Training session with ATCO

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Training package for construction designers

The use of products with recycled content in construction

Prof. Tim Ryley, Griffith University

With inputs from Dr Chamari Jayarathna, Dr Salman Shooshtarian, Dr Savindi Caldera, Dr Ana Maria Cacreres Ruiz, Assoc. Prof. Atiq Zaman & Prof. Peter Wong

Acknowledgement of country

We acknowledge the people who are the traditional custodians of the land, pay respect to the Elders, past and present, and extend that respect to other Aboriginal and Torres Strait Islander peoples.

Course Content

1. Understanding the Construction & Demolition (C&D) Waste problem
2. Sustainability & the Circular Economy
3. The DesignPhase & Sustainable Construction Strategies
4. Products with Recycled Content (PwRC)
5. ATCO case study

Understanding the problem

Construction is booming worldwide driven by population growth, urbanisation and increased need for dwellings, business sites and commercial spaces.

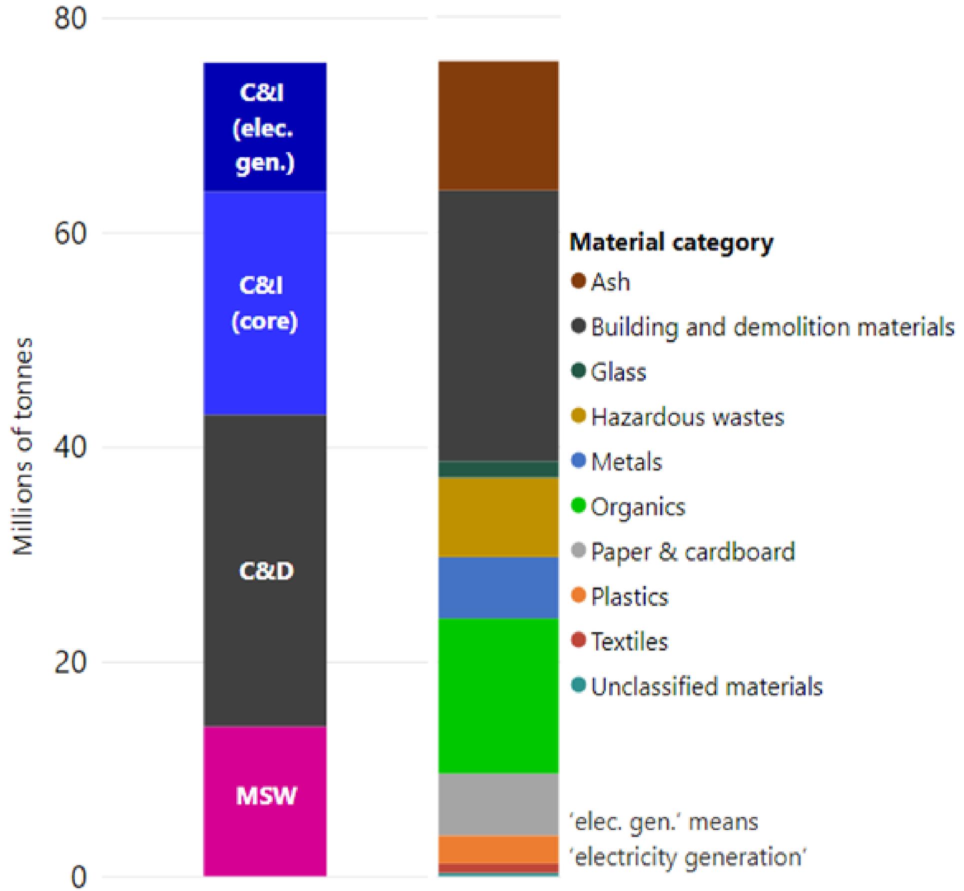
It is expected the construction industry will grow by 85% to $15.5 trillion by 2030 (Global Construction 2030 report).

There is, therefore, a serious challenge to implement **sustainable waste management practices** for construction & demolition (C&D) waste.

Construction and Demolition Waste in Australia

In 2020-21 Australia generated an estimated 75.8 million tonnes (Mt) of waste including 25.2 Mt of construction and demolition materials.

