RAE2026

Regenerative Urban Sustainability through a Local Material Archive and Upcycling

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MCO2

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Contents

Regenerative Urban Sustainability through a Local Material Archive and Upcycling

Descriptor

This research addressed the challenge of managing post-disaster wood waste in Hong Kong, where the increasing number of typhoons results in an annual increase in yard waste, most of which is sent to landfills despite limited landfill capacity. In recognition of the environmental and resource inefficiencies inherent in urban environments, the research project examined how **eco-material archives** and **innovative upcycling approaches** could inform the review of sustainable product–service system design, education, and circular economy practices. Through a research-through-design methodology, the team established **Hong Kong's first public timber archive**, cataloguing and testing numerous local and imported wood species. By reframing wood waste as a valuable resource, the project expanded **knowledge of material performance** and influenced both design opportunities and public perception to the value of local wood. The research also identified and showcased local woodwork artists, craftsmen and architects, **demonstrating diverse design applications** of local wood through exhibitions and forums that encouraged public engagement.

Moving beyond traditional upcycling, the project pioneered a **material-innovation approach** by collaborating with civil engineering researchers to explore the use of wood particles as recycled aggregate in concrete. This led to the development of a low-carbon biochar concrete that reduces cement content by 20%–30% while sequestering carbon. Piloted in public installations with adjustable artistic formwork, the material demonstrated both environmental and creative potential. Funded by the Hong Kong Government (HK$0.9 million), the research addressed three core issues: the **knowledge transfer of local material archives, viable circular applications for wood waste** and the **integration of biochar concrete into design** for environmental benefit and supply chain transformation.

Key outcomes included Hong Kong's first timber archive, expanded practical knowledge of local and imported wood, public showcases of creative applications and the development of biochar concrete applications as a scalable circular material innovation project with HK$1.75 million funding through the Carbon Neutrality Funding Scheme (2023-25) of PolyU Internal Research Fund.

Personal Profile: Associate Professor Brian Lee

Brian Lee is a researcher and designer who focuses on promoting well-being through socio-materiality and collaborative prototyping. He employs design research to empower stakeholders and drive transformation in various sectors.

His research interests include artefact creation, service system innovation, creative citizenship and sustainable living. From 2019 to 2025, he conducted research in two main areas.

In MCO1, he partnered with NGOs in Hong Kong to improve bathing and toileting services in nursing homes, approaching the issue from a humanistic design perspective.

In MCO2, he worked with stakeholders in Hong Kong's recycling ecosystem to develop sustainable supply chains using local resources.

A trained product designer with experience in medical product development, furniture design and lifestyle consumables, he holds a PhD in design and technologies and leads the BA (Hons) in Product Design programme at The Hong Kong Polytechnic University’s School of Design.

Research Questions

1. **What is the definition of the regional reclaimed wood archive for green supply chain?**

Sub-questions include: How can a classification system be defined for labelling local timber and trees? What are the potential applications of local wood resources? How can a physical archive serve as a design-driven knowledge platform to facilitate circular design practices?

2. What knowledge is required to enable viable circular applications for undervalued wood waste in a high-density consumption environment?

Sub-questions include: What insights can be gained from case studies involving reclaimed wood and diverse end users? What challenges exist in fostering local renewable resources in cities with limited manufacturing capacity and high operational costs? How do issues of resource collection, treatment and logistics impact circular design from a designer's perspective?

3. What alternative solutions can extend the use of the large volume of recycled wood waste in Hong Kong?

Sub-questions include: How can material innovation, such as transforming wood particles into biochar and incorporating them into concrete designs, enhance the properties of wood waste? What novel design applications can scale up upcycling models for broader impact?

Research Outputs

Project Timeline

During the RAE 2026 period (October 1, 2019, to September 30, 2025), the project outputs comprise a series of works arising from archival studies, public and school exhibitions, public seminars and demonstrations of design applications featuring novel material innovations.

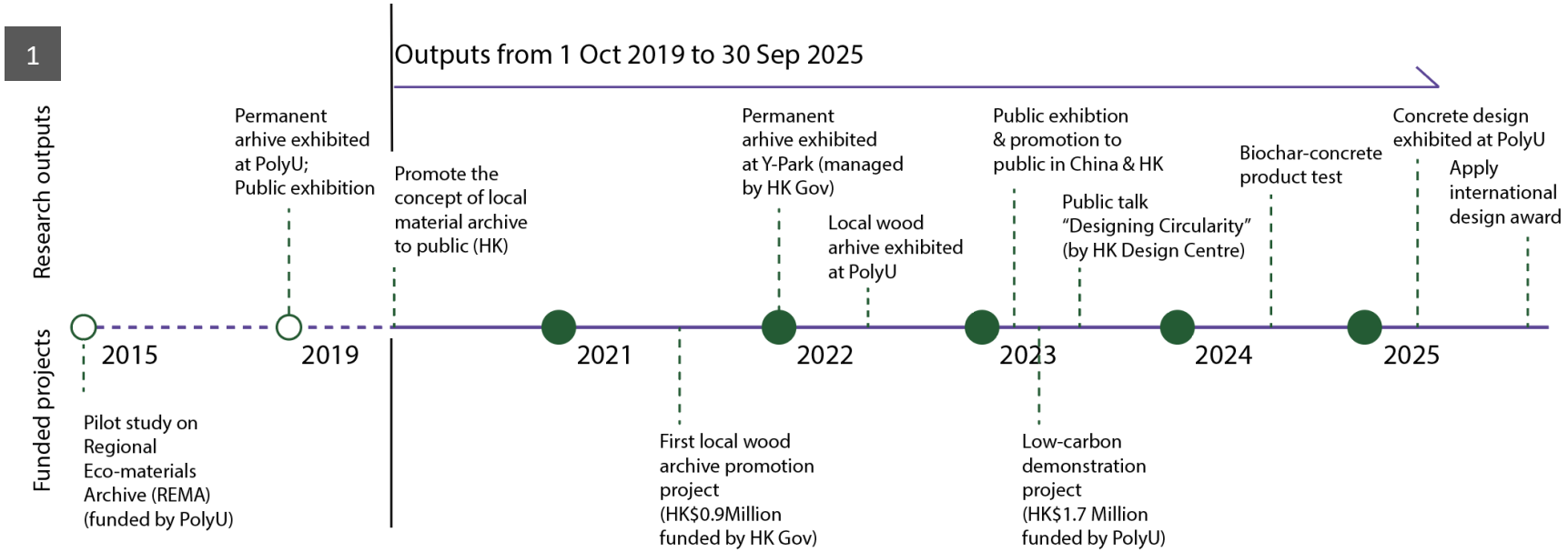


Figure 1. Diagram of project timeline and series of research outputs (illustrated by the project leader).

