ASA 2020

Opportunities to reduce brick waste disposal

By: Salman Shooshtarian

Sustainable Built Environment National Research Centre AUSTRALIA
RMIT UNIVERSITY

Acknowledgement of Country

The authors acknowledges the traditional custodians of the country throughout Australia and recognises their continuing connection to land, waters and community.

We pay our respects to them and their cultures; and to elders both past and present and emerging.

Background

- Brick applications in construction elements
- Brick features as a construction material: lasts for 100 years
- Brick application in Australia: between 85 and 90% in new deswellings (Youl, 2011)
- Brick manufacturing industry performance in Australia (IBIS World, 2020)
- Key demands for brick manufacturing in Australia

RMIT UNIVERSITY

Sustainable Built Environment National Research Centre

Sustainable Built Environment National Research Centre

RMIT UNIVERSITY

What is problem?

- Increased usage of brick has resulted in the generation of a significant brick waste
- Waste generation occurs across the brick supply chain (e.g. manufacturing, procurement, construction and demolition)
- Brick generally generates a large amount of waste (Al-Fakih *et al.* 2019)
- Brick waste in Australia (2018 National Waste Policy) 1,872,467 tonnes of brick waste was recycled in Australia
- Impacts on society, economy and environment (Shooshtarian *et al.*, 2020)

Development of a model: Low of Waste More of Resources (LoWMoR)

- **Aim:** to identify opportunities for reduction of brick waste disposal across its supply chain
- **Aim:** to explore the circularity of this construction material and maximum utilisation of resources across the various supply chains
- **Outcome:** The model provides a pathway to stakeholders to reduce brick waste quantity
- 10 opportunities were identified to reduce brick waste

