Technical Feasibility of Flakeboard Production from Recycled CCA-Treated Wood

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OUTLINE

- INTRODUCTION
- OBJECTIVES
- MATERIALS AND METHODS
- RESULTS AND DISCUSSION
- CONCLUSIONS
- ACKNOWLEDGEMENTS

OBJECTIVES

- To determine the effect of the ratio of recycled CCA-treated wood and untreated virgin wood on flakeboard panel properties.
- To determine copper, chromium, and arsenic retention levels of out-of-service CCA-treated highway guardrails and flakeboard panels.
- To evaluate the leaching performance of flakeboard panels made from five different ratios of recycled CCA-treated wood and untreated virgin wood.

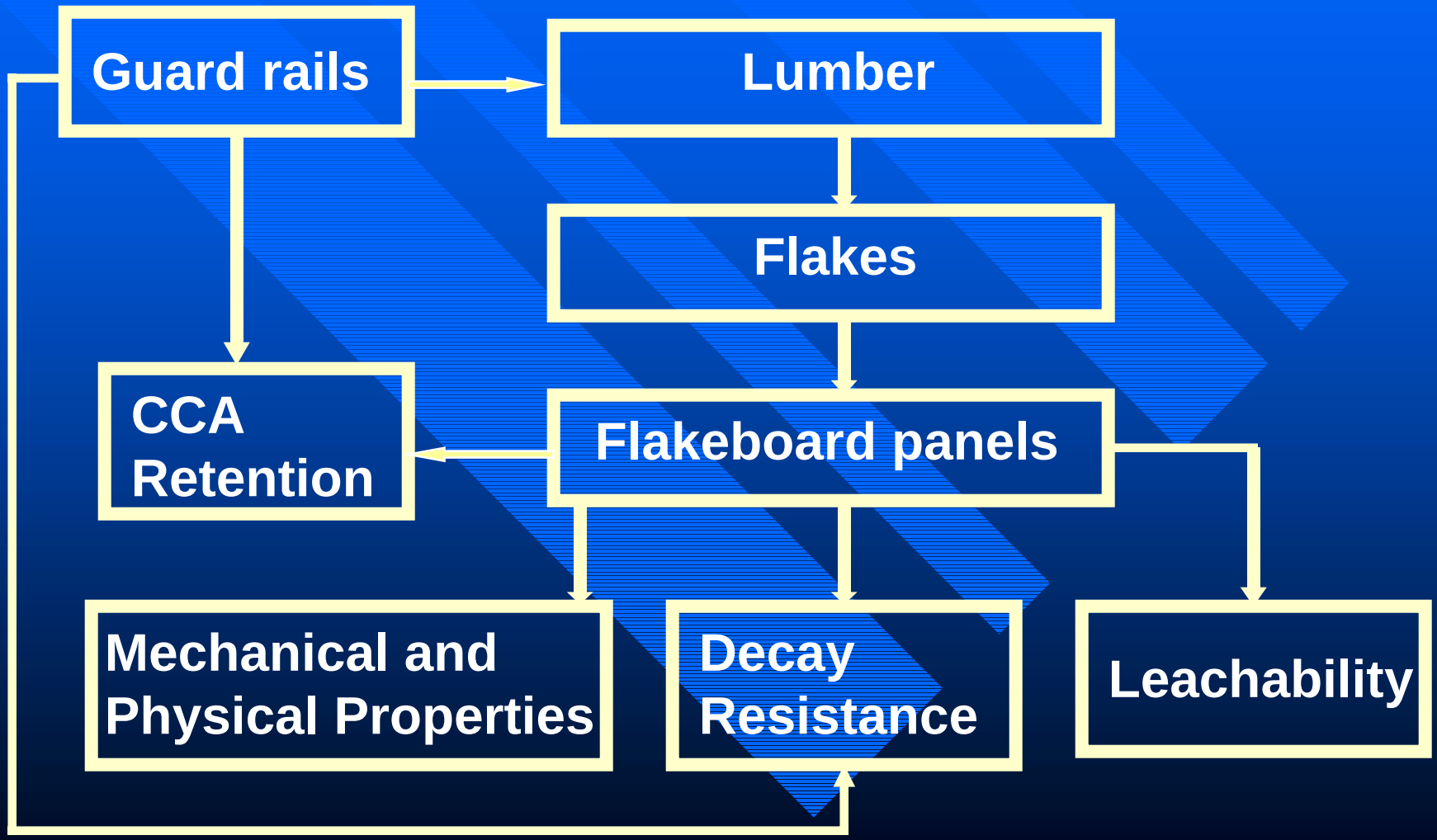
MATERIALS AND METHODS

Guard Rails

Sawmill

Lumber

Flowchart of Experimental Plan



Sample Groups

1. 100% CCA-treated flakes
2. 75% CCA-treated flakes : 25% untreated flakes
3. 50% CCA-treated flakes : 50% untreated flakes
4. 25% CCA-treated flakes : 75% untreated flakes
5. 100% untreated flakes

Panel Assembly

- PF resin 4.5 % by weight.
- Temperature: 370 ºF (188 ºC).
- Hot Press Schedule:
  - 1,225 psi ---- 3 minutes.
  - 307 psi ---- 0.5 minute.
  - 62 psi ---- 0.5 minute.
- Panel size: 14" x 14" x 0.5".
- Target density: 46 pcf.
- Flake orientation: random.
- Two replications.

Tests and Analyses

Mechanical Properties:
- ✓Modulus of Rupture (MOR)
- ✓Modulus of Elasticity (MOE)
- ✓Internal Bond (IB)

Physical Properties:
- ✓Thickness Swell (TS)
- ✓Linear Expansion (LE)
- ✓Water Absorption (WA)

Chemical Properties:
- ✓CCA Retention
- ✓Leachability

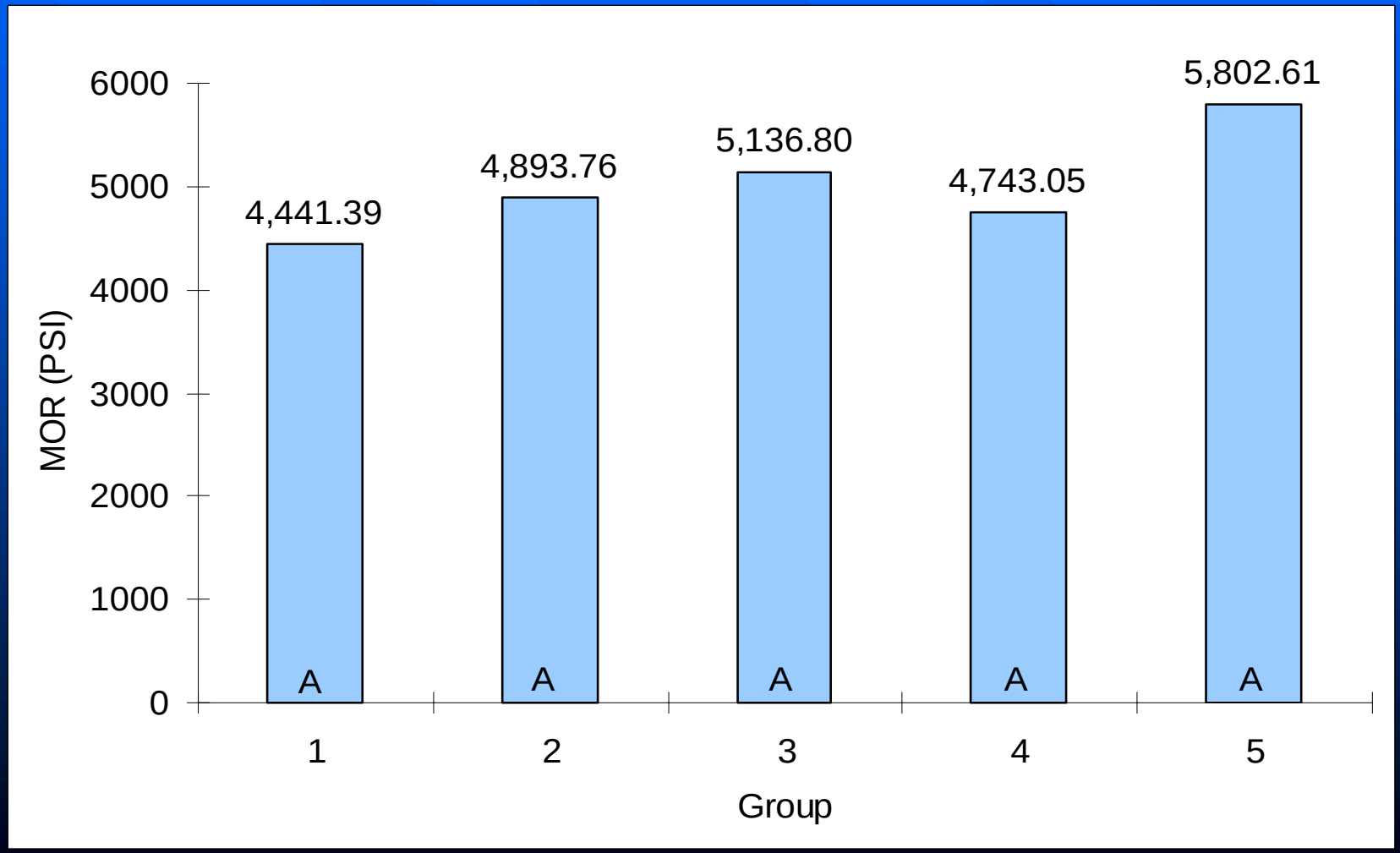
Durability:
- ✓ODVPS
- ✓Decay Resistance

Statistical Analyses :
- ✓Analysis of Variance (ANOVA)
- ✓Regression
- ✓Group Comparison
- ✓Variance proportion

