IIBCC 2024 International Inorganic-Bonded Fiber Composite Conference

Designing concrete for improved durability and sustainability

Modern binder types - Recycled aggregates

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- **Modern binder types**
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Research at UCT (and implementation in SA) / international research efforts

Modern binder types

- Blended cements will remain the best solution to increase the sustainability of cementitious binders

Modern binder types

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- Most promising (available in large quantities) SCM in the long term is calcined clay
- EPFL-led LC^3 project (since 2013)

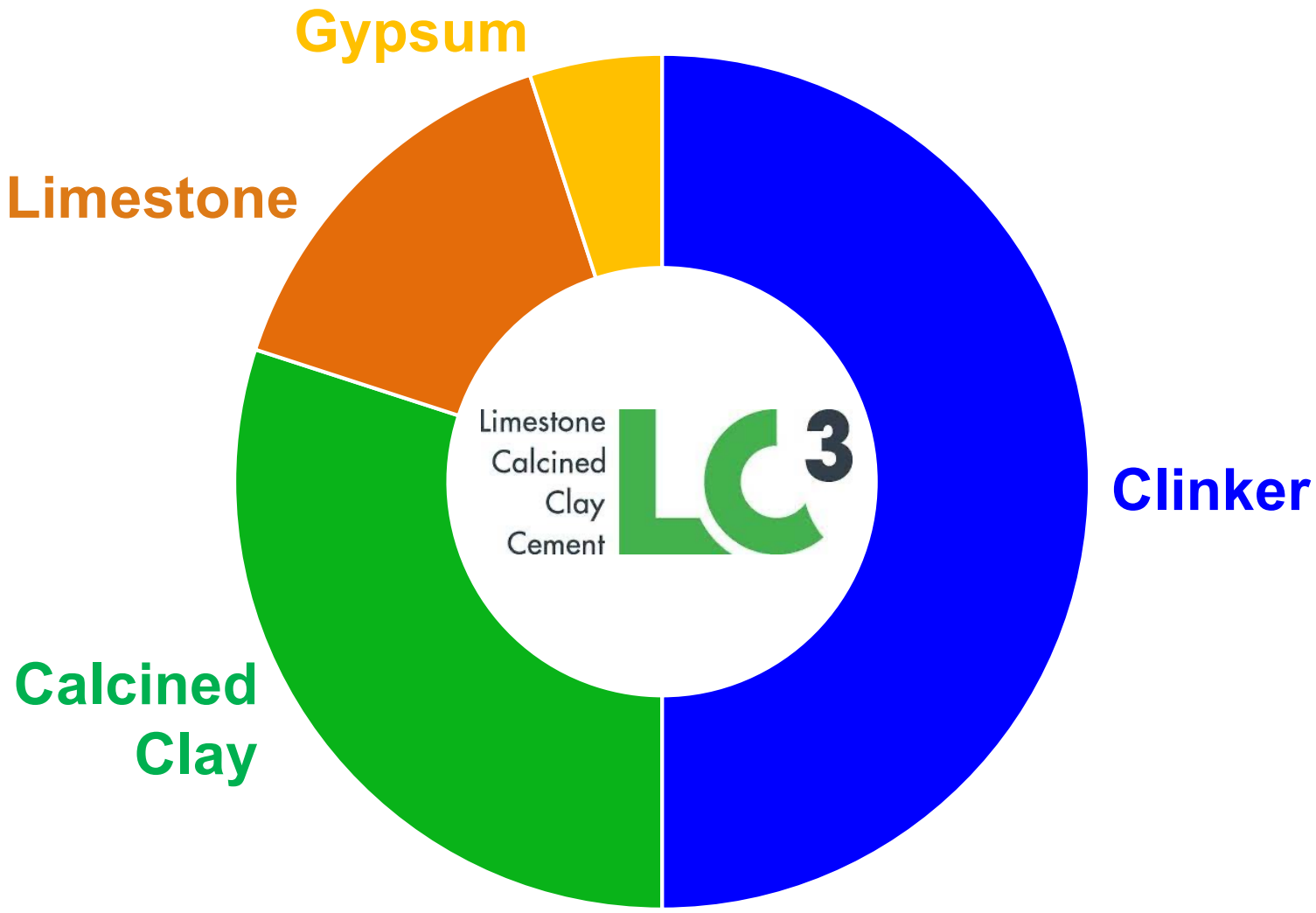
Limestone Calcined Clay Cement LC3

https://lc3.ch

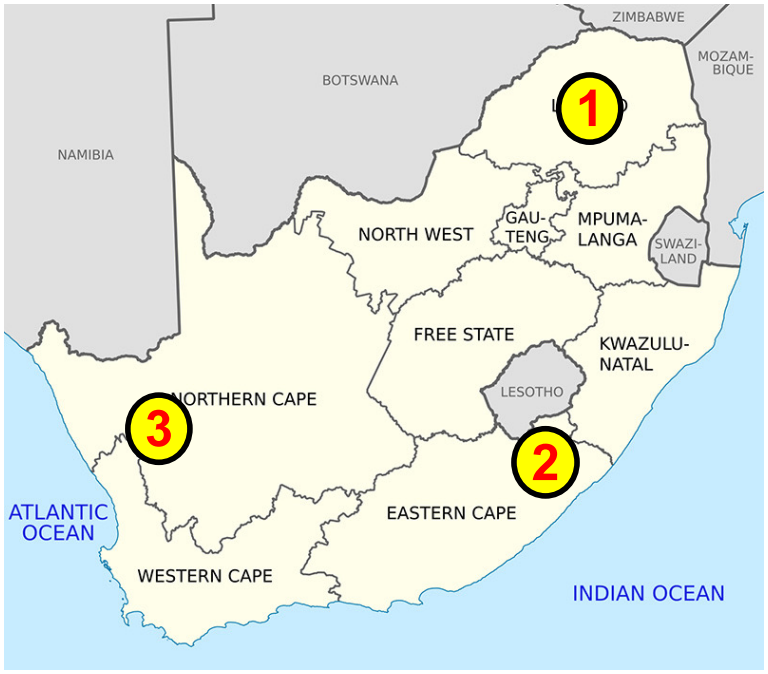
Modern binder types

- Blended cements will remain the best solution to increase the sustainability of cementitious binders
- Most promising (available in large quantities) SCM in the long term is calcined clay
- EPFL-led LC^3 project (since 2013)
  - Clinker / Calcined clay / Limestone / Gypsum
  - Up to 50% less clinker
  - 40% less CO_2
  - Similar strength
  - Superior durability (chloride ingress, ASR)

