Case Study 2: Local Collaboration in Subiaco Oval Stadium Project

Report No 1: Identify the strategies to enhance the economic and environmental performance of projects using products with recycled and recyclable content (Case Study 2: Subiaco Oval Stadium)

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Research Project: Project 1.95 Using recycled and recyclable products: Influencing stakeholders through circular economy practices

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EXECUTIVE SUMMARY

This report offers an insight into the impact of local collaboration as an effective strategy in enhancing the economic and environmental performance of PwRC utilisation in construction projects. The content of this report is based on the review of the relevant existing literature and findings of interviewing the key stakeholders in Subiaco Oval stadium project in Perth, Western Australia. The review of existing literature establishes the economic and environmental benefits emerge from local collaboration on using PwRC in construction projects on the global scale. The findings from the case study illustrates the extent to which this strategy, that is materialised via using waste resources extracted from demolition this stadium in public infrastructure projects, could improve the environmental and economic performance of these resources. The key stakeholders in this case project included WA Development and Western Australia Main Roads.

According to the findings, the main drivers for local collaboration to utilise PwRC in the case project can be categorised in three groups: 'government sustainability commitment and demonstration', 'sustainability recognition at the project level' and 'policies and regulations'. The analytical results also show that 13 key challenges hindered the effective implementation of local collaboration for optimising the recovery of materials from the Stadium demolition waste and utilising the resulting PwRC in other construction projects. These challenges were then categorised under three groups: project physical characteristics, project management, supply chain and policies and regulations.

The research also provided 18 actionable recommendations that will enhance the use of PwRC through local collaboration. These strategies are classified into three groups: 'effective project development and management', 'organisational capacity enhancement' and 'Government support and policies'. Lastly, the findings of this study suggest that local collaboration is emerging as a key trend in the use of PwRC, primarily due to various sustainability benefits. Participants indicated that in the future, the quality and diversity of PwRC are expected to increase as governmental support grows and industry capabilities to manage these resources improve.

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1 INTRODUCTION

In recent years, the optimal use of products with recycled content (PwRC) has been a controversial topic in the field of construction sustainability. There are several strategies[1] that can potentially have a positive impact on the streamlined utilisation of these resources in construction projects.

Local collaboration serves as a powerful strategy where various local stakeholders work together to utilise waste resources that are generated, recycled, and supplied within a certain region. This approach maximises the efficient use of local materials while fostering a circular economy at the regional level, reducing environmental impact and promoting sustainability.

This strategy is also known as territorialisation of the circular economy[2]

Several waste management policies support local collaboration to realise these benefits. For instance, proximity principle (PP) policy[3] that requires organisations that generate waste to deliver it to a location for processing that is within a particular distance from where it originated. This circular economy policy has the potential to prevent the unnecessary transport of waste from one location to another, thus mitigating the need for and minimising levy liabilities while concurrently alleviating both the environmental and economic burdens associated with such practices.

Despite the potential benefits of local collaborations for using these resources, there are several challenges in the way. These challenges can prevent or weaken forming collaborations in a region, promoting the stakeholders seeking alternative options.

[1] Shooshtarian S, Maqsood T, Wong PSP, Caldera S, Ryley T, Zaman A and Caceres Ruiz AAM (2024) 'Circular economy in action: The application of products with recycled content in construction projects: A case study approach'. *Smart and Sustainable Built Environment*. 13(2): 370-394.

[2] Chembessi, C., Bourdin, S. and Torre, A., 2024. Towards a territorialisation of the circular economy: the proximity of stakeholders and resources matters. *Cambridge Journal of Regions, Economy and Society*, p.rsae007. 1-18.

[3] Shooshtarian S, Maqsood T and Wong PSP (2023) 'Policy intervention of waste management'. In: Bandh, S.A., Malla, F.A. (eds) Waste Management in the Circular Economy. Springer, Cham. Springer Nature. DOI: 10.1007/978-3-031-42426-7_5.

2 RESEARCH APPROACH

2.1 Review of literature

This section of the report presents the research approach employed. First, the research team conducted an extensive literature review to offer insight into the role of local collaboration in optimisation of using PwRC in the construction projects. This review identified the main challenges, benefits and drivers of using this strategy in the building and construction sector. The sources used in this step included journal articles and government and industry reports that are freely available online. Care was taken to only capture the literature that describes the use of this strategy in recent years to reflect the contemporary efforts and advances in using these materials in construction projects.

2.2 Case study

In the second step, a case study analysis was conducted to understand Australians' experience in using local collaboration strategy to enhance the use of PwRC in the building and construction sector. In consultation with the project partners and waste experts, the criteria for the selection of the case study were set. The case study had to meet the following criteria:

- *Use of PwRC in a construction project*
- *Evidence of local collaboration for such a utilisation*
- *Ease of access to key stakeholders*

After identifying the project, Subiaco Oval Stadium (Perth, Australia), the perceptions of key stakeholder groups playing an essential role in using PwRC were sought through conducting a series of interviews. The interviewees were selected in consultation with the Development WA sustainability team. An invitation email was sent to each stakeholder to arrange suitable interview times.

