Upcycling Wastes Originating from Construction and Demolition Practices to Manufacture Geopolymeric Construction Materials

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CodeDEMO
DemountableConstruction

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Introduction

- New housing activities due to increasing population, immigration, unplanned urbanization and catastrophic events cause construction sector to grow.

- This means a considerable increase in the demand of raw materials, energy requirement for the production of new construction materials, and the growth of environmental/health problems triggered by greenhouse gas emissions.

- By the end of their service life, structures are demolished creating huge amounts of solid waste, which are hamrful for the health/environment and impossible to store for a long time.

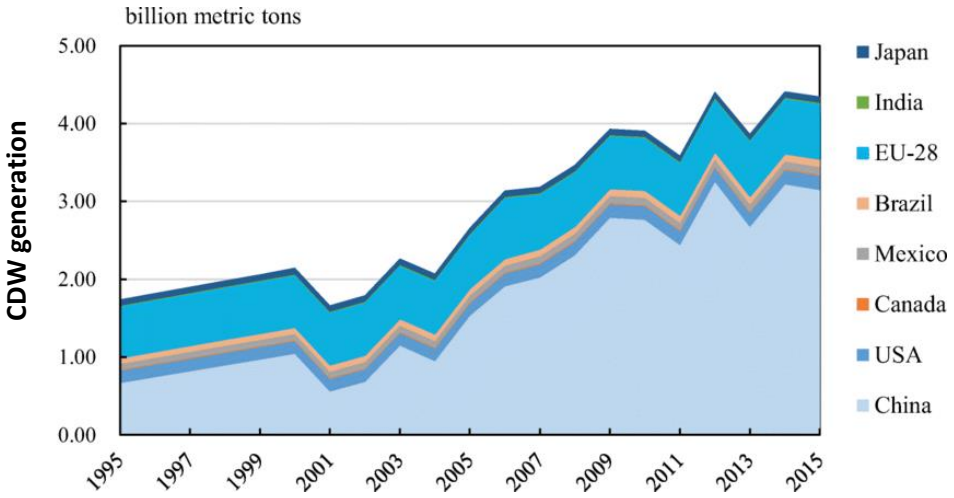
- Taking these issues into account, our focus needs to be increasingly placed on the urgent implementation of the reduce/reuse/recycle strategy in the construction industry.

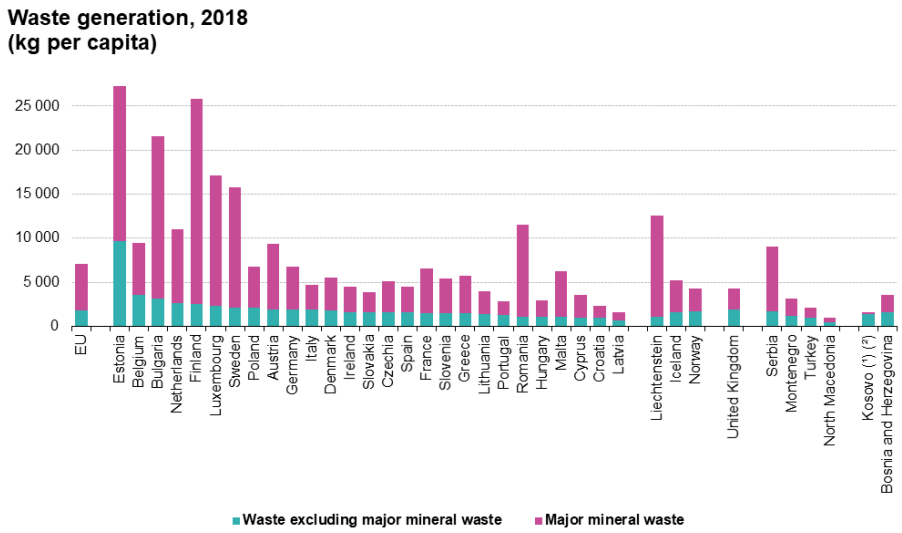
Construction and Demolition Waste

As a result of,

- Ever-increasing urban population and transformation,
- Continuous development of industrialization,
- Continuous development economies of countries around the world,

the production of **Construction Demolition Waste (CDW)** has increased significantly.





Construction and Demolition Waste

There are multiple adverse effects of CDW:

- waste landfilling of very large clean lands,
- causing hazardous pollution which jeopardize the surrounding environment,
- wasting of natural resources.
- requiring additional production of clean raw and construction materials.

