Behaviour and design of cubes and concrete-filled tubular columns using demolished concrete lumps and fresh concrete

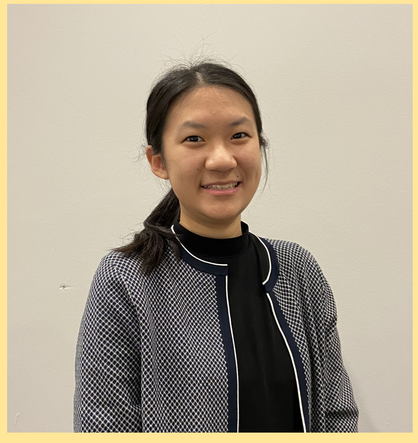
Holly Elizabeth Au

Year 4 Civil Engineering student at the University of Nottingham

LinkedIn: https://www.linkedin.com/in/holly-au/

E-mail address: hollyeau@outlook.com

University of Nottingham
UK | CHINA | MALAYSIA



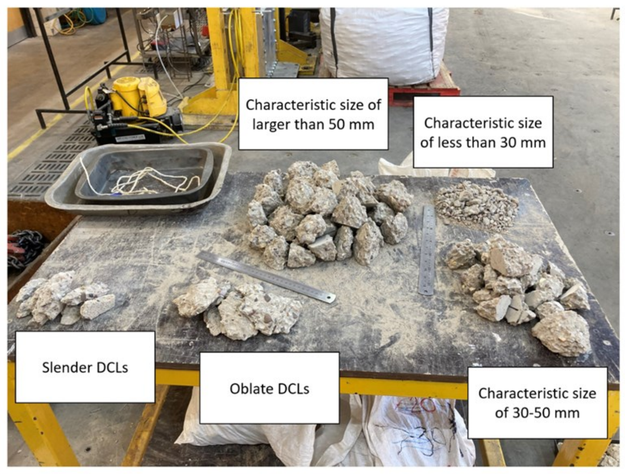
Context

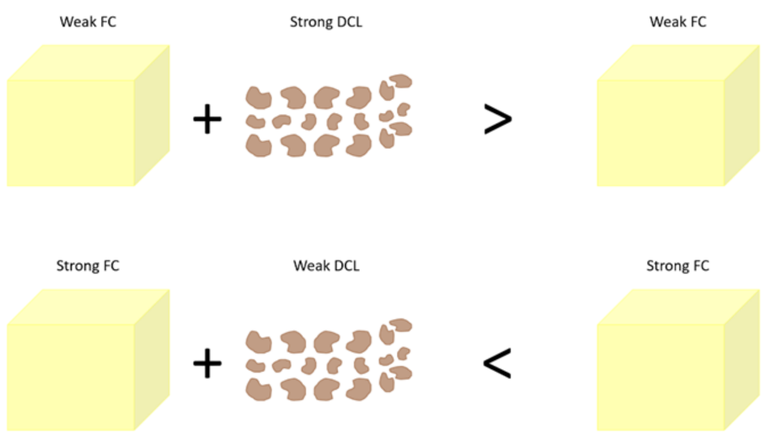
Uncontrolled use of steel and concrete in engineering is causing a depletion in resources, meaning that innovative ways to produce structural members are highly sought after. To reduce the rate of concrete use as a structural material, a new method of using demolished concrete lumps (DCLs) and fresh concrete (FC) has been proposed in the past six years. It involves crushing old concrete to form lumps, before mixing with fresh concrete during casting. DCLs generate less hydration heat than recycled concrete aggregate (RCA). In the long-term, DCLs contribute less to climate change, which aligns with the U.K. government's aim to decarbonise by 2050.

Part 1: Cubic investigation

Methodology

- The size and shape of DCLs can influence the compressive strength of compound concrete, so DCLs were sorted into different categories.
- A 'saturated surface dry condition' for DCLs was achieved.
- Slump tests were carried out to ensure that the concrete was workable.
- DCLs and FC were cast in stratified layers and cured in air.
- 7-day and 28-day axial compression tests were done.