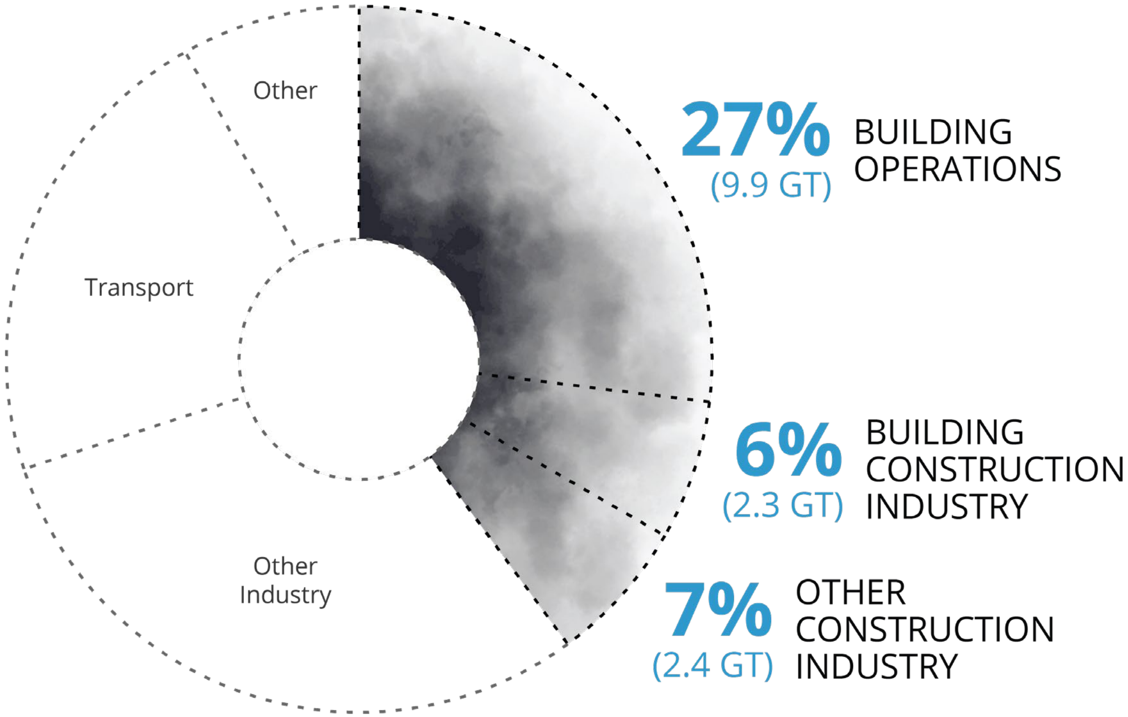
Waste from these activities include **brick, concrete, metal, timber, plasterboard, asphalt, rock & soil.**



Source: National Waste Report 2022. *Blue Environment Pty Ltd.: Docklands, Australia*, 1-156.

Which C&D waste materials have the most potential for creating a circular economy in your organisation?

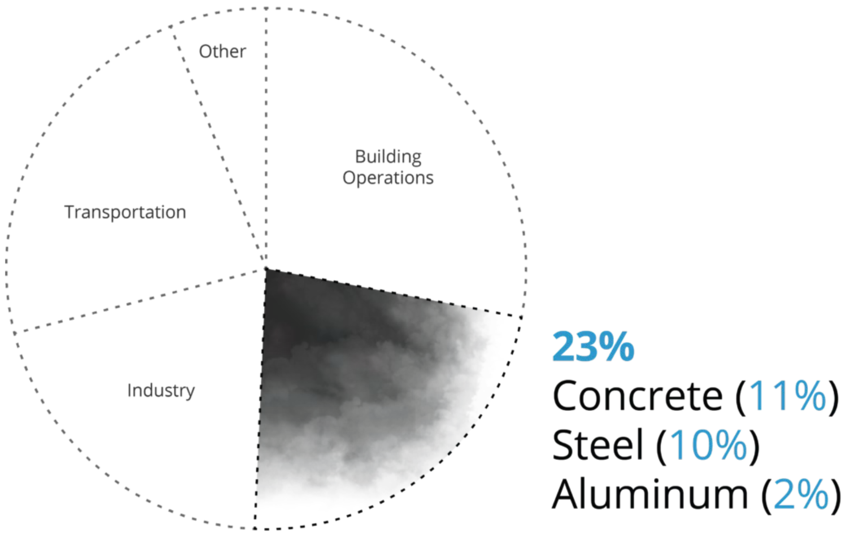
Global emissions and construction



Building Construction Industry and Other Construction Industry represent emissions from concrete, steel, and aluminum for buildings and infrastructure respectively.

The built environment generates 40% of annual global CO2 emissions.

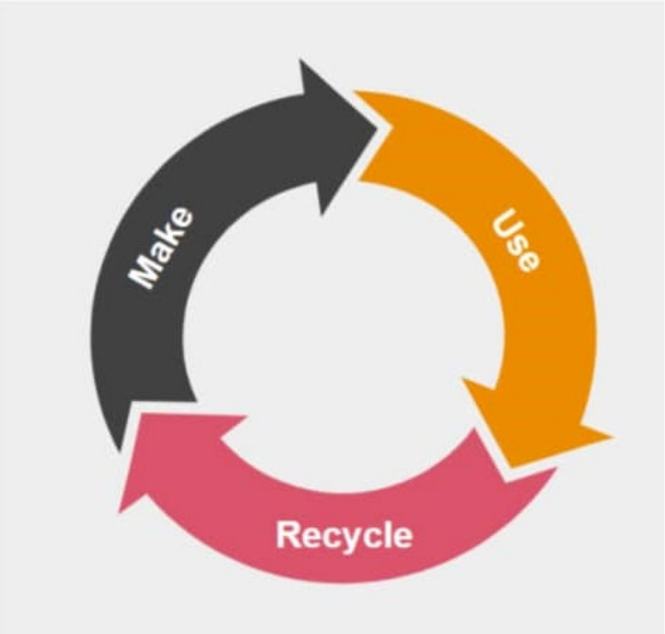
Just three materials – concrete, steel, and aluminium – are responsible for 23% of total global emissions