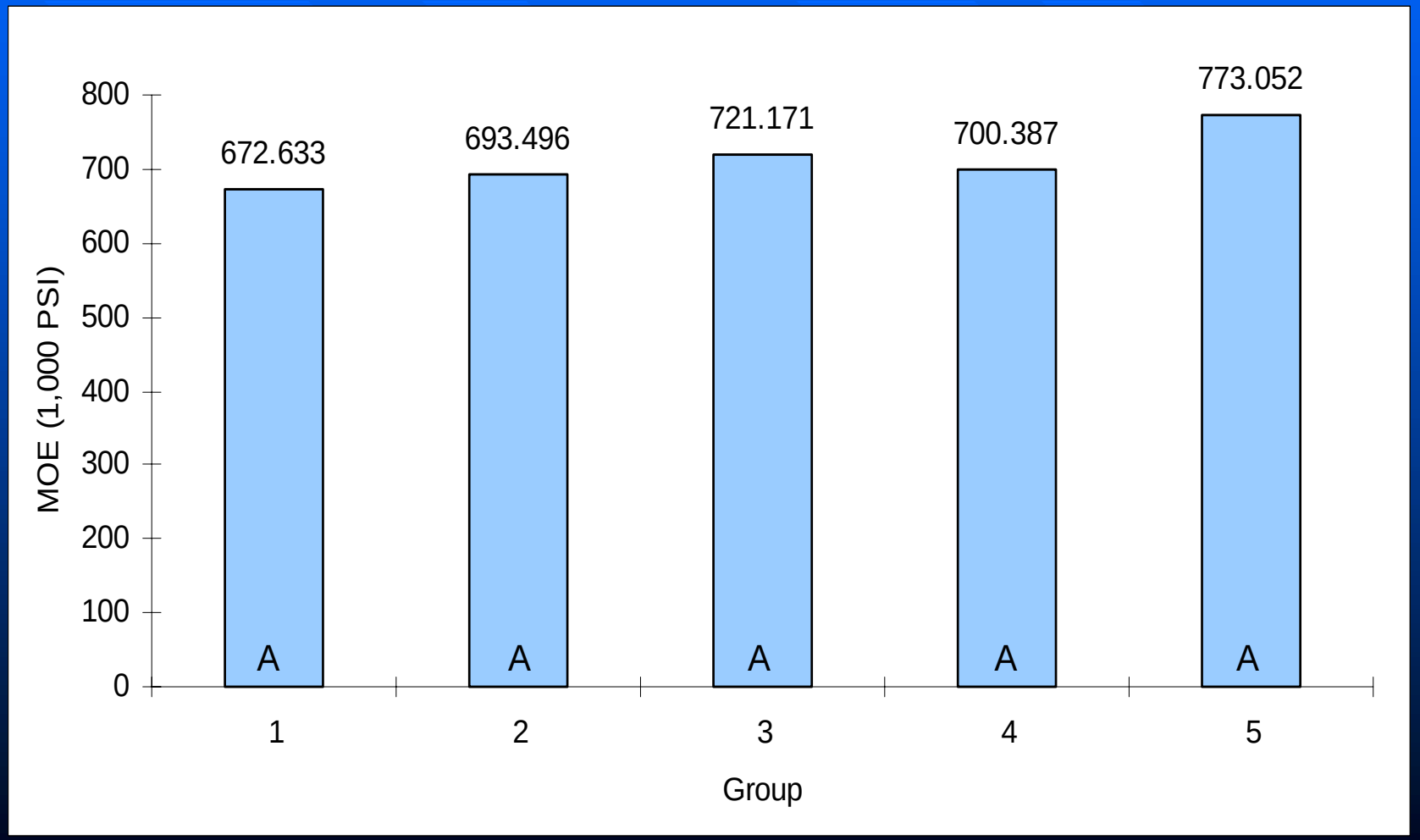
RESULTS AND DISCUSSION

Mechanical Properties

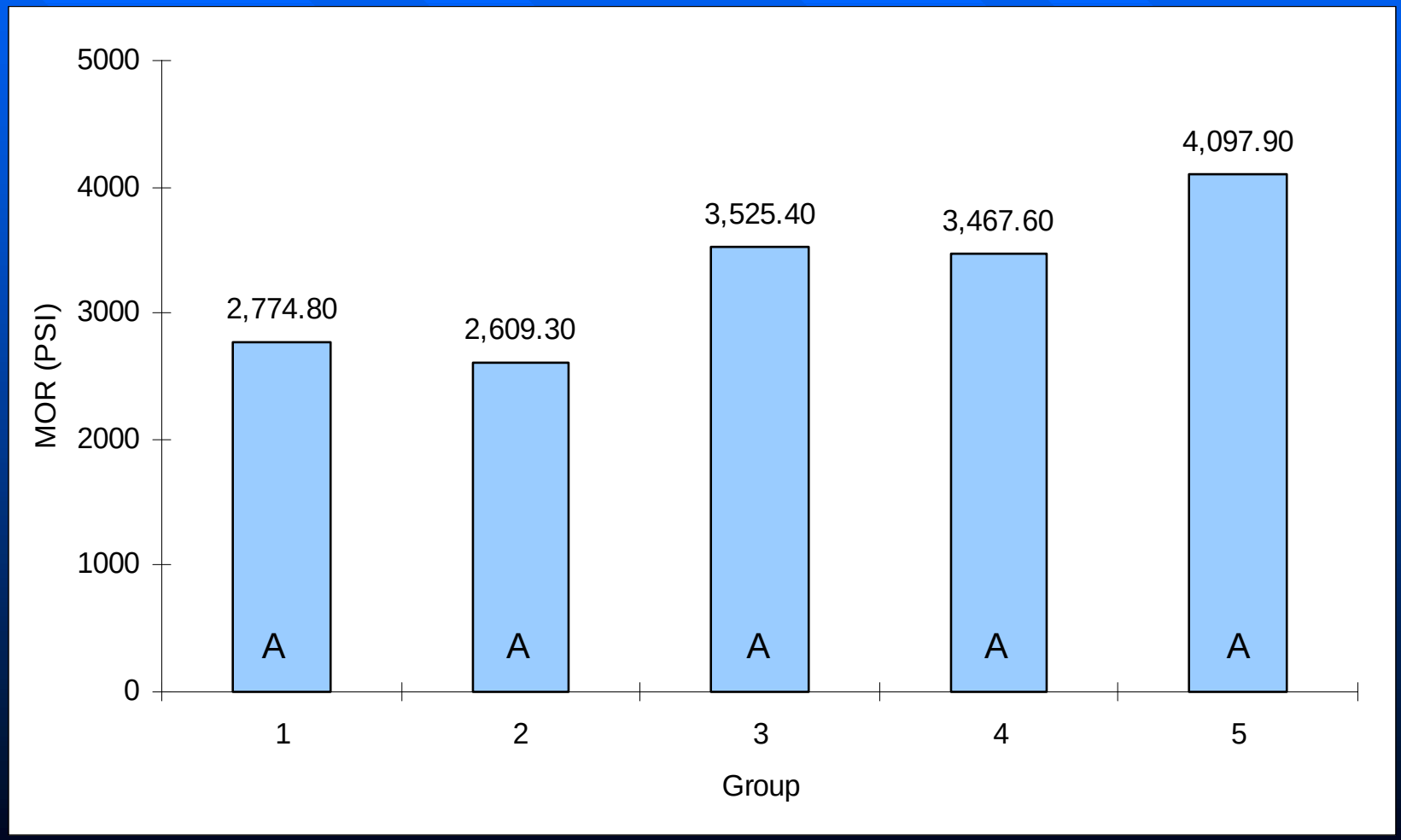
MOR


6000
5000
4000
3000
2000
1000
0
MOR (PSI)
4,441.39
4,893.76
5,136.80
4,743.05
5,802.61
A
A
A
A
A
1
2
3
4
5
Group

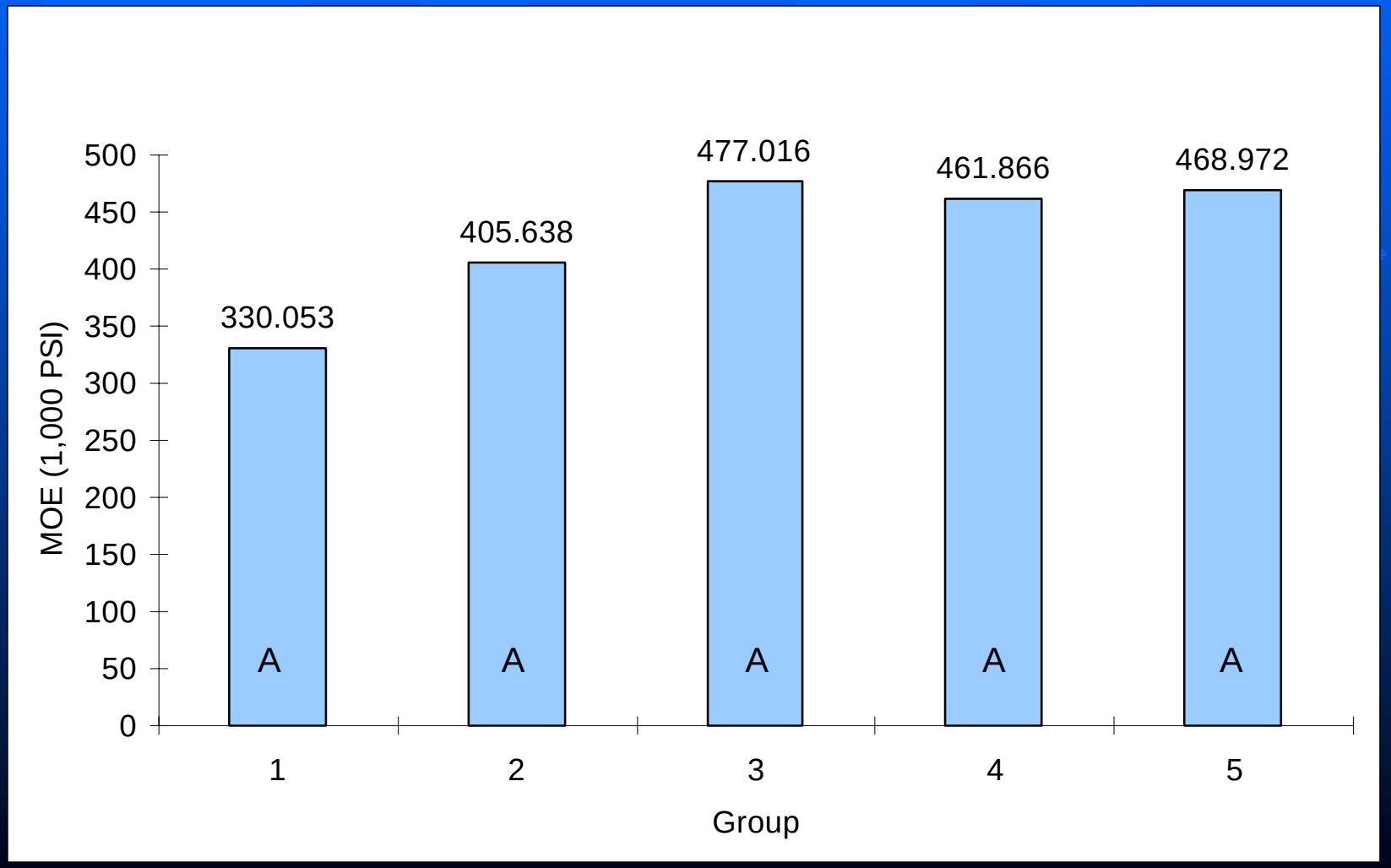
MOE


800
700
600
500
400
300
200
100
0
MOE (1,000 PSI)
672.633
693.496
721.171
700.387
773.052
A
A
A
A
A
1
2
3
4
5
Group

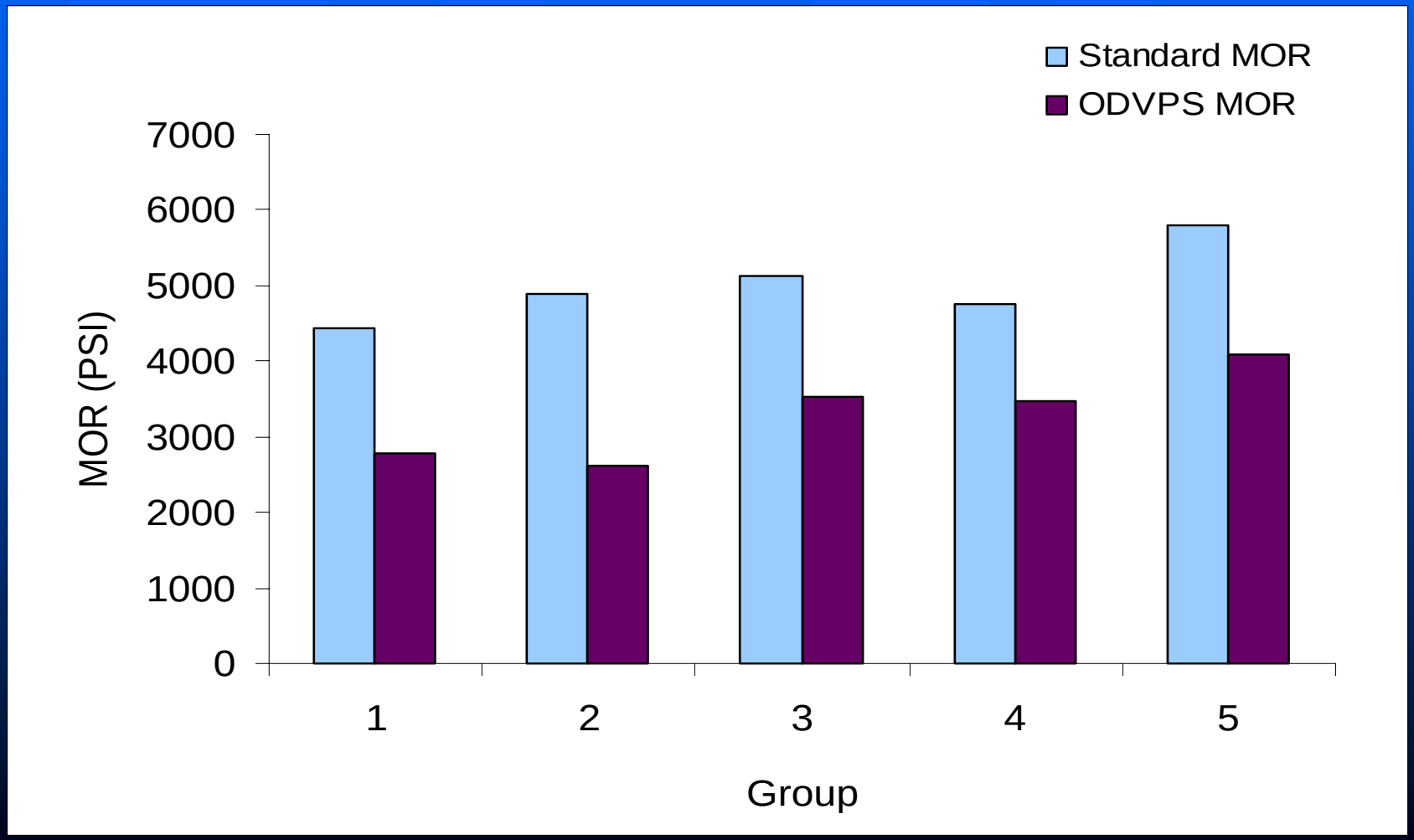
MOR – ODVPS


5000
4000
3000
2000
1000
0
MOR (PSI)
2,774.80
2,609.30
3,525.40
3,467.60
4,097.90
A
A
A
A
A
1
2
3
4
5
Group

