



Federal Ministry
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Promoting Quality Timber Production in Smallholders and
Community-based Teak and Other Valuable Species Plantations
in the Tropics (PP-A/54-331A)

11th Webinar: Teak Wood Characteristics and Engineered Wood

7 October 2026 2:00 – 3:30 PM



11th Webinar : Teak Wood Characteristics and Engineered Wood

A Comparison of Teak Wood Properties from Natural Forests & Plantations & Engineered Wood

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What This Chapter Covers

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Background of teak wood

General background, factor affecting properties, growth and some properties

02

Cultivation and production

Cultivation, natural forests and plantation, management practices, wood production

03

Teak wood characteristics

Comparative analysis of properties, teak wood quality, durability and workability

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Teak wood as structural timber

Structural properties of teak, shrinkage and drying behavior, dimensional stability, case study

05

Engineered wood from teak

Raw materials, production and properties, case study in Thailand

Keywords: Teak, Properties, Natural forests, Forest plantation, Engineered wood

TEAK WOOD CHARACTERISTICS AND ENGINEERED WOOD

Background of Teak Wood

General background, factor affecting properties, growth and some properties



Botany and natural range

- **Species** *Tectona grandis* L.f. (Lamiaceae, formerly Verbenaceae).
- **Native range** Myanmar, India, Thailand and Laos, between 9–26°N.
- **Planted** widely across the tropics (30°N–23°S); introduced to Africa from 1889.
- **Tree** deciduous, 30–40 m tall with a straight bole up to 1–1.5 m in diameter.

4

countries with natural teak forests

≈80

tropical countries grow teak

Site and climate requirements

Climate

- Distinct dry season is essential
- 22–35°C; rainfall 1,200–2,500 mm/yr

Soil

- Deep, well-drained, fertile; pH 6.5–7.5
- Calcium-rich: alluvial and limestone soils

Light

- Prefers full sunlight
- Competition from weeds slows young trees

Site matching

- Poor sites give slow growth and lower quality
- Choose site before choosing spacing or seed

Growth rates and rotation lengths

Region (TRMA 2022)	MAI (m ³ /ha/yr)	Rotation (yr)
Africa	3.0–18.0	3–60
Asia & Oceania	0.4–28.6	15–80
Central America	4.2–8.3	16–22
South America	5.0–19.0	5–40
World	0.4–19	3–80

- **Most countries** report under 12 m³/ha/yr.
- **Exceptions** China 28.6, Laos 21.3, Brazil 19.
- **20–30 yr rotations** give small-diameter logs.
- **40–80 yr** used in Benin, Togo, Tanzania, India, Sri Lanka, Thailand, Brazil.



A century of Shortening Rotations

Teak's historical range spans 100°W–180°E longitude and 23°N–40°S latitude — from its native forests to today's global plantations.

> 100 yrs

Traditional native-range plantations

Historically, teak plantations in India, Laos, Myanmar & Thailand had felling periods exceeding a century

30 yrs

Post-1980 expansion

As teak spread into new tropical regions of Asia, Africa & the Americas, rotations shortened to ~30 years

≤ 20 yrs

Today's fast-growth plantations

Better spacing, genetically enhanced stock, precision silviculture & high-intensity management now enable 20-year (or shorter) rotations

Natural Hardwood Benchmarks

1,070 lbf

Janka hardness rating providing exceptional dent resistance and durability

Dimensional Stability & Performance

Low Volumetric Shrinkage

Minimal movement across fluctuating humidity environments.

Marine Grade Resilience

Withstands constant exposure to saltwater and severe weathering.

LIFESPAN ADVANTAGE

40+ Years

Expected above-ground service life without chemical sealants or extensive maintenance cycles.

Four Established Trends in Wood Density

1

Plantation wood is less dense

Wood density (WD) in plantation-grown teak is consistently lower than in wood from natural forests

2

Density increases with age

As trees mature, wood density rises steadily — a well-documented, near-universal pattern

3

Growth rate has limited effect

Growth rate itself has a smaller influence on WD than commonly assumed — origin and age matter more

4

Stabilization age depends on growth speed

Under fast-growth conditions WD stabilizes by age 6; under slower-growth plantation conditions, stabilization takes until age 15

Why it matters: WD is the most-studied wood trait because it directly predicts many other properties.

TEAK WOOD CHARACTERISTICS AND ENGINEERED WOOD

Cultivation and Production

Cultivation, natural forests and plantation, management practices, and wood production

GLOBAL

Teak at a glance

4.85 M ha

planted teak forests, 2022

30.2 M ha

natural teak forests (4
countries)

1.79 M m³

log removals from planted
teak, 2022 (0.95 M in 2010)

97%

of teak roundwood trade
imported by India

How Much Planted Teak Exists Globally?

Estimates vary by source and methodology, but all agree on the broad regional pattern of where teak plantations are concentrated.

FAO (2010)

4.35M ha

38 countries reporting — likely an underestimate due to missing country data

ITTO (same period)

5.9M ha

Independent estimate of the total global planted teak area

Midgley et al. (2015)

6.89M ha

Most recent and most comprehensive global estimate

Optimum vs. Limiting Site Conditions

Site factor	Optimum	Limiting
Temperature	22–26 °C	< 13 °C in coldest months
Precipitation	1,250–3,000 mm / yr	< 1,200 or > 4,000 mm / yr
Slope	< 25%	High, windy slopes
Soil depth	90 cm – 2 m	< 90 cm, hardpans present
Drainage	Good, no stagnation	Poor or excessive drainage
Altitude	0–900 m AMSL	> 900 m AMSL

Measuring Plantation Productivity

Early growth is rapid — diameter can increase 3–5 cm and height 3–6 m per year in the first 3–6 years — before slowing after about 15 years, even as total volume keeps climbing toward roughly 2.5 m³ per tree overbark.

