Some engineering, transport mechanism and embodied carbon of Ghanaian low grade calcined clay concrete

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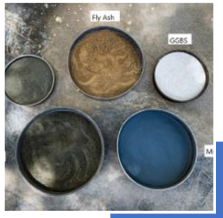
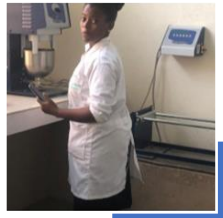
Introduction



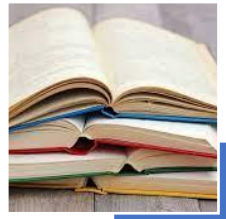
Supplementary materials

- flyash
- Slag
- Silica fume
- Metakaolin
- Calcined clays/shales
- Agrowaste ashes



Attraction to researchers

- Economic value
- Ecological advantages
- Technical benefits

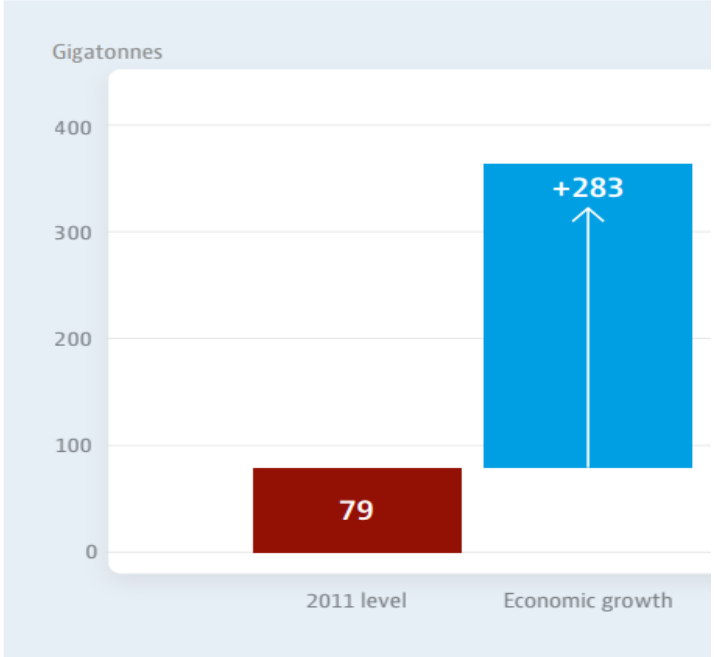


Literature

- Reduction in clinker factor
- Reduced carbon footprint
- Enhanced strength and transport properties

Problem statement *(General)*

Population growth and urbanization	• Population to reach 10billion by 2050 • 66% of people would be urbanized
Africa and Asia	• Highest share of the population density • Economic growth • Creation of overconsumption of materials
Concrete industry	• High consumption of non-metallic materials • Leads to high embodied energy & carbon



