

# Water Absorption by Wood-Plastic Composites in Exterior Exposure

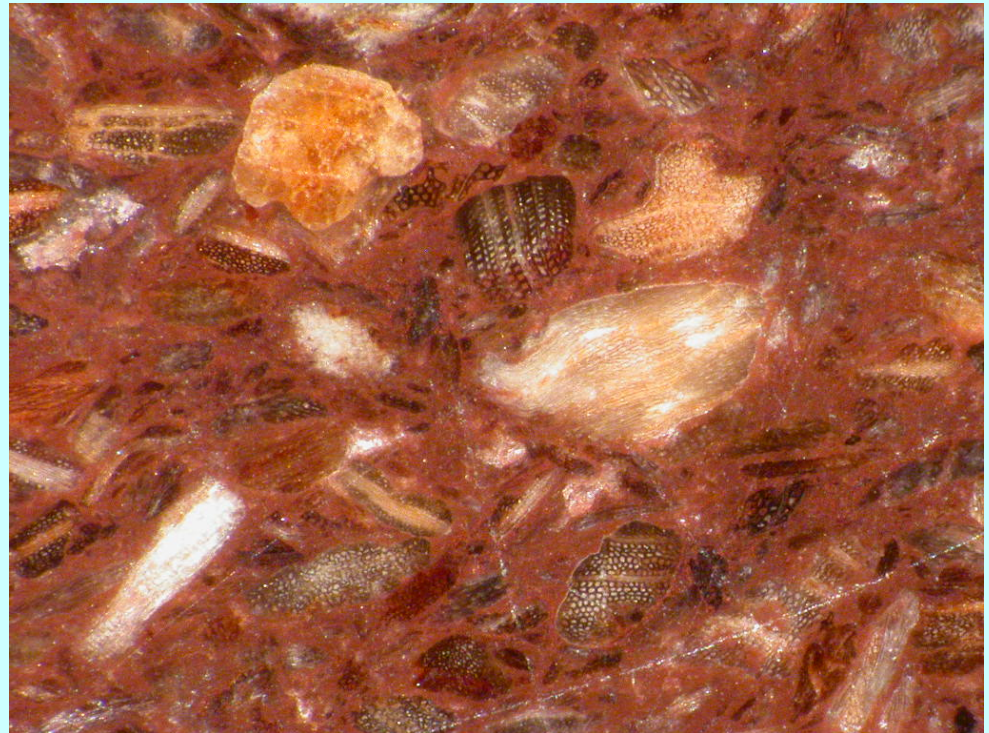
*8<sup>th</sup> International Conference on Woodfiber-Plastic Composites  
May 23-25, 2005*

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Polymer Engineering Company, Ltd.  
Burnaby, B.C. Canada**

## ***Known Facts***

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**Perception:**  
wood particles in WPC  
are encapsulated in plastic

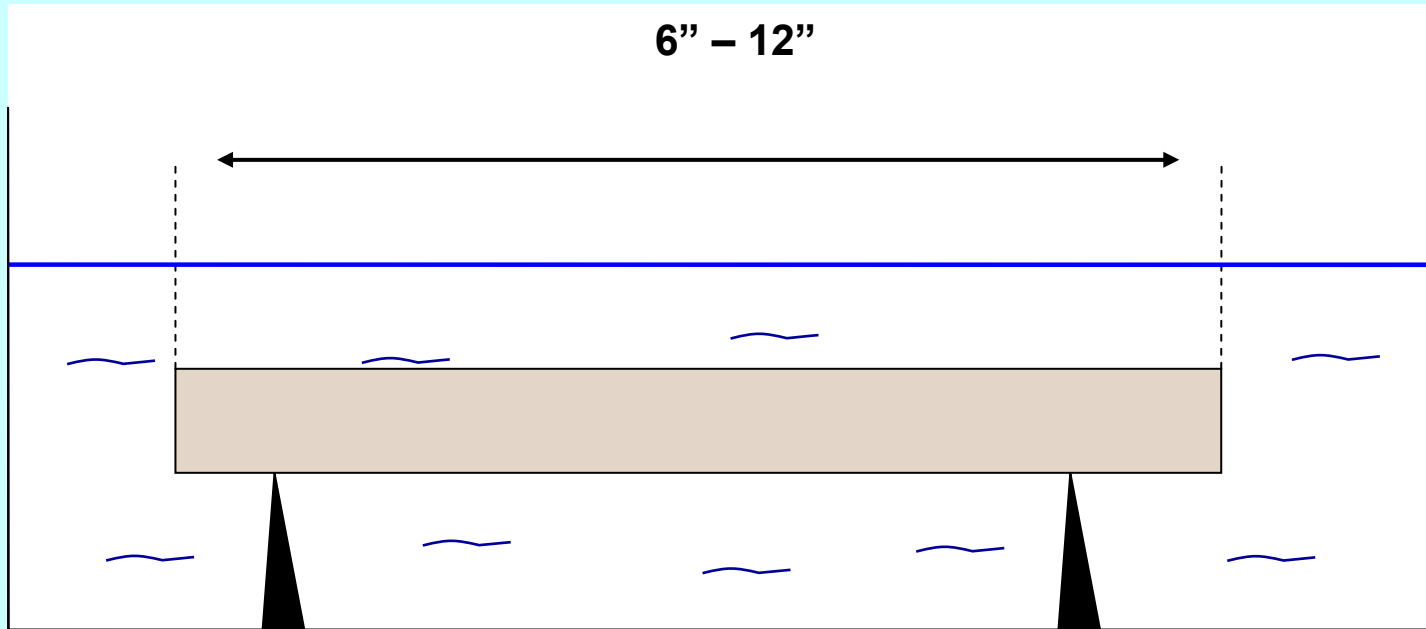


**Optical microscopy of WPC cross-section.  
Visible wood particles encapsulated in resin.**

## ***Known Facts***

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### Industry Standard ASTM D-1037



**Commercial products appear to have water absorption of <2%**

# Known Facts

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WPC are designed to be continuously exposed to an exterior environment

Warping



Decay fungi growth



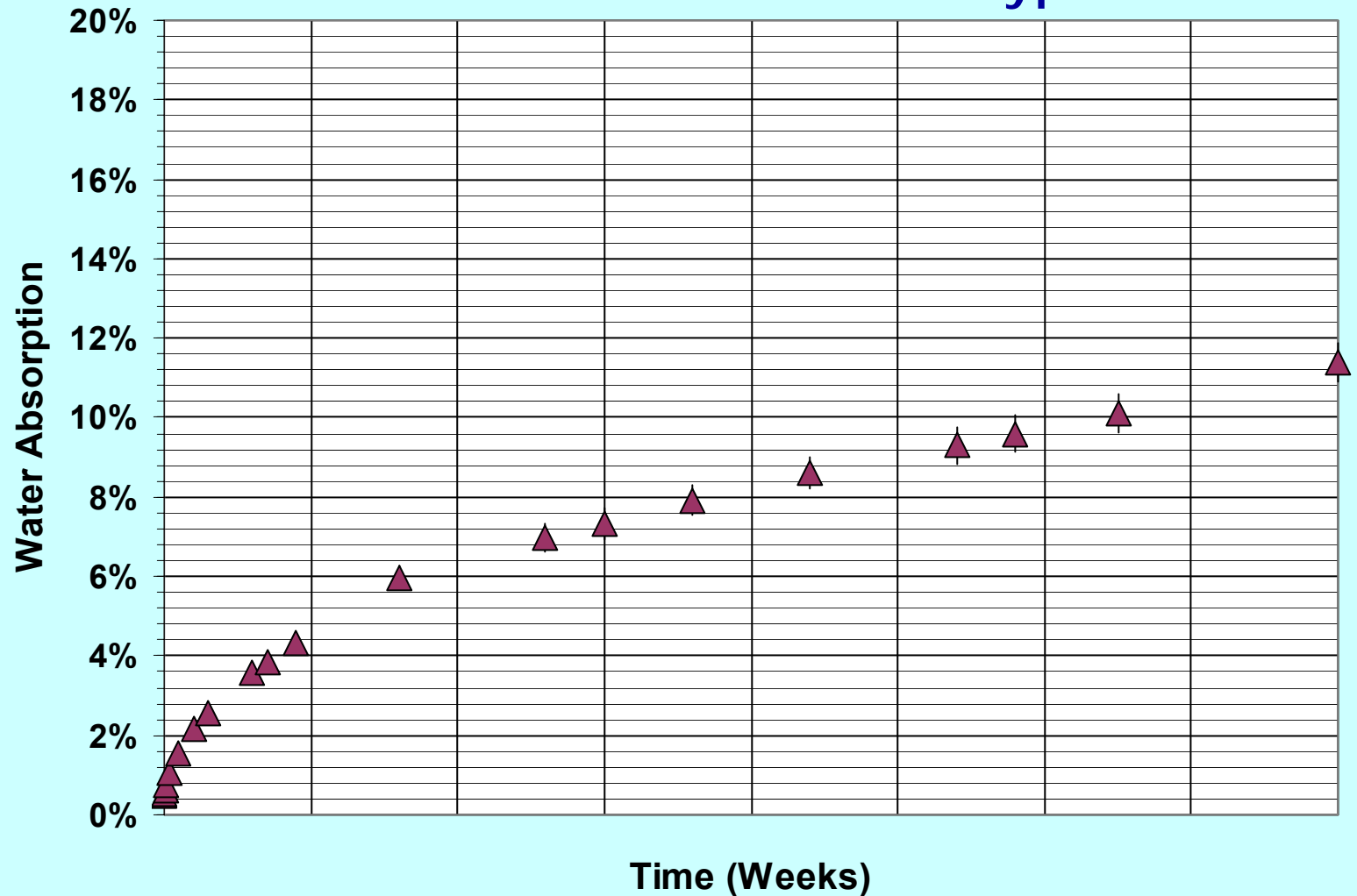
Dimensional changes



1. Morris, P.I. And P.A. Cooper, 1997. Recycled plastic/wood composite lumber attacked by fungi. For. Prod. J. 48 (1): 86-88
2. Manning, M., WPC Conference, Baltimore, MD, October 2004.

