.
   - Short term
     - ✓ Spraying
     - ✓ Dipping
     - ✓ Brushing
   - Long term Non pressure
     - ➢ Soaking /diffusion
     - ➢ Hot and cold
     - ➢ Sap replacement
     - ➢ Steeping
   - Pressure
     - ➢ Vacuum process
     - ➢ Full cell process
     - ➢ Empty cell process and alternative pressure process

Self Check -7	Writ written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: Choose the best answer for the given alternatives (2 points each)

1. Which one is not traditional (non chemical) methods of treatment

A. Soaking /diffusion C. Sap replacement

B. Hot and cold D. Vacuum process

2. From the following one is a short term chemical treatment method

A. Soaking /diffusion C. Sap replacement

C. Hot and cold D. Brushing

3. All are a pressure chemical methods of treatment except

A. Full cell process C. Alternative pressure process

B. Empty cell process D. Smoking /diffusion process

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points Unsatisfactory - below 6 points

Information Sheet 8- Chemical formulation

8.1 Intoduction

Bamboo culms start deteriorating as soon as they have been harvested and they are also vulnerable to attack from insect pests and fungi. It is therefore advisable to treat them as soon as possible after harvest. Simple treatments such as soaking in water or painting the culms impart some durability but they are not covered in this report. All of the methods covered here involve the use of chemical preservatives. The non-pressure methods are the easiest and cheapest to apply, are widely used and are very effective.

8.2 Types of chemical

Many chemicals are used as a preservative for wood, and some have also been used for treating bamboo. The three major chemicals used for preserving timber/bamboo are Creosote, Pentachlorophenol (PCP) and Chromated Copper Arsenate (CCA). These chemicals are usually applied to wood using pressure systems. Creosote and PCP are not soluble in water, so for treatment they are usually dissolved or diluted in a petroleum-based solvent such as light oil. The oil acts as a carrier to help the preservative penetrate a spaced stack of timber when it is heated and pressurized in a large steel cylinder. CCA, on the other hand, is a combination of inorganic salts dissolved in water and forced into the wood. CCA has been applied to bamboo using a Boucherie process that makes use of an air pump to inject the chemicals into the culms.
These chemicals combine well with wood, resulting in little or no loss on subsequent contact with humidity, rain and groundwater. However, they are toxic and hazardous to people!

Phosphate based insecticides that are used in the agricultural industry are known for their allergenic potential, while creosote is carcinogenic. So far, the only petrochemical agents that are more or less acceptable are the pyrethrin based insecticides like Permethrin and Deltamethrin. These products are among the most popular and widely used insecticides in the world. They are used for protecting wood products and by many bamboo furniture industries in Asia. All these agents are applied with turpentine or kerosene, and have a foul odor. They are not recommended for products that will be used indoors. There is a much cleaner and even cheaper solution, which

has been regarded as an eco-friendly wood preservation agent in Europe for over a generation, namely, borax.

Borax is an important boron compound, which occurs naturally as a mineral deposit produced by the repeated evaporation of seasonal lakes. The most commercially important deposits are found in Turkey, South western United States, Chile, Tibet and Romania. It is usually a white powder consisting of soft colourless crystals that dissolve easily in water. It has many industrial applications, and works as a fire retardant, as an antifungal agent, and as an insecticide.

8.3 Chemical formulation

The preservative is available as a ready mix or can be mixed by the user. It is always recommended that toxic salts like CCA, CCB, etc.,be obtained as a premix and dissolved in water to get a solution.

- Boric acid: Borax is available as a pre-mix and can also be prepared by the user easily.
- The purity of the chemicals should be ascertained.
- Chemicals required for compounding various formulations should have at least 98% purity. Also, the chemicals should always be bought from well-established and reliable manufacturers.
- To prepare a solution of any concentration, the weight of the quantity to be dissolved Can be found out by the following method:

  Q = Quantity to be dissolved in water

  C = Concentration of solution required

  V = Volume of solution to be prepared

  S = Concentration of salt/paste Q = (C x V)/S.

If you have to prepare 8%CCA solution where the strength/ concentration of CCA is, say, 95 and the requiredVolume is 100 litres:The quantity of CCA to be dissolved in water = (C.V/S) = 8 X 100 /95 Similarly, for Boric:

- Borax solution: Boric acid and Borax are usually mixed inthe ratio of 50:50.The salts can be pre-mixed in any of these ratios and dissolved in water.
- For a 10% solution of Boron formulation, the procedure is as below:

	Boric acid	Borax	Water
• For 50:50 ratio	5 kg	5 kg	100 liters
• For 1:1.4 ratio	4.2 kg	5.9 kg	100 liters

- Boron salts may be heated to about 50^0C while making solutions or during treatment to hasten the process. However, beyond 50^0c it results in loss of salts.

8.3 Quality check

- Quality control is most essential in any industrial product. Inadequately treated material can develop defects in transportation, storage or use.
- It is handling of preservatives essential to have quality checks during and after the treatment process.
- Several conventional preservatives are easy to detect for their presence with simple spot tests.
- It is not possible to estimate the amount of preservatives in bamboo treated inthe green condition by diffusion methods.
- The only reliable method is to estimate the same by quantitative analysis, which canbe done only in a chemical laboratory
- .However, in most other treatment methods, it impossible to determine the amount of preserving chemicals in the treated bamboo from the quantity of solution consumed during treatment and the solution strength used.

Self check -8	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. List The three major chemicals used for preserving timber/bamboo (3 points)
2. ----------important boron compound, which occurs naturally as a mineral deposit produced by the repeated evaporation of seasonal lakes (3 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points ***Unsatisfactory - below 6 points***

LG#5	LO#2 - Air Dry and Store Bamboo

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Sorting bamboo culms with specification
- Fumigating bamboo culms
- Storing culms following stacking methods and procedure

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Sort bamboo culms according to season harvest, age, species, dimensions, defects, position, culm wall thickness, place of origin, and usage.
- Fumigate Culms to prevent form disease before storage
- Store Culms at their specified location in the storage area by following proper stacking methods and procedures.

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks
- Perform Operation Sheets
- Do the “LAP test”

Information Sheet 1- Sorting bamboo culms with specification

1.1 Sorting of poles

Small-diameter poles dry faster than large-diameter poles. Likewise, freshly-cut poles have higher MC and require longer duration of drying than partially dried poles. To facilitate drying and avoid wide variation of final MC (moister content).Sort the poles to be kiln dried by diameter class, species and MC. During the drying operation, the heat coming from the heat exchanger is sucked by the fans and then blown to the material being dried. The process continues until the desired MC of the material is attained.

Even though, after post-harvest treatment is done, bamboo poles should be stored in a ventilated shelter and not in a closed area. The poles should be piled in stacks of different diameters with distance splits to allow air flow. Sort and classify the preserved culms based on their size, diameter and quality an ideal way of storing treated bamboo culms is in horizontal racks.

Figure 1: Treated bamboo poles stacked for further process.

Self check -1	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions (3 points) each

1. The poles sort to be kiln dried based on

   A----------

   B ----------

   C----------

3. Preserved bamboo culms sort and classify

   A----------

   B----------

   C----------

4. Wite the imprtance of sorting bamboo culms

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 9 points ***Unsatisfactory - below 9 points***

Information Sheet 2- Fumigating bamboo culms

2.1 Introduction

During storage and transport, bamboo should be kept away from insects as best as possible. Elevating the bamboo above the ground can help reduce the risk of subterranean termite attack. Periodic fumigation could be considered where the storage facility is particularly large. Fumigation should use chemicals which kill termites and beetles, however these can be toxic to humans and therefore local health and safety regulations should be followed, including the use of appropriate personal protective equipment such as gas masks.

The preservative is available as a ready mix or can be mixed by the user.It is always recommended that toxic salts like CCA, CCB, etc., be obtained as a premix and disolves dissolved in water to get a solution.

- Boric acid: Borax is available as a premix and can also be prepared by the user easily.
- The purity of the chemicals should be ascertained.
- Chemicals required for compounding various formulations should have at least 98% purity. Also, the chemicals should always be bought from well-established and
- Normally fumigation is done specifically on large diameter canes, using sulphur fumes, to bring out the best of rattan's colour and to kill any larvae of borers present.
- After washing, fumigation is carried out in a chamber (a convenient size of the chamber would be 6 x 5 x 3 m) which is fitted with an external container for burning the sulphur and a flue leading into the chamber to carry the sulphur fumes. The rattan is smoked overnight, sometimes for 24 hours or more, till an even colour is obtained. Then it is air-dried and sorted into different grades.

Self check-2	Written test

Name…… ID……Date……

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. Write the importance of fumigation (3 points)
2. List 2 recommended toxic salts used for bamboo pole fumigation (2 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 5 points ***Unsatisfactory - below 5 points***

Information Sheet 3 - Storing culms following stacking methods and procedure

3.1Store/stock bamboo poles/canes

The most common way to dry bamboo for commercial purposes is "**air drying**". Air drying refers to drying that takes place using the natural wind and sun. Horizontal piling bamboo is stacked on stickers and placed in a manner that allows the prevailing winds to blow through the pile and dry it.

