Ecole d'ingénieurs et d'architectes de Fribourg
Hochschule für Technik und Architektur Freiburg

Institute of Construction and Environmental Technology iTEC

Use of wood waste as a resource for structural wood concrete compounds

Niccolò Macchi / Daia Zwicky

Hes·so // Fribourg Freiburg
Haute Ecole Spécialisée de Suisse occidentale
Fachhochschule Westschweiz

COST FP1303 meeting in Kranjska Gora • Octobre 2014

Resource Wood
National Research Programme NRP 66

- interdisciplinary approach to the wood resource
  - from wood-chemistry to wooden buildings
- making wood more competitive compared to other materials

www.nrp66.ch

Module 5: Wood-based structures and buildings

Project Zwicky: Wood and wood-based concrete

iTEC Institute of Construction and Environmental Technology

Why use timber in urban construction?

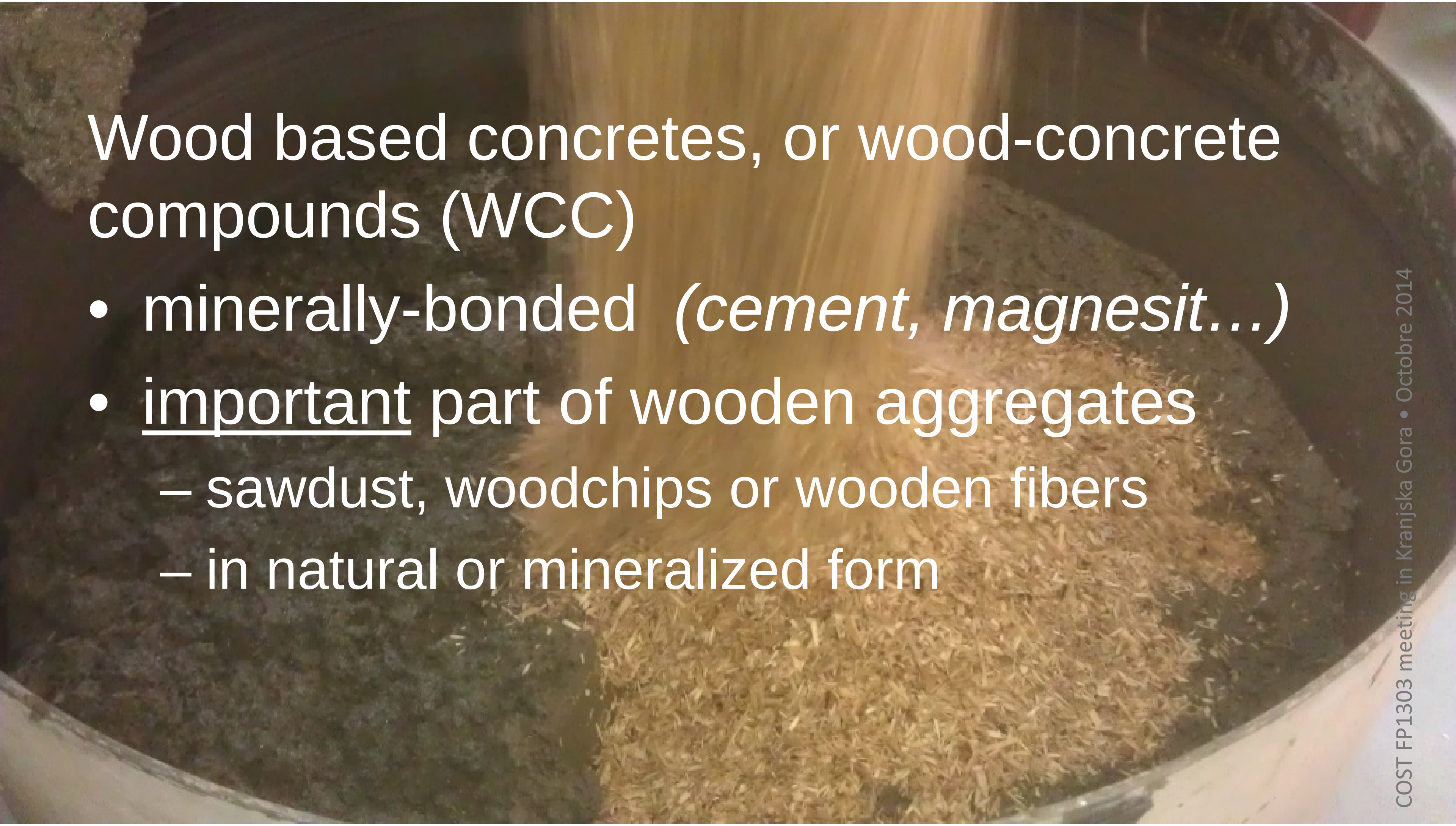
- Speed of construction
- Clean building site
  - Less interference in Urban environment
- High quality control in timber prefabrication
- Problems with fire safety codes & some building physical problems

