Glued laminated timber using combinations of different species

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This poster summarizes the results of research conducted jointly over about ten years by IVALSA (ex-Wood Technology Institute) and ISP (Poplar Research Institute) into the possibility of using fast growing species (Poplar and Eucalyptus) for the production of glued laminated timber (glulam) in combination with more traditional species (Spruce and Larch).
The aim of the research was to find new uses for fast-growing trees (traditionally used for wood based panels) and to reduce importation of timber for glulam production.

The bonding quality proved to be reliable in all instances, including at the interface between different species, showing the possibility of using mixed beams even in severe climate conditions (e.g. EN 386, service class 3).
Choosing the species and their position in the beam with care it was possible to achieve a very high structural efficiency. Glulam elements were obtained - interesting both from an aesthetic and a mechanical point of view - using fast growing trees, which produce materials with low environmental impact, easily renewable, recyclable and manageable in the medium period.

A further advantage of mixed beams is their behaviour in bending, showing a more "ductile" rupture, if compared with the rupture of single-specie elements. This could be very useful, particularly for structural use in seismic zones.
Classification of these kinds of glulam according to the EN 1194 standard (as required by Eurocode 5) seems already possible, although in our opinion this document should be slightly modified to include lower strength classes for weaker materials too, which at the moment are excluded.

Here follow the main points illustrated in the poster for the various wood combinations tested:

Poplar-Uruguayan eucalyptus
Poplar: clone 'Neva';
No correlation was found between the mechanical classification of the laminations and beam behaviour: it seems better to use visual grading;
Changing from poplar-only to 5 poplar + 2 eucalypt: +78 % fm e + 50 % MOE, with G nearly constant, and a more "ductile" rupture;
Excellent bonding also at the interface between the two species;
Possibility of falling within the classification provided by prEN 1194 for mixed beams;
The combination of different woods has proved a great opportunity to improve structural efficiency;
There is a real possibility of producing gluelam elements: interesting both from the aesthetic and the mechanical points of view, by using materials with low environmental impact, easily renewable, recyclable and manageable in the medium period.

Poplar-fir
Poplar: clone 'I-214';
Maximum structural efficiency with 3 pairs of laminations (=6/11 of the section) in fir: + 40 % MOR, +84 % MOE (with respect to poplar-only beams);
Maximum money saving (20 %) with 2 pairs of laminations (=4/11 of the section) in fir: + 40 % MOR,

+68 % MOE (with respect to poplar-only beams);
Complete reliability of bonding quality, also at the interface between the two species;

Fir-larch
The unexpectedly poor characteristics of the larch used altered the results of this experiment.
The mechanical characteristics of larch were similar to those of fir: no interest in these combination, apart from durability;
Complete reliability of bonding quality, also at the interface between the two species;

Larch-poplar
Poplar: clone 'I-214';
Maximum structural efficiency with 2 pairs of laminations (=4/11 of the section) in fir: + 51 % MOR, +63 % MOE (with respect to poplar-only beams) - money saving 25 % with respect to larch-only beams;
Complete reliability of bonding quality, also at the interface between the two species;

Poplar-italian eucalyptus
Among the four eucalyptus clones investigated, clone '330' (green) differs considerably from the others (very similar to each other), showing a higher density and a much better mechanical behaviour (+ 50 % approx. both for bending strength and MOE); this applies both to the raw material as well as to laminated beams.
The above consideration is even more interesting as '330' (green) was the fastest growing clone in the experimental stand.
For all the clones, the combined beams showed higher structural efficiency in bending than those made entirely of poplar or eucalyptus; in particular, the best mechanical performance, with respect to poplar, was obtained using clone '330' (green) (+ 35 % for fm and + 50 % for MOE), while the other three clones showed a much lower increase (+10 % on average for both fm and MOE);
The very good quality of the poplar wood used (compared with the poplar wood of the same clone used in the previous research), together with the knotty eucalyptus materials, caused the low increase of the mechanical properties obtained in the mixed solutions, except in the case where clone '330' (green) was used; with this clone, thanks to its higher density and mechanical properties, a much better performance and structural efficiency was obtained.
No correlation was found between modulus of elasticity and bending strength in the beams:
therefore it seems better to support (or to replace) the mechanical classification of the laminations with a visual one, particularly when the material is strongly affected by physical defects (as was the eucalyptus wood used in the present research).
Excellent bonding quality of the glue lines for all clones, also at the interface between the two species.
Possibility of falling within the classification scheme provided by prEN 1194 for mixed beams.
The combination of wood of different species, in the right proportions, has confirmed the possibility to produce gluelam.
with high structural efficiency, employing materials with low environmental impact, easily renewable, recyclable and manageable in the medium period.

Asymmetric poplar-eucalyptus beams
Specimens of mixed species showed better bending behaviour, both as to the energy dissipated and the ratio between deformation at rupture and elastic deformation.
The energy dissipated at ultimate load, and at a subsequent 5 % reduction of such load, was significantly higher in the mixed beams.
In cyclic bending, the specimens showed perfect elastic behaviour.
The rupture patterns of the specimens with mixed species were very interesting. The compression rupture, across the poplar lamination as a whole, proceeded from the compressed side towards the side under tension, , thus moving the neutral axis close to the glue line (at the interface between poplar and eucalyptus). This caused a macroscopic elongation of the load-deformation graphs.