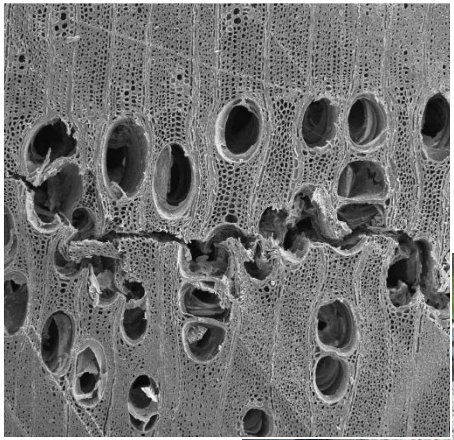
Performance of thermally modified timber in use class 3.2



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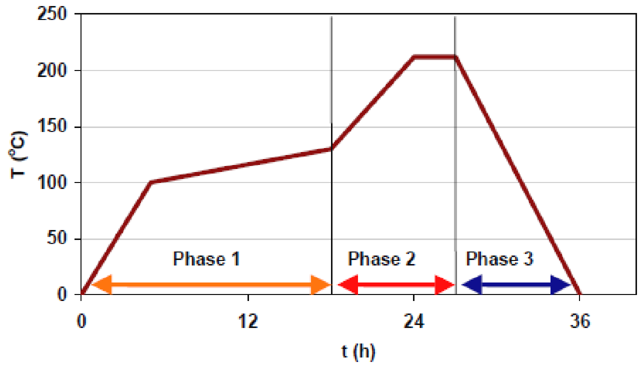
Thermally modified timber / TMT

Thermal modification:

- treatment at temperatures of 160-230°
- partial pyrolysis at reduced oxygen concentration
- chemical composition changes (hemicelluloses degraded)



schematic diagram of Thermowood propcess; source: Thermowood

Result of modification:

- properties permanently changed across entire thickness:
  - increased resistance against wood-destructive fungi
  - improved dimensional stability
  - lower equilibrium moisture
  - darker color shades

but also:

- decreasing stability

ash TMT

Applications of TMT

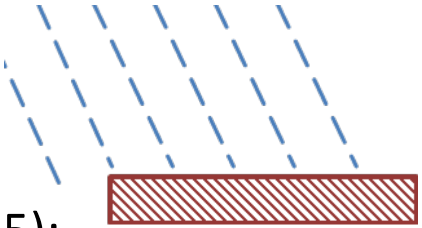
- used for outside purposes:

  - non load-bearing components

  - floorings, windows, doors, facade claddings, deckings

facade, American whitewood TMT, photo: AHEC

deckings:



- high exposure, in horizontal direction
- situation of exposure ≙ **U.C. 3.2** (EN 335):

  - not covered

  - continually exposed to weather, frequent wetting

- additionally mechanically stressed (abrasion, bending)

- DIN 68800-1*: durability class 2 ... 3 sufficient (non load-bearing components)

decking, aspen TMT, photo: Hagensieker

*) German standard for Wood preservation, part 1: General

Situation

- Theory:

  - reduced swelling / shrinking → reduced crack formation?

- But: repeatedly cases of damage with strong crack formation

  - in service (weathering) or
  - directly after heat treatment,
  - various wood species (spruce, beech, ash, …),

Consequences of heavy crack formation

- aesthetic worsening
- hazard of injury (splinters)
- weakening of material
- deposition of dust
- moisture pockets
- loss of value

longer wetting + higher risk of fungal decay

→ complaints and adjunct costs

→ loss of positive image

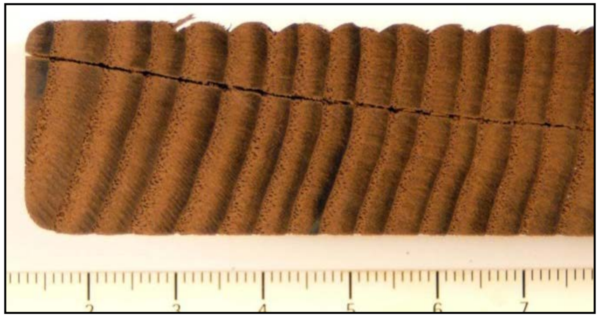
defective decking board, ash TMT, photo: anonym

