

# Accepted Manuscript

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PII: S0959-6526(17)30566-8

DOI: [10.1016/j.jclepro.2017.03.122](https://doi.org/10.1016/j.jclepro.2017.03.122)

Reference: JCLP 9249

To appear in: *Journal of Cleaner Production*

Received Date: 6 December 2016

Revised Date: 22 February 2017

Accepted Date: 18 March 2017

Please cite this article as: Teh SH, Wiedmann T, Castel A, de Burgh J, Hybrid life cycle assessment of greenhouse gas emissions from cement, concrete and geopolymer concrete in Australia, *Journal of Cleaner Production* (2017), doi: 10.1016/j.jclepro.2017.03.122.

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1 Submission to: [Journal of Cleaner Production]  
2 Category: [Original article]  
3 Word count: 12628 (total), 8467 (main text only)

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## 6 **Hybrid Life Cycle Assessment of Greenhouse Gas Emissions from** 7 **Cement, Concrete and Geopolymer Concrete in Australia**

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### 15 **Abstract**

16 Concrete is the second most used material after water and the production of cement is  
17 responsible for 5-8% of global carbon dioxide emissions. The development of low-carbon  
18 concretes is pursued worldwide to help the construction industry make its contribution to  
19 decarbonising the built environment and achieving carbon reduction targets agreed under the  
20 Paris Climate Agreement. However, there is uncertainty around the actual amount of  
21 greenhouse gas emissions that can be avoided by employing alternative types of concrete.  
22 This study quantifies the carbon footprint intensities of Australian cement and concrete  
23 production, including ordinary Portland cement, standard ordinary Portland cement concrete,  
24 blended cement-based concrete and geopolymer concrete production. For the first time, an  
25 input-output based hybrid life-cycle assessment method is used for these products. The main  
26 goal of this paper is therefore to make a methodological comparison between process-based  
27 and hybrid life cycle assessment using the Australian cement and concrete production as a  
28 case study. A comparison with published results from process-based life-cycle inventories as  
29 well as a decomposition of results into product categories is provided. The hybrid life cycle  
30 assessment resulted in higher greenhouse gas emissions for ordinary Portland cement and all  
31 types of concrete due to the methodology incorporating an economy-wide system boundary,  
32 which includes the emissions from upstream processes. For geopolymer concrete in particular,  
33 the results are also dependent on the method applied for allocating greenhouse gas emissions  
34 from fly ash and slag. The findings from this study are likely to inform the development of  
35 strategies and policies aimed at greenhouse gas reduction in the cement and concrete  
36 industries.

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