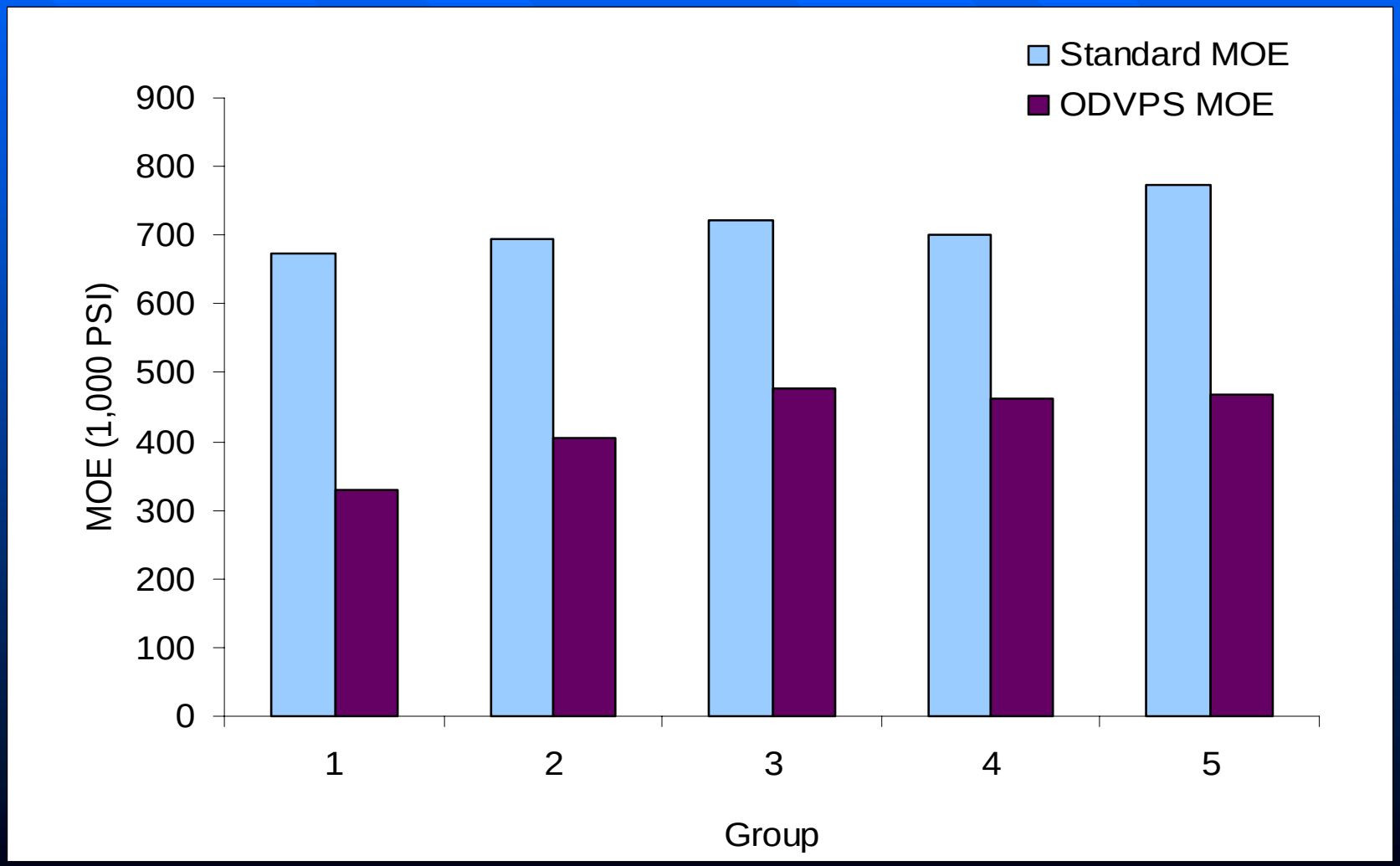
MOE – ODVPS


500
450
400
350
300
250
200
150
100
50
0
MOE (1,000 PSI)
330.053
405.638
477.016
461.866
468.972
A
A
A
A
A
1
2
3
4
5
Group

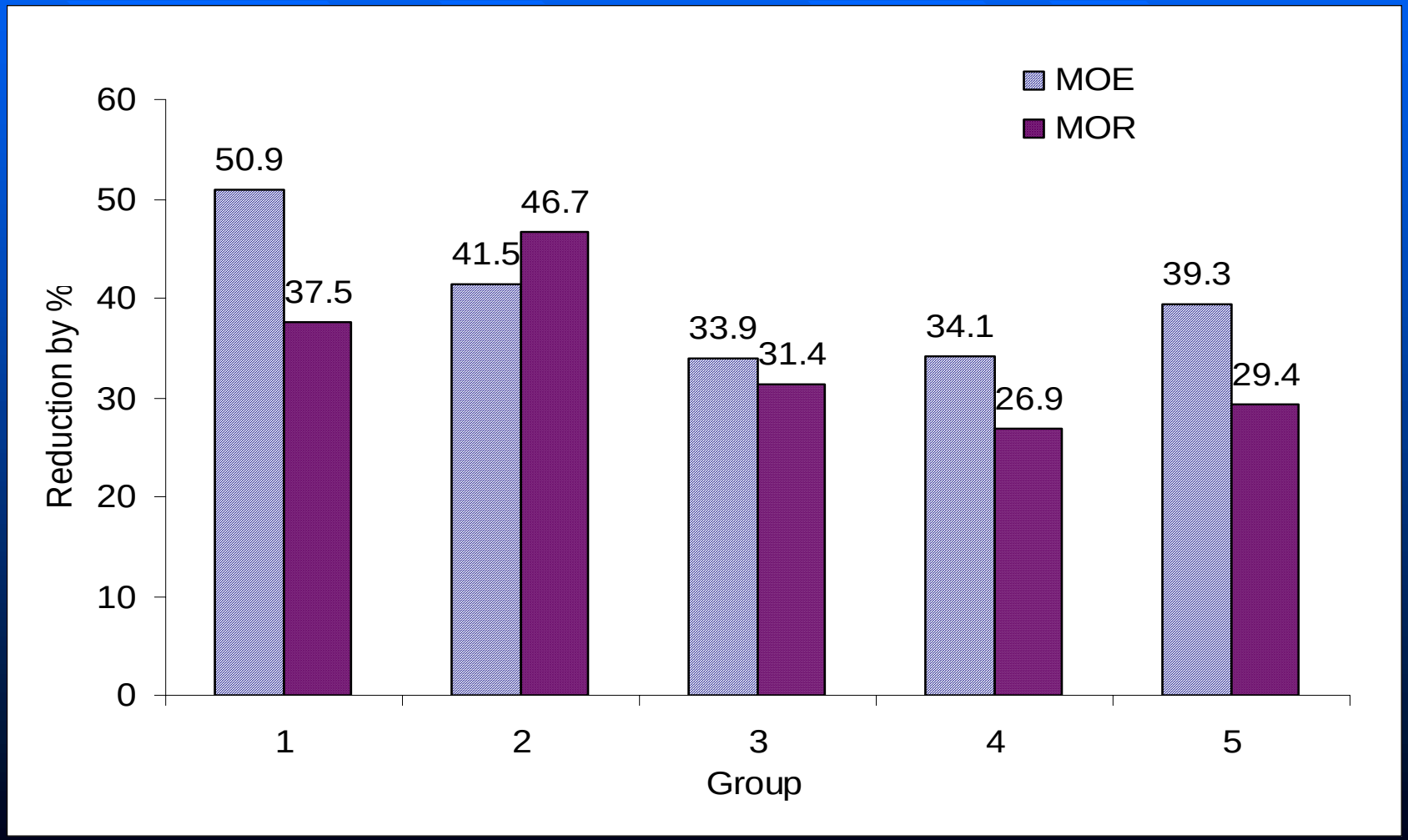
Contrast of MOR between Standard and ODVPS



Contrast of MOE between Standard and ODVPS



Bending Strength Reduction



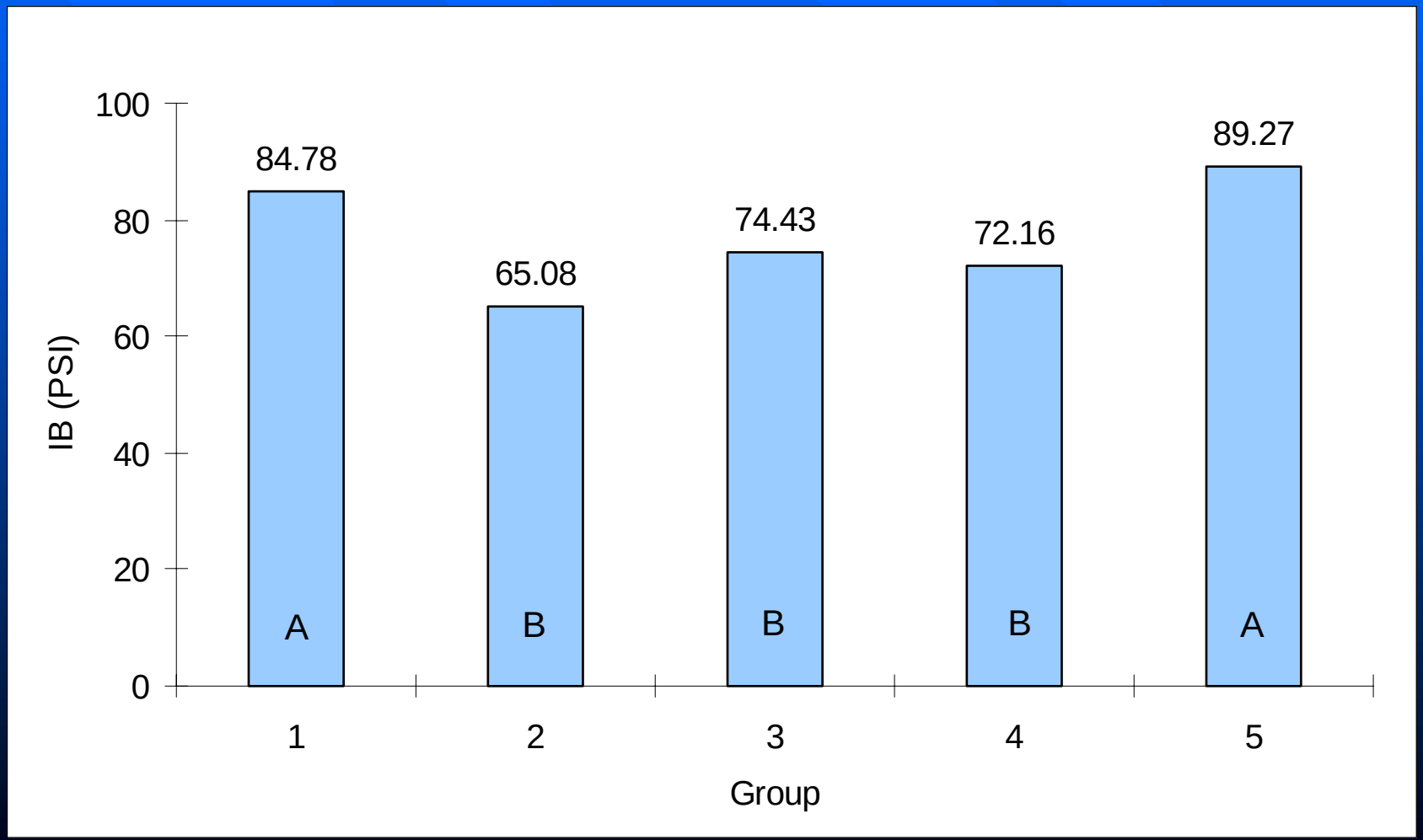
Flakeboard with 100 % Untreated SYP (Group 5)

Flakeboard with 100 % CCA-treated Guard Rails (Group 1)

