Civil Engineering Materials
SAB 2112

Introduction to Wood & Timber

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CONTENT SCHEDULE – 3rd Meeting

1. Timber classification, its structure and moisture content, types of strength, factors affecting the strength of timber
2. Defect in timber and its causes, seasoning and wood preservatives, timber products and their use, types of bricks, blocks and their use
Learning Objectives

1. Discuss about the different types of timbers.
2. Discuss the application and use of timbers in construction.
3. Understand the properties of timber.
4. Discuss about the defects in timber.
5. Discuss about different types of preservatives treatments.

Forest Land Use in Malaysia

<table>
<thead>
<tr>
<th>Forest Land Use in Malaysia, 2006 (MILLION HAE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data and Allocated Land (10%)</td>
</tr>
<tr>
<td>Total Preceded</td>
</tr>
<tr>
<td>122</td>
</tr>
</tbody>
</table>

Annual Allowable Cut in the Permanent Reserved Forest (ha/year)

<table>
<thead>
<tr>
<th>Malaysia Plan (MP)</th>
<th>Pen. Malaysia</th>
<th>Sabah</th>
<th>Sarawak</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>6th MP (1991-1995)</td>
<td>52,000</td>
<td>30,000</td>
<td>96,000</td>
<td>178,000</td>
</tr>
<tr>
<td>7th MP (1996-2000)</td>
<td>46,000</td>
<td>60,000</td>
<td>170,000</td>
<td>276,000</td>
</tr>
<tr>
<td>8th MP (2001-2005)</td>
<td>42,870</td>
<td>60,000</td>
<td>170,000</td>
<td>272,870</td>
</tr>
<tr>
<td>9th MP (2006-2010)</td>
<td>36,940</td>
<td>60,000</td>
<td>170,000</td>
<td>266,940</td>
</tr>
</tbody>
</table>
Forest Cover in Malaysia

Wood Energy Usage

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood from Trees Used</td>
<td>2.5</td>
<td>30.09</td>
<td>6</td>
</tr>
<tr>
<td>Wood from Residues</td>
<td>4.1</td>
<td>60.20</td>
<td>12</td>
</tr>
<tr>
<td>Prepared Indirect Use</td>
<td>6.2</td>
<td>79.25</td>
<td>16</td>
</tr>
</tbody>
</table>

Wood - the most environmentally friendly material

The following replacement energy requirement is given in Table 3 of the study. The study concludes that the substitution of wood energy results in a lower energy demand and a decrease in CO2 emissions, making it a sustainable solution.
**Canopy Layers of the Malaysian Rainforest**

- **Upper or emergent canopy:**
  - Composed of Shorea spp.,
  - Usually (Koompassia excelsa),
  - Dipterocarpus spp. and tempas
  - (Koompassia malaccensis) trees, characterized by widely spaced crowns.

- **Main canopy:**
  - Generally a continuous layer of
  - Some-crowned trees and epiphytic
  - Ficus spp. and a rich habitat for birds and monkeys.

- **Lower tree canopy or understory:**
  - Consists of densely-packed
  - Seepings and palms from whose
  - Branches lianas hang, rotuins
  - Climb and on which epiphytic ferns
  - And orchids sit.

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**Protected Areas in Peninsular Malaysia**

<table>
<thead>
<tr>
<th>No.</th>
<th>Protected Areas</th>
<th>Size (ha)</th>
<th>Date of establishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Endau Kuang Wildlife Reserve</td>
<td>52,493</td>
<td>25.10.1993</td>
</tr>
<tr>
<td>2</td>
<td>Four Islands Wildlife Reserve</td>
<td>N.A</td>
<td>07.10.1954</td>
</tr>
<tr>
<td>3</td>
<td>Nine Islands Wildlife Reserve</td>
<td>N.A</td>
<td>04.02.1971</td>
</tr>
<tr>
<td>4</td>
<td>Tanjung Tuan Wildlife Reserve</td>
<td>61</td>
<td>04.02.1971</td>
</tr>
<tr>
<td>5</td>
<td>Port Dickson Islands Wildlife Reserve</td>
<td>N.A</td>
<td>15.10.1926</td>
</tr>
<tr>
<td>6</td>
<td>Krau Wildlife Reserve</td>
<td>52,395</td>
<td>15.06.1923</td>
</tr>
<tr>
<td>7</td>
<td>Pahang Tua Wildlife Reserve</td>
<td>1,335</td>
<td>07.01.1954</td>
</tr>
<tr>
<td>8</td>
<td>Pital Ulu Temuan Islands Wildlife Reserve</td>
<td>9,455</td>
<td>13.09.1984</td>
</tr>
<tr>
<td>9</td>
<td>Batu Gajah Wildlife Reserve</td>
<td>4</td>
<td>26.05.1952</td>
</tr>
<tr>
<td>10</td>
<td>Chior Wildlife Reserve</td>
<td>4,330</td>
<td>27.03.1903</td>
</tr>
<tr>
<td>11</td>
<td>Sungkai Wildlife Reserve</td>
<td>2,468</td>
<td>05.12.1940</td>
</tr>
<tr>
<td>12</td>
<td>Bukit Klu Wildlife Reserve</td>
<td>1,943</td>
<td>26.12.1922</td>
</tr>
<tr>
<td>13</td>
<td>Fraser's Hill Wildlife Reserve</td>
<td>2,979</td>
<td>07.04.1922</td>
</tr>
<tr>
<td>14</td>
<td>Klang Gate Wildlife Reserve</td>
<td>130</td>
<td>06.03.1936</td>
</tr>
<tr>
<td>15</td>
<td>Kuala Selangor Hill Wildlife Reserve</td>
<td>44</td>
<td>05.04.1922</td>
</tr>
<tr>
<td>16</td>
<td>Bukit Sungai Puluh Wildlife Reserve</td>
<td>36</td>
<td>04.11.1932</td>
</tr>
<tr>
<td>17</td>
<td>Sungai Dusun Wildlife Reserve</td>
<td>4,330</td>
<td>11.06.1964</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>142,003</strong></td>
<td></td>
</tr>
</tbody>
</table>

