Durability of Zinc Borate Incorporated WPC: Laboratory and 7-year Field Test Results

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6-7 September 2017,
COST FP1303 Meeting, Zagreb, Croatia.

Importance of WPCs

- Increased utilization of WPCs
  - Gaining acceptance in construction
  - New composite technologies
  - Very high market growth rate (up to 20% per year)
- Protection requirements for WPCs
  - Originally marketed as “maintenance free” or “low maintenance” and durable
  - Must be protected against weathering, biological agents (decay fungi, termites) if used in outdoor environments

WPC durability depends on

- Wood/polymer ratio
- Wood particle size
- Moisture content during service life
- Photo/thermal degradation
- Fabrication method

Major protection methods for WPC

- Incorporating biocide during the manufacturing (in-line or in-process treatments)
- Utilization of treated wood
- Modified wood
- Heat treated wood

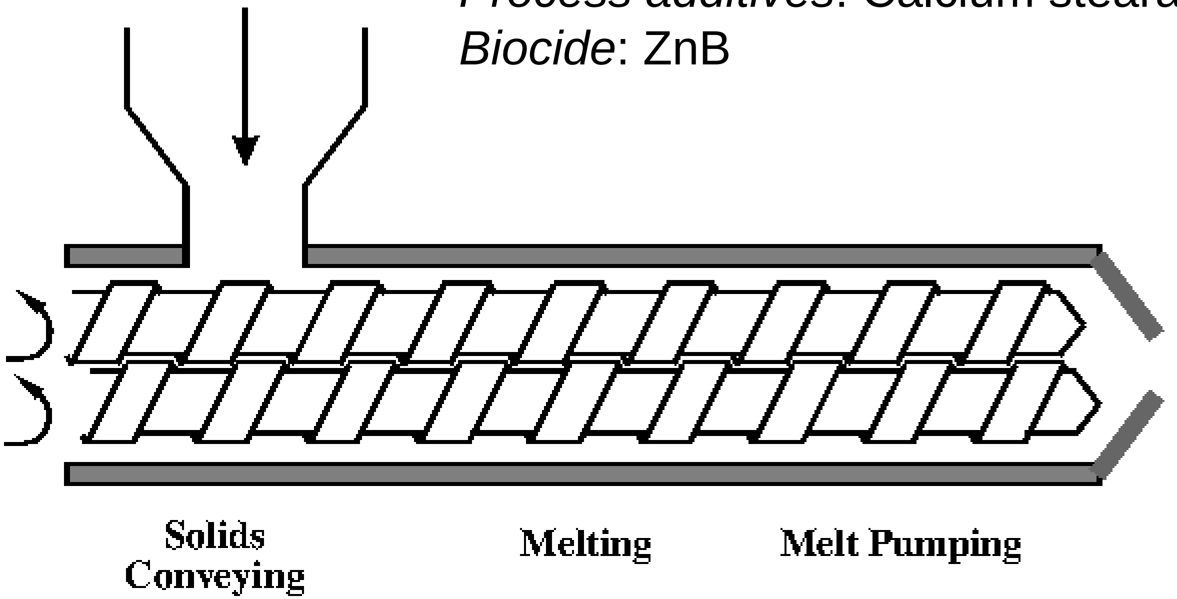
Objectives

- examine feasibility of incorporating zinc borate (ZnB) during manufacturing of WPCs
- investigate the effectiveness of ZnB on biological performance of WPCs in laboratory and field tests
- study effects of wood particle size and surface grooves for moisture infusion
- To inquire long term field test data (10 years)

Materials and Methods

WPC manufacturing process

Wood particles: 30 and 60 mesh Scotts pine
Polymer: Polypropylene (PP)
Process additives: Calcium stearate, wax, pigments
Biocide: ZnB



Twin-screw extruder

Grinding

Pressing

Fabrication details of WPCs

WPC type	Wood content (%)	Particle size (mesh)	PP content (%)	Processing additive (%)	Zinc borate (%)
1	51	60	42	7	0
2	51	30	42	7	0
3	70	60	23	7	0
4	70	30	23	7	0
5	69	60	23	7	1
6	69	30	23	7	1

