Wood assortment and quality forecast

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Introduction

Wood quality is a broad term reflecting compliance with specific requirements and is strongly driven by the intended application (e.g. appearance application or structural application). The quality assessment can be done at different stages of the production chain, including forestry stands and primary and secondary wood processing, which is in the current analysis of the most interest (Fig 1).
Forestry management has a crucial impact on the formation of wood quality, reflected in dimensional and internal wood quality. Such aspects as the choice of the wood species/mixtures and the application of species-specific silvicultural treatments yield a certain quality level. Within the current project, several aspects of forestry management are evaluated regarding the properties of the final product – primarily sawn timber.

Fig. 1: Wood processing. From tree to log and further to sawn wood

Methodology

The analysis combines data from multiple research projects run at TUM with precise knowledge of the location and the applied silvicultural treatments: beech in a mixture with the other wood species (Douglas fir, Norway spruce, Oak, and Scots pine) and Douglas fir timber coming from the forestry areas of different initial plant densities. Different scanning and non-destructive measurement technologies on the timber are applied (Fig. 2a to d), as well as mechanical properties are determined in tension test (Fig. 2e) to assess the quality in terms of structural application and address these measurements so that performance is optimized.

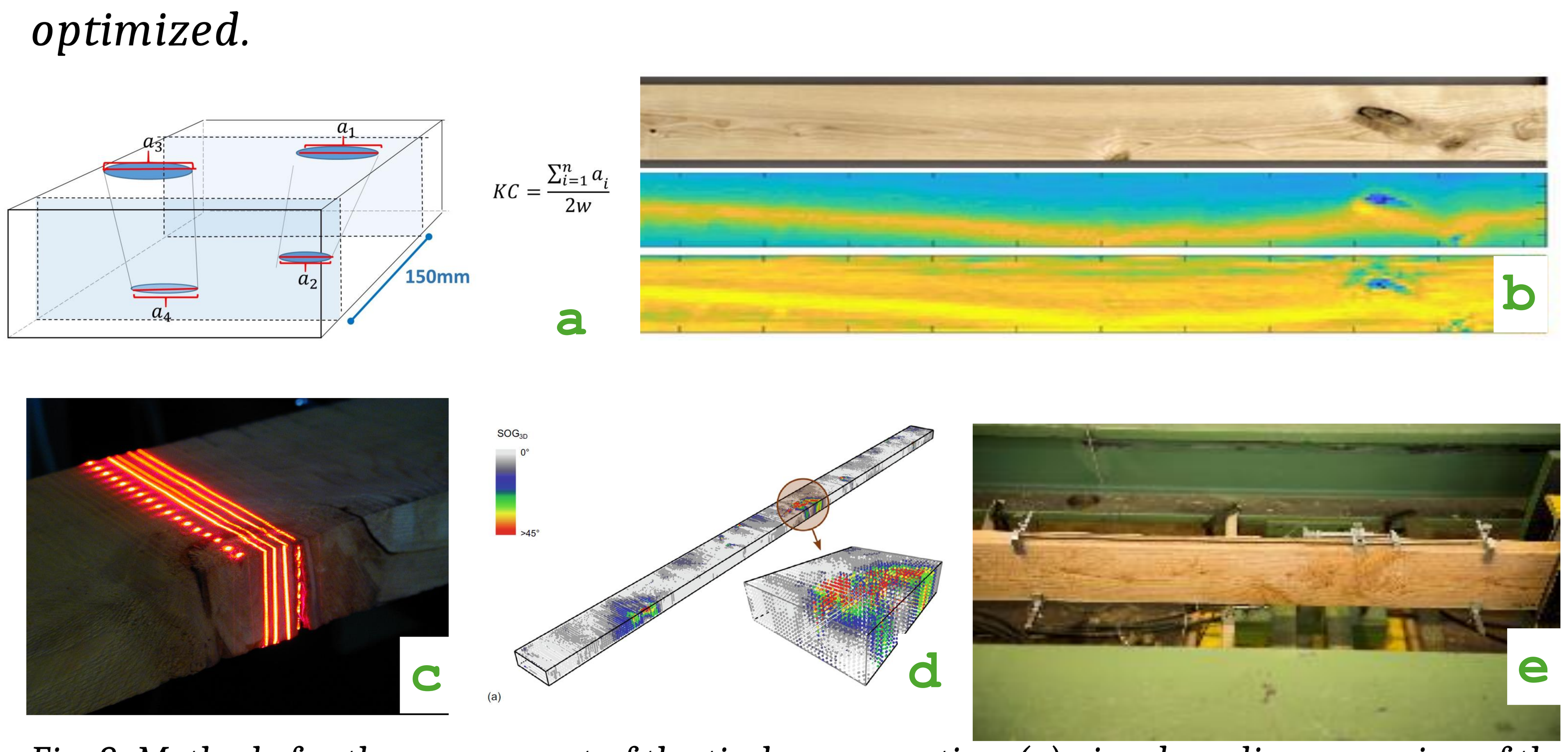


Fig. 2: Methods for the assessment of the timber properties: (a) visual grading; scanning of the wood using ultrasound (b) and laser scattering (c and d), as well as mechanical test to failure (e)

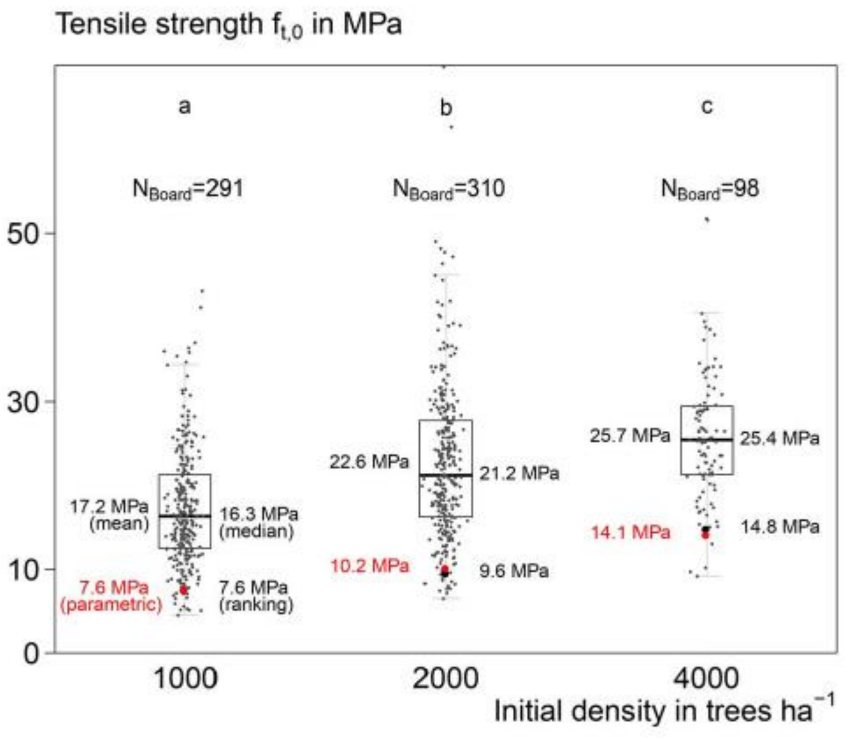
Results

Silvicultural treatments, such as the admixture of wood species, impact the mechanical properties of the timber produced (Table 1).

Table 1: The mechanical properties of beech timber from different stands (Rais et al. 2022b)

		Fagus sylvatica (n=84)	*Pseudotsuga menziesii* (n=84)	*Picea abies* (n=76)	*Quercus petraea* (n=82)	*Pinus sylvestris* (n=81)
$f_{t,0}$	MPa	65.2 (32.6)[a]	52.7 (30.2)[b,c]	55.4 (28.5)[a,c]	49.0 (27.8)[b,c]	46.6 (26.9)[b,c]
$f_{t,0,k}$	MPa	19.8	16.7	18.1	16.3	15.7
$E_{t,0}$	GPa	16.2 (3.2)[a,1)]	14.9 (3.1)[a]	15.4 (2.6)[a]	14.4 (2.7)[a]	14.3 (2.2)[a]
E_{dyn}	GPa	15.5 (2.4)[a,2)]	14.8 (2.3)[a]	15.0 (1.9)[a]	14.4 (1.9)[a]	14.1 (1.6)[a]
ρ	kg m^{-3}	735 (39)[a,3)]	715 (37)[a]	720 (41)[a]	708 (35)[a]	718 (35)[a]

[1] The F-statistics revealed a F-value of 2.2 and a p-value of 0.08, no post-hoc tests were done
[2] The F-statistics revealed a F-value of 1.8 and a p-value of 0.14, no post-hoc tests were done
[3] The F-statistics revealed a F-value of 1.7 and a p-value of 0.16, no post-hoc tests were done



The highest strength is achieved for timber coming from beech forests without any admixture of the other wood species. Also, the initial plant density impacts the mechanical properties, as shown in Fig 3 for the Douglas fir, coming from forests with different initial plant densities. The higher the plant density, the higher the tensile strength.