Source: Department of Wildlife & National Parks
MANGROVE MONKEYS

The silvery leaf monkey and dusky leaf monkey share a common feature with the proboscis monkey: all consume swamp vegetation.

1. Proboscis monkey (Nasalis larvatus)
2. Silvery leaf monkey (Presbytis cristata)
3. Dusky leaf monkey (Presbytis obscurus)
Tree Growth

1. Dead Bark – Protective Layer
2. Living Bark – Composed of hollow longitudinal cells that conduct nutrients down the truck from the leaves to the roots
3. Cambium – Thin layer which creates new bark cells toward the outside of the trucks, and new wood cells toward the inside.
4. Sap Wood – the thick layer of living wood cells inside the cambium – nutrients are stored and sap is pumped upward from roots to leaves.
5. Heartwood – sap wood dies progressively and becomes heartwood – no longer participates in the life processes of the tree but continues to contribute to its structural strength.

1. Summer growth
2. Spring growth
6. Pitch – of the tree is a small zone of weak wood cells from first year’s growth.
Heart Wood The dark colored, center of a tree, consisting of dormant wood. Heart wood of soft wood generally contain slightly less lignin and cellulose than the sap wood.

Sap Wood The fluid part of the tree that moves up from the roots through the outer portion of the trunk and branches and contributes to its growth. The acetyl content is higher in sap wood compared to heart wood.

- Wood consists primarily of tubular cells whose long axes are parallel to the long axis of the trunk.
- The cells are structured of tough cellulose and are bound together by a softer cementing substance called lignin.
- The direction of the long axes of the cells is referred to as the direction of the grain.
- Grain direction is important to the strength of the wood.
- Tree grown under continuously moist, cool conditions grow faster but not as strong.
Classification of Trees

• All commercial timbers can be classified into 2 broad groups: **softwoods** and **hardwoods**.

• Do not confused with both terms, its can be quite misleading: take for instance, **balsa** is a hardwood but is softer and less dense than any softwood, while **pitch pine** is a softwood which is harder and more dense than many hardwoods.

• The true distinction between the 2 groups of timber are:
  
  • **Softwood** is produced from the gymnosperms, the coniferous trees such as pines and spruces, which have characteristic needle-like leaves. These trees are generally evergreen. Traditionally softwoods have been used primarily for structural timbers and are graded specifically for this purpose.

  • **Hardwood** is produced from one group of the angiosperms, known as dicotyledons, which are the broad leafed trees, such as oak, beech and ash. The temperature zone hardwoods generally season-based, while most tropical hardwoods retain their leaves all year round. The major use of hardwoods is in furniture and cabinet manufacture.
- Softwoods come from coniferous trees
- Hardwoods come from broad-leafed trees.
- Names can be confusing because many coniferous trees produce harder woods than broad-leafed.
- Softwood trees have a much simpler cell structure than hardwoods consisting of mainly large longitudinal cells – uninteresting patterns of grain.
- Hardwoods have complex cell structures – and beautiful grain patterns.

### Hardwood

- Wood from trees of angiosperms class, usually with broad leaves.
- Trees grown in tropical climates are generally hardwood.
- Hardwood grows faster than softwood but have shorter fibers compared to softwood.
• The trees classified as softwoods have needle like or scale like leaves that, with a few exceptions, remain on the tree all through the year.
• Hence softwood trees are sometimes called evergreens.
• Botanically, they are known as gymnosperms, from the Greek word meaning "naked seeds." Instead of bearing seeds from flowers, gymnosperms have exposed seeds in cones.
• Generally grown in cold climates, softwood grows slower than hardwood but have longer fibers compared to hardwood.