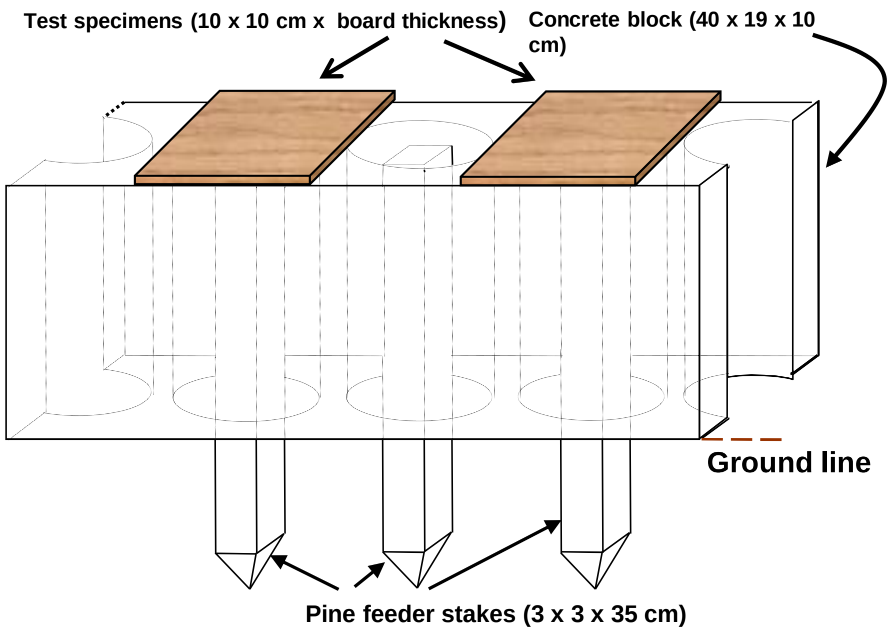
Selection of biocide

- Zinc borate (ZnB)
  - Low cost
  - Low water solubility (less leaching)
  - Resistance to high processing temperatures (e.g. extrusion, pressing)
  - Low environmental impact

Laboratory Tests

- Decay
  - JIS K 1557, white and brown rot
  - 20 (L) x 20 (W) x 4 (T) mm specimen size
  - 9 replicates for each WPC type, 3 months exposure
- Termite
  - JIS K 1557, *C. formosanus*, 150 workers + 15 soldiers, no-choice test,
  - 20 (L) x 20 (W) x 4 (T) mm specimen size
  - 3 replicates for each WPC type, 21 days exposure

Field Test



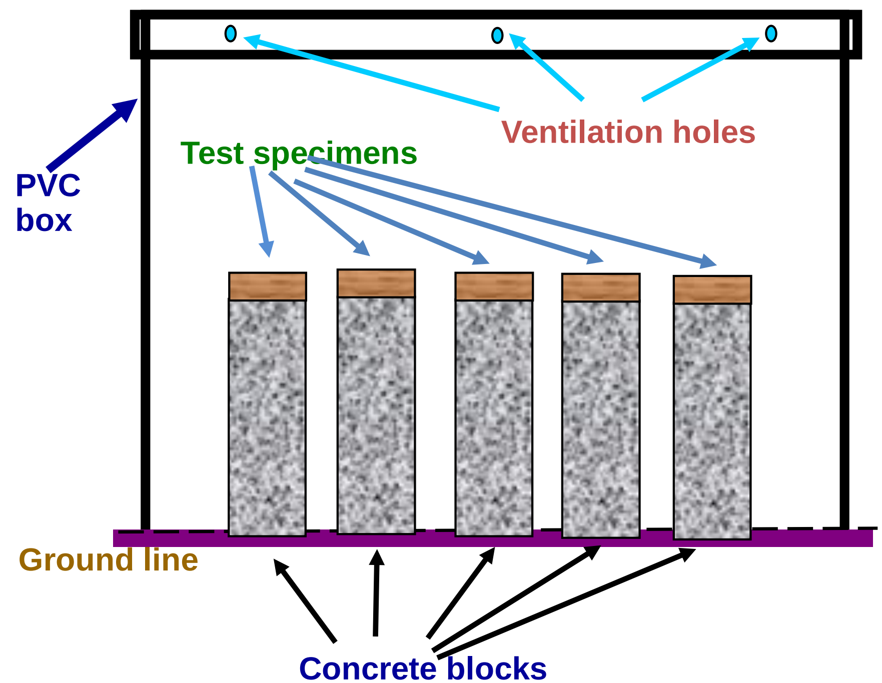
The Living Sphere Simulation Field (LSF) in Kagoshima Prefecture