Aims & Scope

In order to lower environmental, economical, and societal adverse effects of CDWs and propose solutions for non-eco-friendly traditional Portland cement and concretes:

- To utilize the currently unutilized portion of CDWs in obtaining precursors which can be used in the development of geopolymeric materials,
- Determination of geopolymerization performance of CDW-based materials when used individually and in combination,
- Determination of the optimum rate of alkali material usage,
- Determination of the optimum curing conditions,
- Determination of maximum grain size and utilization rate of RCAs
- To achieve a reasoanable level of compressive strength and proper microstructural/durability characteristics.

Greenhouse gas emissions

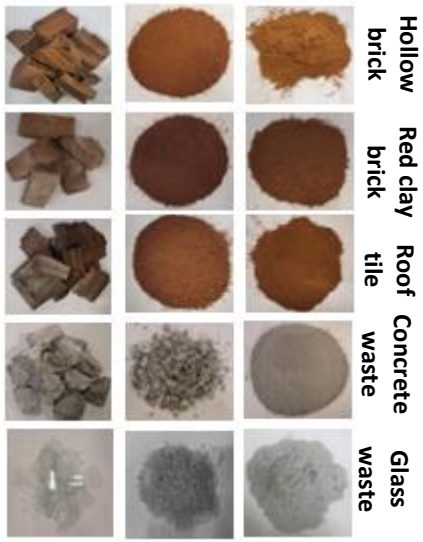

Aggregate quarrying

Permanent marks on the planet

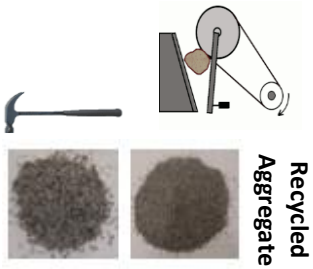
Experimental Program

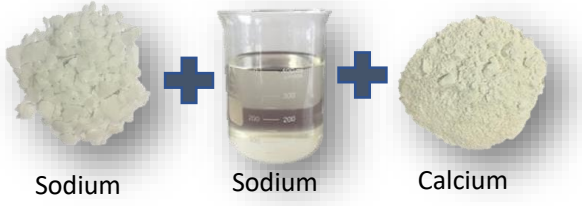
Mixed CDW-based geopolymer binders and mortars