Volume Mean Annual Increment (VMAI) — the standard yardstick

$\geq 15\text{--}20 \text{ m}^3/\text{ha}/\text{yr}$

Excellent plantation
performance

$6\text{--}15 \text{ m}^3/\text{ha}/\text{yr}$

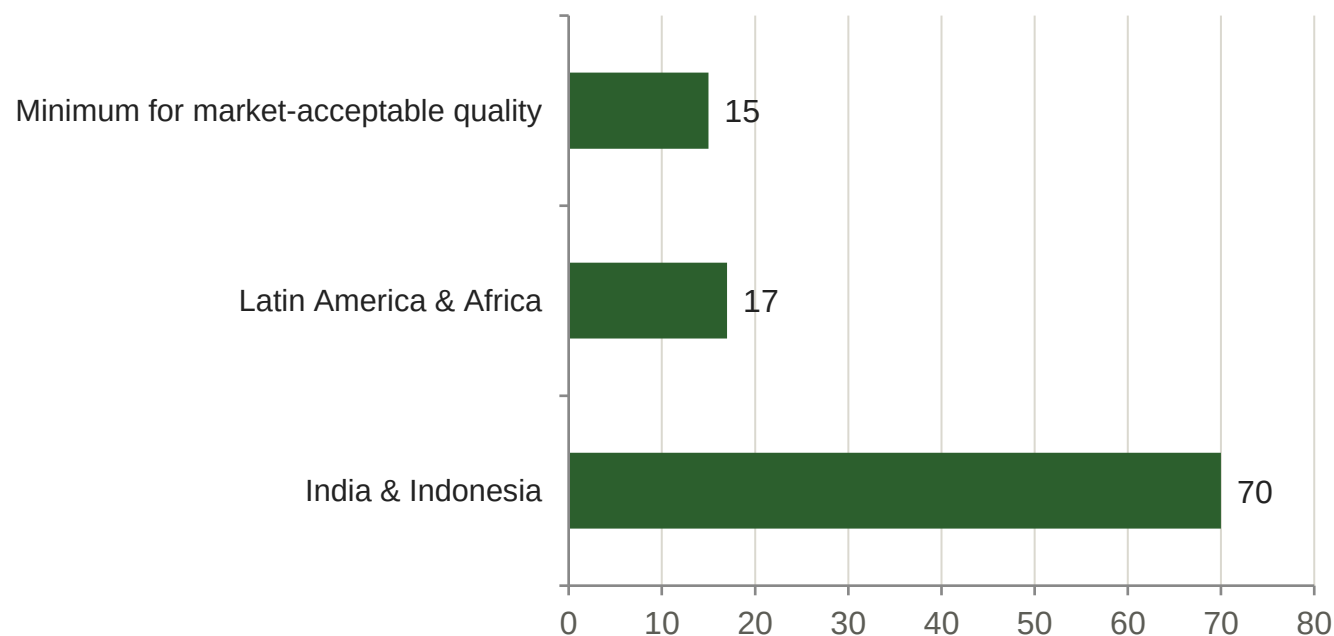
Acceptable, typical performance
range

$< 6 \text{ m}^3/\text{ha}/\text{yr}$

Economic viability should be
reviewed

Rotation Age Is an Economic Decision

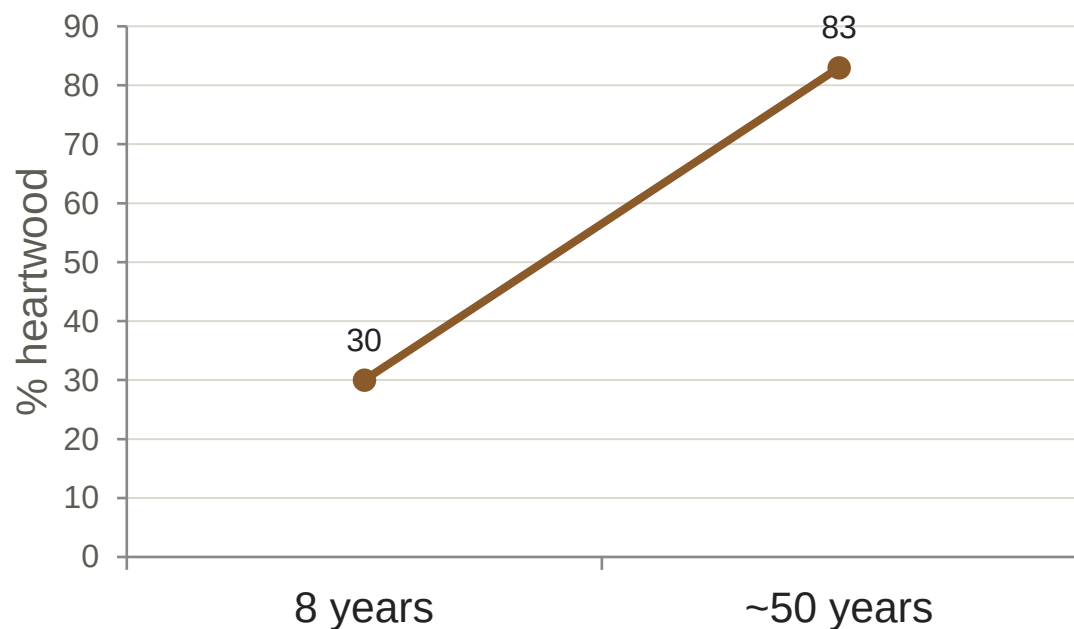
Optimum rotation depends on stand and tree volume, wood quality, market appeal, financial returns, and environmental goals.



Interest rates shorten rotations

Raising the assumed investment interest rate from 2% to 5% can push growers to cut rotation age from 60 down to 40 years — a 20-year reduction — to keep returns commercially attractive.