# Known Facts

## Moisture Content vs. Time for a Typical WPC



# ***Objective***

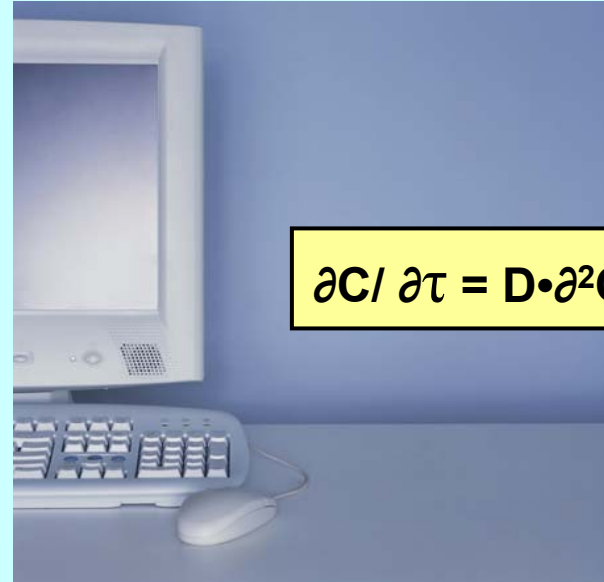
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***To identify water absorption  
and distribution in WPC materials  
exposed to exterior conditions***

# *Two Ways to Address the Objective*

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1. Computer modeling  
and simulation



2. Exterior exposure



# *Sample Preparation*

## Experimental Wood Plastic Composite Formulation

Ingredients	Formulation			
	#5	#6	#12	#13
Pine wood (20 mesh)	51	48	66	63
HDPE	45	45	30	30
Lubricants	3	3	3	3
Talc	1	1	1	1
Zinc Borate	0	3	0	3
Boards Cross-section (in)	6 x 1/2	6 x 1/2	6 x 1	6 x 1