Mean annual rainfall : 2265 mm

Mean annual temp.: 18ºC

Scheffer's climate index: 90

C. formosanus, R. speratus and wood-rotting basidiomycetes are present.

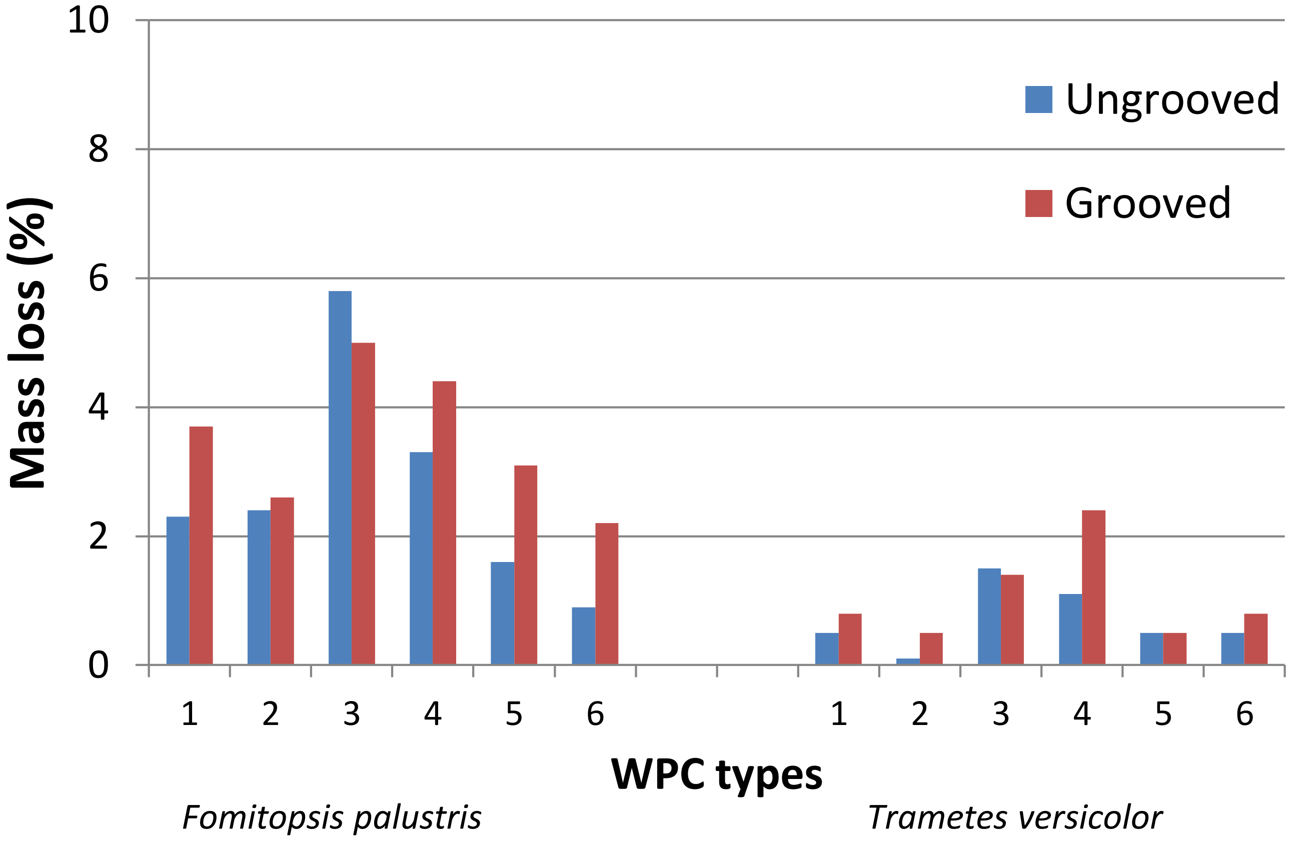