Heartwood: The Short vs. Long Rotation Debate

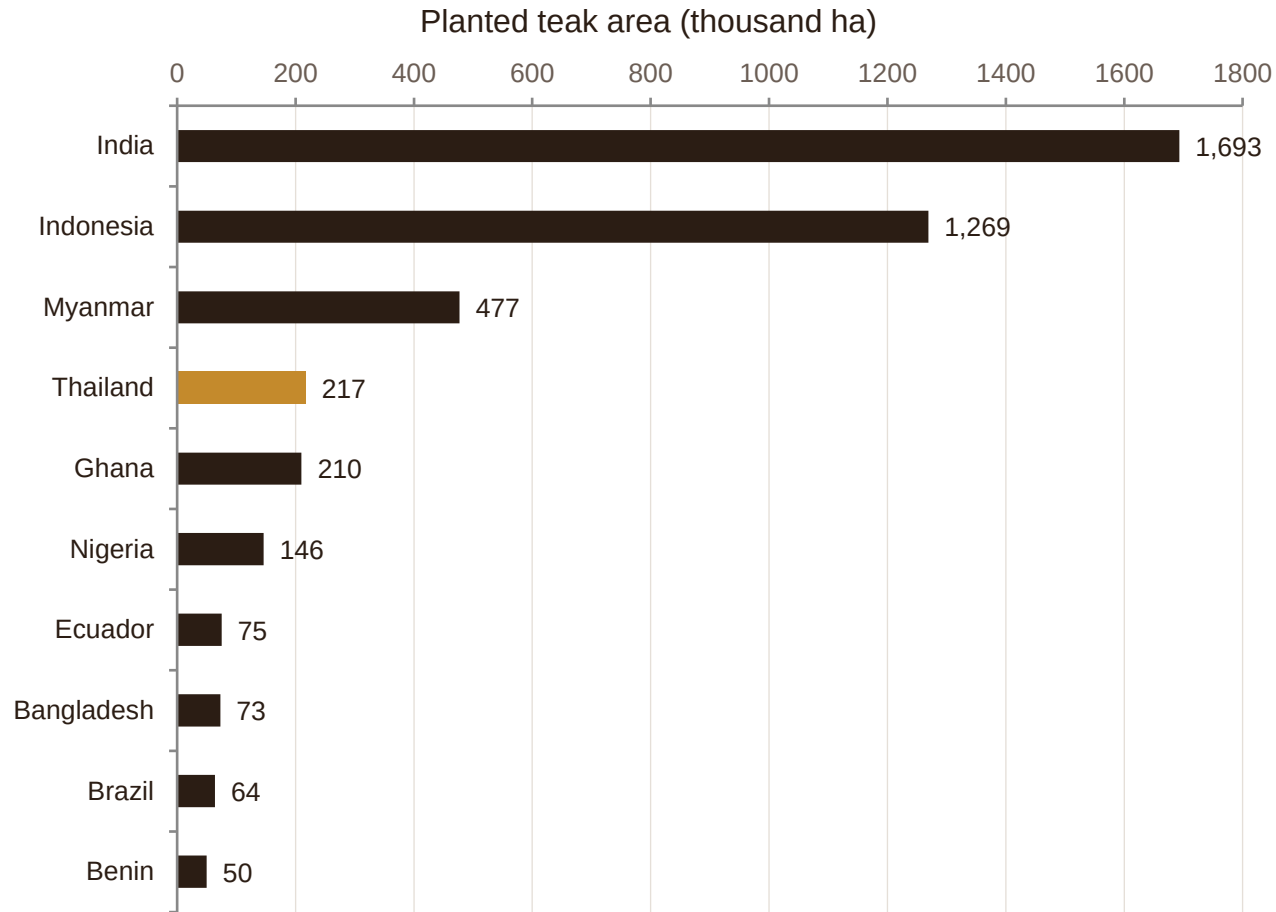


Heartwood proportion rises steeply with age — from roughly 30% at 8 years to 77–90% around 50 years.

What the research shows

- Darker, denser, high-heartwood teak is preferred by consumers and artisans over fast-grown, lower-heartwood timber.
- Yet studies find short-rotation timber comparable to long-rotation or natural teak in density, elasticity, and decay resistance.
- Long rotations remain attractive for carbon sequestration and emerging carbon-credit opportunities.

Top 10 planted-teak countries (2022)



- **Top 3** India 35%, Indonesia 26%, Myanmar 10%.
- **Thailand** 4th largest, rising from 128,000 to 217,000 ha.
- **Top 10** hold 88% of world planted area.

Teak in Thailand: overview

8.84 M ha

natural teak forests, 2022 (8.74 M in 2010)

217,000 ha

planted teak, 2022 (128,000 in 2010)

≈80,000 ha

teak managed by FIO, the largest grower

- **Natural teak** grows in mixed deciduous forest in northern and western Thailand.
- **Institutions** RFD manages reserved forests, FIO runs plantations, DNP runs parks.
- **Decline** teak-bearing forest fell from 2.32 M ha (1954) to 1.88 M ha (1993).

Natural teak forests in Thailand

- **Habitat** mixed deciduous forest, with a dry season from November to April.
- **Companions** Lagerstroemia, Burma padauk, ironwood, Siamese sal and bamboo.
- **Policy** the 1989 logging ban may have helped natural teak recover (FAO reported +2.9 M ha).
- **Threats** slash-and-burn, encroachment, mining and dams.

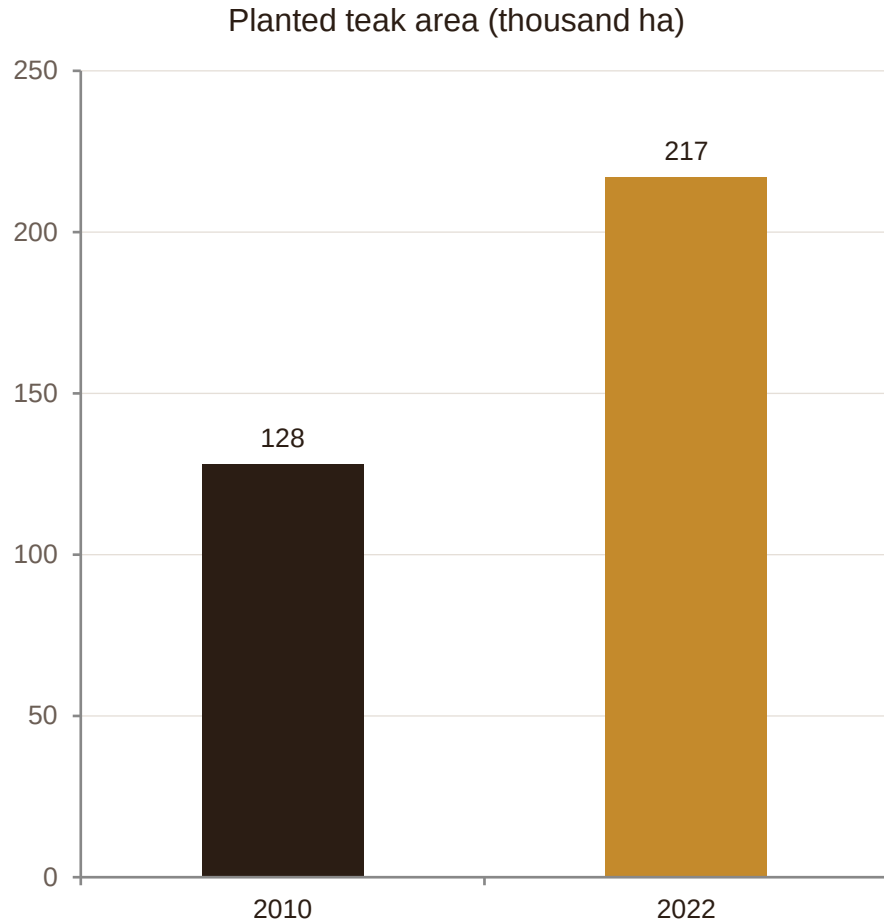
1989

nationwide ban on logging natural forests

8.84 M ha

natural teak forest, 2022

Planted teak in Thailand



- **FIO** state enterprise; 32 stations FSC-certified.
- **Private firms** e.g. TS Teak (Uttaradit): plantations since 1984, with a sawmill.
- **Smallholders** RFD subsidy (1994–2001) planted about 150,000 ha of teak.
- **Loss** 56.8% of subsidised reforestation was later converted to rubber and other cash crops.