Classification of Trees
• The ease with which softwoods are grown, their speed of growth and the abundant supply of timber available from the northern temperature zone forests make softwood much cheaper than hardwood.
• Softwood is also much easier to work with than hardwood. Due to this reason, the bulk of all timber used in construction is softwood.
• Hardwood higher cost due to higher quality, increasing scarcity and greater transport costs.
• Generally, hardwoods are only used in situations where their superior appearance, better natural durability, and higher strength can justify their greater cost.
Malaysian Timber Durability

• In Malaysia, natural durability of Timber is determined using a ‘graveyard’ test. In this test, wood stakes 50mm x 50mm in section are inserted in the ground so that half of the length of the stake is buried.

• The average time taken for these stakes to fail is used to assign a natural durability rating. In Malaysia, four natural durability ratings exist.

<table>
<thead>
<tr>
<th>species</th>
<th>X value</th>
<th>durability rating</th>
<th>description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soraya</td>
<td>0.0638</td>
<td>1</td>
<td>Very durable</td>
</tr>
<tr>
<td>Meranti tembaga</td>
<td>0.2209</td>
<td>2</td>
<td>Durable</td>
</tr>
<tr>
<td>Oak</td>
<td>0.2997</td>
<td>2</td>
<td>Durable</td>
</tr>
<tr>
<td>Gerutu</td>
<td>0.3625</td>
<td>3</td>
<td>Moderately durable</td>
</tr>
<tr>
<td>Bintangor</td>
<td>0.4572</td>
<td>4</td>
<td>Slightly durable</td>
</tr>
<tr>
<td>Merpmadh</td>
<td>0.6387</td>
<td>4</td>
<td>Slightly durable</td>
</tr>
<tr>
<td>Rubberwood</td>
<td>0.7021</td>
<td>4</td>
<td>Slightly durable</td>
</tr>
</tbody>
</table>

Source: http://www.mtc.com.my/

Wood & Timber Classification

• Wood classification is extremely important for differentiation of specifications in regards of utilization.

• Timber classification is to ensure that buyers and sellers use the same commercial languages to unify and codify empirical practises and general costumes.

• The specific objectives of timber classification are the follows:
  – to sell the timber at highest value possible depending on species, diameter classes and different quality classes (wood quality can be classified according to defects such as knots, checks, bend, holes, etc.);
  – to develop precise rules to be able to refer in case of disputes.
The chart showed that the average price increased in the past 12 years continuously. However, in the period of 1995-1997, the price of logs did not change considerably because wood classification had not been done. The price of logs increased rapidly from 1998, when timbers were classified into utility oriented species groups.

Sources: http://www.ptm.org.vn/index.php?option=com_docman&task=doc_download&id=244
Uses of Timber in Construction

- Structural members; such as column, beam, floor joist, truss.

- Scaffoldings and formworks
Uses of Timber in Construction

- Timber partitions

- Doors & windows
Grade Stresses & Strength Classes

- BS 5268 is the current code of practice for the design of timber structures in the UK.
- The code introduced a system of 9 strength classes, SC1 to SC9, which have single stress values for each strength property.
- i.e. bending, tension, compression parallel and perpendicular to grain and shear, together with a modulus of elasticity value.
- As an example, the grade stress values for dry timber that bending parallel to the grain for the nine strength classes.
- In general, strength classes SC1 to SC5 cover the common construction softwoods while SC6 to SC9 comprise the denser hardwoods.

<table>
<thead>
<tr>
<th>Strength Class</th>
<th>Bending Strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SC1</td>
<td>2.8</td>
</tr>
<tr>
<td>SC2</td>
<td>4.1</td>
</tr>
<tr>
<td>SC3</td>
<td>5.3</td>
</tr>
<tr>
<td>SC4</td>
<td>7.5</td>
</tr>
<tr>
<td>SC5</td>
<td>10.0</td>
</tr>
<tr>
<td>SC6</td>
<td>12.5</td>
</tr>
<tr>
<td>SC7</td>
<td>15.0</td>
</tr>
<tr>
<td>SC8</td>
<td>17.5</td>
</tr>
<tr>
<td>SC9</td>
<td>20.5</td>
</tr>
</tbody>
</table>

Chemical Composition Of Wood

<table>
<thead>
<tr>
<th>Wood Components</th>
<th>Hardwood (%)</th>
<th>Softwood (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellulose</td>
<td>40 - 50</td>
<td>40 - 50</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>25 - 35</td>
<td>25 - 30</td>
</tr>
<tr>
<td>Lignin</td>
<td>20 - 25</td>
<td>25 - 35</td>
</tr>
<tr>
<td>Pectin</td>
<td>1 - 2</td>
<td>1 - 2</td>
</tr>
<tr>
<td>Starch</td>
<td>Trace</td>
<td>Trace</td>
</tr>
</tbody>
</table>

Sources: http://www.paperonweb.com/wood.htm
Slope of Grain

- The grain direction in a timber section is the direction of the main wood cells, fibres and vessels, in relation to the long axis of the section.
- In the living tree these cells do not always grow perfectly vertical, straight and parallel to the long axis of the trunk.