To simulate crawl space conditions in Japanese homes

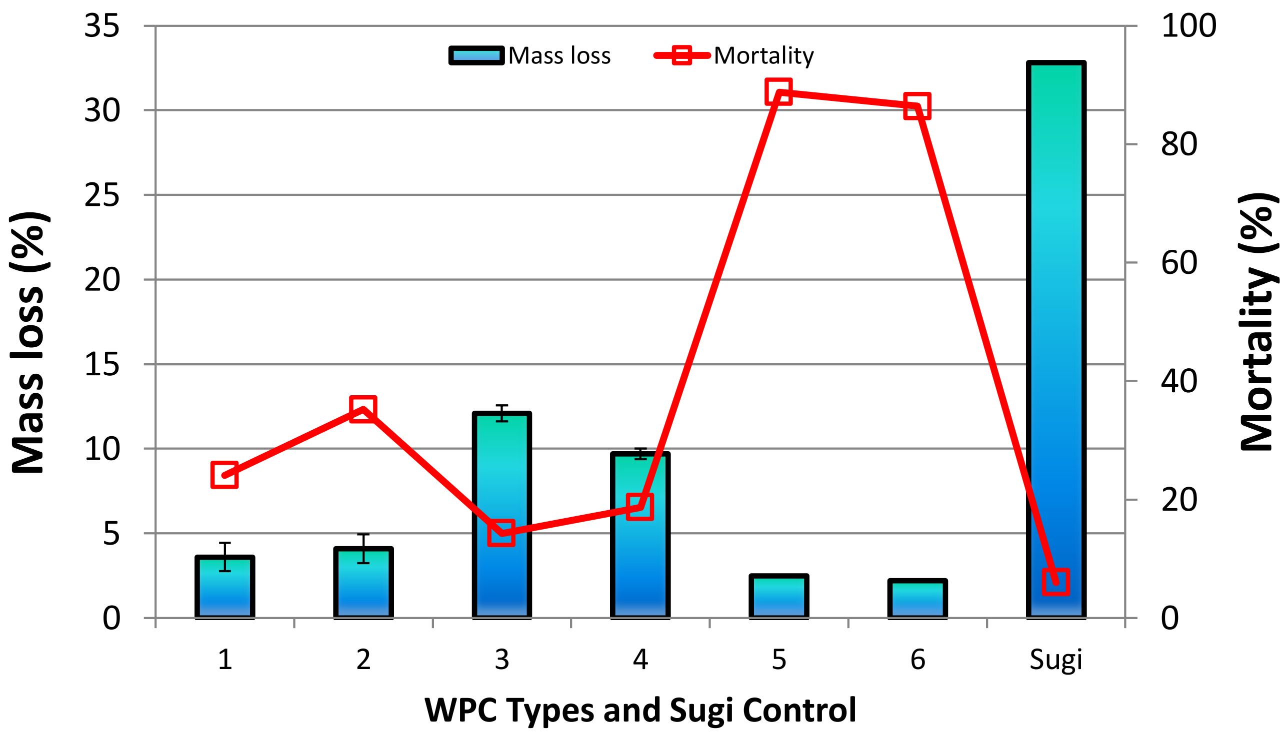
AWPA Rating; 10 sound, 9 Trace of attack, 7 Moderate attack, 4 Heavy attack, 0 Failure, disintegration of specimen