The online interviews were conducted between March 2024 and April 2024 using the Microsoft Teams online platform. Each interview took a maximum of one hour and was recorded for transcription purposes. Three types of questions were asked during interviews: participants' details, their experience using the PwRC modular construction, and the enablers of and barriers to using such resources in this section of the industry. Table 1 provides the full interview questions:

Table 1. Interview questions used in the case study analysis

No	Question
1	Please introduce yourself, including your employment history and recent activities in the field of construction and demolition (C&D) waste management.
2	Can you please tell me a bit about the project and your respective involvement?
3	Can you please tell me about your organisation's experience using PwRC in this project?
4	What is the process of procuring waste materials and repurposing them into usable products in your organisation?
5	What were your main five motives to use recycled content in this project?
6	What were the main five challenges to using recycled content in this project?
7	In your opinion, how could these challenges (and their impact) be overcome?
8	What are the specific benefits and challenges of local collaborations for supplying and application of recycled materials?
9	What are the primary social, environmental, and economic advantages of using local collaboration in this project?
10	How do you envision the future of applying proximity principles to enhance the adoption of recycled materials in Australia?

11 Has your organisation published any relevant documents describing the project planning, design and execution that you could share with us?

2.3 Data analysis

The data extracted from the literature review was thematically analysed preceding the creation of the major clusters of benefits, challenges and barriers to implementing local collaboration principles for optimal use of PwRC in construction projects. The literature analysis provided the basis for a case study analysis in the Australian construction industry.

Audio data captured from 3 interviewees were carefully transcribed by a professional transcriber using the word-for-word method prior to the quality verification of the text data by the research team. The transcripts were analysed using the NVivo Pro 12 application, which facilitates codifying text-based qualitative data. A thematic analysis method was applied to identify emerging themes that were related to the three research objectives. Furthermore, to better compare the qualitative data, quantitative descriptive analysis methods were adopted. The frequency of distribution of various categories of factors identified in the interviews was the main statistical measure used to conduct these comparisons.

3 LITREATURE REVIEW

There is a scarcity of evidence showing how local collaboration could result in optimal utilisation of PwRC in construction projects. This section of report explores how previous literature documented the economic and environmental benefits of utilisation of PwRC on the global scale.

3.1 Local collaboration for enhanced environmental impacts

Collaboration between waste generators, waste resource processor and the user of PwRC is highly recommended under proximity principle. Challenges tend to emerge more prominently on smaller scales. For example, issues related to the proximity of facilities often surface, and changing behaviours typically necessitates collaboration among various stakeholders. In this regard, Raoms et al (2023)[4] stated that it is crucial to understand that if local operations do not function effectively, achieving the broader goals of circularity within the construction industry is unlikely. This highlights the importance of local dynamics in the success of circular economy initiatives. When stakeholders work together effectively at a local level, it enhances the potential for reaching significant sustainability objectives in the construction sector.

In Australia, on the national level, some states, such as New South Wales Proximity Principle is legally enforced for certain zones[5]. In this state, the maximum distance is 150 kilometres from the premises of the waste origin. Globally, European Environment Agency has established this principle in EC Framework Directive on waste[6]. Several environmental benefits are reported to be associated with meeting proximity principles when managing waste resources and utilisation of PwRC. **Table 1** summarises these benefits.

Table 2. Environmental benefits of local collaboration in utilisation of PwRC in construction projects

Key benefits	Description	Reference
Reduced carbon emissions	The waste is not transported in long distances by motor vehicles that produce carbon emissions	Authors
Improved waste data	When local governments, businesses, and organisations work together, they can establish standardised data collection methods, leading to more accurate and comprehensive reporting of waste generation, recycling rates, and material flows	Aslam et al (2020)[7]

First, proximity principal results in waste transport occurring in shorter distances which in turn causes less carbon emissions. It is reported that recycled aggregate can have lower embodied energy in addition to reduced transport emissions, especially where recycled materials are reused in close proximity to the site[8].

[4] Ramos M, Martinho G, Vasconcelos L and Ferreira F (2023) 'Local scale dynamics to promote the sustainable management of construction and demolition waste', *Resources, Conservation & Recycling Advances*, 17:200135

[5] EPA NSW. 2014. Protection of the Environment Operations (Waste) Regulation 2014. Available from https://bit.ly/3zjzkFf

[6] European Environment Agency. 2008. Directive 2008/98/EC of The European Parliament and of the Council. Available from https://bit.ly/4diLso0

[7] Aslam MS, Huang B and Cui L (2020) 'Review of construction and demolition waste management in China and USA', *Journal of Environmental Management*, 264:110445.

[8] Shooshtarian, S.; Caldera, S.; Maqsood, T.; Ryley, T. using recycled construction and demolition waste products: a review of stakeholders' perceptions, decisions, and motivations. *Recycling* 2020, 5, 31.

3.2 Local collaboration for enhanced economic performance

The shorter transport distances can significantly improve the economic PwRC performance. As shown in Table 3, there are eight major economic benefits associated with using local collaboration to use PwRC. These benefits can significantly justify the use of PwRC in local construction projects. These benefits collectively highlight the economic advantages of local collaboration in promoting the use of recycled materials in the construction sector, fostering sustainability while enhancing community resilience.

