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Pruning guidelines to counteract common branch breaking modes

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The information in this Research Technical Note is based on the research project "Branch attachment strength study in Singapore". It discusses the correlation between the breaking modes[i] of branches and their diameter ratios[ii] and recommends branch pruning guidelines to prevent branch breakages.

Introduction

In 1985, Shigo found that branches of temperate trees were connected to the attachment branches/trunks only at the base and sides. Subsequently in 2008, a similar phenomenon was observed for the tropical tree species, *Syzygium grande* and *Khaya senegalensis*.

Examples of tree branches failure – snapping along the branch (**left**) and splitting at the union (**right**).

A *Syzygium grande* branch union with small branch diameter ratio and attachment branch fibres.

Khaya senegalensis branch union with small branch diameter ratio. If both the branch and attachment branch/trunk grow at a similar rate, it is unlikely to have similar kind of attachment branch fibre arrangement.

Branches split at the unions when the branch attachments are weak. Weak branch attachment could be due to either one or a combination of the following factors: (1) Branch diameter ratio has exceeded the threshold value of 0.80, (2) Included bark[iii] has formed in the union, (3) excessive dynamic loading from strong wind, and (4) excessive static loading of self weight and moisture from rainfall.

Photo: Simon Poh

Photo: Lee Jia Hwa

Photo: Siti Zubaida

In these examples, the branches split because the branch diameter ratios at the unions exceeded the threshold value of 0.80.

In these examples, the branches split because the branch diameter ratios exceeded the threshold value of 0.80 and the presence of included bark was observed in the unions.

Materials and Methods

Branch attachment strength for five tree species (*Samanea saman*, *Khaya senegalensis*, *Syzygium grande*, *Tabebuia rosea* and *Pterocarpus indicus*) was evaluated using the "static branch-pulling" methodology modified from Kane, et al. (2008). This method involved the pulling of cut green branch unions to failure with a force applied perpendicular to the pulled branches. After the split, the breaking modes of branches at the unions were classified using the systems defined by them and described below.

Results & Discussion

Both tropical and temperate tree branches at unions split from the attachment branches/trunks in three common breaking modes: Ball-in-Socket, Imbedded-Branch and Flat- Surface. However, an additional common breaking mode: Snapped- at-Union was observed for all tropical species studied. They are illustrated in the following pictures.

Ball-in-Socket breaking mode: the branch breaks from within the attachment branch/trunk without tearing much of the attachment branch below the union.

Imbedded-Branch breaking mode: the union breaks parallel to the attachment branch/trunk grain but do not split down the middle, only the attachment branch/trunk wood associated with the branch split out, leaving a grove in the attachment branch/trunk.

Flat-Surface breaking mode: the union also breaks parallel to the attachment branch/trunk grain with the union splitting roughly in half longitudinally.

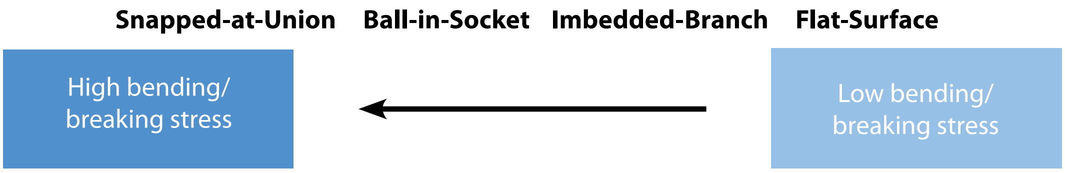
Snapped-at-Union breaking mode: the branch snaps at the union without tearing the attachment trunk/branch below the union. This indicates that the union of branches is stronger that the wood strength.

In the local study on the five tree species, it was observed that Imbedded-Branch was the most common breaking mode, followed by Snapped-at-Union, Ball-in-Socket and Flat-Surface (Table 1).

Table 1 Four common breaking modes for five wayside trees in Singapore.

Tree species	Number of branch unions tested (n)	Breaking mode (%)			
		Snapped-at-Union	Ball-in-Socket	Embedded-Branch	Flat-Surface
All species below	1421	28	10	58	4
S. grande	232	25	12	61	2
K. senegalensis	258	31	18	49	2
P. indicus	278	49	11	37	3
S. saman	342	13	4	80	3
T. rosea	311	26	7	55	12

The four breaking modes described are the result of different fibre orientation within the unions, and thus resulting in different reactions to the bending/breaking stress applied.



Branch unions with Snapped-at-Union breaking mode could withstand the highest bending/ breaking stress than those with Ball-in-Socket. This indicated that branch unions with Snapped-at-Union is the strongest followed by Ball-in-Socket, Imbedded-Branch and Flat-Surface.

Branch unions with Flat-Surface and Imbedded-Branch breaking modes usually have diameter ratios that are more than 0.80 and those with Ball-in-Socket and Snapped-at-Union breaking modes usually have branch diameter ratio below 0.80.

Table 2 Breaking modes of branch unions of all the five species studied were highly correlated to the mean branch diameter ratios.

Mean branch diameter ratio			
Breaking mode			
Snapped-at-Union	Ball-in-Socket	Imbedded-Branch	Flat-Surface
0.66	0.68	0.81	0.89

Application – Branch pruning guidelines derived from the correlation of breaking mode of branches with branch diameter ratios

Unions with strong breaking modes such as Snapped-at-union and Ball-in-Socket usually have small branch diameter ratios that are less than the threshold value 0.80. Therefore:

1. Keep all branch diameter ratios at 0.50 or below. A branch diameter ratio of 0.80 should not be exceeded. These kinds of union have strong breaking modes and the branches remain well attached to the tree.
2. For those unions with branches that have already exceeded branch diameter ratio 0.80, immediate pruning action needs to be taken as the unions could be weak. Some of the pruning actions to be taken can be one of the following: (1) cut off one of the branches at the unions, (2) reduce the length of one of the branches at the unions every pruning cycle until the diameter ratios slowly reduces to 0.50 or below, (3) cut off the branch unions with branch diameter ratios more than 0.80 and (4) cut the entire tree with many weak unions. This will prevent branch splitting either due to excessive dynamic loading from strong wind or static loading due to self weight and moisture from rainfall.

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[i] Breaking mode is defined as the manner in which the union of branches breaks (Farrell, 2003)

[ii] Diameter ratio or Aspect ratio is defined as the ratio between branch diameter and attachment branch/trunk diameter measured just beyond (above) the union (Gilman, 2012). Diameter ratio 0.80 is the recommended threshold value to be used to guide branch pruning in Singapore (Fong, 2011)

[iii] Included bark: Bark pinched or embedded between two adjoining stems or between a branch and trunk, preventing or reducing the intermingling of branch and trunk collars, and preventing formation of a branch bark ridge; an indication of a weak union; a crack in the union (Gilman, 2012)

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