Figure 2: horizontal stacking

Leaning piling bamboo is piled leaning in a wall or on a brace

Figure 3: Oblique (Leaning piling) bamboo culms for open air drying

3.2 Shed Air Drying

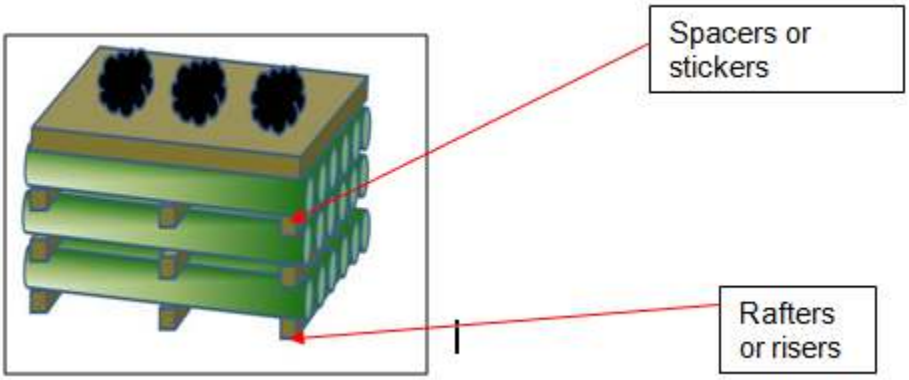
Rain and direct sun can severely damage wood while air drying. So instead of air drying lumber, some people put lumber under a roof or shed to protect it from the elements. This enhances quality somewhat over air drying, but it extends the drying time. It also requires an

investment in sheds—and it still doesn't allow much control over factors like humidity, air flow, and temperatures.

Figure 4: shade

Do's and don'ts in Air Drying

1. Avoid direct contact with the ground.
2. Minimize direct sun contact especially during noontime and avoid rain
3. Make sure the drying area has free continuous air flow.
4. Make sure there is air space between bamboo materials. (use stickers or rafters)



5. Make sure the drying yard is clean

A designated place for air/sun drying of bamboo

Should have a good air circulation.

Should be sterilized by spraying preservatives.

Self check-3	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write true or false

1. Air drying is the most common way to dry bamboo for commercial purposes.

Test II. Write short answer

2. Write what Do's and don'ts in Air Drying (4 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 5points ***Unsatisfactory - below 5points***

Operation Sheet 2	Air drying of bamboo culms

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Tools and equipment

- PPE's
- Matchete
- Ropes
- Stickers and Rafters

Procedures

I. Set up an A- Frame to support treated culms for drying.

II. Choose a shady location with good air circulation.

III. Use diagonal braces to support the A-frame so that it does not fall over under a heavy load.

IV. Use broken or unusable culms to elevate the drying culms from the ground.

V. Never dry the culms under direct sunlight.

VI. If there is direct sunlight, the culms should be rotated several times a day.

VII. The drying process should be slow otherwise the culms will crack.

VIII. Withdraw from the A-frame after 3 - 4 weeks.

IX. Store the poles in a dry area.

LAP TEST 1	Performance Test

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **8** hour. The project is expected from each student to do it.

Task-1 Perform air drying of bamboo culms

LG #6	LO #3- Kiln drying

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Preparing bamboo material
- Identifying and Operating kiln dryer
- Measuring Moisture content
- Carrying out pre-start-up checks on equipment
- Loading kiln
- Positioning baffle and blanket
- Adjusting kiln control settings and checking drying schedule

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Prepare bamboo materials according to drying method
- Identify and operate kiln dryer
- Measure moisture and routinely compare with anticipated levels in accordance with standard operating procedures.
- Carry out pre-start-up checks on equipment in accordance with site requirements
- Select racks and kiln is loaded for processing complete and report
- Position baffles and blankets in accordance with standard operating procedures
- Regularly adjust and routinely check kiln control settings and drying schedules

Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks
- Perform Operation Sheets
- Do the “LAP test”

Information Sheet 1- Preparing bamboo material

1.1 Sorting of bamboo prior to drying

Kiln-drying is more efficient than air-drying. By this method, bamboo can be dried to the required moisture content in shorter time. With great demand for production to export, kiln-drying is a better alternative for air-drying and could ensure high level bamboo quality.

- The purpose of sorting is to segregate possible bamboo materials with similar drying characteristics into one kiln charge.
- Sorting can be done in different ways like:
  - ✓ Sorting according to Species
  - ✓ Sorting according to diameter
  - ✓ Sorting According to Length
  - ✓ Sorting according to moisture content
  - ✓ Sorting according to type of bamboo material

- **Sorting according to species**
  - ✓ Whenever possible, kiln charge should consist of the same species.
  - ✓ Drying characteristics of lowland and highland bamboo have some differences.

- **Sorting according to diameter**
  - ✓ Bamboo with uniform diameter will not only simplify piling (box type piling) but also reduce stress on the bamboo, sticker breakage and deformation.

- **Sorting according to length**
  - ✓ For box type piling, bamboo with the same length is easier to pile.

- **Sorting according to Moisture Content**
  - ✓ This is preferably done when the stock is intended for kiln drying
  - ✓ It is not advisable to mix together the green, partially air dried, and the air dried bamboo materials in the same kiln charge.

- ✓ Green bamboo material require a milder initial drying conditions and longer drying time
- ✓ A moisture meter is frequently used for sorting bamboo materials to MC

- **Sorting according to type of bamboo materials**
  - ✓ Semi processed bamboo materials like slats, crushed bamboo, slivers, spikes, etc, are easier to dry compared to a round bamboo component.

Self check-1	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. List ways of sorting bamboo poles (5 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6points ***Unsatisfactory - below 6points***

Information Sheet 2- Identifying and Operating kiln dryer

2.1 Introduction

Kiln-drying is basically a process of stacking bamboo culms or bamboo splits in a chamber where air circulation and the temperature and relative humidity are maintained and controlled so that the moisture content of bamboo can be reduced to a target level.

Kiln-drying is more efficient than air-drying. By this method, bamboo can be dried to the required moisture content in shorter time. With great demand for production to export, kiln-drying is a better alternative for air-drying and could ensure high level bamboo quality.

2.2 Dry Kilns

Dry kilns are classified in some different ways and often described and named according to its operational technique, type of heating or energy source. The three most common types of kilns are

A. Conventional
B. Dehumidification
C. Solar.

A. Conventional kiln dryer

- A conventional kiln uses heat provided by either steam or hot water coils or a furnace to heat the kiln chamber and remove water from the bamboo.
- The water removed from the bamboo is turned into water vapour by evaporation, and then exhausted from the kiln with the heated air.

B. Dehumidification kiln dryer

- A dehumidification kiln uses a heat pump system to remove the water from bamboo.
- One primary advantage of this type of system is that it recycles heat continuously

C. Solar dryer

- Rely on some type of solar collector to provide the heat energy that evaporates the water in the lumber.
- Drying times in a solar kiln are dependent upon the weather, and thus unpredictable
- Solar kilns often use electric–powered fans to circulate air through the charge

Self check-2	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. List ways of classifying kilns (2 points)
   A. ----------
   B. ----------

2. List the most common types of kilns
   A. ----------
   B. ----------
   C. ----------

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 5points ***Unsatisfactory - below 5points***

Information Sheet 3- Measuring Moisture content

3.1 Moisture content

Moisture content is the amount of water in bamboo expressed in percent (%) of the oven-dry weight of bamboo

Oven dry weight (Wo):- The weight of bamboo wherein moisture content is at 0 level (0%MC)

Green weight (Wg):- Weight of bamboo prior to drying.

3.2 Moisture content determination

Moisture content of bamboo materials can be determined by using:

A. Moisture meter

- A device use to determine the moisture content of bamboo materials by employing the principles of electricity.
- A moisture meter could be a digital or analog
- Take the moisture content reading at the center of the sample or component by inserting the moisture meter needle approximately ½ of the Culm wall thickness.
- Below is an example of digital moister meter

Figure 3 digital moister meter

B. Oven drying method

- The process of determining the moisture content of bamboo using a successive weighing within a given interval.
- The initial weight (Green weight and the oven-dry weight is determined

Drying samples

- Determining the moisture of all bamboo materials could be cumbersome and costly.
- Moisture determination using a sample poles or sample is more economical and easier.
- Factor to consider in selecting sample:
  - ✓ The sample should represent the majority of the poles or the components.
  - ✓ Probably a pole or component that has the highest moisture content
  - ✓ The bamboo pole or component that has thickest culm wall
  - ✓ Take test sample from bottom, middle **and top part of the bamboo**

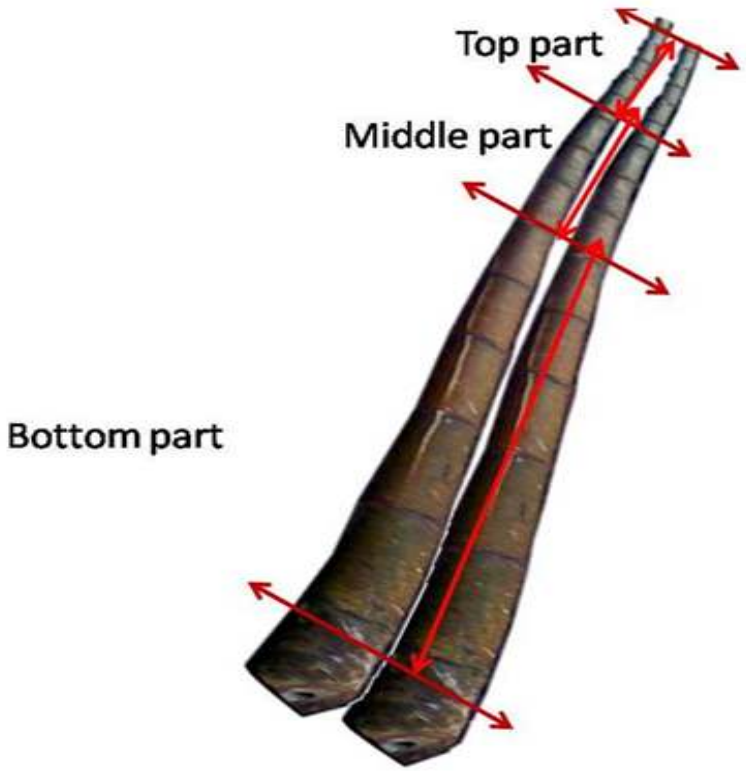


Figure 4: drying sample

Self check-3	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. What is moisture content (MC)? explain (2 points)
2. List the factor consider in selecting sample bamboo materials to determine moisture contents (4 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6points ***Unsatisfactory - below 6points***

Information Sheet - 4 Carrying out pre-start-up checks on equipment

4.1 Pre-start-up checks

Once the materials make ready to load on the kiln dryer, pre start up checks will carried out. Pre-start-up check classified by operational techniques distinguishes between the more common compartment - type kiln and the less common progressive-type kiln.