Results

Laboratory Decay Tests



Laboratory Termite Tests

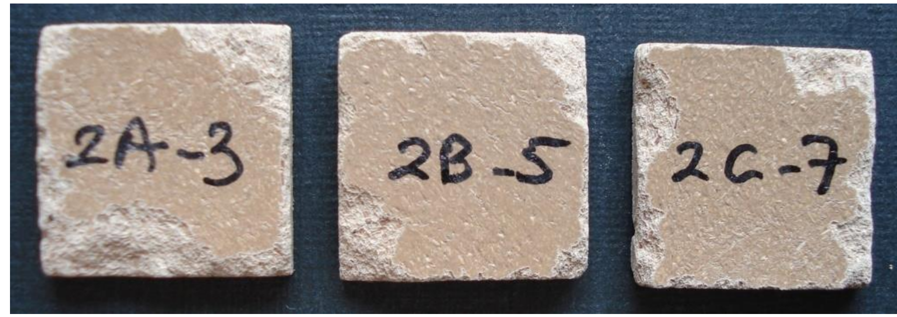


Damage Modes (Lab. Termite)

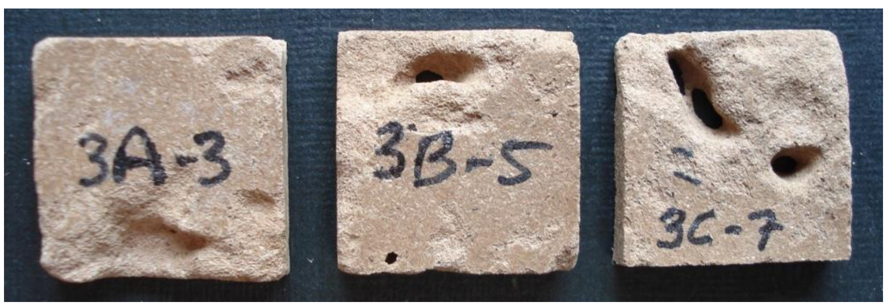
60 mesh

50/50

30 mesh

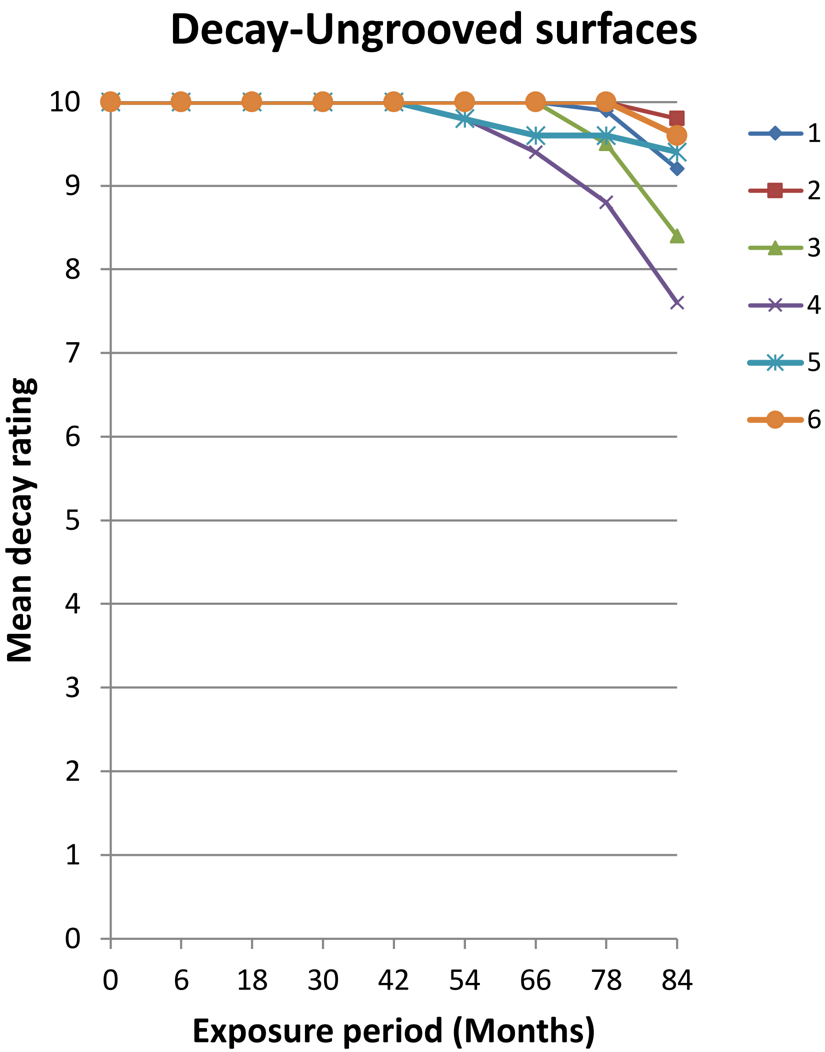


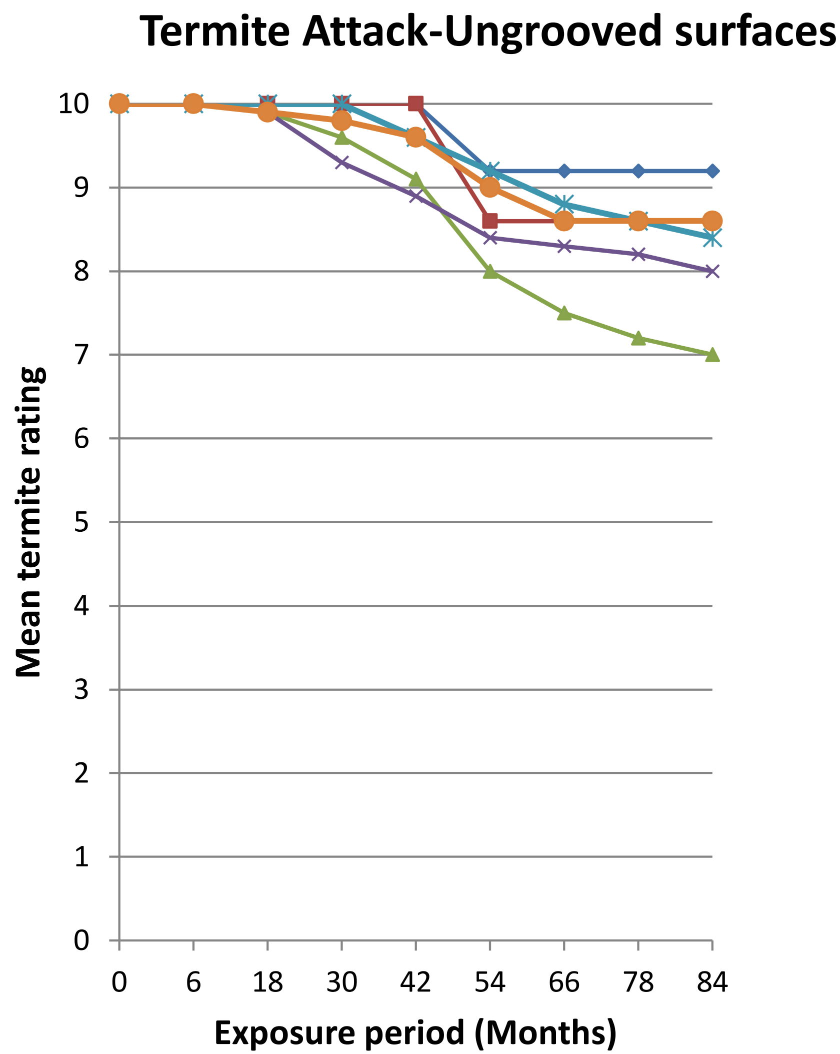
70/30



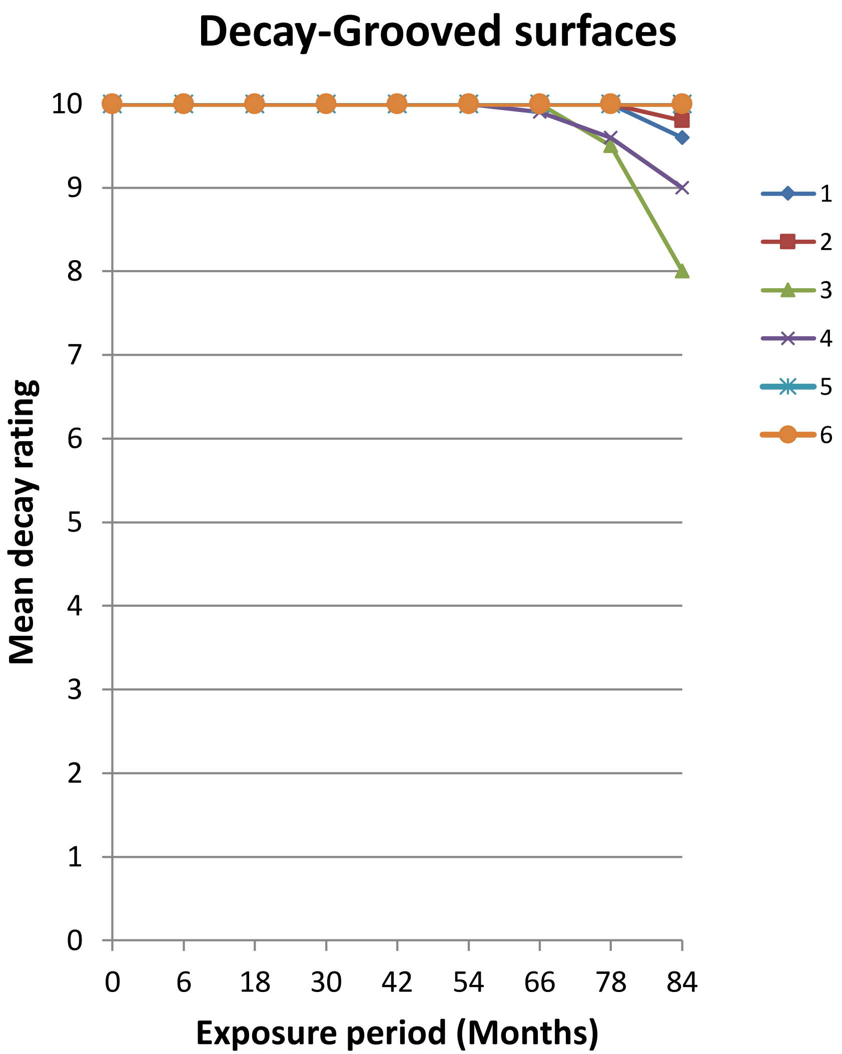
70/30 with 1% ZnB

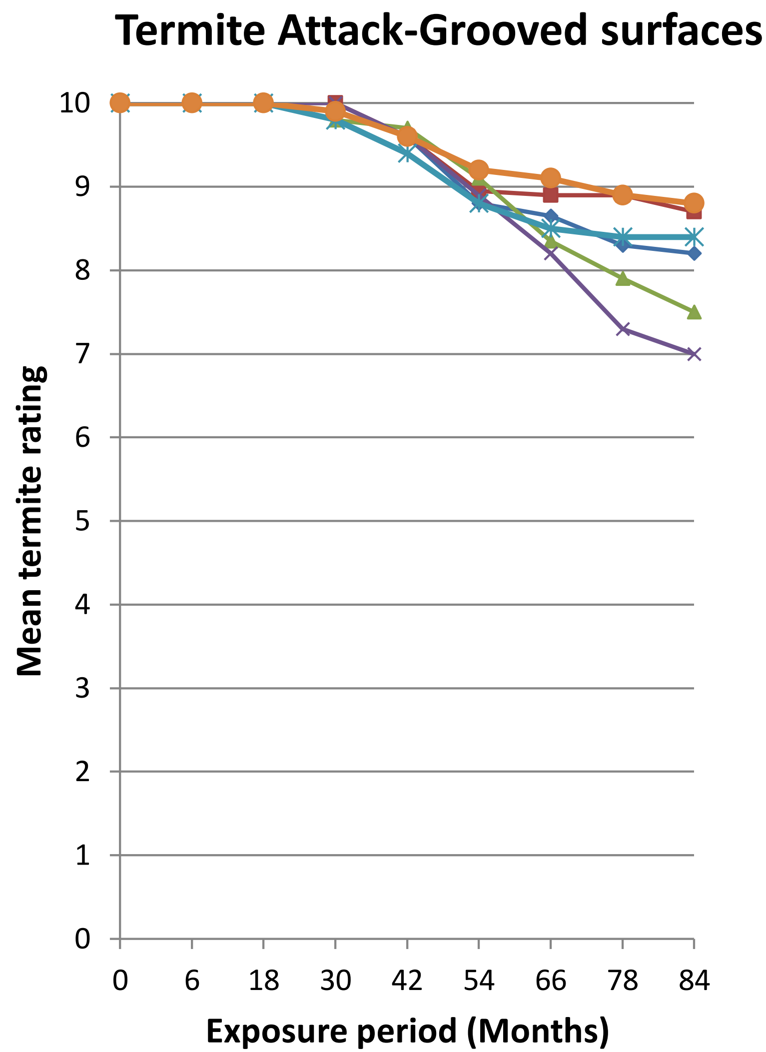
Field Tests (84 months exposure)



