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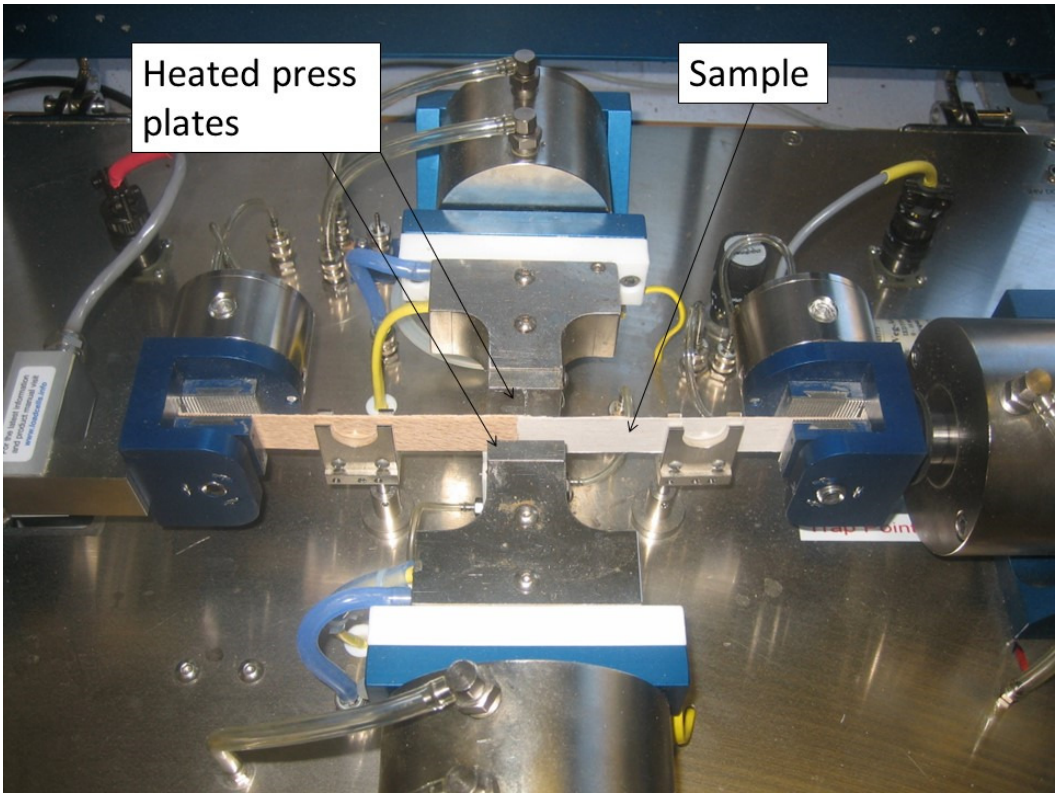

Influence of different pressing parameters on urea-formaldehyde adhesive-bond strength in laminated veneer products

Lars Blomqvist, Magdalena Sterley

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Abstract

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The aim of the present study was to investigate the relationships between contact pressure, temperature, hardener content and pressing time fixed at different levels and the strength of the UF adhesive bond, in order to develop a model to predicting the bonding strength. Bond strength was measured with the Adhesive Bonding Evaluation System, and a linear model for predicting adhesive bond strength using four independent variables was developed (R2 = 0.75). The strongest parameter was pressing time, followed by hardener content and temperature, all of which explained variation in bond strength at the same level. Pressure had no significant influence on the bond strength.

Key words: wood, beech; ABES; multilinear regression model

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The Figure on the front page shows the Automated Bonding Evaluation System.

Content

Preface

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Summary

Syftet med denna studie var att undersöka sambanden, hos urea-formaldehyd limmade fanerprodukter, mellan presstryck, presstemperatur, härdarandel, presstid och styrkan i limfogen, för att utveckla en modell för att förutsäga limfogens styrka. Limfogens styrka mättes med Adhesive Bonding Evaluation System och en linjär modell för att förutsäga limfogens styrka med hjälp av de fyra oberoende variablerna utvecklades (R^2 = 0,75). Parametern som hade störst påverkan var presstid, följt av härdarandel och temperatur. Presstrycket hade ingen signifikant inverkan på limfogens styrka.