Research project

Objectives

- minimise crack formation (quality assurance)
- avoid complaints → improve attractivity of TMT

ash TMT, cracks



Approach + method

(1) Analysis of cases of damage

→ clarify reasons + mechanisms

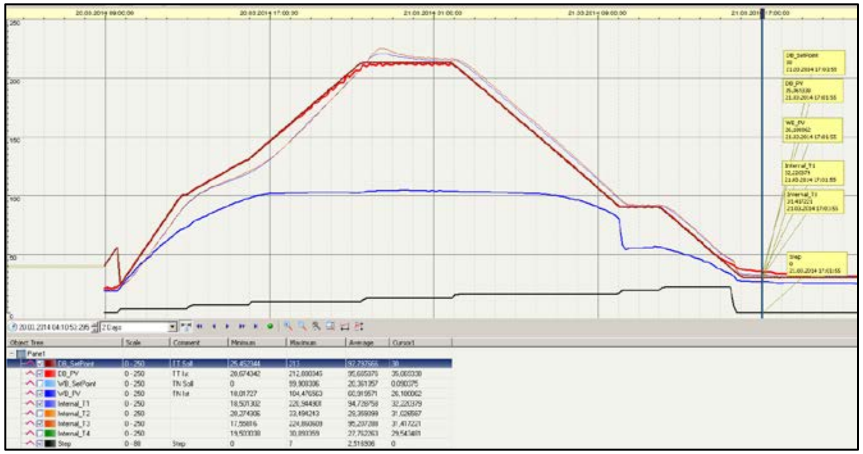
- trace back the material (chain of custody)
- investigate development of defects
- systematise the defects (type, dimension)

(2) Production of TMT

before: characterise raw timber

- experimental (IHD) + industrial (partners)
- variation of:
  - wood species, cut direction, characteristics
  - intensity treatment
- analysis of internal tensions

experimental thermo kiln of IHD



graph of heat treatment process

assessment of case-hardening, spruce TMT

Research project

(3) Weathering + assessment

- exposure: use class 3.2
  - orientated to south
- artificial + natural weathering
- monitoring of crack formation

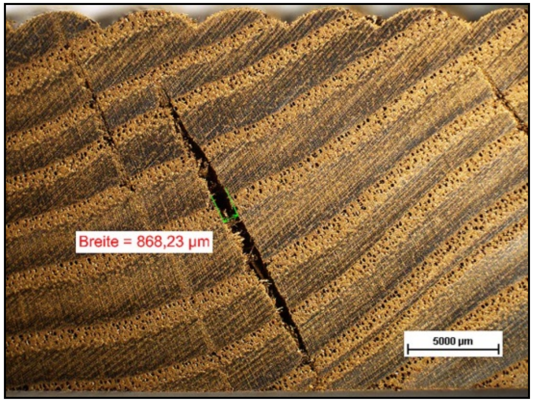
outdoor test field of IHD

subsequently:

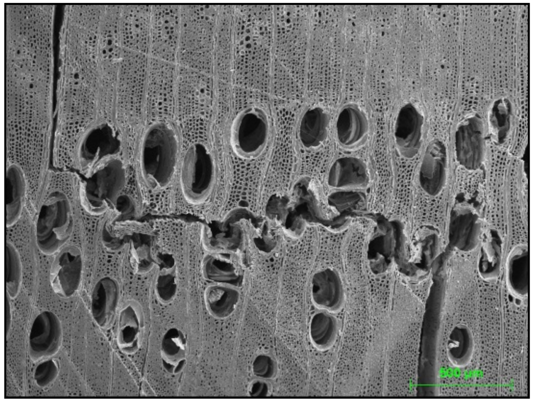
- assessment of cracks, classification
- comparison (sorting, intensity of treatment)