Table 3. Economic benefits of local collaboration in the use of PwRC in construction projects

Key benefits	Description	Reference
Reduced transportation costs	Sourcing recycled materials locally decreases the distance they need to be transported, leading to significant savings on fuel and logistics costs. This not only lowers overall project expenses but also contributes to lower carbon emissions associated with transportation	Aslam et al (2020)[7]
Reduced complexity for managing waste resources	Local collaboration streamlines the management of waste resources, as stakeholders can coordinate more effectively to ensure proper handling, processing, and recycling of materials. This simplification can lead to improved efficiency and reduced administrative burdens	Raoms et al (2023)[4]
Reduced pressure on the local and state road infrastructure	By decreasing the volume of transport trucks traveling long distances to dispose of waste or deliver materials, local recycling efforts can alleviate congestion and wear on road infrastructure. This can lead to lower maintenance costs and improved safety for local communities	Authors
Reduced depreciation of transportation vehicles	With less frequent and shorter trips needed for transporting PwRC, the wear and tear on transportation vehicles is minimised. This can extend the lifespan of vehicles, reducing maintenance costs and overall depreciation	Authors
Increased local resilience	Collaborating on recycling initiatives enhances the resilience of local economies by fostering self-sufficiency. Communities can rely on local resources for construction needs, reducing vulnerability to external supply chain disruptions	Authors
Provision of sustainable feedstock for local waste recovery facilities	Local collaboration ensures a consistent supply of recycled materials, providing a sustainable feedstock for local recycling and recovery facilities. This supports the circular economy and encourages investment in local waste management infrastructure	Authors
Reduced lead time for material procurement	Local sourcing of recycled materials can significantly shorten lead times, as materials are readily available within the community. This allows for more efficient project timelines and reduces delays associated with long-distance procurement	Authors
Reduced impacts on the material quality	Collaborating locally can enhance quality control measures for recycled materials, as stakeholders are more closely involved in the sourcing and processing. This can help maintain high standards and ensure that recycled materials meet necessary specifications for construction	Raoms et al (2023)[4]

The first obvious benefit of following proximity principle is reduced transportation cost. Previous studies have reported that one of the major barriers for optimal utilisation of PwRC in construction projects is transportation costs[8,9].

3.3 Local collaboration for enhanced social performance

Like the other two sustainability indicators mentioned, research on the social aspect of local collaboration for using PwRC in construction projects remains limited. Nonetheless, the authors of this report successfully identified five significant social benefits associated with this strategy. These benefits are detailed in Table 4.

Table 4. Social benefits of local collaboration in utilisation of PwRC in construction projects

Key benefits	Description	Reference
Creation of local jobs	Initiatives focused on recycling and the use of local materials can create job opportunities in the recycling sector, construction, and related industries	Authors
Community engagement and empowerment	Collaborating on recycling initiatives fosters a sense of community ownership and participation. Local stakeholders can work together towards common sustainability goals. This engagement can empower communities by encouraging active participation in decision-making processes and fostering a sense of pride in local initiatives	Authors
Enhanced social cohesion	Working together on environmental projects can strengthen relationships among community members and organisations. Such collaboration builds networks and trust, which can enhance social cohesion and create a more resilient community	Authors
Improving local constructors' capacity to handle with PwRC	By working together, local construction firms can share knowledge and resources, improving their capacity to effectively utilise PwRC. This capability enhancement can lead to higher quality construction practices and more successful projects	Authors
Educational and awareness opportunities	Local collaboration facilitates the sharing of knowledge and resources, improving awareness of recycling practices and sustainability issues among community members. Educational programs can empower individuals and organisations to make more informed choices regarding waste management and resource utilisation. This knowledge can inspire future generations to adopt environmentally friendly habits and practices	Authors

[9] Hiete, M.; Stengel, J.; Ludwig, J.; Schultmann, F. Matching construction and demolition waste supply to recycling demand: A regional management chain model. *Building Research & Information*. 2011, 39, 333–351.

4 CASE STUDY BACKGROUND

Subiaco Oval (also known as Domain Stadium), situated in the Subiaco suburb of Perth, was a sports stadium inaugurated in 1908. Its operations ceased in 2017 with the unveiling of the new Perth Stadium in Burswood. When it was in operation (, the stadium held a capacity of 43,500 individuals, which was the largest stadium in WA and a prominent sport venue in the country.

Figure 1. Subiaco oval stadium

The demolition of the stadium was the largest demolition activity across the state. The demolition began after its final sporting event in November 2017. The demolition was part of a broader urban transformation of the area, preserving parts of the stadium's legacy while repurposing the land for community development. The demolition of above ground infrastructure was completed in December 2019 (Figure 2). The demolition led to removal of more than 100,000 tones of materials. 95% of the materials were recovered.

Figure 2. Overview of demolition activities in Subiaco Oval stadium project
Source: Development WA (2021)

When Subiaco Oval in Perth was decommissioned, many of its features were sold at auction to preserve memories of its 50-year history (Figure 3). Some items, such as pieces of turf, goalposts, and seats, were highly sought after by sports fans and collectors, eager to own a part of Western Australia's sporting heritage. These auctions allowed locals to cherish memorabilia from the oval, which hosted countless historic football games and events.

Figure 3. Some of the features extracted from the stadium were sold at auction.
Source: Hocking Heritage Studio (2020)

After the demolition of Subiaco Oval, a large urban redevelopment project known as "Subi East"[10] has been underway in Perth. This project aims to transform 35 hectares of land into a vibrant mixed-use precinct. The old stadium was replaced with a range of developments, including residential, commercial spaces, and community amenities. Part of the site has been retained for public use, with the oval's playing field preserved for community sports and integrated into a new high school, Bob Hawke College. The school opened its first stage in 2020 and is designed to serve up to 2,000 students. Additionally, the heritage of Subiaco Oval, including the historic entry gates and elements of football history, has been incorporated into the new landscape. The broader Subi East precinct is set to include a mix of social and affordable housing, public art, and Noongar cultural trails, celebrating the local heritage while providing new housing options and public spaces.