# *Sample Preparation*

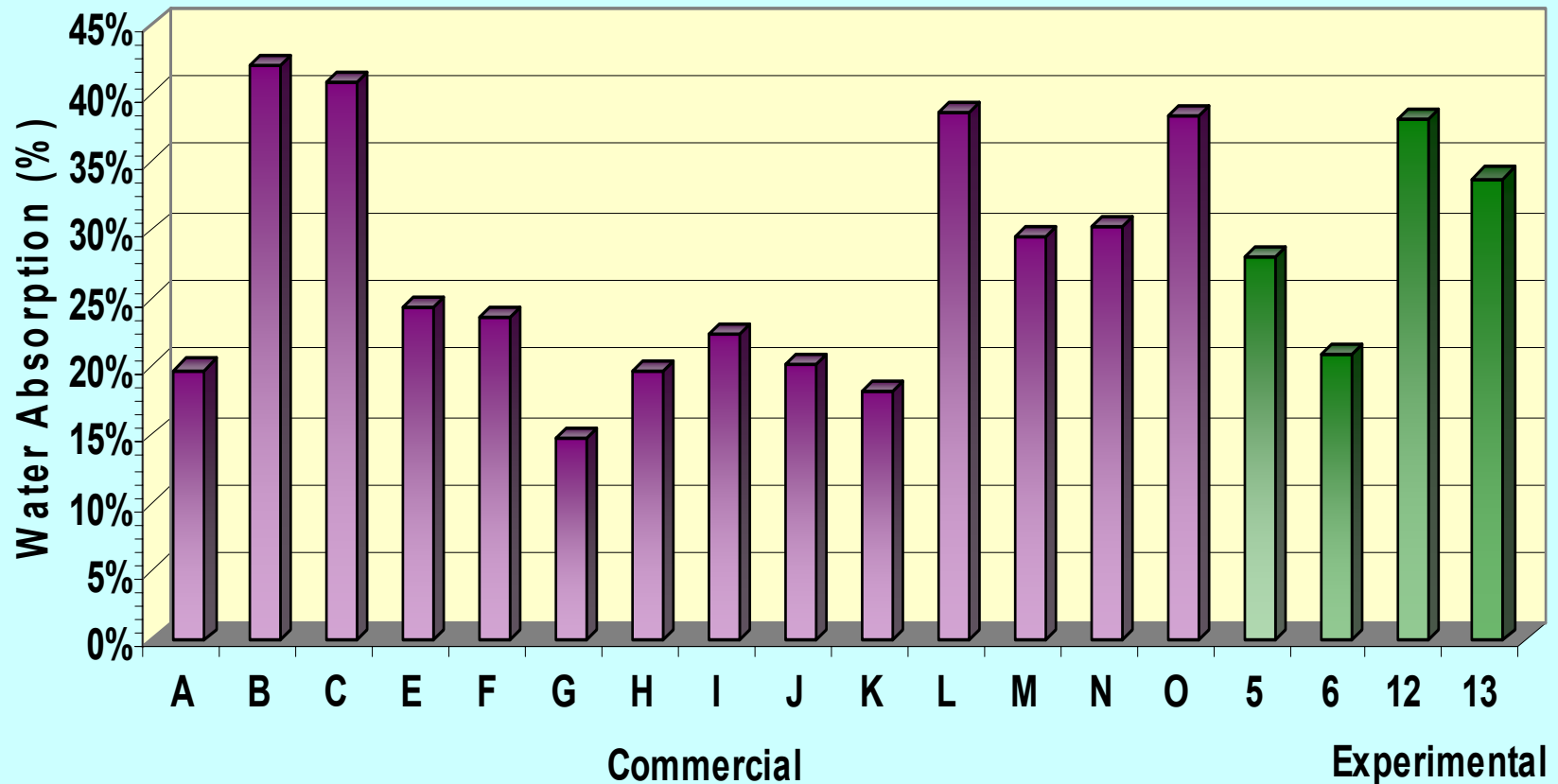
## Extrusion



**Extrusion at Washington State University  
Materials and Engineering Laboratory**

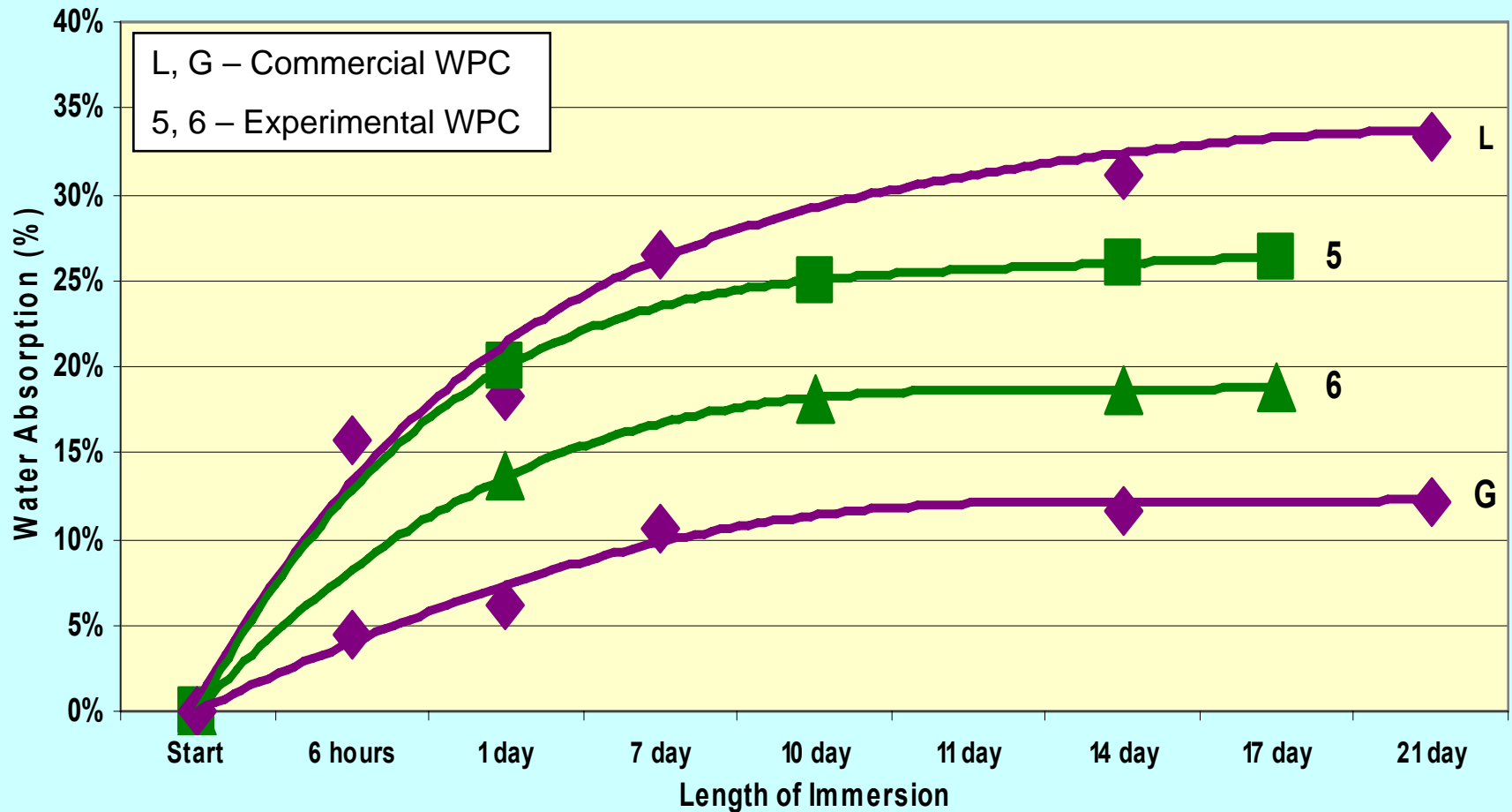
# *Sample Preparation*

Comparison of water absorption at equilibrium  
for experimental samples and commercial WPC's



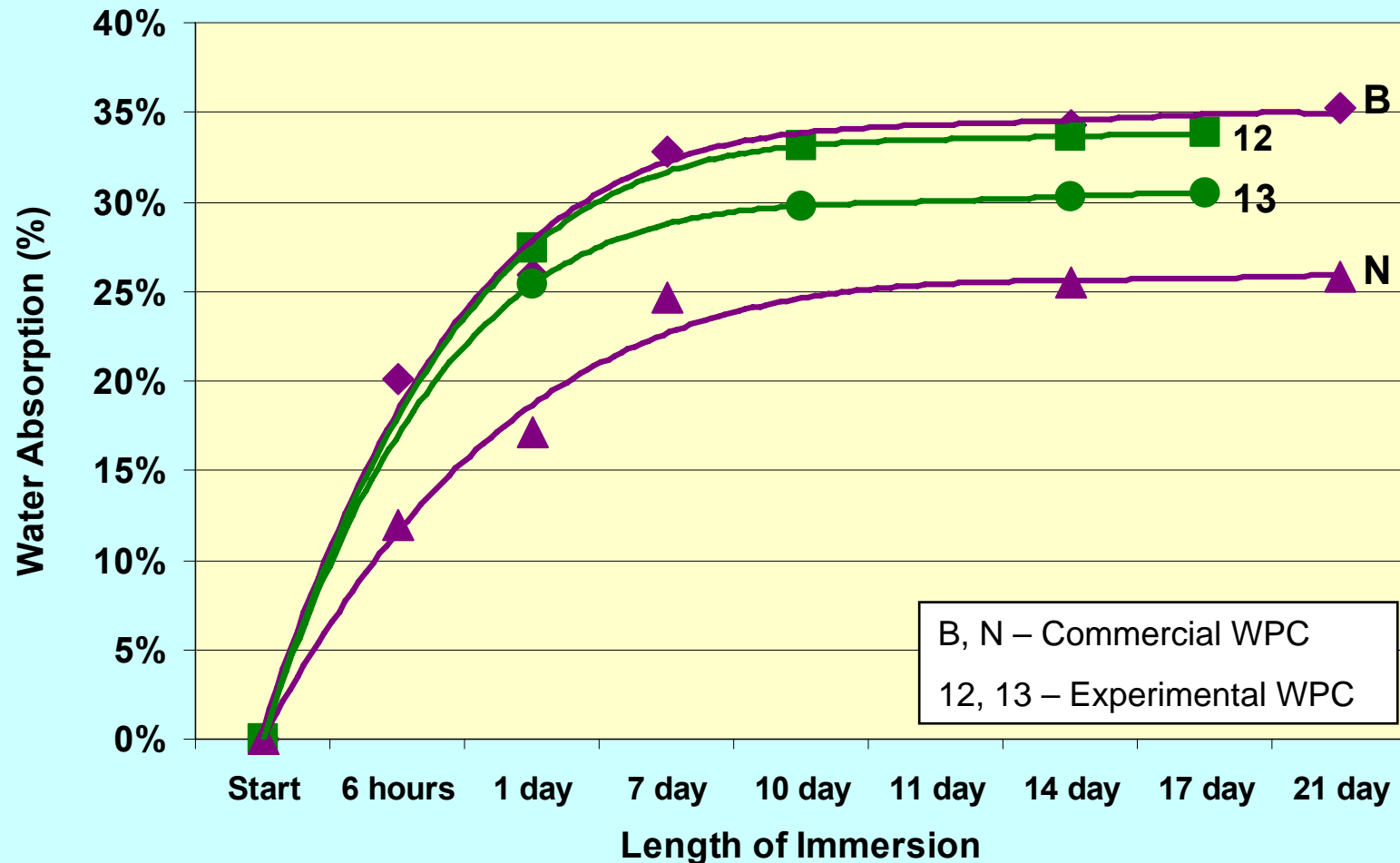
# Sample Preparation

Comparison of kinetics of water absorption for experimental materials and commercial WPC's



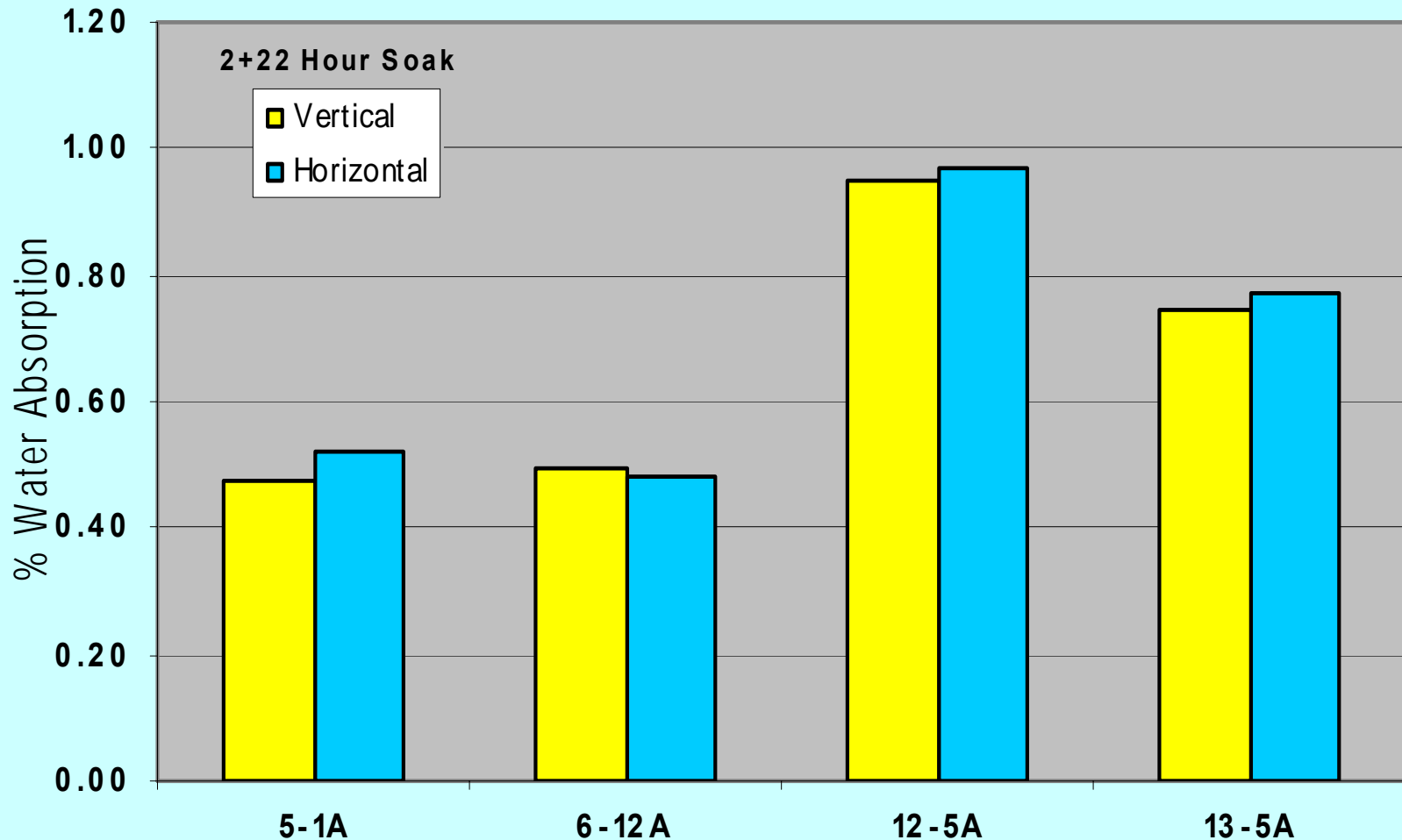
# Sample Preparation

Comparison of kinetics of water absorption for experimental materials and commercial WPC's