Compartment-type kilns are designed for a batch process in which the kiln is completely loaded or charged with lumber/bamboo in one operation, and the lumber remains stationary during the entire drying cycle. Temperature and relative humidity are kept as uniform as possible throughout the kiln, and they can be closely controlled over a wide range of temperature and humidity.

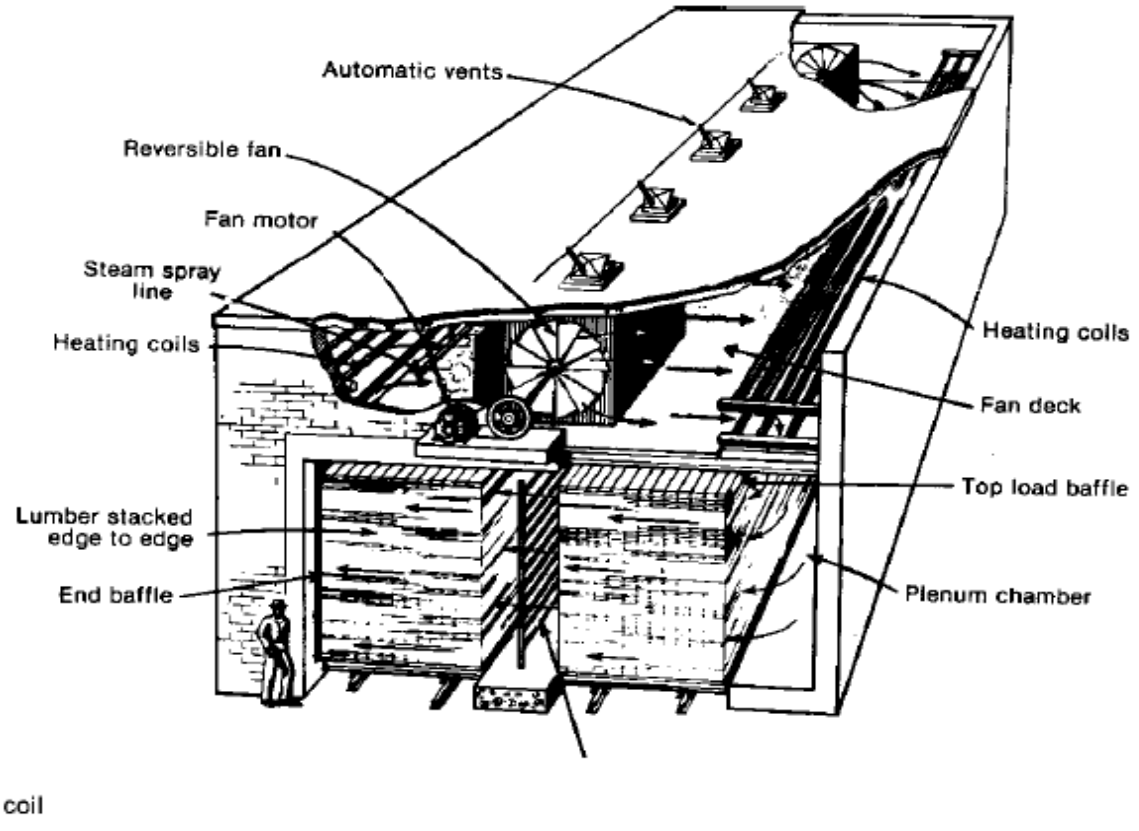


Figure1: Lines haft, double-track, compartment kiln with alternately opposing fans.

Self check- 4	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. Write the basis for classification of pre-start-up check?(4points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 4points ***Unsatisfactory - below 4points***

Information Sheet - 5 Loading kiln

5.1 Stacking of bamboo in the drying chamber

Box Piling; - Just like wood seasoning, the box type stacking is recommended for bamboo especially for split bamboo.

Figure 2: box piling

- Use of tray or racks for round bamboo poles is effective to minimize drying defects. Bamboo is telescopic so employing a box type stacking is quite difficult.

Front View

Side View

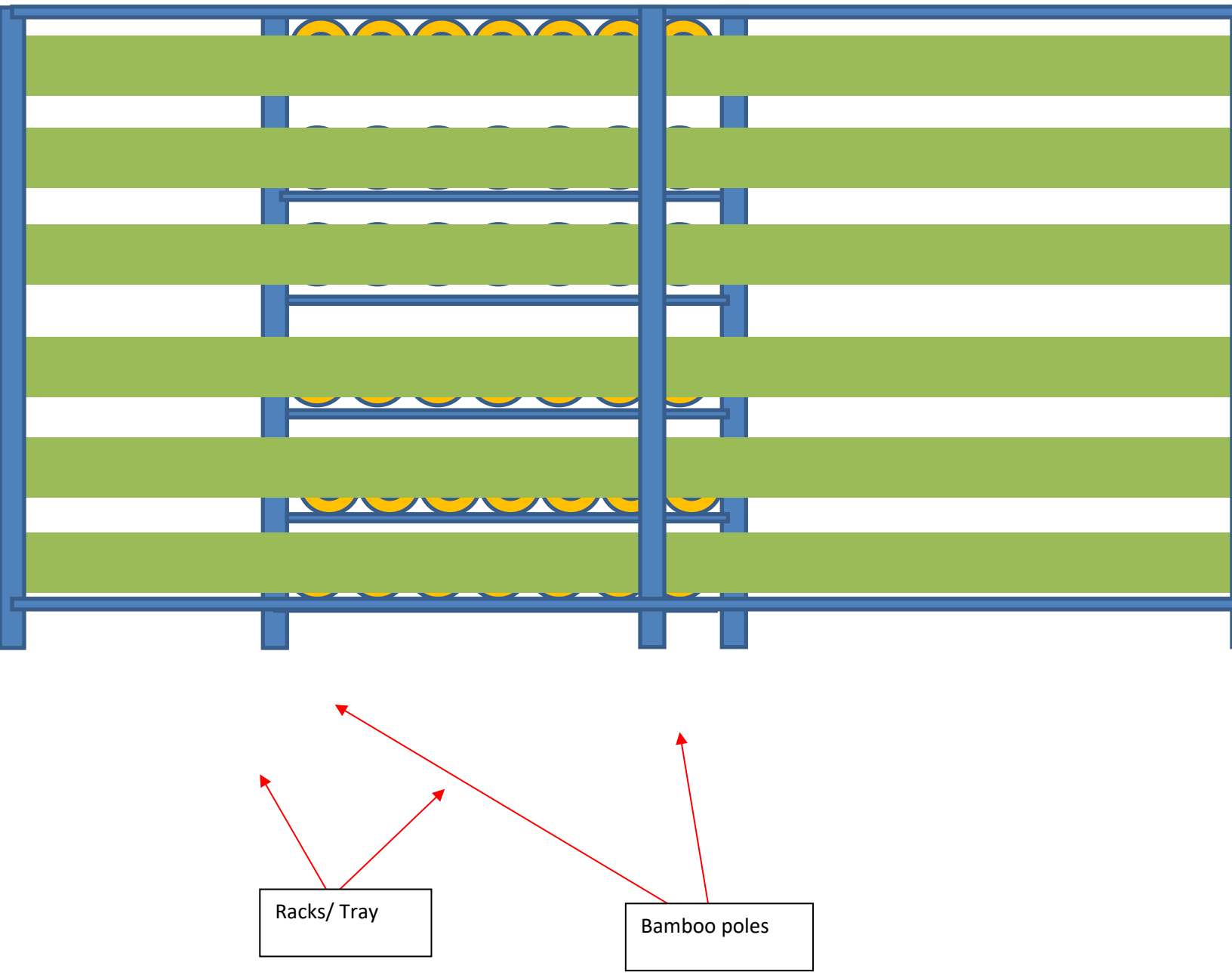


Figure 3 racks

Width and height of kiln charge

- The effect on the horizontal air movement, pile width and spacing affects the drying rate.
- The pile width should not be wider than 1.83 meters to accelerate or speed up horizontal air movement
- Height of kiln charge affects drying rate.
- Increasing the height of the pile tends to retard drying especially in the lower portion.
- Hand stack piling 2.7 – 4.9 meters in height.