4.1 Key stakeholders

As shown in Figure 1, the case study has three major players including two public organisations and one privately owned construction and manufacturing organisation. The following sections provide an insight into these organisations' operations including their sustainability drivers and their involvement in Subiaco Oval project.

[10] NDY (2024) Sustainability Report. Accessed via https://bit.ly/48hOmIs

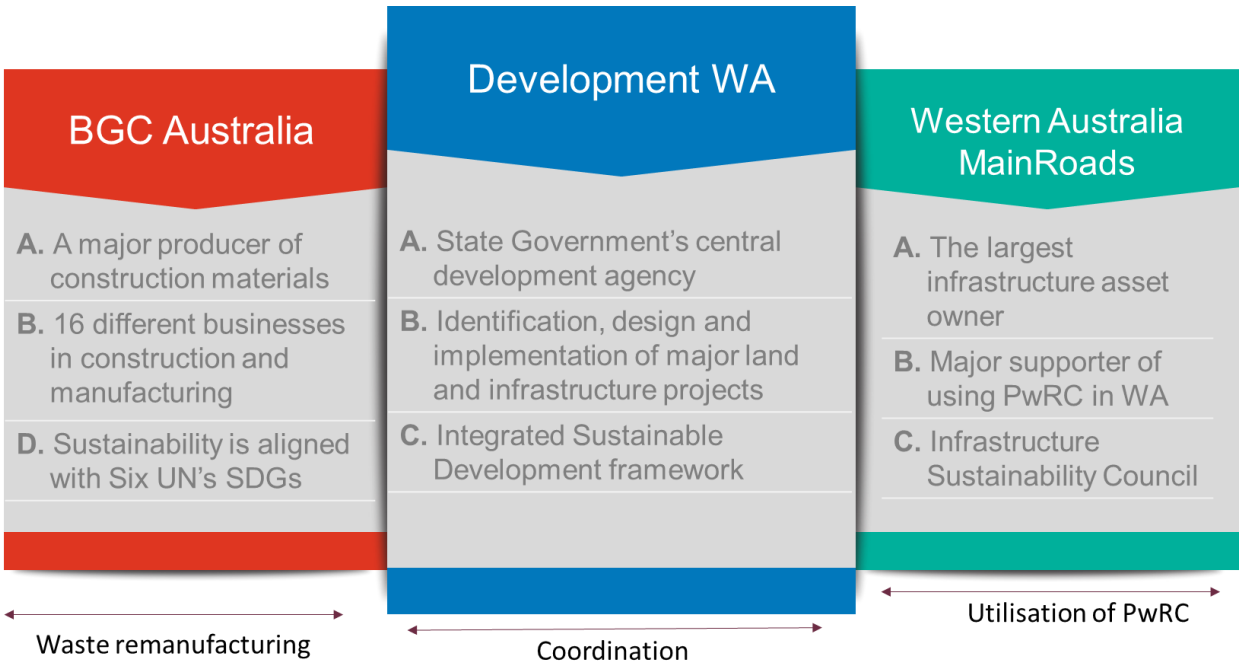

Figure 4. The major players in Subiaco Oval stadium project.

Development WA

This organisation is the State Government's central development agency, operating across Western Australia with a diverse portfolio of industrial, commercial and residential projects. By working closely with government, partners, industry and the community, this organisation aims to provide a bridge between private industry and the WA Government to secure sustainable community outcomes. Central to this work is the identification, design and implementation of major land and infrastructure projects. This involves undertaking long-term, complex and challenging projects and collaboration with many different stakeholders to deliver the best outcomes for the State.

The organisational sustainable activities and initiatives are informed by four pillars of their Integrated Sustainable Development framework[11]. These pillars include community wellbeing, environmental responsibility, design excellence and economic health. This public organisation uses Global Reporting Initiative (GRI) Standards to reflect transparency, accountability and the continuous improvements of their activities. The GRI Standards represent global best practice for reporting publicly on a range of economic, environmental and social impacts.

Western Australia MainRoads

Main Roads Western Australia has played a pivotal role in advancing the use of recycled materials in road construction and maintenance projects across the state. Their commitment to sustainability is reflected in various initiatives aimed at reducing the environmental footprint of infrastructure development.

Main Roads WA has also collaborated with various stakeholders, including local governments and the construction industry, to create a robust framework for incorporating recycled materials into large-scale projects. Their work includes conducting trials and studies to ensure that the recycled materials meet quality and durability standards for road construction. The organisation has also supported training programs and knowledge-sharing initiatives that aim to build capacity within the industry for

[11] Development WA. 2024. Attachment 3 – Sustainable development at Development WA.

using recycled products. Through these efforts, Main Roads WA has become a leader in sustainable road-building practices, setting an example for other Australian states and contributing to the wider adoption of circular economy principles in public infrastructure projects

This agency contributed to development of the Roads to Reuse program in Western Australia to promote the use of PwRC. The program encourages the integration of high-quality PWRC, like crushed concrete, into road bases and embankments. Through stringent quality controls and testing, the program ensures that recycled materials meet the required safety and performance standards. This initiative supports both environmental sustainability and economic efficiency by reducing landfill waste and promoting resource recovery in the state's infrastructure projects

4.2 Regulations, policies and guidelines

This section is concerned with the main regulations, policies and guidelines that were referred to by the project owners and other stakeholders involved in planning, execution and the use of PwRC emerging from this case project. Table 5 summarises these resources.