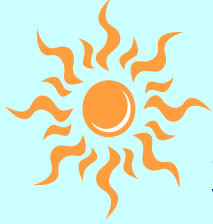


# *Water Absorption Evaluation*

## Water Absorption Tested According to ASTM D-1037

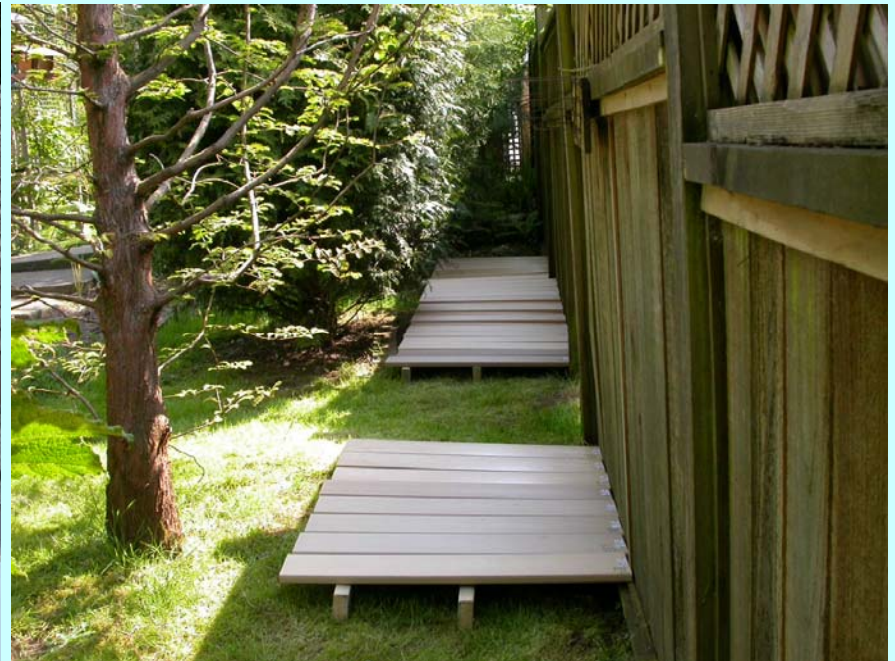
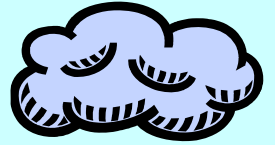


# *Exterior Exposure*



Sun  A

Shadow  B

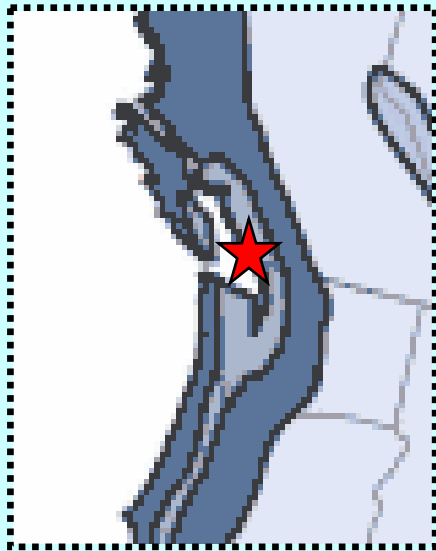


# Exterior Exposure

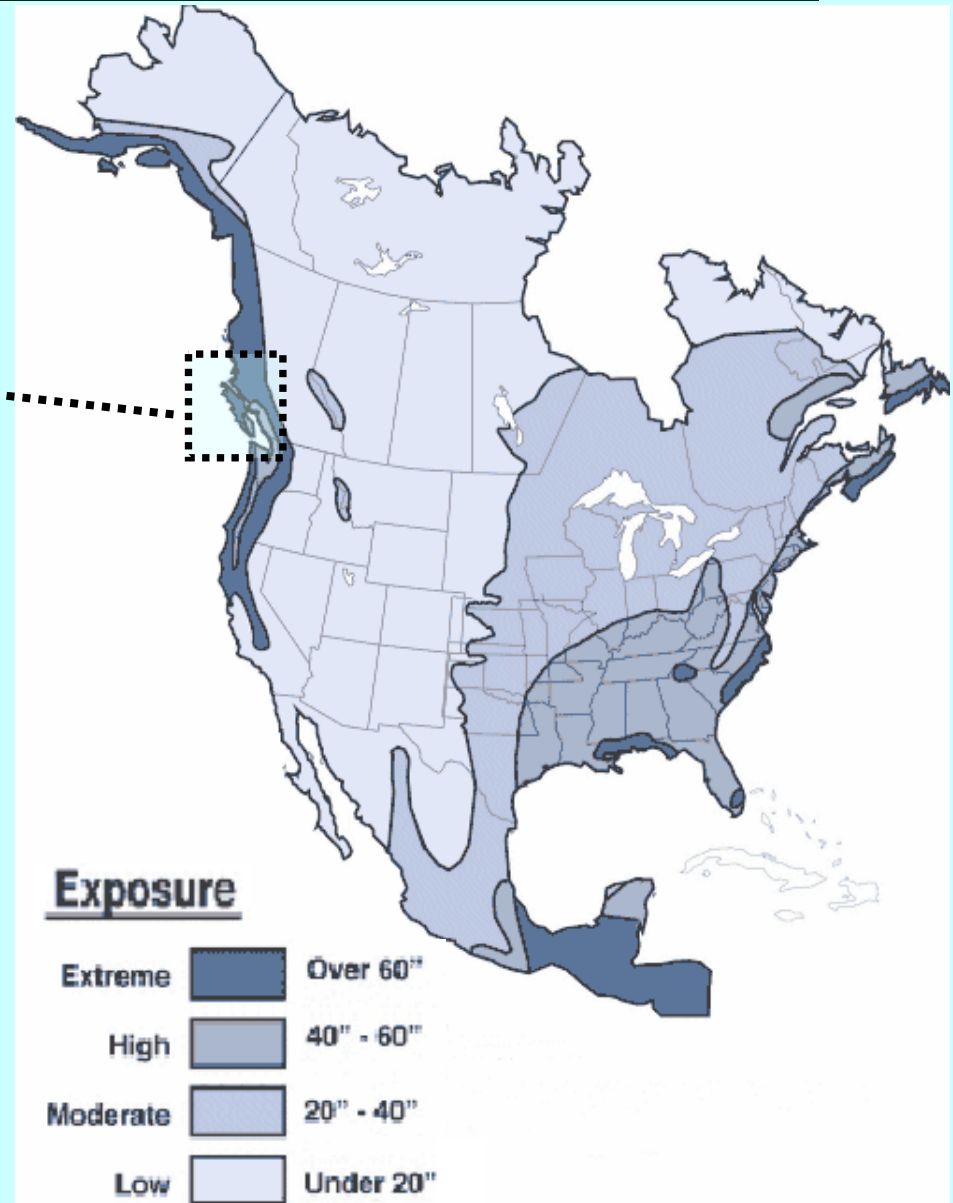
## Weather data for exposure period in Vancouver, BC\*

Month	2003			2004			2005		
	Mean Temp °C	Total Rain	Total Snow	Mean Temp °C	Total Rain	Total Snow	Mean Temp °C	Total Rain	Total Snow
Jan	-	-	-	4.1	151.6	0	3.7	229	17.6
Feb	-	-	-	5.9	83.4	0	-	-	-
Mar	-	-	-	8.1	101.2	0	-	-	-
Apr	-	-	-	11.1	15.0	0	-	-	-
May	12.6	49.3	0	14.1	60.8	0	-	-	-
June	16.8	12.8	0	17.3	22.8	0	-	-	-
July	19.1	19.8	0	19.7	16.6	0	-	-	-
Aug	18.6	4.1	0	19.3	75.0	0	-	-	-
Sept	15.8	40.2	0	14**	64.4**	0	-	-	-
Oct	11.6	248.2	0	10.8	117.2	0	-	-	-
Nov	4.6	167.4	0	6.8	199.6	0	-	-	-
Dec	4.4	97.2	5	5.3	188.2	0	-	-	-
2004 total rainfall					1096 mm 43.15 in		*Environment Canada **Multiyear average		