Thai plantation silviculture (FIO)

Practice	Intensive protocol	FIO practice
Spacing	1,000–1,100 stems/ha	625/ha (4 × 4 m)
Pruning	Regular	Mostly none
Thinning	Early	After about 15 and 20 yr
Rotation	15–25 yr (extensive 50+)	30 yr (40 on poor sites)
Weed control	Intensive	Intercropping

30 yr

FIO rotation length

625/ha

initial stocking

Short-rotation teak from smallholders

- **Harvest age** smallholders often cut thinnings at 7–12 years for furniture, charcoal or fuel.
- **Young-teak defects** high sapwood, short fibres, thin cell walls, large microfibril angle, low density and lower strength.
- **Market** Thai furniture makers do not favour young teak.
- **Why farmers leave** 10+ years without income; many switched to rubber.

7–12 yr

typical smallholder harvest age

56.8%

of reforested area converted to other crops

Thailand: natural vs plantation teak wood

Aspect	Natural-forest teak	Plantation teak
Legal supply	Logging ban since 1989	FIO, private firms, smallholders
Harvest age	Old, slow-grown stands	About 30 yr (FIO); 7–12 yr (thinnings)
Heartwood, durability	High heartwood; generally highly durable	More sapwood; durability varies with age and origin
Density, strength	N/A	Lower if young; similar when mature
Shrinkage	Low	More movement in young wood
Uniformity	Highly variable	More even with selected seed

TEAK WOOD CHARACTERISTICS AND ENGINEERED WOOD

Teak Wood Characteristics

Comparative analysis of properties, teak wood quality, durability and workability



Five Factors Define Teakwood Quality

Aesthetic	Color · Grain · Texture
Physical	Shrinkage · Tangential/radial ratio · Absorption (FSP)
Mechanical	MOE · MOR · Max. crushing stress · Hardness · Growth stresses
Geometrical	Heartwood/sapwood ratio · Bole shape · Knot characteristics
Biological	Decay resistance · Insect resistance · Weather resistance

Source: Kollert and Kleine (2017)

Durability and workability

Durability

- Heartwood decay class 1–3, very to moderately durable, depending on age and origin
- Termites: class M (moderately durable)
- Dry-wood borers: durable, risk limited to sapwood
- Non-corrosive to metals; good weathering

Workability

- Easy to saw, machine, peel and slice
- Silica up to about 1.4% blunts tools: use carbide
- Oily: glue freshly machined surfaces
- Pre-bore for nails and screws (slight splitting)

A Genuine, Naturally Durable Hardwood

~100 MPa

Modulus of rupture at 12% moisture — meets Thailand's hardwood standard

642–650 kg/m³

Air-dry density (specific gravity $\approx$ 0.63)

11–18 yrs

Natural durability of old-growth forest teak outdoors

- **Naturally resistant** — Contains tectoquinone, which deters termites and wood-boring insects without chemical treatment.
- **Easy to work** — Saws, planes, carves and finishes easily; dries quickly and remains dimensionally stable, resisting warping.
- **A caveat for plantation wood** — Younger plantation-grown teak (13–16 years) has much lower natural durability — only about 2–6 years outdoors — because of its higher sapwood content.

Origin Shapes Durability and Color

Natural Forest Teak

- Dark brown heartwood color
- Class 1 (very durable) decay resistance — CEN & ASTM standards
- High extractive content and intense mechanical properties
- High structural resistance from natural, slow growth

Fast-growth Plantation Teak

- Lighter, more variable color (light-brown to brown)
- Class 2–3 durability — lower than native-site wood
- Irregular black streaks often visible in growth rings
- Lower natural durability linked to lower extractive content

TEAK WOOD CHARACTERISTICS AND ENGINEERED WOOD

Teak (*Tectona grandis*) Wood as Structural Timber

Structural properties of teak, shrinkage and drying behavior, dimensional stability, case study in Thailand



Structural properties of teak

Property at 12% MC	PROSEA range	CIRAD
Bending strength (MOR)	85–106 N/mm ²	98 MPa
Modulus of elasticity	10,000–13,400 N/mm ²	13,740 MPa
Compression ∥ grain	47–60 N/mm ²	56 MPa
Compression ⊥ grain	6–7.5 N/mm ²	n/a
Shear	8–14.5 N/mm ²	n/a
Janka side hardness	3,730–4,510 N	n/a

≈650

kg/m³ air-dry density: medium weight

High

strength-to-weight ratio

Shrinkage and drying behaviour

0.7–1.5 / 1.1–2.5%

radial / tangential,
green to 12% MC

2.5–3.0 / 3.4–5.8%

radial / tangential,
green to oven-dry

1.8

tangential/radial ratio

24%

fibre saturation point

- **Stability** very low shrinkage suits frames, doors and decking.
- **Drying** dries well but slowly: 2.5 cm boards air-dry (40 to 15% MC) in about 30 days.
- **Kiln** 2.5 cm boards from 40 to 10% MC in 5–6 days at 60–80°C.
- **Treatment** poorly permeable to preservatives (class 3–4).

Plantation vs natural teak: global evidence

Often similar

- Strength, shrinkage and form are often similar
- 21- and 65-year-old teak showed similar mechanical properties
- Mature plantation teak can match natural durability

Weaker when young

- More sapwood and juvenile wood
- Lower density and strength
- Larger microfibril angle, so more shrinkage
- Less durable heartwood

Management decides

- Targets for fast-grown logs: heartwood above 85%, density above 0.675 g/cm³
- Site, genetics, thinning and rotation drive quality

Heartwood: The Valuable Core



Sapwood is the living outer tissue that transports water and nutrients.

Heartwood is the non-functional, golden-to-dark-brown core made of dead cells — fine-textured, strongly decay-resistant, and the most valuable part of the trunk.

The heartwood proportion (measured at breast height) is a key global quality indicator, varying from 60–90% depending on diameter, height, age, genetics and site.

