Recycled concrete aggregates: Giving new life to old concrete

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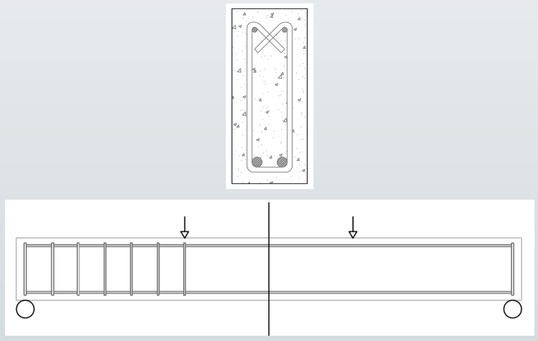
Introduction

An issue in the construction industry is sustainability. Once a building has exceeded its service life, the old concrete can be used to create Recycled Concrete Aggregates (RCA), instead of it being demolished and put into a landfill, while reducing carbon dioxide emissions. These aggregates can replace new aggregates in a concrete mix rendering it more sustainable than conventional concrete. The behaviour of concrete made with RCA must be determined and predicted in order to put them into practice. Shear failure happens suddenly where aggregates are separated from the new cement paste leaving rough surfaces which results in higher friction and load resistance. However if the aggregate splits, the surfaces are smooth, the friction between them is small, and the load resistance decreases. The chosen approach was to build concrete reinforced beams and to test them to analyse the shear behaviour.

Methodology

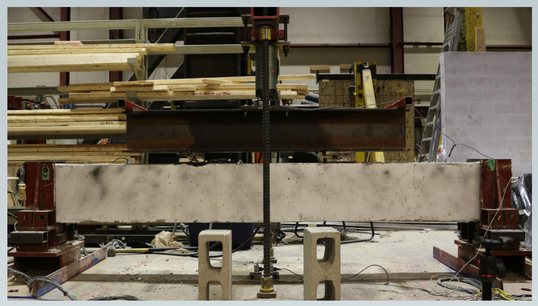
Reinforced concrete beams made with RCA and new aggregates were made by Meika Hayles. These beams had steel reinforcements (stirrups) placed in them at one extremity of the beam and none in the other to encourage shear failure at this extremity.

Stirrups configuration



An increasing load was applied to the beams using a beam testing device until the beams failed. The beams will have a large diagonal crack at the extremity lacking steel stirrups. The beam had a deflection capturing device connected at the center to measure its deflection with respect to the load. Once the beam was cracked, they were cut open to see how the aggregates behaved under shear.

Beam testing device



Results

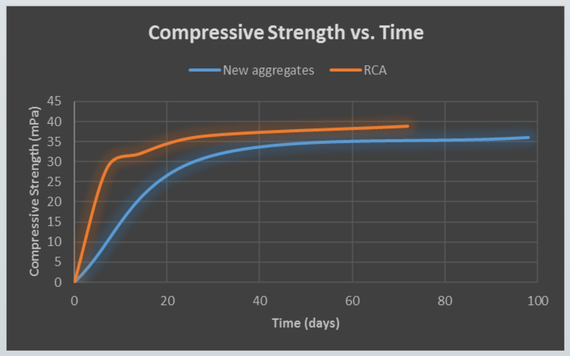
Sheared beams

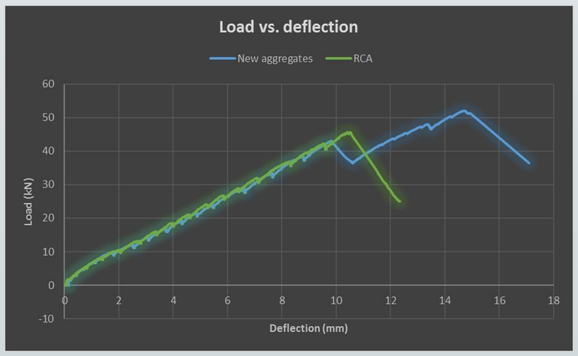
- Both cracks propagate from the support to the loading point.
- The angle of the crack in the RCA beam is greater than that of the new aggregate beam.

New aggregates

Recycled concrete aggregates

Graphical results





Sheared sections

New aggregates

- Sheared at aggregate and cement paste interface
- Rough surface
- Increase in aggregate interlock
- Increase in load capacity

Recycled Concrete Aggregates

- Sheared through aggregate
- Smooth surface
- Decrease in aggregate interlock
- Decrease in load capacity

Conclusion

The results show that the shear crack passes through the RCA when 100% of the aggregates are replaced with RCA as opposed to cracking around the new aggregates. The cause of the RCA splitting is unknown. However, according to Meika Hayles, when 50% of the aggregates are replaced with RCA, the shear capacity increases. The shear capacity is influenced by the amount and quality of the residual mortar on the RCA and the roughness of the shear section. Thus, to understand the shear behaviour of the RCA, it is important to know its characteristics.

The shear crack propagation is similar in both beams however, the angle of the crack is different. The compressive strength of the RCA concrete is higher than for the new aggregates. The deflection with respect to the load is constant for both beams. The next steps are to further analyse the data obtained by using Digital Image Correlation (DIC) technology to measure crack widths in reinforced concrete beams with the DIC *Ncorr v1.2* software. Meika Hayles will work on developing a method to measure the degree of aggregate interlock in the shear crack. All of these steps will help to determine whether the behaviour of RCA can be predicted.

Predicting the behaviour of RCA will encourage the construction industry to use RCA instead of, or along with, new aggregates. This will potentially become a standard practice in the construction industry that will lead to a more sustainable future.

References

Fathifazl, G., Abbas, A., Razaqpur, G., Isgor, O. B., Fournier, B., & Foo, S. (2009). New Mixture Proportioning Method for Concrete Made with Coarse Recycled Concrete Aggregate. *JOURNAL OF MATERIALS IN CIVIL ENGINEERING*, 601-611.

Acknowledgements

I would like to thank Dr. Martin Noel for his supervision and constructive feedback, and Meika Hayles (M.ASc Candidate) for allowing me to accompany her in her research.

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