1 Introduction

Laminated veneer products (LVPs) are produced by forming and gluing veneers, most often with urea formaldehyde (UF) adhesive (Dunky and Pizzi 2002), against a mould to achieve a predetermined shape. The method is commonly used for manufacturing complex forms for use in furniture and interior items (Blomqvist 2016). In curved structures, the strength of the adhesive bond can vary depending on the hardener content, temperature, contact pressure and pressing time (Marra 1992; Sernek and Dunky 2010; Gavrilović-Grmuša et al. 2016; Hänsel et al. 2022). The aim of the present study was to investigate the relationships between contact pressure, temperature, hardener content and pressing time fixed at different levels and the strength of the UF adhesive bond, in order to develop a model to predicting the bonding strength.

2 Materials and methods

The shear strength of wood adhesive bonds, or the adhesive bond strength, glued with different combinations of parameters was evaluated in an Automated Bonding Evaluation System (ABES) (ABES 2022; Piirlaid et al. 2012). ABES allows to press adhesive bonds and determining shear strength directly after the pressing in a hot or cold state. Beech (*Fagus sylvatica* L.) veneer with a thickness of 0.7 mm was used. The overlap of the shear samples was 3 mm, while the bond area was 60 mm^2. Pressing parameters tested are presented in Table 1.

Table 1. Pressing parameters tested in the study.

Parameter	Quantity or level	Comment
Veneer conditioning climate	20 °C and 50% relative humidity	Before testing
Bond area (mm2)	60	20 mm test slip width and 3 mm of overlap
Adhesive quantity (g)	0.03	UF adhesive system (Akzo Nobel Adhesives
Hardener content (%)	5, 20, 40	AB, Sweden, resin A201 and hardener H201)
Temperature (°C)	70, 90, 140	—
Pressure (MPa)	0.1, 1.0, 3.0	Contact pressure
Pressing time (s)	30, 60, 90, 180, 300	—
Cooling time (s)	30	Shear strength was determined after 30 s cooling in the ABES

Pressing times of 30–300 s were tested to examine the development of the bond strength in terms of how fast it increases, when maximum strength is reached and whether long pressing times, up to 300 s, can initiate the disintegration or depolymerisation of the UF adhesive. For the same reason, the highest temperature examined (140 °C) was applied, while the highest pressure (3 MPa) was applied to test whether a “starving” bond line resulted in less strength in combination with other parameters. Lower and higher levels of those parameters were chosen to have a full factorial experimental design, with three factors on three levels and one factor on five levels (Table 1). In each of the 135 different parameter combinations, three replicates were used. The bond strength was calculated by dividing the maximum force (N) by the bond-line area (20 x 3 mm^2) used in the ABES test.

2.1 Statistical evaluation

To evaluate the influence of different factors on bond strength, statistical methods were used.

First, multilinear regression (MLR) was used to develop linear models for predicting bond strength depending on gluing factors used. MLR is a statistical technique that reveals the best-fitting linear relationship between the explanatory (independent) variables—in the study presented here, pressing time, temperature, pressure and hardener content—and the response (dependent) variable—in the study, bond strength. That relationship can be described with following formula:

$$\text{Bond strength} = \text{Intercept} + A \times \text{Time} + B \times \text{Temperature} + C \times \text{Pressure} + D \times \text{Hardener content}$$

in which Intercept is a constant, A is the regression coefficient (RC) for time, B is the RC for temperature, C is the RC for pressure, and D is the RC for hardener content. Regression coefficients can be standardised or non-standardised; between them, standardised ones are scaled to unit variance, meaning that they can be directly compared with each other. Thus, the magnitude of those coefficients allows comparing the relative contribution of each independent variable (i.e. pressing factor) in predicting the dependent variable (i.e. bond strength).

Non-standardised coefficients (i.e. unscaled) were used in making predictions (i.e. calculations) with the mentioned formula, while the pressing factors were used in the magnitude in which they are measured.