Properties of Timber

- Angle of the grain direction in a cut section of timber is not parallel to the longitudinal axis. The variation due to poor cutting, but mostly the deviation is due to irregular growth of the tree.
- In assessing grade, it is the general direction of the grain which must be determined.
- The effect of sloping grain have a significant influence on the bending resistance of a timber section.
- If the angle of sloping grain (deviation) increases, the strength of the timber section decreases.
Properties of Timber

Density

- Density is an indicator of the properties of a timber and is a major factor determining its strength.
- Specific gravity or relative density is a measure of timber's solid substance. It is generally expressed as the ratio of the oven-dry weight to the weight of an equal volume of water.
- Since water volume varies with the moisture content of the timber, the specific gravity of timber is expressed at a certain moisture content. Specific gravity of commercial timber ranges from 0.29 to 0.81.

Moisture Content

- Wood’s reaction to moisture provides more problems than any other factor in its use. Wood is hygroscopic (wet); that is, it picks up or gives off moisture to equalize with the relative humidity and temperature in the atmosphere.
- As it does so, it changes in strength; bending strength can increase by about 50% in going from green to moisture content found in wood members in a residential structure.
Properties of Timber

Strength

- Strength of timber is affected by density and a wide range of naturally occurring defects, consideration of which form the basis of the grading system.
- Timber is **anisotropic** because of its cellular structure, and thus strength properties must be considered in relation to the direction of loading relative to the grain direction.

\[
\text{Variation of bending strength with grain direction}
\]

<table>
<thead>
<tr>
<th>Material</th>
<th>Strength in bending (N/mm²)</th>
<th>Parallel to span</th>
<th>Perpendicular to span</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwood A</td>
<td>85</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Hardwood B</td>
<td>69</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

- The table illustrates 2 timbers cut from wide boards such that their grain direction was either parallel to the span or perpendicular to the span at test.

- Timber strength is also affected by moisture content, rate of application and duration of loading and temperature.
- The dry strength of timber in bending can be up to 50% more compared with wet strength.
- The effect on strength in compression can be even greater, as shown below, which were obtained from 50 x 50 x 200mm clear specimens.
- The reason for the effect of moisture content on strength is generally considered to be related to the strengthening of the secondary bonds between microfibrils in the cell walls as they come closer together, owing to the removal of intervening water on drying.
- In timber design, allowance is made for the effect of moisture content that would be exposed to wet conditions by multiplying the grade stresses of BS 5268 by reduction factors which vary from 0.6 for compressive strength to 0.8 for bending and tension and 0.9 for shear.

\[
\text{Effects of moisture content on compressive strength (compression parallel to grain, imported whitewood)}
\]

<table>
<thead>
<tr>
<th>Moisture content (%)</th>
<th>Strength (N/mm²)</th>
<th>Elastic modulus (kN/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>37</td>
<td>8.5</td>
</tr>
<tr>
<td>33</td>
<td>16.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>
Properties of Timber

Temperatures

- Although wood is an excellent heat insulator, its strength and other properties are affected adversely by exposure for extended periods to temperatures above about 100°F.

  - Used in moist environments find $emc$ from graph

\[ k_1 = 1 - 0.05(emc - 15) \]
Properties of Timber

Temperatures

• The combination of high relative humidity or moisture content and high temperatures, as in unventilated high areas, can have serious effects on roof materials and structural elements over and above the potential for attack by decay organisms.
• The strength of timber is also affected by temperature, the general effect being a linear decrease in strength with increase in temperature.
• This effect is also very dependent on moisture content, dry timber suffering much less decrease in strength per °C rise in temperature than wet timber.

Properties of Timber

Age Effects

• If wood in use is kept dry and free from mechanical and insect damage, it will remain nearly unchanged in its properties over time.
• Timbers removed from old structures may be reused. The only cautionary action is to have any structural members having cracks or splits due to the continued drying of a piece in use.
• Although wood strength may be expected to increase as the moisture content decreases, defects that occur due to the drying process tend to offset or nullify strength increases. This which may develop large cracks.
• Shear strength may be affected in beams, and column strength / stability may also be affected.
Timber Defects

- Heart shakes, sometimes called star shakes, are rifts, or cracks, which radiate from the center of the tree, as shown at Figure.
- They are common in nearly all classes of timber, and are caused by the shrinkage of the layers, incidental to loss of vitality; after the period of maturity has been passed and decline has begun, the outer rings being more active, derive their nutriment by absorbing the juices from the heart wood, thus causing a gradual but sure loss of its strength and virtue.