Table 5. The regulatory documents that were referred to in this case project

Title	Main relevance	Used by
Western Australia Land Authority Act (1992)	It requires the case project stakeholders to take account of and balance social, economic and environmental outcomes	Development WA
Roads to Reuse Specifications	Specify the quality of PwRC to be used in the state road infrastructure projects	MainRoads WA, demolition contractors, recyclers and local governments
Metropolitan Redevelopment Authority Act 2011[12]	By promoting sustainable redevelopment, the Act indirectly encourages better waste management practices within urban settings	Development WA
Development WA's Sustainable Development Framework	The sustainable waste recovery and the use of PwRC is aligned with the four pillars of this framework (i.e. community wellbeing, environmental responsibility, design excellence and economic health)	Development WA

[12] Western Australia Government (2024). Metropolitan Redevelopment Authority Act 2011. Accessed via https://bit.ly/3TJkMG1

5 PRIMARY DATA

5.1 Interviewees profiles

This section of the report is based on interviewing three key stakeholders in this project. As outlined in Table 6 the interviewees were heavily involved in planning and/or execution of the case project. C_2P_1 has been involved in the planning phase of this project 15 years ago when the stadium was considered as a prospective project. The interviewee contributed to agency consulting activities to plan for the end of life of the stadium, when the state government decided to build a new stadium in another location.

Table 6. Summary of participants' profiles in Case Study 2

Stakeholder type	Experience/expertise	Participant code
Manager, Strategy & Innovation	Working for the agency for 30 years and has been involved in planning for Subiaco Oval project	C_2P_1
Project Delivery Manager	Extensive experience as a development and project manager; currently working in the Development WA's operations team	C_2P_2
Principal Advisor Sustainability Strategy	15 years of experience in the field of circular economy, with a strong focus on advocating for incentives to promote the use of PwRC	C_2P_3

C_2P_2, joined the project 7 from the beginning of the execution phase as a development manager. The interviewee led the demolition of the stadium. C_2P_3 serves as a sustainability advisor at MainRoads Western Australia, focusing on waste management processes and advocating for the use of PwRC in road infrastructure projects.

5.2 The interaction model for the utilisation of PwRC

This part of the report sheds light on the process of interaction between the key stakeholders to use demolition waste in construction projects. In the planning phase, the Development WA team engaged consultancy companies to advise them on the best possible outcomes of the project. The site visit to the project was carried out by an engineer and an architect to determine the best method of demolition of the stadium and the reuse of the resultant waste materials. Next, the agency team met with the prospective demolition and recycling contractors to go through the process of the project execution. This involved site visits to the project and the recycling facilities before awarding the contract. As a result, the waste recovery targets and requirements were included in the tender process which required the bidder to demonstrate it in their demolition management plans. The process is visualised in Figure 5.

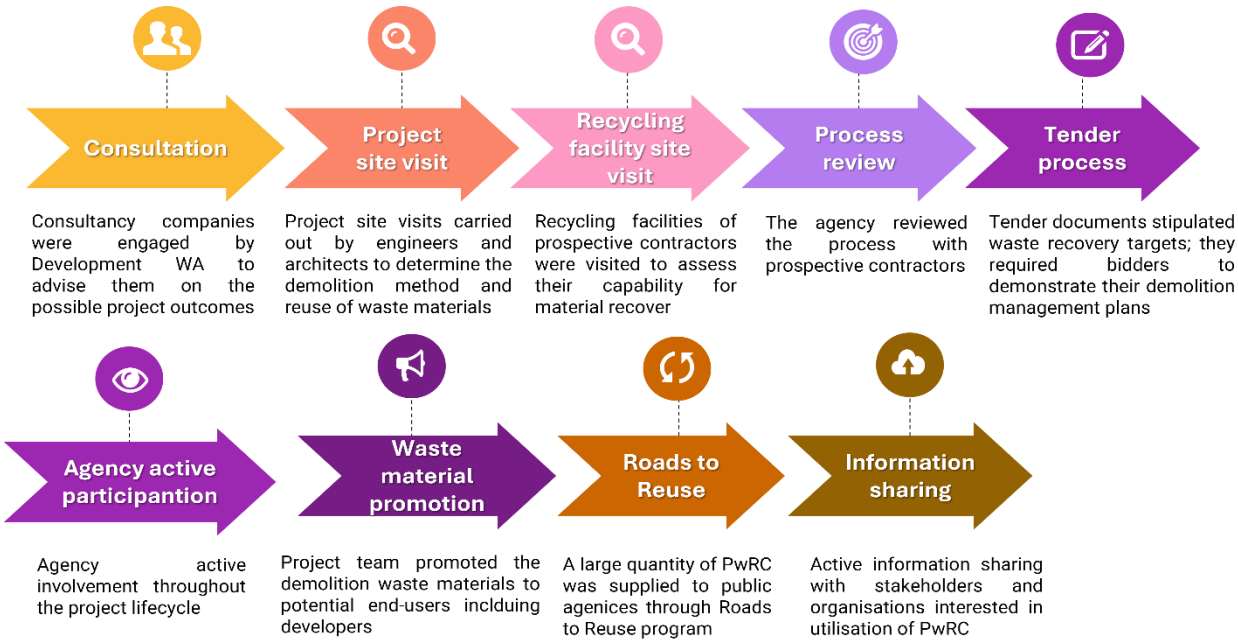

Figure 5. The interaction model for utilisation of PwRC in Subiaco Oval project

6 FINDINGS FROM INTERVIEWS

6.1 Key challenges

The thematic analysis of the interviews identified 13 key challenges hindering the effective implementation of local collaboration for optimising the recovery of materials from the Stadium demolition waste and utilising the resulting PwRC in other construction projects. As presented in Table 7, these challenges were then categorised under three groups: project physical characteristics, project management, supply chain and policies and regulations.

