MODELING THE RELATIONSHIPS BETWEEN WOOD PROPERTIES AND QUALITY OF VENEER AND PLYWOOD OF CHINESE PLANTATION POPLARS

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ABSTRACT

Following our earlier studies on the relationships between wood properties and the quality of veneer and plywood of Chinese plantation poplars, this study attempted to model their relationships with stepwise and multiple linear regression. The results show that the selected three indices of wood quality of veneer and plywood of plantations poplars grown on the shore of the Yangtse River in China, which are the variance of veneer thickness (VVT), the ratio of lathe check in veneer (ratio of the depth of check to the thickness of veneer) (RLC), and the glue-bond strength of plywood (GS), can be satisfactorily predicted with the key wood properties using the individual regression equations. The variance of veneer thickness (VVT) is a function of fiber width (FW), proportion of vessel (VP), and fiber (FP): VVT = −3.414 + 0.063 FW + 0.049 FP − 0.033 VP. The ratio of lathe check in veneer (RLC) is a function of wood hardness on tangential surface (TH), modulus of elasticity in bending (MOE), air-dry wood density (WD), and total volumetric shrinkage of wood (SV): RLC = 9.472 + 0.005 TH + 0.003 MOE + 8.366 WD − 2.302 SV. The glue-bond strength of plywood (GS) is a function of pH values (PH), fiber length (FL), fiber width (FW), vessel length (VL), and proportion of vessel (VP) and ray (RP): GS = 3.326 − 0.268 PH − 0.002 FL + 0.191 FW − 0.004 VL − 0.033 VP + 0.095 RP. The correlation coefficients (r) of the above regression equations are 0.73–0.93. The determination coefficients (r^2) for the regression equations are 0.54–0.88. The regression equations are highly statistically significant at the 1% level. The differences between the model predicted and experimentally measured values are not statistically significant.

Keywords: Plantation poplar, wood properties, quality of veneer and plywood, regression equations.

INTRODUCTION

It is well known that wood processing and utilization are directly affected by wood properties (Panshin and De Zeeuw 1980; Haygreen and Bowyer 1982). For a long time, wood scientists placed emphasis on determining wood properties, while wood technologists mainly studied methods of wood processing and utilization. In recent years, there has been a growing interest in combining studies on these two aspects: wood properties and wood product quality. Moreover, since wood quality is directly affected by growth conditions, some authors emphasize the importance of connecting silviculture and wood quality through modeling approaches and simulation procedures (Goudie 1999; Lindeberg et al. 1999; Nepveu and Malan 1999; Seifert 1999).

Fast-growing plantation poplars have been

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widely planted all over the country in China since the 1960s. It is estimated that the area of plantation poplar currently totals 6,670,000 ha (Wang 1995). Studies on the properties of wood from fast-growing forest plantations were listed in the Eighth Five-Year (1999–1995) and Ninth Five-Year (1996–2000) Plan of National Key Technologies R&D Programs in China; and preliminary study of wood properties of fast-growing plantation poplar in combination with pulping and plywood processing has been carried out (Bao and Jiang 1998), but this field needs to be further developed.

In our previous research (Bao and Liu 1999), the relationships between wood properties and the quality of veneer and plywood of plantation poplars were studied. It was observed that the quality of veneer and plywood is closely related to some of the wood anatomical, chemical, and physical-mechanical properties. In the present study, an attempt was thus made to model their relationships with stepwise and multiple linear regression in order to explore the possibility for predicting the quality of veneer and plywood through the key wood properties measured.

BACKGROUND

In our previous study (Bao and Liu 1999), the indices of wood properties that were listed in the IAWA list of microscopic features for hardwood identification (IAWA Committee 1989) and the Chinese National Standards (Chinese National Technique Monitoring Bureau 1981, 1991) were followed as much as possible. The anatomical properties include: fiber dimensions (fiber length, fiber width, thickness of cell wall, diameter of lumen, ratio of cell wall to lumen, ratio of lumen to cell diameter), vessel dimensions (vessel length, tangential vessel diameter, number of vessels per mm^2), microfibril angle, vessel proportion, fiber proportion, ray proportion, and percentage of cell wall. The chemical properties include: pH value, acid buffer, and alkali buffer. The physical-mechanical properties include: growth ring width, density, shrinkage, hardness, modulus of elasticity, and modulus of rupture. The quality criteria of veneer are the variance of veneer thickness, the ratio of lathe checks in veneer; the degree of surface roughness of veneer, and the transverse modulus of rupture. Among these four indices, the first and the second are primary; the larger and the deeper the lathe checks, the lower the modulus of rupture and the rougher the veneer surface. The quality of veneer depends mainly on the variance of veneer thickness and the ratio of lathe checks of veneer (the ratio of the depth of check to the thickness of veneer) (Cahalin 1987; Northeast Forestry University 1989). Therefore, the variance of veneer thickness and the ratio of lathe checks of veneer were selected as the criteria of veneer quality. The physical and mechanical properties of plywood mainly include moisture content, density, glue-bond strength, heat conduction, and ratio of strength to weight. Among these, glue-bond strength is the primary index that reflects the mechanical strength of plywood (Cahalin 1987). It is also the property that must be tested according to the Chinese National Standard (Chinese National Technique Monitoring Bureau 1981). In our studies, the glue-bond strength of plywood is determined and analyzed as the index of plywood quality.