Global material usage and Projection in the year 2060

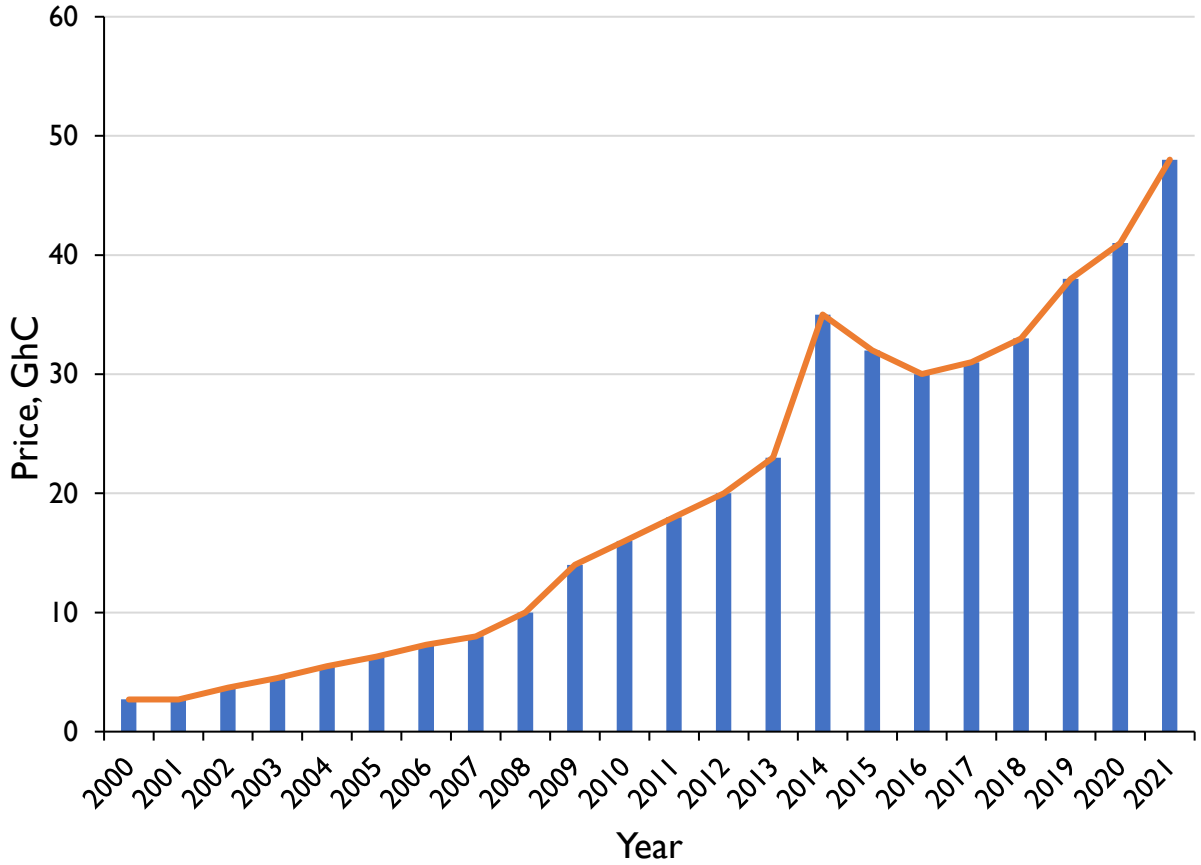
- concrete consumption responsible for about 9% of the total greenhouse gas emissions (OECD, 2018).
- Cement mass is responsible for approximately 96% of the carbon and other greenhouse gas emissions (Schokker et al, 2010)

Problem statement *(local)*

Booming economy with many constructional activities (rails, concrete roads, etc)

- ✓ High cement consumption
- ✓ Over $400million spent on clinker and gypsum importation
- ✓ Price has increased by 1678%

- ✓ Increased at 6% per annum
- ✓ Cement consumption predicted to reach 10million tonnes by 2025



High cost of cement is a local problem that needs urgent attention for Ghanaian people

Motivation of the study

UN common goal to promote solutions to rising green house gases

Sustainable concrete

Advancing the use of clay pozzolan in Ghana

Global material usage and Projection in the year 2060

Objective of the study

To use Ghanaian processed low grade calcined clay as cement substitute for concrete

- Mechanical properties
- Compressive strength
- Flexural strength

- Transport mechanism
- VPV
- RCPT

- Embodied carbon

Objective of the study

To use Ghanaian processed low grade calcined clay as cement substitute for concrete

Mechanical properties

-Compressive strength

-Flexural strength

Transport properties

-Volume of Permeable voids

-RCPT

Embodied Carbon

-Concrete

Materials

Portland cement 42.5N

Coarse aggregate (20mm)

Pit sand

High range water reducer (PCE)

Potable water (Tap water in the lab)

METHODS

Concrete mix design (ACI 211.1)

Compressive strength determination (BS EN 12390-3)