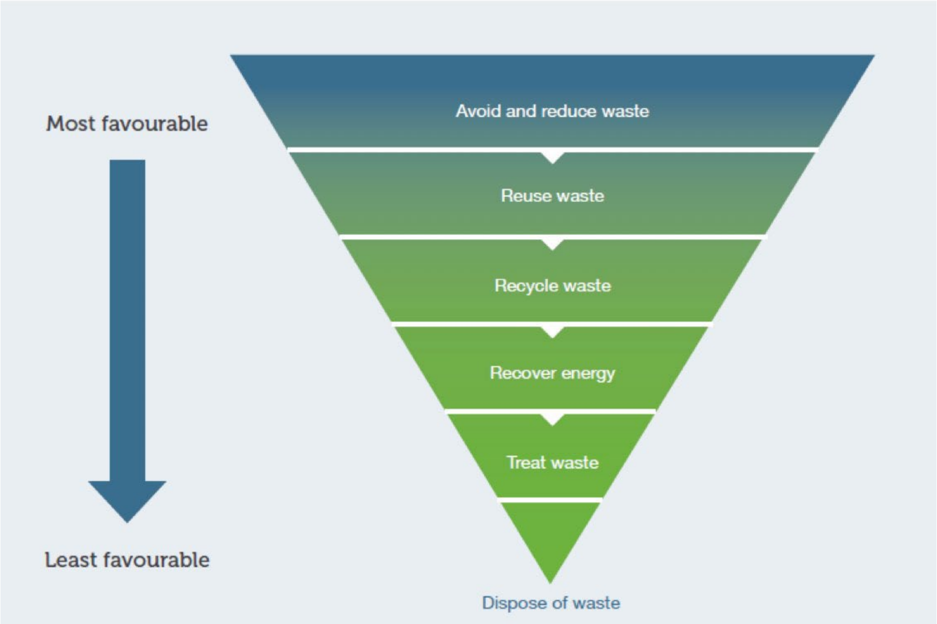
Data Sources: Global ABC Global Status Report 2018, EIA

A sustainable approach to minimise C&D waste

Circular Economy



Waste Hierarchy



Recycling: Evidence from the literature (Shooshtarian et al., 2020)

Recycling has been identified as one of the targeted approaches to minimise C&D waste.

Studies found that compared with natural coarse aggregates, recycled coarse aggregates leads to a reduction of up to 65% GHG emissions.

In Japan, a typical residential building constructed of recycled materials would save a minimum of 10% of energy demand.

In Australia, the energy consumption and the resulting GHG emissions from the recycling of aggregate have been calculated to be around 4 kg CO2 per ton, representing 22% - 46% fewer than an equivalent conventional quarry product.

Sustainability recognition of construction projects

Leadership in Energy and Environmental Design (LEED)

Building Research Establishment Environmental Assessment Method (BREEAM)

