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SPACER BLOCK: A UNIQUE TIMBER COMPONENT IN CANOPY WALKWAY STRUCTURE

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Canopy walkway

A canopy walkway is an elevated man-made pedestrian access to the forest canopy. The structure of a canopy walkway is mainly made up of bridges, interconnected with platforms built around the main branches of the trees. It provides a practical footpath for research initiatives on biota at the canopy tier, reaching more than 30 meters above the ground. Besides, canopy walkway is a magnificent attraction for recreational activities and ecotourism. In Malaysia, there are a few canopy walkways (CW) open for visits such as FRIM's CW in Bukit Lagong Forest Reserve (Figure 1), National Park CW in Kuala Tahan, Sungai Sedim CW in Kulim, Penang National Park CW in Penang, Mulu National Park CW in Mulu, Bukit Gemuk CW in Tawau, Madai Caves CW in Kunak and Poring CW in Ranau.

The structural components of a canopy walkway consist of beams, joists, timber boards, metal cables, polyester ropes, synthetic netting and spacer blocks. Timber platforms are built on beams and joists which are fixed and fastened to the tree branches. The suspended bridges spaning from 10 meters up to 30 meters, firmly hung between trees using metal cables. High-grade aluminium ladders are laid horizontally along primary cables and secured using polyester ropes. Timber boards of heavy hardwood species are arranged in parallel on the aluminium ladder as a solid footpath. Synthetic netting of approximately 1.2 meters in height is installed along the pathway as an additional safety measure for visitors. In general, almost 100% of loading elements of the canopy bridge rely on the fixing of the cables and ropes to the trees. Thus, complex engineering and ecological factors have to be considered in ensuring the reliability of the whole structure. Besides, a canopy walkway is entirely an artificial system, built in the heart of nature. Hence, the method of the construction is crucial to avoid adverse effects on the health and growth of the supporting trees, plus to conserve the surrounding ecosystem.

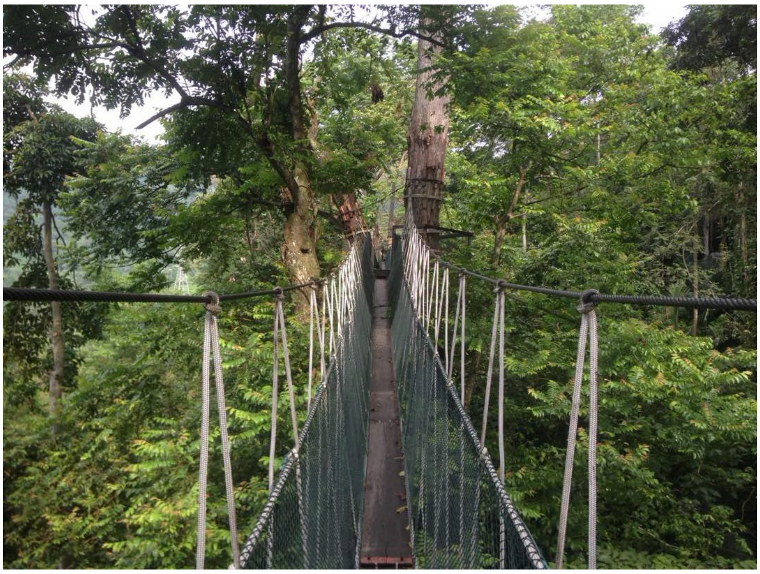


Figure 1 FRIM's canopy walkway in Bukit Lagong Forest Reserve

Spacer block application

The spacer block is one of the most important structural components of a canopy walkway. It is constructed in sets of blocks made of solid timbers. The spacer block has several important functions associated with the stability of the bridges and the health of the trees.