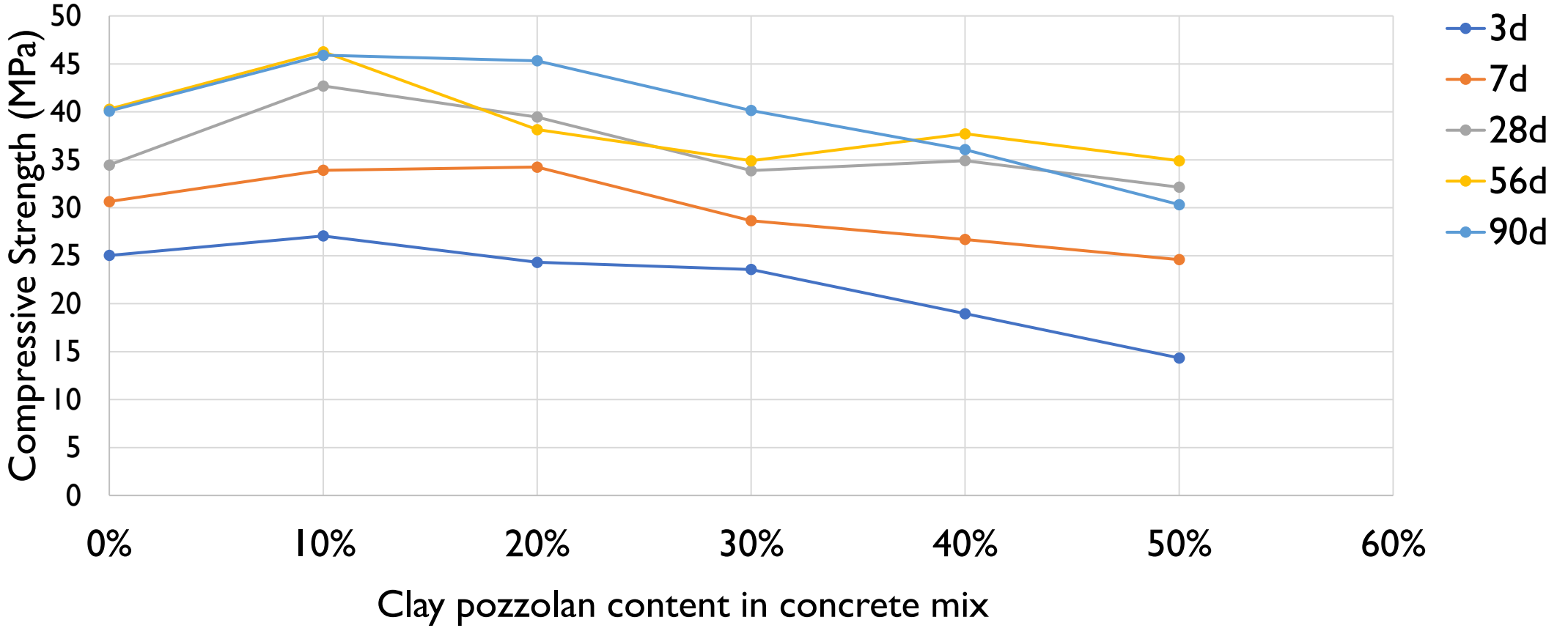
Flexural strength

Volume of Permeable Voids (ASTM C642)

RCPT (ASTM C1202)