What we want to achieve

- Replacement of traditional concrete in (prefabricated) timber structures with wood-concrete compounds
- Benefits :
  - Optimization of “waste” management in timber construction
  - Thermal and sound insulation
  - Fire protection
  - Light weight
  - Partially combustible material (recycling)
    - resource for clinker production?

➢ Hybrid, multi-layer construction system with wood-concrete compounds and timber

What are WCC



Wood based concretes, or wood-concrete compounds (WCC)

- minerally-bonded *(cement, magnesit…)*
- important part of wooden aggregates
  - – sawdust, woodchips or wooden fibers
  - – in natural or mineralized form

Problems of existing WCC

- Usually in form of prefabricated boards
- Board sizes around 3.5 m x 1.25 m
- Structural connections between multiple layers of boards difficult, expensive and environmentally challenging
  - (epoxies, steel screws…)

Sawdust-based castable WCC

- Untreated sawdust
  - economically advantageous
  - Sawdust from industrial processes can be used
- Good workability
- Current development : self-compacting WCC

Sawdust-based WCC

- Tested WCC compositions* with sawdust

	Saw dust	CEM I 52.5	Aluminate cement	t/c	Active charcoal	Water
1	105 kg	340 kg	--	0.33	--	190 kg
2	105 kg	340 kg	--	0.33	17 kg	190 kg
3	105 kg	--	340 kg	0.33	--	190 kg
4	105 kg	240 kg	100 kg	0.33	--	190 kg
5	110 kg	540 kg	--	0.20	--	190 kg
6	110 kg	540 kg	--	0.20	27 kg	190 kg
7	110 kg	--	540 kg	0.20	--	190 kg