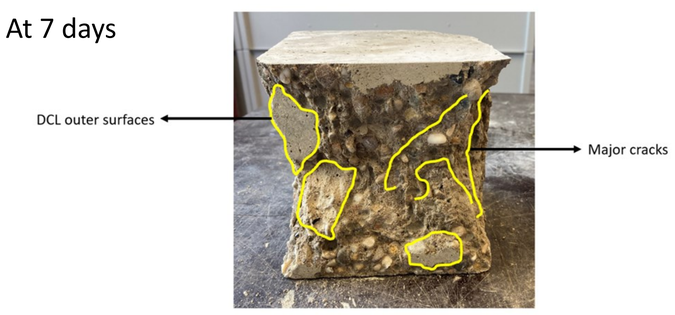


Results and analysis

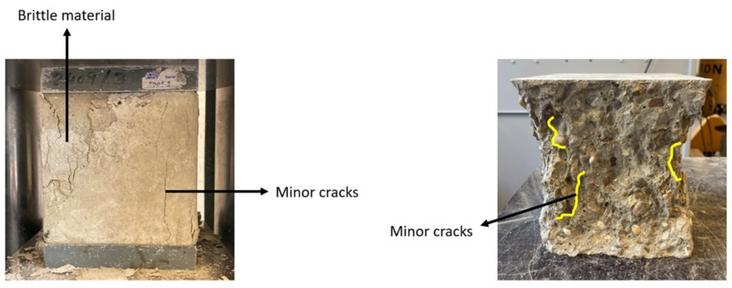
- The addition of DCLs weaken the concrete strength.
- Compound concrete tended to crack along DCL outer surfaces. Failure along DCL surfaces were more clearly seen after 7 days than after 28 days. At 28 days, the DCLs and FC had bonded well together.
- There was a more uniform failure mode on all four sides of FC-only cubes than compound concrete. This suggests that material tended to break away along lines of weak concrete mixing.
- C40 largely retained its original cubic shape, whilst C20 had a more conical shape.

