MODERN INSTRUMENTAL METHODS TO INVESTIGATE THE MECHANISM OF BIOLOGICAL DECAY IN WOOD PLASTIC COMPOSITES

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OUTLINE

- Objective
- \succ CT Imaging \rightarrow void analysis
 - > Laboratory (experimental) samples
 - Field (commercial) samples
- MR Imaging
 - Field (commercial) samples
- Conclusions
- Acknowledgements

OBJECTIVE

To investigate novel nondestructive approaches for evaluating internal damage and moisture content in wood plastic composites (WPC) →with a focus on decay

- Micro- and Nano- X-ray
 Computed Tomography (CT)
- Magnetic Resonance Imaging (MRI)





EXAMPLES OF DECAY IN FIELD WPC'S



Everglades, FI; Gnatowski



Everglades, FI; Gnatowski



Hilo, HI; Gnatowski









Hilo, HI; Laks

Everglades, FI; Morris

INSPECTION OF FIELD SAMPLES

Comparison of commercial decking board reference and exposed cross-sections did not seem to show decay



Reference

Field → 68% wood loss Exposed

CT IMAGING: LABORATORY SAMPLES

Various void analysis perspectives of Lab Reference sample



3D volume

> 2D slice

CT IMAGING: LAB REFERENCE

Defect volume [mm ³]
0.020
0.016
0.014
0.012
0.010
0.008
0.006
0.004
0.002
0.000



CT IMAGING: LAB CONDITIONED





2D slice \rightarrow

←3D volume





CT IMAGING: LAB CONDITIONED & DECAYED

		←3D volume
Defect volume [mm ³] 4.000		Detecteducid
3.600	A Charles and	Detected void
3.200		volume: 12.3%
2.800		March 1
2.400		John Strand Strand
2.000		and the state of the state
1.600		
1.200	2D slice \rightarrow	
0.800		
0.400		Contraction of the second
0.000		and the second second
		A MANA

CT IMAGING: 2D SLICES IN CORE VOID VOLUMES

Defect volume [mm³] 0.020 0.018 0.016 0.014 0.012 0.010 0.008 0.006 0.004 0.002 0.000

Lab Reference

³] Detected void volume: 2.3%

Defect volume [mm³] 4.000 3.600 3.200 2.800 2.400 2.000 1.600 1.200 0.800 0.400

0.000

Lab Cond.&Decayed

Detected void volume: 11.4%

CT IMAGING: REFERENCE FOR FIELD SAMPLE

Defect volume [mm ³]
2.000
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000



2D slice \rightarrow

←3D volume

Detected void volume: 4.9%



CT IMAGING: FIELD SAMPLE (8YRS IN HAWAII)

		←3D volume
Defect volume [mm ³] 2.000	mm"].	Detected void
0.180		volume: 28.7%
0.160		
0.140		
0.120		
0.100		
0.080		
0.060	2D slice →	
0.040	· ····································	
0.020		
0.000		
	2 S .	

SEM VERIFICATION OF DECAY IN FIELD SAMPLE

- Fungi were present in voids in all examined areas of the Field Exposed sample
- > Wood was heavily degraded with severe destruction



MR IMAGING: FIELD EXPOSED (8YRS IN HAWAII)







CONCLUSIONS

- X-ray CT is an effective method for imaging the internal structure of WPC's and detection of voids, including those associated with decay
- MRI is an effective method for detecting free water distribution in WPC's
- A significant degree of WPC damage by decay was found in a commercial decking board exposed for 8 years in Hawaii
 - Moisture content and distribution of this material provide insight into the mechanism of decay

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QUESTIONS?

CT IMAGING: LABORATORY SAMPLES

Experimental formulation containing 66% pine wood flour and 24% HDPE, with UV stabilizers

- Lab Reference (8R2)
- Lab Conditioned* (8G2)
- Lab Conditioned* and Decayed (8F2)

Sample	Void Volume [%]	Detected Vol. Range [mm ³]
Lab Reference	1.7% (0.5)	2.8 x 10 ⁻⁶ - 1.9 x 10 ⁻²
Lab Conditioned	3.8% (1.2)	2.8 x 10 ⁻⁶ - 0.81
Lab Cond.&Decayed	12.5% (1.2)	2.8 x 10 ⁻⁶ - 4.9
*Water immersion for	() std dev.	

CT IMAGING: FIELD SAMPLES

Commercial decking board with 53% wood flour
 Reference (1000R)
 Field-Exposed (1000B)

->shadow site near Hilo, Hawaii for 8 years

Sample	Void Volume [%]	Detected Vol. Range [mm ³]
Reference	5.4% (4.3)	8.0 x 10 ⁻⁶ - 0.52
Field-Exposed	31.3% (4.9)	8.0 x 10 ⁻⁶ - 15
,,,,,,,,,,,,,,,,,,		() std dev.

HISTORICAL DATA FOR FIELD SAMPLE



NANO-CT IMAGE OF FIELD SAMPLE