LC^3

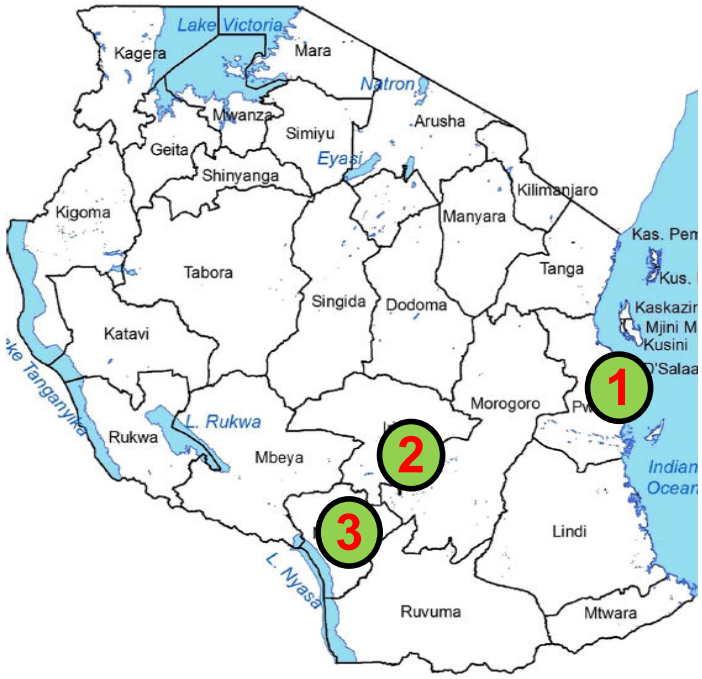

Gypsum
Limestone
Calcined
Clay
Clinker
Limestone
Calcined
Clay
Cement
LC3

Research at UCT

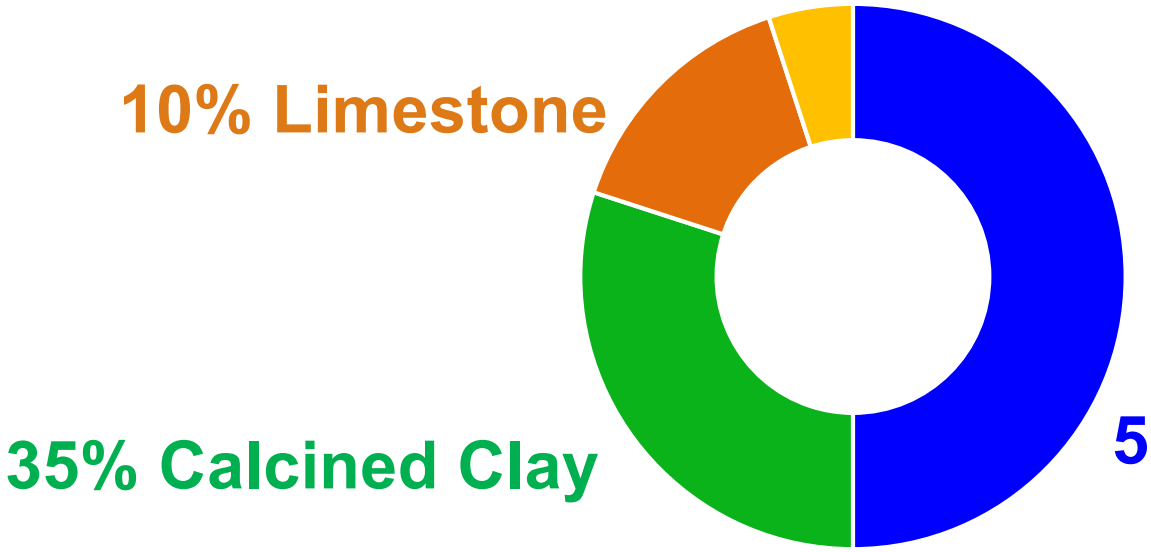


1. Bronkhorstspruit (35 Mio. tons)
2. Grahamstown (60 Mio. tons)
3. Hopefield (1 Billion tons)

1. Pugu (2 Billion tons)
2. Matamba (56 Mio. tons)
3. Malangani (?)



LC^3 concrete development and testing



Other mixes tested:

LC^3- 45(40/15)

LC^3- 55(35/10)

LC^3- 65(25/10)

An optimisation study indicated that for optimum strength performance, regardless of the type of calcined clay, the lowest practical clinker content is 55% at which the CC content is 35% and the LS content is 10%, **LC^3- 55(35/10)**.

LC^3 concrete performance summary

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- Early strength – lower than PC concrete, higher than GGBS
- Long-term strength – (less) lower (around 0-15%, depending on PC content)
- Penetrability significantly reduced
- Electrical resistivity increased, AASHTO T 358
- Chloride penetration reduced (drastically, compared to PC)
- Carbonation increased (drastically, compared to PC)
- Performance generally dependent on the type of clay

Modern binder types

Current research worldwide

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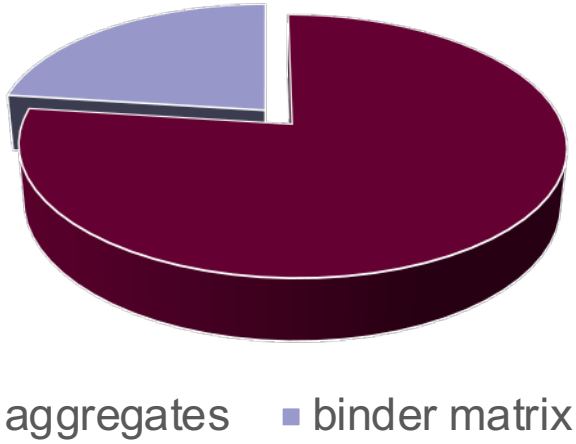
- Identification of possible resources for modern binder types (e.g., Kaolin deposits)
- Chemical characterization
- Concrete mix design and testing
  - Hydration characteristics
  - Mechanical properties
  - Durability
- Production, standardization, marketing