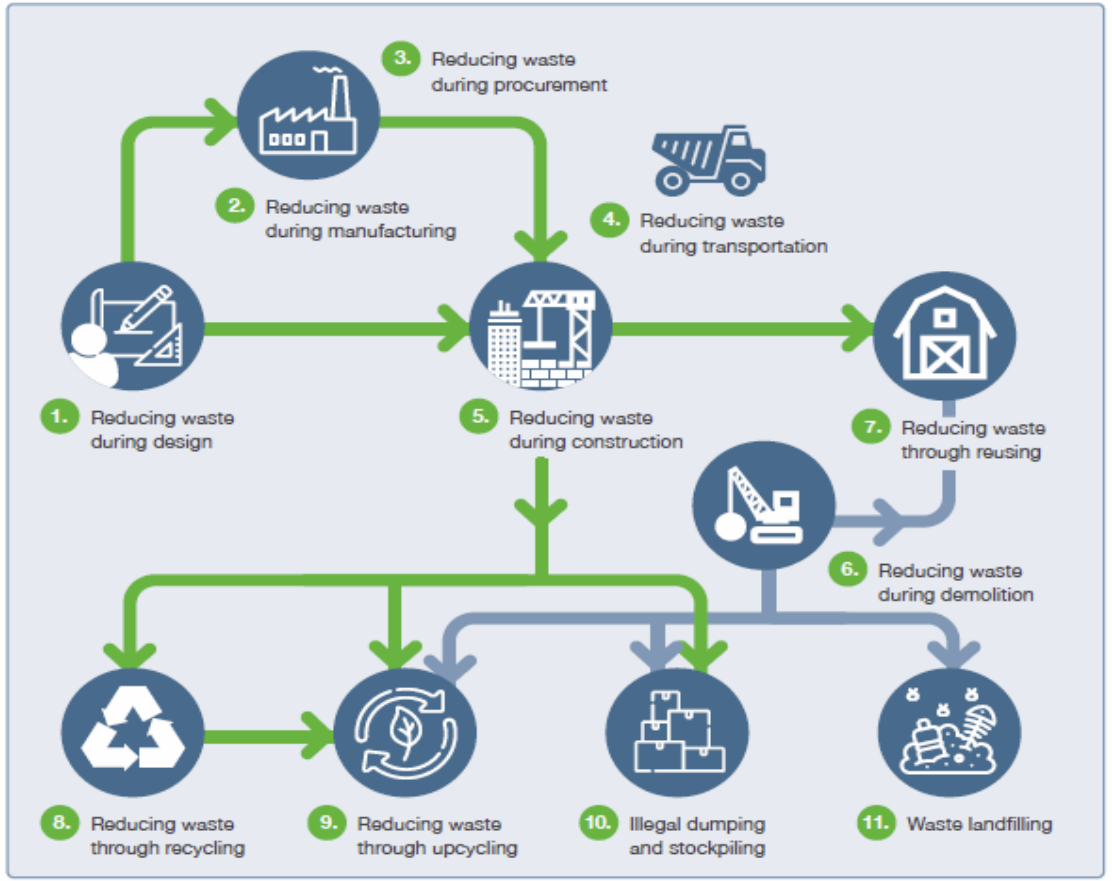

Figure 1. The integrated supply chain lifecycle model for brick waste

Results: 1. Manufacturing

- The industry is one of the efficient users of virgin resources
- In Australia, there are numerous initiatives among manufacturers to reduce waste during production
- **Ex. 1:** BGC's Brikmakers® returns all clay brick production waste back into the product mix
- **Ex. 2:** Austral Bricks® reduced the instance of malformed or off-specification green (unfired) bricks
- Production of half bricks that are sometimes necessary for certain constructions
- Integrate other waste materials which in turn reduces the need for using brick raw materials (Scarvaci and Barrett, 2019)
- The application of lean and parallel-line manufacturing model aids in waste reduction during manufacturing (Shah and Ward, 2003)

Results: 2. Design, contract and planning

- Design out waste: structures and goods that last longer, are easily repaired, upgraded or used differently in future cycles
- Substantial amount of C&D waste is attributed to design errors (Ekanayake and Ofori, 2000)
- Design changes as the most significant contributor to waste generation
- Complexity of detailing, selection of low-quality materials and lack of familiarity with alternative products
- Errors in contract clauses or incomplete contract documents
- Standardisation of design to improve buildability and reduce the number of offcuts and waste
- Innovative and modern designs promote the idea of reusing old bricks
- Partnerships between government, industry, the media, and community organisations

Results: 2. Design, contract and planning

- Some studies suggest using contractual clauses to discipline poor waste management (Dainty and Brooke, 2004)
- Integrated waste minimisation system at the contractual stage is necessary to identify and communicate the responsibilities for waste minimisation between all project stakeholders
- The type of contract: “Fix only”
- A contracting model similar to plastering subcontractors: (Scarvaci and Barrett, 2019).

Results: 3. Procurement

- Correct estimation of the bricks can save a significant quantity of unwanted materials
- Inaccurate quantity take-off and/or over-ordering ultimately create extra waste
- The false economy created by the structure of the brick ordering
- Builders typically order 2-3% more than is required to allow for offcuts and waste
- A significant contributor in small jobs if bricks are only supplied in large order increments and only a small amount of the last order increment is required
- Suppliers can be encouraged to provide more flexible “last pack” sizes—i.e. a “fractional” pallet instead of a full pallet—in order to minimise the waste because of over-ordering

Results: 4. Transportation and delivery

- Damage during transportation due to the unpacked supply is one of the two main reasons for brick wastage (Tam et al., 2006)
- A lack of hard strap protectors at corners and edges of brick stacks and hand unloading can increase waste
- an uneven landing pad for stacks could cause damage to bricks
- Waste incurred through transportation can be reduced if the transportation companies typically contracted by brick manufacturers exercise good work practices
- Replacing site bricklaying with drywall panel systems.

Results: 5. Construction

- The second major brick waste generation occurs at the construction site and mostly during construction activities (Poon et al., 2004)
- Damaged bricks due to over-stacking in the storage area and poor products of layering are all possible causes of wastes
- The main source of waste brick comes from inaccurate brick cutting, which is primarily done by chopping at bricks with a trowel (Forsythe & Máté, 2007)
- Poor workmanship could generate up to 75% of brick waste at a construction waste
- Handling and stacking breakages, use of bricks for scaffolding and other unintended uses, and bricks contaminated by dirt

Results: 5. Construction

- Training of those who are directly and indirectly dealing with the brick
- Brick-laying robotic systems
- Estimate the quantity of waste to be generated at a construction site
- Poor documentation of waste generation rates and composition
- Proper storage of bricks at the site
- Effective construction methodologies: prefabrication

Results: 6. Demolition

- Brick waste during demolition is generally sourced from residential or pavement demolition
- The resource recovery market strongly prefers separation at the source for masonry materials
- Utilisation of fixed equipment and automated sorting systems being employed to segregate materials (Hyder, 2011)
- De-construction, as opposed to demolition, is a building removal technique that aims to dismantle buildings with the goal of maximising the reuse potential of its components
- Selective deconstruction is the advance extension of deconstruction wherein some materials are targeted for reusing and recycling
- Deconstruction is cheaper than demolition, by anywhere between 55% (Asbestos fibro) and 294% (full brick)