# *Annual Rainfall Map of North America<sup>3</sup>*



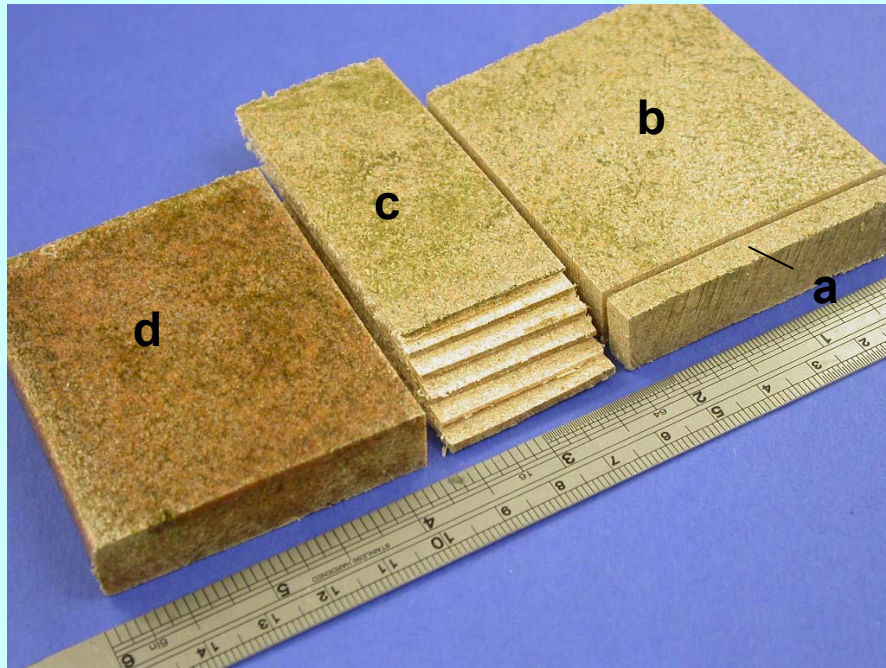
Exposure location  
in the Vancouver area  
2004 total rainfall 43.15 inches



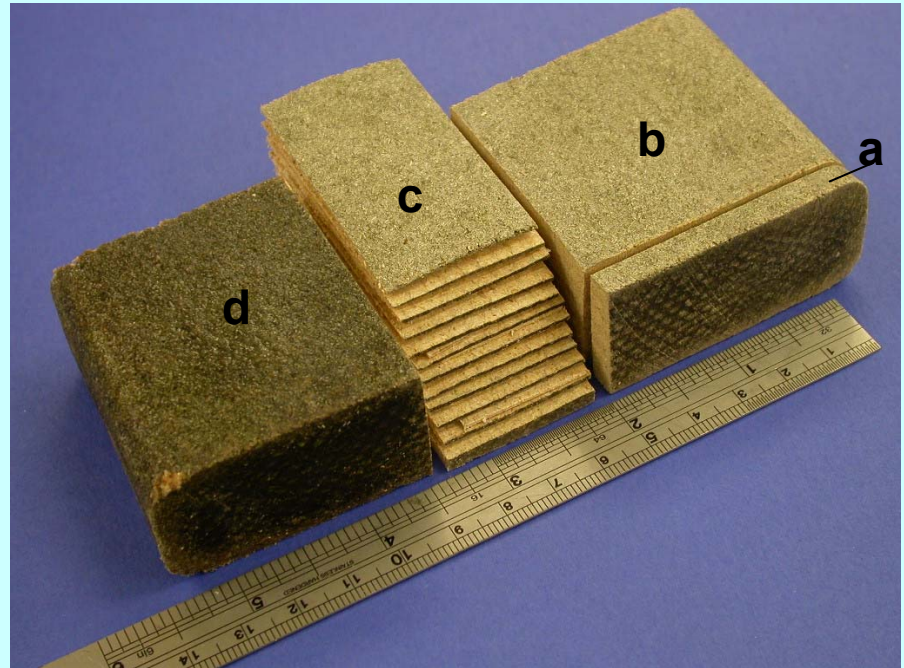
# *Water Absorption/Moisture Content Evaluation*

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## Specimen preparation #5 and #6

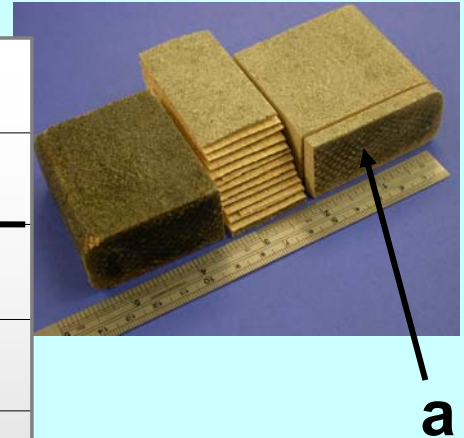
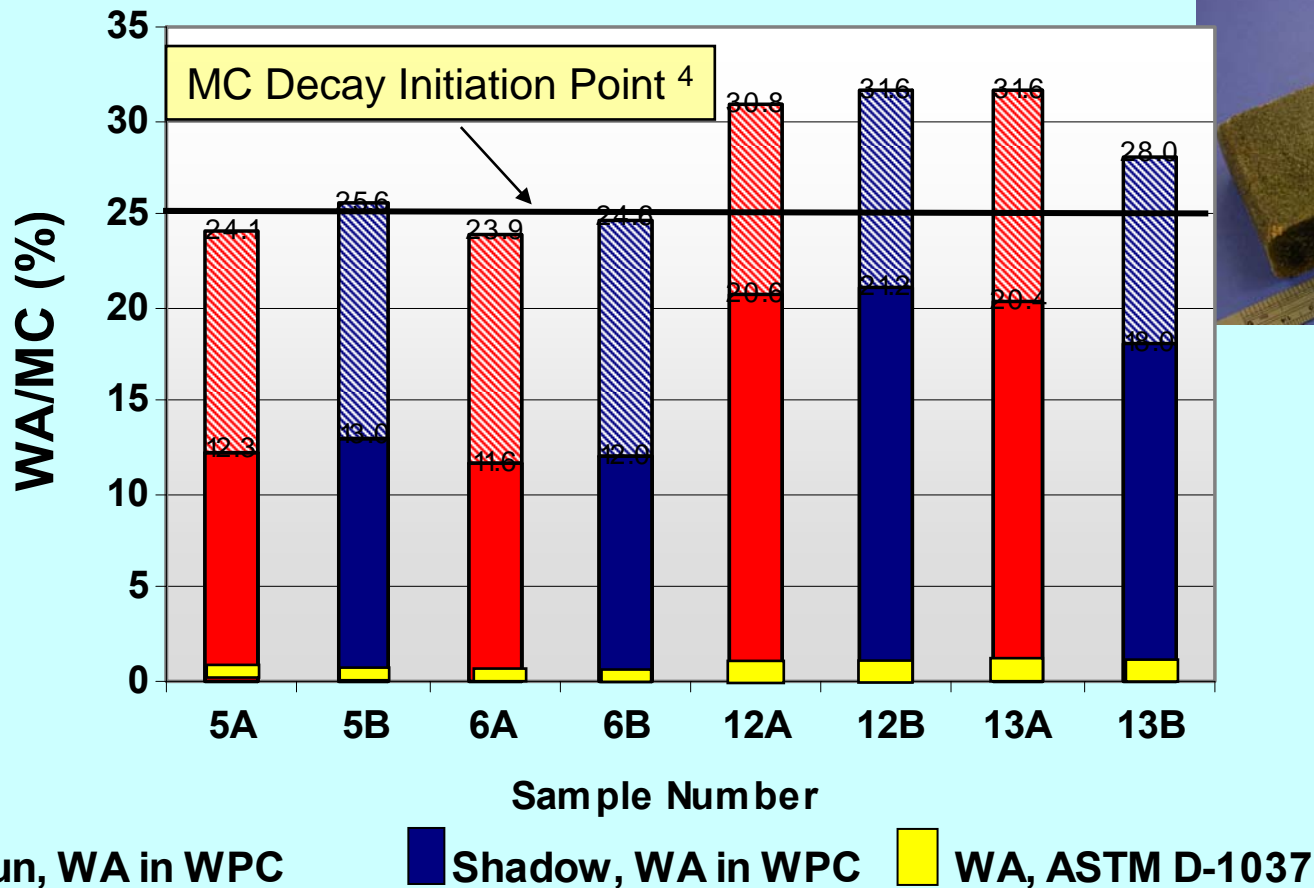