Research Outputs

Major Outputs

Archive as a Tool to Enable Epistemic Boundaries

1. **First local wood study and public archive:** Information was collected from recyclers, government sources and the literature to identify potential reclaimed timber. The selected timber samples were tested and compared with imported wood. A labelling system was developed, and sample boards were produced containing information on the wood species and their mechanical testing performance.

Resource Centres/Exhibitions to Promote Knowledge Transfer

2. **Educational centre for the public (exhibition):** Since January 2023, studies of local wood species and potential local wood applications conducted by other participants have been exhibited in Y · PARK – the first and only public facility for collecting and recycling yard (wood) waste in Hong Kong. This is a permanent installation for education and promotion purposes (see the Y · PARK website: https://www.ypark.hk/en/).

3. **Resource centre for design students:** Real samples and the wood study report are displayed at the Material Resources Centre at PolyU (open access to all academics, students and the public in Hong Kong).

4. **Public exhibition outside Hong Kong** (in Mainland China): The *4th China Design Exhibition & Public Art Thematic Exhibition* in Shenzhen from Feb 20 to March 16, 2023.

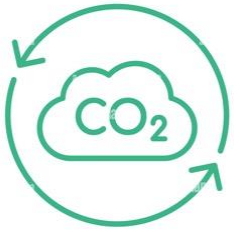
Material Invention and Design Demonstration

5. **Prototype test and demonstration:** The first design application case in Hong Kong implementing biochar concrete for low load-bearing structural demonstration (see the prototype introduction video at https://youtube.com/shorts/SP1aUVrS3Iw).

6. **Exhibition:** Display of the mechanical test results of biochar concrete and the prototype.

Research Field and Key References

Global Problem, Local Impact



Cement, the most widely used man-made material, accounts for approximately 8% of global anthropogenic CO2 emissions, primarily from clinker production which is the major element of cement. , which involves the de-carbonation of limestone. With annual cement production reaching around 3.4 billion tons, it represents 15% of total industrial energy demand. Producing one ton of clinker requires about 3.5 GJ of energy and emits roughly 0.8 tons of CO2. To mitigate emissions from the construction sector, reducing clinker use is essential.

Innovative waste-to-resource technologies are vital for sustainable waste management, supporting a circular economy and aligning with the Waste Blueprint for Hong Kong 2035. Currently, Hong Kong generates hundreds of tonnes of yard waste daily, with potential for significant reduction in carbon emissions through the application of biochar—a product derived from recycling yard waste. One kilogram of biochar can offset up to 3.3 kilograms of carbon emissions, making it an effective substitute for cement.

This research project seeks to implement a sustainable biochar-augmented concrete solution that enhances carbon sequestration in concrete products, such as public benches, planters, and pavement tiles. Key benefits include reducing landfill waste, cutting cement use by at least 30%, improving air quality through biochar properties, and enhancing the living environment at PolyU. The project also aims to connect with local manufacturers and stakeholders to foster an eco-system for sustainable practices.

Recent studies indicate that biochar can create carbon-negative concrete, attracting significant attention for its potential in civil infrastructure. The project intends to demonstrate the versatility of biochar-augmented concrete in various applications, showcasing its CO2 emission reduction and economic benefits through life cycle assessments and cost-benefit analyses. This exploration not only addresses environmental concerns but also enhances public spaces and community engagement.

Research Field and Key References

The Local Perspective – Why Study Reclaimed Wood as a Resource?

A high-density city in a tropical climate with frequent typhoons faces the challenge of disposing of large amounts of yard waste, such as felled trees, every year. Combined with the substantial wood waste generated by building development, this is a valuable resource that presents both a challenge for the government and an opportunity for the sustainable product design industry.

Hong Kong has limited renewable resources, while those that are imported lead to a high carbon footprint. Various stakeholders, including Hong Kong Government's Environmental Protection Department (EPD), NGOs, woodwork practitioners and academics, have embarked on initiatives to collect, test and utilise reclaimed wood. Since 2021, with the aim of exploring and evaluating viable ideas that can contribute to the ecosystem, we have identified and reviewed 14 useful tree species recovered from government sources (local resources) and compared their wood properties with 23 imported wood species commonly available in the local market. We tested the mechanical properties of the wood samples as the existing data of the same species compiled by international specialists. This provided reliable data for comparative analysis and enabled visitors to handle real samples of the wood and assess their hardness.

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Figure 2. The problem of felled trees after Typhoon Mangkhut in 2018. In recent years, the Hong Kong Government has collected 180 tonnes of yard waste every day. The large volume of daily and seasonal yard waste places great pressure on the Environmental Protection Department.

In addition, we explored different ways of applying the wood and summarised the creative outcomes – such as joinery furniture, musical instruments and decorative pieces – by highlighting the nature and beauty of the material through exhibitions and material resource archives located in government facilities open to both the public and professionals. This is the first official timber resource archive in Hong Kong, designed to promote knowledge dissemination in the surrounding area.