Fig.3: Tensile strength of Douglas fir timber coming from the stands with different initial plant densities ranging from 1000 to 4000 trees per ha. (Rais et al. 2022a)

The differences arising from specimen mixtures, silvicultural treatments and wood species combinations may be reduced by applying complex and advanced grading methods in further steps of the processing. Fig. 4 shows for the grading of multiple wood species at a time. In the example of the grading to strength class, DT38, improved yield and less deviation from the GDP are observable for more complex IPs.

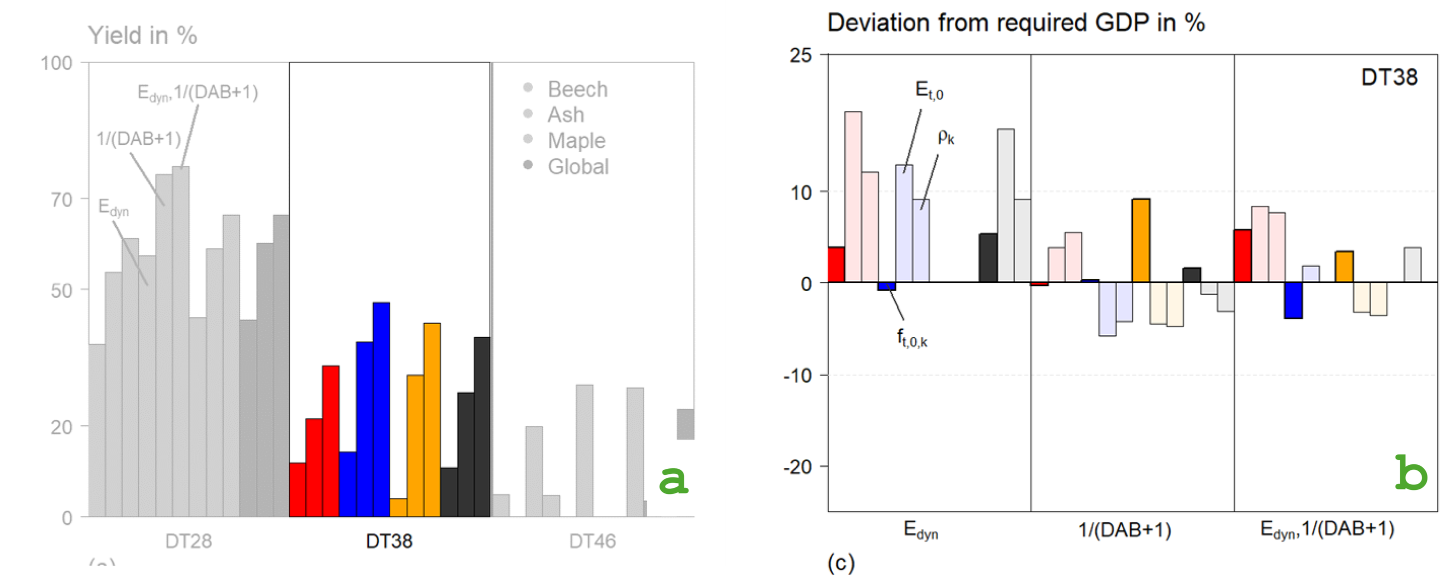


Fig. 4: Grading the combination of wood species (beech, ash, maple) in one run: (a) Yields for grading to strength class DT38 using different parameters; (b) Deviation from required GDP for grading using different grading parameters (IPs)

Conclusions

- *Influences of growth circumstances of various tree species in mixed forests on the mechanical properties have been identified and quantified.*
- *Advanced scanning methods and machine grading systems allow for improved strength grading of soft- and hardwoods, irrespective of their growth circumstances and geographical origin.*
- *Strength class profiles for soft- and hardwoods can be further optimized, allowing new and lesser used species to gain market access in engineered wood structures.*

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