Analysis of variance (ANOVA) with factor analysis was used to determine each factor's influence on bond strength. Each factor was analysed separately.

Projection to latent structures, or partial least squares (PLS), regression was used to test whether a prediction or explanation of the model could be achieved that was superior to the MLR prediction.

3 Results

Figure 1 shows the influence of the investigated parameters on bonding strength. Within the 135 groups, the mean standard deviation was 0.46 MPa, and the highest standard deviations (1.4–1.86 MPa) were found in six groups (Appendix).

With a contact pressure of 0.1–3.0 MPa, low hardener content in combination with a 70 °C pressing temperature yielded poor bond strength (Figure 1a, 1d and 1g). Low hardener content thus required both longer pressing times and higher temperatures in order to obtain satisfactory bond strength (Figure 1a, 1d and 1g). The highest bond strength with 5% hardener content was less than the highest for 20% and 40% hardener content (Figure 1).

With 20% and 40% hardener content and a contact pressure of 0.1–3.0 MPa, a 70 °C pressing temperature yielded low bond strength when coupled with short pressing times (30–90 s) and, by the same token, higher bond strength when coupled with longer pressing times (Figure 1b, 1c, 1e, 1f, 1h and 1i). Pressing at 140 °C resulted in

lower bond strength than at 70 °C and 90 °C in combination with longer pressing times (Figure 1b, 1c, 1e, 1f, 1h and 1i). However, pressing at 140 °C for a short time produced a relatively high bond strength (Figure 1b, 1c, 1e, 1f, 1h and 1i). At that temperature, pressing times exceeding 30 s had little influence on bond strength. At 70 °C and 90 °C, bond strength increased with longer pressing times (Figure 1b, 1c, 1e, 1f, 1h and 1i).