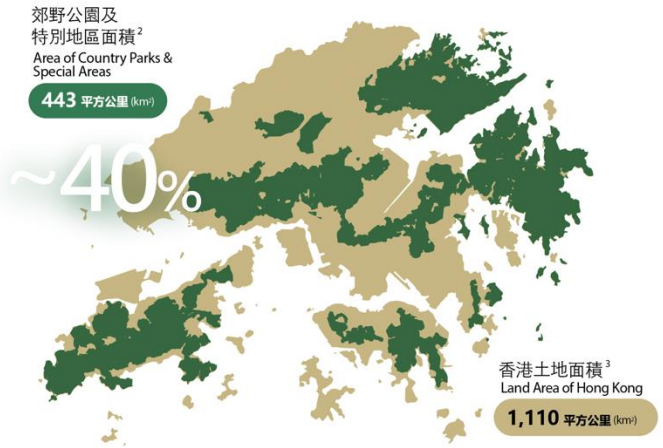
Research Field and Key References

From a Regional to a Global Perspective

Hong Kong, Singapore, London and New York face similar urban challenges, including dense populations, significant waste production and dependence on limited landfill or incineration infrastructure. Besides, though HK is relatively small, approximately three-quarters of its total 1,114 square kilometres of land is countryside and forest. Rich in biodiversity and ecosystems (more than 3,300 species of vascular plants, 55 species of terrestrial mammals, over 580 species of birds… 134 species of dragonflies, etc.). which is a great resource. Sustainable growth of the urban environment is critical.

All four cities recognise the potential of wood waste within circular economies and are making progress in terms of recycling and upcycling to varying degrees. However, Hong Kong's inability to export recycled or reusable materials to neighbouring regions, such as mainland China, due to geopolitical and policy constraints creates a greater demand for localised solutions and results in a smaller circular green supply chain ecosystem.

Unlike other cities that leverage regional networks to offset costs, Hong Kong must manage the **full lifecycle of waste** within its borders, thereby exacerbating the economic and spatial challenges of wood recycling. This study provides a valuable case for Hong Kong and other cities seeking to anticipate systemic problems and identify localised solutions.



This isolation makes Hong Kong a unique case study for testing self-sufficient, high-value upcycling models. Although the city lags behind in terms of infrastructure and holistic policy support, its compact urban fabric and existing industries – such as logistics, construction and design – present opportunities for untapped synergies.

For example, repurposing wood waste to create premium furniture or modular building materials could address the demands of Hong Kong's luxury market and its need for space-efficient housing. However, success depends on overcoming challenges such as securing land for processing facilities, providing incentives for SMEs and establishing public–private partnerships.

Addressing these challenges could enable Hong Kong to pioneer scalable strategies for cities constrained by geography or policy, demonstrating that localised

Research Field and Key References

Outlining the Problems

Since 2018, Y · PARK has operated as a recycling *yard* aimed at improving reuse and recycling across Hong Kong. However, the utilisation rate of recycled wood at Y · PARK remains low. Key challenges include the difficulty of identifying different species of felled trees once they have been transported to the facility, high end-user expectations regarding timber quality and the difficulty of transporting large pieces. Most of the wood – whether cut or felled – is collected from other government departments or construction sites, and the majority of pieces are narrow and short. End users generally seek longer and wider timber or planks.

Given the diverse mix of timber species, the challenges in identification and the variability in size, the research team – working with government agencies – explored how such timber might be chipped and converted into biochar for use in cement products. This approach aimed to increase both the construction and commercial value of recycled wood, meet growing demand and achieve greater environmental impact. Cement production is one of the largest sources of CO_2 emissions in the world.

Figure 3. Most of the yard waste collected daily contains only limited amounts of usable or high-quality and large enough timber. It is the reason why it is necessary to explore an alternative approach to consume small tree branches or low-quality wood.

Figure 4. One of the wood processing machines at Y · PARK. Handling different wood species is costly and time consuming, as timber characteristics and treatment methods vary. The facility is therefore difficult to optimise for efficiency and quality control.

Research Field and Key References

Explore Creative Solutions To Solve the Problems

Working with the government, the co-PI – in collaboration with civil engineering researcher – explored the potential benefits of biochar as a concrete additive and as a means to transform yard waste (e.g. felled trees) while reducing cement usage. Biochar-augmented concrete design applications were developed to demonstrate potential solutions for lowering cement consumption and to establish Hong Kong's first 'carbon sink' public facility design case.

The project team investigated a range of outdoor concrete products to demonstrate the possibilities of applying biochar-augmented concrete and to evaluate the carbon-sequestering potential of the admixture in concrete-made products. These included benches, planters and paving designs. The team then identified a new campus renovation project as the site for implementing the pilot design.

Remark: 1 m^3 biochar-augmented concrete could **stabilize at least 0.142 tonne CO_2**

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Figure 5. Biochar made by the Environmental Protection Department. One of the Co-PI s of this project from Civil Engineering Department of HKPolyU played a role as a consultant to advise EPD to produce a stable quality of Biochar.

Research Field and Key References

Team members and project partners

Team member	Name and organisation	Major roles in the project
Principal leader	**Prof. Brian Y. H. LEE**, School of Design, The Hong Kong Polytechnic University	Taking the lead in devising and conducting research and prototyping activities, facilitating collaboration, meeting key stakeholders, carrying out iterations and evaluations and promoting outcomes.
Research collaborator	**Prof. Dan TSANG**, Department of Civil and Environmental Engineering, Hong Kong University of Science and Technology	Providing knowledge about the production and characteristics of biochar concrete and offering advice on its application.
Research associate	**Ms Ada Y. M. CHAN**, School of Design, The Hong Kong Polytechnic University	Coordinating and providing support for site visits, sample testing, prototyping and exhibition design.

Key project partner	Major roles in the project
(1) Y・PARK, Environmental Protection Department, HKSAR (https://www.ypark.hk/en/)	Providing resources including research and promotional funds, timber collection for testing purposes and wood processing into biochar, as well as a venue for engagement activities.
(2) PolyU-NAMI Research Centre for 3D Robotic Concrete Printing (RCC3D), The Hong Kong Polytechnic University (https://www.polyu.edu.hk/cee/research---old/polyu-nami-3d-concrete-robotic-printing-research-centre/)	Providing technical support and advice on the production and mechanical testing of concrete samples and products.

Research Methods, Prototypes and Materials

To guide the research and design process, the team adapted the circular design principle, simplifying it into a '4Ls' model comprising four interrelated values – local resource (accessibility), local production (lower carbon footprint), local consumption (supporting local demand first) and local recycling.

One of the research objectives, at the systems level, focused on the use of felled trees and emphasised systems thinking through design research.

Our findings revealed that the potential of felled trees is not being fully realised. In addition, we investigated supply chain and business models that could enable designers to realise local resources, local production, local consumption and local recycling.

