

Simulating Corrosion Induced Damage in Recycled Aggregate Concrete Systems

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WHY RECYCLED CONCRETE AGGREGATES (RCA)

Limited aggregate resources and environmental impact

Aggregate mining
Aggregate transport

Poor quality aggregates
High quality aggregates

Recycling and reuse of demolished concrete

Demolished structure
Reuse aggregate

USGS (2014)

WHAT IS RCA

- Produced from demolished waste concrete materials
- RCA pertains two material phases:
 - Original natural aggregate
 - Adhered mortar
- Two interfacial transition zones
 - Old ITZ
 - New ITZ

Jayasuriya et al. (2018) *JCBM Journal*

APPLICATIONS OF RAC IN STRUCTURES

- Industry goal of reducing carbon emissions associated with the production of concrete
- Less than 1% recycle aggregate used in structural components in Europe
- End user concern of mechanical and durability properties

Sustainability concerns

→

Expand the use of RAC in structures

→

Durability issues in reinforced RAC

Ignjatović et al. (2017) *Engineering Structures*

MECHANICAL PROPERTIES OF RAC

Increasing RCA replacement level →

Compressive strength [MPa]

Applied strain

Peak response Principal compressive strains

0 -1.5x10⁻³ -3x10⁻³

Applied strain = 1x10⁻³

Jayasuriya et al. (2022) *ACI Materials Journal*

MESO-SCALE NUMERICAL INVESTIGATIONS

↑ Rust Expansion
↑ Chloride Ingress

Mortar Matrix
New ITZ
Adhered Mortar
Old ITZ
Natural Aggregate

CHLORIDE DISTRIBUTION

Cl concentrations (mol/m³)

Depth (mm)

Rust thickness (μm)

CI Ingression

CORROSION INDUCED DAMAGE

Increasing AM level →

Increasing rust level ↑

(a) 2% AM-20% Rust
(b) 10% AM-20% Rust
(c) 2% AM-2% Rust
(d) 10% AM-10% Rust

5.00e-4
3.75e-4
2.50e-4
1.25e-4
6.25e-5
0

CONCLUSIONS & TAKE AWAY

- Meso-Scale numerical approach** is effective in quantify the corrosion performance of reinforced RAC systems
- Higher AM content results **faster** chloride ingress and corrosion propagation
- Heterogeneous** material leads to unsymmetrical chloride distribution
- The **impact of AM is limited** at low AM levels
- Higher adhered mortar leads to **greater** damage
- Rust level is **more influential** on corrosion induced damage compared to AM level

1. USGS National Water-quality Assessment (NAWQA) Program Annual Pesticides Use Maps, U.S. Geological Survey (2014).
 2. Jayasuriya, Anuruddha, Matthew P. Adams, and Matthew J. Bandelt. "Understanding variability in recycled aggregate concrete mechanical properties through numerical simulation and statistical evaluation." *Construction and Building Materials* 178 (2018): 301-312.
 3. Ignjatović, Ivan S., Snežana B. Marinković, and Nikola Tošić. "Shear behaviour of recycled aggregate concrete beams with and without shear reinforcement." *Engineering Structures* 141 (2017): 386-401.
 4. Jayasuriya, Anuruddha, Matthew J. Bandelt, and Matthew P. Adams. "Stochastic Mesoscopic Modeling of Concrete Systems Containing Recycled Concrete Aggregates Using Monte Carlo Methods." *ACI Materials Journal* 119, no. 2 (2022): 3-18.