Crushing & Grinding



Crushing & Sieving





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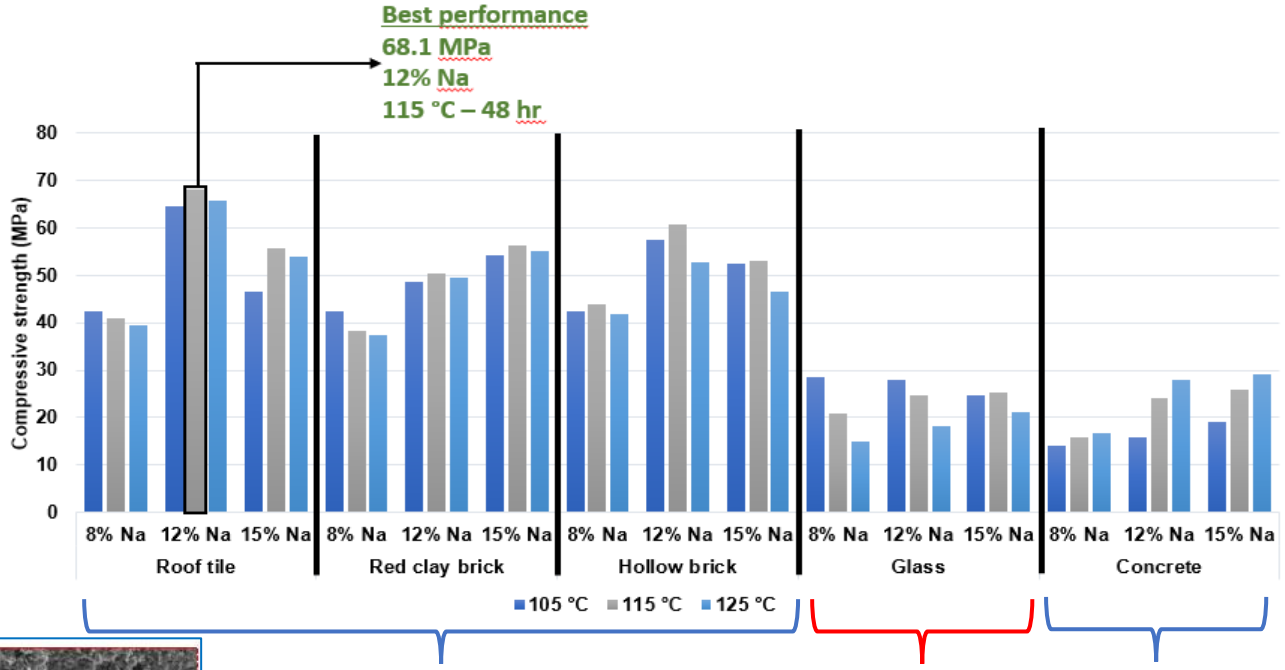
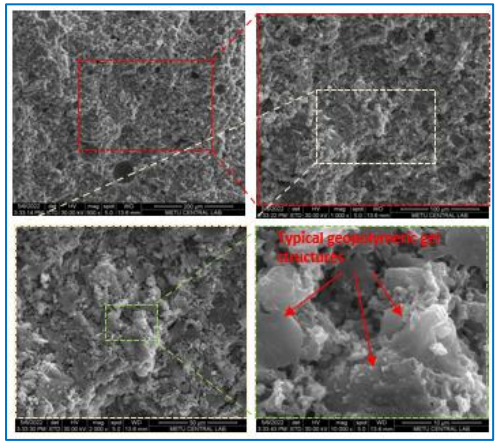
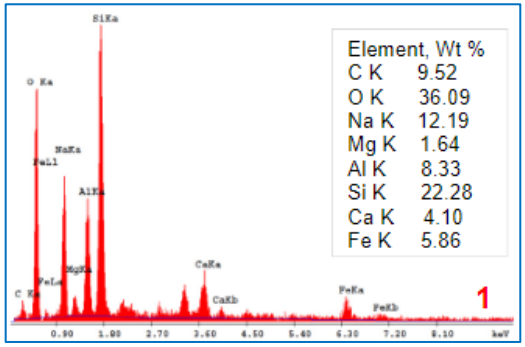
SUSTAINABLE PLACES

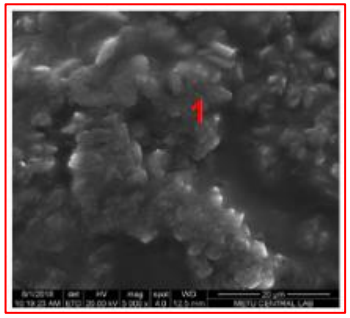
Development of CDW-based heat-cured geopolymer pastes

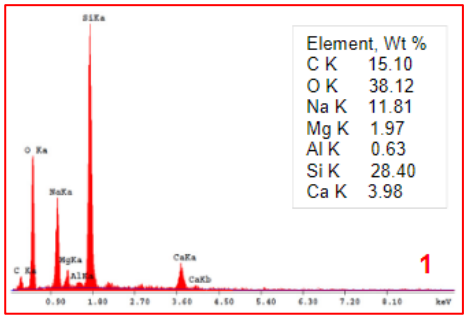
Compressive strength results of geopolymers based on the sole use of CDWs