- Active charcoal added for better compatibility of sawdust with Portland cement

*Inspired by: Urbonas, H. «TP 16: Holzbeton» Technical Univ. Munich TUM, Germany

Castable WCC

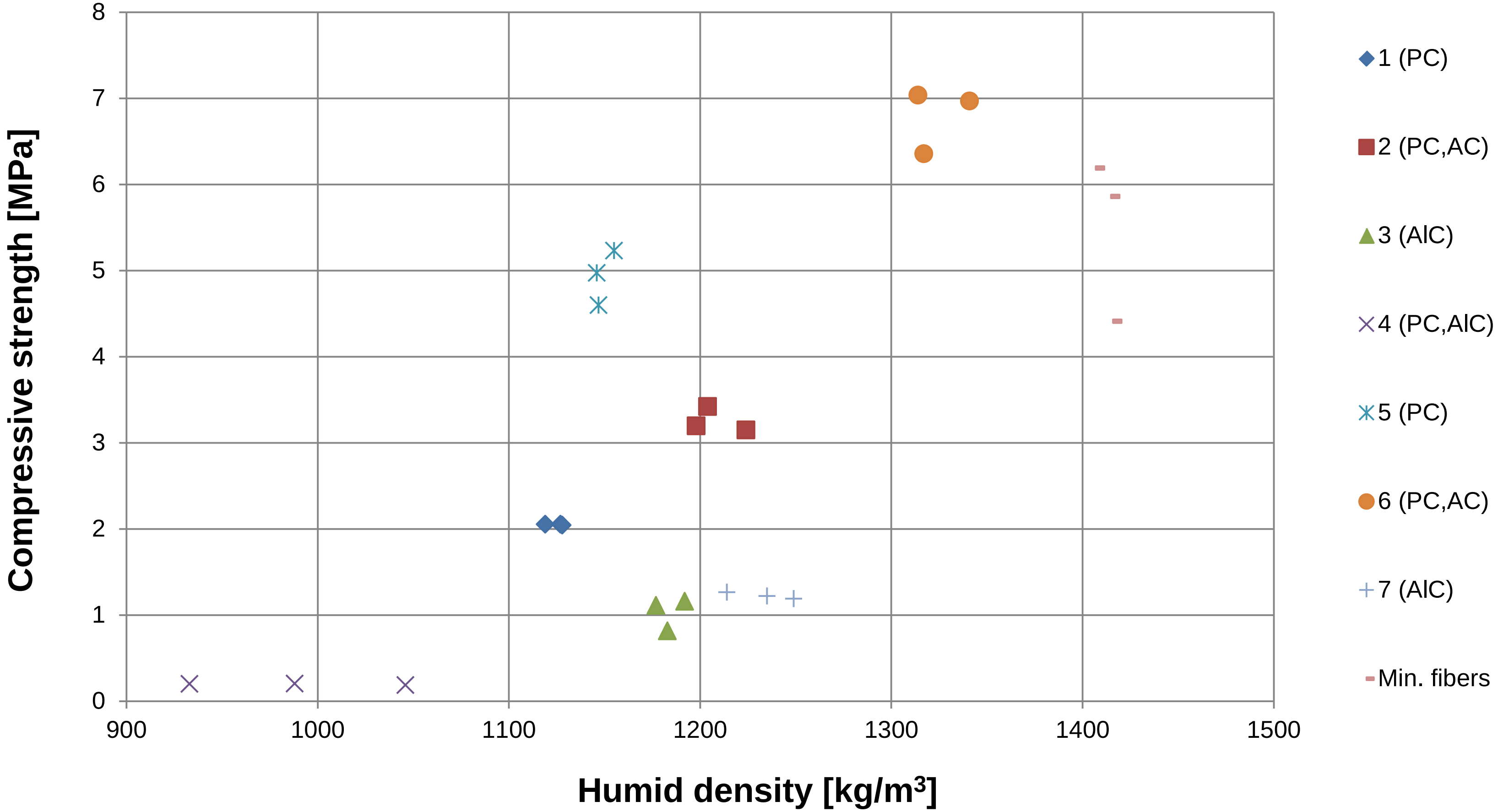
Agreslith *Recipe 1* *Recipe 2* *Recipe 3*