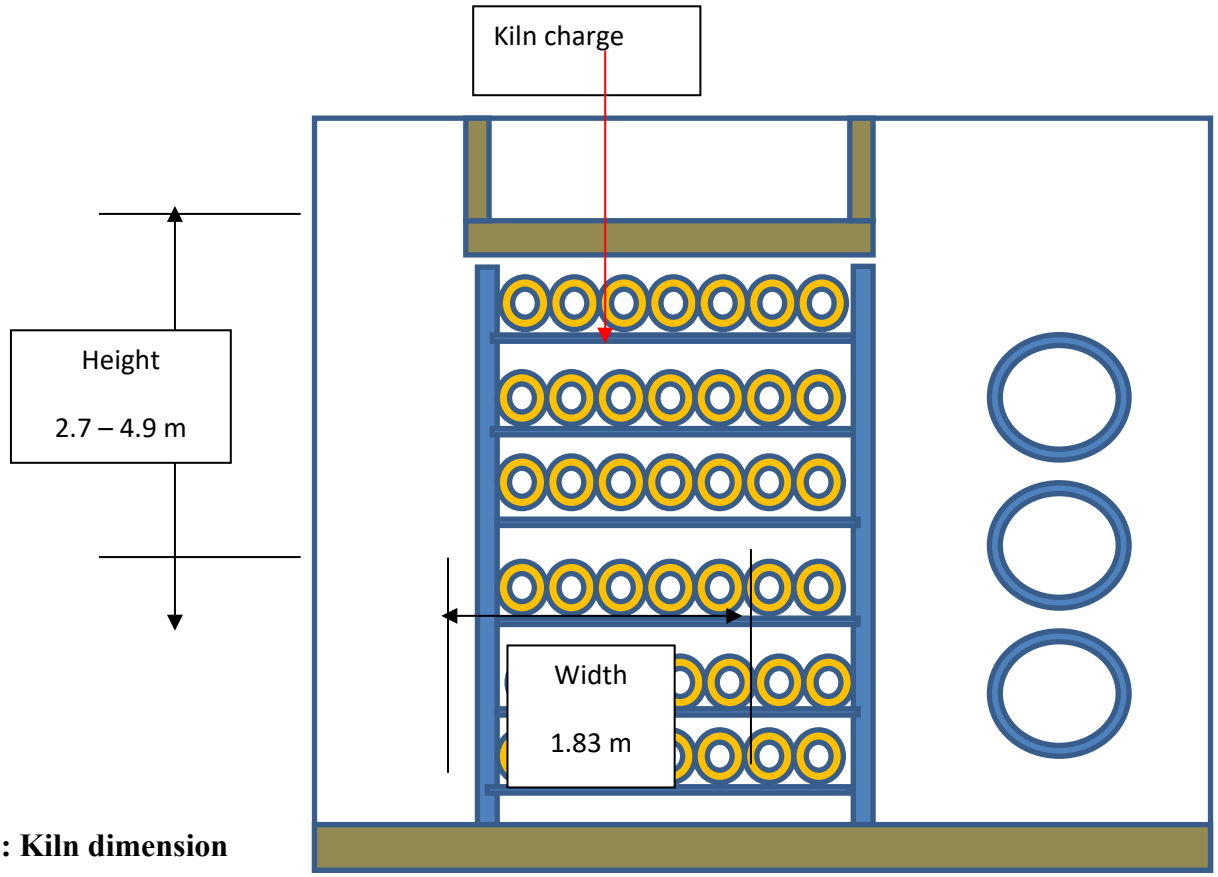


Figure 4: Kiln dimension

Stickers

- The strips or boards separating the layers of bamboo materials to be dried.
- The size of stickers varies from 1.9cm to 3.125 cm in thickness and 2.54 cm to 5 cm in width.
- Stickers should be prepared from sound lumber and free from decay and staining fungi.
- The stickers will give the opening for the air to flow. The thicker the stickers to be used the wider the air passage (Will reduce kiln capacity)

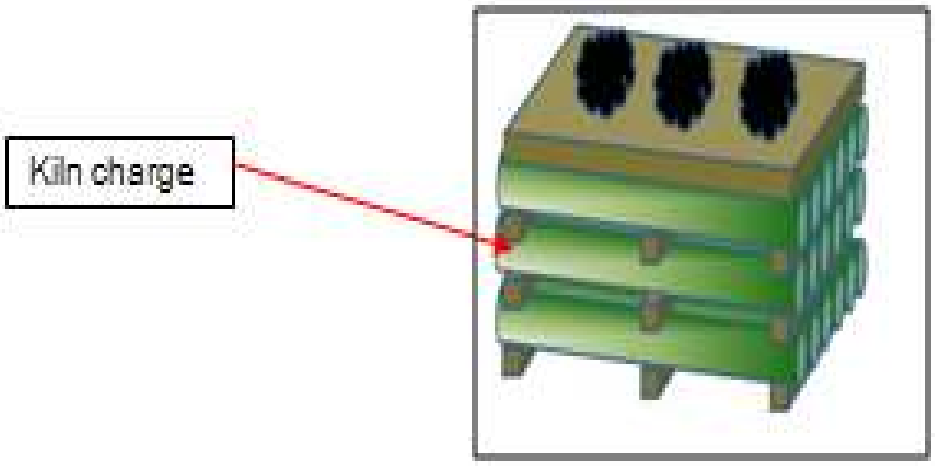


Figure 5: strikers

- Proper alignment of stickers spacing and location will reduce warp, end checks and splits. In designing trays or racks for drying, these should be taken into account.
- The spacing of the stickers depends on the thickness or diameter of the bamboo materials. Spacing is from 0.68 meters to 1.2 meters.

6.1 Placement of kiln samples in the kiln load

- Kiln samples are representative of the stock being dried
- Locate the samples at places in the load where they can be easily removed and replaced.

TYPE OF DRYING CHAMBER	SAMPLE LOCATIONS
End piled forced circulation kiln	Samples can be place in the cat walk on both sides
Double track kiln	Placed in the sides of the load nearest the walls
Natural circulation kiln and kilns of external blower type	Placed in leaving air side
Cross piled dry kiln	Kiln samples placed at the end of the load facing the door.

Self check-5	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: Say true or false write (2 point each)

1. The drying rate is affected by height of kiln charge.
2. The thicker the stickers to be used the wider the air passage (Will increase kiln capacity).
3. Use of tray or racks for round bamboo poles is effective to minimize drying defects.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6points ***Unsatisfactory- 6 below 6points***

Information Sheet - 6 Positioning baffle and blanket

6.1 Baffles

Baffles are flow-directing or obstructing vanes or panels used to direct a flow of liquid or gas. It is used in some household stoves and in some industrial process vessels (tanks), such as shell and tube heat exchangers, chemical reactors, and static mixers

Thus, in the context of kiln drying of bamboo/wood to achieve uniform and, where desired, rapid drying, the properly heated and humidified air must be uniformly directed to and through the lumber/bamboo. To do this effectively, all alternate flow paths must be blocked so that airflow over, under, and around the load is prevented. The best practical way to do this is by using hinged baffles. The lack of effective use of baffling is one of the major causes of uneven or too slow drying.

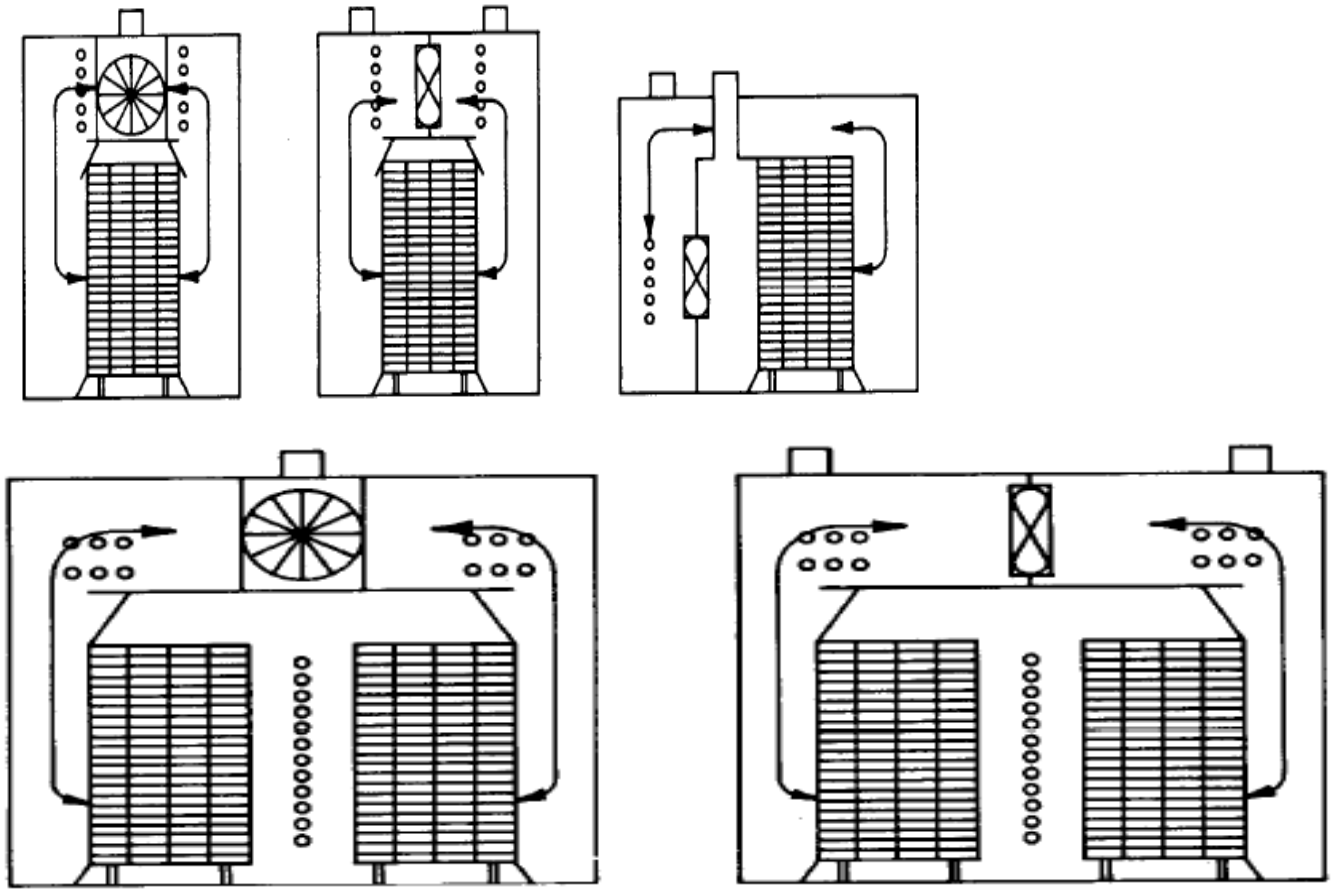


Figure 10 some plans for location of fans and baffles

Self check-6	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. Explain Baffles (2 points)
2. Wrote the importance of positioning baffle (2 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 4points ***Unsatisfactory below - 4points***