WELL Building Standard

Green Star

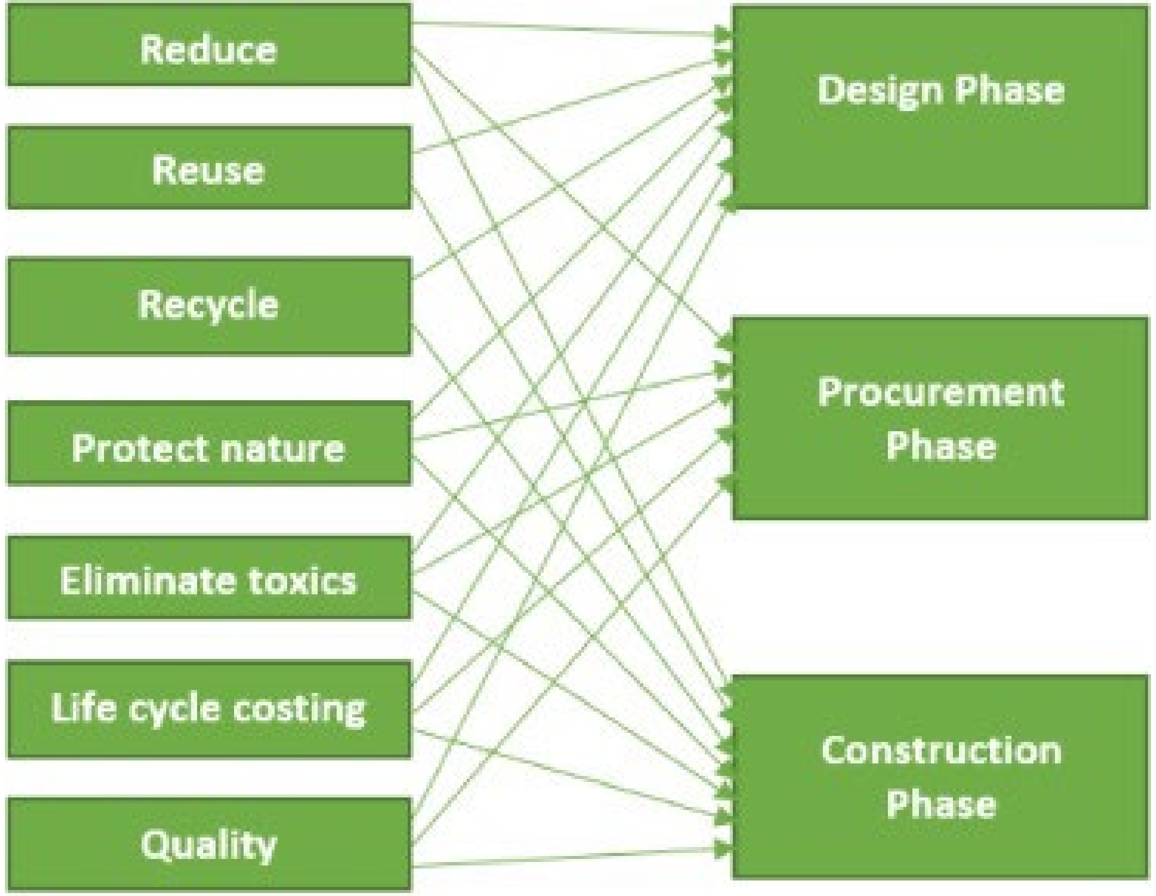
Source: https://www.cim.io/blog/navigating-popular-green-building-certifications-requirements-benefits-and-how-to-choose

Training package focus

- The focus of this training is on **construction designers**, at the design phase of construction.
- Therefore, this is the Designer / Architect (D/A) position.
- Development Managers are key in this aspect as they are the decision-makers & commissioners.

How to minimise construction waste?

Construction principles | **Construction phases**



Sustainable construction strategies

Design Phase:
- Design for deconstruction
- Design for flexibility and adaptability
- Design for long life
- Design for material optimisation
- Design for reuse and recovery

Procurement Phase:
- Circular economy procurement
- Prompt delivery
- Adequate storage
- Procurement of less packaged material
- Limiting over ordering of materials
- Just-in Time approach

Construction Phase:
- Off-site construction
- Sorting
- Reusing
- Recycling

Sources: Ogunmakinde et al., (2022); Ogunmakinde (2019); Zaman et al., (2023)

Construction waste at the design stage

A substantial amount of construction waste originates as a result of poor design

Causes of waste at the design stage

- Design changes
- Design & detailing complexity
- Detailing errors
- Unclear specifications
- Lack of information on drawings
- Poor coordination & communication

1/3 of on-site waste is due to architects' failure to implement waste reduction during design stage

Role of architects at the design stage

- Inform clients about the impact of waste and benefits of waste minimisation
- Initiating waste reduction strategies at a project level
- Improving design practices by addressing key causes of design waste

Minimising waste at the design stage

Architect strategies

- Standardisation of design and prefabrication

- Influencing reusing and recyclability of materials

- Using educational programmes to help clients and other stakeholders to understand the importance of waste minimisation

- Using clear and comprehensive designing tools to assist them in waste minimisation

Designing Tools and Resources

Eco Design Circle
https://circulardesign.tools/

Circular design
https://www.circulardesign.it/design-for-x/#Reuse

Sustainability Guide
https://sustainabilityguide.eu/

Circular Experience
https://www.circular-experience.org/library

Design for deconstruction

Deconstruction is the careful, piece-by-piece disassembly of buildings.

Deconstruction of a building is also known as selective demolition or disassembly.

The main goal is to maximise the potential reuse and recovery of a building’s components and materials and to prevent demolition at the end-of-life.

The benefits of conducting deconstruction processes outweigh the cost so long as the value of the building component is preserved when it reaches its end-of-life.