Recipe 4 *Recipe 5* *Recipe 6* *Recipe 7*

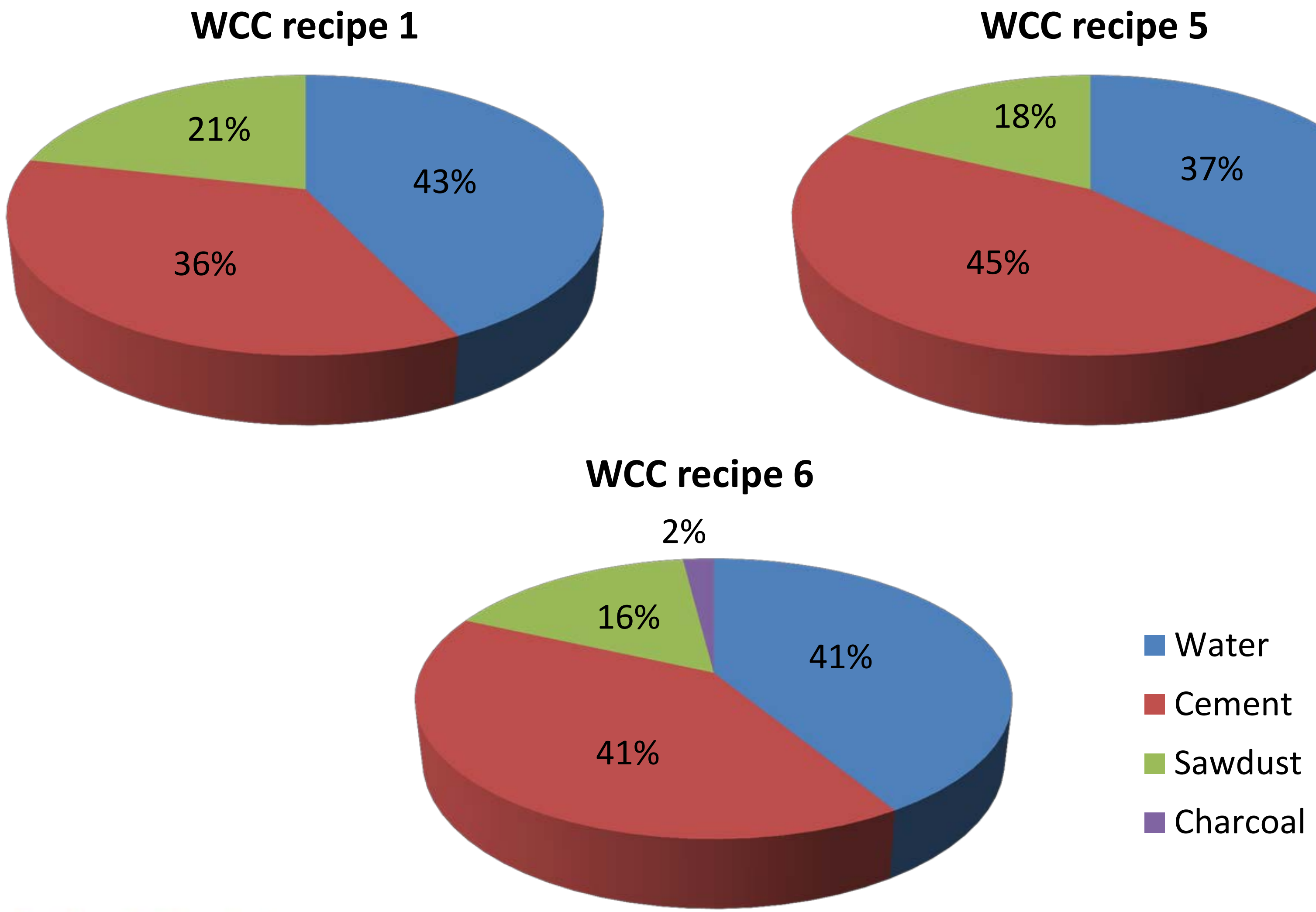
Synopsis of WCC properties

Average	Min. fibers	1	2	3	4	5	6	7
f_c [MPa]	4.9	2.1	3.3	1.0	0.2	4.9	6.8	1.2
f_t [MPa]	0.8	0.26	0.38	0.13	--	0.52	0.8	0.18
Humid density [kg/m^3]	1'385	1'125	1'209	1'184	989	1'149	1'324	1'233
Dry density [kg/m^3]	--	451	--	--	--	783	866	--

