A LIFE-CYCLE ASSESSMENT OF GREEN, STANDARD AND ULTRA-HIGH PERFORMANCE CONCRETE FOR STRUCTURAL APPLICATIONS

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ConcLCA™

Introduction

A full life-cycle assessment (LCA) is a system for evaluating the environmental impacts of a product, incorporating processes from the extraction of raw materials to waste management.

A robust and flexible input-output LCA tool (ConcLCA™) was built to quantify the global warming potential (GWP) and financial cost of selected green, standard and ultra-high performance concrete (UHPC) mixes. ConcLCA™ focuses on a cradle-to-gate (raw material extraction to the factory gate) analysis of concrete production.

Motivation

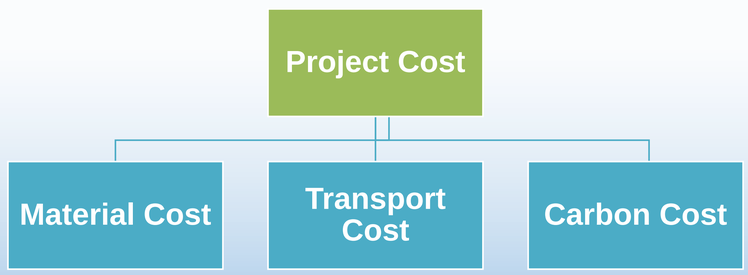
One tonne of cement produces approximately 0.9 tonnes of CO_2 and accounts for more than 5% of global CO_2 emissions [1]. The Australian Government aims to reduce greenhouse gas emissions to 26-28 percent below 2005 levels by 2030 [2].

ConcLCA™ can be utilised in the construction industry and the public sector to help make informed decisions on concrete mix design selection. This will help to reduce greenhouse gas emissions and financial costs.

Objectives

1) Life-Cycle Assessment for a Cubic Metre of Concrete
   Quantify the GWP for a cubic metre of green, standard and UHP concretes
2) Financial Assessment for a Cubic Metre of Concrete
   A financial component was implemented into ConcLCA™ which computed the production cost of various concrete compositions
3) Life-Cycle Assessment for a Floor System
   An environmental and financial analysis was then completed for a 10-storey floor system

Financial Assessment



References

[1] Jayasuriya, A, Adams, M & Bandelt, M. (2018). Understanding variability in recycled aggregate concrete mechanical properties through numerical simulation and statistical evaluation. *Construction and Building Mateirals*. 178, 301-312.

[2] Australian Government (2015). *Australia's 2030 Emissions Reduction Target*. http://www.environment.gov.au/system/files/resources/f8f337c2-2d58-4d70-a1fd-acc71254a137/files/factsheet-2030-emissions-reduction-target.pdf [Accessed 15 May 2018].