The relationships between wood properties and quality of veneer and plywood in Chinese plantation poplars were developed in our previous study (Bao and Liu 1999) as follows; it was found that the variance of veneer thickness (VVT) was highly statistically significantly related with the fiber width (FW), the fiber proportion (FP), and the vessel proportion (VP), and statistically significantly related to the fiber length (FL), the thickness of cell wall (TCW), the ratio of cell wall to lumen (TCW/LD), the ratio of lumen to cell diameter (LD/D), the vessel length (VL), and the ray proportion (RP). The ratio of lathe checks of veneer (RLC) was highly statistically significantly related with the lumen diameter (LD), the modulus of elasticity (MOE), and statistically significantly related with the air-dry wood density (WD), the total volumetric shrinkage (SV), and the tangential hardness (TH). The glue-bond strength (GS) was highly statistically significantly related to the pH values (PH), the fiber width (FW), the ray proportion (RP), the vessel proportion (VP), the vessel length (VL), the fiber length (FL), the lumen diameter (LD), the thickness of cell wall (TCW), the ratio of cell wall to lumen (TCW/LD), the microfibril angle (MFA), and statistically significantly related with fiber proportion (FP).

Obviously, the quality of veneer and plywood is closely related to the anatomical, chemical, and physical-mechanical properties of the wood from which it is made. Thus, it is possible to model their relationships with stepwise and multiple linear regression for prediction of the quality of veneer and plywood through the key wood properties.

MATERIALS AND METHODS

Testing materials

Three plantation poplar clones, poplar 72 (*Populus* × *euramericana* cv.I-72/58), poplar 63 (*P. deltoides* cv.I-63/51), and poplar 69 (*P. deltoides* cv.I-69/55), grown on three different shores of the Yangtse River in China (Islet beaches of Xinzhou in Anhui provinces, river beaches of Huangzhou in Hubei provinces, and lake beaches of Yuanjinag in Hunan provinces), and at three different planting densities (3 m × 4 m, 4 m × 5 m, 5 m × 6 m) were selected as the testing materials. In total, 18 plantation poplar trees were cut down for this study. The growth conditions of Chinese plantation poplars are given in Table 1.

Test methods

From each poplar tree, one disc about 5 cm in thickness at the height of 1.3 m was removed for measuring anatomical and chemical properties. One log (about 90 cm in length at the height of 0.3 m to 1.2 m) was used for rotary cutting of veneer, and the other log (about 2 m in length at the height of 1.3 m to 3.3 m) was used for measuring wood physical-mechanical properties. The fiber length was measured under a projector with the macerated fibers. The microfibril angle was determined on 15–20μm thickness tangential sections with the help of a polarized microscope at 100× magnification. The other cell dimensions were measured using an image analysis system (Quantimet-570). The chemical and physical-mechanical properties of wood were determined according to the Chinese National Standards (Chinese National Technique Monitoring Bureau 1981, 1991).

The procedures of rotary cutting veneer and making plywood are as follows: log → rotary cutting → drying → gluing → matching → solidifying → heat pressuring → trimming → sanding.

Rotary cutting.—The wood of fast-growing poplars is soft as well as high in moisture content, so the green wood was rotary cut directly. The parameters for rotary cutting follow: the grinding angle of the rotary cutting knife was 19~21°, the clearance angle was 4~1°, the veneer compression rate by the nose-bar was 8%. In order to compare the effect of different veneer thickness on veneer quality under the same rotary cutting condition, three kinds of veneer thickness, namely 1.01 mm, 2.02 mm, 3.03 mm were adopted for each of the three poplars. In total, 18 logs were cut; 9 logs were cut for 1.01-mm veneer, 6 logs for 2.02-mm veneer, and 3 logs for 3.03-mm veneer. All of the veneer was peeled with a rotary lathe (3VKKT/L665 made in Finland) in the testing factory of Research Institute of Wood Industry of Chinese Academy of Forestry.