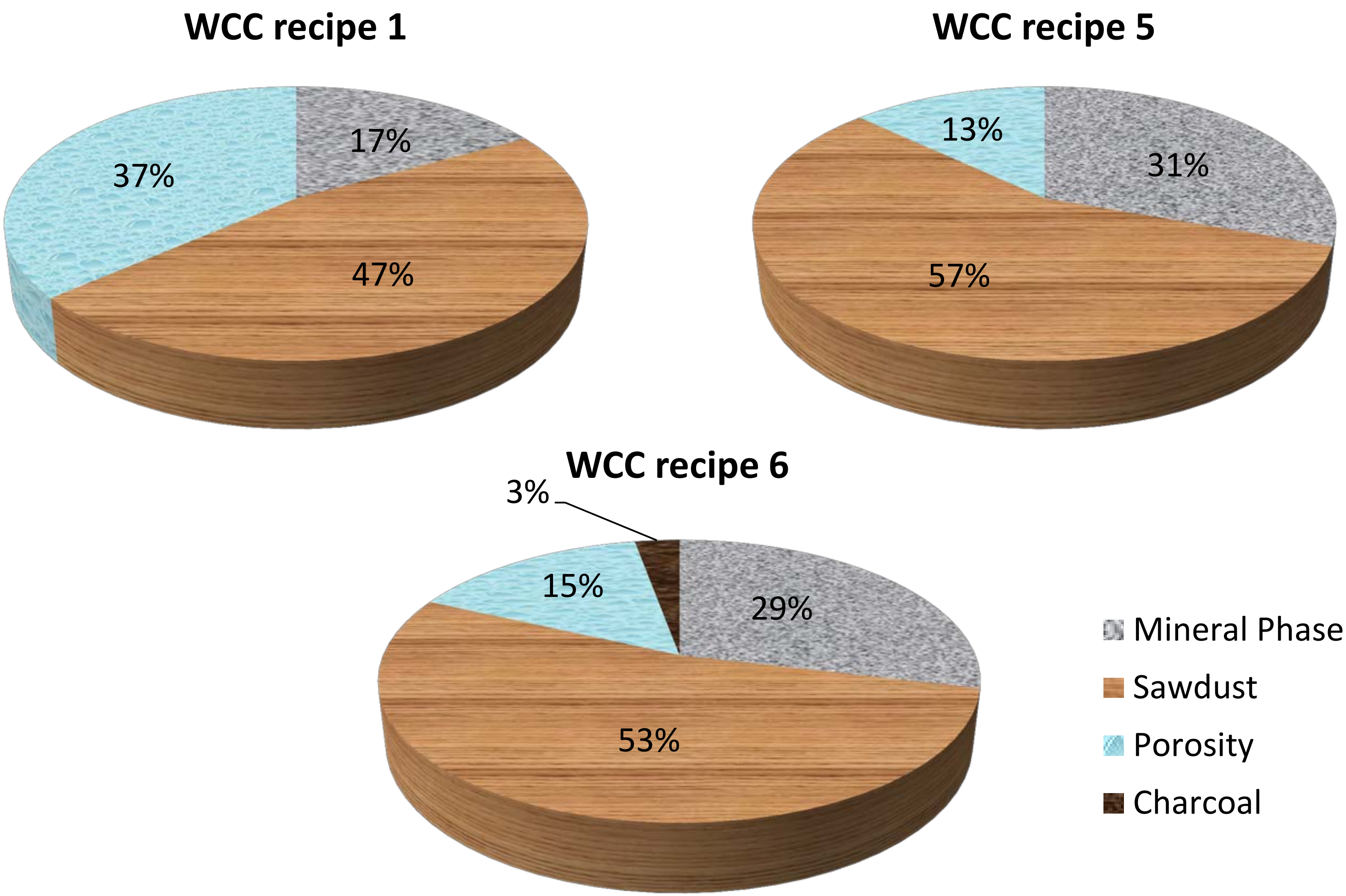
Synopsis of WCC properties



WCC 1, 5 & 6 – % in weight



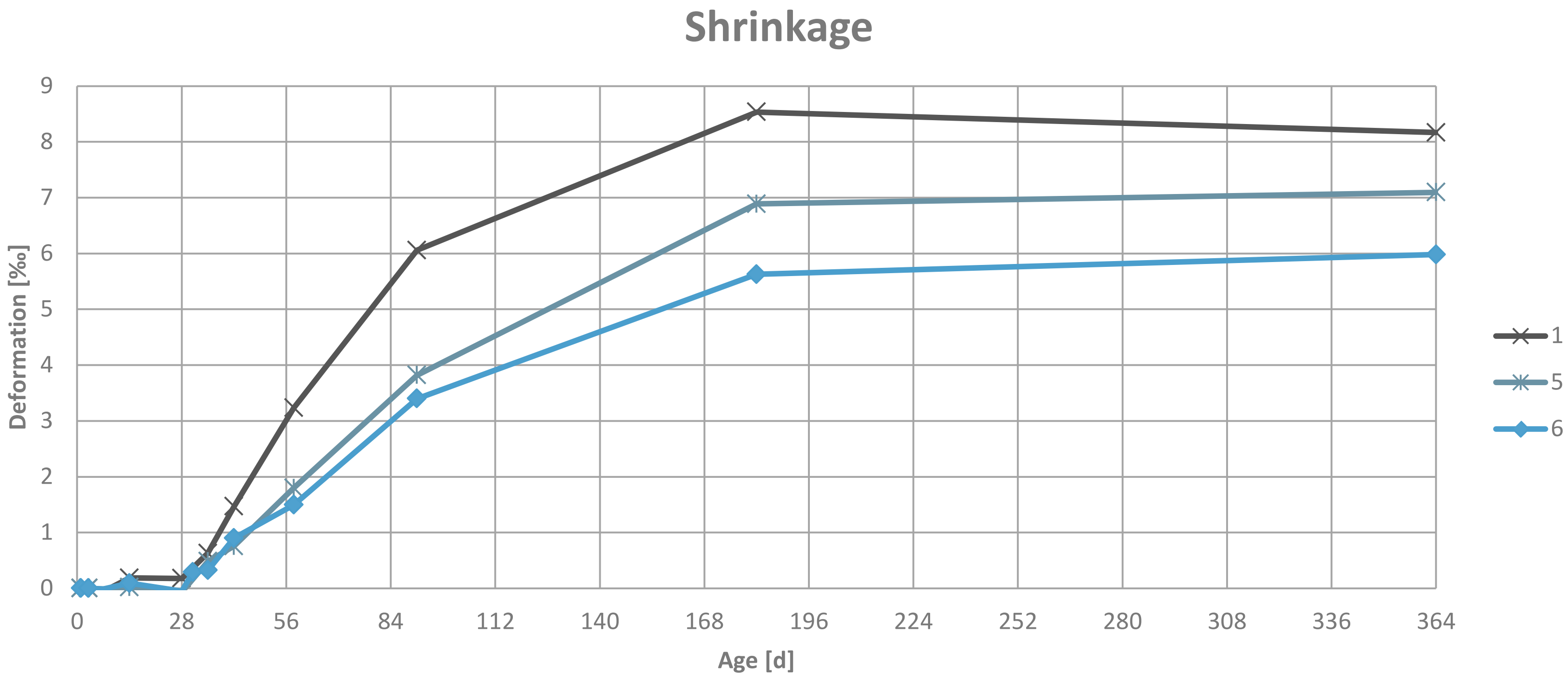
WCC 1, 5 & 6 – Vol.-%



WCC recipe 1
17%
37%
47%
WCC recipe 5
13%
31%
57%
WCC recipe 6
3%
15%
29%
53%
Mineral Phase
Sawdust
Porosity
Charcoal