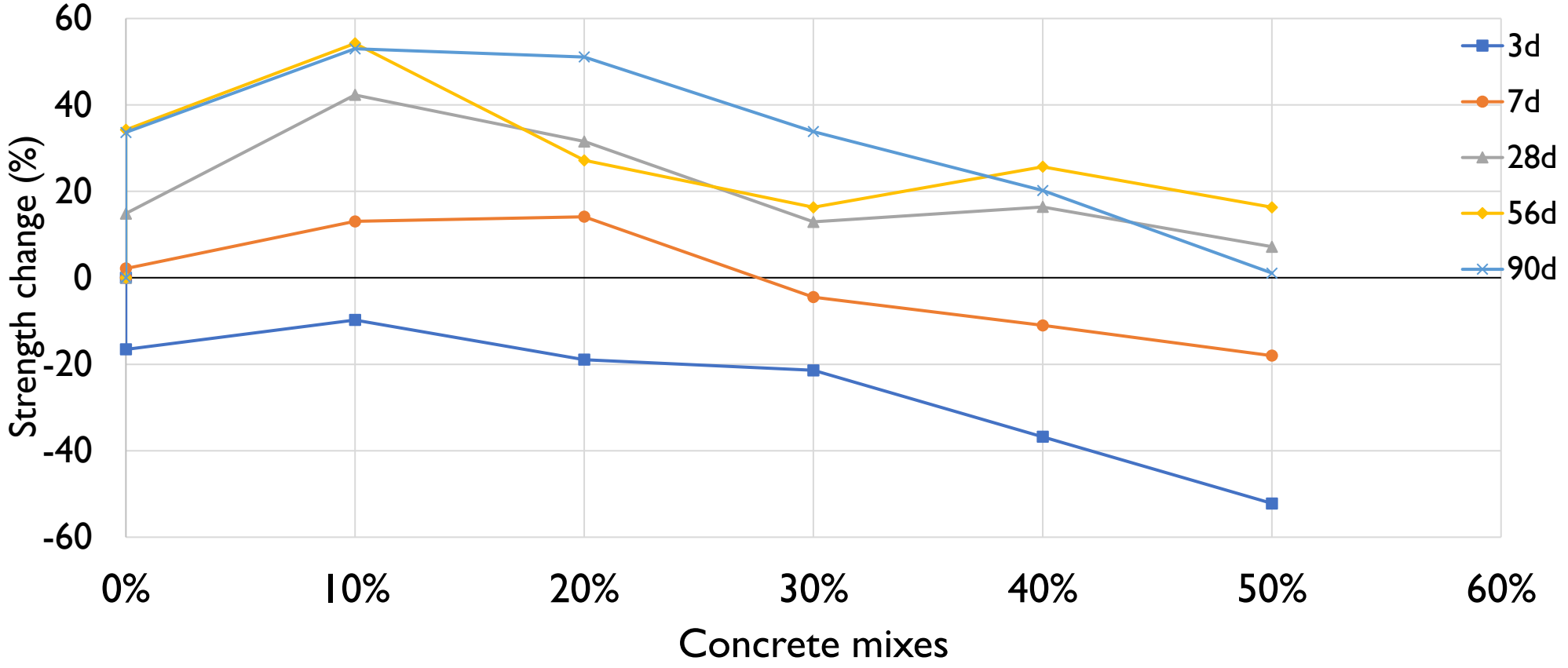
Results and discussion

Compressive strength



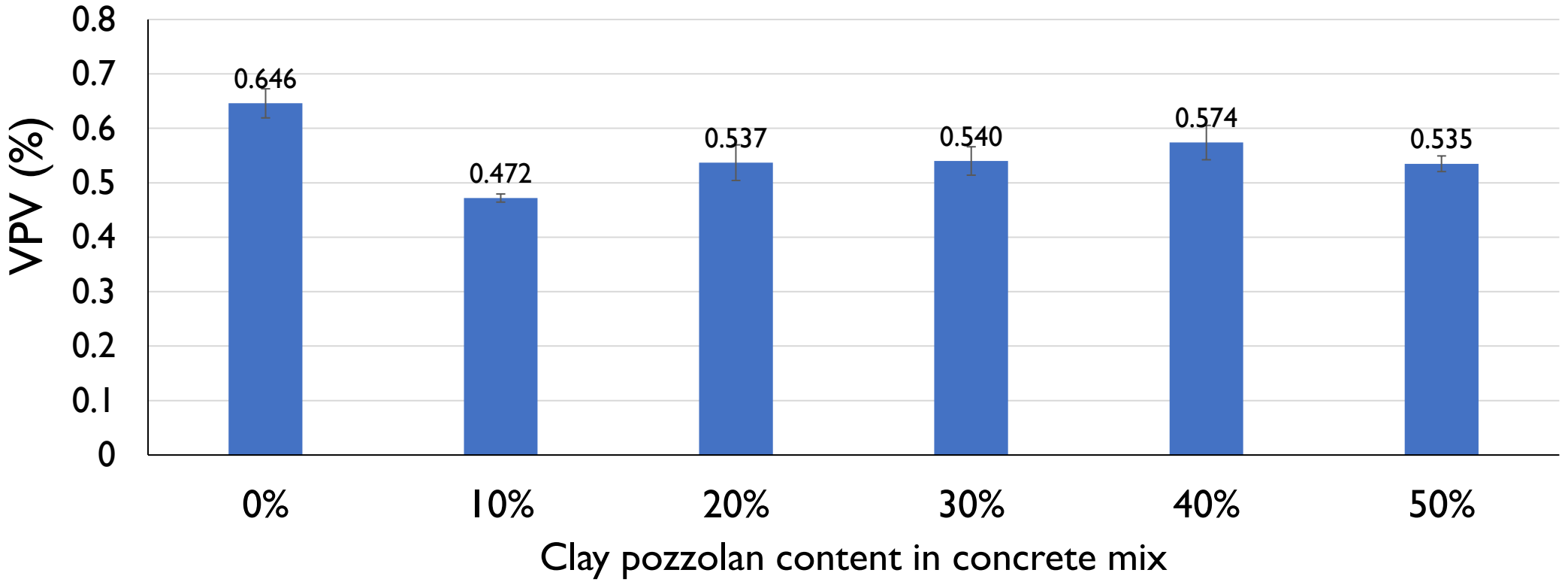
Results and discussion

Achieving the characteristic strength



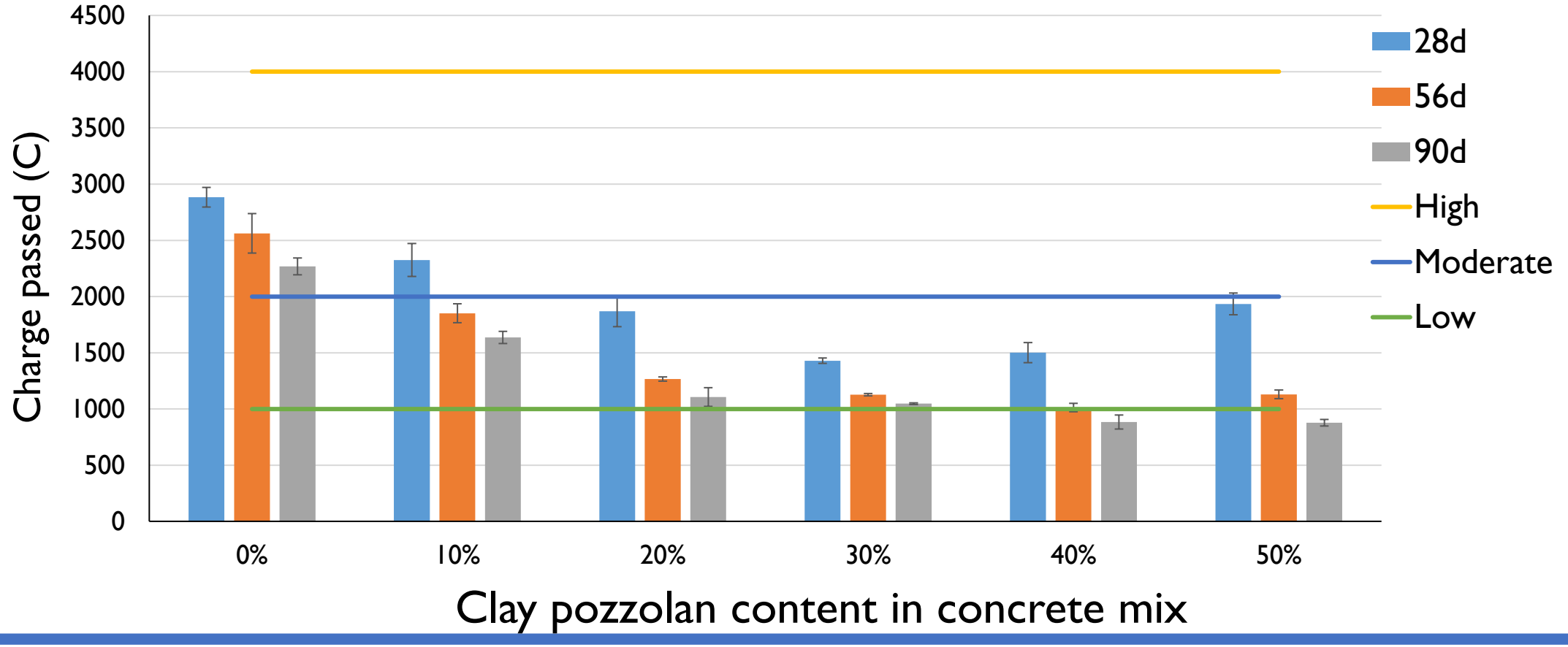
Results and discussions

VPV at 28days



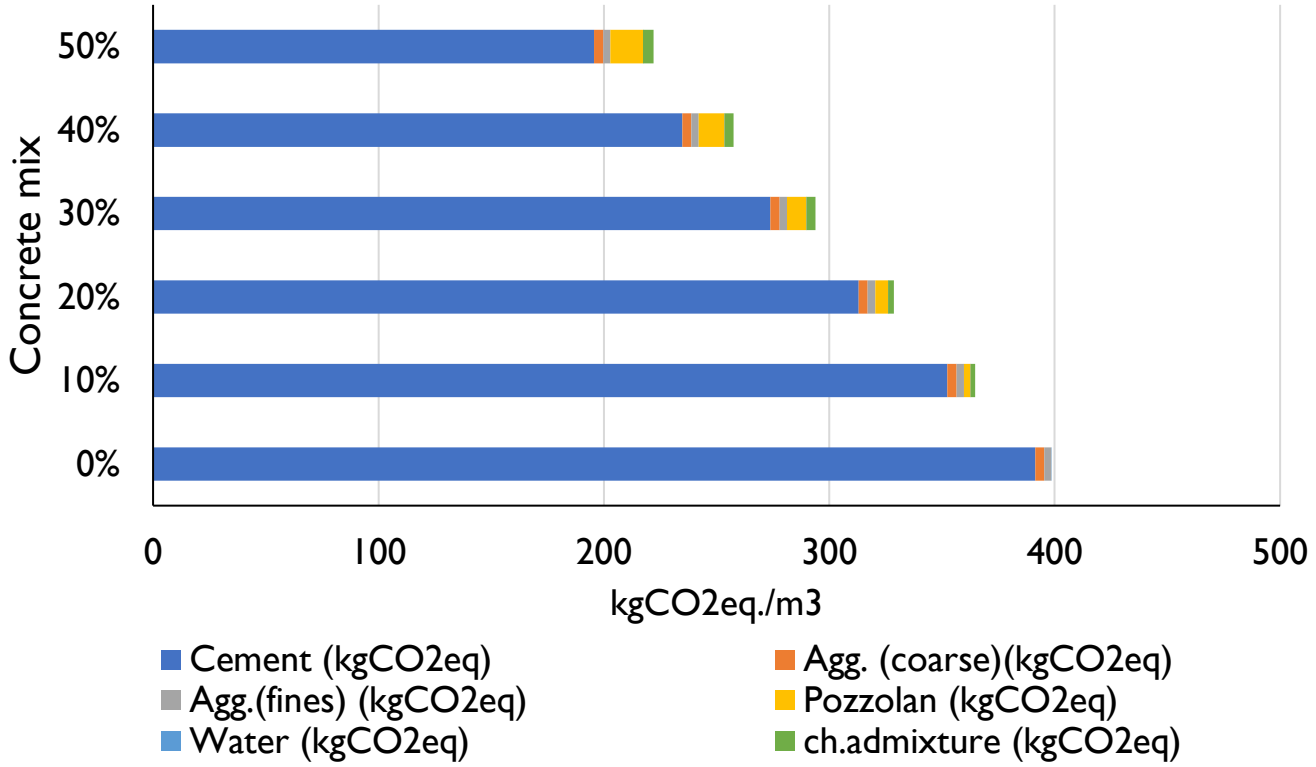
Results and discussions

RCPT



Results and discussions

Embodied Carbon of concrete



Key points

- Highest emissions was the OPC concrete
- Progressive reduction of carbon emissions with increasing pozzolan content
- Marginal emissions of other constituents compared to OPC
- Emissions increased significantly ($p=0.000888$) from other constituents of concrete as pozzolans increased

Conclusions

1. Binder made using 50% cement and 50% pozzolan obtained compressive strength of approximately 32, 34 and 30MPa at 28, 56 and 90 days respectively. The results obtained at all curing period meet the 30MPa grade concrete
2. The VPV of the clay pozzolan concretes were lower than the control by between 10 and 26%. Thus shows that there is pore size refinement due to pozzolanic action
3. The embodied carbon of the different concrete mixes progressively reduced with increasing pozzolan content in a cubic meter of concrete. OPC concrete mix had the highest embodied carbon of approximately 399kgCO_2eq whereas the 50% concrete mix had the least of approximately 222kgCO_2eq

CONCLUSIONS

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- Beyond 28 days i.e 56days, all the pozzolan concrete mixes were located in the low region (1000-2000C) at .This indicates that clay pozzolan concretes will resist chloride attack much better than the control

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- 40 and 50% pozzolan concrete mixes fell in the range of very low chloride permeability characterization (100-1000C) at a 90days. This shows that 50% pozzolan is suitable to stop chloride attack in concrete than 100% cement concrete

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