Actions that support for DfD

Actions
Allow parallel rather than sequential disassembly.
Use lightweight materials to facilitate the easy handling of components.
Size components to suit the proposed means of handling.
Separate structure from cladding to allow changes to the building envelope.
Provide access to all parts of the building that are to be disassembled
Arrange components in a hierarchy of access related to life spans.
Use a modular system that is compatible with existing standards.
Reduce, simplify, and standardise connections.
Provide a means of identification of components and assembly instructions.
Design using an open system that allows for structural alternatives.
Allow for disassembly at all scales, from materials to whole buildings.
Logistics/manual of disassembly.
Avoid cast-in-place composite systems unless they are recyclable and reusable and do not cause negative environmental impacts.
Avoid the use of joints and/or screws.
Avoid the use of chemical connections (e.g., adhesives, coatings).
Avoid the use of hazardous materials and compounds.

Design for Flexibility and Adoptability

The design for flexibility entails the **ability to transform with low resource consumption** and the design for adoptability involves **structural and material alterations to reuse materials in the future.**

This design seeks to provide the building with multiple life cycles to make the most of resources and materials in terms of spatial and technical domains.

Some Specific Actions

Increase convertibility: Allow for changes in building use by designing the building envelope to allow for more than one use or to allow modifications in window size and spacing.

Use standard, simple construction tools and technologies.

Avoid bespoke / tailor-made solutions and complex building geometries.

Design for long life

A key objective is to keep the value of materials and resources as long as possible by intensifying their use.

Actions to support this is by extending the service life of buildings by:

- specifying durable components
- avoiding the use of synthetic materials that do not allow refurbishment
- prioritising standardised, modular elements
- maximising the durability of the building structure through careful selection, protection, and maintenance of components
- making use of Whole Life-Cycle Cost assessment (WLCC) as a design assessment tool
- assembling in a systemic manner that is suitable for maintenance and allows for the possibility of replacements

Other key Circular Economy design strategies include…

- Design for **dematerialisation** – To reduce materials and resource inputs
- Design for **reuse** – Focused on creating new uses for materials rather than recycle them
- Design for **restoring and regenerating** – Geared towards generating a positive impact on human and natural systems
- Design for **climate resiliency** – Aimed at lowering embodied carbon footprint of materials
- Design for **sharing** – Intended to maximise the use of materials/spaces
- Design for **waste prevention** - Targeted at reducing on-site waste

Key circularity design practices – How circular?

	Aligned with EMF CE principle?		
CE Strategy	Design out waste & pollution	Keep products & materials in use	Regenerate natural systems
Design for Deconstruction (DfD)	High	Medium	Low
Design for flexibility and adaptability	Medium	High	Low
Design for long life	High	High	Low
Design for dematerialisation	High	Low	Low
Design for reuse	High	High	Medium
Design for restoring and regenerating	Low	Low	High
Design out hazardous/pollutant materials	Medium	Low	High
Design for climate resiliency	Medium	Low	High
Design for sharing	High	High	Medium
Design for waste prevention	High	High	Medium

Low

Medium

High

CE Strategy focus – aligned with your company's circular vision and goals

SAMPLE CHECKLIST FOR IMPLEMENTING THE CE GUIDELINE STRATEGIES

CE Strategy	Action	Implemented?
Design for flexibility	The design allows for any possible future changes (e.g., change in window size) – design envelope	☐
	Use standard, simple construction tools and technologies	☐
	Bespoke/tailor-made solutions and complex building geometries are avoided	☐
	Technologies and tools are standard and simple, not complex	☐
	Adaptability manual available	☐
Design for longevity	Durable components have been specified	☐
	Use of Whole Life-Cycle Cost assessment (WLCC) as design assessment tool	☐
	Assembly allows for maintenance and for the possibility of replacements	☐
	Design for long service life been factored in (e.g., allowing for maintenance, replacements, repairs)	☐
Design for Deconstruction (DfD)	Parallel disassembly design	☐
	Use lightweight materials that facilitate easy handling of components	☐
	Components are sized to suit the proposed means of handling	☐
	The structure is separated from cladding to allow changes to the building envelope	☐
	There is access to all parts of the building that are to be disassembled	☐
	Components have been arranged in a hierarch of access related to life spans	☐
	Modular system that is compatible with existing standards	☐
	Connections have been reduced, simplified, and/or standardised	☐
	Provide a means of identification of components and assembly instructions	☐
	Design using an open system that allows for structural alternatives.	☐
	The design allows for disassembly at all scales from materials to whole buildings	☐

Four project case study examples

Case study selection criteria:

1. Recent history of using a significant quantity of PwRC
2. Access to project information
3. The ability to recruit research participants

Case studies:

1. Brickworks Shopping Centre
2. Mordialloc Freeway
3. Tonkin Gap Highway
4. Hamilton Hill (Residential)

What D&A teams told us in four case studies

Motivations

Designer
- Contractual obligation
- Reduced carbon footprint

Designer
- Contractual obligation
- Provide workable design solutions
- Develop sustainable design
- Superior PwRC's physical characteristics
- Less energy intensive
- Recyclable
- Minimise the need for virgin materials
- Certification for PwRC quality and performance