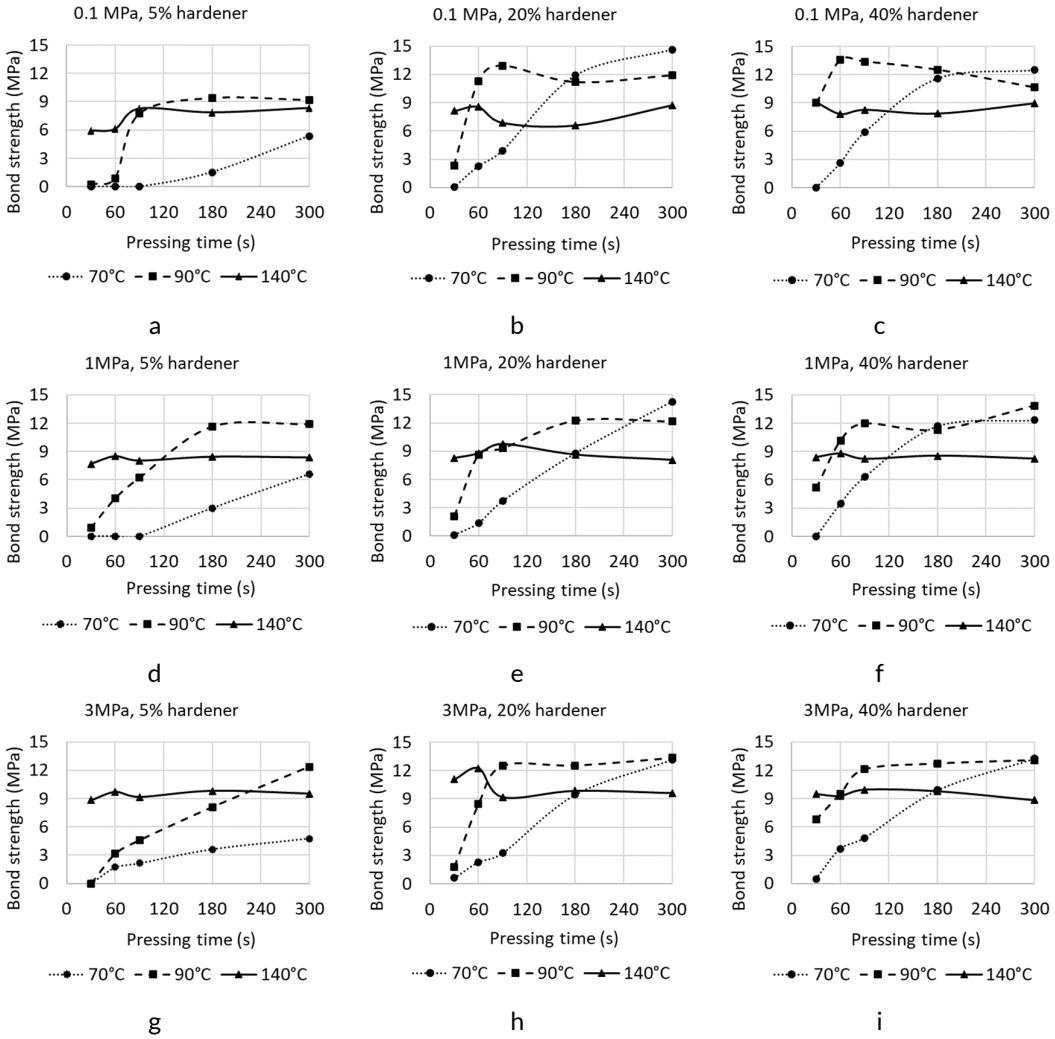

Figure 1. Pressing time versus bond strength for pressing at 70 °C, 90 °C and 140 °C with three hardener contents and three contact pressures.

3.1 MLR

Two MLR models were developed: Model 1 (MLR1), which included all data, and Model 2 (MLR2), which was based on data without the variable temperature 140 °C (Table 2). Predicted bond strength values were calculated with non-standardised coefficients (Appendix). For MLR1, the correlation of predicted versus observed R2 values was 0.47. High-temperature pressing did not contribute to the prediction model and thus did not explain any variation in bond strength. Pressing at 140 °C resulted in bonds that cured after only 30 s, and their strength did not depend on pressing time or hardener content and only somewhat depended on pressure. The R2 value for MLR2 was 0.75, meaning that the model including only data for 70 °C and 90 °C was linear and could predict bond strength with considerable accuracy.

Table 2. Standardised and non-standardised coefficients of MRL1 and MRL2.

			Regression coefficients			
Model	Type of coefficient	Intercept	A (Time)	B (Temp.)	C (Press.)	D (Hard.)
MLR1	Non-standardised	-2.11435	0.022050	0.043673	0.197594	0.093290
MLR1	Standardised		0.518557	0.308983	0.057553	0.321437
MLR2	Non-standardised	-16.5095	0.033000	0.201900	-0.037300	0.133900
MLR2	Standardised		0.655617	0.410230	-0.009175	0.389927

Standardised regression coefficients for MRL were highest for time and approximately the same for temperature and hardener content. For pressure, the regression coefficient was quite small, especially for MRL2.

3.2 ANOVA

Significant differences surfaced in the ANOVA for all parameters except pressure, as shown in Table 3. Significant difference was considered for $p < 0.05$.

Table 3. Results of ANOVA.

Parameter	Range of mean bond strength (MPa)	Significant difference
Time	4.0 to >10.0	Significant difference between 30 s and all other times but no significant difference between 60 and 90 s, 90 and 180 s or 180 and 300 s
Temp.	5.0 to approx. 9.0	Significant difference between 70 °C and all other temperatures but no significant difference between 90 °C and 140 °C; some negative influence of the highest temperature observed on bond strength
Pressure	<1.0	No significant difference
Hardener	5.0 to 9.0	Significant difference between 5% and both 20% and 40% but no significant difference between 20% and 40%

3.3 PLS

The results of PLS regression were the same for the MLR and PLS models and did not contribute to explaining any variation in bond strength.

4 Discussions

When low pressure (e.g. 0.1 MPa) was applied, too much adhesive remained between the veneers (cf. Blomqvist and Sterley 2022) and no penetration into the veneers of adhesive occurred. However, that thick bond-line was overheated when the temperature was too high (e.g. 140 °C), and the adhesive somewhat decomposed and lost strength.