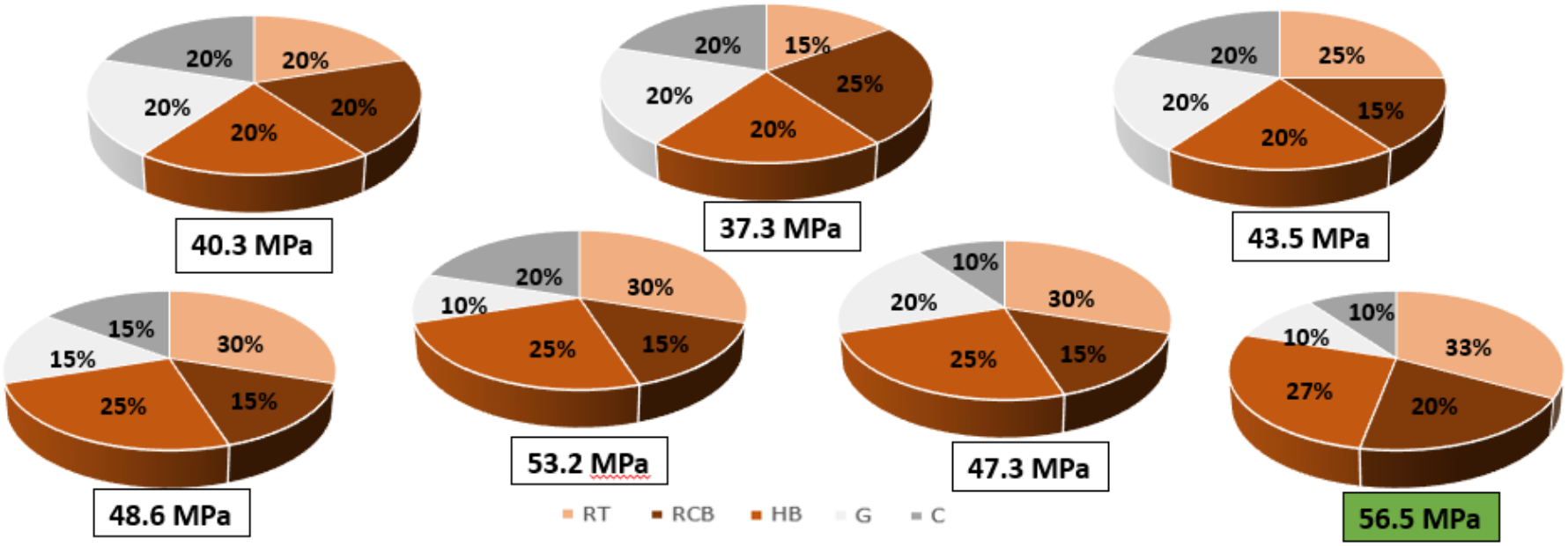


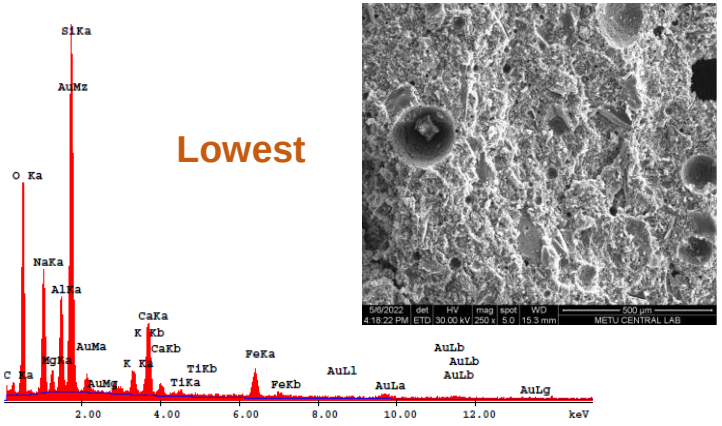


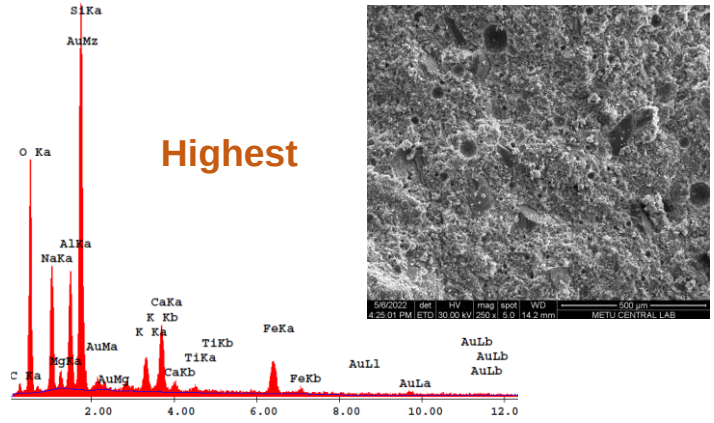


Development of CDW-based heat-cured geopolymer pastes

2-day compressive strength results of geopolymers based on quinary mixture of CDWs







Development of CDW-based ambient-cured geopolymer mortars

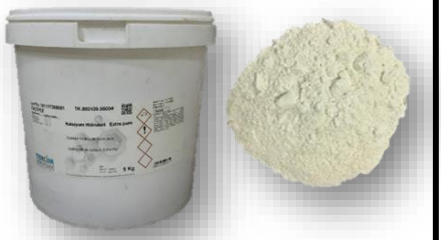
CDW-based precursors

Waste Concrete

Fine/coarse recycled concrete aggregates

Sodium hydroxide ($NaOH$)