Recycled aggregates

- Aggregates account for approx. 75% of concrete vol.
- Global shortage of natural aggregates, particularly sand
- Sand presently mined at rate that exceeds natural rate of production
- 40-50 billion tons of sand mined annually
- Environmental and social issues

- Replacement of natural aggregates with recycled aggregates



Recycled aggregate

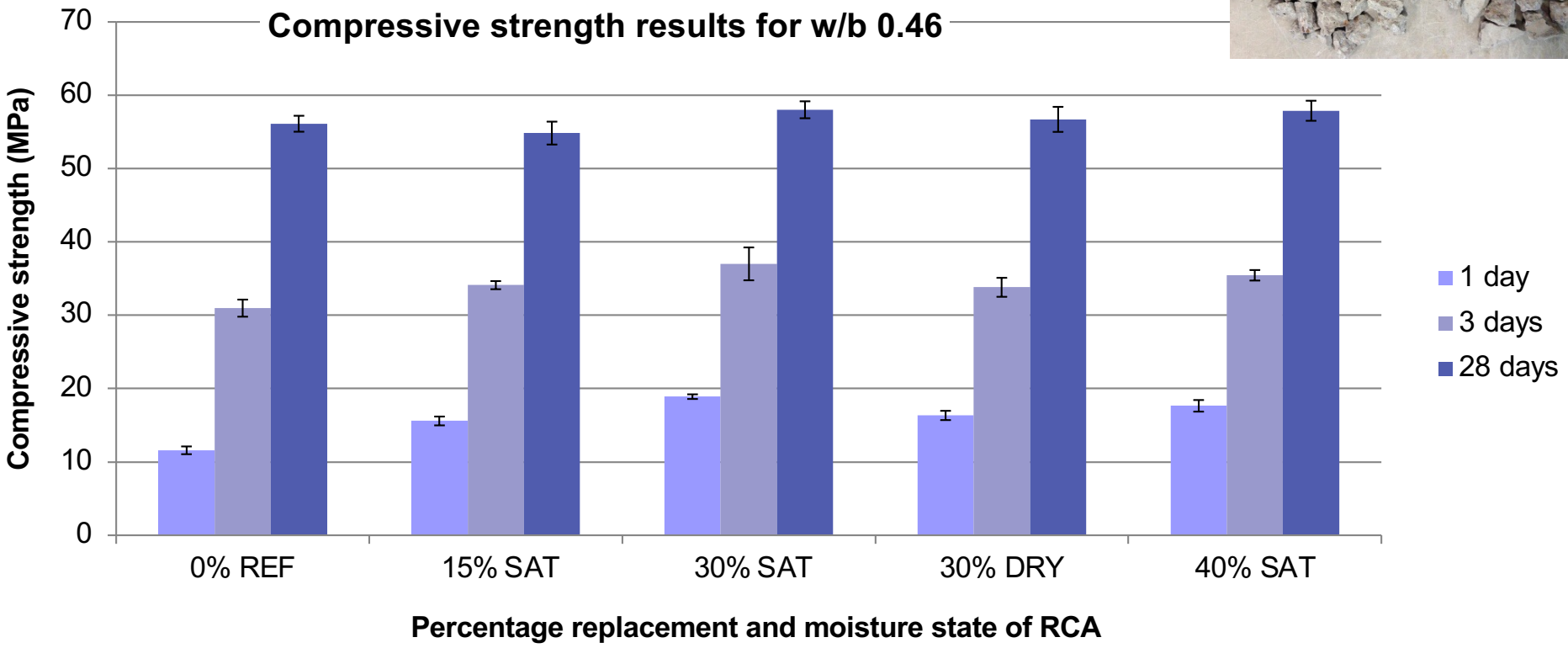
Coarse aggregate

- Recycled precast elements
- Coarse aggregates

Recycled aggregate

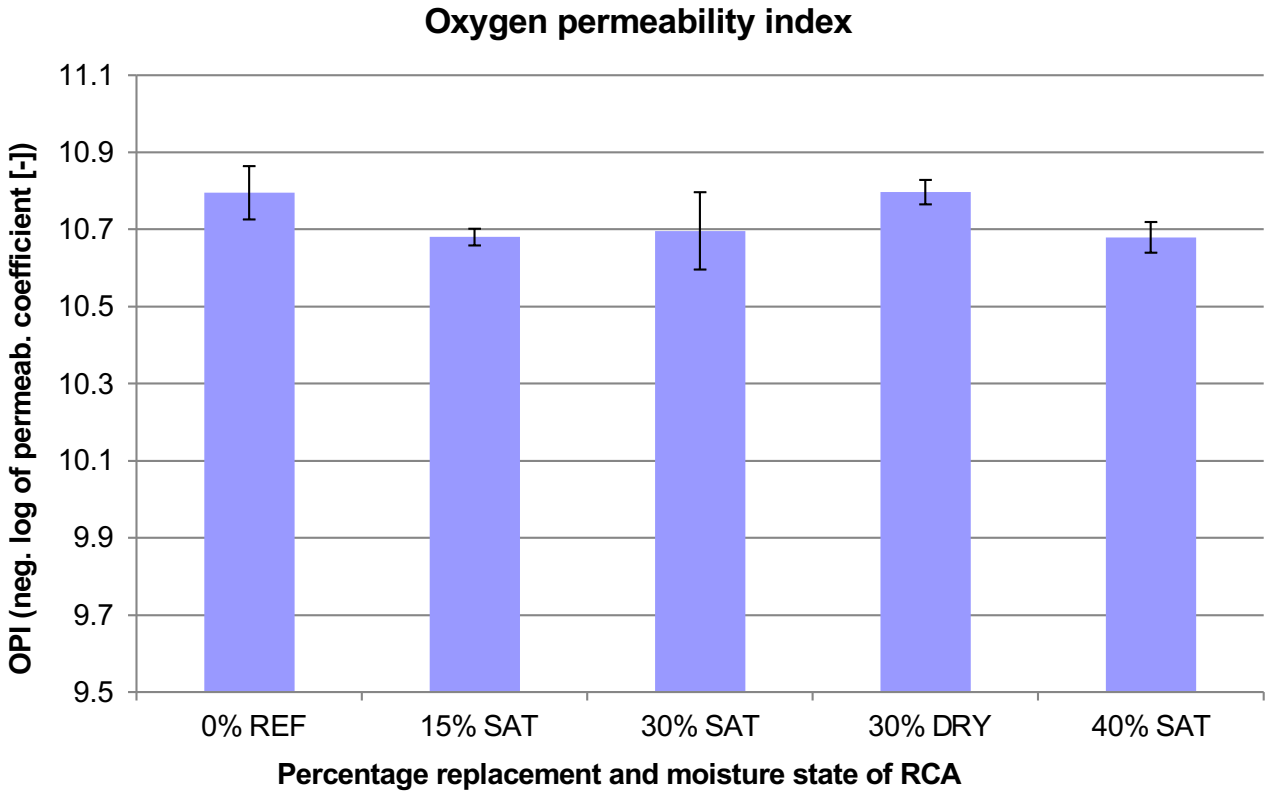
Coarse aggregate

- Saturated / unsaturated
- 15 – 40% replacement
- Generally equal or superior mechanical properties and shrinkage