Designer
- Heritage and aesthetic aspects
- Reduce the need for materials extraction
- Solve PwRC stockpiling issues
- Alignment with circular economy

Designer
- Client's commitment to sustainability
- Contractor's desire to win future similar projects
- Contractor's fear of reputational damage if not using PwRC
- Social responsibility

Strategies

Designer
- Effective time management planning
- Early engagement of stakeholders
- Mandate site visits for contractors

Designer
- Develop demonstration projects
- Test materials before applying them

Designer
- Early engagement of stakeholders
- Develop understanding of budget requirements
- Develop understanding of PwRC's cost performance
- PwRC's post-occupancy

Designer
- Promote the economy of scale
- Allow reasonable lead time to recyclers to produce the required PwRC
- Develop the right contractual mechanisms

Barriers

Designer
- Extended delays in obtaining permission for setting up the temporary waste recovery plant
- Approval from the nearby city council to use PwRC
- The limited industry capacity to handle PwRC
- Unavailability of PwRC

Designer
- Negative perceptions
- Unsupportive specifications
- Unavailability of PwRC

Designer
- PwRC's cost
- PwRC's sourcing time
- Finding qualified sub-contractors
- Unique design process
- Materials application standards & requirements
- Functionality & maintenance
- Specific warranty requirements
- Client's understanding & commitment
- Unavailability of PwRC

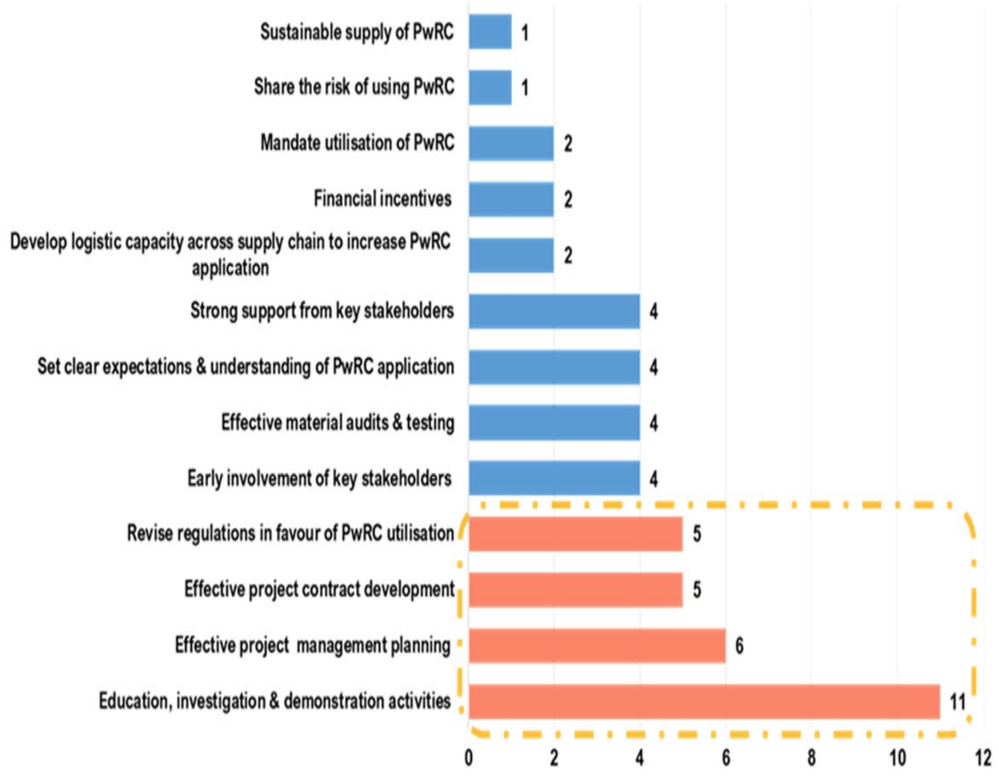
Designer
- Under-developed capacity of recycling facilities
- Absence of a mandatory utilisation of PwRC in road infrastructure
- Industry's lack of commitment to using PwRC
- Removal of the design organisation's quality considerations in the contract
- Client's tendency to place all the risk on the contractor's shoulder
- Higher transport cost
- Discouraging client's back processes to use PwRC

Main strategies to address barriers

45 factors were identified as the main strategies to reduce the impact of challenges faced in the case study projects when using PwRC.

These strategies were categorised into 13 groups.

The top two categories were: 'effective education, investigation & demonstration activities' and 'effective project management planning'.



ATCO - Modular construction

Modular construction is a building method where individual components, or modules, are prefabricated in a factory-controlled environment and then transported to the construction site.

These modules are typically designed to fit together seamlessly to form a complete structure, such as a home or commercial building.

Modular construction comes in several forms. It can be delivered “as a box” in finished form, as a flat pack – separate parts such as wall frames and floor panels – or as a kit of smaller

Top (educational building), bottom (correctional facility).