Source: <https://balconylivingcph.com/blogs/practical-guides-blog/bark-sapwood-or-different-grades-of-heartwood-become-a-little-wiser-about-the-teak-jungle>

A Moderately Dense, Stable Timber

80–120%

moisture content when
freshly cut (green)

0.44–0.63

oven-dry basic density
(g/cm³)

~637

mean density at 12%
MC (kg/m³)

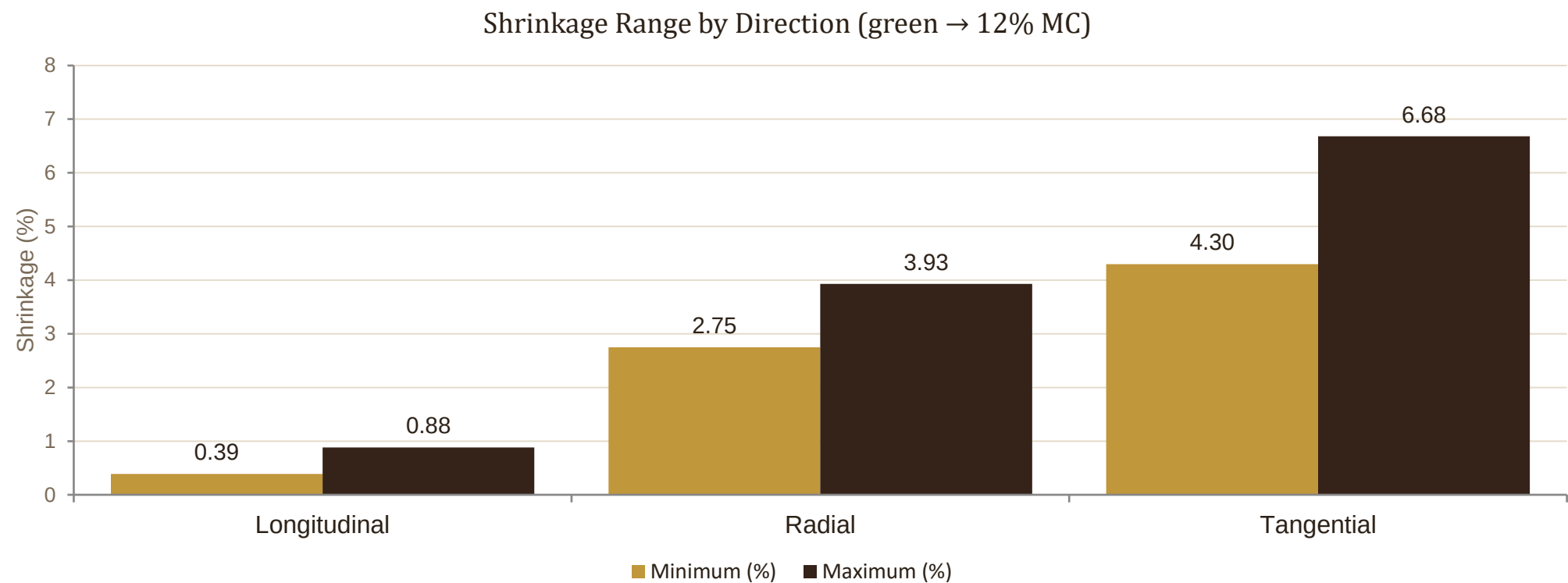
0.53–0.57

average density, green
volume basis (g/cm³)

Density at 12% MC varies by origin — around 690 kg/m³ in Indonesia, 620 kg/m³ in Thailand and 700 kg/m³ in Myanmar for natural-forest teak, and about 650 kg/m³ for West African plantation teak (Togo, Benin, Burkina Faso, Côte d'Ivoire). No significant density difference has been found between young and mature teakwood, although differences do occur between sites.

Low Shrinkage Supports Dimensional Stability

Shrinkage from green to 12% moisture content determines how much a timber will move in service. Teak's low values across all three directions make it exceptionally stable.



Source: Kokutse et al. (2004)

Rotation Length Shapes Wood Strength

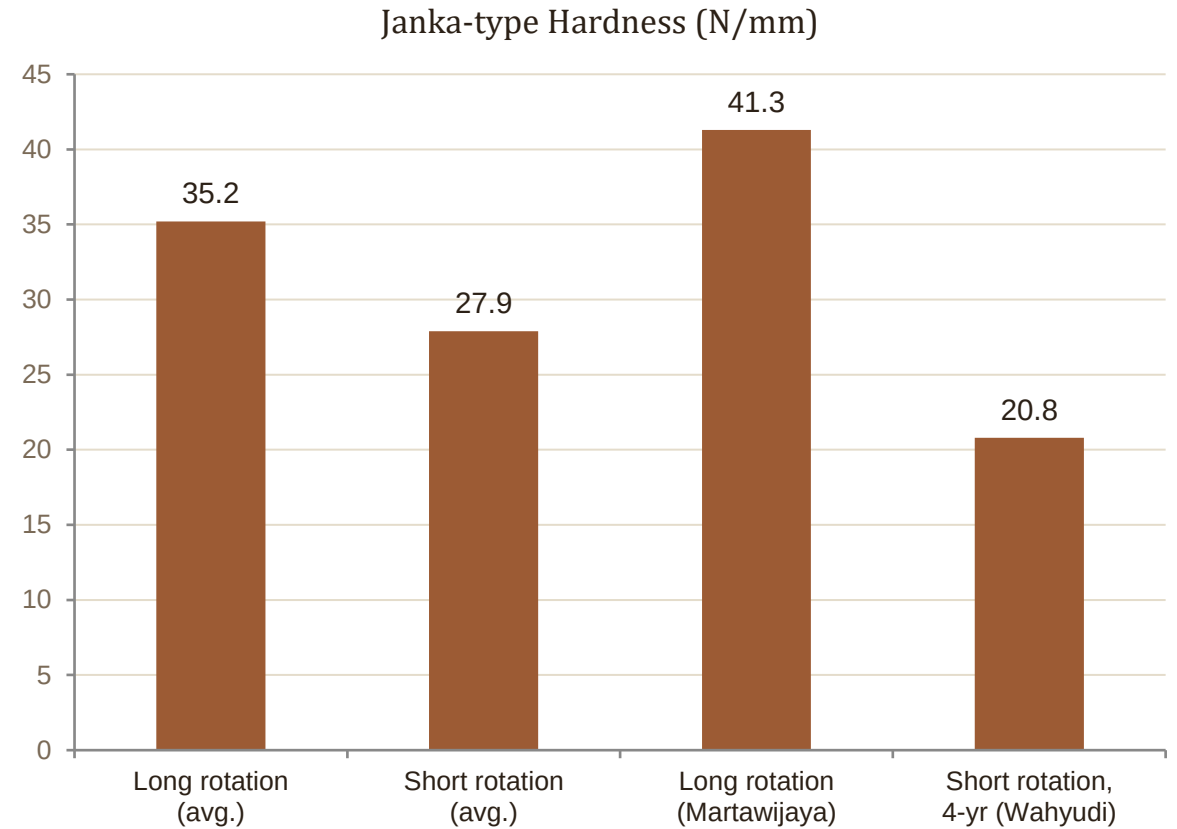
12.5 GPa

average Modulus of
Elasticity (MOE)

101.1 MPa

average Modulus of
Rupture (MOR)

Long-rotation teak develops greater hardness than short-rotation teak — a direct result of higher extractive content built up over more years of growth.