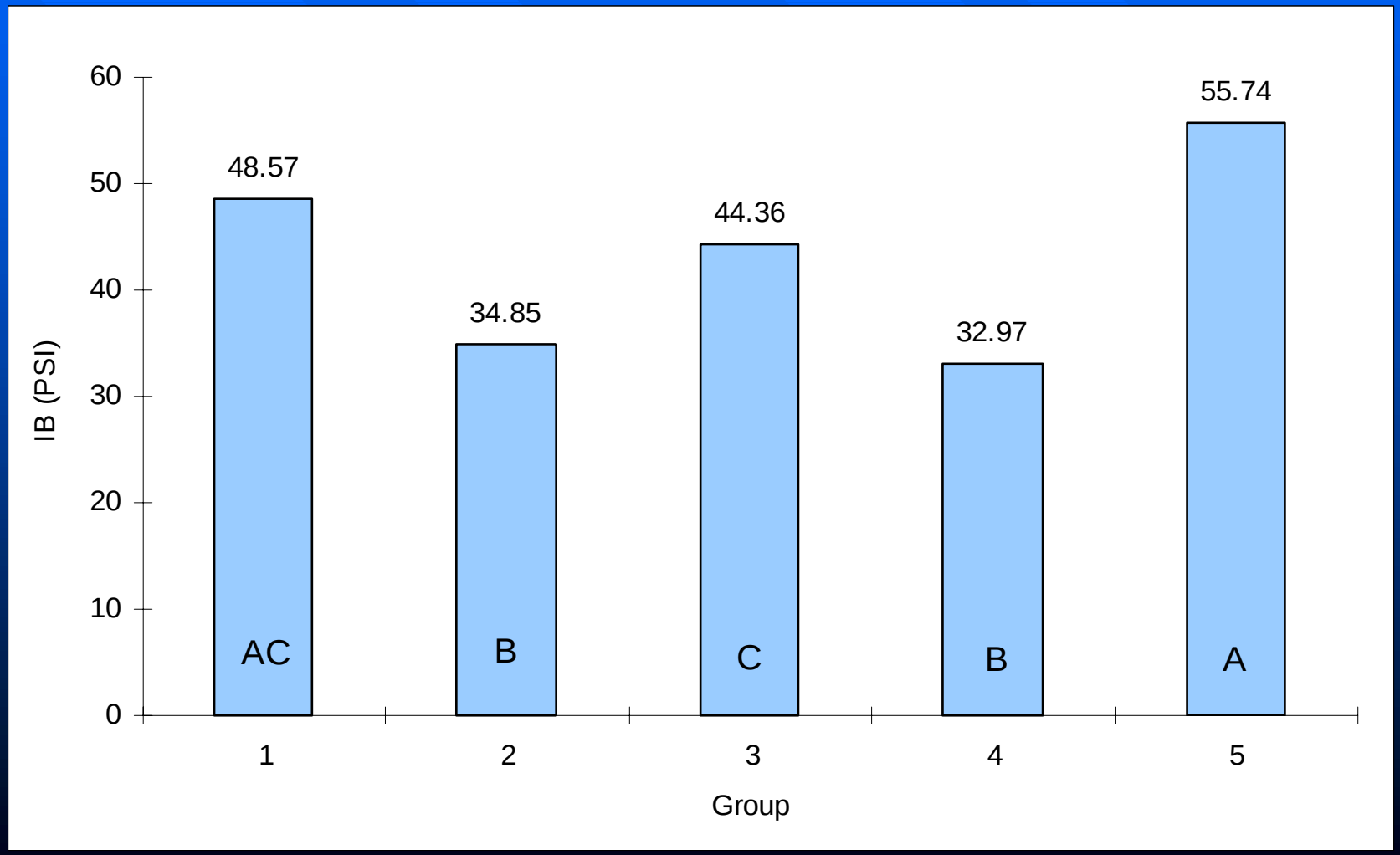
Group 1

Group 5

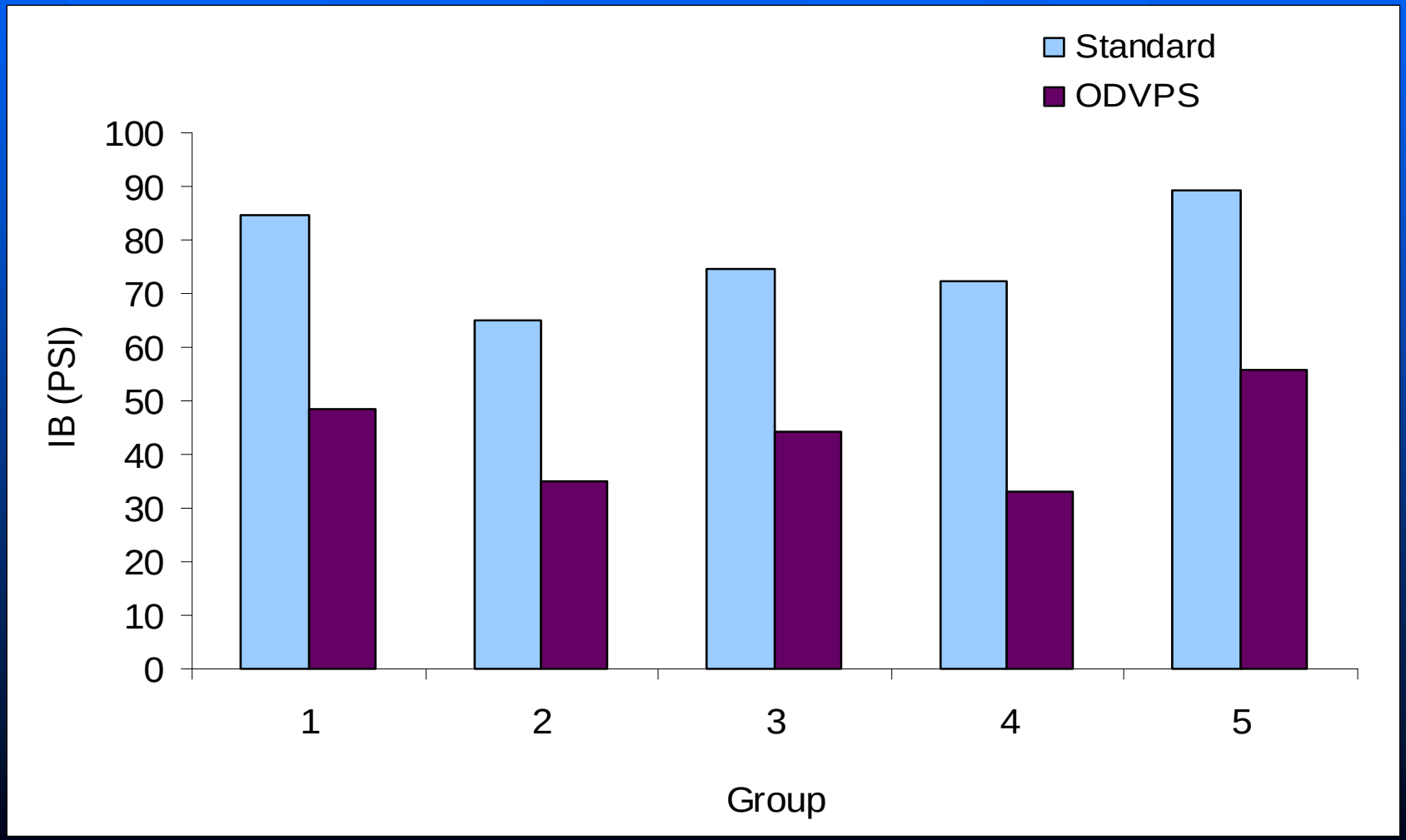
Internal Bond



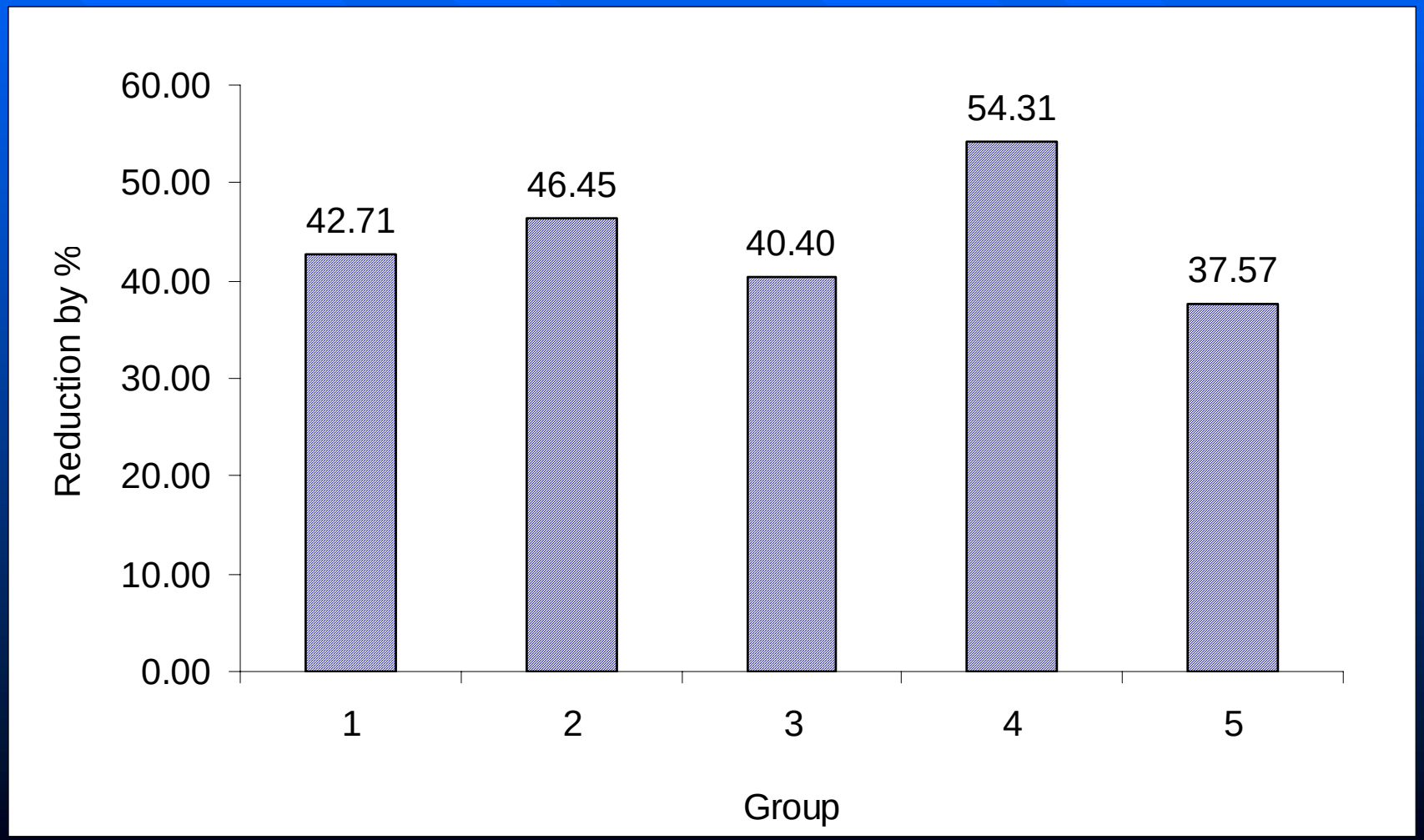
Internal Bond – ODVPS



Contrast of IB between Standard and ODVPS



Internal Bond Reduction

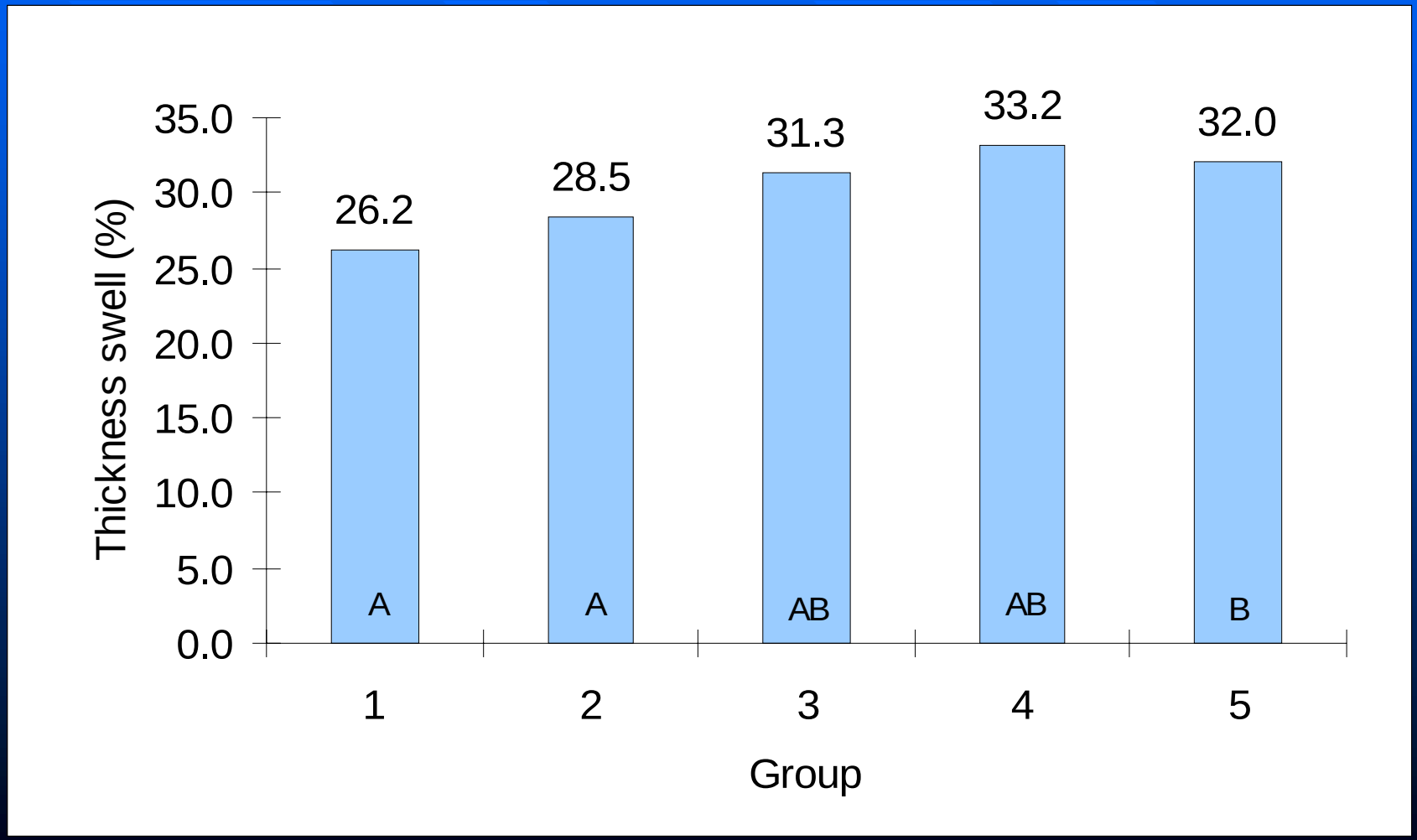


Physical Properties

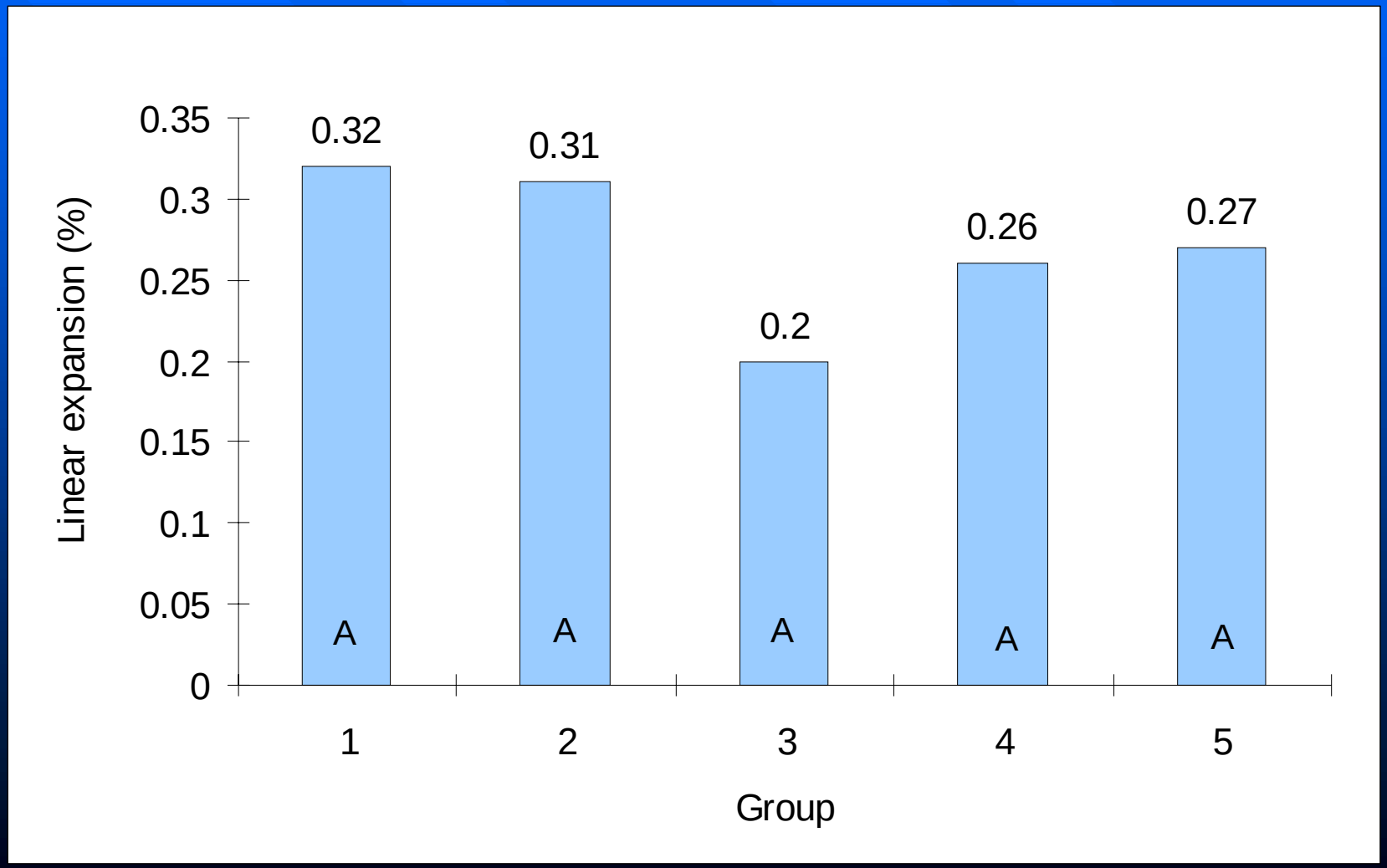
Physical Properties of Flakeboards

Treatment	Thickness (in.)	Density (pcf)	Moisture Content (%)
Group 1	0.47	47.70	7.8
Group 2	0.47	47.21	7.6
Group 3	0.48	47.20	7.6
Group 4	0.48	47.21	7.3
Group 5	0.48	49.48	7.1