Malaysian Wood

- In general, there are three types of construction which is
  - building construction,
  - heavy/civil construction and
  - industrial construction.

- Each type of construction project requires a unique team to plan, design, construct, and maintain the project.

- Industrialised building system (IBS) is a system where all building components are mass produced either in factory or at site under strict quality control and minimal on site activities.

- It is an industrialisation essentially as an organisational process- continuity of production implying a steady flow of demand; standardisation; integration of the different stages of the whole production process.

- It can speed up construction process and with less labour on site and, if possible, at less cost and minimized effects of risk.
## Malaysian Wood

<table>
<thead>
<tr>
<th>Heavy Hardwood</th>
<th>Medium Hardwood</th>
<th>Light Hardwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balau/Selangan Batu</td>
<td>Kedang</td>
<td>Babai</td>
</tr>
<tr>
<td>Red Balau/Selangan Batu Merah</td>
<td>Belum/Tulang</td>
<td>Bintangor</td>
</tr>
<tr>
<td>Belian</td>
<td>Kulim</td>
<td>Durian</td>
</tr>
<tr>
<td>Bitis</td>
<td>Mempening</td>
<td>Kelumpang</td>
</tr>
<tr>
<td>Chengal</td>
<td>Merpauh</td>
<td>Melunak</td>
</tr>
<tr>
<td>Giam</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kekatong</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Keranji</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malagangai</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penaga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penyau</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tembusu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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## Malaysian Wood

- Tunang
- Kepai
- Palu
Lumber / Timber

Lumber is defined as length of squared wood used in construction.

1. Cut Down
2. Transported.
3. Milled.
4. Seasoned
Milling Process

- Head Saw – may be band saw or curricular saw – used to reduce it to untrimmed slabs of lumber – pieces have rough textured surfaces may have very slightly in dimension from end to end.
- Plain saw – used for framing of buildings – most economic – produces the greatest yield – but the grain in the wood varies – from perpendicular to the face – diagonal – parallel causes pieces to distort differently during seasoning and have different surfaces.
- Quarter saw – used for flooring, interior trim and furniture – usually only hardwoods annual rings run parallel with surface this lets boards remain flat with little change over time.
The Theory and Practice of Drying

• Although many methods of drying timber have been tried over the years only a few of these enable drying to be carried out at a reasonable cost and with minimal damage to the timber.

• The most common method of drying is to extract moisture in the form of water vapour. To do this, heat must be supplied to the wood to provide the latent heat of vaporisation. There are several ways of conveying heat to the wood and removing the evaporated moisture.

The Theory and Practice of Drying

- Nearly all the world's timber is, in fact, dried in air. This can be carried out at ordinary atmospheric temperatures (air drying), or in a kiln at controlled temperatures raised artificially above atmospheric temperature but not usually above 100°C, the boiling point of water.
- Air drying and kiln drying are fundamentally the same process because, with both, air is the medium which conveys heat to the wood and carries away the evaporated moisture.


Seasoning

- Growing wood can contain 30% to 300% of the oven dry weight of wood (water content)
- Free water – first to leave – 28% to 32% of the tree moisture – starts to leave as soon as the tree is cut.
- Bound water – held by the cell walls – wood starts to shrink and strength and stiffness increase.
- Farming lumber is considered seasoned when moisture content is less than 19%
  - No use to season framing lumber below 13% because wood is hygroscopic (which means over time moisture content will change varying on moisture content of the surrounding area)
- Swelling and shrinking are dependent on moisture in the air.
### Seasoning II

- **Two types of drying**
  - Air dry – takes months
  - Dried in kiln – takes days – most commonly used.

• A timber drying kiln may be defined simply as 'a closed structure designed or adapted for the purpose of reducing the moisture content of timber and wood based panel products'.

• An efficient kiln will provide controlled heating, air circulation, humidification and ventilation or dehumidification.

• Heating is required to:
  – Increase the rate of movement of moisture from the centre to the surface of the wood.
  – Increase the rate of evaporation of moisture from the surface of the wood.

• Air circulation is required to:
  – Ensure satisfactory heat transfer from the heat source to the air and from the air to the timber surface.
  – Mix the heated and humidified air so that it is distributed uniformly throughout the timber load.
  – Remove evaporated water from the wood surfaces.
  – Aid removal of excess moisture from the kiln by means of ventilation.
• **Ventilation** of the kiln chamber is needed to keep the kiln relative humidity down to the required levels when large quantities of moisture are being evaporated from the timber.
• **Dehumidification** is an alternative means of removing surplus moisture from the kilns.
• **Humidification** is required to maintain the kiln humidity at the desired level when the moisture coming from the wood is insufficient. It is usually needed during the warm-up phase and towards the end of drying, particularly when applying final high humidity treatments.
**Shrinking and Swelling**

- Moisture shrinkage along the length of the log (longitudinal shrinkage) is negligible for practice purposes.
- Shrinkage in the radial direction (radial shrinkage) if very large in comparison to shrinkage around the circumference of the log (tangential shrinkage) is about half again greater than radial shrinkage.