Study at a Glance

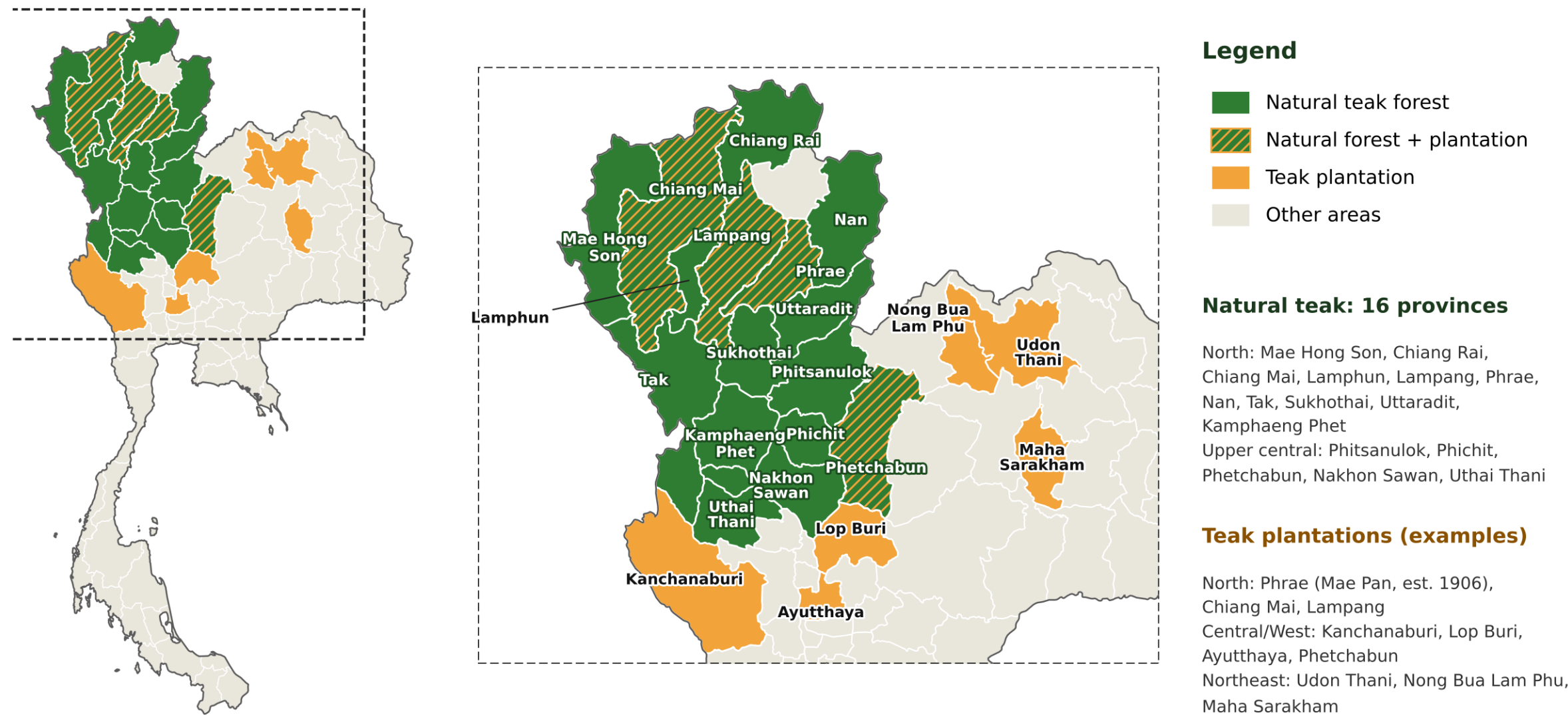
This study evaluated the physical and mechanical properties of teak (*Tectona grandis*) obtained from thinning operations (2007–2010) at three plantation sites, comparing juvenile-age thinning stock against Royal Forest Department hardwood standards.

3 Plantation Sites Lopburi, Kanchanaburi, Sukhothai	13–16 Years Old Range of thinning ages tested	30 Specimens per Test Both dry & wet condition samples	6 Properties Measured Strength, stiffness & hardness
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Properties were tested under air-dry and wet conditions, then adjusted to a standard 12% moisture content for comparison.

Natural Teak Forests and Teak Plantations in Thailand

Provincial distribution of natural teak (*Tectona grandis*) forests and documented teak plantations



Sources: Royal Forest Department (Thai Teak Knowledge); JIRCAS; Economic Zoning of Teak in Thailand | Province boundaries: Natural Earth
Note: Province-level view, not actual forest boundaries. Plantation list shows documented examples and is not exhaustive.

Six Properties Tested

Static Bending

MOR & MOE via center-point loading, specimens 2×2×30 cm, supports 28 cm apart

Compression $\perp$ Grain

Load applied perpendicular to grain, specimens 2×2×6 cm

Compression $//$ Grain

Load applied parallel to grain, specimens 2×2×6 cm

Shear Strength

Shearing force applied parallel to grain, specimens 2×2×2 cm

Impact Bending

Pendulum hammer drop test, specimens 2×2×30 cm, supports 24 cm apart

Hardness

Steel ball (11.20 mm) pressed into radial & tangential faces

Mechanical Properties at 12% Moisture Content

Property	Lopburi (13y)	Kanchanaburi (15y)	Sukhothai (16y)
MOR (MPa)	88	107	95
MOE (MPa)	8,420	11,600	9,660
Compression ⊥ grain (MPa)	12	15	14
Compression // grain (MPa)	43	53	51
Shear // grain (MPa)	13	15	17
Impact bending (kg-m)	2.60	2.04	1.39
Hardness (N)	2,800	3,400	3,120

Modulus of Rupture (Bending Strength)

MOR measures the maximum bending stress a specimen can withstand before failure, at 12% moisture content.



Kanchanaburi (15 years) recorded the highest MOR at 107 MPa (1,090 kg/cm²), exceeding the ~98 MPa (1,000 kg/cm²) threshold the Royal Forest Department uses to classify “hardwood.” Lopburi and Sukhothai fall just below it.

Modulus of Elasticity (Stiffness)

MOE reflects how stiff the wood is — its resistance to deflection under load — at 12% moisture content.



Stiffness follows the same pattern as strength: Kanchanaburi (15 years) is stiffest at 11,600 MPa, followed by Sukhothai and Lopburi — age and site conditions both appear to influence stiffness.

Compression Strength

Compression strength (MPa) at 12% moisture content, perpendicular and parallel to the grain.

Site (age)	Perpendicular ⊥ (MPa)	Parallel // (MPa)
Lopburi (13y)	12	43
Kanchanaburi (15y)	15	53
Sukhothai (16y)	14	51

Note

Parallel-to-grain compression is far stronger than perpendicular — typically 3–4× higher — reflecting how wood fibers resist axial loads much better than side loads.