Cutting samples for testing quality of veneer.—The veneer strips for testing were cut from the rotary cut veneer pith outward. In the 1.01-mm veneer, they were cut every ten rotations, and in the 2.02-mm and 3.03-mm veneer every 5 rotations. Every time a veneer strip with width 50 mm (W) and length 1000 mm (L) was cut for testing, the ratio of lathe check in veneer and roughness of veneer surface were measured. Four veneer strips 80 mm (W) and 1,000 mm (L) were taken for testing

TABLE 1. *Growth conditions of Chinese plantation poplars.*

Sample site	No. of tree	Age of tree (a)	Diameter at 1.3 m height (cm)	Depth of flood-ing (m)	Periods of flooding (month)	pH values	Soil type	Average tempera-ture (°C)	Precipi-tation (mm)	Longitude	Latitude
Islet beach	6301	12	23.5	2	2	6.5–7.0	Stone brash	16.5	1,300–1,500	117° E	33° N
	6303	12	23.6								
	6304	12	25.0								
	6905	12	24.0								
	6906	11	22.0								
	7209	11	24.0								
River beach	69 × 3 × 4	10	21.9	3	2.5	7.4–8.5	Sandy soil	16.9	1,182	114° 45′	30° 30′
	63 × 3 × 4	10	21.4								
	72 × 3 × 4	10	21.8								
	72 × 4 × 5	8	22.3								
	69 × 5 × 6	11	21.6								
	63 × 5 × 6	8	20.8								
Lake beach	7201	11	23.8	1	1	7.0–7.8	Damp soil	16.9	1,319	111° 6′	28° 39′
	7202	11	25.9								
	6901	9	22.5								
	6902	9	21.6								
	6301	9	26.5								
	6302	9	26.6								

Note: 63-Poplar 63; 01-Number of tree, 3 × 4-Planting density.

the variance of veneer thickness and difference in shrinkage.

The veneer sheets were cut into veneers with width 900 mm (W) and length 1,000 mm (L), which were numbered from pith outward in order to readily distinguish the heartwood and sapwood in the course of making plywood.

Testing the quality of veneer.—Variation in veneer thickness was measured by micrometer calipers on four veneer strips (80 mm × 1,000 mm) at each of the two ends and the middle point of the strip. The thickness of veneer was measured at the same points before and after being dried in order to determine the ratio of radial shrinkage of veneer. The ratio of lathe check in veneer was tested on the veneer strip of 50 mm (W) × 1,000 mm (L). The method of testing was as follows: two bands of blue ink were coated on the two ends of veneer strip and they were cut out after drying. If there was a check in veneer strip coated with ink, the check was blue and could be seen easily. The number and depth of lathe check in veneer were observed with a microscope (10×).

Drying.—All the veneer drying work was done in a Mode RD-6 Roll dryer, made in MARUNAKA TEKKOSHO INC, in the plywood testing factory of the Research Institute. The machine uses heated oil as a heating medium. The 1.01-mm veneer needed drying only one time; however, 2.02-mm and 3.03-mm veneer had to be dried twice to satisfy the requirement for final moisture content of veneer (surface board 10–12%, heart board 8–10%).

Cutting, gluing, and heating pressure.—The veneer sheets of 900 mm (W) × 1,000 mm (L) were further cut into small veneer of 300 mm (W) × 300 mm (L) after being dried; three pieces of small veneer were selected every 4–8 rotations from pith outward to glue and press into plywood. Urea-formaldehyde resin glue was used in the study (named MN-2, degree of stick 1.35 Pa·5, content of resin 55.72%, time to solidify 25 s). The quantity of glue used (double faces) was 280 g/m^2 in the 1.01-mm veneer, 420 g/m^2 in the 2.02-mm veneer, and 440 g/m^3 in the 3.03-mm veneer. A solidifying agent, 1.5 g NH_4CL, and 15 g flour as filling agent were added to every 300 g urea-formaldehyde resin glue. About one hour after being glued, the veneer was pressed into plywood. Testing of pressing was done at the Research Institute. In this test, the loading pressure was 10 kg/cm^2, and the pressure was sustained 2.5 min for three layers of 1.01-mm veneer, and 5 min and 7.5 min for 2.02-mm and 3.03-mm veneer, respectively. The temperature was controlled at 115°C. The plywood so produced was numbered according to the original veneer number (i.e., number of rotation) in order to examine the glue-bond strength variation of plywood from the pith outward.