(4) Analysis of TMT microstructure

- microscopy: structural changes
- reflected-light, transmitted-light, SEM



ash TMT, cross section, M 5:1



ash TMT, SEM-photo; photo: Bäucker, TU Dresden

Deduction of measures

- requirements on quality of raw timber (wood selection, sorting, drying quality)
- parameters for appropriate thermal processing (high temperature, cooling rate)

reduction of crack formation

Typical phenomena of cracks in TMT

- tangential delaminations: conifers, plain sawn boards, on inside face

tangential delaminations, facade cladding, spruce TMT,

spruce TMT, cross section

- deep radial surface cracks: esp. beech

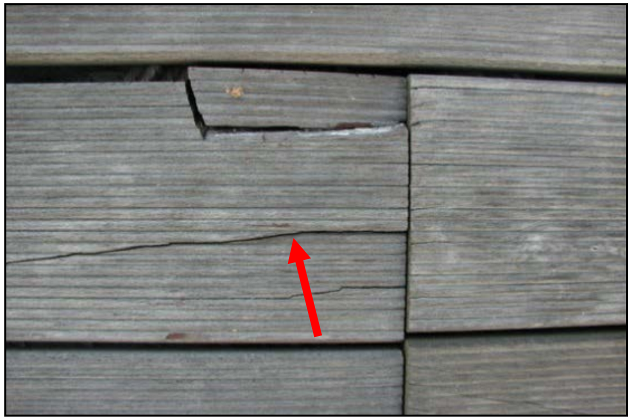
decking board, beech TMT, cross section

beech TMT, cross section

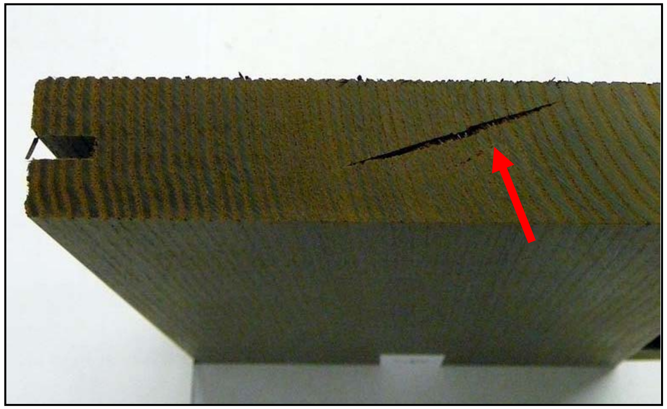
Typical phenomena of cracks in TMT

- long, traversing end cracks

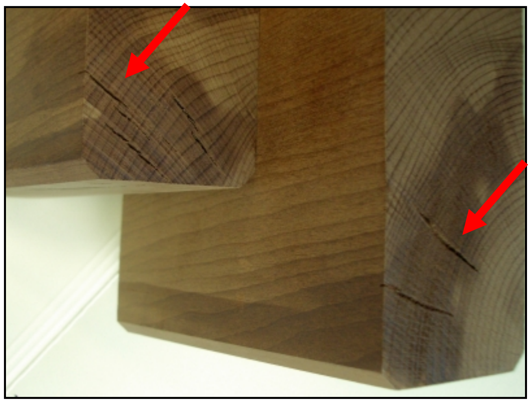
decking board,
beech TMT



- internal cracks (radial): heavy deciduous wood esp. susceptible (ash, beech), but also conifers



decking board, ash TMT



beech TMT

Typical phenomena of cracks in TMT

- tangential cracks in ash TMT

decking board, ash TMT,
photo: anonymous

Influences: wood species

- conifers: tangential cracks (different densities earlywood-latewood)

- beech: relatively high swelling/shrinking values
  → broad cracks

beech TMT

- poplar (diffuse-porous, relatively low density):
  only little crack formation

poplar TMT

Influences: wood species (ash)

Favourable characteristics for TMT

- high density
- high strength level

also after modification
→ deckings

- nice texture: stripe grain

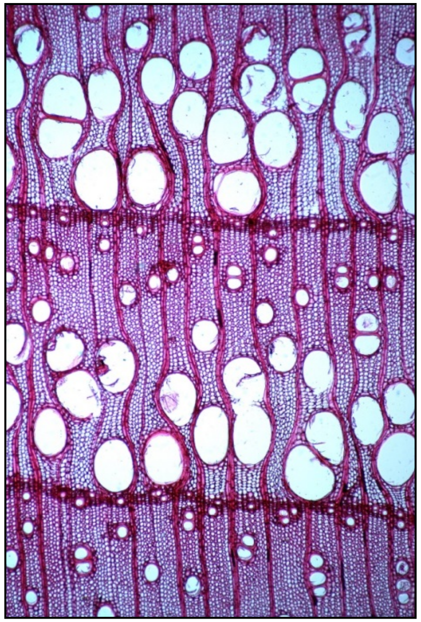
- brown heart: similar strength properties
- easily available