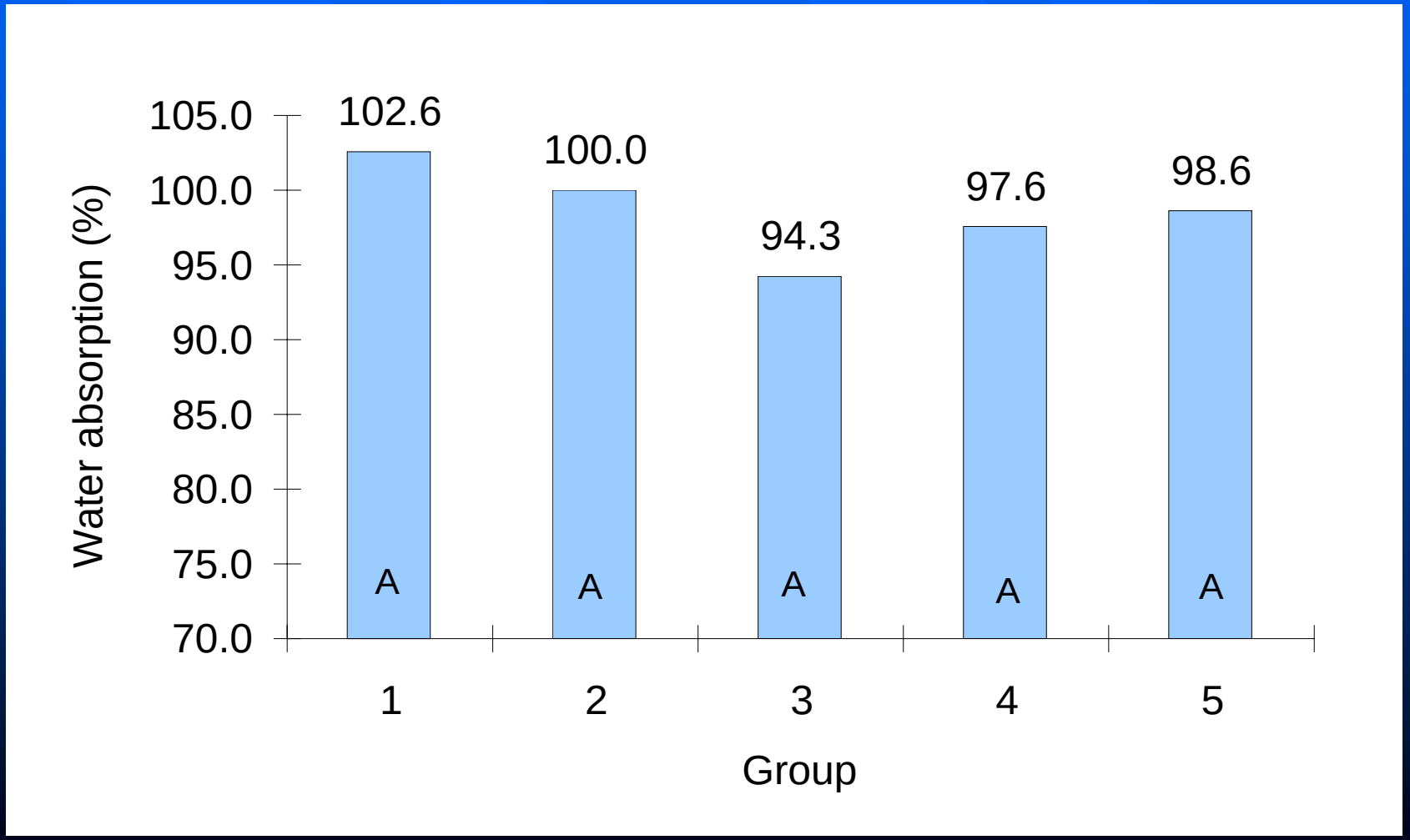
Thickness Swell



Linear Expansion



Water Absorption



Analysis of Variance (ANOVA)

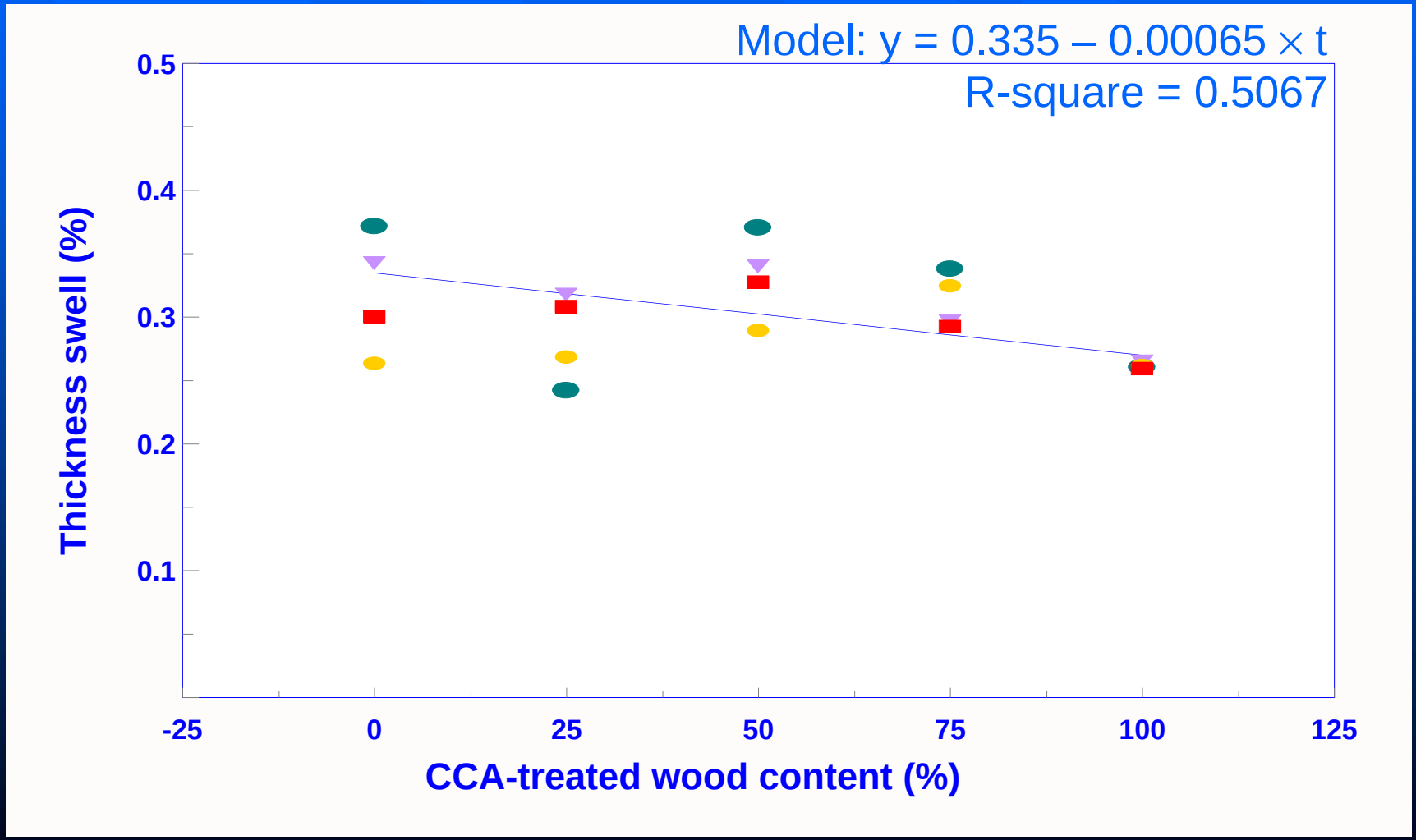
Sources	Numerator DF	Denominator DF	TYPE III MS	F value	Pr>F
MOR	4	5	1052192	1.06	0.4254
MOE	4	5	583829	1.59	0.2518
MOR-ODVPS	4	5	1468313	1.27	0.3454
MOE-ODVPS	4	5	1531942	0.60	0.6739
IB	4	5	2299	8.94	<0.0001**
IB-ODVPS	4	5	1361	9.47	<0.0001**
Thickness swell	4	5	0.0033	4.46	0.0252*
Linear expansion	4	5	9.335E-7	1.05	0.4272
Water absorption	4	5	0.0038	1.10	0.4091

Regression Analysis

- Linear regression

Source	Regression model	P-value for slope	R-square
Thickness swell	$y = 0.335 - 0.00065 \times t$	0.0209*	0.5067

Thickness Swell Regression Plot

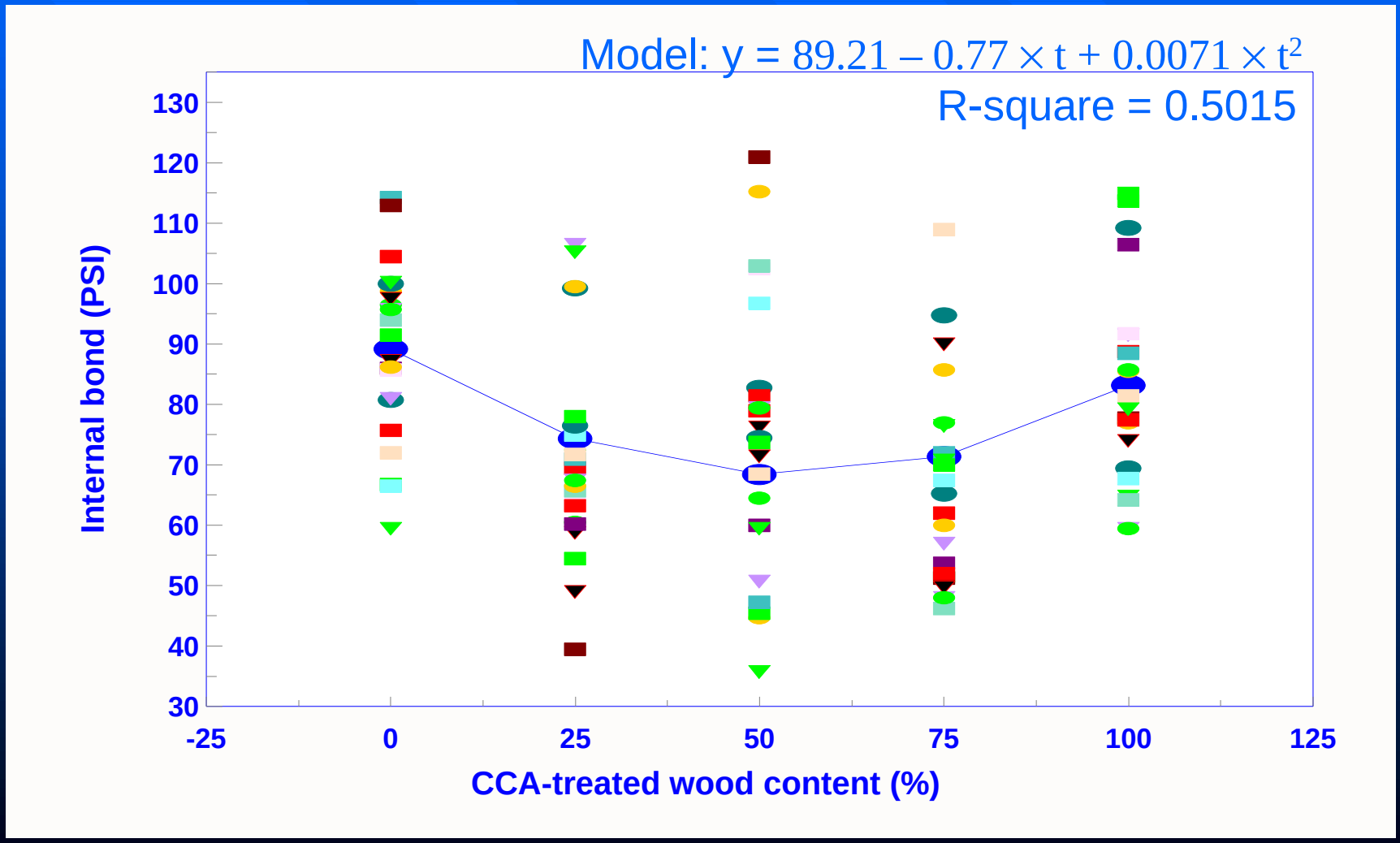


Regression Analyses

- Quadratic regression

Sources	Regression models	P-value for coefficients	R-square
IB	$y = 89.21 - 0.77 \times t + 0.0071 \times t^2$	t: 0.0328* t^2: 0.0388*	0.5015
IB-ODVPS	$y = 53.08 - 0.64 \times t + 0.0059 \times t^2$	t: 0.0775 t^2: 0.0864	0.3792