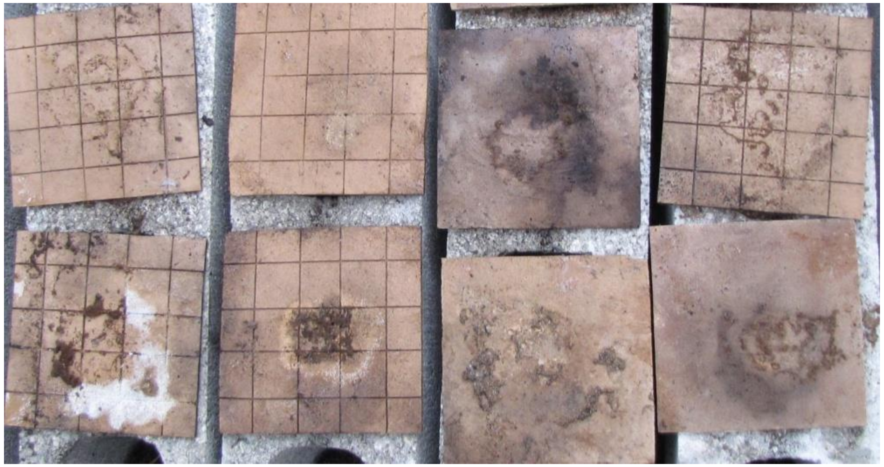


Field Tests (84 months exposure)





Field test results (84 months exposure)



Conclusions

- Unprotected WPCs are prone to biological attacks even the 50/50 formulations
- Mass loses activity increased with increased wood content, surface groves affected mass loss for only T. versicolor, wood particle size was ineffective on decay activity but significantly effect mass loss in laboratory termite test (60 mesh seemed to be consumed easily by termites)
- Incorporation of ZnB at 1% level significantly reduced mass losses even in high wood content formulations
- In the filed tests, termite damage started earlier and the severity of attack was always higher than fungal decay. Termite damage was started much earlier (after 24 months), fungal damage was visible after 54 months exposure. No significant differences between grooved and ungrooved surfaces.
- ZnB addition slowed down termite damage but was not enough to provide full protection except the first 36 months of exposure.

Acknowledgements

For my current collaboration and field tests

- Prof. Tsuyoshi Yoshimura
- Mr. Aiko Adachi
- Mr. Masami Kato from Misawa Homes Co. Ltd.
- Staff and graduate students in the RISH laboratory, Kyoto University.

THANK YOU FOR YOUR TIME