Testing of the samples of glue-bond strength of plywood.—The tests of glue-bond strength were made according to standard GB 9846.9-88 (Chinese National Technique Monitoring Bureau 1988). The size of samples was 100 mm (L) × 25 mm (W). Twelve samples were cut from a piece of plywood (300 × 300 mm). Five pieces of plywood were made for each log from pith outward. Therefore, 18 trees produced 18 × 5 × 12 = 1,080 test samples. The glue-bond strength of plywood was determined according to standard GB 9486. 12-88 (Chinese National Technique Monitoring Bureau, 1988). The wood properties and quality of veneer and plywood have been tested according to the Chinese National Standards (Chinese National Technique Monitoring Bureau 1981, 1988, 1991).

Statistical methods

Based on the relationships obtained between wood properties and the quality of veneer and plywood in our paper mentioned above (Bao and Liu 1999), we used stepwise regression and multiple linear regression to model their relationships in two steps. At first, we used stepwise regression to be sure which of the wood properties were the key in affecting the quality of veneer and plywood (Lang and Tang

TABLE 2. *Variables entered or rejected through stepwise regression analysis.*

	VVT		RLC		GS	
Model	Variables entered	Variables rejected	Variables entered	Variables rejected	Variables entered	Variables rejected
1	FW		WD		PH	
2	FP		SV		FW	
3	VP		MOE		RP	
4		FL	TH		VP	
5		TCW		LD	VL	
6		TCW/LD			FL	
7		LD/D				LD
8		VL				TCW
9		RP				TCW/LD
10						MFA
11						FP

1987); then the relationships between the key wood properties and the quality of veneer and plywood were further modeled by multiple linear regression (Hu and Feng 1996).

Stepwise regression.—The variance of veneer thickness (VVT), the ratio of lathe check of veneer (RLC), and the glue-bond strength (GS) of plywood were taken as dependent variables. The anatomical, chemical, and physical-mechanical properties mentioned above, which were statistically significantly related to VVT, TLC, and GS respectively, were regarded as independent variables. The independent variables were examined one by one through stepwise regression of statistical software package (Lang and Tang 1987) to find whether the sum of squares of partial regression of the independent variable exceeded the selected critical *F*-values. Generally, the selected critical F value is $F_{0.05}$ (1, n − q/2) or $F_{0.01}$ (1, n − q/2), where q is the number of independent variables, n is the number of observations. If the sum of squares exceeds the selected critical *F*-value, it means that the independent variable affected the dependent variable statistically significantly, and is chosen to enter the regression equation; otherwise, the independent variable is rejected.

Models of multiple linear regression.—After the key wood properties were chosen, we used the following equations to express the relationships between key wood properties and quality of veneer and plywood:

$$Y_i(\text{VVT, RLC, GL}) = \beta_0 + \beta_{i1}x_{i1} + \beta_{i2}x_{i2} + \cdots + \beta_{im}x_{im} + \epsilon \quad (1)$$

where i = 1 to 3, Y_i, instead of VVT, RLC and GL; $x_{i1}, x_{i2}, \ldots, x_{im}$, instead of the key wood properties; ϵ, represents the errors in the model. Then, we used the obtained poplar data to perform the regression equations and at last to test the regression equations by comparing the measured data with the predicted data.

RESULTS AND DISCUSSION

Results of relationships between the key wood properties and the quality of veneer and plywood of Chinese plantation poplars