The research team noted that the definition of 'local' was potentially contradictory in this context, given that collaboration with various stakeholders across Hong Kong may not have been stable enough to provide assurance and reliability. To realise a sustainable business model, the researchers identified the need to change the mindset from what was constituted as 'local' in Hong Kong to include nearby regions. The research also examined the recycling infrastructure within 1–2 hours' travel distance between Mainland China and Hong Kong to ensure that transportation remains viable when assessing material lifecycles and green and circular supply chains.

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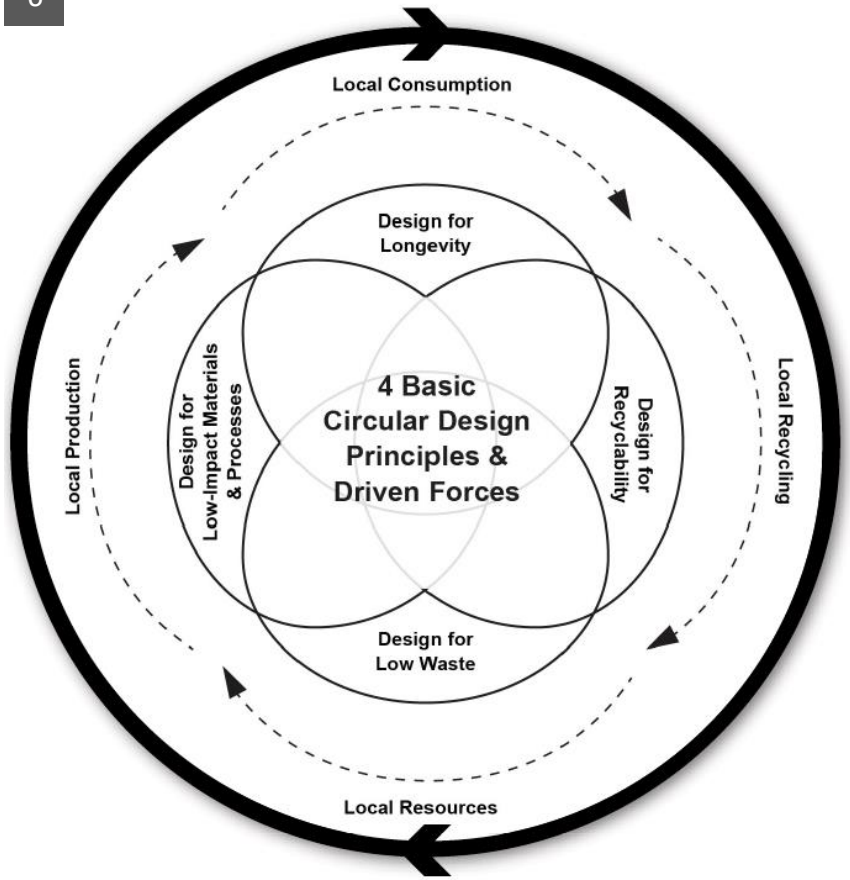

Figure 6. The closed-loop circular design '4Ls 'model

Research Methods, Prototypes and Materials

Methods

The methodologies applied in this multi-component output included the following, ensuring that all stages of the research were captured:

1) Formation of an archive: This involved establishing a local reclaimed wood archive and database – the first of its kind in Hong Kong. This archive has serves as an agent and catalyst for knowledge development and stakeholder engagement, including the government, manufacturer partners, artists, craftsmen and designers in identifying needs and requirement as well as how these might be used within a more circular economic model.

2) Triangulation: Multiple perspectives and reflections were gathered from 'resource reclaimers' – including policymakers – resource distributors, resource users and resource recyclers. These were compared, and the results informed subsequent actions aimed at developing a circular economic model.

3) Prototyping: Prototyping was deployed as research tool to identify wood-based experiments and to evaluate the challenges of green supply chains in a 'local' and more immediate context, given the precarity of support. This included the design and implementation process of experiments and prototypes, which revealed and exposed the critical issues and limitations of both the existing and proposed supply chains and product–service systems.

Research Methods, Prototypes and Materials

Y · PARK operates as both a wood recycling *factory* and a resource centre that enables local stakeholders to access reclaimed wood resources in Hong Kong. The researchers engaged Y · PARK as a key partner and adopted a multidisciplinary approach to the identified challenges, drawing on research expertise from the School of Design (PI) and the Department of Civil Engineering (co-PI) at PolyU. The research team also collaborated with other stakeholders, including government agencies and NGOs. A major constraint to establishing a full-scale closed-loop economy in Hong Kong is the lack of space and the high cost of constructing recycling and production facilities. Conversely, the advantage of a compact urban area lies in its efficient transportation network and the close interactions among different stakeholders. These factors provided key parameters for the research and guided considerations of how to achieve viable circularity within the manufacturing and business model.