Source: ATCO Structures and Logistics (2024)

ATCO focus

- Materials to give buildings extensive lives but are easier to repurpose once it has reached its end-of-life phase.
- Spatial design, understanding how to design the most adaptable floor layouts so structures can be reused across multiple sites.
- Repurposing of materials and offcuts.
- Education on alternative construction techniques.

Top (office building), bottom (sporting facility)

Source: ATCO Structures and Logistics (2024)

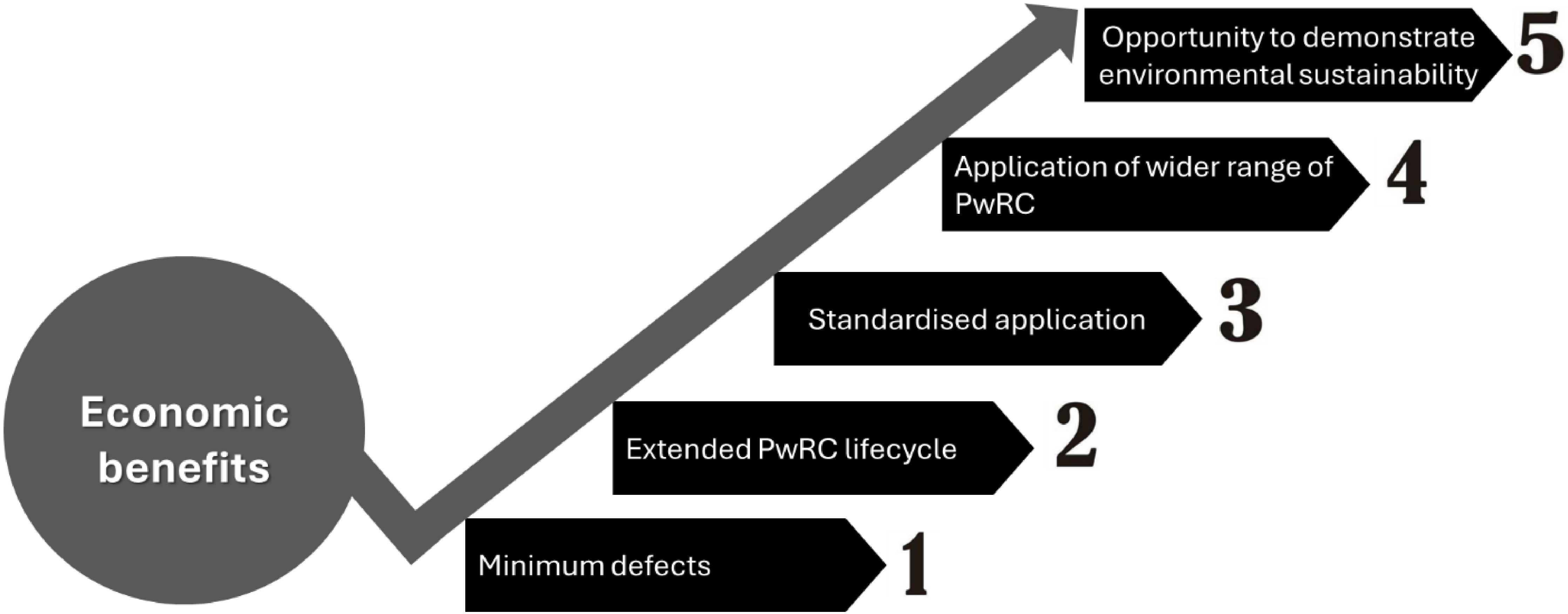
The main barriers to using modular construction in Australia

Limited knowledge of applicability	Industry yet to adopt the new processes and models at scale
Capital costs	Significant initial investments for acquiring production facilities, specialised equipment, and marketing campaigns
Insufficient buyback fund	Significant initial investments for acquiring production facilities, specialised equipment, and marketing campaigns
Inefficient rollouts	Inefficient process due to excessive delays, ineffective site preparation and poor communication with the stakeholders