Recycled aggregate
Coarse aggregate

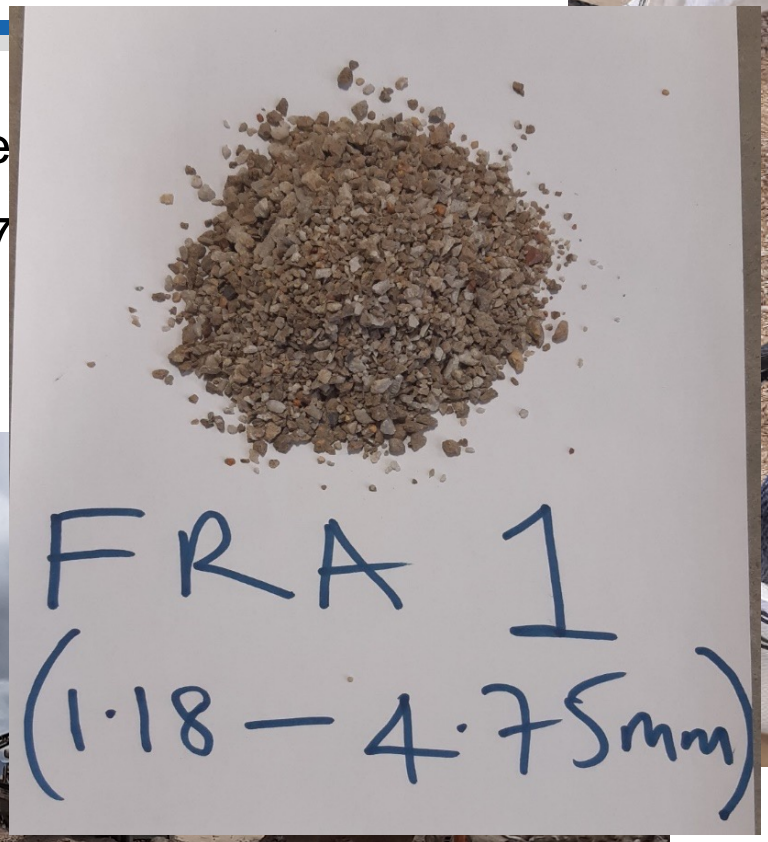
- Equal permeability and durability properties



Recycled aggregate

Fine aggregate

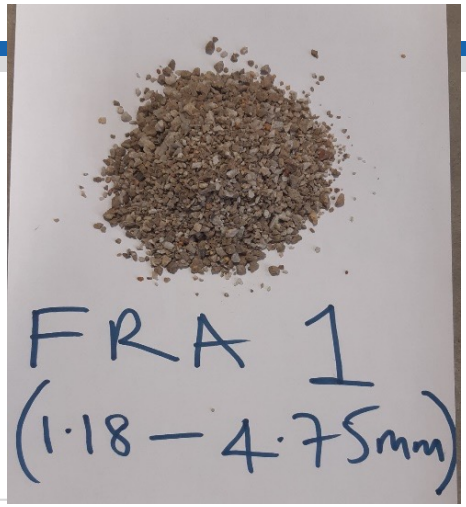
- Recycled C&DW (concrete
- Fine aggregates 1.18 – 4.7