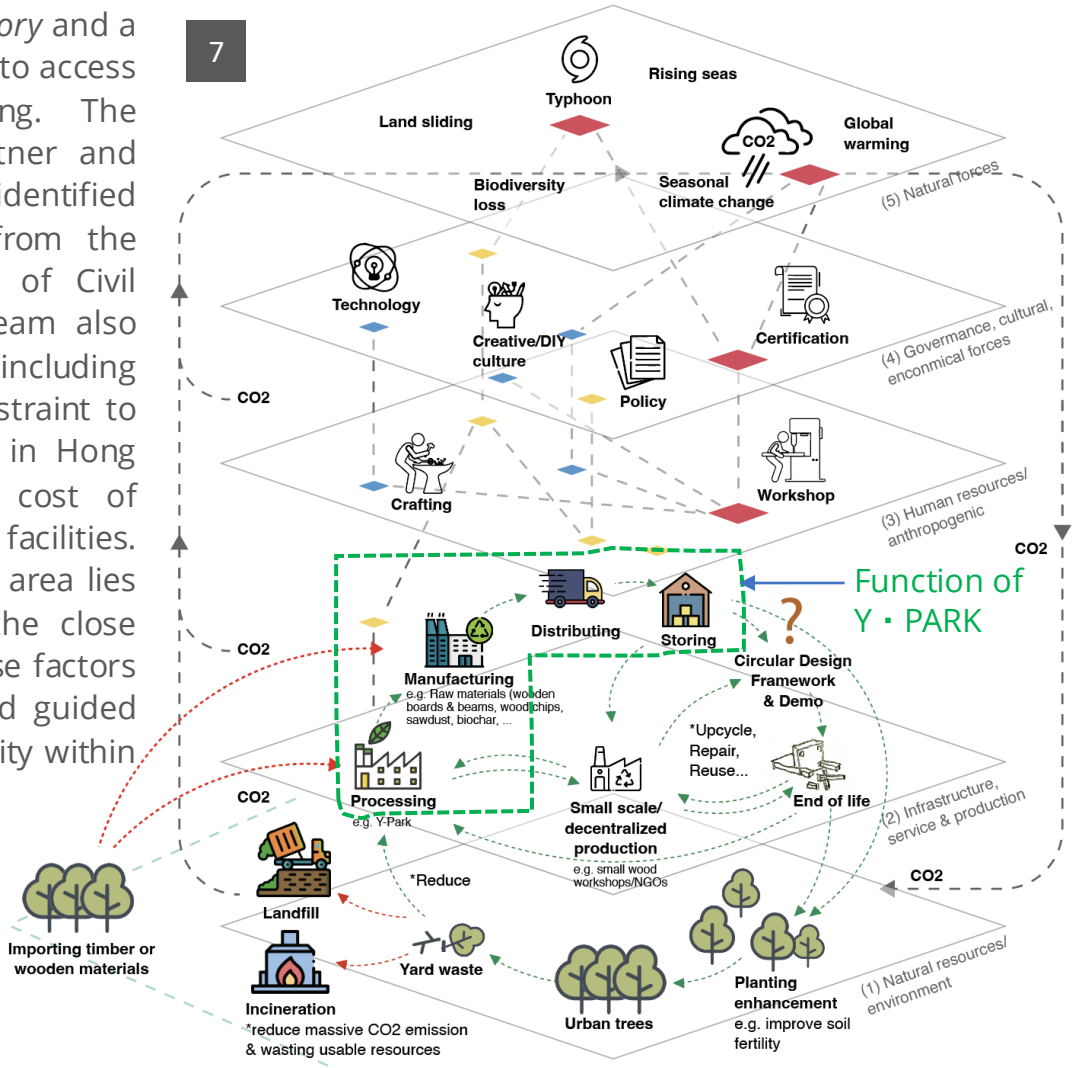

Figure 7. Networks and boundaries of local resources driving production, consumption and recycling, emphasising how distributed production (e.g. a small wood workshops, schools and commercial projects) can meet local needs within a city. In this research, the project team articulated the processes and interactions of each boundary and stakeholder (illustrated by the project team).

Research Methods, Prototypes and Materials

Prototypes and Materials : Selection and Evaluation of the Characteristics of Local Timber

Figure 8. The researchers individually checked the timber species and quality.

Figure 9. The team identified 14 local wood species for further material tests.

Research Methods, Prototypes and Materials

Prototypes and Materials: Testing and Evaluation of the Characteristics of Local Timber

Figure 10. Local trees carry high aesthetic, mechanical and technical properties. For example, *Acacia confusa* (相思樹) is a commonly grown tree in Hong Kong.

Acacia is wind-resistant and serves as an effective windbreak and greening species.

Acacia has a high relative density of approximately 0.75, a strong carbon dioxide storage capacity and excellent carbon reduction properties. Internationally, they are used in the production of high-quality furniture, speakers and flooring.

Figure 11. A wooden shelf made by the research team using Acacia.

Mortise-and-tenon joints were used to evaluate differences compared with commercial woods. The acacia wood proved to be very hard, compared with most medium and soft woods, effectively demonstrating the quality of fine woodwork.

Figure 12. A traditional Chinese journey master was invited to craft a piece of Ming-style furniture using local reclaimed wood.

The visual and structural qualities were comparable to those of many commonly used precious hardwoods.

Research Methods, Prototypes and Materials

Prototypes and Materials: Testing and Evaluation of the Characteristics of Local Timber

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Figure 13. Mechanical testing of timber, including compression, bending and tension tests.

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Figure 14. Exploration of different texture treatments.

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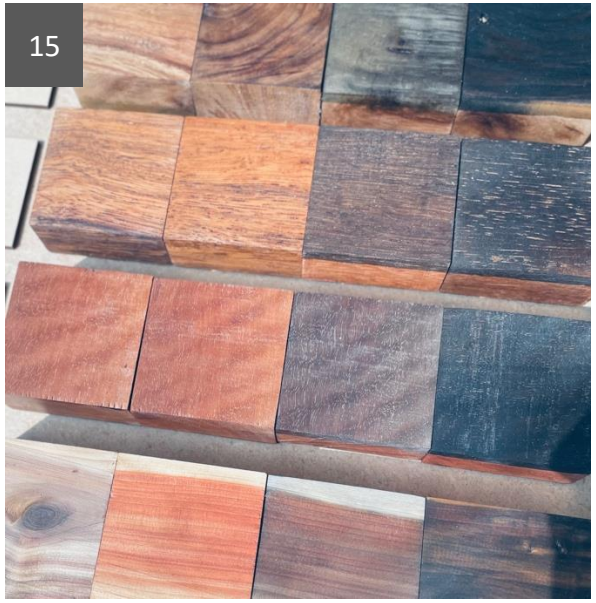


Figure 15. Assessment of different colour treatments.

Research Methods, Prototypes and Materials

Prototypes and Materials: Material Innovation Approach to the Problem

Traditional wood upcycling models cannot address the current daily accumulation of wood waste, and suitable applications for utilising large and variable volumes of urban waste remain limited. As cement production is a key source of CO_2 emissions, the principle of transforming 'yard waste' in Hong Kong and reducing cement use through the production and application of biochar as a cement additive demonstrates significant potential.

The research team explored a range of outdoor concrete products to identify opportunities for applying biochar-augmented concrete and to evaluate carbon-sequestering admixtures in concrete-based products, such as benches, planters and paving designs. These prototypes will be implemented and monitored on the PolyU campus.

Massive yard waste problem in Hong Kong

100 tonnes of reclaimed wood collected by Y · PARK in Hong Kong per day.