The installation of spacer blocks encircling the trunk provides the tree with a protective layer from the tightening of cables and ropes (Figures 2 and 3). At the same time, they produce an appropriate circular-bind and steadier tie on branches of asymmetrical shapes. A sturdy and unwavering cable-to-tree connection is vital for bridge stability, especially during foot traffic and gusty hours. In terms of structural performance, spacer blocks provide mechanical impedance upon excessive loading which most likely will damage the tree. Excessive loading on spacer blocks could be caused by natural growth of the trunk or by external force that increase the tightening stress. On the whole, the installation of spacer blocks improves the safety of canopy walkway system and protects the trees from potential damage.

Figure 2 Metal cables and polyester ropes tied around sets of spacer blocks

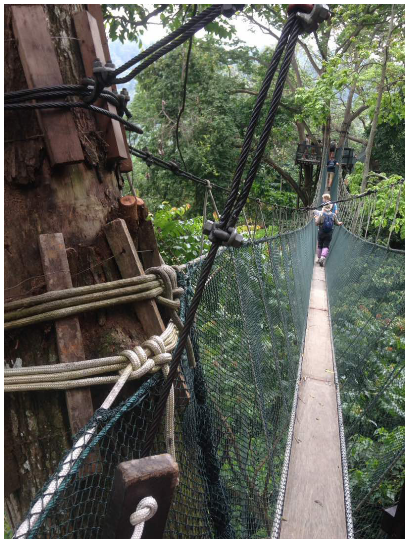


Figure 3 Sets of spacer blocks supporting the weight of 30 m bridge and visitors

The force exertion on the spacer blocks is the outcome of tightening stress of the cable, quantified by components' mass and number of visitors. The total mass of a bridge plus visitors (in kg) is estimated by the formula:

Total mass = Mass of footpath board + Mass of aluminium ladders, cables, ropes and net + Weight of visitors

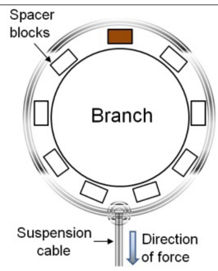
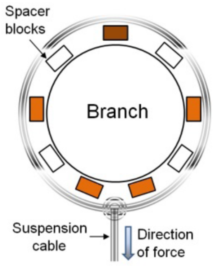
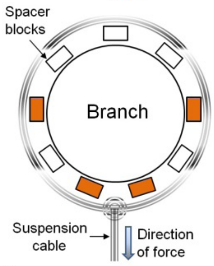
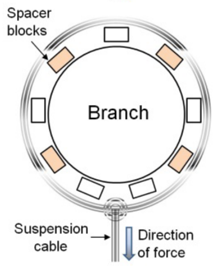
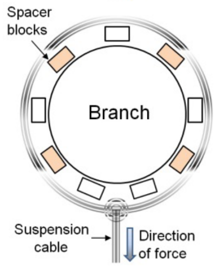
= $(t \times w \times 1 \times \rho)$ + (Estimated 10 kg/meter) + (100 kg × Number of visitors)

where t is the thickness of the board (in meter), w is the width of the board (in meter), l is the length of the board (in meter) and ρ is the density of the board (in kg/m^3). The number of visitors on one bridge at a time is restricted depending on the bridge length. As a rule of thumb, the minimum distance between two visitors on a bridge shall not be less than 5 meters apart. Thus, the total number of visitors on one bridge at a time is basically the length of the bridges in meters divided by five.

Types and characteristics of timber

The selection of appropriate timber species is essential to ensure the effectiveness of spacer block application. The timbers in a set of spacer blocks are carefully chosen from Heavy Hardwood to Light Hardwood based on mechanical strength to tolerate the masses. In unison, a set of spacer blocks should be able to impede mechanical damage on the branch upon excessive force. Thus, a specific positioning pattern of different timbers is applied within a set of spacer blocks, functioning as protective layer and secured connection simultaneously. The important mechanical properties of spacer blocks are density, bending strength, compressive strength perpendicular to the grain and Janka hardness. Sapwood and non-durable timbers should not be used since they attract insects which could not only damage the spacer blocks but the supporting trees as well. The recommended timbers for spacer blocks, their properties (Wong 2002, Lee et al. 1993) and positioning are shown in the table below.

