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DEFECTS OF PLANTATION LOG: END CHECK, SPLIT, RING SHAKE, HOLE, CAVITY, AND OTHER MECHANICAL DAMAGE

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BRIEF OVERVIEW

Depending on the severity, physical injury of harvested logs can adversely affect the yield of log production from plantation forest. Bodily defects such as end checking, splitting, and ring shaking are commonly found in production logs. These mechanical defects are the results of moisture changes within the log after felling, which initiated the release of internal stresses. Some injuries on logs are direct outcomes of logging operations such as crushing of logs by a grapple or a choker chain. Occasionally, thinning operations may also cause damage to residual trees due to accidental contact with the harvesting machines or the harvested stems (Dykstra 2009). Mechanical damage to tree stems can also be contributed by animals (Richter 2015). Scrubbing and scratching of large mammals such as elephants and bears can cause great injuries to the bark and trunk. Woodpeckers use strong bills for drilling and pecking on trees to nest and feed on insects and other invertebrates (Remm 2008).

Regardless of the causes, small logs tend to break or suffer significant damage more easily than larger logs (Dykstra 2009). The national timber industry is shifting its production from large, older trees of natural forests to young plantation trees that are comparatively smaller in diameter and much different in properties. Physical damage to plantation logs reduces both the quality and the value of the products. Therefore, accurate analysis of the physical defects is essential to quantify the productivity and economics of the commodity.

A log grading system is necessary to determine the relative quality and value of plantation outputs, and to efficiently convert a log to its best end use. Thus, scientific work is being conducted to develop a grading protocol for logs of locally planted timber trees. Due to the vast number of quality-influencing factors, quantitative and qualitative parameters that could limit the value of plantation logs are discussed in phases. The diameter measurement and volumetric computation of plantation logs were previously demonstrated (Mohd-Jamil & Nor Marzuina 2020). Also, log analyses regarding bark thickness and sapwood proportion have already been described (Mohd-Jamil et al. 2021). Subsequently, geometrical parameters of log such as taper, bow, crook, pith eccentricity, and ovality, as well as their evaluation methods were deliberated (Mohd-Jamil et al. 2022). This article aims to be a quick reference for the readers when evaluating bodily defects of plantation logs such as end check, ring shake, hole, and other mechanical damage. The measurements and formulae presented herein are based on standard methodologies and supported by various research outputs.

END CHECK AND SPLIT

An end check is the separation of fibres that appears as a radius line on the cross-sectional surface of a log. As a log loses moisture, the end surfaces dry much faster than the circumferential surface. This results in shrinkage and stress at the end surfaces that eventually develop checks. The end check is often initiated at the pith and extended towards the bark and causes a longitudinal split (Figure 1). Superficial end checks and splits are normally disregarded. However, delaying the processing of a log can severely increase the width of the end checks and the length of the splits. Some species of timber are more prone to end checking and splitting than others, depending on various factors such as wood density and green moisture content. A severe split is a serious defect and can cause the log to be rejected for structural timbers and veneering.

Figure 1 End checks and splits in *Tectona grandis*

Evaluation of end check

The end check should be analysed for both bottom and top ends. The rate of end check is measured as the percentage of split length at both ends per length of the log. Hence, the rate of end check, EC (%) is evaluated based on the formula (Tan et al. 2010):

$$EC = \frac{S_b + S_t}{L} \times 100\%$$

where, S_b is the length (m) of the longest split (if more than one) of the bottom end, S_t is the length (m) of the longest split (if more than one) of the top end, and L is the length (m) of the log (Figure 2). The end check, C is normally used as the opening cut during sawing.

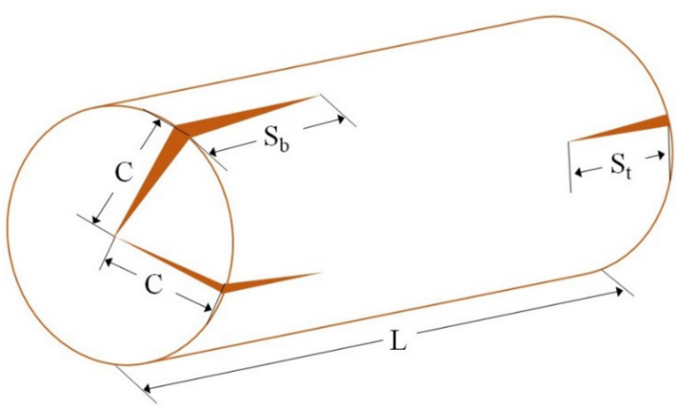

Figure 2 Measurements of end checks and splits

RING SHAKE

A ring shake is a tangential separation of fibres that appears as a ring-line in some sections of the growth rings (Figure 3). It is a log defect that normally resulted from abnormal tree growth such as cankers, overgrown knots, old wounds, and included bark. A ring shake is often so fine that it is not visible in green timber and can be visually detected only when the timber is dried. The occurrence of a ring shake anywhere in the quality zone of a log degrades its quality, especially for veneer logs. There is normally no visible indicator of ring shake when observing the exterior of a tree trunk. Only some clues to the presence of abnormal growth, such as galls, crooked stems, and bulges that indicate the possibility of a ring shake existence.