IB Regression Plot



Decay Resistance

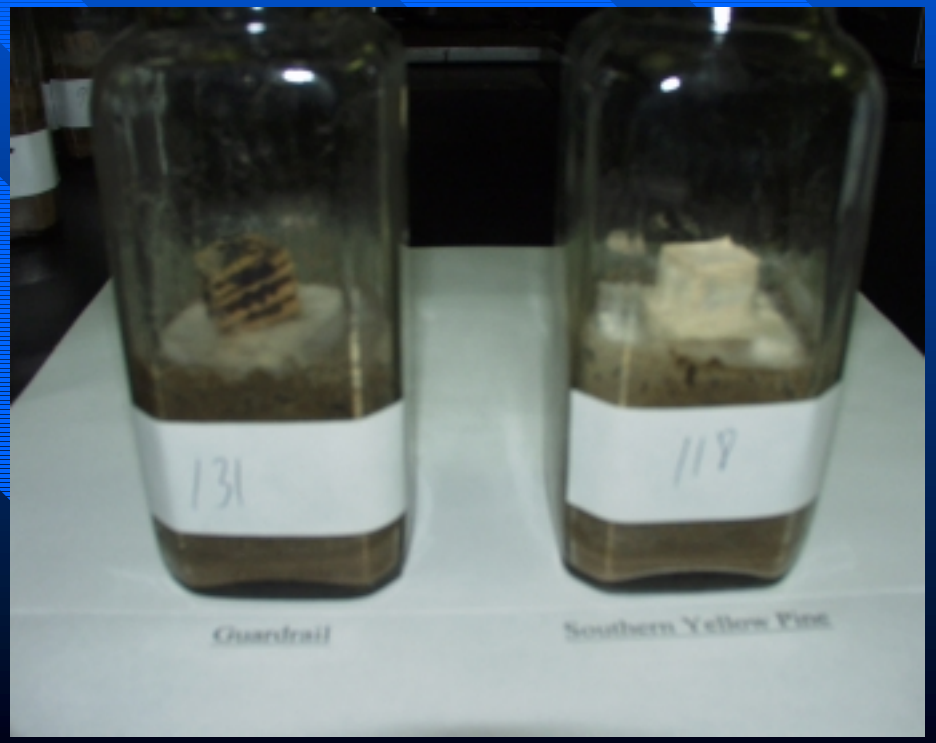
Soil Block Decay Test Methodology

- Tests performed in accordance with AWPA E10-91.
- Sample dimensions were ½ $in.^3$.
- White rot (*Trametes versicolor* (ATCC isolate 42462)) and brown rot (*Gloeophyllum trabeum* (ATCC isolate 11539)).
- 8 weeks for brown rot and 16 weeks for white rot.

Soil Decay Tests

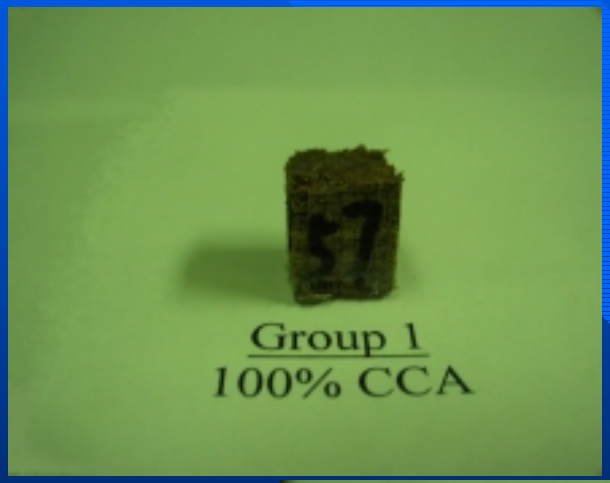
Five experimental group samples

Control group samples




B1
Guardrail


Southern Yellow Pine


57
Group 1
100% CCA


Group 2
75% CCA : 25%
Virgin


Group 3
50% CCA : 50%
Virgin

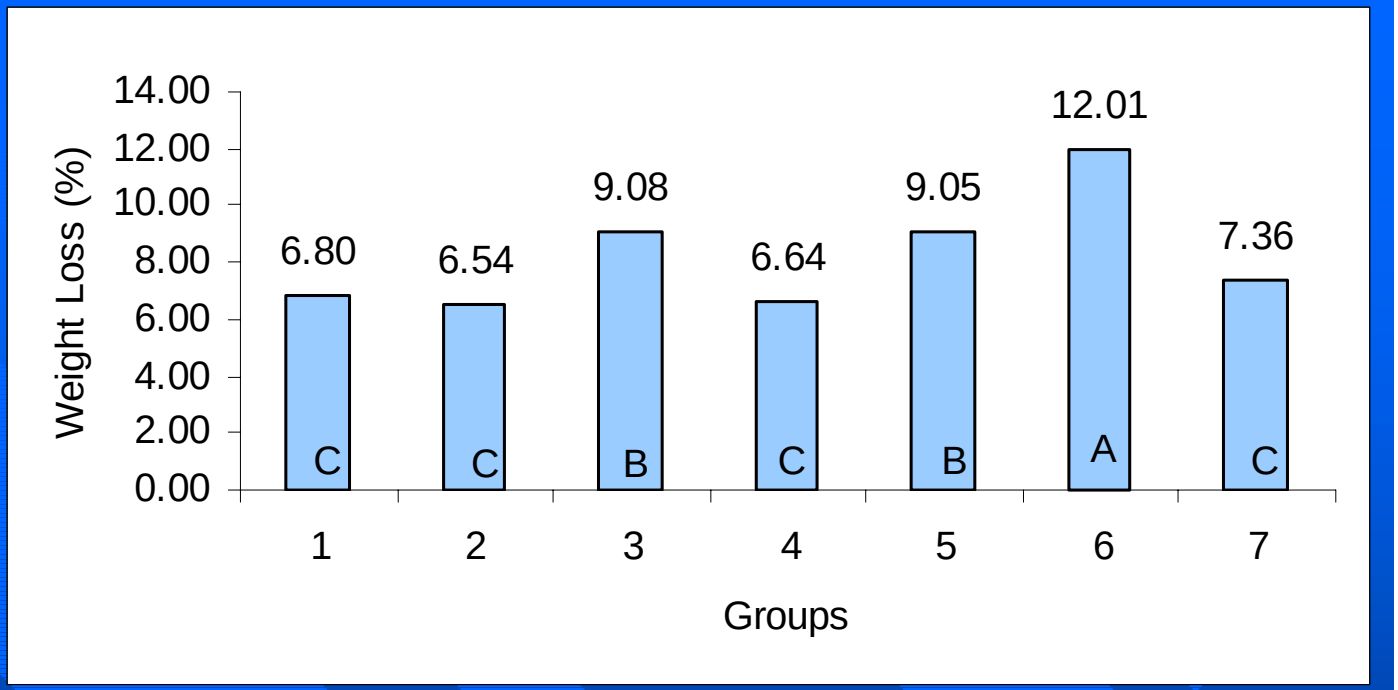

Group 4
25% CCA : 75%
Virgin


Group 5
100% Virgin

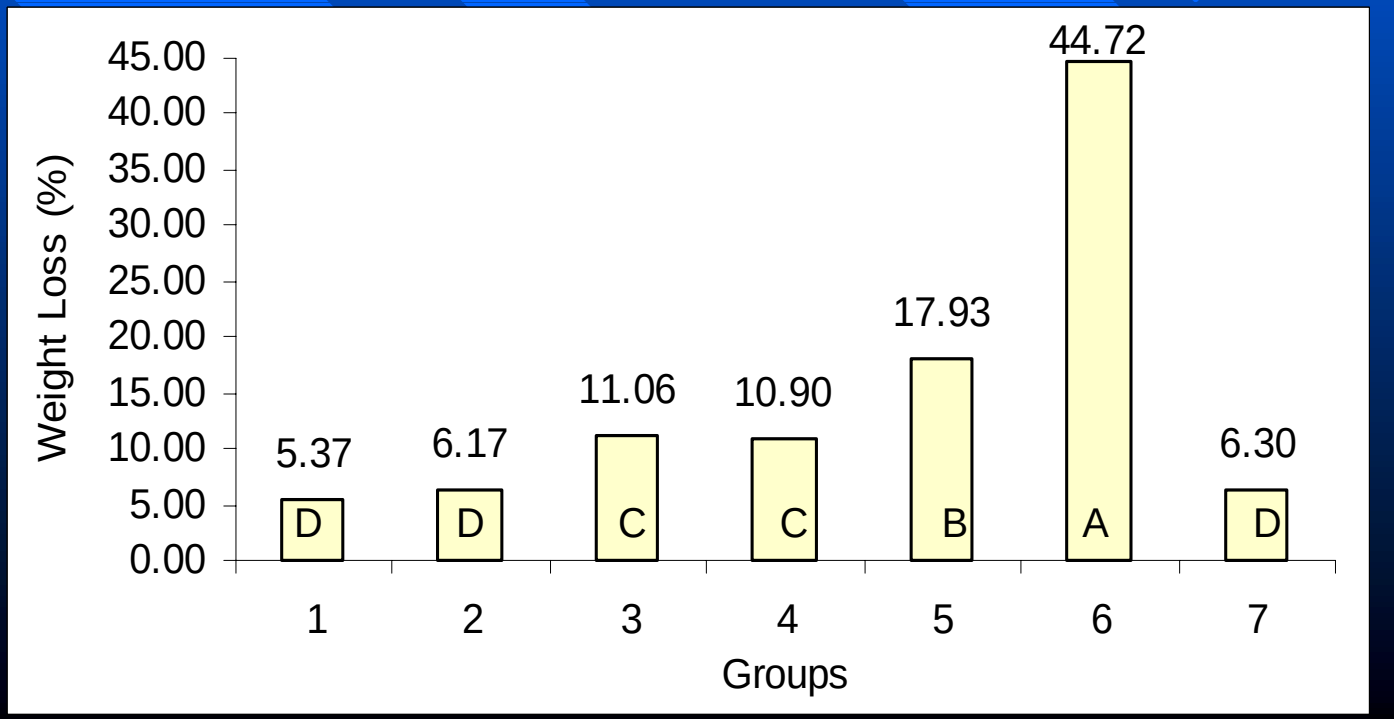
Analysis of Variance (ANOVA)

Sources	Numerator DF	Denominator DF	TYPE III MS	F value	Pr>F
Brown rot	6	63	1949	74.46	<0.0001**
White rot	6	63	40	19.78	<0.0001**