Shear Strength Parallel to Grain

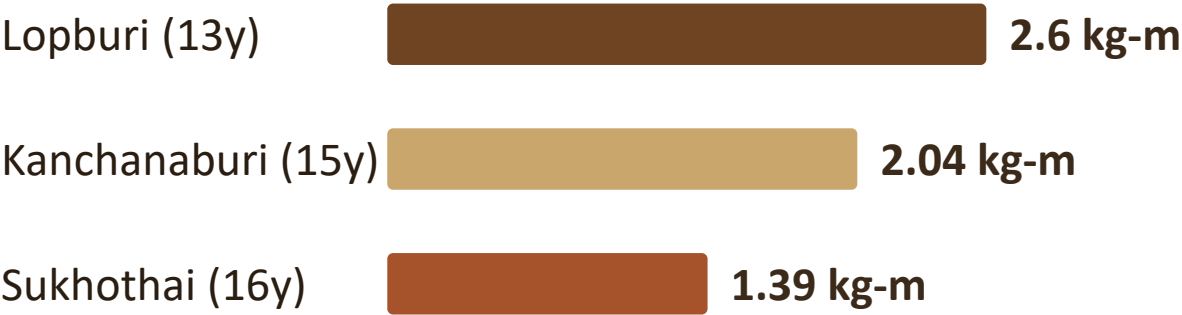
Shear strength (MPa) at 12% moisture content, measured parallel to the grain direction.



Shear strength increases steadily with site age — 13, 15, and 17 MPa respectively — suggesting more mature thinning stock resists sliding failure along the grain better.

Impact Bending & Hardness

Impact bending (kg-m)



Notably decreases with age — older thinning stock is less tough under sudden impact.

Hardness (N)



Kanchanaburi (15 years) is hardest; Lopburi (13 years) softest — consistent with its higher MOR and MOE.

Moisture Content Changes Strength Sharply

Example: Modulus of Rupture (MOR) across the three moisture conditions tested, kg/cm²

Site	Air-dry (kg/cm ²)	Wet (kg/cm ²)	12% MC (kg/cm ²)
Lopburi (13y)	914	687	895
Kanchanaburi (15y)	1,050	825	1,090
Sukhothai (16y)	954	799	973

Wet (green) wood is consistently weaker than air-dry or moisture-adjusted wood — by roughly 20–25% for MOR. This is why mechanical properties are always reported at a standardized 12% moisture content for fair comparison.

Is Thai plantation teak structural-grade?

Requirement	Why it matters	Thai plantation practice
Heartwood above 85%	Decay resistance	Longer rotation raises it; thinnings are sapwood-rich
Density above 0.675 g/cm ³	Strength and stiffness	Mature stands can reach it; young stands often lower
Straight, few knots	Grade yield and capacity	Little pruning by FIO: more knots
Stress grading	Design values	Visual grade D40 possible (EN 1912); test local timber

Conclusion: mature, thinned and pruned plantation teak can serve as structural timber; young unpruned teak is the weak link.

TEAK WOOD CHARACTERISTICS AND ENGINEERED WOOD

Engineered Wood from Teak (*Tectona grandis*)

Raw materials, production and properties, case study in Thailand



What engineered wood is, and why teak

Engineered wood

Composite wood products made from glued fibre, lumber and/or veneer to meet specific design criteria. Knots, splits and checks are cut out, so natural defects have minimal effect.

Finger-joint boards

Short pieces joined end-to-end with interlocking fingers, keeping the look of solid wood, unlike MDF or plywood.

Why teak

Golden to tobacco-brown colour with dark streaks, straight grain, and heartwood rated durable to very durable.

Why engineer it

Teak is a luxury wood, so stretching each log further matters.

Natural-forest vs plantation teak

Natural forest

- Burma teak is slightly stronger than Java teak
- Thai teak is slightly lighter and less strong than Java teak
- Thailand has banned natural-forest logging since 1989

Plantation

- Supply that can be traced and FSC-certified
- Export-grade rotations of about 20–30 years
- Limits: board width and length, and variable grading

Plantation boards are short and narrow; engineering joins them into wide, long panels. In Myanmar, 25–34-year plantation teak was more dimensionally stable than natural teak (except at 25 years).

Product types

Finger-joint board

Thicknesses of about 18–24 mm, 8 × 4 ft sheets; tabletops, joinery, stair treads

Engineered flooring

3–5 mm teak wear layer over a multi-layer base; typical 14 mm plank

Decking

Glued-and-reassembled teak slats, 8–15 mm thick, up to 4 m long

Tongue-and-groove floor/wall boards

Dried, planed, grooved, sanded; ready to finish or install

Veneer

Thin teak-faced sheets, flexible for small-radius curves





Preparation (1-4)