## Specimen preparation #12 and #13



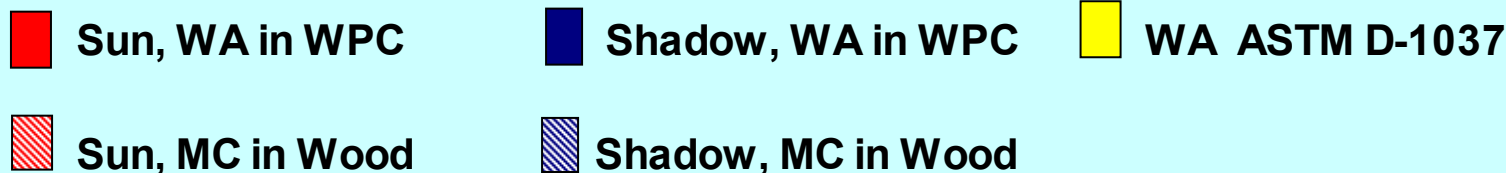
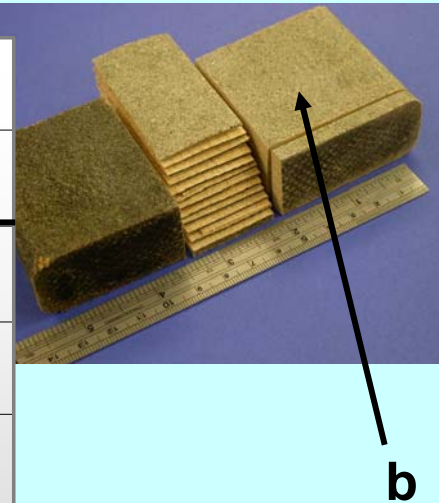
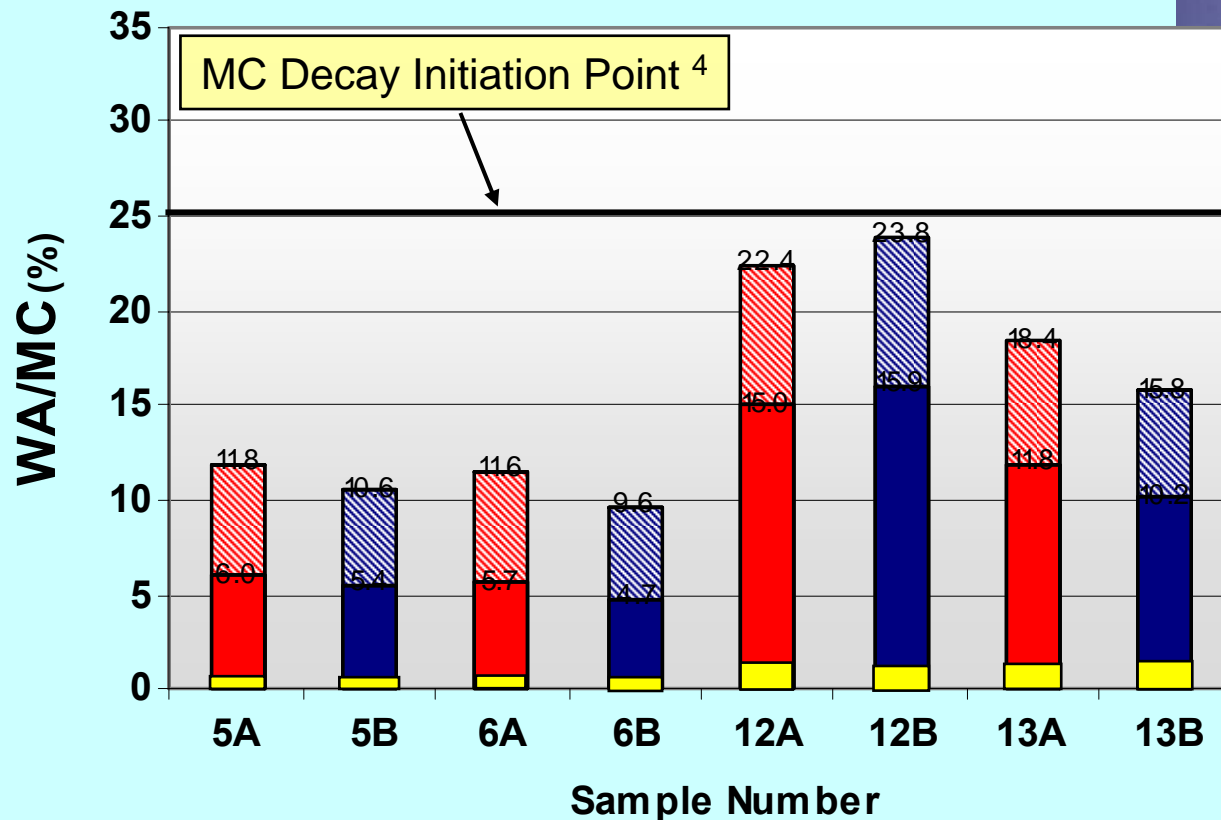
# Water Absorption/Moisture Content Evaluation

Water absorption in WPC and moisture content in wood of sections a



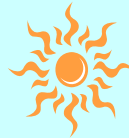
# Water Absorption/Moisture Content Evaluation

Water absorption in WPC and moisture content in wood of sections b

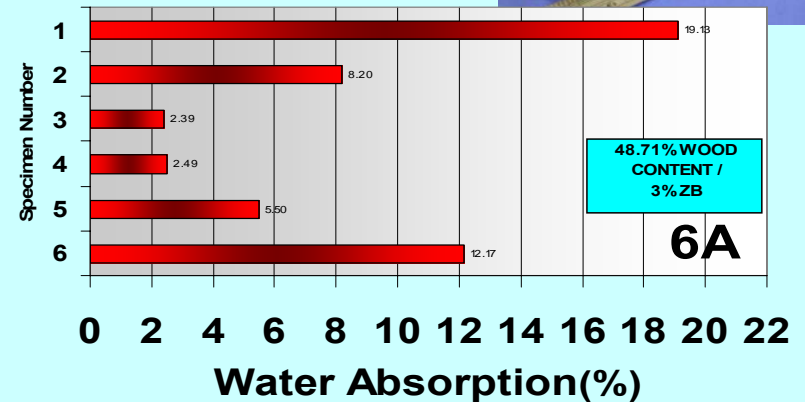
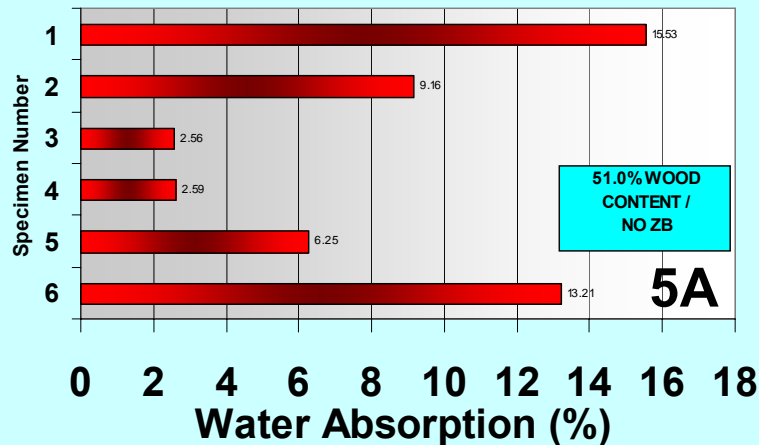


# Water Absorption in WPC

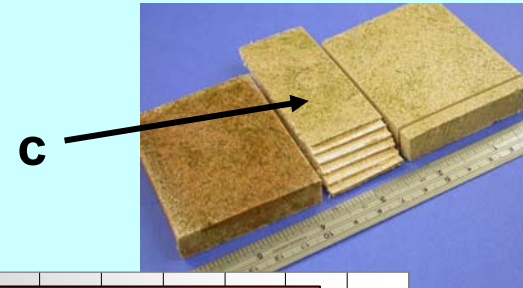
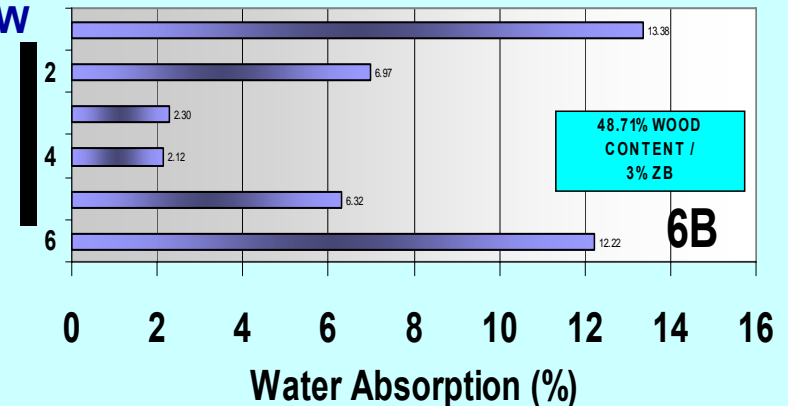
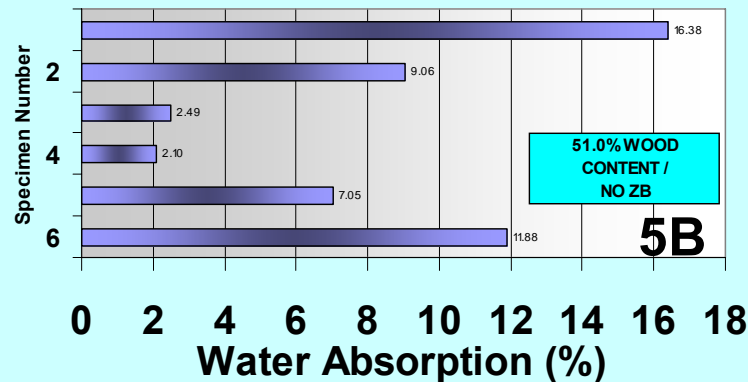
## Distribution of moisture in tested specimens c