Table 7. The key challenges identified in the interviews

Category	Challenge description
Project physical characteristics	▪ The old characteristics of the build making it difficult to deconstruct ▪ The presence of contamination in demolition waste materials ▪ Nosie pollution for some on-site recycling activities ▪ The physical characteristics of the project making it hard to reuse the extracted materials
Project management	▪ Cost implications of implementing additional management techniques ▪ Difficulty for finding end users for demolition waste materials particularly in local governments ▪ Design warranty risk related to use PwRC ▪ Time constraints caused by the urgency to utilise the demolition site ▪ The government political pressure to deliver the project
Supply chain	▪ Limited experience within the construction team in utilising PwRC ▪ Previous negative experiences with using PwRC in projects ▪ Preference for working within the existing conventional supply chain ▪ Uncertainty about the cost of deconstruction process
Policies and regulations	▪ Unsupportive material specifications

1) Project physical characteristics

The physical characteristics of the demolition site appear to pose significant challenges to achieving the project's objectives. Specifically, these challenges have impeded both deconstruction efforts and on-site recycling activities. Additionally, interviewees highlighted two key issues regarding the handling of demolition waste materials: noise pollution and the presence of asbestos contaminants. The noise pollution was largely attributed to the site's location in a bustling suburb of Perth. Below are two illustrative statements from participants regarding the physical characteristics of the project:

> *'Because of the general shape of it being cyclic or however it is like being roundish, it was really hard to make good use of and like I said it was very specialised for what it was at the time'* [C_2P_1]

> *'Through the project in terms of the management of the material, because there is the risk potentially for of contamination. So therefore, you have to implement some different management techniques'* [C_2P_3]

2) Project management

Several challenges reported by the interviewees could be related to the project management aspects. These aspects included cost management, stakeholder management, risk management, and time management. In terms of cost management, the interviewees indicated that the higher costs for

implementation of additional management techniques for handling materials presents a challenge towards optimal use of PwRC through local collaboration. C_2P_3 expressed that *'Obviously there are potentially some extra costs or different costs through the project in terms of the management of the material, because there is the risk potentially for of contamination. So therefore, you have to implement some different management techniques for the product'*.

Moreover, participants' responses indicated that managing stakeholders for local collaboration proved to be challenging. This included addressing government requests for the project's delivery and identifying suitable end-users for the demolition waste materials. C_2P_2 reported that *'I was really trying to work with our local government to reuse on site for the internal roads and at that time that wasn't successful'*. Another significant challenge was related to the project's tight delivery schedule. There was a pressing urgency to complete the project, as the land, once vacated, was earmarked for a major urban redevelopment into a mixed-use precinct. The need to align with the development timeline added considerable pressure to the project's execution. Some statements from participants highlighting the urgency of the work are provided below:

> *'We had to get this done and there was a very short time spans of the obviously delivering the Oval so that it would time or align with the opening of the new college'* [C_2P_1]
>
> *'There could be local government use because I know they had a section where they wanted part of that land for a community building'* [C_2P_2]

The final challenge in managing the project was handling the risks associated with using PwRC in construction. Respondents pointed to uncertainties surrounding the performance of structures utilising PwRC. These materials require tailored design strategies to mitigate the risk of underperformance, making it difficult to guarantee both the design integrity and overall performance of the build.

3) Supply chain

The supply chain challenges stemmed from the fact that, at the time of project execution, the use of PwRC had not yet become standard practice in the industry. As a result, there was uncertainty regarding the costs associated with deconstruction and how PwRC in new construction projects need to be utilised. C_2P_2 highlighted that '*the cost was a bit unknown, particularly with that sort of large scale'.* C_2P_3's response suggests the challenge of lack of experience with utilisation of PwRC: *'The construction team wasn't used to using it so that in itself brings its own challenges for the team itself and getting used to handling the product'.* Previous negative experiences with the use of products with PwRC in other state projects likely contributed to the complexity. C_2P_3 noted that '*I can't remember which project it was, but they had a bad experience with one of them and I think that they might have been a cross contamination...and it really did cause an issue for them, and they just hit the pause button for a while'.*

Additionally, the industry's preference for conventional supply chains, which had limited capacity to handle deconstruction waste materials and recycled products, further complicated the situation. As described by C_2P_3 '*there were commercial challenges, so supply chains of projects in many cases are already arranged to work together so therefore they'll seek to use the products that they have available to them and support their own supply chains'.*

4) Policies and regulations

The participants noted that prior to the introduction of the Roads to Reuse materials specifications, local governments were unable to utilise these materials due to existing specifications that prohibited their use in local roads and other applications.

6.2 Project's key sustainability benefits

The completion of the project offered several sustainability benefits that are also aligned with several SDGs goals. These benefits were in the domain of environmental, social and economic sustainability. These benefits are visualised in Figure 6. According to the participants, achieving these benefits has opened the door for similar projects with comparable conditions and requirements across the state.