Long-term mechanical behavior

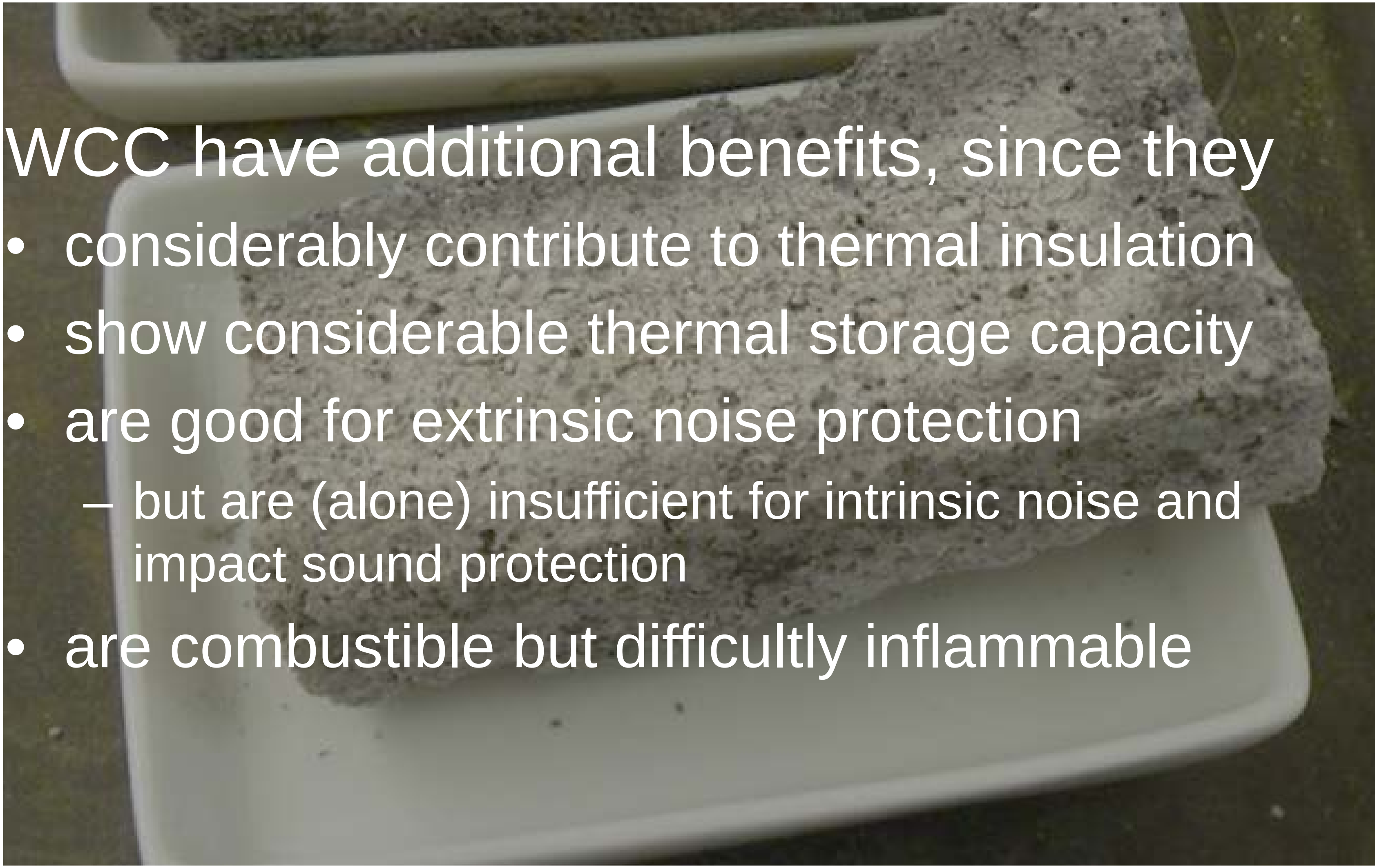
- Creep and shrinkage tests were conducted on WCCs 1, 5 & 6



Long-term mechanical behavior

Recipe	Initial displacement	Final displacement	φ
WCC 1	-70 µm	-372 µm	5.32
WCC 5	-85 µm	-556 µm	6.48
WCC 6	-169 µm	-647 µm	3.82

Other benefits of WCC materials



WCC have additional benefits, since they

- considerably contribute to thermal insulation
- show considerable thermal storage capacity
- are good for extrinsic noise protection
  - but are (alone) insufficient for intrinsic noise and impact sound protection
- are combustible but difficultly inflammable

Conclusions

- Timber-WCC composite construction offers interesting opportunities for light-weight structural elements
  - for residential, school and office buildings
- Shrinkage of WCCs is difficult
- Mechanical performance is sufficient for intended use