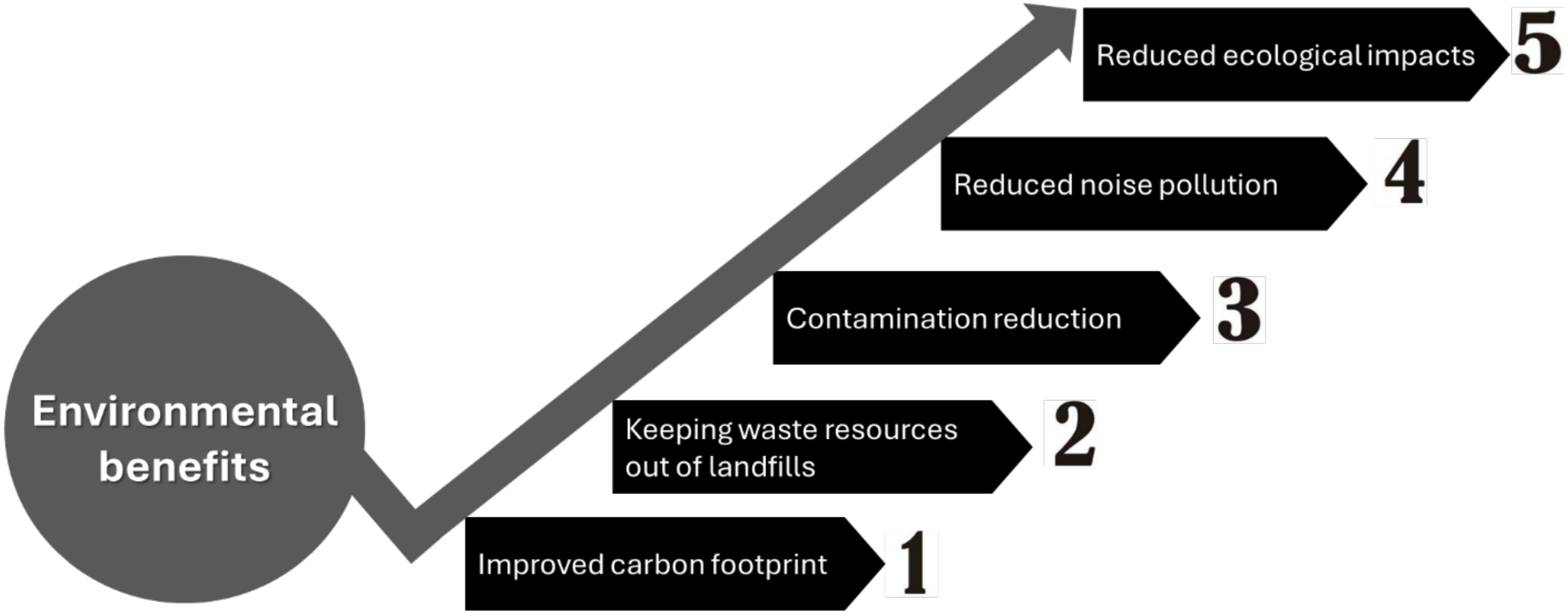
Drivers for using PwRC in the ATCO case study

1. Supportive organsiational targest
2. Financial benefits
3. Client preference and obligations
4. Securing public projects
5. Moral obligations

ATCO study: Economic benefits of using PwRC in modular construction



ATCO study: Environmental benefits of using PwRC in modular construction



Sustainable material options: Hempcrete (against traditional concrete)

- Absorbs carbon dioxide from atmosphere during growth and continues to absorb carbon dioxide through its life span within the building. After use the product can be broken down and the carbon dioxide can be returned to the soil sediment, promoting new growth.
- No need to use fossil fuels in the production of hempcrete products
- ATCO can implement Hempcrete products, by substituting traditional block footings for hemp-based products. Further site elements such as walkways and ramps can also be installed using Hempcrete.

Hempcrete

Strengths	Weaknesses
Strong thermal performance	Limited precedence for use in commercial structures
Breathable mould resistant	Not enough testing being done on the products construction properties, including resilience to corrosion, fire resistance, thermal expansion and compression, conductivity and acoustic management
Naturally breaks down	Longer curing time
Lighter than traditional concrete	Lack of established methods for production and application

Sustainable material options:
Bio-SIP (Plant Based Ridging Foam)

- Can be manufactured from a large variety of products including bamboo and flax fibres, recycled plastics, recycled cardboards and plant starch.
- Ideal material for modular construction
- ATCO can implement Bio-SIP by incorporating panel-based floor and roof systems. By doing so there will be less need for typical insulation batts and potential to save on construction times. The use of Bio-SIP technology in ATCO construction would mean more of the building can be reused at end-of-life.

Bio-SIP (Plant Based Ridging Foam)

Strengths	Weaknesses
Can be manufactured from recycled material - does not depend on the availability of raw material.	Depending on material compounds used, toxic non bio-degradable additive may be required to achieve resistance to fire, moisture and pests.
Ability to locally source the materials required - less dependency on overseas imports.	Potential for initial costs and demand for infrastructure/ technology to be high in order to manufacture products on a commercial scale.
The use of panels reduces the need for harmful adhesives. When a building reaches end-of-life a panel system ensures efficient disassembly and prioritises the ability to reuse the material.	Further testing required to understand how plant-based foams interact with other materials and the Australian climate.

Certificate of Completion

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Feel free to ask any questions.

Attendees can request a certificate of participation from RMIT if they would like.

Feel free to contact us if you have any questions.

Prof Tim Ryley

t.ryley@griffith.edu.au

Dr Salman Shoostarian

salman.shooshtarian@rmit.edu.au

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