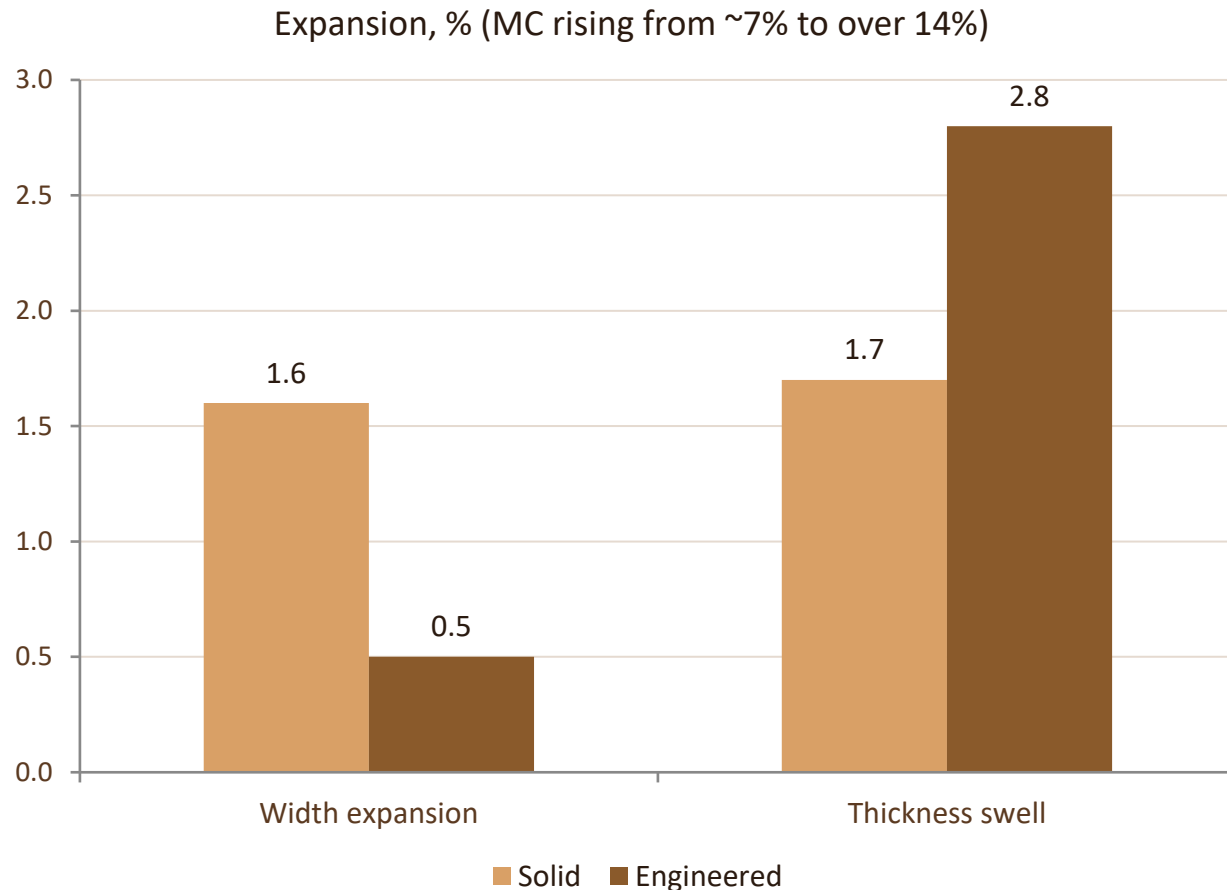


Joining and laminating (5-8)



Finishing (9-12)

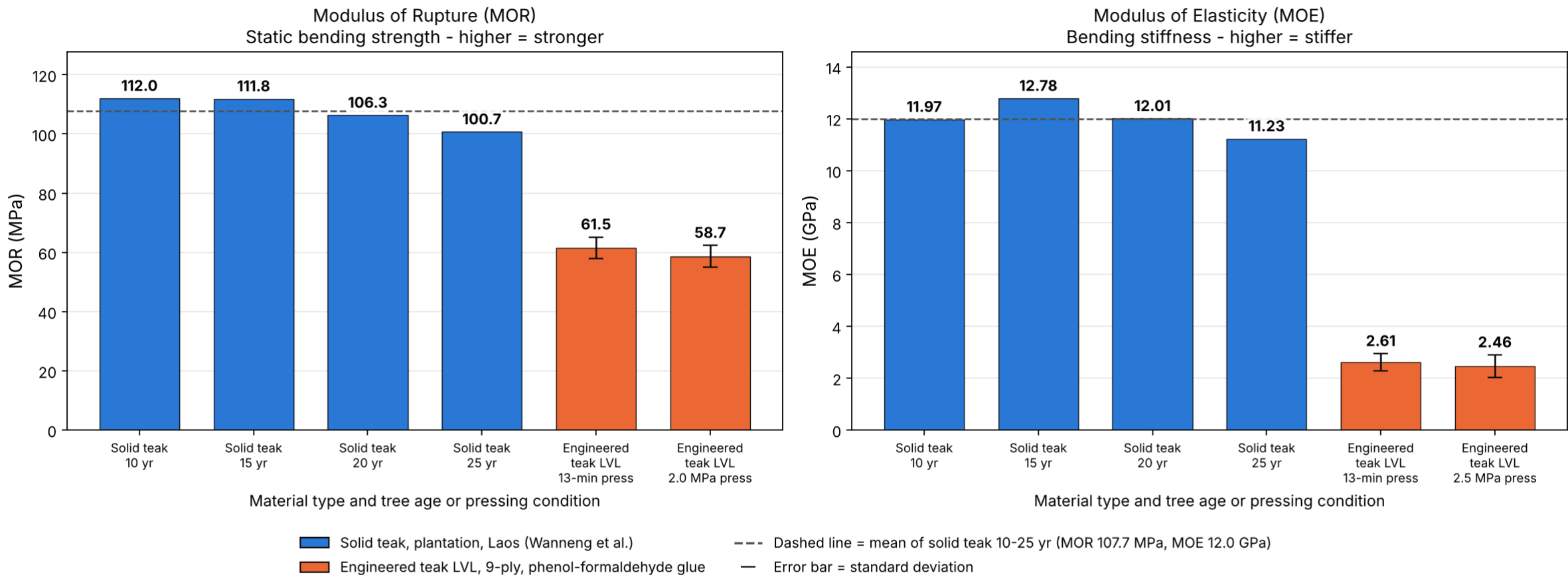
Dimensional stability: engineered vs solid



What the test shows

- Cross-laminated construction restrained width expansion to about one third of solid
- Thickness swell was higher in the engineered sample
- Length change was about 0.1% for both
- Test used white oak, an illustration of the construction effect, not teak data

Teak Mechanical Properties: Engineered Wood (LVL) vs Solid Wood (Laos)



- Notes
1. The tested engineered teak (LVL, 13-min press) reached about 57% of mean solid-teak MOR and about 22% of mean solid-teak MOE.
 2. Engineered teak: laminated veneer lumber from plantation teak, Faculty of Forestry, Vientiane, Laos; 9 plies of 2.3 mm veneer, PF resin, pressed at 120 C; specimens 20 × 20 × 360 mm at 6-10% moisture, ISO 16978.
 3. The LVL values are the means the paper reports for the 13-min pressing time (MOR, MOE) and for 2.0 MPa (MOR) or 2.5 MPa (MOE) pressure; each panel uses the pressure the paper quotes for that property.
 4. Solid teak: MOR and MOE of 10-, 15-, 20- and 25-year-old Laos plantation teak, quoted in the LVL paper from Wanneng et al.; moisture condition and test method were not stated there.
 5. These are different test methods and sample sizes, so the gap may partly reflect lab pressing and testing conditions; do not read it as the performance of commercial engineered flooring.
 6. No numeric bending data was found for engineered teak flooring itself. A Korean study of cross-laminated panels with a teak top layer reported bending strength 1.4-2.5 times the floorboard standard (KS), without numbers in the abstract.
 7. Teak glulam (Indonesia) was reported to beat mangium and trembesi glulam, but no solid-teak comparison was given. For real flooring, use the maker's test data.

Conclusions



A acceptable, typical performance range for plantation productivity is 6-15 m³/ha/yr for volume mean annual increment (VMAI). Under management of site, genetics, thinning and rotation, the target for fast-grown logs is heartwood above 85% and density above 0.675 g/cm³.



Wood density is the most-studied wood trait because it directly predicts many other properties. A less than 20 years old is today's fast-growth plantations. A rotation age of economic decision is less than 20 years old making them to have approximately 50% of heartwood ratio.



Natural hardwood benchmarks Janka hardness rating is 1,070 lbf providing exceptional dent resistance and durability. A expected above-ground service life without chemical sealants or extensive maintenance cycles is over 40 years