Figure 6. Sustainability benefits delivered in the case study

6.3 Drivers for local collaboration and PwRC utilisation

The interviewees were also asked for their views regarding the main drivers for local collaboration to utilise PwRC in the case project. The respondents expressed eight drivers that are visualised in Figure 7. These drivers can be categorised in three groups: 'government sustainability commitment and demonstration', 'sustainability recognition at the project level' and 'policies and regulations'.

As part of the state government, Development WA, the project owner, is legally obligated to align with the state's targets and ambitions to adopt innovative, sustainable and circular economy practices and incorporate PwRC in their construction projects. According to C_2P_1, '*it's an iconic sight and to some extent it's a demonstration project. So it's got a lot of public attention and so innovation in whatever form we could and in whatever phases of the project we're taking, you know, being innovative in terms of how we deal with waste and recycling'.*

Figure 7. The main drivers supporting the local collaboration in the case project.

Furthermore, achieving sustainability status on the project was a strong motivator, as it facilitated the use of demolition waste in other state construction projects. The project team was particularly driven to make this a reality, aiming to secure a Green Star rating for waste recovery, reflect these efforts in their GRI reports, and contribute to the state's Roads to Reuse program.

Lastly, the change in the material specifications allowing to a greater uptake of PwRC drove was a big driver, as it could convince the local governments to utilise the demolition waste in their local road projects. Also, by facilitating the use of PwRC and enhance waste recovery, the project team were able to align their project objectives with the Metropolitan Redevelopment Authority Act 2011[12] requirement to balance triple bottom lines of sustainability. One participant remarked '*Western Australian government has its own waste strategy, policy and implementation plan, and this project was specifically named and had its own set of recycling targets that we had to report on'*[C_2P_1].

6.4 Key strategies to enhance local collaboration in using PwRC

There were several strategies that were employed to enhance local collaboration aiming to optimise the use of PwRC emerged from the demolition project. These strategies fall into three categories of 'effective project development and management', 'organisational capacity enhancement' and 'Government support and policies'. Table 8 summarises these strategies.

Table 8. The key strategies to address the challenges identified

Category	Strategy description
Effective project development and management	▪ Site visits with potential contractors ▪ Tender process mandating demolition contractors to recycle waste generated from the project ▪ Contractual requirement for using PwRC in state construction projects ▪ Provision for risk-taking throughout the project lifecycle ▪ Using technology to address dust pollution ▪ Engagement of external environmental hazmat auditors to ensure PwRC quality ▪ Effectively communicating with other agencies for adopting PwRC ▪ Effective communications with prime contractor and subcontractors

	▪ Applying the learning from previous projects to avoid certain risks such as contamination ▪ The agency (Development WA) active participation in the project ▪ Reassuring the local community of the project's sustainability benefits
Organisational capacity enhancement	▪ Establishing clear alignment between all levels of the business ▪ Running pilot trials prior to full implementation ▪ Granting design concessions to facilitate the utilisation of PwRC in state's construction projects ▪ Providing training to the industry on the use of PwRC
Government support and policies	▪ Offering grants to support the use of PwRC in state's construction projects ▪ Land Corp sustainability policies ▪ Creating guidelines for local governments on the use of PwRC

1) Effective project development and management

This category includes numerous strategies aimed at promoting locally collaborative efforts to boost the use of PwRC. These approaches have proven effective, particularly since many can be integrated during the project's planning stage, where objectives and management methodologies are established.

The three first strategies focus on the method of engaging head contractors in circular economy initiatives embedded in the state projects. These involve: (1) mandatory requirements for contractors to recycle demolition waste, (2) contributing to the facilitation of utilising PwRC in other construction projects, and (3) conducting site visits prior to bid acceptance or contract awards.

The next three strategies fall under risk management, where the project team responsible for developing the project management plan (PMP) should allow for an acceptable level of risk throughout the project lifecycle. The participants also indicated that, regarding environmental risks, utilising advanced technology to manage dust pollution (e.g., mist technology) and engaging external hazmat auditors can be beneficial. C_2P_2 noted that '*we undertake the auditing process as we go through to remove hazardous materials. So, we do have those additional steps into guarantee that we do not contaminate any of the recycling products'*.

Communication management was reported as a crucial factor for success in projects involving PwRC. According to the participants, effective communication with head contractors, subcontractors, and other state agencies is essential to ensure that the project's sustainability and circularity objectives are achieved. This communication management should also extend to include information and knowledge-sharing activities that aim to learn from and avoid certain risks encountered in previous projects.

The other two strategies relate to stakeholder management, which requires project owners to become active participants throughout the project lifecycle, interacting with various stakeholders, including local communities that could potentially be affected by project execution. According to C_2P_1 '*they* [the community] *would have understood that we're driving towards recycling. In fact they probably would have been curious as to what we were doing with the material. If we had have said, we're just going to bury them in landfill, I think you would have seen them protesting about that'*.

2) Organisational capacity enhancement

Some key strategies identified in the interviews focus on enhancing organisational capacity to manage projects with circularity objectives. These strategies include establishing clear alignment across various sections of the organisation and conducting pilot trials of PwRC before large-scale application. Participants also emphasised that organisations should building the capacity to provide education and training to the industry on the use of these resources, as well as grant design concessions, both of which facilitate the utilisation of these resources in alignment with the organisation's sustainability objectives. C_2P_3 noted that '*education is necessary for the recycling industry, to allow them to produce*

a product that was to a high standard and to give them an understanding of the scheme itself, scheme of the Roads to Reuse scheme'.