In order to quantitatively determine the key wood properties affecting the quality of veneer, the wood properties that were highly statistically significant or significantly correlated to the variance of veneer thickness (VVT), the ratio of lathe check of veneer (RLC), and the glue-bond strength (GS) reported in our previous study (Bao and Liu 1999), were taken as the independent variables, and the variance of veneer thickness, the ratio of lathe check of veneer, and the glue-bond strength were taken as the dependent variables. Then we used the statistical software package (Lang and Tang 1987) to undertake the stepwise regression analysis. Table 2 shows the independent variables chosen to enter the regression equation or rejected through stepwise regression analysis. It was revealed that the key wood properties affecting the variance of veneer thickness (VVT) were the fiber width (FW), fiber proportion (FP), and vessel proportion (VP). However, the independent variables of fiber length (FL), thickness of cell wall (TCW), ratio of cell wall to lumen (TCW/LD), ratio of lumen to cell diameter (LD/D), vessel length (VL), and ray proportion (RP) were rejected. The key wood properties affecting the ratio of lathe check of veneer (RLC) were air-dry wood density (WD), total volumetric shrinkage (SV), modulus of elasticity (MOE), and tangential hardness (TH); but the independent variable of lumen diameter (LD) was rejected. The key wood properties affecting the glue-bond strength (GS) were pH values (PH), fiber width (FW), ray proportion (RP), vessel proportion (VP), vessel length (VL), fiber length (FL); but the independent variables of lumen diameter (LD), thickness of cell wall (TCW), ratio of cell wall to lumen (TCW/LD), microfibril angle (MFA), fiber proportion (FP) were rejected. These results were partly in accordance with the other reports on poplar (Wang et al. 1995) and pine (Li and Wang 1996).

Models of relationships between the key wood properties and the quality of veneer of Chinese plantation poplars

Based on the above analysis, the multiple linear regression was used to further analyze the key wood properties, the variance of veneer thickness, and the ratio of lathe checks, respectively. Table 3 shows the results. It indicated that the variance of veneer thickness (VVT) is a function of fiber width (FW), the vessel proportion (VP) and the fiber proportion (FP):

$$VVT = 3.414 + 0.063\ FW + 0.049\ FP - 0.033\ VP \qquad (2)$$

The correlation coefficient (r) of this regression equation is 0.9076. The determination coefficient (r^2) is 0.8237, which indicates

TABLE 3. *Models of the regression between the key wood properties and the quality of veneer and plywood of Chinese plantation poplars.*

Multiple Linear Regression Equation	r	r^2	F values	$F_{0.01}$	Observed no.
VVT = −3.414 + 0.063FW + 0.049FP − 0.033VP	0.9076	0.8237	5.606**	0.029	12
RLC = 9.472 + 0.005TH + 0.003MOE + 8.366WD − 2.302SV	0.7375	0.5407	4.414**	0.0174	18
GS = 3.326 − 0.268PH − 0.002FL + 0.191FW − 0.004VL − 0.033VP + 0.095RP	0.9399	0.8834	6.313**	0.0307	12

Note: r − correlation coefficient, r^2 − determination coefficient, ** − highly statistically significant at the 1% level.

TABLE 4. *The comparison between the predicted values and the measured values of the variance of veneer thickness, the ratio of lathe check of veneer, and glue-bond strength of plywood of Chinese plantation poplars.*

		The variance of veneer thickness			The ratio of lathe check of veneer			Glue-bond strength		
Sample site	No. of tree	Measured values (mm)	Predicted values (mm)	Relative errors (%)	Measured values (%)	Predicted values (%)	Relative errors (%)	Measured values (Mpa)	Predicted values (Mpa)	Relative errors (%)
River Beach	72 × 3 × 4	0.15	0.144	3.953	25.5	26.115	2.270	2.21	2.118	3.928
	69 × 3 × 4	0.13	0.085	31.965	37.7	37.991	0.737	1.97	1.925	2.295
	63 × 3 × 4	0.07	0.076	9.009	37.7	33.462	11.227	1.90	1.916	0.642
	72 × 4 × 5	0.11	0.102	5.296	31.3	31.071	0.818	1.77	1.904	7.416
	69 × 5 × 6	0.22	0.187	13.130	26.3	27.038	2.804	2.09	2.129	1.880
	63 × 5 × 6	0.07	0.090	28.571	25.3	31.836	25.996	1.85	1.698	8.015
Islet Beach	6301	0.36	0.343	4.649	34.2	26.983	21.196	2.03	1.928	5.027
	6303	0.05	0.045	9.873	25.7	26.365	2.636	1.33	1.340	0.774
	6304	—	—	—	29.0	30.852	6.349	—	—	—
	6905	0.04	0.060	33.333	32.4	28.530	12.067	1.49	1.536	3.349
	6906	—	—	—	28.4	22.673	20.194	—	—	—
	7209	—	—	—	35.7	30.067	15.801	—	—	—
Lake Beach	7201	0.21	0.178	13.861	18.4	23.330	26.929	1.85	1.823	1.478
	7202	—	—	—	28.3	28.498	0.843	—	—	—
	6301	—	—	—	24.9	27.168	9.107	—	—	—
	6302	0.02	0.029	42.708	32.0	33.365	4.364	1.62	1.660	2.673
	6901	0.09	0.120	38.462	30.3	27.874	7.995	1.90	2.025	6.460
	6902	—	—	—	23.7	28.825	21.497	—	—	—