Pyrolysis

Biochar

Biochar is a safe and promising solution to foster carbon neutrality, as **1 tonne of biochar** can trap **2.0–2.6 tonnes of CO_2.**

New forming technique

Biochar-concrete application

High aesthetic and design application values with carbon neutrality properties.

Research Methods, Prototypes and Materials

Prototypes and Materials: Material Innovation Approach to the Problem

The team systematically explored different approaches to replacing cement with biochar, evaluating the mechanical and other properties of concrete blocks throughout the process. Biochar concrete is particularly suitable for use in planters and garden products that require moisture retention and cooling. The team formulated a biochar concrete mixture that uses 20%–30% less cement and developed a new casting technique that enhances its appearance, producing richer colour variations and an organic, luxurious finish – qualities not achievable through standard concrete-making processes.

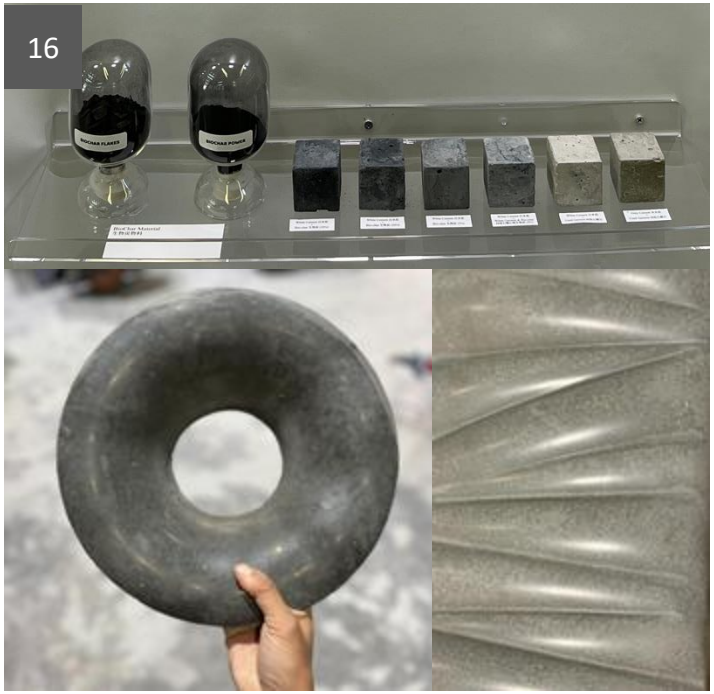


Figure 16. Samples showcased at an exhibition, illustrating the testing results of incorporating biochar into concrete.

Our team investigates the use of biochar to reduce the **use of cement** (by 20-30% less) in concrete forming. This project focuses the use of l**ow-carbon concrete** in non-structural products.

	Compressive Strength	Humidity Maintance	Passive Cooling	Thermal Insulation
Pure Cement	●●●●●	●●	●	●
50 - 50 Ratio Cement - Biochar	●●	●●●●	●●●●●	●●●●●
40 - 60 Ratio Cement - Biochar	●	●●●●	●●●	●●●●
30 - 70 Ratio Cement - Biochar	◐	●●●●●	●●●●	●●●

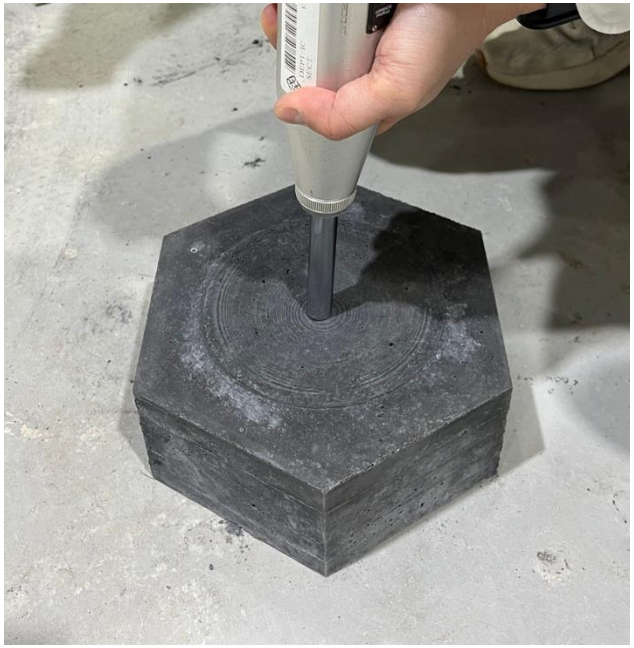
*According to our team's previous study, the use of biochar-augmented concrete could save around 100-300 kg CO_2 per tonne of concrete (depending on the type of concrete).

Research Methods, Prototypes and Materials

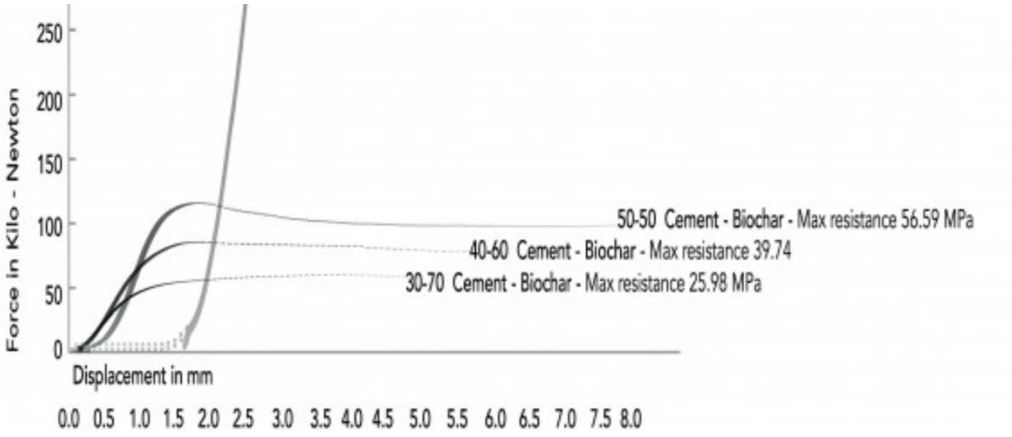
Prototypes and Materials: Material Innovation Approach to the Problem

The testing results of the biochar concrete samples suggest that replacing 20%–30% of cement with biochar provides an optimal composition for supporting most low-load-bearing designs.