**Surfacing**

- Purpose to make it smooth and more dimensional: precise – easier to work with – less damaging to hands – square and uniform in shape.
  - (S4S) surfaced on all four sides
  - (S2S) surface on two sides leaving the edges to be surfaced by craftsman
  - (S-DRY) in a lumber grade stamp indicates that the piece was surfaced (planed) when in a seasoned condition
  - (S-GRN) in a lumber grade stamp indicates that the piece was planed when green
Lumber Defects

- Two Types
  1. Growth Characterizes – comes from tree
  2. Manufacturing characterizes – comes from mill

Growth Defects

- Knots – reduce the structural strength
- Knot holes
- Decay – generally only affect the wood if organisms are still alive
- Insect damage
**Manufacturing Defects**

- Splits – caused by shrinkage stresses
- Checks
- Crooking – occur non uniform shrinkage
- Bowing – occur non uniform shrinkage
- Twisting – occur non uniform shrinkage
- Cupping – occur non uniform shrinkage
- Wane – is an irregular rounding of edges or faces that is caused by sawing pieces too close to the perimeter of the log
- Crown – usually place up so the structural load will straighten the piece
Defects in Lumber / Timber

Natural Defects
Occur during the growing period. These may include:

- **Cracks due to dryness**: Occur in various parts may indicate the presence of decay. Separations of the wood cells, result of drying stresses as the wood shrinks. Cracks are small, whereas splits extend completely through the thickness of a piece.
- **Knots**: The **most obvious natural defect**. A knot is the part of a branch which becomes enclosed within the expanding trunk as the tree grows.

- **Grain defects**: Grain defects can occur in the form of twisted-grain, cross-grain, flat-grain and spiral-grain, all induce problems in use.

Defects in Lumber / Timber

Natural Defects
Occur during the growing period. These may include:

- **Shakes**: A lengthwise separation of the wood, occur as a result of severe wind that bends a tree to produce an internal shear failure, or as a result of rough handling of the tree or its products.

- **Annual ring width**: critical in respect of strength in that excess width of such rings can reduce the density of the timber.
Defects in Lumber / Timber

Natural Defects
Occur during the growing period. These may include:

- **Insect damage:** Damage is caused by tunnelling, which with some species of insect is done by the larvae while with others it is the adult beetle.

- **Fungal decay:** Occur in growing mature timber or recently converted timber, and in general it is good practice to reject such timber. Decay, caused by wood-destroying fungi, decay organisms require moisture to live and grow; hence, the presence of active decay implies access to a source of moisture.

Defects in Timber

Chemical Defects

- These may occur when timber is used in unsuitable positions or in association with other materials.

- Timbers such as oak and western red cedar contain tannic acid and other chemicals which corrode metals. Gums can inhibit the working properties of timber and interfere with the ability to take adhesives.
Defects in Timber

Seasonal Defects

• Directly related to the movement that occurs in timber due to changes in moisture content.

• Excessive or uneven drying, exposure to wind and rain, and poor stacking & spacing during seasoning can all produce defects or distortions in timber.

• All such defects have an effect on structural strength as well as on fixing, stability, durability and finished appearance.
<table>
<thead>
<tr>
<th>The name of defect</th>
<th>The defect which is taken into account</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in round timber</td>
</tr>
<tr>
<td>1. Knots</td>
<td>+</td>
</tr>
<tr>
<td>uncovered knot</td>
<td>+</td>
</tr>
<tr>
<td>- round</td>
<td>--</td>
</tr>
<tr>
<td>- oval</td>
<td>--</td>
</tr>
<tr>
<td>- spike</td>
<td>--</td>
</tr>
<tr>
<td>- face</td>
<td>--</td>
</tr>
<tr>
<td>- edge</td>
<td>--</td>
</tr>
<tr>
<td>- arris</td>
<td>--</td>
</tr>
<tr>
<td>- end</td>
<td>--</td>
</tr>
<tr>
<td>- stitching</td>
<td>--</td>
</tr>
<tr>
<td>- single (scattered)</td>
<td>--</td>
</tr>
<tr>
<td>- group</td>
<td>--</td>
</tr>
<tr>
<td>- branched</td>
<td>--</td>
</tr>
<tr>
<td>- intergrown</td>
<td>--</td>
</tr>
<tr>
<td>- partially intergrown</td>
<td>--</td>
</tr>
<tr>
<td>- unintergrown (dead or dry)</td>
<td>--</td>
</tr>
<tr>
<td>- loose</td>
<td>--</td>
</tr>
<tr>
<td>- sound</td>
<td>+</td>
</tr>
</tbody>
</table>

--- light -- + +

Notes:
+ - means, that defect is taken into account;
+ * - means, that defect meets only in softwoods;
+ ** - means, that defect meets only in hardwoods.