When a higher pressure was used, in some cases the bond strength was higher at 140 °C, especially with short pressing times. Even when the adhesive had somewhat deteriorated due to high temperature, the mechanical anchorage into the wood cells was able to enhance the adhesion forces, thereby resulting in higher bond strength. Those results suggest that the penetration of adhesive into wood, which provides mechanical anchorage for the adhesive, is more important for bond strength than overheating. However, the maximum bond strength was highest for 70 °C and 90 °C, and a lower temperature required longer pressing times. Higher hardener content created a faster system with higher bond strength values reached after only 30 s of pressing. When pressing was conducted at 140 °C, the influence of the amount of hardener on the reaction speed disappeared.

Generally, the influence of temperature and amount of hardener was clear, whereas the influence of pressure was not. However, as described, higher pressure allowed the deeper penetration of the adhesive, which improved the bond strength only when short pressing times were used. When pressing at 70 °C and 90 °C and using longer pressing times, the bond strength was higher than at 140 °C.

5 Conclusions

The bond strength for bonds pressed at 90 °C was significantly higher than that pressed at 70 °C. Moreover, 5% hardener content significantly decreased bond strength compared with 20% and 40% content.

Low hardener content requires both a longer pressing time and a higher temperature to obtain a higher bond strength. A pressing temperature of 140 °C reduced bond strength, especially with long pressing times. The best pressing temperature was 90 °C. For pressing at 140 °C with 5% hardener content, a slight increase in bond strength was observed at 3.0 MPa. For pressing at 140 °C, pressing time did not influence bond strength.

Greater hardener content creates a faster system, with higher bond strength values obtained after only 30 s of pressing. That effect was strongest at a 90 °C pressing temperature. For bonds pressed at 140 °C, the effect of hardener content disappeared. The MLR model had greater predictive strength when the higher temperature of 140 °C was excluded and could predict bond strength with an R2 of 0.75.