Our sample test (without SCMs):
40–60 cement–biochar ratio = **20–25 MPa**



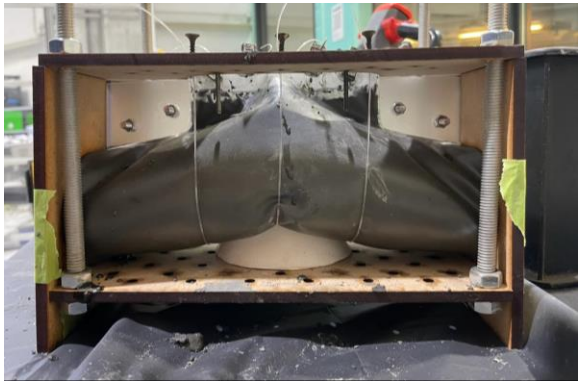
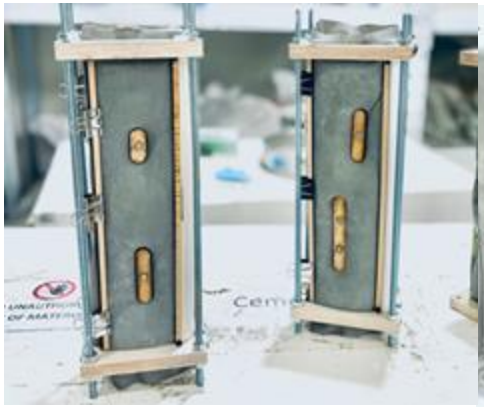
Reference sample:
30–70 cement–biochar ratio = **25.98 MPa**



Research Methods, Prototypes and Materials

Prototypes and Materials: Exploration and Demonstration of Biochar Concrete Applications

Tension adjustable membrane forming was explored through various moulding structures and surface-tension adjustments. The aim was to achieve a fine surface quality and texture resembling marble, highlighting its dimensional and organic characteristics rather than the traditional smooth, low-quality concrete surface.

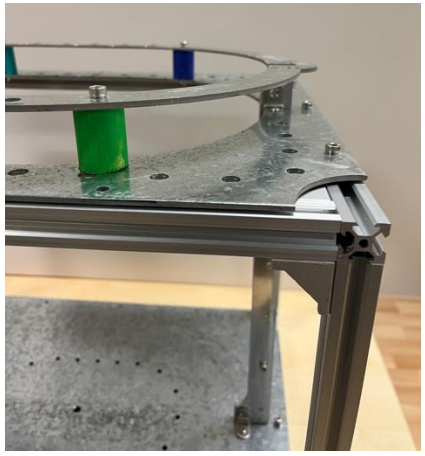




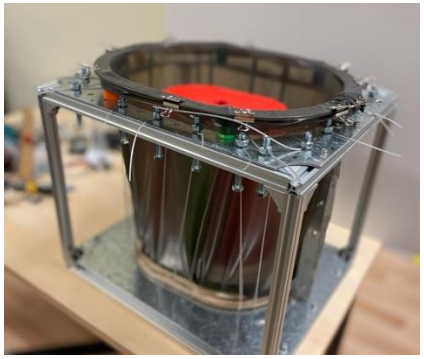



Research Methods, Prototypes and Materials

Prototype and Materials: Exploration and Demonstration of Biochar Concrete Applications

The team carried out iterative development of a tension-adjustable membrane mould design. The images below show the final prototype of the mould, created to support batch production of the concrete seating structure. Future research will explore the construction of larger moulds to develop alternative forms for use in public spaces.





Research Outcomes, Findings and Further Research

[1] Outcomes: Exhibition and Archive

Year	Categories
	• ***Exhibition in China***
2023	• Lee, Brian, and Ada Chan (2023). **Creative Repurpose Archive For Felled Trees (CRAFT)**, The 4th China Design Exhibition & Public Art Thematic Exhibition, Shenzhen Museum of Contemporary Art Urban Planning (The Great Bay Area Special Exhibition), China (20 Feb to 16 March, 2023).
	• ***Archive at Y・PARK*** *(facility managed by Hong Kong Government)*
2023	• Lee, Brian, and Ada Chan (2023). **Creative Repurpose Archive For Felled Trees (CRAFT)**, Resource Centre, Y・PARK, Environmental Protection Department, The Hong Kong Government, China (since January 2023).
	• ***Archive at the Material Resources Center*** *(facility managed by PolyU Design)*
2023	• Lee, Brian, and Ada Chan (2023). **Creative Repurpose Archive For Felled Trees (CRAFT)**, Material Resources Centre, School of Design, The Hong Kong Polytechnic University, Hong Kong Government, China (since March 2023).

Research Outcomes, Findings and Further Research

[1] Outcomes: Local Wood Archive Label System

The research team devoted considerable time to developing a categorisation system to ensure that the appropriate information was provided.

This included tree species, type of wood (hard or soft), mechanical properties, common applications and considerations and visual characteristics such as wood grain and the texture.

Figure 17. Wood samples with labels from 28 species have been prepared and showcased.