Figure 3 Ring shake in a *Fagraea fragrans*

Evaluation of ring shake

Similar to the end check, the ring shake should be analysed for both bottom and top ends. The rate of ring shake is measured as the percentage of shake length per circumference. Hence, the rate of ring shake, RS (%) is evaluated based on the formula (Tan et al. 2010):

$$RS = \left(\frac{vw + xy - xz}{P_b} + \frac{v'w' + x'y' - y'z'}{P_t} \right) \times 100\%$$

where, O is the pith, vw and xy are the length measurements (cm) of ring shake(s) of the bottom end, v'w' and x'y' are the length measurements (cm) of ring shake(s) of the top end, P_b is the circumference (cm) of the bottom end, and P_t is the circumference (cm) of the top end (Figure 4).

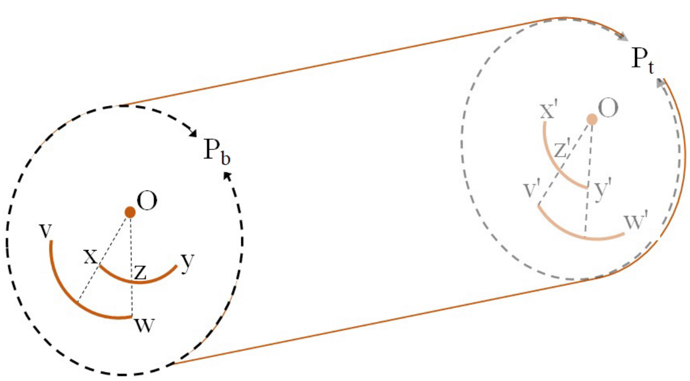

Figure 4 Measurements of ring shakes

HOLE & CAVITY

Holes are unoccluded openings on the circumferential surface of a log that are varied in size. Small holes are caused by wood-boring insects. Medium and large holes are caused by decayed knots or woodpeckers. A bird peck is a small spot or hole in the trunk attributed to damage by birds. Heavy bird peck is normally caused by repeated attacks and extends the damage in the form of bark flecks, callus pockets, and stain spots. Cavities are empty spaces within a log which can be observed only after crosscutting. Cavities and hollow logs are normally results of decay and rot (Remm 2008). Holes and cavities are grade defects depending on their size and depth in relation to the dimension of the log (Figures 5 to 8). A log with a large hole or a cavity is usually excluded from the production of veneer. The log of *Paulowni*a has a natural rounded-hollow pith varying from 0.5 to 2.0 cm in diameter throughout the length (Figure 9). Although it is not considered as a defect, the size and eccentricity of the hole of *Paulownia* logs could affect sawing recovery.

Measurements of hole

It is difficult to evaluate the size or magnitude of a hole or cavity in a log. The visible part of the hole does not necessarily represent the true proportion within the log. However, there are parameters that can be measured to give some indication of the size of a hole, such as diameter, width of entrance, height of entrance, and distance to the back wall. In order to assess the quality of a plantation log, holes and cavities are measured quantitatively based on these parameters (Remm 2008).