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Appendix

Time	Temp	Press	Hard	Bond strength (MPa)					Stat		
(s)	(°C)	(MPa)	(%)	y_1	y_2	y_3	$y_{average}$	$y_{STD.p}$	MRL1	MRL2	PLS
30	70	0.1	5	0.00	0.00	0.00	0.00	0.00	2.09	-0.72	2.04
60	70	0.1	5	0.00	0.00	0.00	0.00	0.00	2.75	0.27	2.70
90	70	0.1	5	0.00	0.00	0.00	0.00	0.00	3.41	1.26	3.36
180	70	0.1	5	1.50	1.67	1.45	1.54	0.09	5.40	4.23	5.34
300	70	0.1	5	4.12	6.82	5.15	5.36	1.11	8.04	8.19	7.98
30	70	0.1	20	0.00	0.00	0.08	0.03	0.04	3.49	1.29	3.44
60	70	0.1	20	2.17	2.40	2.32	2.29	0.10	4.15	2.28	4.10
90	70	0.1	20	3.83	4.13	3.80	3.92	0.15	4.81	3.27	4.76
180	70	0.1	20	11.47	12.52	11.68	11.89	0.45	6.80	6.24	6.74
300	70	0.1	20	14.83	14.27	14.80	14.63	0.26	9.44	10.20	9.38
30	70	0.1	40	0.00	0.00	0.00	0.00	0.00	5.36	3.97	5.31
60	70	0.1	40	2.43	2.83	2.63	2.63	0.16	6.02	4.96	5.97
90	70	0.1	40	6.25	5.58	5.83	5.89	0.27	6.68	5.95	6.63
180	70	0.1	40	10.82	12.27	11.75	11.61	0.60	8.66	8.92	8.61
300	70	0.1	40	12.50	12.28	12.70	12.49	0.17	11.31	12.88	11.25
30	70	1	5	0.00	0.00	0.00	0.00	0.00	2.27	-0.75	1.87
60	70	1	5	0.00	0.00	0.00	0.00	0.00	2.93	0.24	2.53
90	70	1	5	0.00	0.00	0.00	0.00	0.00	3.59	1.23	3.19
180	70	1	5	2.68	3.30	3.00	2.99	0.25	5.58	4.20	5.17
300	70	1	5	6.35	6.87	6.63	6.62	0.21	8.22	8.16	7.81
30	70	1	20	0.08	0.10	0.17	0.12	0.04	3.67	1.25	3.27
60	70	1	20	1.07	1.33	1.65	1.35	0.24	4.33	2.24	3.93
90	70	1	20	3.22	3.72	4.18	3.71	0.39	4.99	3.23	4.59
180	70	1	20	8.25	9.08	8.97	8.77	0.37	6.97	6.20	6.57
300	70	1	20	14.12	14.47	14.17	14.25	0.15	9.62	10.16	9.21
30	70	1	40	0.00	0.00	0.00	0.00	0.00	5.53	3.93	5.13
60	70	1	40	3.38	3.58	3.50	3.49	0.08	6.19	4.92	5.79
90	70	1	40	6.00	6.50	6.42	6.31	0.22	6.86	5.91	6.45
180	70	1	40	11.32	12.13	11.63	11.69	0.34	8.84	8.88	8.43
300	70	1	40	11.25	12.73	13.00	12.33	0.77	11.49	12.84	11.07
30	70	3	5	0.08	0.00	0.00	0.03	0.04	2.66	-0.83	1.47
60	70	3	5	1.37	2.10	1.70	1.72	0.30	3.32	0.16	2.13
90	70	3	5	2.42	1.92	2.13	2.16	0.20	3.99	1.15	2.79
180	70	3	5	3.30	3.93	3.65	3.63	0.26	5.97	4.12	4.77
300	70	3	5	4.37	5.18	4.75	4.77	0.33	8.62	8.08	7.41
30	70	3	20	0.10	0.37	1.35	0.61	0.54	4.06	1.18	2.87
60	70	3	20	2.38	2.03	2.48	2.30	0.19	4.72	2.17	3.53
90	70	3	20	3.03	3.42	3.30	3.25	0.16	5.39	3.16	4.19
180	70	3	20	8.28	10.75	9.27	9.43	1.01	7.37	6.13	6.17
300	70	3	20	13.00	12.70	13.67	13.12	0.40	10.02	10.09	8.81
30	70	3	40	0.50	0.48	0.52	0.50	0.01	5.93	3.86	4.74
60	70	3	40	3.67	3.83	3.65	3.72	0.08	6.59	4.85	5.40
90	70	3	40	4.07	5.65	4.83	4.85	0.65	7.25	5.84	6.06
180	70	3	40	9.58	10.17	9.97	9.91	0.24	9.24	8.81	8.04
300	70	3	40	13.68	12.80	13.35	13.28	0.36	11.88	12.77	10.68

