South African file elaborated for Herrmann & Vogel and HWZ International South Africa Ltd.

Context

South African industry works wood of local tree species. For production of finger jointed timber and glue laminated timber, species usually processed are:

- Pinus patula (patula pine)
- Pinus elliotii (slash pine)
- Pinus taeda (loblolly pine)
- Pinus radiata (monterey pine, insignis pine or radiata pine)
- Pinus pinaster (maritime pine or cluster pine)

Czech Republic has great resource of Picea abies (European spruce) so the Czech traders are looking for new market, such as South Africa. It is an opportunity of trading but the European spruce is little known in South Africa which is why the aim of this study is to compare Picea abies to African pine.

Study

Mechanical proprieties comparison:

Wood as an engineering material is studied in laboratory and is described by many mechanical characteristics. It is a complicated material due to his organic structure and there is lot of criterion of variability (orthotropy, moisture content, species, etc.). To give a representative value and to allow comparison, testing is usually done on clear and straight grain sample of wood.

The table 1 shows three mechanical characteristics of each species of our interest. The values are from two different sources:

- Pinus pinaster, Pinus patula and Picea abies come from Tropix 7
- Pinus radiata, Pinus elliotii and Pinus taeda come from: Wood Handbook, wood as an engineering material

The Wood Handbook is a well known reference from the United States Department of Agriculture, summarizing information on wood as an engineering material. The information is reliable and testing are in accordance with American methods.

Tropix 7 is the product of the French research team BioWooEB. It is a data base aiming to summarize the main proprieties of 245 tree species from tropical and temperate forests. The information is also reliable and testing are in accordance with European methods.

More detail information on the sources are available in annex.

NB: values are valid for a wood moisture content of 12%. As a reminder, the strength class from the European standard EN 338 gives values valid for a wood moisture content of 12 %.

Table 1: Mechanical characteristics of south African pine and European spruce

	Compression parallel to grain (MPa)	Mean static bending strength (MPa)	Modulus of elasticity (MPa)
Pinus pinaster	39	80	8 800
Pinus patula	39	69	11 350
Picea abies	46	78	11 900
Pinus radiata	41,9	80,7	10 200
Pinus elliotii	56,1	112	13 700
Pinus taeda	49,2	88	12 300

Table 2 ranks the species according to each criterion.

Table 2: Ranking of the species

Ranking	Compression parallel to grain (MPa)		Mean static bending strength (MPa)		Modulus of elasticity (MPa)	
1st	Pinus elliotii	56,1	Pinus elliotii	112	Pinus elliotii	13700
2nd	Pinus taeda	49,2	Pinus taeda	88	Pinus taeda	12300
3rd	Picea abies	46	Pinus radiata	80,7	Picea abies	11 900
4th	Pinus radiata	41,9	Pinus pinaster	80	Pinus patula	11 350
5th	Pinus patula	39	Picea abies	78	Pinus radiata	10200
6th	Pinus pinaster	39	Pinus patula	69	Pinus pinaster	8800

The grading shows that Pinus elliotii is always first and Pinus taeda always second. We can also notice that Picea abiesis is never the last and is always before Pinus pinaster.

We could say that Picea abies is a little under the quality of Pinus ellioti and Pinus taeda but it is equivalent to Pinus radiata, patula and pinaster.

Conclusion:

The previous study gives an idea of the mechanical properties of European spruce compared to South African pine species. Since the properties of wood depend on many parameters and are very variable, I propose to look at the question from another point of view: compare African standards with European standards.

Standards approach

The South African standard proposes a structural classification of timbers, as well as the European standard. To verify the compatibility of European spruce in the South African industry, it is necessary to compare which class of European timber corresponds to the class South Africa.

In the laminated timber standard SANS 1460:2015, section 3.12 it is required that each glued laminated member shall comply the requirement for stress grade of timber grade 5, 7, 10 or 14. As we know that SA pine is used in laminated timber industry, we shall compare the grade stress table for SA pine (from SABS 0163-2) to the softwood strength classes table (from EN 338:2016).