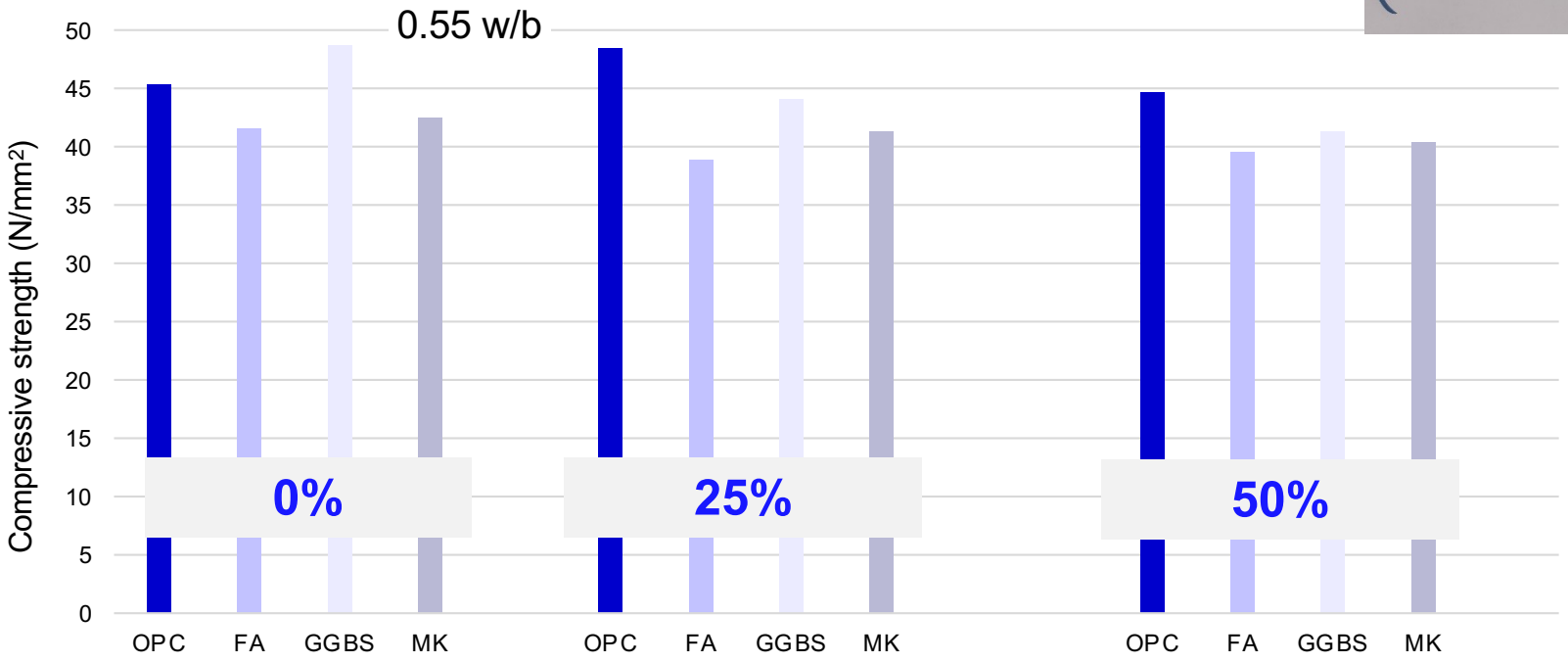


Recycled aggregate

Fine aggregate

- 25 and 50% replacement
- Little impact on workability (low additional dose of SP required)
- Generally equal or superior mechanical properties





Recycled material

Current research worldwide

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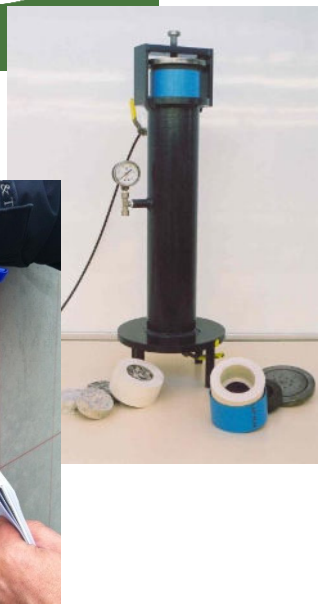
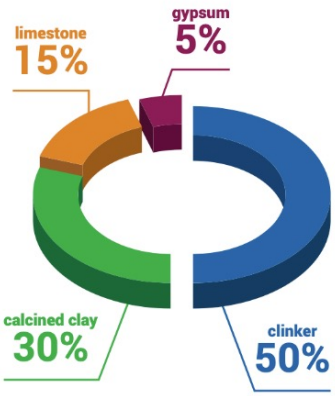
- Industrial production of recycled aggregates and fines
- Mix composition and optimization
  - Fresh concrete properties
  - Mechanical properties & Durability
- Optimization of recycled materials
  - Pre-conditioning | Grading | Blending |Chemical activation
- Quality control procedures and standardization

Concluding remarks

- Sustainability of concrete
- Durability and service life
  - Performance approaches
- Modern binder types
- Recycled aggregates





Thank you for your attention