Time	Temp	Press	Hard	Bond strength (MPa)					Stat		
(s)	(°C)	(MPa)	(%)	y_1	y_2	y_3	$y_{average}$	$y_{STD.p}$	MRL1	MRL2	PLS
30	90	0.1	5	0.77	0.00	0.00	0.26	0.36	2.96	3.32	2.92
60	90	0.1	5	1.22	0.67	0.83	0.91	0.23	3.63	4.31	3.58
90	90	0.1	5	7.80	8.90	6.47	7.72	0.99	4.29	5.30	4.24
180	90	0.1	5	10.53	7.95	9.67	9.38	1.07	6.27	8.27	6.22
300	90	0.1	5	8.47	9.70	9.33	9.17	0.52	8.92	12.23	8.86
30	90	0.1	20	1.53	2.10	3.47	2.37	0.81	4.36	5.33	4.32
60	90	0.1	20	10.77	11.18	11.85	11.27	0.45	5.02	6.32	4.98
90	90	0.1	20	14.23	13.58	10.98	12.93	1.40	5.69	7.31	5.64
180	90	0.1	20	9.88	10.80	12.87	11.18	1.25	7.67	10.28	7.62
300	90	0.1	20	11.53	11.70	12.50	11.91	0.42	10.32	14.24	10.26
30	90	0.1	40	8.60	9.88	8.50	8.99	0.63	6.23	8.00	6.18
60	90	0.1	40	14.52	13.88	12.40	13.60	0.89	6.89	8.99	6.84
90	90	0.1	40	13.93	13.02	13.17	13.37	0.40	7.55	9.98	7.50
180	90	0.1	40	9.95	13.60	13.98	12.51	1.82	9.54	12.95	9.48
300	90	0.1	40	9.63	11.87	10.47	10.66	0.92	12.18	16.91	12.12
30	90	1	5	1.85	0.00	0.83	0.89	0.76	3.14	3.28	2.74
60	90	1	5	3.40	4.40	4.32	4.04	0.45	3.80	4.27	3.40
90	90	1	5	6.57	6.77	5.33	6.22	0.63	4.46	5.26	4.06
180	90	1	5	11.50	10.77	12.70	11.66	0.80	6.45	8.23	6.04
300	90	1	5	11.53	12.00	12.20	11.91	0.28	9.09	12.19	8.68
30	90	1	20	2.47	1.63	2.20	2.10	0.35	4.54	5.29	4.14
60	90	1	20	7.93	9.68	8.30	8.64	0.75	5.20	6.28	4.80
90	90	1	20	7.63	10.30	9.98	9.31	1.19	5.86	7.27	5.46
180	90	1	20	13.72	12.88	10.12	12.24	1.54	7.85	10.24	7.44
300	90	1	20	13.25	10.57	12.65	12.16	1.15	10.49	14.20	10.08
30	90	1	40	6.00	4.52	4.92	5.14	0.63	6.41	7.97	6.00
60	90	1	40	8.35	12.35	9.83	10.18	1.65	7.07	8.96	6.66
90	90	1	40	11.53	12.52	11.83	11.96	0.41	7.73	9.95	7.32
180	90	1	40	10.28	12.28	11.33	11.30	0.82	9.71	12.92	9.30
300	90	1	40	13.15	14.68	13.75	13.86	0.63	12.36	16.88	11.94
30	90	3	5	0.00	0.00	0.00	0.00	0.00	3.54	3.21	2.34
60	90	3	5	3.37	2.92	3.20	3.16	0.19	4.20	4.20	3.00
90	90	3	5	5.17	3.67	4.92	4.58	0.66	4.86	5.19	3.66
180	90	3	5	8.62	7.52	8.13	8.09	0.45	6.84	8.16	5.64
300	90	3	5	12.78	11.67	12.63	12.36	0.49	9.49	12.12	8.28
30	90	3	20	1.98	1.20	2.20	1.79	0.43	4.94	5.22	3.74
60	90	3	20	8.92	8.40	8.05	8.46	0.36	5.60	6.21	4.40
90	90	3	20	10.98	12.13	14.37	12.49	1.40	6.26	7.20	5.06
180	90	3	20	13.23	11.47	12.90	12.53	0.77	8.24	10.17	7.04
300	90	3	20	13.67	11.97	14.35	13.33	1.00	10.89	14.13	9.68
30	90	3	40	6.62	7.02	6.75	6.79	0.17	6.80	7.90	5.61
60	90	3	40	9.15	10.10	9.33	9.53	0.41	7.46	8.89	6.27
90	90	3	40	11.45	13.13	11.75	12.11	0.73	8.12	9.88	6.93
180	90	3	40	11.40	14.12	12.67	12.73	1.11	10.11	12.85	8.91
300	90	3	40	10.47	14.43	14.38	13.09	1.86	12.76	16.81	11.55