Information Sheet - 7 Adjusting kiln control settings and checking drying schedule

7.1 Temperatures of Operation

Most lumber/bamboo dry kilns are designed to operate within a specified range of temperatures. This range depends largely on the species to be dried and quality and end use of final products. Also considered are amount of production expected, source of energy, and limitations of certain components of the system, such as compressors and electric motors. A common classification of kilns based on maximum operating temperatures is as follows:

- Low-temperature kiln . . . . . 120 °F
- Conventional-temperature kiln . . . 180 °F
- Elevated-temperature kiln . . . . . 211 °F
- High-temperature kiln . . . …….above 212 °F

Regardless of the temperatures used, the basic requirements of controlled heat, humidity, and air circulation apply. Therefore, kilns of different temperature classification differ primarily in terms of the source of heat energy and the type of materials and equipment used in the kiln structure.

Low-Temperature Kilns

Low-temperature kilns typically operate in the range of 70 to 120 °F, though some may not exceed 110 °F. This classification typically includes fan dryers, pre dryers, shed dryers, and some types of vacuum, dehumidification, and steam-heated kilns.

Conventional-Temperature Kilns

Conventional-temperature kilns typically operate in the range of 110 to 180 °F. The majority of hardwood lumber and sizeable amounts of softwood lumber are dried to final moisture content in kilns operating in this temperature range. These include steam-heated kilns and those designs of dehumidification kilns that operate up to 160 °F. The bulk of the kiln schedules available for the various species and thicknesses are for kilns operating at “conventional temperature.”

Elevated-Temperature Kilns

Elevated-temperature kilns typically operate in the range of 110 to 211 °F. The final dry-bulb temperature in a schedule for use in an elevated-temperature kiln is commonly 190 or 200 °F and occasionally as high as 210 °F. Many western softwood operations and some southern pine operations have kilns operating in this range. A few easy-to-dry hardwood species may use elevated temperatures in the final step of the schedule.

High-Temperature Kilns

High-temperature kilns typically operate for most of the drying schedule at temperatures above 212 °F, usually in the range of 230 to 280 °F. Perhaps the majority of southern pine lumber and increasing amounts of western softwood lumber are dried in high-temperature kilns. These kilns are more often used for drying construction-grade lumber where some surface checking and end splitting are acceptable in the grade, rather than upper-grade lumber where these defects are less acceptable. A very small amount of hardwood lumber is dried at high temperatures.

7.2 drying schedule

Kiln schedules are used to define the temperature and relative humidity needed in the kiln to dry bamboo with a minimum occurrence of degrades and in the shortest time possible. A typical kiln schedule is a series of drying conditions, expressed as temperature and relative humidity, which is used as a directive on how to operate a kiln throughout a period of time comprising the whole drying process. A drying schedule may be designed for manual, semi-automatic or fully automatic control system.

Table 2 Drying schedule for bamboo

Step	Drying time (hours)	T (°C)	RH (%)
1	24	38	30
2	48	38	30
3	56	49	25

A chart used to monitor the drying process in bamboo drying. Drying schedule could be of two types

A. Moisture content based
B. Time based

Moisture Content Based Drying Schedule

- The drying conditions are controlled with respect to the current moisture content of the bamboo materials being dried
- The moisture content is monitored regularly.

Self check-7	Written test

Name…… ID……Date……..

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I: write short answer for the following questions

1. List the common classification of kilns based on maximum operating temperatures (4points).

2. What is drying schedule? (2 points)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 4points ***Unsatisfactory below - 4points***

Operation Sheet 2	Determining Moisture content using the oven-dry method

1.1 Tools and equipment

- Cross cut saw
- Weighing scale (at most 1 gram graduation)
- Oven (at least 300 ˚C temperature capacity
- Pen and Paper
- Tong

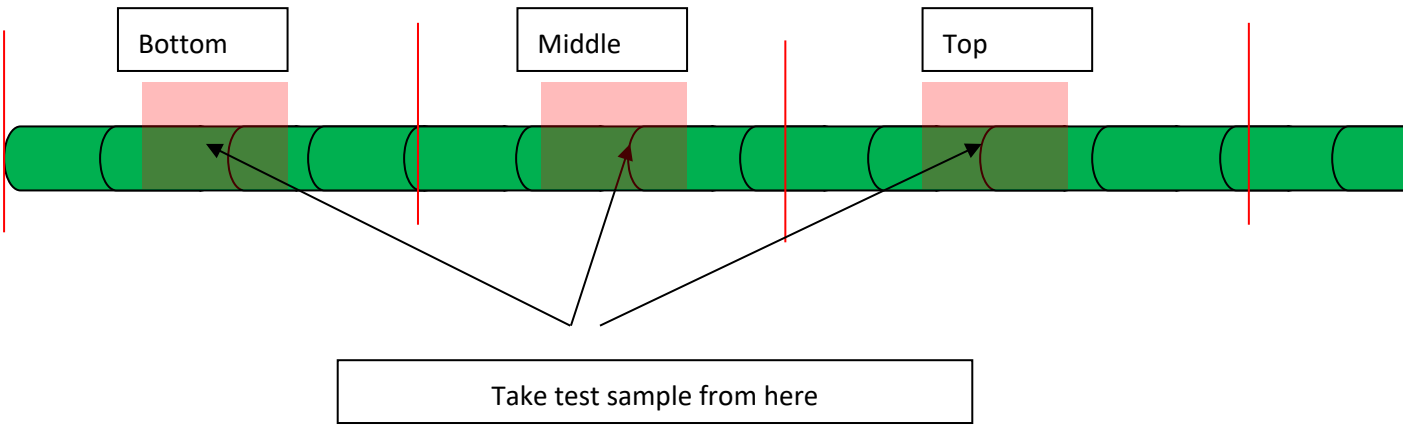
1.2 Procedures:

I. Prepare a table for recording the weight of each test specimen

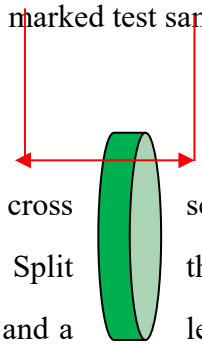
Trial	Bottom	Middle	Top	Average Weight
Wi				
1				
2				
3				
4				
6				
7				
8				
Wo				

II. Select a bamboo poles to where bamboo samples will be cut(consider the factors in selecting a good bamboo sample).

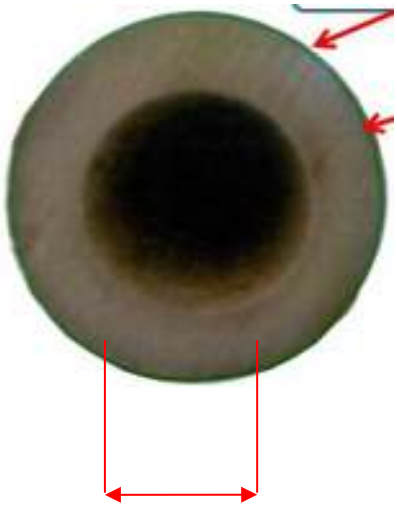
From the selected bamboo poles mark the portion where the test sample will be cut. The length of the test samples is 10 – 15 cm. In marking the test sample, avoid the nodal part.



III. Cut the marked test sample 10-15cmm long



IV. In the cross section of each of the samples, make a mark that has a width of 2.5 cm. Split the test sample to get the specimen with a dimension of 2.5 cm width and a length of 10-15 cm. Mark the samples in consecutive order using a pencil. i. e top, middle bottom. Do not use ball pen.



V. Using the weighing scale get the initial weight of each of the sample. And record it in the prepared table in the Wi (initial weight row.) Initial weight should be taken immediately after cutting the test specimen.

VI. Put the test specimen inside the oven and set it to 103˚C. Heat the samples for an hour.

Notes: Follow the procedures in using the oven. Read the operations manual on how to use the oven.

VII. After an hour turn of the oven and by using a tong, take out the test samples and take their weight immediately.

VIII. Record the weight in the row W1.

IX. Repeat steps 7 and 8 and record the weight in the rows W2, W3 and so on until the weight of each specimen becomes constant. If the weight becomes constant, that means the test specimen has no more water inside. The constant weight will become now the Oven-dry weight (Wo)

X. Take the average initial weight of each test specimen (Average Wi)

Average Wi = Wi Bottom + Wi Middle + Wi top

XI. Take the average oven dry weight of the specimens (Average Wo)

Average Wo = Wo bottom + Wo middle + Wo top

XII. Compute the moisture content of the bamboo using this formula

$$\%MC = \frac{\text{Ave Wi} - \text{Ave Wo}}{\text{Ave Wo}} \times 100$$

Note: If there is only one test specimen the formula for calculating the moisture content is:

$$\%\ M\ C = \frac{Wi - Wo}{Wo} \times 100$$

Where Wi = initial weight

Wo = Oven dry weights

Operation Sheet 3	Loading Kiln Charge

.