- durability class 5 (EN 350-2) → high grade of improvement by modification

Influences: wood species (ash)

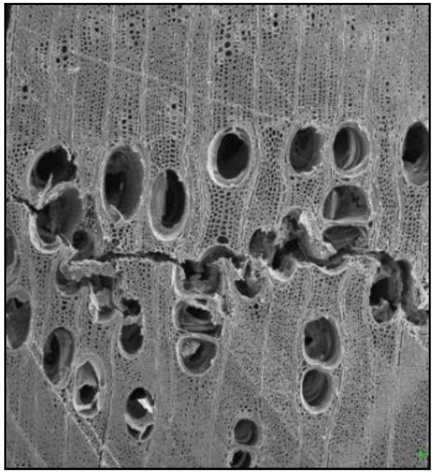
Rather adverse characteristics for TMT

- ring-porous → inhomogeneous structure:
  - high differences in densities earlywood-latewood
  - large early-wood vessels → possibly predetermined breaking points
- wide annual rings (> 5 mm) → very hard
- strongly alternating ring width



ash, cross section, transmitted-light; photo: Weiß

→ tends more to tangential cracks (mostly within early wood)



ash TMT, cross section, SEM, photo: Bäucker, TU Dresden

→ **timber selection**: soft ash + homogeneous ring width preverable

Influences: sorting

- generally: poor wood quality not compensable by modification
- not suitable: red heart in beech, large knots, strong slope of grain, strongly alternating annual ring widths
- no influence: brown heart (ash)

cracks due to slope of grain, ash TMT, photo: anonym

- compression wood (spruce): no negative influence, even less crack formation

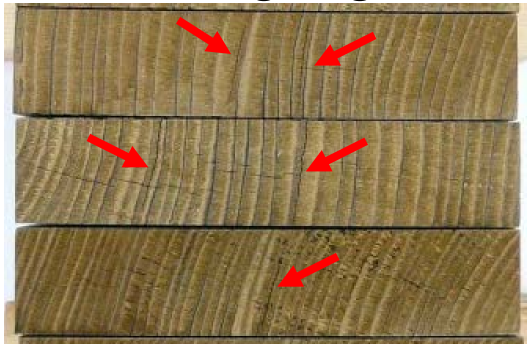
spruce TMT, hardly compression wood

spruce TMT, high amount of compression wood

Influences: sorting

- annual ring arrangement (example: spruce TMT)

standing rings:

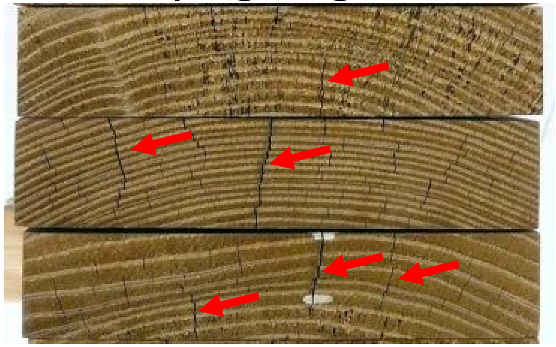


more tangential, hardly radial cracks visible

diagonal rings:

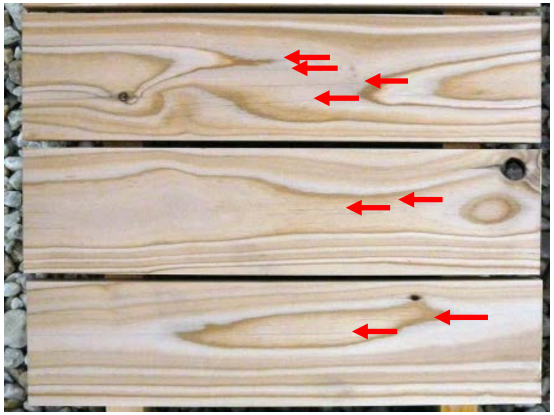
few radial, hardly tangential cracks visible

lying rings:



more radial, hardly tangential cracks visible

spruce TMT, standing rings



more radial surface cracks

spruce TMT, lying rings

Influences: pre-drying

- drying defects (tensions, cracks) more visible after modification (cracks enlarged)