Results: 7. Reuse

- The demolished brick or the brick that is damaged during transport, construction or renovation can be reused in construction projects without recycling
- Reusing old bricks creates environmental benefits such as saving 0.5 kgCO2-e (Gamlemursten, 2019)
- There are initiatives to encourage the application of old bricks in new builds: Think Brick Australia
- A new European Union-funded project called REBRICK (Gamlemursten, 2019)
- Reuse as a raw material: Demir *et al.* (2013) studied the use of brick waste as an additive to raw materials for brick production. They reported that up to 30% mixture of fine brick waste additives could be successfully used in new brick production

Results: 8. Recycling

- Brick waste can be processed and further used in the construction industry (recycling) or in other industries (upcycling)
- Brick waste is highly recyclable due to the inert nature and physical reprocessing requirements
- The utilisation of bricks waste in other applications is well documented
- Crush the waste and to use the final product as a landscaping aggregate or low-grade road base (Forsythe and Máté, 2007)
- In Japan, demolished bricks are burned into slime burnt ash and commonly crushed to form filling materials in Hong Kong (Tam and Tam, 2006).

Results: 9. Illegal dumping and stockpiling

- Illegal dumping and stockpiling are prevalent with all construction materials, including clay brick
- It is mainly incentivised by landfill charges inclusive of government-issued landfill levy scheme
- Cowboy operators
- State Governments and territories have created task forces to exercise restrictions on waste stockpiling which have not been effective to date (Shooshtarian et al., 2019).

Results: 10. Landfilling

- On a world-scale, the world annual production of clay bricks, which is approximately 6.25×10^8 tonnes, about 7×10^6 tonnes of brick goes to landfills each year (Adamson *et al.*, 2015)
- Due to different factors, including unavailability of land, the cost of landfilling has increased so substantially that recycling is considered to be more cost-effective
- Lack of updated and accurate data about current activities in the field of brick waste management
- In 2016-17, in South Australia, of 40,320 tonnes brick waste generated 11,498 tonnes was landfilled (2018, National Waste Report)

Conclusion

- This study developed the Brick- LoWMoR to conceptualise the opportunities across the brick supply chain to reduce waste disposal.
- **Recommendations:**
  - consider building standardisation to improve buildability and reduce the number of offcuts;
  - suppliers to provide more flexible “last pack” sizes i.e. a “fractional” pallet instead of a full pallet;
  - use of the “Supply and Lay” model to eliminate brick leftovers on site;
  - develop an agreement where a contractor “sells back” the recycled waste from the original material supplier; ensure the bottom layers of bricks remain useable by preventing soil contamination;
  - store bricks in a stable flat area to avoid breakages from fall overs;
  - determine a means for cutting bricks into half more accurately so that both halves can be used and breakages are avoided;
  - take unwanted bricks back to the brickyard or nearest material recovery facility for crushing and reuse—this can be also complemented by offering the customer leftover (full) bricks;
  - Include a clean-up payment in the scope of the bricklayer’s subcontract to assist recycling and to discourage wasteful site practices; take brick left-overs away to use as aggregate or landscaping cover;
  - and strengthen controls over licensed landfill sites

Q&A

References

Adamson, M., Razmjoo, A. and Poursaee, A. (2015) Durability of concrete incorporating crushed brick as coarse aggregate, Construction and Building Materials, 94, 426-432.

Al-Fakih, A., Mohammed, B. S., Liew, M. S. and Nikbakht, E. (2019) Incorporation of waste materials in the manufacture of masonry bricks: An update review, Journal of Building Engineering, 21, 37-54.

BRE Group (2019) The true cost of waste.

Brickworks Building Products (2012) Build for Living: Building a platform of commitment and responsibility, BrickWorks, Melbourne, Australia

Cheng, J. C. and Ma, L. Y. (2013) A BIM-based system for demolition and renovation waste estimation and planning, Waste management, 33(6), 1539-1551.

Crowther, P. (2000) Building deconstruction in Australia, Overview of deconstruction in selected countries, 14-44.

Dainty, A. R. and Brooke, R. J. (2004) Towards improved construction waste minimisation: a need for improved supply chain integration?, Structural Survey, 22, 20-29.

Dalecki, J. (2017) Reuse & Recycle Materials - Brickworks Building Products.

Damptey, E. F. (2011) Optimising the Use of Recycled C&D Waste Material in Civil Construction Projects, Faculty of Engineering and Industrial Sciences, Centre for Sustainable Infrastructure, Swinburne University of Technology, Melbourne, Australia.