Table 1 The block spacer arrangement

Timber name	Botanical name	Bending strength	Compressive strength perpendicular to the grain	Janka hardness	Density	Positioning	Remarks
		N mm^{-2}	N mm^{-2}	kN	kg m^{-3}		
Balau	*Shorea* spp.	115–142	7.5–12.6	8.0–10.0	850–1155		To sustain the total mass of the bridge. High strength and durability.
Kempas	*Koompassia malaccensis*	100–122	6.3–7.5	6.6–7.6	770–1120		To sustain the total mass of the bridge. Moderate strength and durability.
Keranji	*Dialium* spp.	109–156	9.2–19.7	8.7–16.6	755–1250		To sustain the tightening force of the tie. Moderate strength and durability.
Keruing	*Dipterocarpus* spp.	46–128	3.2–9.2	2.9–7.8	690–945		To support the circular shape tie. Serve as a mechanical impedance upon excessive force. Low strength and slightly durable.
Meranti, light red	*Shorea* spp.	46–77	2.0–2.5	2.1–3.9	385–755		

In general, the dimensions of a spacer block is 5.1 cm × 7.6 cm × 91.4 cm (2 inch × 3 inch × 3 ft) for single tie and 5.1 cm × 7.6 cm × 121.9 cm (2 inch × 3 inch × 4 ft) for double ties. The spacer blocks are set on the trunk in a flatwise manner. The spacing between each block is approximately 10 cm apart.

Structural failure of spacer block

The spacer block will break once the force exceeds the strength limit of the timber. The failure of spacer blocks is frequently a combined result of biological and mechanical deterioration. Continuous exposure to recurring heat and rain accelerates the wear and tear of the timbers. The rupture of a spacer block leads to a tilted and unstable bridge. Crack or breakage of spacer block could be confirmed through visual inspection. When such failure occurs, the spacer blocks need to be replaced in order not to damage the trees and to ensure the safety of the bridges (Figures 4 and 5).

Figure 4 Mechanical failure of a spacer block due to excessive bending load

Figure 5 Damaged blocks as a result of both biological deterioration and mechanical force

Spacer blocks installation and replacement

A major maintenance of the entire canopy walkway structure is conducted at least once a year. The repair and replacement of spacer blocks on each branch is the most important work during restoration. The purpose of the maintenance is not only to change the old spacer blocks, but to allow the bark that was under them to recover and compensate for tree growth as well. During this period, all supporting cables and ropes on each bridge will be dismantled. Beyond that juncture, immediate repair and replacement is necessary when more than one spacer blocks are fractured during service (Figures 6, 7 and 8).

The maintenance works of the entire canopy walkway structure usually take 3 months to be completed depending on weather condition. The replacement of new sets of spacer blocks can be done within 2 to 3 weeks. The correct arrangement and installation of spacer blocks will ensure the stability and levelness of the suspended bridge.

Figure 6 Spacer blocks are fasten together using wires to simplify the installation

Figure 7 A sufficient and orderly placements of spacer blocks to keep the cable and rope separated from the bark

Figure 8 A set of spacer block was replaced with a new timber at different positions to avoid further damage of the bark

Conclusion

This paper has shown the importance of the choice of timber species as well as the configuration during installation of spacer blocks on tree branches. The correct placement of appropriate timber species at the tying knot, i.e. between the cables and tree bark, will ensure that minimal stress is being imparted onto the tree branch. The strongest timber species is configured to receive the highest stress while the weaker timber species acts as a mechanical damper, thus keeping the knot taut around the holding branch. The spacer blocks of weaker species are bound to be deteriorated earlier, and they are planned to be replaced during the maintenance exercise of the walkways.

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