internal cracks, pine TMT; photo: anonym

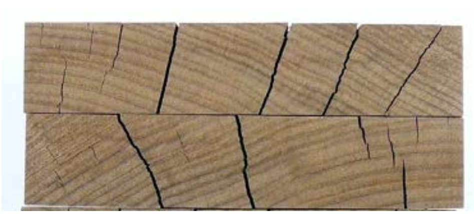
Influences: treatment intensity

- varying crack formation depending on treatment intensity:

beech, untreated

beech TMT 180

low modification:
broader cracks than in untreated wood



beech TMT 190

beech TMT 200

with rising treatment intensity:
decreasing breadth of cracks

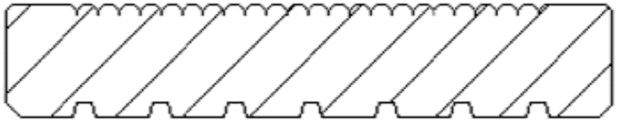
- but: too heavy thermal treatment → loss of stability; strong embrittling + increasing risk of delaminations

clean break, TMT

Influences: processing, mounting, maintenance

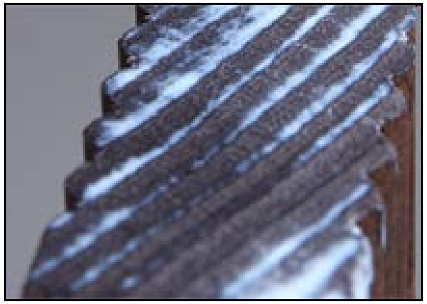
additional stress because of unsuitable wood processing/mounting facilitate the crack formation:

- corrugated profile → facilitates delamination
- wide boards screwed through
  → movement of wood hindered → splitting



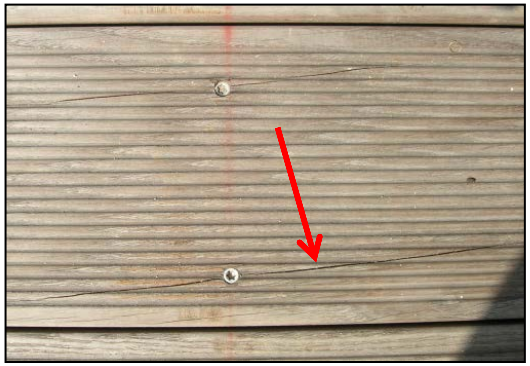
corrugated profile,
picture: Archeholz

- gap width too small → swelling → bulging
- no protection of cross-cut end → more end cracking
- no water-repellents (pigmented oil) + maintenance → more surface cracking



end-seal,
photo: Firstwood

decking, cracks
around the screws,
photo: anonym



Summary

- TMT: generally suitable for non load-bearing outdoor applications
- durability mostly sufficient (UC 1 … 3)
- predominantly good TMT performance, but
- frequent cases with checking after short weathering period
  (despite of reduced hygroscopicity + improved dimensional stability)

- different **influence factors** on crack formation:

  - wood selection: wood species, vessel distrubution, …

  - sorting: annual-ring arrangement, ring width (e.g. soft ash), slope of grain, knots, ...

  - pre-drying: defects

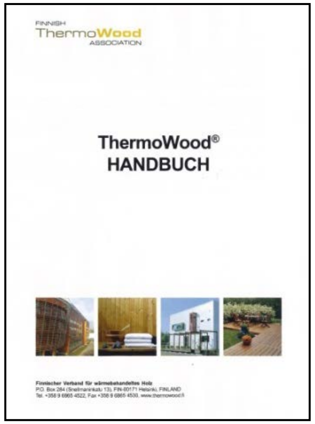
  - thermal modification: intensity

  - wood processing + mounting: not adapted on characteristics of TMT

Further information about TMT

- Thermowood-handbook (www.thermowood.fi)
- IHD-fact sheets (www.tmt.ihd-dresden.de)

1 Definition of terms
2 Durability
3 Load-bearing purposes
4 Colour shading stability
5 Standardisation, quality assurance
6 Methods for manufacture
7 Fire behaviour
8 Disposal
9 Beech TMT
10 Windows
11 Coating
12 Decking boards (in progress)



Thank you for your attention.