Sodium silicate (Na_2SiO_3)



Calcium hydroxide ($Ca(OH)_2$)

Development of CDW-based ambient-cured geopolymer mortars

100% CDW + Fine Recycled Aggregate

8M NaOH SS/SH=0 | 8M NaOH SS/SH=1 | 8M NaOH SS/SH=2

Ambient Curing – 28 days

9.1 MPa | 24.3 MPa | 25.4 MPa

80% CDW + 20% GBFS + Fine Recycled Aggregate

8M NaOH SS/SH=0 | 8M NaOH SS/SH=1 | 8M NaOH SS/SH=2

Ambient Curing – 28 days

29.5 MPa | 33.2 MPa | 35.1 MPa

SS: Sodium silicate
SH: Sodium hydroxide

Drying shrinkage of CDW-based ambient-cured geopolymer mortars

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100% CDW-based

SH + SS → 15100 microstrain

SH + SS + CH → 18000 microstrain

SH + CH → 5100 microstrain

80% CDW + 20% Slag

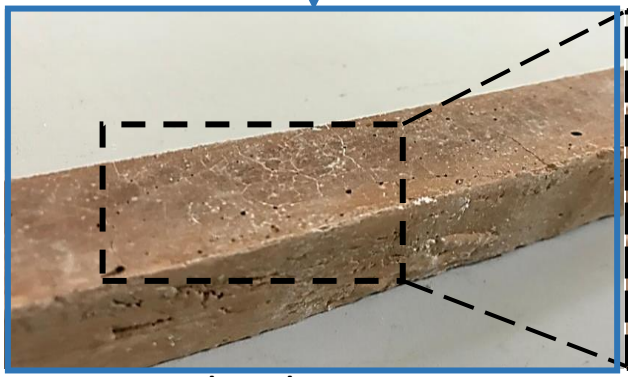
SH + SS → 11500 microstrain

SH + SS + CH → 12500 microstrain

SH + CH → 4700 microstrain

No micro crack!

Drying shrinkage specimen



Drying shrinkage specimen

Surface microcracks

Efflorescence behavior of CDW-based ambient-cured geopolymer mortars

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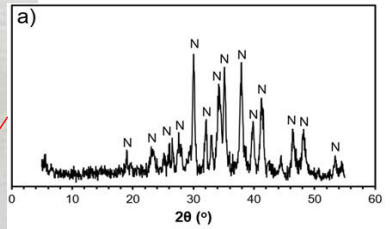
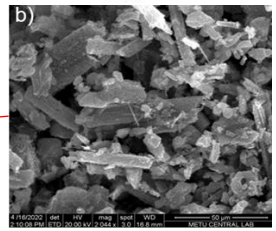
Sodium hydroxide + Calcium hydroxide