Devenny, A. and Khalaf, F. (1999) Use of crushed brick as coarse aggregate in concrete, Masonry International, 12(3), 81-84.

Edge Environment (2012) Construction and Demolition Waste Guide - Recycling and Re-Use Across the Supply Chain, The Department of Energy and Environment Canberra, Australia.

Forsythe, P. and Máté, K. (2007) Assessing brick waste on domestic construction sites for future avoidance, 41st Annual Conference of the Architectural Science Association: Towards solutions for a liveable future: progress, practice, performance, people, Geelong, Australia, 1-8.

Gamlemursten (2019) The REBERICK project. Available from: <http://www.gamlemursten.eu> (accessed 5/06/2020).

Greenwood, R. (2003) Construction Waste Minimisation – Good Practice Guide, CRiBE (Centre for Research in the Build Environment), Cardiff, United Kingdom.

Hall, J. (2018) World-first': WA's Fastbrick robot builds 3x2 home in three days. Available from: The West Australian

Hirschl, B., Konrad, W. and Scholl, G. (2003) New concepts in product use for sustainable consumption, Journal of Cleaner Production, 11(8), 873-881.

Hyder (2011) Construction and Demolition Waste Status Report: Management of Construction and Demolition Waste in Australia Department of Energy and Environment (Department of Sustainability, Environment, Water, Population and Communities), Australia

IBISWorld (2020) Clay Brick Manufacturing in Australia: AUSTRALIA INDUSTRY (ANZSIC) REPORT C2021, in R. Dean (ed.), IBISWorld, Australia.
Minunno, R., O'Grady, T., Morrison, G. M., Gruner, R. L. and Colling, M. (2018) Strategies for applying the circular economy to prefabricated buildings, Buildings, 8(9), 125.
NSW Office of Environment and Heritage (2010) House deconstruction fact sheet: Bricks and concrete removal.
Oguchi, M., Tasaki, T. and Moriguchi, Y. (2010) Decomposition analysis of waste generation from stocks in a dynamic system: Factors in the generation of waste consumer durables, Journal of Industrial Ecology, 14(4), 627-640.
Phonphuak, N., Kanyakam, S. and Chindaprasirt, P. (2016) Utilisation of waste glass to enhance physical–mechanical properties of fired clay brick, Journal of Cleaner Production, 112, 3057-3062.
Pickin, J., Randell, P., Trinh, J. and Grant, B. (2018) National Waste Report 2018, Australian Department of the Environment and Energy, Canberra, Australia.
SA EPA (2001) Barriers and Opportunities for Re-use and Recycling of Clean Fill and Building and Demolition Waste
Sanchez, B., Rausch, C. and Haas, C. (2019) Selective Deconstruction Programming for Adaptive Reuse of Buildings, in, Computing in Civil Engineering 2019: Data, Sensing, and Analytics, American Society of Civil Engineers Reston, VA, 225-232.
Scarvaci, V. and Barrett, C. (2019) Brick supply and lay model, BGC (Australia) Pty Ltd: Group Manager Energy and Environment, Brickmakers (Australia) Pty Ltd: General Manager, Perth, Australia.
Shah, R. and Ward, P. T. (2003) Lean manufacturing: context, practice bundles, and performance, Journal of operations management, 21(2), 129-149.
Shih, P.-H., Wu, Z.-Z. and Chiang, H.-L. (2004) Characteristics of bricks made from waste steel slag, Waste management, 24(10), 1043-1047.
Shooshtarian, S., Maqsood, T., Khalfan, M., Wong, S. P. and Yang, J. R. (2019) Managing construction and demolition (C&D) waste in Australia, CIB World Building Congress 2019 'Constructing Smart Cities', Hong Kong, China, 17-21 June
Shooshtarian, S., Maqsood, T., Khalfan, M., Yang, J. R. and Wong, S. P. P. (2020) Landfill levy imposition on construction and demolition waste: Australian stakeholders' perceptions Sustainability, 12(11), 1-15.
Sustainability Victoria (2014) Factsheet: Market summary – recycled brick, stone and concrete, Melbourne, Australia.
Tam, V. W. and Hao, J. J. (2014) Prefabrication as a mean of minimising construction waste on site, International Journal of Construction Management, 14(2), 113-121.
Tam, V. W. and Tam, C. M. (2006) A review on the viable technology for construction waste recycling, Resources, Conservation and Recycling, 47(3), 209-221.
Thinkbrick (2019) Accreditation Courses.