TABLE 5. *Differences between the predicted and measured values of VVT, RLC, and GS in Chinese plantation poplars.*

Quality indices of veneer and plywood	Average measured values	Average predicted values	Alpha values (α)	Significant difference*
VVT (mm)	0.126	0.123	0.893	No
RLC (%)	29.269	29.002	0.861	No
GS (MPa)	1.834	1.834	0.995	No

* There was no statistically significant difference between the predicted and measured values if the alpha value >0.05.

that 82.37% of the variance of veneer thickness can be accounted for by the fiber width, the fiber proportion, and the vessel proportion. The regression equation is highly statistically significant at the 1% level. The ratio of lathe check (RLC) is a function of wood hardness on the tangential surface (TH), modulus of elasticity in bending (MOE), air-dry wood density (WD), and total volumetric shrinkage of wood (SV):

$$RLC = 9.472 + 0.005\ TH + 0.003\ MOE + 8.366\ WD - 2.302\ SV. \quad (3)$$

The correlation coefficient (r) of this regression equation is 0.7375. The determination coefficient (r^2) is 0.5407, which indicates that 54.1% of the ratio of lathe check of veneer can be explained by the tangential hardness, the modulus of elasticity, the air-dry wood density, and the total volumetric shrinkage. The regression equation is highly statistically significant at the 1% level.

The model of the relationships between wood properties and glue-bond strength of plywood of Chinese plantation poplars.

Table 3 shows that the regression equation of the glue-bond strength (GS) changes with the key wood properties of Chinese plantation poplar. It is observed that the glue-bond strength of plywood (GS) is a function of pH values (PH), fiber length (FL), fiber width (FW), vessel length (VL), and proportion of vessel (VP) and ray (RP):

$$GS = 3.326 - 0.268\ PH - 0.002\ FL + 0.191\ FW - 0.004\ VL - 0.033\ VP + 0.095\ RP. \quad (4)$$

The correlation coefficient (r) of the regression equation (GS) between the glue-bond strength of plywood and the key wood properties is 0.9399, the determination coefficient is 0.8834, and the regression equation is highly statistically significant at the 1% level. Based on the coefficient of determination, it is shown that 88.34% of the variation of the glue-bond strength can be explained through the pH values, fiber length (FL), fiber width (FW), vessel length (VL), vessel proportion (VP), and ray proportion (RP).

Test of the regression equations

Before these equations can be accepted, they must be tested. The regression equations presented in Table 3 were evaluated by comparing model-predicted values with experimentally measured values. As shown in Table 4, the predicted values are generally close to the measured values, and the difference between the predicted values and the measured values are not statistically significant (Table 5). This verifies that the quality of veneer and plywood can be predicted satisfactorily with the selected key wood properties through the regression equations obtained. However, it is also found from Table 4 that there exist different relative errors between the predicted values and measured values which shows that further researches are recommended to consider a greater number of sample trees.

CONCLUSIONS

Results from this study led to the following conclusions:

The variance of veneer thickness (VVT) is a function of fiber width (FW), the proportions of vessels (VP), and proportion of fibers (FP):

$$VVT = -3.414 + 0.063\ FW + 0.049\ FP - 0.033\ VP$$

The ratio of lathe check (RLC) in veneer is a function of wood hardness on the tangential surface (TH), modulus of elasticity (MOE), air-dry wood density (WD), and oven-dry volumetric shrinkage (SV):

$$RLC = 9.472 + 0.05\ TH + 0.003\ MOE + 8.366\ WD - 2.302\ SV$$

The glue-bond strength of plywood is a function of the pH values (PH), fiber length (FL), fiber width (FW), vessel length (VL), and the proportions of vessels (VP) and rays (RP):

$$GS = 3.326 - 0.268\ PH - 0.002\ FL + 0.191\ FW - 0.004\ VL - 0.033\ VP + 0.095\ RP$$

The correlation coefficients (r) of the above regression equations are 0.73 − 0.93. The determination coefficients (r^2) for the regression equations are 0.54 − 0.88. The regression equations are highly statistically significant at the 1% level. The difference between the predicted and measured values is not statistically significant. It is possible to satisfactorily predict the quality of veneer and plywood of Chinese plantation poplars with the key wood properties selected.

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