Sodium hydroxide + Sodium silicate

Sodium hydroxide + Sodium silicate + Calcium hydroxide

100% CDW-based



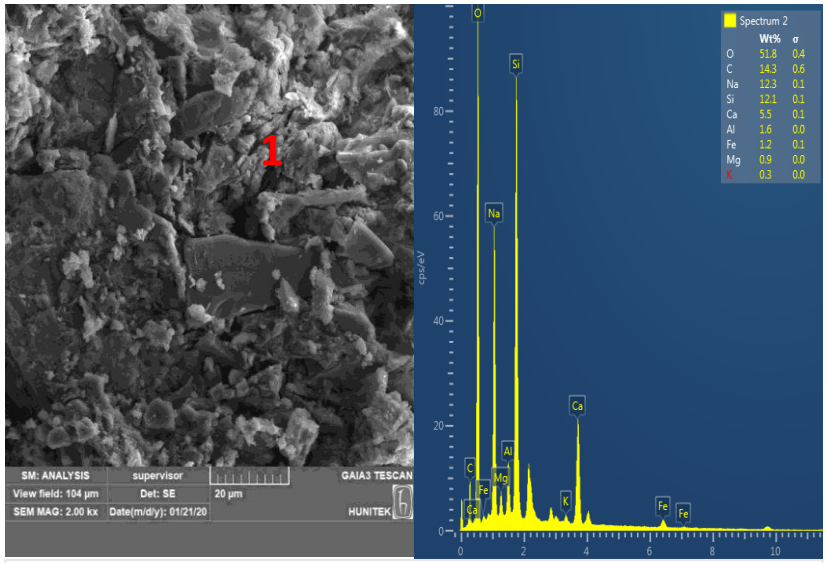


SEM/XRD analysis of efflorescence products

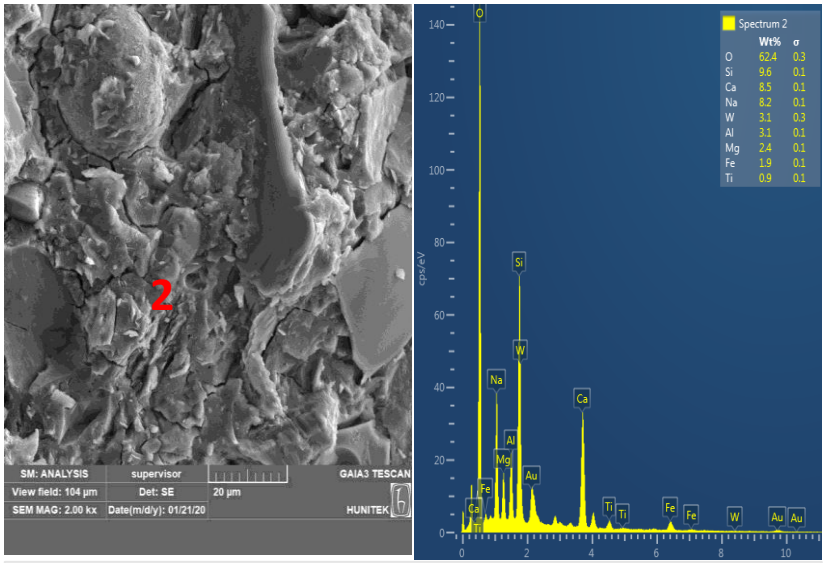
80% CDW + 20% Slag

90-day efflorescence behavior of the CDW-based geopolymer mortars

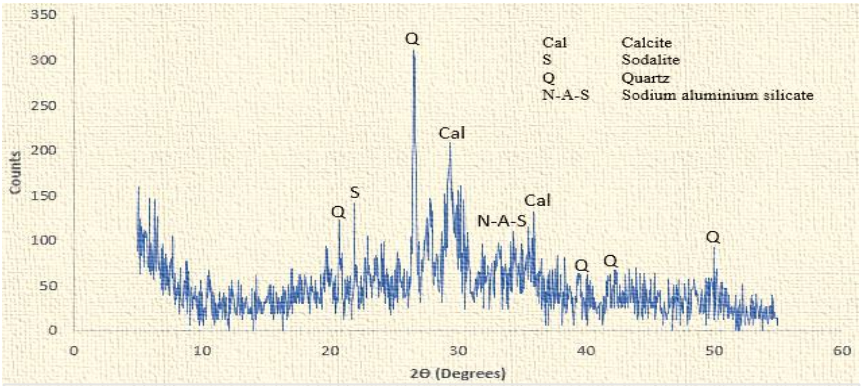
Development of CDW-based ambient-cured geopolymer mortars