The table 3 compare respectively the grades 5, 7, 10 and 14 of the S.A. standards to the classes C18, C24, C30 and C50 of the E. standards. The values of the E. classes which are above the S.A. grades are highlighted in green and the values under: highlighted in red.

Table 3: Comparison of the grade stress table for SA pine to the European softwood strength classes table.

Grades of timber	Bending	Tension parallel to grain	Tension perpendicular to grain	Compression parallel to grain	Compression perpendicular to grain	Shear parallel to grain	Mean modulus of elasticity
C50	50	33,5	0,4	30	3	4	16000
14	14,6	8,6	0,47	14,2	5,8	1,8	16000
C30	30	19	0,4	24	2,7	4	12000
10	10,5	6	0,33	10,8	4,1	1,3	12000
C24	24	14,5	0,4	21	2,5	4	11000
7	7,1	4,5	0,23	9,4	3	0,9	9600
C18	18	10	0,4	18	2,2	3,4	9000
5	5,2	3	0,16	7,4	2,1	0,7	7800

I selected the European classes according to their modus of elasticity, insuring that it is similar to the South African grade. In this way, we notice that the characteristics are always far above the south African requirement, apart for the compression perpendicular to grain.

Conclusion:

The strength of a timber doesn't depend only of the mechanical properties such as displayed in the first part. The quality of the timber as a great impact on the strength, so a hardwood timber with lot of knot can be less resistant than a clear softwood timber.

Even if the European spruce's strength is slightly under the slash pine's strength, it is possible to supply timber suiting the South African market. The European spruce timbers, in accordance with the classes C18, C24, C30 and C50, is commonly use for structural purpose in Europe and I confirm that it would be suitable for the same purposes in South Africa, according to their own standards.

Annex

Information from Wood Handbook:

Name	Moisture content	Specific gravity	Modulus of rupture kPa	Modulus of elasticity MPa	Work to maximum load KJ/m3	Impact bending mm	Compression parallel to grain KPa	Compression perpendicular to grain KPa	Shear parallel to grain KPa	Tension perpendicular to grain KPa	Side hardness N
Pinus radiata	Green	0.42	42 000	8 100			19 200		5 200		2 100
	12%		80 700	10 200			41 900		11 000		3 300
Pinus elliotii	Green	0.54	60 000	10 500	66		26 300	3 700	6 600		
	12%	0.59	112 000	13 700	91		56 100	7 000	11 600		
Pinus taeda	Green	0.47	50 000	9 700	57	760	24 200	2 700	5 900	1 800	2 000
	12%	0.51	88 000	12 300	72	760	49 200	5 400	9 600	3 200	3 100

Results of tests on small clear specimens in the green and air-dried conditions (12%).

Definition of properties:

- impact bending is height of drop that causes complete failure, using 0.71-kg (50-lb) hammer;

- compression parallel to grain is also called maxi- mum crushing strength;

- compression perpendicular to grain is fiber stress at proportional limit;

- shear is maximum shearing strength;

- tension is maximum tensile strength

- side hardness is hardness measured when load is perpendicular to grain.

Specific gravity is based on weight when ovendry and volume when green or at 12% moisture content.

Modulus of elasticity measured from a simply supported, center-loaded beam, on a span depth ratio of 14/1. To correct for shear deflection, the modulus can be increased by 10%.

Values for side hardness of the true hickories are from Bendtsen and Ethington (1975).

NB: For Pimus radiata:

Results of tests on small, clear, straight-grained Asian specimens. Property values were taken from world literature (not obtained from experiments conducted at the Forest Products Laboratory). Other species may be reported in the world literature, as well as additional data on many of these species. Some property values have been adjusted to 12% moisture content.

Information from Tropix 7:

Results of tests on small clear specimens in the air-dried conditions (12%).

	Mean crushing strenght	Mean static bending strenght	Modulus of elasticity
Pinus pinaster	39 MPa	80 MPa	8800 MPa
Pinus patula	39 MPa	69 MPa	11 350 MPa
Picea abies	46 MPa	78 MPa	11 900 MPa