Source: http://wood.appua.com/defects.shtml#4
Timber/Lumber Grading

- Graded either for appearance or structural strength and stiffness
- Lumber is sold by species and grade (higher the grade the higher the price)

Lumber Structural Strength

- Depends on species and grade, and the direction in which the load is acting with respect to grain of the piece.
- Wood average tensile strength 700 psi.
- Compressive strength 1,100 psi.
Lumber Dimensions

- 1 – nominal dimensions
  - 1”=3/4”
  - 2”=1-1/2”
  - 3”=2-1/2”
  - 4”=3-1/2”
  - 5”=4-1/2”
  - 6”=5-1/2”
  - 8”=7-1/4”
  - 10”=9-1/4”
  - 12”=11-1/4”
  - 12+”=3/4” less

Lumber Dimensions

- Pieces of lumber 2 in. or less in thickness are considered boards
- Pieces larger are consider – dimension lumber
- Pieces larger then 5 + thick, 5+ wide are consider timbers
- Dimensional lumber comes in lengths of 2’ increments with some special sizes.
- Nominal sizes are 8’, 10’, 12’ 14’ and 16’
Board Feet

- Board foot – how large quality of lumber is sold. Calculation is based on nominal size not actual. (1” x 12” x 12”)

\[ \text{Board Feet} = \frac{A \times B \times C}{12} \]

For example if the piece of lumber was
3 inches thick (A)
8 inches wide (B)
10 feet long (C), we would have
\[ \frac{3 \times 8 \times 10}{12} = 20 \text{ board feet.} \]

Wood Products Types

- Three Types
  - Laminated wood
  - Wood panel products
  - Structural Composite lumber
Laminated Wood

- Laminated wood – small strips of wood glued together
  - Advantages
    - Size
    - Shape
    - Quality
  - Types of joints
    - Scarf joint
    - Finger joint

Structural Composite Lumber

- Structural Composite lumber – products that are made up of ordinary plywood veneers
  - Two types
    - Laminated veneer lumber (LVL) uses the veneers in sheets and looks like a thick sheet of plywood with no cross bands
    - Parallel strand lumber (PSL) the veneers are sliced into narrow strands that are coated with adhesive oriented longitudinally pressed into a rectangular cross section and cured under heat and pressure.
Wood Panel Products

- Panels require less labor for installation than boards because fewer pieces must be handled
- More useful use of forest resources

- Better strength characteristics in both principle directions

Wood panel product types

- Veneered panels
  - Plywood – thin wood veneers glued together grain on front and back pieces run in same direction
    - While grain in the middle pieces runs in opposite direction (better strength)
  - Composite panels – two parallel face veneers bonded to core of wood fiber.

- Non-Veneered panels
  - Oriented strand board (OSB)
    - Made up of long strand like wood particles compressed and glued into 3 to 5 layers
  - Wafer Board
    - Large wafer like flakes of wood compressed and bonded
  - Particle Board
    - Small wood particles compressed and bonded
Plywood Production

- Logs are soaked in hot water to soften wood
- Made in 4’ x 8’ sheets – ¼” to 1” in thickness
- Veneer is cut either using a plain slicing or quarter slicing.

Plywood Veneer grades

- n – smooth surfaced natural finished veneer all heartwood or sapwood – no defects
- A – smooth paint able surface – not more than 18 neatly made repairs.
- B – solid surface – tight knots permit up to 1 in.
- C plugged – splits limited to 1/8” width, knotholes and boreholes limited to ¼” to ½” C – tight knots to 1-1/2” knotholes to 1 in. discoloration and sanding defects allowed
Plywood Grade Stamps

- **Span rating**
  - First number for roof sheeting
  - Second number for sub floor

- **Exposure durability classifications**
  - Exterior – used of siding or other continuous exposed applications
  - Exposure 1 – fully water proof glue – but do not have veneers of as high quality – may be exposed to wetting during construction
  - Exposure 2 – fully protective from weather.