White Rot



Brown Rot

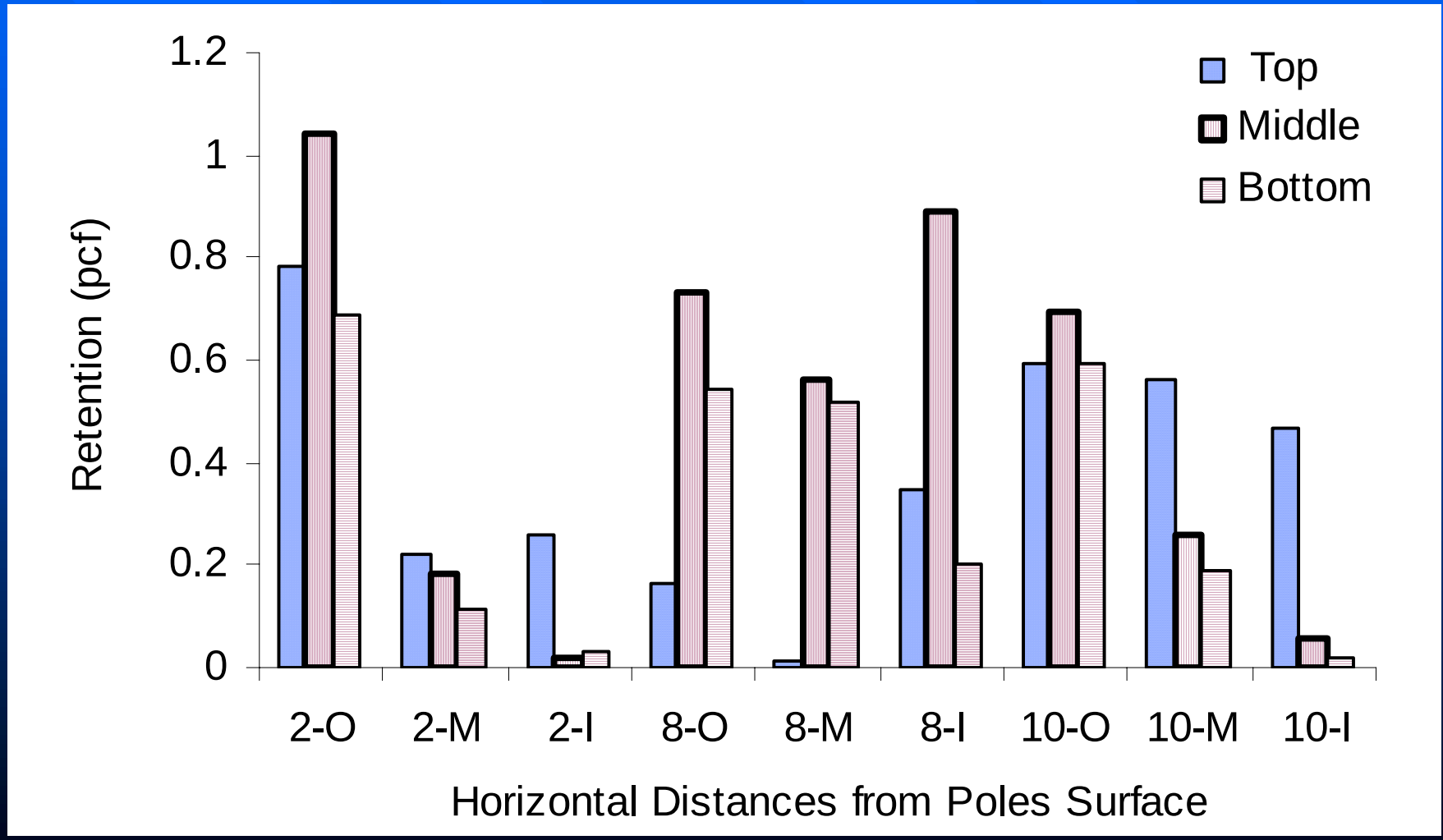


Chemical Analyses

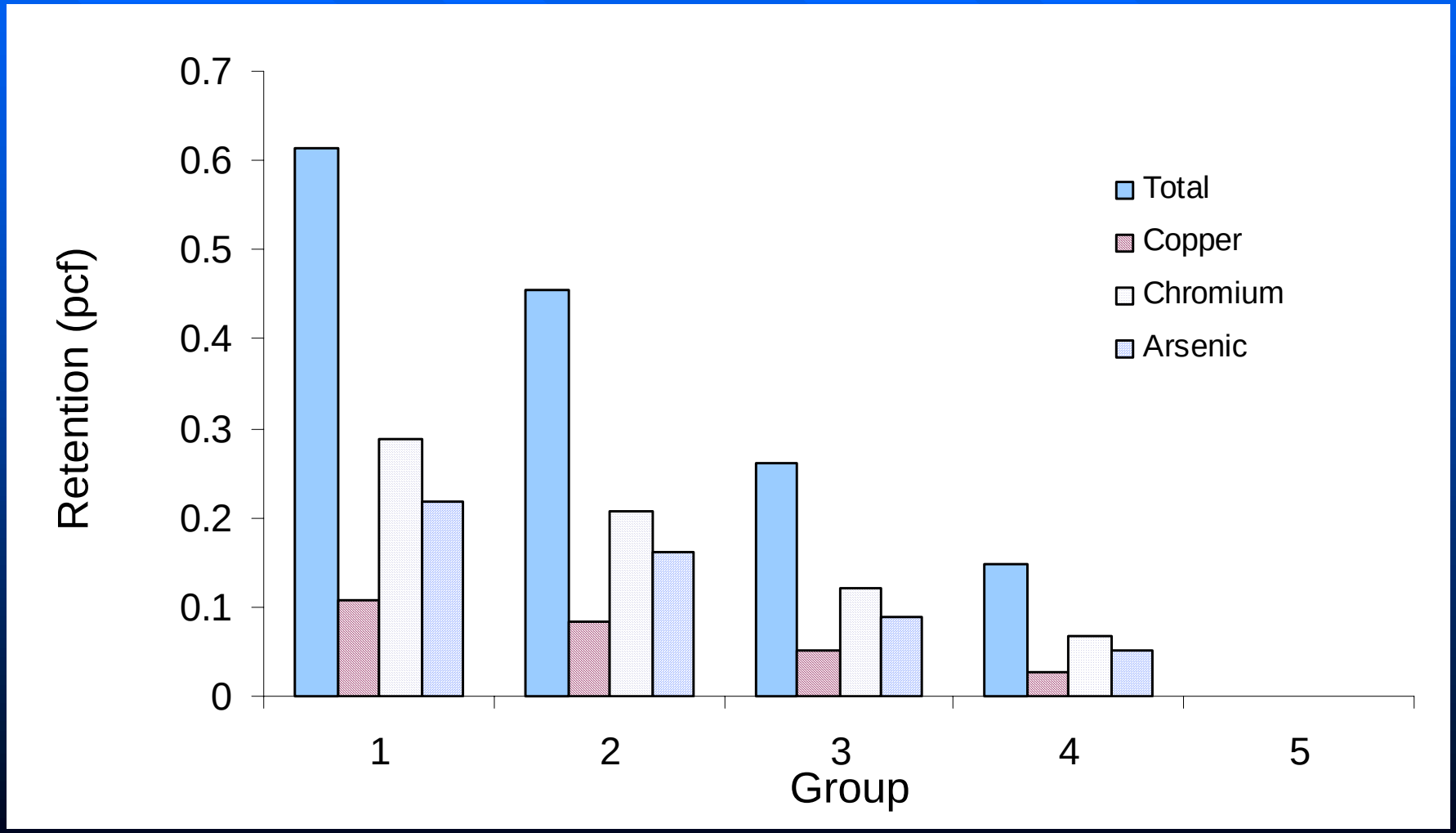
- CCA retention level of guard rails and flakeboards
- CCA leaching property of flakeboards

ICP Test

CCA Retention of Guard Rails

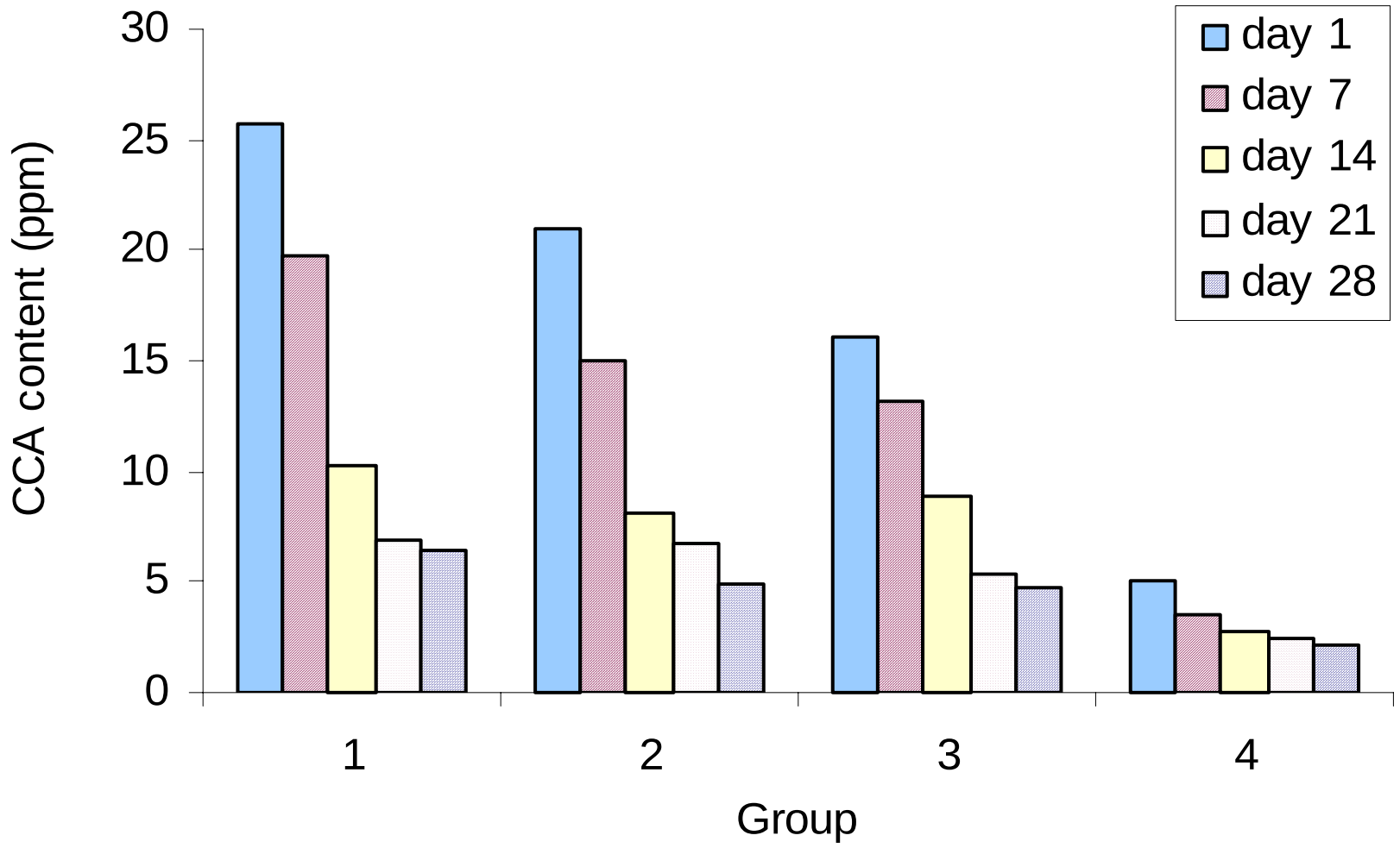


CCA Retention of Flakeboards



Leaching Test

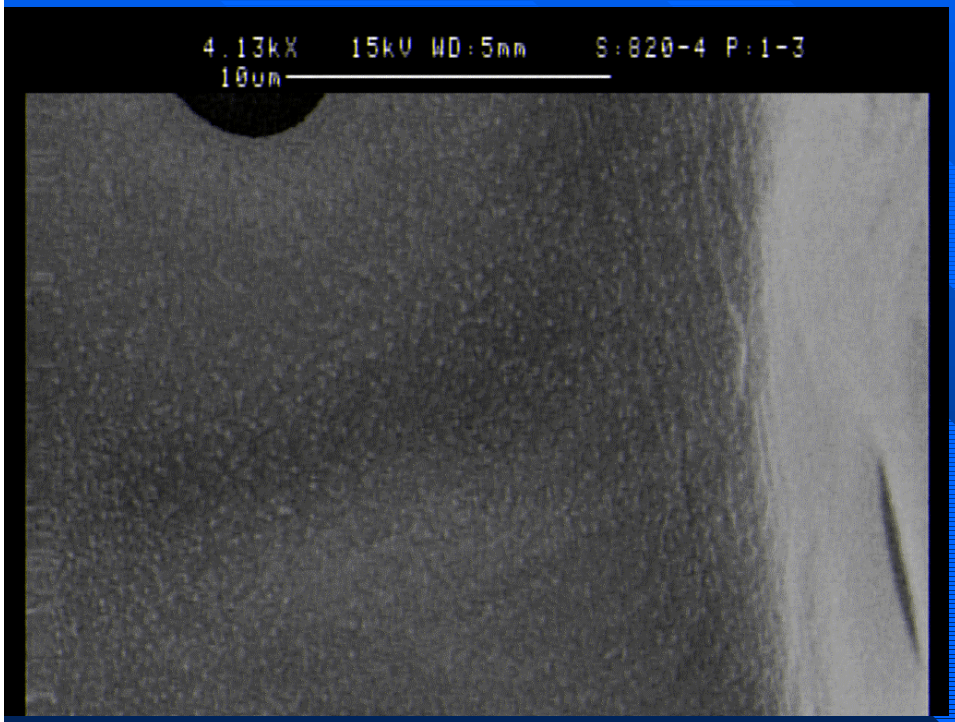
CCA Leaching Tests of Flakeboards



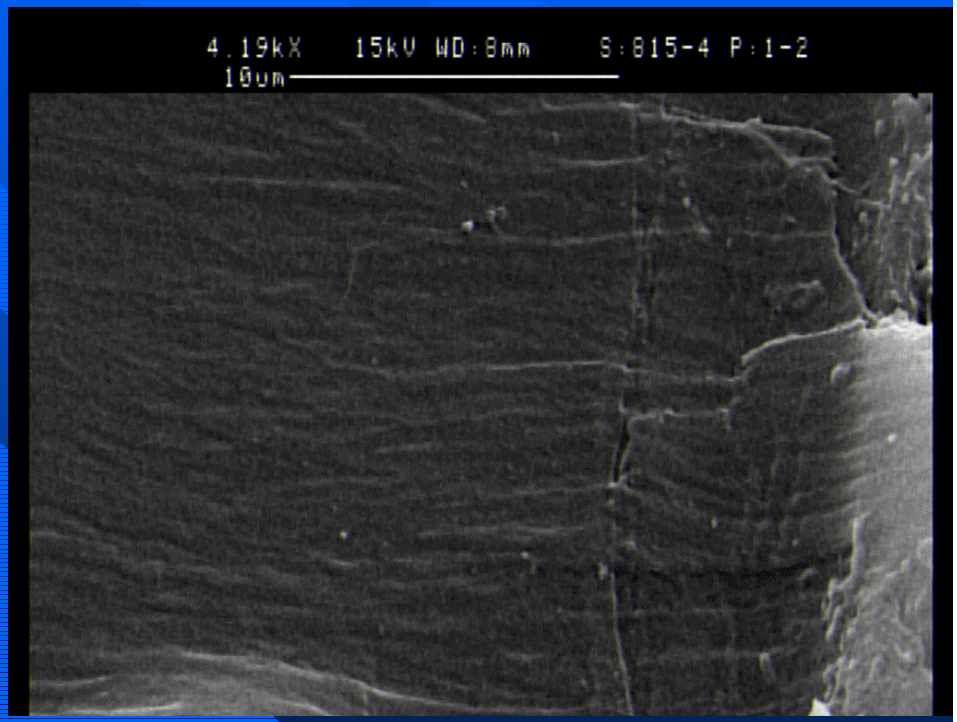
Supplementary Experiments

- Microscopic analyses
- Wettability
- Hot water solubility
- Gel time and viscosity