SUN

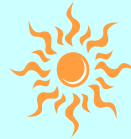


SHADOW

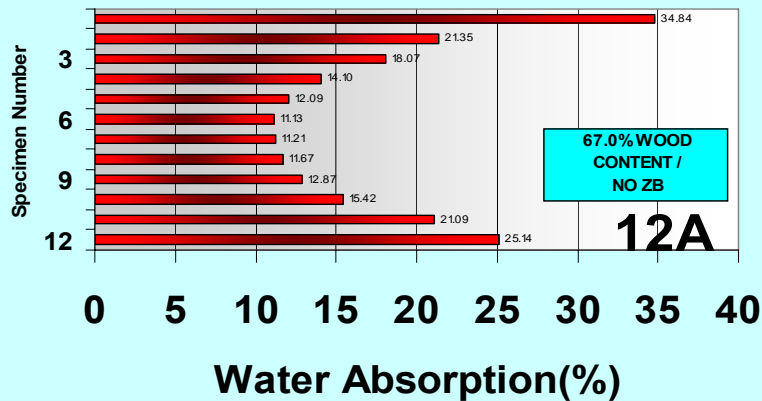


# Water Absorption in WPC

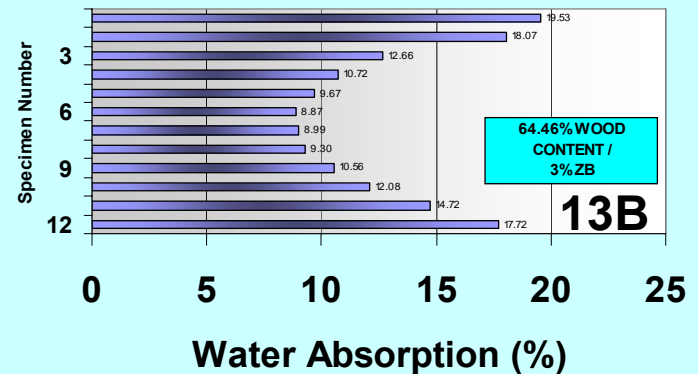
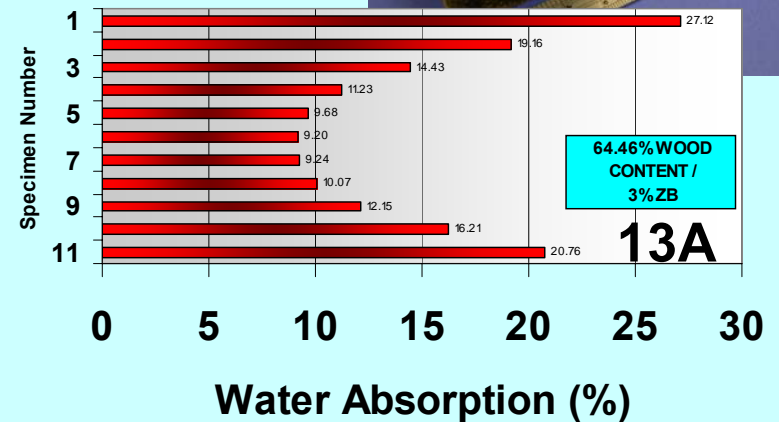
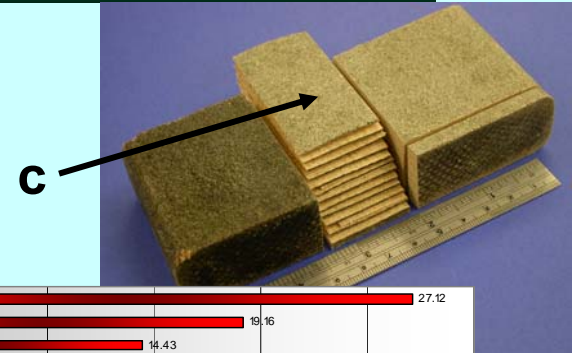
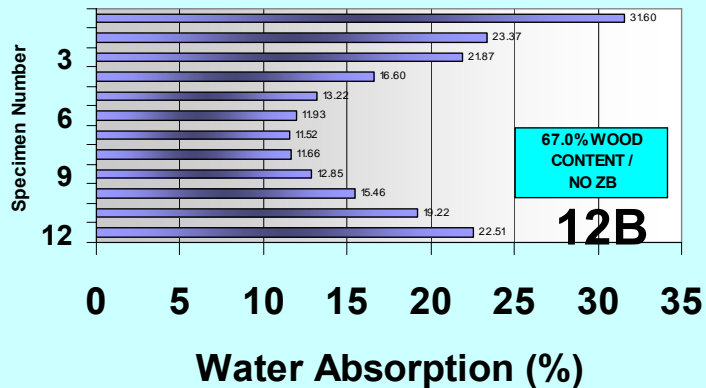
## Distribution of moisture in tested specimens c



SUN

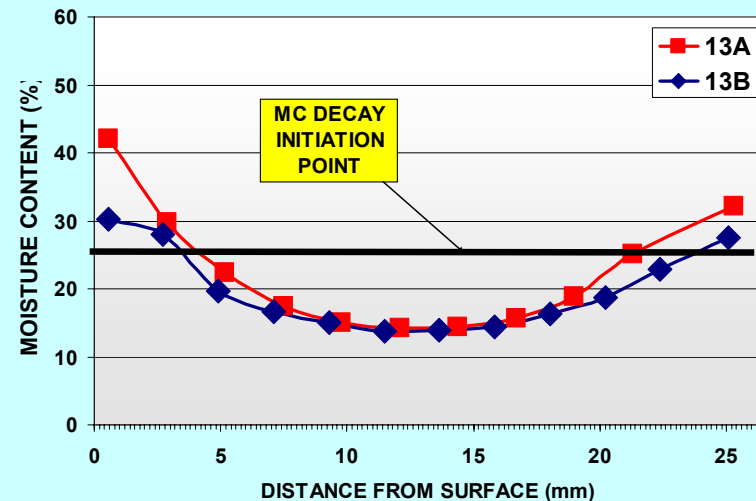
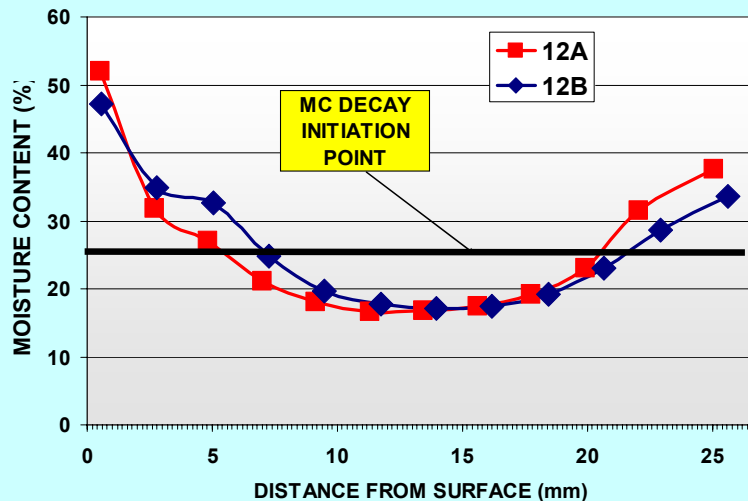
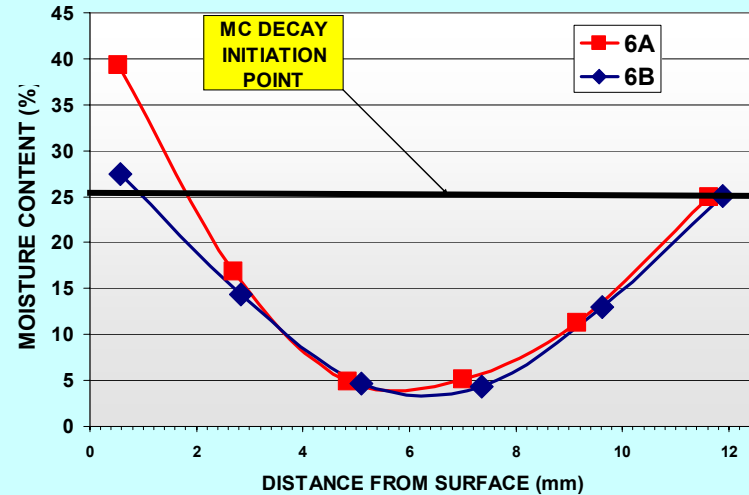
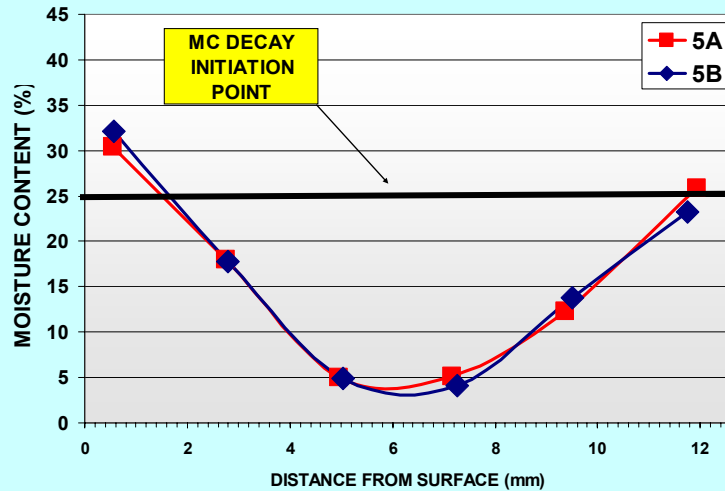