Wood Treatment

- **Two weakness of wood**
  - Combustibility
  - Susceptibility to attack by decay and insects

- **Treatment**
  - Fire rated lumber is place in a pressure vessel and impregnated with chemical salts that greatly reduce its flammability
  - Decay and insects – pressure impregnated
  - Creosote is an oily derivative of coal that is widely used in engineering structures but because of its toxicity and un paint ability it is unsuitable for most purposes.
  - Pentachlorophenol – cannot be painted
  - Waterborne salts – greenish color to wood – typically used
  - Heartwood of some species of wood is naturally resistant
    - Redwood
    - Bald cypress
    - Cedar
    - (sapwood of these species is no more resistant to attack – so an all heartwood grade should be specified)
Wood Fasteners

- Are the weakest link in wood construction
- Types
  - Nails – sharpened metal pins
  - Screws
  - Lag screws
  - Machine bolts
  - Carriage bolts
  - Tooth plates

Wood Manufactured Building Components

- Trusses – both roof and floor
  - Made with 2” x 4” or 2” x 6”
  - Roof trusses – use less wood than comparable frame of conventional rafters and ceiling joists
  - Span the entire width of building
  - Gives designer complete freedom to locate interior partition
  - Disadvantages is attic space is limited or unusable
- Plywood beams
  - I beams
  - Box beams
  - Uses wood more efficiently
  - Made up of plywood and dimensional lumber.
http://www.pefc.org/images/stories/images/articles/chart-itto.jpg

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**Log Prices**

<table>
<thead>
<tr>
<th>Product</th>
<th>Price Range (US$ per m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarawak log, FOB</td>
<td>233-258</td>
</tr>
<tr>
<td>Meranti SQ up</td>
<td>216-247</td>
</tr>
<tr>
<td>Small</td>
<td>208-232</td>
</tr>
<tr>
<td>Super small</td>
<td>222-234</td>
</tr>
<tr>
<td>Keruing SQ up</td>
<td>202-232</td>
</tr>
<tr>
<td>Small</td>
<td>180-210</td>
</tr>
<tr>
<td>Super small</td>
<td>212-237</td>
</tr>
<tr>
<td>Kapur SQ up</td>
<td>193-230</td>
</tr>
<tr>
<td>Selangan Batu SQ up</td>
<td></td>
</tr>
</tbody>
</table>

**Pen. Malaysia logs, domestic**

<table>
<thead>
<tr>
<th>Product</th>
<th>Price Range (US$ per m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR Meranti</td>
<td>239-258</td>
</tr>
<tr>
<td>Balau</td>
<td>304-333</td>
</tr>
<tr>
<td>Merbau</td>
<td>336-368</td>
</tr>
<tr>
<td>Rubberwood</td>
<td>71-106</td>
</tr>
<tr>
<td>Keruing</td>
<td>223-239</td>
</tr>
</tbody>
</table>

Peninsular Malaysian meranti logs are top grade and are used for scantlings for the EU. Their prices are higher than Sarawak’s.
### Sawnwood Prices

<table>
<thead>
<tr>
<th>Description</th>
<th>US$ per m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysia Sawnwood, FOB</td>
<td></td>
</tr>
<tr>
<td>DR Meranti</td>
<td>397-433♣</td>
</tr>
<tr>
<td>White Meranti A &amp; up</td>
<td>286-316♣</td>
</tr>
<tr>
<td>Seraya Scantlings (75x125 KD)</td>
<td>437-450♣</td>
</tr>
<tr>
<td>Sepetir Boards</td>
<td>254-276♣</td>
</tr>
<tr>
<td>Sesendok 25,50mm</td>
<td>348-366♣</td>
</tr>
<tr>
<td>Kembang Semangkok</td>
<td>306-325♣</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>US$ per m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaysian Sawnwood, domestic</td>
<td></td>
</tr>
<tr>
<td>Balau (25&amp;50mm,100mm+)</td>
<td>328-348♣</td>
</tr>
<tr>
<td>Merbau</td>
<td>461-513♣</td>
</tr>
<tr>
<td>Kempas 50mmx(75,100 &amp; 125mm)</td>
<td>262-302♣</td>
</tr>
<tr>
<td>Rubberwood</td>
<td></td>
</tr>
<tr>
<td>25x75x660mm up</td>
<td>217-267♣</td>
</tr>
<tr>
<td>50-75mm Sq.</td>
<td>256-288♣</td>
</tr>
<tr>
<td>&gt;75mm Sq.</td>
<td>278-307♣</td>
</tr>
</tbody>
</table>

Sources: [http://www.globalwood.org/market/timber_prices_2009/aaw20100602.htm](http://www.globalwood.org/market/timber_prices_2009/aaw20100602.htm)
MTIB targets RM53 billion exports by 2020!

- The Malaysian Timber Industry Board (MTIB) targets RM53 billion in wood and timber product exports by 2020. The target is achievable if the current trend in sales continues, says an analyst.
- The Malaysian timber industry is recovering after two years of recession. Exports of Malaysian wood and timber products reached RM6.9 billion in the first four months of 2010, up 22% from the same period in 2009.

Sources:
Flow of timber export statistics

Current flow of forest industry statistics