SEM Pictures

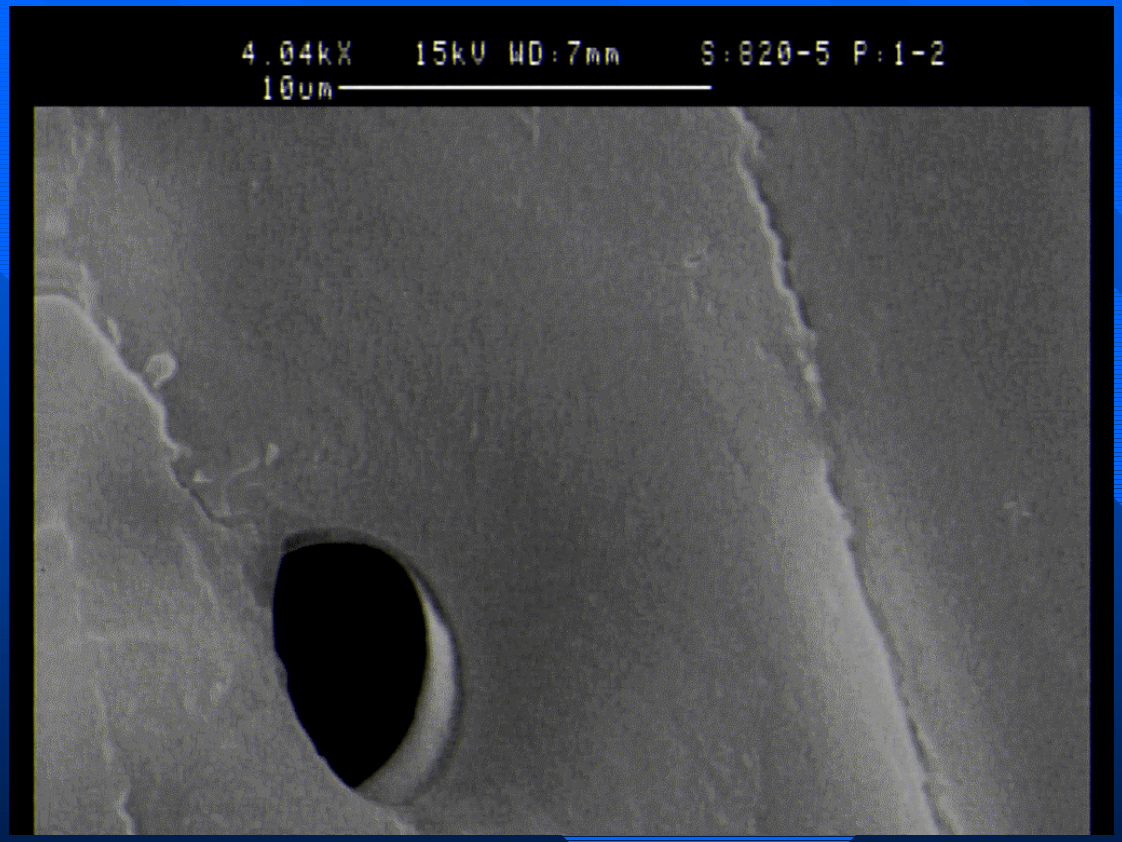


CCA-treated flake of sapwood



CCA-treated flake of heartwood

SEM Picture



Untreated southern pine flake

Wettability Determination

- Contact angles determined with PF resin at ambient room conditions.
- Angle recorded within 5 seconds after introduction of resin to wood.
- Flake conditions: air dry and oven dry.
- Wood types: earlywood and latewood.

Contact Angles of Flakes with PF Resin

Flake conditions	Wood types	Contact angle (°)	
		Untreated southern pine	CCA-treated recycled southern pine
Air dry	Earlywood	72.52 (10.09)[a]	93.50 (13.37)
	Latewood	71.06 (10.23)	84.91 (10.39)
Oven dry	Earlywood	42.40 (7.24)	64.32 (21.34)
	Latewood	43.48 (6.58)	65.59 (23.53)

[a] Values in parentheses are standard deviations.

Hot Water Solubility

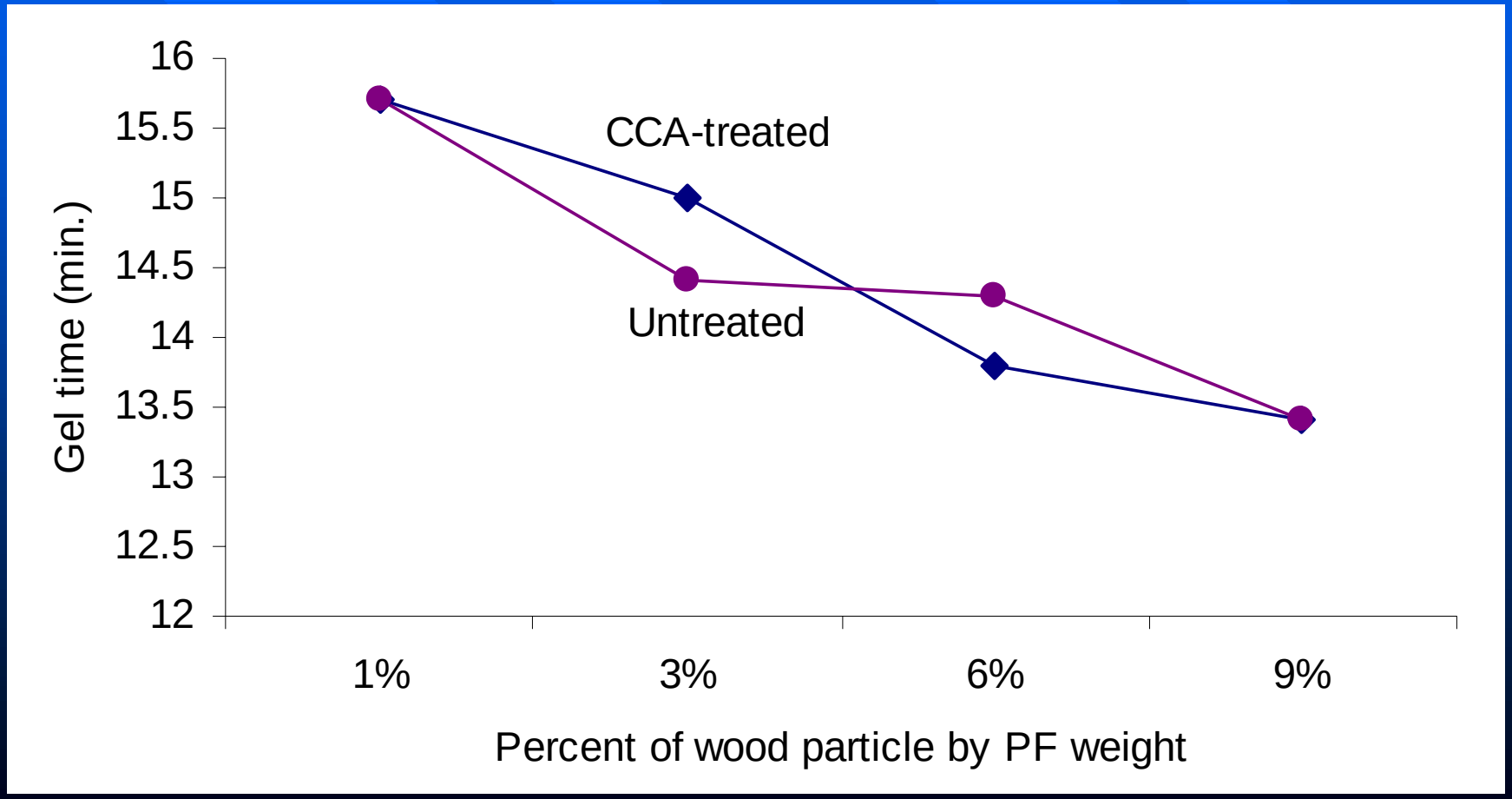
- Tests performed in accordance with ASTM D 1110-84.
- Five groups with same mixture ratios and resin content as experimental flakeboards. Two control groups.
- Wood particles were between 40 – 60 micron.
- PF resin blended with wood particles cured at 130°C, 20 min.

Hot Water Solubility

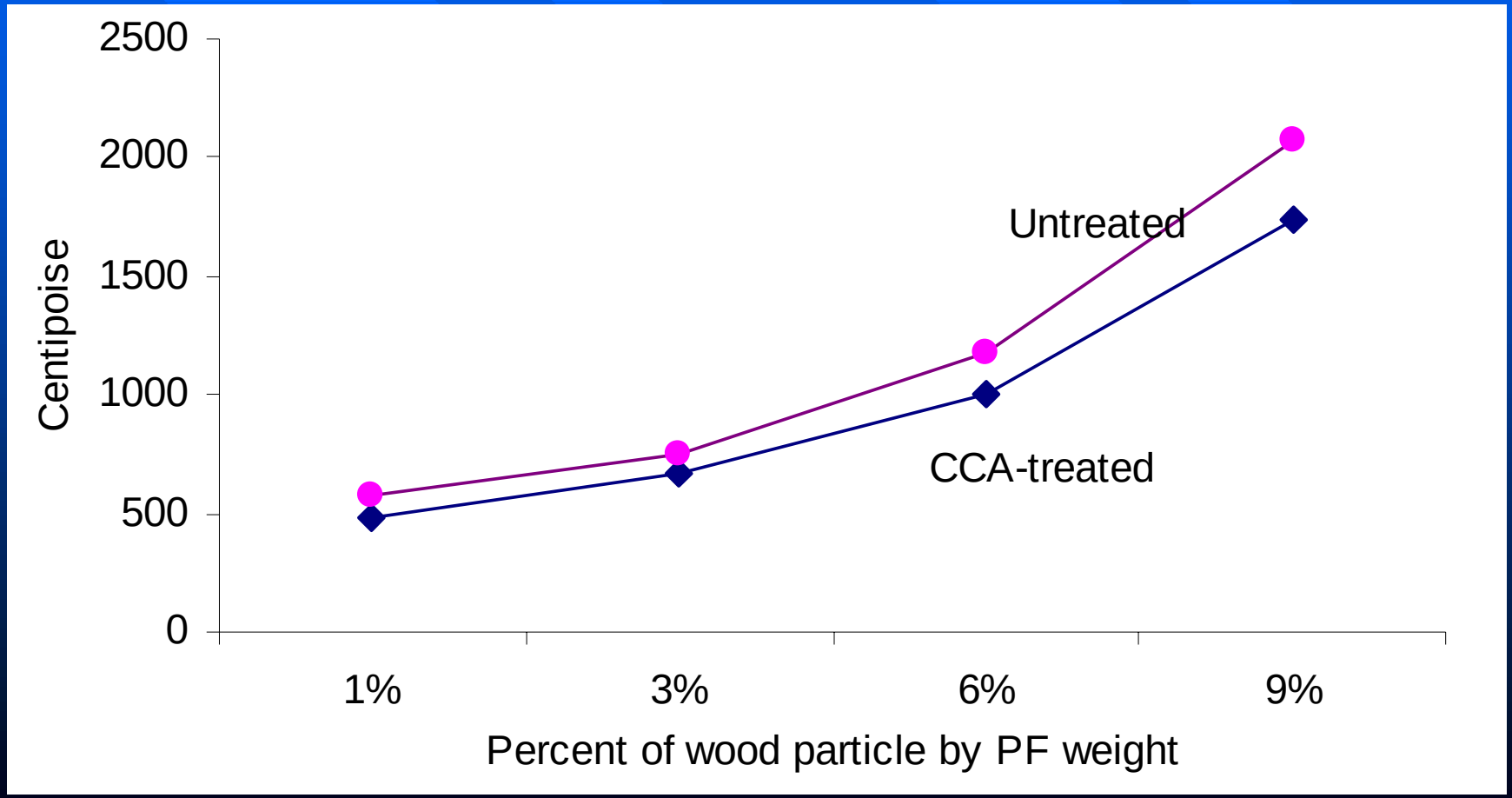
Group	Hot water solubility
1	6.17 (1.53)[a]
2	4.33 (1.26)
3	5.00 (0.50)
4	5.67 (0.58)
5	5.83 (1.61)
Untreated wood	5.00 (1.32)
CCA-treated wood	4.50 (0.50)

[a] Values in parentheses are standard deviations.

Gel time of PF blended with wood particle



Viscosities of PF blended with wood particle



Contrast of Experimental Results and ANSI Standards

	MOR (psi)	MOE (psi)	IB (psi)	LE (%)
Grade M-1	1,595	250,200	58	0.35
Grade M-2	2,103	326,300	65	0.35
Group 1	4,441	672,600	84.8	0.32
Group 2	4,894	693,500	65.1	0.31
Group 3	4,743	700,400	74.4	0.26
Group 4	5,137	721,200	72.2	0.20
Group 5	5,803	773,000	89.3	0.27

CONCLUSIONS

- As expected, most mechanical and physical properties improved as the percent of recycled treated wood in the furnish decreased.
- As expected, decay resistance increased as the percent of recycled treated wood in the furnish increased.

CONCLUSIONS

- Flakeboard made from recycled CCA-treated wood is technically feasible.
- Mechanical and physical properties do not substantially decrease with as much as 50 percent recycled treated material in the furnish of the panels.

ACKNOWLEDGEMENT

- Drs. Shupe, Hse, Marx, and Vlosky
- American Wood Preservers Institute
- Arch Wood Protection, Inc.
- Arnold Forest Products Co., Shreveport, LA
- Louisiana Dept. of Transportation and Development

Comments and Questions