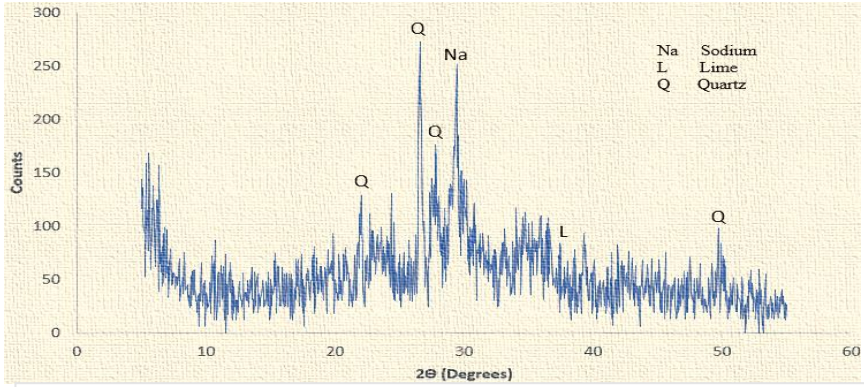
SEM/EDX analysis of %100 CDW mortar



SEM/EDX analysis of CDW + Slag mortar

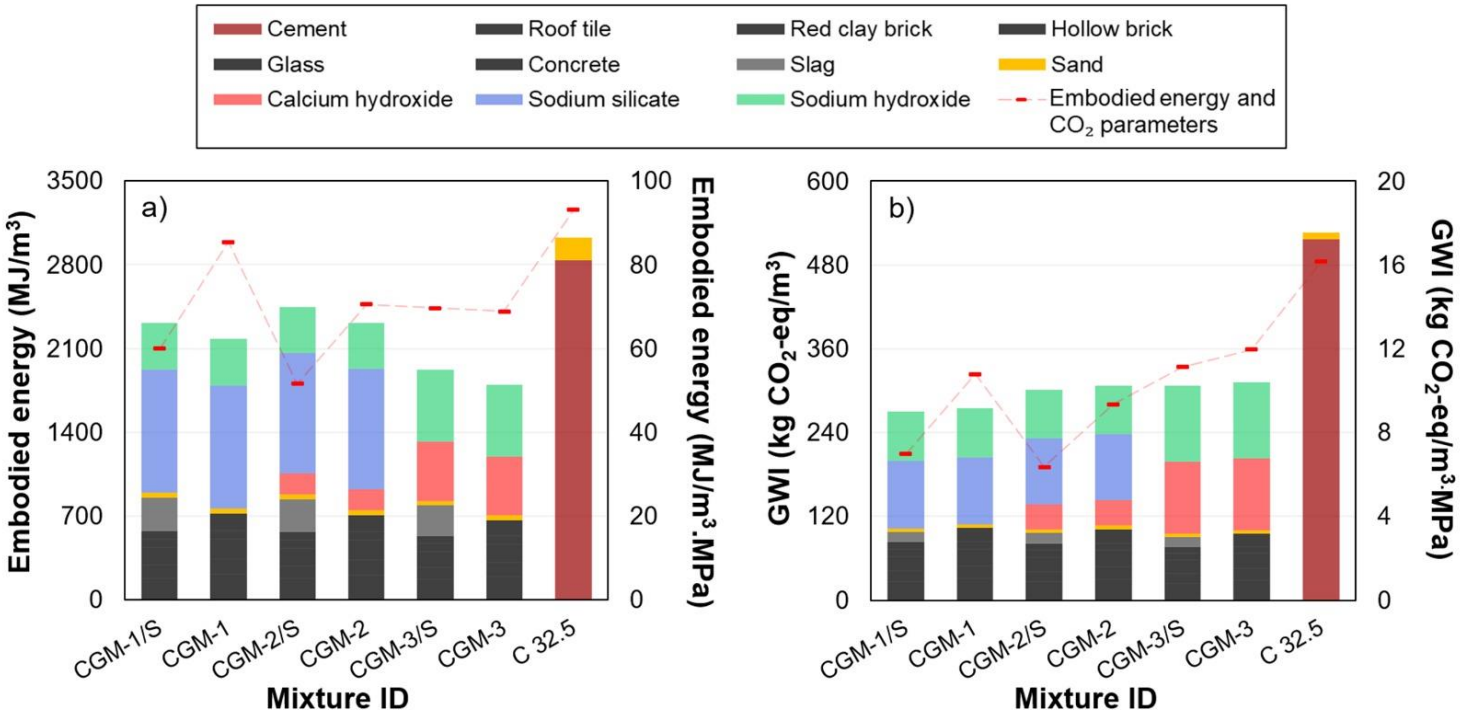


XRD analysis of %100 CDW mortar



XRD analysis of CDW + GBFS mortar

Sustainability Analysis



Conclusions

- It is possible to use source materials from CDWs in the production of geopolymers and mortars with the adequate strength.
- More eco-friendly building materials with lower CO2 emission and energy requirement minimizing CDWs are possible,
- Up to 56.5 MPa compressive strength of heat-cured mixed geopolymer binders,
- Up to 35 MPa compressive strength of ambient-cured mixed geopolymer mortars
- Comparable compressive strength and durability properties to Portland cement-based systems.

ECO-FRIENDLY

SUSTAINABLE

COST-EFFECTIVE

HIGH PERFORMANCE

SUSTAINABLE PLACES

Thank you for your attention!

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Construction and Demolition Waste-based "Green" Demountable Structural Components

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