Figure 5 Small holes in *Tectona grandis* caused by wood-boring insects

Figure 6 Medium hole of decayed knot in *Eucalyptus* hybrid

Figure 7 Hollow logs of *Acacia* hybrid filled with termite nest

Figure 8 Heartwood cavities in *Eucalyptus* hybrid

Figure 9 Logs of *Paulownia* with a rounded-hollow pith

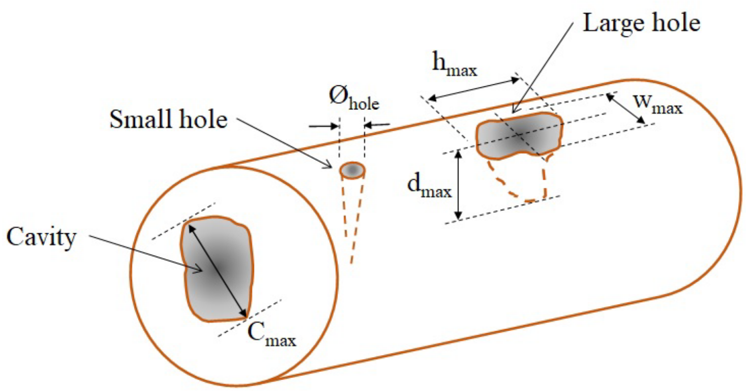

Figure 10 Measurements of hole and cavity

Referring to Figure 10, C_{max} is the measurement of the largest cavity opening (cm) on a cross-section, w_{max} is the maximum width (cm) of a large hole, h_{max} is the maximum height (cm) of a large hole, d_{max} is the maximum distance (cm) from center-opening to the back wall of a large hole, and $Ø_{hole}$ is the maximum diameter (mm) of small hole(s). If there is more than one hole or cavity in a log, the number should be quantified for better description.

INJURY AND OTHER MECHANICAL DAMAGE

Log injuries and wounds are caused by impacts of physical or mechanical elements such as harvesting works, equipment, and animals. Although small logs are generally easier to handle than large logs, they are also easily damaged by heavy equipment or inappropriate handling. Tree species of thin-barked or loose-barked are particularly prone to injuries (Dykstra 2009). Trees of low density timber are usually prone to mechanical damage during felling and handling (Figures 11 to 13). In some cases, the mechanical forces might not change the physical profile of the log. Instead, the log suffered an impact that caused internal cracks and fractures (Figure 14).

A bark injury is often considered a minor type of log defect unless it is extensive. However, a complete debarked condition of a log could also mean a possible dead tree, an old-unprocessed log, or an inappropriately managed log (Figure 15). In some hardwood species, abrasion of bark when a felled tree rubs along the trunk of a residual tree may lead to epicormic branching and consequently to a proliferation of pinhole knots (Meadows & Skojac 2006). Scrubbing and scratching of large mammals such as elephants and bears can cause great injuries to the bark and trunk. Such an injury is normally referred to as stripping damage (Richter 2015).

Wounds are injuries that expose the sapwood and sometimes the heartwood, and they may be either new or old (Figure 16). A deep wound is usually regarded as serious damage because it is often associated with permanent scarring, gouging, or other defects that will degrade the quality of sawn timber. Depending on the length of time that elapses from the inception of the injury, until the log is converted into sawn timber or veneer, discolouration or decay may occur to the exposed wood. Besides, even a small injury can permit the introduction of wood-deteriorating agents such as insects and decay fungi, as well as the spreading of tree diseases.

Thinning could also contribute to several types of mechanical damage to residual trees, including bark damage, deep bole wounds, crown damage, stem breakage, and root damage (Dykstra 2009). Significant crown damage may lead to loss of vigor and prevent the tree from achieving the desired growth rate. Stem breakage usually results in the death of the tree or deforms it. Root damage may structurally weaken the tree, making it more susceptible to windthrow, and damaged roots are likely to serve as conduits for the introduction of root rot. This type of damage is occasionally caused by heavy machinery, especially crawler tractors during tree thinning.

Trees are usually tagged using nails and metal plates. As the trees grow, failure to remove those materials could end up with them being embedded into the trunk (Figure 17). Metal plate and wire are normally found embedded in *Hevea brasiliensis* logs. The metal plate was used as latex gutter and the metal wire was used to hold a latex cup for rubber tapping. Some logs of *Aquilaria* spp. are embedded with metal tubes used for the inoculation process to produce the valuable gaharu.

Figure 11 Splintering fracture of *Eucalyptus* hybrid log due to improper felling cut

Figure 12 Deep injury inflicted on small log of *Eucalyptus* hybrid due to felling impact

Figure 13 The trunk of *Dyera costulata* severely fractured due to the felling impact with a stump

Figure 14 Internal non-linear cracks due to felling impact

Figure 15 Completely debarked logs of *Tectona grandis*

Figure 16 Old wound on *Eucalyptus* hybrid trunk

Figure 17 An embedded metal plate in *Terminalia* sp. log

Types of log injury

Mechanical injuries in logs are practically impossible to quantify. The degree of the damage is relative to various factors such as the amount of force, frequency, depth of wound, as well as time and point of impact. Nevertheless, initial analysis on the probable causes could provide some insight for acceptance or rejection of the logs. Although the log was subjected to fracture stress, the destructive effect is generally restricted to breakage paths. Hence distinguishing the clear and undamaged fractions from fractured log via visual inspection is practical. Common types of log injuries and probable causes are listed in Table 1.