Time	Temp	Press	Hard	Bond strength (MPa)					Stat		
(s)	(°C)	(MPa)	(%)	y_1	y_2	y_3	$y_{average}$	$y_{STD.p}$	MRL1	MRL2	PLS
30	140	0.1	5	5.55	6.53	5.67	5.92	0.44	5.15		5.10
60	140	0.1	5	5.87	6.33	6.13	6.11	0.19	5.81		5.76
90	140	0.1	5	8.35	8.38	8.03	8.26	0.16	6.47		6.42
180	140	0.1	5	8.45	7.15	7.97	7.86	0.54	8.45		8.40
300	140	0.1	5	8.12	8.33	8.50	8.32	0.16	11.10		11.04
30	140	0.1	20	8.32	8.13	7.92	8.12	0.16	6.55		6.50
60	140	0.1	20	8.80	8.42	8.50	8.57	0.16	7.21		7.16
90	140	0.1	20	6.50	6.00	8.10	6.87	0.90	7.87		7.82
180	140	0.1	20	6.25	6.92	6.58	6.58	0.27	9.85		9.80
300	140	0.1	20	9.18	8.70	8.38	8.76	0.33	12.50		12.44
30	140	0.1	40	8.82	9.13	9.17	9.04	0.16	8.41		8.36
60	140	0.1	40	7.90	7.57	8.00	7.82	0.19	9.07		9.02
90	140	0.1	40	9.05	7.67	8.08	8.27	0.58	9.74		9.68
180	140	0.1	40	7.77	7.87	8.00	7.88	0.10	11.72		11.66
300	140	0.1	40	8.33	9.30	9.17	8.93	0.43	14.37		14.30
30	140	1	5	7.55	7.77	7.72	7.68	0.09	5.32		4.92
60	140	1	5	7.42	9.38	8.67	8.49	0.81	5.99		5.58
90	140	1	5	7.97	8.02	8.08	8.02	0.05	6.65		6.24
180	140	1	5	8.75	8.15	8.42	8.44	0.25	8.63		8.22
300	140	1	5	8.65	8.98	7.42	8.35	0.67	11.28		10.86
30	140	1	20	8.15	8.12	8.57	8.28	0.20	6.72		6.32
60	140	1	20	8.67	8.87	8.77	8.77	0.08	7.39		6.98
90	140	1	20	9.08	10.32	9.88	9.76	0.51	8.05		7.64
180	140	1	20	8.40	9.22	8.30	8.64	0.41	10.03		9.62
300	140	1	20	8.38	8.05	7.80	8.08	0.24	12.68		12.26
30	140	1	40	8.62	8.22	8.35	8.39	0.17	8.59		8.18
60	140	1	40	7.87	8.52	9.97	8.78	0.88	9.25		8.84
90	140	1	40	8.80	7.63	8.17	8.20	0.48	9.91		9.50
180	140	1	40	8.65	8.23	8.75	8.54	0.22	11.90		11.48
300	140	1	40	7.98	8.33	8.37	8.23	0.17	14.54		14.12
30	140	3	5	9.10	8.20	9.18	8.83	0.45	5.72		4.52
60	140	3	5	10.57	8.45	10.10	9.71	0.91	6.38		5.18
90	140	3	5	8.57	9.67	9.30	9.18	0.46	7.04		5.84
180	140	3	5	9.05	10.22	10.18	9.82	0.54	9.03		7.82
300	140	3	5	9.97	9.10	9.52	9.53	0.35	11.67		10.46
30	140	3	20	11.38	10.83	10.97	11.06	0.23	7.12		5.92
60	140	3	20	12.20	12.50	11.97	12.22	0.22	7.78		6.58
90	140	3	20	9.20	9.67	8.67	9.18	0.41	8.44		7.24
180	140	3	20	9.97	9.55	10.02	9.84	0.21	10.43		9.22
300	140	3	20	9.47	10.20	9.17	9.61	0.43	13.07		11.86
30	140	3	40	9.32	9.68	9.53	9.51	0.15	8.99		7.79
60	140	3	40	11.08	8.00	8.83	9.31	1.30	9.65		8.45
90	140	3	40	10.02	10.03	9.83	9.96	0.09	10.31		9.11
180	140	3	40	10.40	9.65	9.33	9.79	0.45	12.29		11.09
300	140	3	40	8.73	8.85	9.00	8.86	0.11	14.94		13.73

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