SHADOW



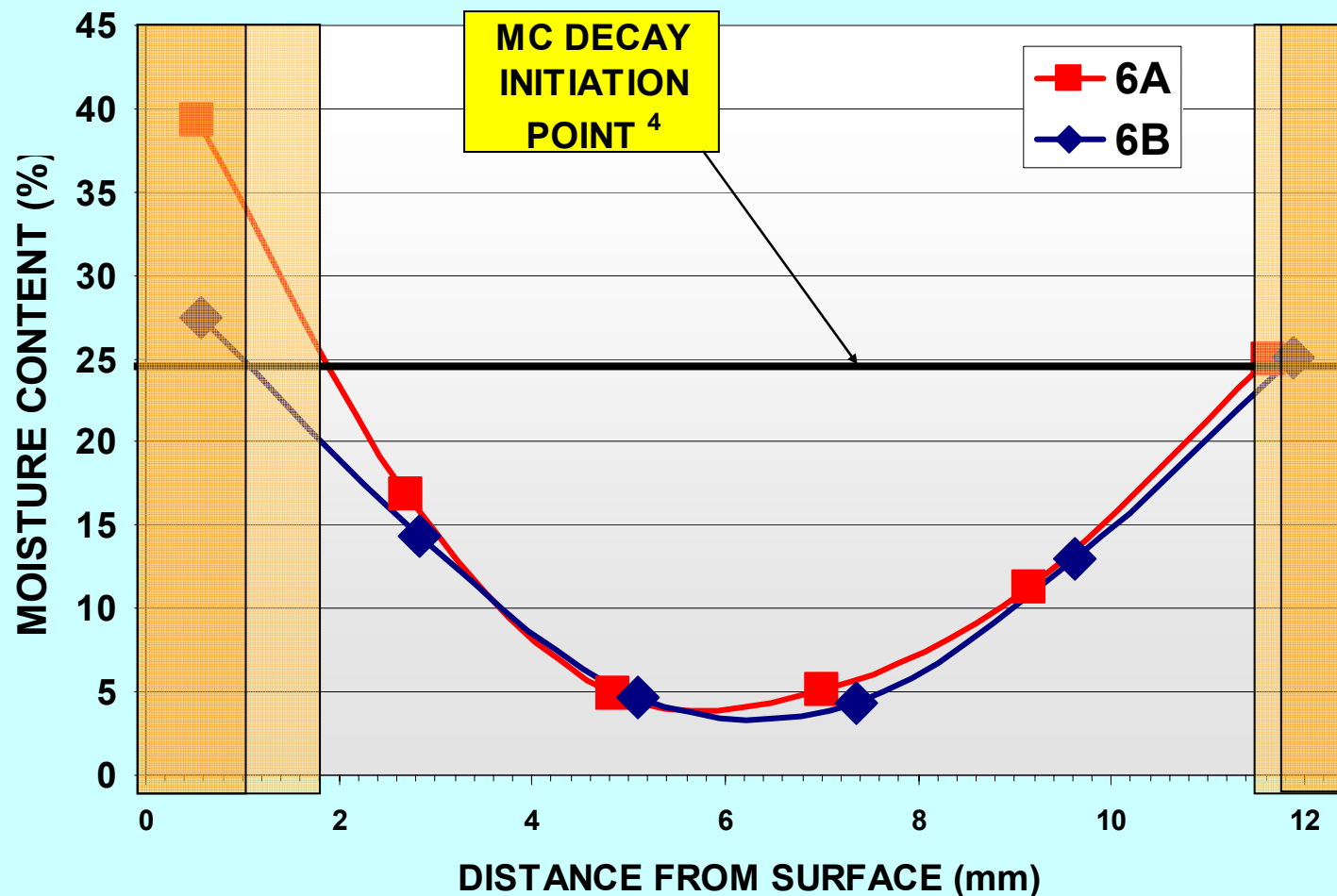
# Moisture Content in Wood

## Distribution of moisture content in wood of WPC exposed in sun and shadow



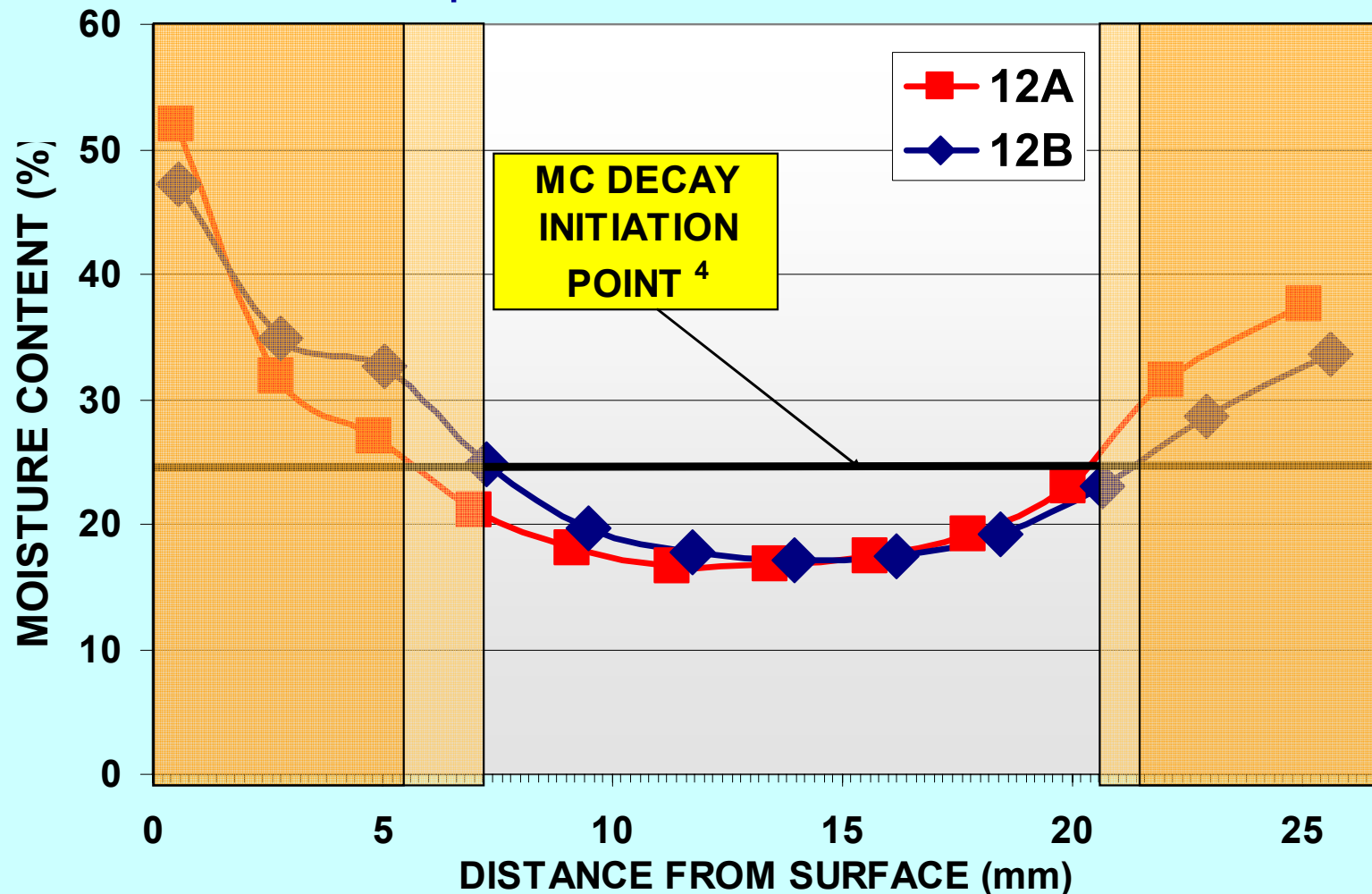
# Moisture Content in Wood

Distribution of moisture content in wood of WPC #6  
exposed in sun and shadow



# Moisture Content in Wood

Distribution of moisture content in wood of WPC #12  
exposed in sun and shadow



## *Comments and Conclusions*

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1. There seems to be no obvious correlation between water absorption of WPC as measured according to ASTM D-1037 and moisture content in the same materials exposed to exterior conditions. Samples tested according to ASTM D-1037 showed approximately 1% water absorption, while the same material exposed to exterior conditions may absorb 15% water in the bulk of composite.
2. Wood plastic composite will absorb a significant amount of moisture when exposed to an exterior environment. Water is distributed unevenly across the board. The core may have very low moisture content while the surface layer may be significantly saturated with water

## *Comments and Conclusions*

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3. Moisture content in the wood of WPC exposed to exterior conditions may significantly exceed 25% in some areas. 25% is widely accepted as minimum to initiate the decay process. The areas of high moisture content frequently exceeding 25% are the board ends and the region up to 1-7 mm below the board surface.
4. Material sensitivity to water entry depends on the material formulation and likely the processing conditions. Higher wood concentration may promote water absorption and increase the thickness of the layer with high moisture content.
5. The presence of zinc borate in the formulation seems to reduce water absorption by WPC.

# *Acknowledgements*

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Polymer Engineering Company Ltd. Staff

David Lesewick  
Beverley Start

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Presentation will be available on the PEC website

[www.polymerengineering.ca](http://www.polymerengineering.ca)