3) Government support and policies

Key strategies under this category include offering monetary incentives for the use of PwRC, implementing sustainability policies set by Land Corp, and developing guidelines for local governments. These guidelines aim to empower local authorities to foster collaboration and increase the adoption of PwRC in their construction projects. C_2P_3 remarked that '*we're also developing guidelines for the local governments to overcome the technical. Capability gap that might be there. To assist with that decision making and broader uptake'.*

6.5 Future of local collaboration for application of PwRC

In response to the question regarding future trends for the optimal uptake of PwRC through local collaborative initiatives, participants identified seven contributing factors. These trends are summarised in Table 9.

Table 9. Future trends of using PwRC through local collaboration.

Trend	Description
The important role of local governments	As local governments become more supportive, the use of PwRC is expected to rise in areas where these materials are produced.
Focus on local utilisation	Efforts are shifting toward local utilisation of PwRC to reduce emissions from transporting materials from demolition and construction sites.
Iconic projects as catalysts	High-profile projects like Subiaco Oval are helping promote the local adoption of PwRC in building and construction
Information sharing enhances advocacy	Transparent information-sharing mechanisms, such as industry submissions and sustainability award pitches, are empowering key stakeholders to advocate for PwRC use.
Cost advantages	In the future, there will likely be cost advantages to using PwRC due to the proximity of recycling facilities to construction projects.
Broader range of PwRC	Local collaboration is expected to expand to include a wider range of PwRC, such as glass and plastic.

As local governments have become more supportive, the use of PwRC is expected to increase in the areas where these materials are generated. C_2P_1 explained that *'I think also the general acceptance of recycled materials, standards have changed. Local governments have been more receptive, state governments are more receptive'*. Furthermore, the focus is shifting toward local utilisation of these resources to reduce emissions associated with truck movements from demolition and construction sites.

Through iconic projects like Subiaco Oval and transparent information-sharing mechanisms—such as industry submissions and pitching for sustainability awards—informed key stakeholders are now able to advocate for the local adoption of PwRC in building and construction projects. As highlighted by one participant *'communicating the nuts and bolts of how things have occurred, making submissions to industry or pitching projects for awards; that's all done deliberately around communication, external communications to stakeholders, shareholders and industry to try and change practise. It's done with clear intent'* [C_2P_1]

One participant also indicated that the in future there will be cost advantages for using PwRC due to proximity of recycling facilities to construction projects. Lastly, local collaboration for using PwRC will expand to include a broader range of materials, such as recycled glass and plastic. In the words of one

participant*. 'other types of material will come online so. I think recycle plastic I think. Crush use of recycled glass are different materials. That could benefit. From the adoption for having recyclers within the state or within the city at this point in time'* [C_2P_3]

6.6 Sustainability demonstration mechanisms

The project team and their partners utilised two key demonstration mechanisms to showcase the project's sustainability achievements. These included obtaining a 6-Star Green Star rating provided by the Green Building Council of Australia (GBCA), which represents world leadership in environmental and social sustainability practices. In addition, the project earned an Infrastructure Sustainability (IS) rating awarded by the Infrastructure Sustainability Council (ISC). The IS rating evaluates the sustainability performance of infrastructure projects across various categories, such as environmental management, resource use, and social outcomes, ensuring a holistic approach to sustainable infrastructure development.

7 RECOMMENDATIONS

The key takeaway from this case study is that local collaboration is poised to become the most significant trend in the future of using PwRC in construction projects. By fostering partnerships between local governments, industry stakeholders, and recycling facilities, communities are better positioned to utilise locally generated materials efficiently. This approach not only helps reduce transportation emissions but also encourages sustainable practices in construction, making local collaboration a cornerstone for the broader adoption of circular economy principles in the built environment.

However, the process of local collaboration for the purpose of increasing the use of PwRC in construction projects requires careful attention to detail and the implementation of strategies that mitigate potential risks. According to this case study, these risks span several domains, including environmental, financial, business, political, technical, and material and construction performance-related risks. Each of these areas must be addressed to ensure that collaboration efforts lead to sustainable and effective outcomes. For instance, environmental risks such as dust pollution or inadequate waste handling need to be managed alongside technical and performance-based concerns like the quality and durability of recycled materials used in construction. The key strategies to mitigate risks associated with local collaboration in using PwRC can be categorised into three main areas:

1. Effective project development and management
2. Organisational capacity enhancement
3. Government support and policies

These strategies work together to create a robust framework that promotes the sustainable use of PwRC in construction projects while mitigating various risk. Furthermore, the findings of this case study contribute to three main areas as indicated below. These contributions highlight the broader implications of the case study for advancing sustainability in the construction sector and fostering a circular economy.

Policy development- The insights gained can inform policymakers on the importance of supporting local collaboration initiatives and providing frameworks that encourage the use of recycled materials in construction. By understanding the challenges and successes highlighted in the study, policymakers can create more effective regulations and incentives that promote sustainability.

Industry practices- The case study's findings serve as a valuable resource for the building and construction industry stakeholders, offering practical strategies and best practices for integrating PwRC into projects. This can lead to enhanced awareness of the benefits and feasibility of using recycled materials, ultimately driving industry-wide change toward more sustainable construction methods.

Knowledge development- The research highlights the critical role of local collaboration in the effective uptake of PwRC within construction projects. By providing overall insight into the interactions among stakeholders, including project owner, state agencies, local governments, contractors, and communities, the study provides a nuanced understanding of how these relationships can influence sustainability outcomes. This adds to existing literature on collaborative governance and community engagement in sustainable development.