$C40_1$ DCLs and C20 FC, with DCL RR = 30%

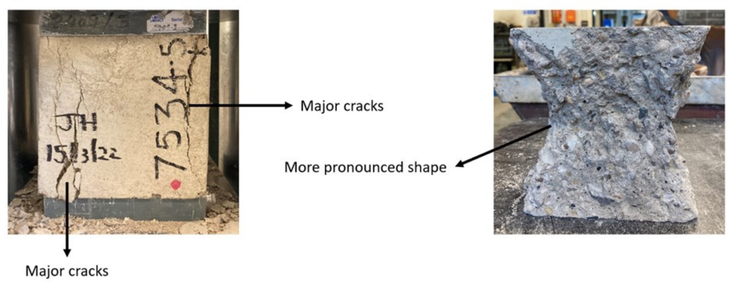
At 7 days



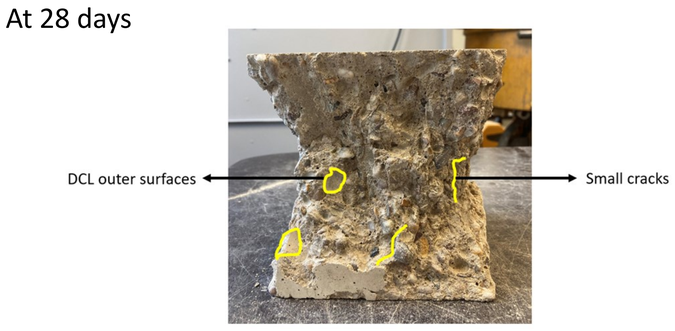
C40 FC-only at 28 days



C20 FC-only at 28 days



At 28 days



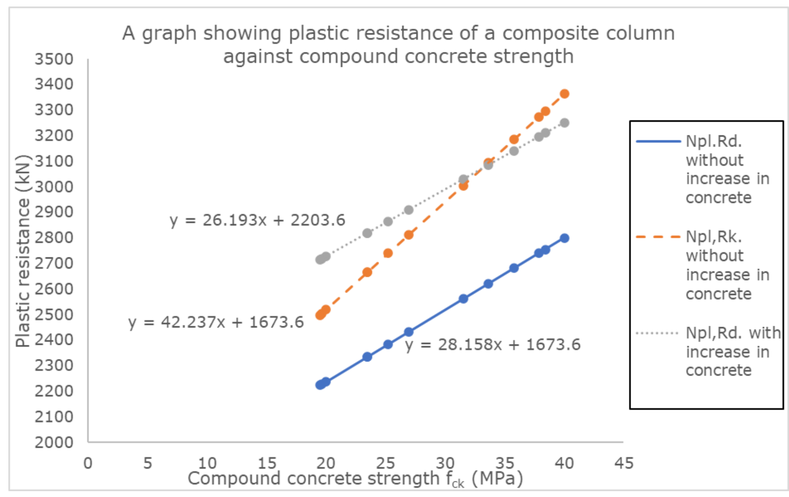
Part 2: Cylindrical investigation

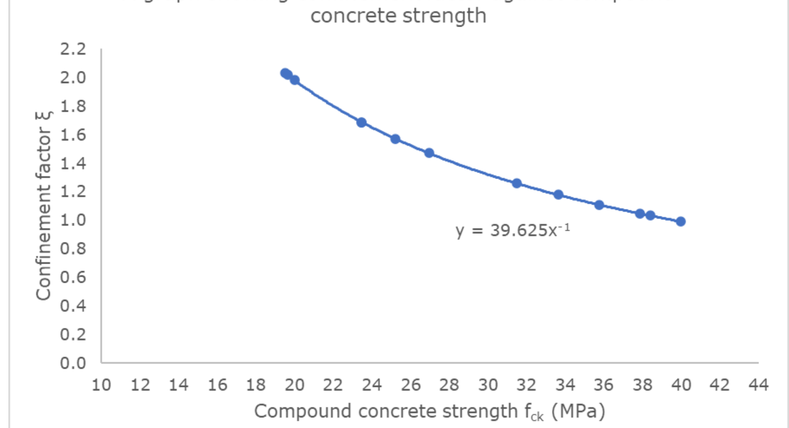
Methodology

- 13 steel CHS columns filled with DCLs and FC will be tested. Both the outer steel tube and the inner concrete core contribute to the total compressive force on the column.
- The columns will be strengthened to prevent 'elephant foot failure' occurring at the column ends. It is a premature failure. The concrete expands laterally, making the steel bulge outwards.

Theoretical results and analysis based on Eurocode 4

- As the DCL replacement ratio (RR) increases, the plastic resistance of the column decreases. When C40 FC-only is used, 3 252 kN is needed to fail a CHS 244.5 x 6.3 column, but this drops by 6.87% when the maximum possible RR of 40% is used.
- As the compound concrete strength increases, the strength index decreases linearly. Concrete of higher strengths are more able to push the steel tube outwards radially, causing the confinement effect to reduce.





Acknowledgements

Holly Elizabeth Au would like to personally give thanks to her tutor, Dr Fangying Wang, and PhD student, Mr James Hay, for their advice and guidance.

This research was financially supported by the Department of Civil Engineering of the University of Nottingham (with permission from Professor Glenn McDowell), the Centre for Structural Engineering and Informatics (with permission from Dr Walid Tizani) and Holly Elizabeth Au's tutor, Dr Fangying Wang.

Note

The topic of the submitted poster is an ongoing research project. At the time of submission, not all cube test data is available, but will be before the conference in June 2022. For the cylindrical investigation, theoretical results have been calculated, but experimentation will only be carried out after the conference.