1.1 Tools and Equipment

- Drying racks/ tray
- Stickers
- Baffles
- Risers
- Moisture probes

1.2 Procedures

I. Identify the bamboo materials to be loaded in the kiln.

II. Sort the bamboo materials

III. Make sure the drying chambers are clean and free of water residues.

IV. Stack the bamboo materials. (Consider the factors in stacking like width and height of the pile, size and spacing of stickers, and location of samples)

V. Check for any wide spaces on the kiln charge. Use baffles to close wide spaces. (Wide spaces may result to uneven drying).

VI. Double check the location of the samples. (Check for accessibility. When moisture probes are used, check if they are securely connected to the samples

Operation Sheet 4	Controlling drying conditions

Tools and Equipment

- Moisture Meter
- Drying Schedule

Procedures

1. Check the operator's manual of the kiln drying equipment.
2. Check the drying equipment. Make sure all motors and other parts are in good working conditions.
3. Check the Wet Bulb and Dry Bulb Thermometers.(See Operator's Manual of the equipment.
4. Double check the kiln charge. (Stacking, location of samples baffles etc.)
5. Closed all unnecessary openings to minimize heat loss.
6. Identify the drying schedule to be used based from the initial moisture content of the kiln charge.
7. Operate the kiln following the identified drying schedule.

Videos

- **https://www.youtube.com/watch?v=91o2zqCNKJY&t=100s DIY Coconut shell charcoal carbonization furnace charcoal stove kiln.mp4.crdownload**
- **https://www.youtube.com/watch?v=Csgj7GSKDCw Dryer for drying 1.3mm round bamboo stick. No electricity required..mp4.crdownload**

LAP TEST 2	Performance Test

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within **2** hour. The project is expected from each student to do it.

Task-1 Determine moisture content using the oven-dry method

Task-2 Load kiln charge

Task-3 Control drying conditions

LG #7	LO #4- unload kiln

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Checking equilibrium moisture content of bamboo material.
- Unloading bamboo material
- Pilling and storing bamboo materials
- Disposing sub-standard material

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Check moisture content of bamboo materials in accordance with anticipated equilibrium moisture content.
- Unload bamboo materials from the chamber following workplace procedures
- Pile and store bamboo materials following standard work place procedure.
- Reject and dispose sub-standard material accordance with site requirements

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Information Sheet 1- Checking equilibrium moisture content of bamboo material.

1.1 Equilibrium Moisture Content (EMC)

- The moisture content of bamboo is equal to the moisture content of its surrounding. Around 15 – 18%

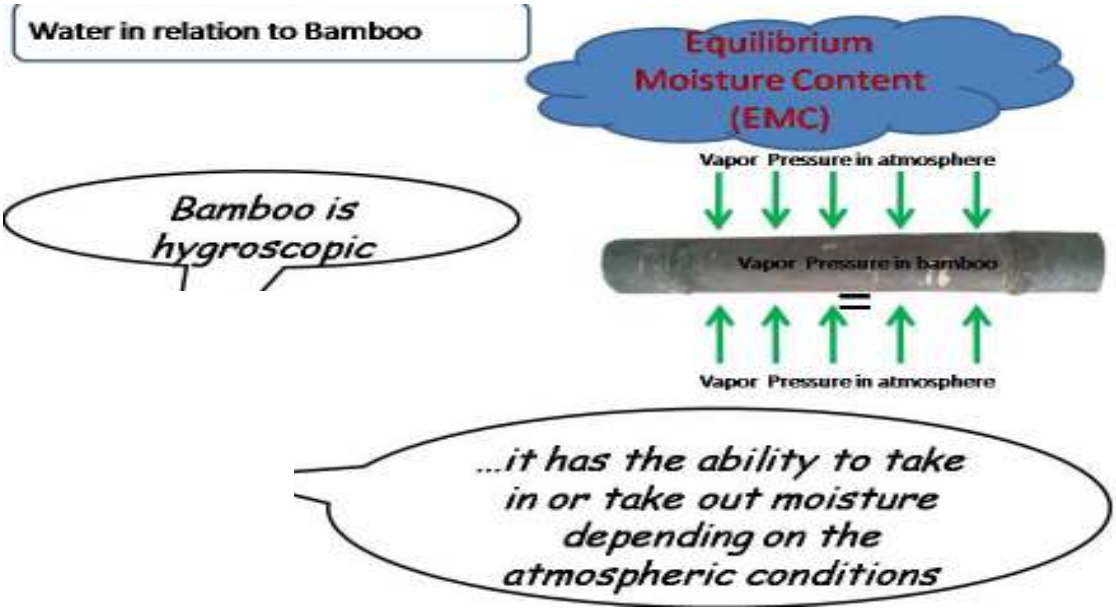
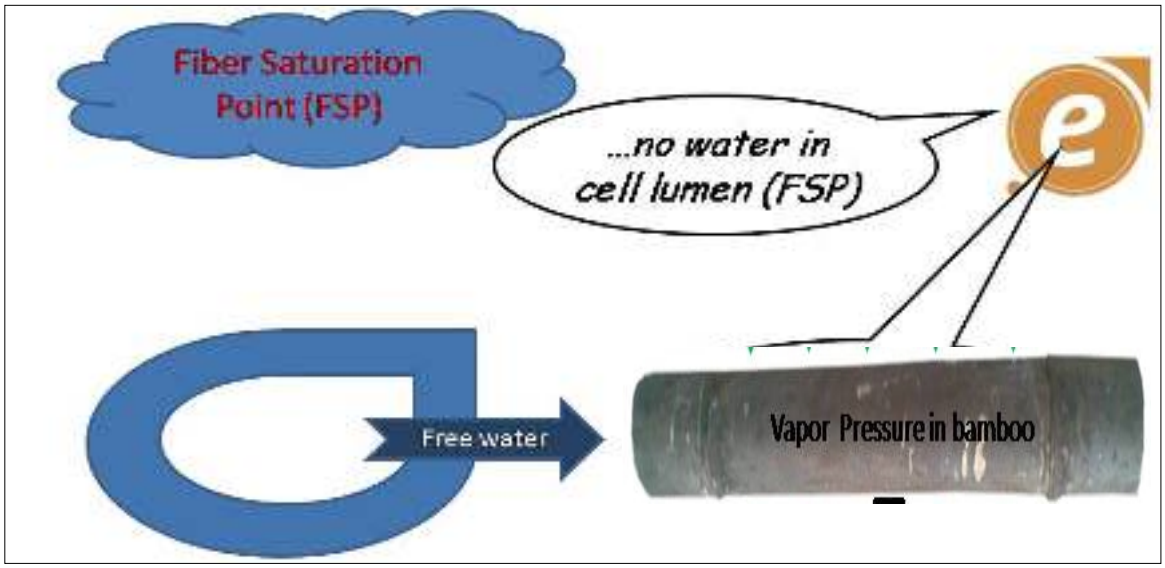


Figure 1; water in relation to bamboo

21 Fiber Saturation points

- Shrinkage and swelling occurs in bamboo below the fiber saturation point (FSP)



Example:

- Moisture content reduces from 25% to 15 %, shrinkage will occur
- Moisture content increased from 18% to 28%, swelling will occur

Self - check five	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. What is equilibrium moisture content?(3point)

Test II true or false

1. Shrinkage and swelling occurs in bamboo below the fiber saturation point

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 3 points Unsatisfactory – 3 below points

Information Sheet 2- Unloading bamboo material

2.1. Introduction

The main purposes of Unloading of bamboo is expulsion of the treatment vat

1.1 Methods of unloading

- A kiln area operator may direct forklift using hand signal, when positioning to drop of the load
- Check the situation of drying or treatment
- Wight for cooling bamboo
- Holding perfectly

Figure2: unloading bamboo splits

Self check- 2	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Write methods of unloading?(5 point)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 5 points ***Unsatisfactory – 5 below 5points***

Information Sheet 3- Pilling and storing bamboo materials

3.1 Introduction

The uses of pilling and storing Keep storage areas free from accumulated materials that may cause slips, trips, falls, or fires or that may contribute to harboring pests.

3.1 Materials handling and storage

3.1.1 Storage of Other Materials

A. When storing materials, employees shall:

- Prevent creating hazards when storing materials by being aware of the material's height and weight; how accessible the stored materials are to the user – consider the need for availability of the material; and the condition of the storage containers. All materials stored in tiers must be stacked, racked, blocked, inter-locked, or otherwise secured to prevent sliding or collapse.
- Keep storage areas free from accumulated materials that may cause slips, trips, falls, or fires or that may contribute to harboring pests.
- If possible, place bound materials on racks and secure it by stacking, blocking, or inter-locking to prevent it from sliding, falling, or collapsing.
- Stack Bamboo no more than 16 feet high if handled manually and no more than 20 feet if using a forklift.
  - ✓ Remove all nails from used bamboo before stacking it.
  - ✓ Stack and level bamboo on supported bracing.
- Ensure stacks are stable and self-supporting. Observe height limitations when stacking materials.
- Stack bags and bundles in interlocking rows and limit the height of the stack to keep them secure.
- Block the bottom tiers of drums/barrels/kegs to keep them from rolling if stored on their side.
  - ✓ Stack drums/barrels/kegs symmetrically.