CUT-TO-QUALITY

If a log is long enough, it may be possible to cut it into shorter sections while removing the defective parts. The practice of cutting a long log into shorter sections for quality is simply known as bucking (ATTC 1988). The resulting shorter logs are usually referred to as bolts. With skilled selection of the point to cut and correct crosscutting techniques, the quality of the logs can be upgraded and ultimately improve the sawing recovery. However, the process may reduce the overall value of the logs and may incur additional operational and logistics costs.

Table 1 Types and causes of plantation log injuries

No.	Log injury	Probable causes
1.	Partly debarked	- Stripping damage (by animals) - Hauling damage - Thinning process - Log grapple or choker chain
2.	Completely debarked	- Standing dead tree - Old-unprocessed log
3.	Deep wound	- Felling damage - Log grapple or choker chain
4.	Splintering fracture	- Felling damage - Improper sawing
5.	Internal crushing	- Felling damage - Log grapple or choker chain
6.	Root damage	- Harvesting machine, crawler tractor and truck
7.	Fresh or old bird peck	- Feeding and nesting of birds
8.	Foreign material	- Tree tagging - Rubber tapping - Inoculation process

SUMMARY

A log grader is responsible for assessing the quality and characteristics of production logs, particularly logs that are harvested from forest plantations. The grading practice is a critical stage in timber processing, where each log is evaluated for various attributes such as size, defects, and overall quality. Thus, a quantitative study concerning bodily defects and injury of plantation logs is absolutely necessary to evaluate the overall wood quality and economics of forest plantations. Disregarding the importance of log quality may cause significant errors in calculating sawing recovery and result in monetary losses. Common defects such as end check, split, ring shake, hole, cavity, and other mechanical damage are explained herein so that the quality of the plantation logs can be estimated for grading and valuing purposes. Distinguishing the defected or fractured fractions could provide some insight for acceptance or rejection of a log. Besides, logs can be cut into shorter sections by removal of the defective parts through accurate crosscutting techniques, ultimately improving the quality and sawing recovery.

REFERENCES

ATTC. 1988. Upgrading lathe bolt quality. *The ASEAN Timberlink* Volume 1(3). ASEAN Timber Technology Centre, Kuala Lumpur.

Dykstra DP. 2009. Influence of forest operations on timber quality. *Proceedings of the International Conference on Forest Growth and Timber Quality: Crown Models and Simulation Methods for Sustainable Forest Management*. United States Department of Agriculture, Portland. pp. 103–108

Meadows JS & Skojac DA. 2006. Third-year growth and bole-quality responses to thinning in a late-rotation red oak-sweetgum stand in East Texas. *Proceedings of the 13th Biennial Southern Silvicultural Research Conference*. General Technical Report SRS-GTR-92. United States Department of Agriculture, Washington.

Mohd-Jamil AW & Nor Marzuina FKN. 2020. Diameter and volumetric computation of plantation sawlogs. *FRIM Timber Technology Bulletin* No. 104. Forest Research Institute Malaysia, Kepong.

Mohd-Jamil AW, Zairul AR, Nor Marzuina FKN & Nabil FSM. 2021. Sapwood/heartwood proportion of plantation logs. *FRIM Timber Technology Bulletin* No. 111. Forest Research Institute Malaysia, Kepong.

Mohd-Jamil AW, Zairul AR & Nor Marzuina FKN. 2022. Geometrical analyses of plantation logs: taper, bow, crook, pith eccentricity, and ovality. *FRIM Timber Technology Bulletin* No. 115. Forest Research Institute Malaysia, Kepong.

Remm J. 2008. *Tree-cavities in Forests: Density, Characteristics and Occupancy by Animals*. Dissertation for the degree of Doctor of Philosophy. Faculty of Science and Technology, University of Tartu, Estonia.

Richter C. 2015. *Wood Characteristics Description, Causes, Prevention, Impact on Use and Technological Adaptation*. Springer, Switzerland.

Tan YE, Lim NPT, Gan KS, Wong TC, Lim SC & Thilagwathy M. 2010. *Testing Methods for Plantation Grown Tropical Timbers*. ITTO project on improving utilization and value adding of plantation timbers from sustainable sources in Malaysia. Project No. PD 306/04(1). Forest Research Institute Malaysia, Kepong.

Bodily defects and physical damage are common in production logs. These mechanical defects adversely affect the quality and the value of the commodity. Therefore, accurate analysis of the defects is essential to quantify the productivity and economics of forest plantations. This article is a quick reference for graders and researchers on the recommended evaluation of bodily defects in plantation logs such as end check, ring shake, hole, and other mechanical damage.

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