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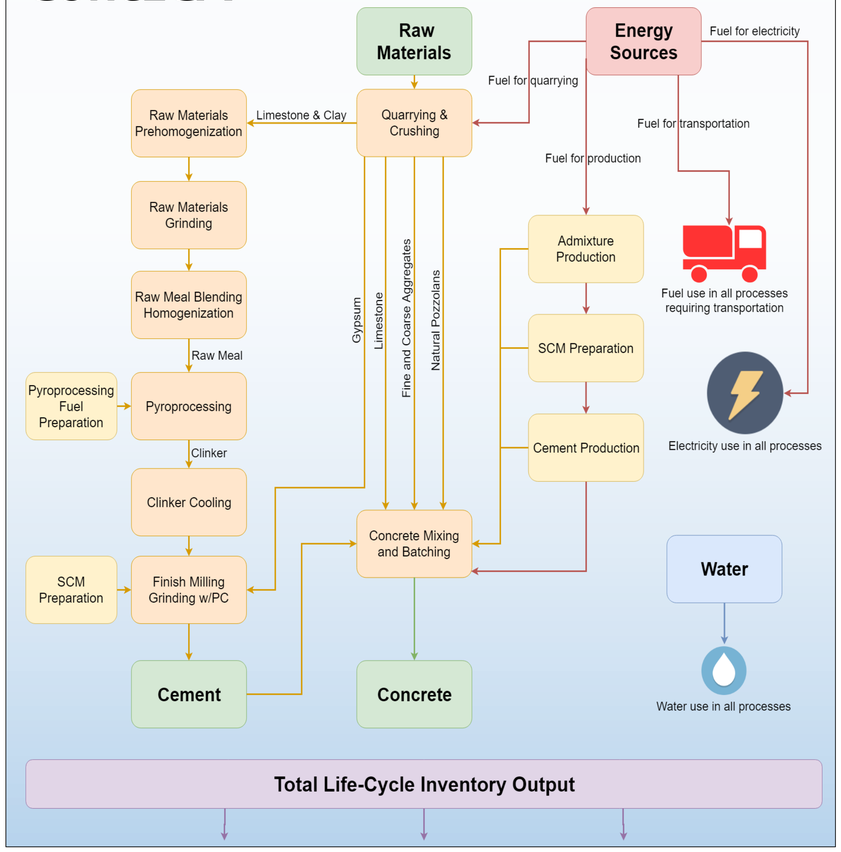
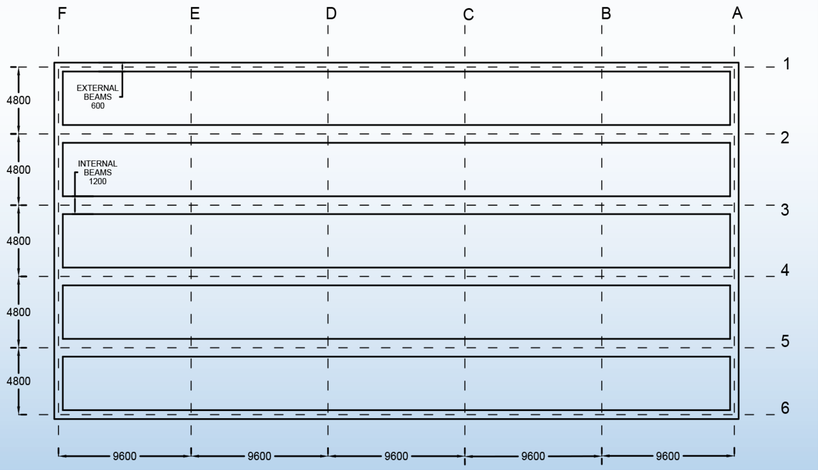
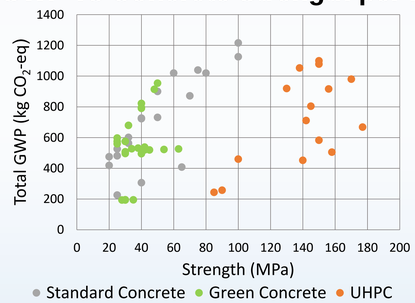


10-Storey Floor System



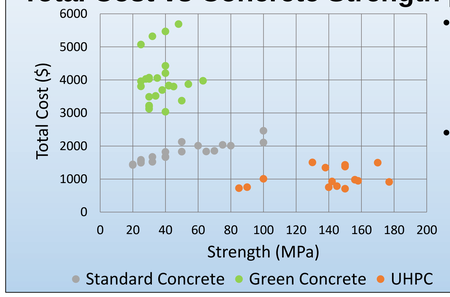
Outcomes - Cubic Metre

GWP vs Concrete Strength per m³ – 150 Year Duration



- Green, standard and UHP concretes are assumed to have lifespans of 50, 75 and 150 years respectively
- Large spread of GWP across various concrete mixes
- GWP increases linearly with concrete strength

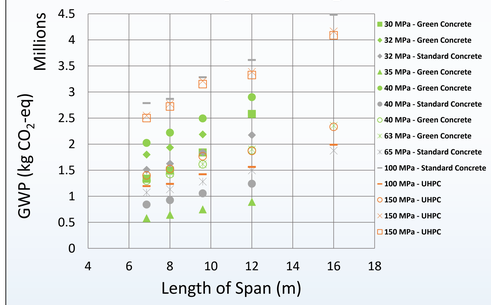
Total Cost vs Concrete Strength per m³ – 150 Year Duration



- UHPC maintains greater strength for equivalent total cost in comparison to standard concretes
- Green concrete mix designs have the highest project costs per cubic metre, followed by standard and UHP concretes due to additional constructions required within the 150-year lifespan

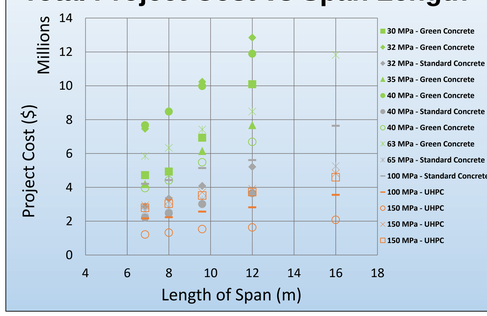
Outcomes – Floor System

Total GWP vs Span Length – 150 Year Duration



- Some UHPC mix designs were found to have similar levels of GWP in comparison to standard and green concretes
- GWP levels were then offset through purchasing carbon credits – this is outlined in the figure below

Total Project Cost vs Span Length – 150 Year Duration



- After incorporating project costing, 'UHPC without steel fibres' was found to be the cheapest and most environmentally viable option for the floor system
- This defeats the 'UHPC myth' and indicates it can be the most suitable option for certain applications