- ✓ Place planks, pallets, etc. between each tier of drums/barrels/kegs to make a firm, flat stacking surface when stacking on end.
- ✓ Chock the bottom tier on each side to prevent shifting in either direction when stacking two or more tiers high.

- Materials must not be stored on scaffolds or runways in quantities exceeding those needed for immediate operations.

B. Additional safe material storage practices include:

- ✓ Ensuring shelves and racks are sturdy and in good condition.

- Stacking all materials on a flat base.
  - ✓ Placing heavier objects closer to the floor and lighter/smaller objects higher.
  - ✓ Not stacking items so high that they could block sprinklers (18” of clearance) or come in contact with overhead lights or pipes.
  - ✓ Using material-handling equipment or a ladder to place or remove items above your head.
  - ✓ Never standing on a shelf, rack, boxes, or a chair.

Self- check -3	Writ written test

Name…… ID…… Date……

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. List the uses of pilling?(4point)
2. Write how stacking materials on a flat base (3point)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 7points ***Unsatisfactory below 7 points***

Information Sheet 4- Disposing sub-standard material

4.1 Waste disposal

On completion of the process all waste material should be removed from the work area. This could include any materials such,

- Shavings
- Saw dust,
- Scraps.
- Chemical container
- Defective bamboo
- hazardous materials

Removed in the correct manner and that relevant environmental legislation for Waste disposal is followed.

Hazardous materials can include adhesives and glues, cleaning products, Finishing products and some manufactured board. The appropriate disposal of hazardous material can be identified from the material safety data sheets (MSDS) for these products.

Figure3: Waste disposal image

Self - check 4	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Write waste material that may occur during treatments (4pint)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 4 points ***Unsatisfactory – 4below 4points***

LG #8	LO #5- Cary out Treatment

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Identifying bamboo treatment methods
- Preparing bamboo material for treatment
- Identifying and preparing chemicals
- Appling treatment chemical

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:.

- Identify bamboo treatment methods.
- Check and prepare bamboo materials for treatment according to job specifications.
- Identify and prepare chemicals according to the specification.
- Done treatment according to the standard procedures

Learning Instructions:

7. Read the specific objectives of this Learning Guide.
8. Follow the instructions described below.
9. Read the information written in the information Sheets
10. Accomplish the Self-checks
11. Perform Operation Sheets
12. Do the “LAP test”

Information Sheet 1- Identifying bamboo treatment methods

1.1 Importance of bamboo treatment and preservation

- Bamboos are a natural material and will decay with time.
- They are also susceptible to insect and fungal attack
- Preserved bamboos increase the durability of the culms and increase the lives ofthe products they are used to produce.
- If used as structural components they need to be replaced less often which reducescosts in th e long term
- Preserved bamboos fetch higher prices than non-preserved bamboos

1.2 Bamboo Preservation Methods

Basically there are two methods:

A. Non-Chemical, Traditional Bamboo Treatment Methods

B. Chemical Bamboo Treatment Methods

Method A -Non-Chemical, Traditional Bamboo Treatment:

- These are ancient methods which have been practiced in areas where bamboo commonly grows.
- They are simple and cost-effective without the use of chemicals or supporting equipment.

A. Leaching

- Leaching helps remove starch and also enhances permeability for future
- treatment by diffusion and pressure.
- This method is appropriate for treating any quantity of bamboo.
- It is also recommended for craft and mat applications where flexibility is required

B. Smoking

- Traditionally, culms are stored over the fireplace.
- The moisture content in smoked culms is thus reduced so that biological
- degradation cannot take place.

- Built-up deposits from smoke form a protective layer on the culm.
- Smoke drying also reduces splitting.

Method B -Short Term Chemical Bamboo Treatment

A. Brushing

- It is suitable for small handicraft and household items.
- 2-3 coats of chemicals should be given using a brush.

B. Dipping

- Dipping is used for medium quantities of bamboo/bamboo products.
- Dipping is more effective than spraying or brushing.
- A momentary dip of 30 seconds to a minute is sufficient to protect the material.
- The excess material should be drained and reused.

Long Term Chemical Bamboo Treatment

A. Diffusion Method:

- Diffusion is suitable for green bamboo only.
  Round bamboo, splits and slivers can be treated by keeping them submerged in water-borne preservative solution. (water-borne preservatives like Boric acid: Borax 1:1.4 ...etc)
- The method of diffusion can be varied by increasing the concentration ofpreservative to reduce treatment time
- Scale: The process is slow, requiring a large number of tanks. It is suitable fortreating 50 -100 culms a month.

B. Hot and cold Method:

- Hot and cold treatment requires air-
  dry bamboot is based on the principle that on heating, air from the cells will expand and partially escape.
- During cooling a slight vacuum is created due to contraction of the residual airand causes t he entry of preservative into the cell.
- Scale: Large quantities can be treated at one time
- Preservatives :- Creosote for exterior uses (can be heated to 900 C

- Boric acid-Borax (should be heated to 500 C)

Figure1: Dipping water or chemicals for treatment

Self - check 1	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

Test I. Write short answer for the following answer.

1. List A -Non-Chemical, Traditional Bamboo Treatment methods(2points)
2. List a long term chemical treatment metods (2points)
3. _____ is a treatment method suitable for green bamboo only.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 7 points ***Unsatisfactory – 7below 4points***

Information Sheet 2- Preparing bamboo material for treatment

2.1 Bamboo selection

- Sorting bamboo Culm with specification age, species, dimension, defect
- Freshly cut Culm are cut to desired length
- Remove branches without causing damage of Culm
- Cleaning stacking area
- Fumigate staking area to minimizing bamboo Culm from insect, termite, and other insect

2.2 Air drying round bamboo takes about 6-12 weeks. Drying time depends on:

- Initial moisture content
- Bamboo wall thickness
- Environmental humidity
- Quantity of solar radiation
- The absence or presence of rain
- Speed of the surrounding air

Self - check 2	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. How to select bamboo for treatment?(4points)
2. Bamboo drying time depends on (4point)

1----------

2. ----------

3. ----------

4. ----------

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 8 points ***Unsatisfactory – below 8points***

Information Sheet 3- Identifying and preparing chemicals

3.1 Born chemicals

Bamboo can be treated with boron in a number of different ways (Liese & Kumar, 2003; Kaminski et al., 2016c). All methods allow the boron to diffuse through the walls of the culm, with the aim of treating the entire thickness of the culm walls. The most appropriate for Cox's Bazar are given below.

3.1.1 Treatment chemicals

There are a number of boron-containing compounds which can all be used for treating bamboo. These compounds are slightly different in their ease of use, but they are all equally effective, and can be used interchangeably with the different methods of treatment. The compounds are normally available as fertilisers.

- Disodium octoborate tetrahydrate ($Na_2B_8O_{13}.4H_2O$) (also known as the acronym "DOT"). This comes as a single ready to use compound. It is the most readily soluble of the boron-containing compounds. Trade names include "borosol" and "solubor".
- Borax ($Na_2[B_4O_5(OH)_4].8H_2O$) and boric acid (H_3BO_3). These two boron- containing compounds need to be used together, as they are only soluble when mixed. A general rule for quantities is 3kg borax + 2kg boric acid, per 45 litres of water.

All boron-compounds are soluble and will therefore leach out when exposed to rain. It is not possible to chemically fix boron into the bamboo.

In order to be affective, it is recommended to add boron to water such that the concentration reaches 10-12%, although lower concentrations will still likely have some affect (Liese & Kumar, 2003).

It is generally recommended to treat bamboo with boron via the methods below while it is still fresh – normally between 7-14 days after cutting – and therefore ideally the bamboo

will be treated with boron immediately upon arrival in the camps. If bamboo which is less fresh is treated, the treatment methods are still likely to be relatively affective, but it is harder for the boron to diffuse through the full thickness of the culm wall

The water used for the boron treatment should be clean freshwater. It is possible that salt-water may interfere with the solubility of the boron (both compounds above). If there is a demand to use salt-water for boron treatment, it is recommended that a laboratory boron solubility test is conducted, to see if and how much the salt interferes with the boron's solubility, and whether this is acceptable or not (i.e. whether enough still dissolves for the treatment method to be effective).

The boron liquid can be re-used in all of the following methods, however, over time, the liquid will fill with dirt and sap, which may affect the hydrometer reading, and may interfere with the efficacy of the treatment. The liquid should therefore be periodically cleaned in the following ways:

- Filtered through a fine filter to remove dirt.
- Coagulating the sap and then removing it and disposing of it safely (Section 5.2.8).
- Experienced bamboo treatment workers can advise on the best methods.

Self - check five	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Write the main purpose of bamboo treatment?(4point)
2. Write how to clean boron chemicals?(2point)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points ***Unsatisfactory – 4 below 6 points***

Information Sheet 4- Applying treatment chemical

4.1 applying chemicals with short term chemical protection

1. Spraying

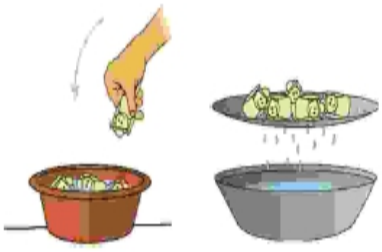
- This method is suitable only for large stacks of bamboo especially in the lumber yard.
- It is preferably used during periodic disinfection of the bamboo storage area.

2. Brushing

- Suitable for small handicrafts and household items.
- Applying 2-3 coats of the solution is Preferable
- The size of the brush to be used depends on the material surface to be covered. For wide surfaces a wider brush is better, for smaller surfaces, a smaller brush is more advisable.

3. Dipping

- Used for medium quantities of bamboo products/ materials.
- More effective compared to brushing or spraying.
- Dip the material for about 30 to 60 seconds.



Operation Sheet 5	Applying chemical by spraying

Tools and Equipment

- Back pack Sprayer or similar tools with the needed chemicals
- Appropriate PPE's
- Polyethelene Sheet or similar materials

Procedures

- Stack bamboo horizontally on a raised flat form
- preferably sloping ground and on a polyethylene shee

1. For large bamboo stacks, use industrial sprayer. For small stacks a backpack is sufficient
2. Spray chemicals from the top taking special care to cover ends and cut surfaces
3. Collect the drained solution for reuse. This solution can be applied using dipping or brushing method.
4. Place the collected solution in a secured and covered container.
5. When all materials is applied with chemicals, remove unused chemicals from the sprayer and place in a securely covered container. (This should not be mixed with the collected drained solution.)
6. Wash sprayer with clean water. (Do not store sprayer containing chemicals).

Notes and Precautions

- Check if the area is suitable for spraying process.
- Check that the solution is free of foreign objects
- Spraying position is along the direction of the wind
- Observe proper handling of preservatives
- Use appropriate PP

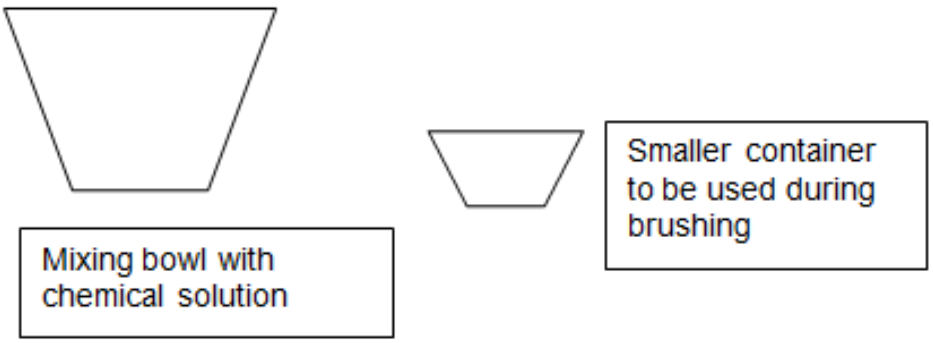
Operation Sheet 6	Applying chemicals by Brushing

Tools and Equipment

- Paint Brush (# 25 – 100)
- Mixing bowl with the needed preservative solution
- Small Bucket/pan or can
- Stirring rod

Procedures:

1. Check and clean the materials to be treated.
2. Check components of any damage. Damaged components should be replace prior to chemical treatment.
3. Check that the work area is suitable for brushing process.
4. Identify and prepare the suitable paint brush to be used for the project
5. Using a smaller container, transfer chemical solution from the mixing bowl. (Do not immerse the brush directly in the mixing bowl.)



6. For finished products like chairs, apply chemicals first in the under parts by positioning it up-side down.
7. For processed components, apply chemicals on all the surface of the component giving special care to the ends, nodes and other open cuts.
8. Apply chemicals on the product in normal position starting from the top going down. Make sure all surfaces is covered with chemicals.
9. Apply 2-3 times coating. Wait for few minutes before applying succeeding coats.
10. When all materials is applied with chemicals, replace the chemical solution in a securely covered container. (This should not be mixed with unused solution in the smaller container.)

Operation Sheet 7	Applying chemicals by dipping

Tools and Equipment

- Dipping bowl (size depends on the size of materials to be dipped) with the needed preservative solution
- Stirring rod
- Appropriate PPE's

Procedures:

1. Check and clean the materials to be treated.
2. Check components of any damage. Damaged components should be replaced immediately prior to chemical treatment.
3. Check that the work area is suitable for process.
4. Dip the materials momentarily for about 30 – 60 second

5. When all the materials are treated, placed the chemical solution in a secured and covered container for future use.

Notes and Precautions

- ***Check that the solution is free of foreign objects***
- ***Observe proper handling of preservatives***
- ***Use appropriate PPE's***

Videos

- ✓ https://www.youtube.com/watch?v=1h8ychAqqJE&t=46s Bamboo Treatment.mp4.crdownload
- ✓ https://www.youtube.com/watch?v=qcr9lFxOIuc&t=126s BAMBU TRATAMENTO ORGÂNICO.mp4.crdownload

- ✓ https://www.youtube.com/watch?v=MIfHk1Dscb0&t=3s Bamboo Treatment - How it's done (1).mp4
- ✓ https://www.youtube.com/watch?v=V9nKLpUdzD0&t=167s Bamboo Treatment Process for Building Construction.mp4

Lap test 3	Treating bamboo materials

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary workshop, tools and materials you are required to perform the following tasks within 8 hours.

Task 1. Treat bamboo materials using spraying with chemicals

- Set-up area
- Apply chemicals by spraying with chemicals
- Store unused chemical
- Clean and sore tools and equipment

Task 2 . Treat bamboo materials using bureshing with chemicals

- Set-up area
- Apply chemicals by bureshing with chemicals
- Store unused chemical
- Clean and sore tools and equipment

Task 3 . Treat bamboo materials using dipping with chemicals

- Set-up area
- Apply chemicals dipping with chemicals
- Store unused chemical
- Clean and sore tools and equipment

LG #9	LO #6 Complete Work

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Collecting and storing reusable materials
- Removing waste and scrap
- Maintaining and storing tools and equipment

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:.

- Collect and stored reusable materials following workplace procedures.
- Remove waste and scrap following environmental laws.
- Maintain and store tools and equipment following manufacturer's manual.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the "LAP test"

Information Sheet 1- Collecting and storing reusable materials

1.1 Introduction

The main purpose of collecting and storing reusable material is to increasing incomes and to minimize work place injury. Working area, Good organization of stored materials is essential for overcoming material storage problems whether on a temporary or permanent basis. There will also be fewer strain injuries if the amount of handling is reduced, especially if less manual materials handling is required. The location of the stockpiles should not interfere with work but they should still be readily available when required. Stored materials should allow at least one meter (or about three feet) of clear space under sprinkler heads.

1.2 Collecting and storing reusable material

- Select small size material
- Select defected material

1.3 Reuse Wood Waste and Sawdust

For many years wood waste was open burned or disposed of in landfills. As the cost of both wood and disposal will continue to rise, and open burning is usually no longer an option, it makes sense to find ways to recycle wood waste.

Reusing options include:

- Collect small size bamboo Culm
- Collect stripes
- Collect defected bamboo
- Collect saw dust
- Collect crooked Culm this all waste material using for charcoal

Self - check 1	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Write the main purpose of reusing material?(4point)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 4 points ***Unsatisfactory – 4 below 4 points***

Information Sheet 2- Removing waste and scrap

2.1 Implement housekeeping activities

Regular inspections are carried out in the work area according to workplace procedures and standards. Areas and amenities are cleaned and maintained in accordance with Occupational Health and Safety (OHS) and 5S procedures. Disposal of waste and dangerous chemicals are checked in accordance with OHS regulations and organizational policies.

2.2 Methods of removing waste or scrap

- Select un necessary material or saw dust
- Removing stripes
- Sweep the floor
- Sweep the tool and equipment
- Sweep the wall
- Select chemical container
- Washing the wall

Figure1: Cleaning work area

Self check -2	Writ written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Write methods of removing waste or scrap?(4Point)

   You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 4 points ***Unsatisfactory – below 4points***

Information Sheet 3- Maintaining and storing tools and equipment

3.1 storing tools and equipment

- Sort with item
- Cleaning tool equipment
- Stacking with item

Methods of simple maintenance

- Cleaning tool and equipment
- Lubrication
- Sharpening of scraper

3.3 Defective equipment's

The employer is responsible for the safe condition of tools and equipment used by employees but the employees have the responsibility for properly using and maintaining tools. Employers should caution employees that saw blades, knives, or other tools be directed away from aisle areas and other employees working in close proximity. Knives and scissors must be sharp.

Dull tools can be more hazardous than sharp ones. Appropriate personal protective equipment, e.g., safety goggles, gloves, etc., should be worn due to hazards that may be encountered while using portable power tools and hand tools. Safety requires that floors be kept as clean and dry as possible to prevent accidental slips with or around dangerous hand tools.

self check -3	Writ written test

Name…… ID…… Date……

Directions: Answer all the questions listed below accordingly. Examples may be necessary to aid some explanations/answers.

1. Write methods of simple maintenance?(6point)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 6 points ***Unsatisfactory – 6 below 7points***

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WEB ADDRESSES

- https://www.youtube.com/watch?v=1h8ychAqqJE&t=46s Bamboo Treatment.mp4.crdownload
- https://www.youtube.com/watch?v=qcr9lFxOIuc&t=126s BAMBU TRATAMENTO ORGÂNICO.mp4.crdownload
- https://www.youtube.com/watch?v=MIfHk1Dscb0&t=3s Bamboo Treatment - How it's done (1).mp4
- https://www.youtube.com/watch?v=V9nKLpUdzD0&t=167s Bamboo Treatment Process for Building Construction.mp4
- https://www.youtube.com/watch?v=91o2zqCNKJY&t=100s DIY Coconut shell charcoal carbonization furnace charcoal stove kiln.mp4.crdownload
- https://www.youtube.com/watch?v=Csgj7GSKDCw Dryer for drying 1.3mm round bamboo stick. No electricity required..mp4.crdownload
- http://www.iitg.ac.in/spal/Methods%20of%20mounting%20of%20jobs%20and%20cutting%20tools.ppt
- http://www.iitb.ac.in/safety/sites/default/files/Machine%20Safety_0_0.pdf)

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