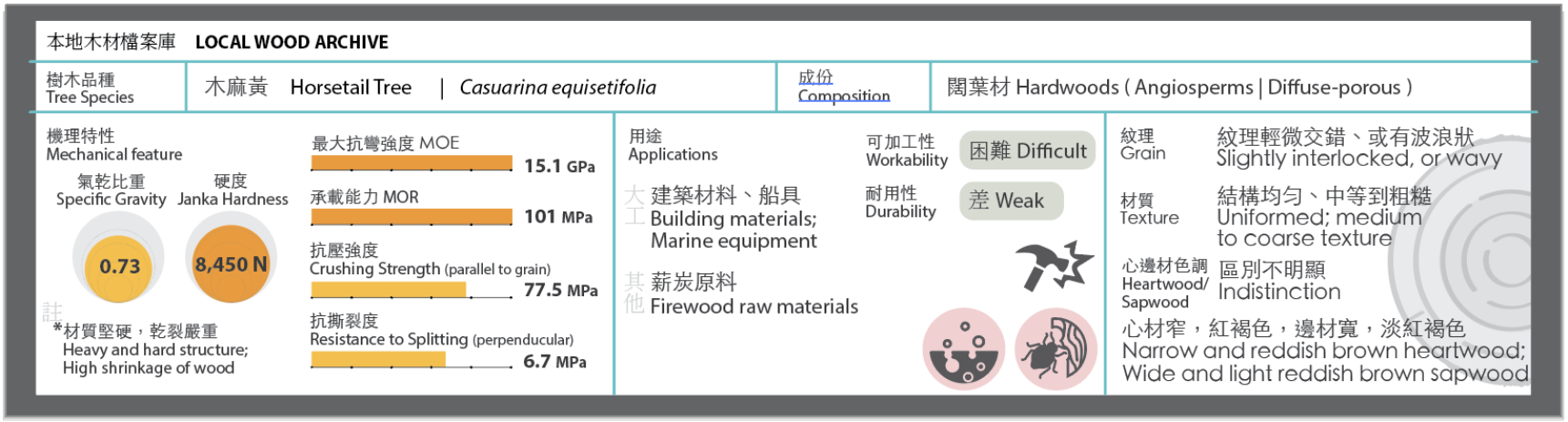


Figure 18. Label system design for the Hong Kong Wood Archive.

Research Outcomes, Findings and Further Research

[2] Findings: Real Scenario (Biochar Concrete Evaluation on Carbon-Neutral Product Design)

In application, the use of 1 kg of biochar is equivalent to reducing up to 3.3 kg of carbon emissions. The estimated total volume of biochar-augmented concrete used at the demonstration site is approximately 28 m^3. The site can stabilise at least 3964.8 kg CO_2 and generate overall profits of USD 966 when carbon emissions are priced. The researchers have identified a new campus renovation project to implement the pilot design.

The overall impact includes:

- Reducing the problem of landfill yard waste in Hong Kong
- Reducing carbon emission by minimising cement use in the production process
- Preparing a lifecycle analysis of biochar concrete products to facilitate large-scale applications

The impact also includes establishing a real case that reduces landfill yard waste in Hong Kong through circular design; lowering carbon emissions by minimising the use of cement in the production process; and enhancing the visual identity and preparing lifecycle analysis of biochar concrete to facilitate large-scale applications through circularity

Figure 19. LiquidStone bench design: A set of benches with a planter made from two materials: biochar concrete and reclaimed wood.

Research Outcomes, Findings & Further Research

[2] Findings

The project represents the **first large-scale local wood resources archive and study** sponsored by the Environmental Protection Department of the Hong Kong Government and its appointed manufacturer since July 2021. The current findings are as follows:

I. We compared the hardness and other properties of 23 commonly imported wood species (data from the General Technical Report 2010 by the USDA Forest Service, Forest Products Laboratory) and 14 local wood species from our collection. One significant finding is that the local wood resources are evenly distributed among commercially viable woods in three density categories –high, medium and low. For instance, the high-density pair is pecan and horsetail tree, medium pair is red oak and lebbeck and the low-density pair is fir and kapok.

II. Although the densities of local woods are comparable to those of imported commercial species, their pre- and post-treatments differ, affecting material processing, machining, treatment and applications. This requires further investigation.

III. Y · PARK encountered a bottleneck after 1 year of operation. The main challenges include (i) the massive amount of yard waste collected daily; (ii) difficulty in correctly identifying and sorting wood types; (iii) frontline workers cutting trees too short to meet users' needs; (iv) difficulty in standardising wood treatments, which affects the quality and durability of wood products; and (v) much wood residue cannot be fully utilised.

IV. We invited local wood artists, craftsmen and designers to explore the uses of local wood for very fine hardwood furniture making, sculpture and workshop purposes. It is clear that the local wood can support a wide variety of applications to meet local needs via one-off and small-scale production.

V. Hongkongers – including individuals, schools and practitioners – have shown greater willingness to engage actively in the use of local wood. However, while demand is high, supply remains limited. Improved logistics management and related technology innovation may contribute to a full-scale circular product and service system.

Research Outcomes, Findings & Further Research

[3] Further Research

The research team recognised the limitations of existing cases. To investigate closed-loop material flows and the effects of green supply chains on product design – and vice versa – a broader range of case studies will be required. The research continues to explore other design applications, such as a modular planter system. The team is also collaborating with the PolyU–NAMI 3D Concrete Robotic Printing Research Centre (RCC3D) to product and evaluate the concrete design.

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Figure 20. Our team is exploring stackable vertical gardens and fence wall applications.

Research Dissemination

Study of Local Wood – Creative Repurpose Archive For Felled Trees (CRAFT)

The reuse, repurposing or upcycling of local resources – such as recycled wooden pallets, red wine boxes, plastic bottles, metal cans, textiles and paper – has been explored by academics and practitioners for many decades. However, the applications of reclaimed wood, particularly from felled trees, remain limited to individual or small-volume production and DIY projects. In Hong Kong, there are many potential wood users, including small workshops operated by individual wood artists, designers or craftsmen, NGOs and schools. A key constraint in promoting the use of felled tree resources is the lack of critical services throughout the production chain, including collection, sorting, cutting and wood log treatment. Furthermore, Hong Kong lacks large-scale facilities to provide quality and cost-effective recycling. In 2021, the Hong Kong Government established Y · PARK, a facility that aims to fill the current void. Felled trees represent a sustainable local resource; however, their full potential and characteristics remain underexplored due to limited value, logistical challenges and insufficient design knowledge. This includes the constraints of the local wood from felled trees that could potentially support a commercially viable production cycle that is both impactful and sustainable. This research was an attempt to bridge these gaps.

According to waste data and statistics from the Hong Kong Waste Reduction Website, published by the Environmental Protection Department, the total amount of solid waste (wood/rattan) sent to landfill in 2018 was approximately 165,000 tonnes. Among the total 5900 tonnes of recyclables recovered from Hong Kong in the same year, only 0.3% of recyclable material comprised wood waste. Instead, recovered paper and plastics amounted to 39.1% and 3.6%, respectively. However, wood waste is considered less usable within the current recycling industry. Our research aims to increase the application rate of reclaimed wood in this region.

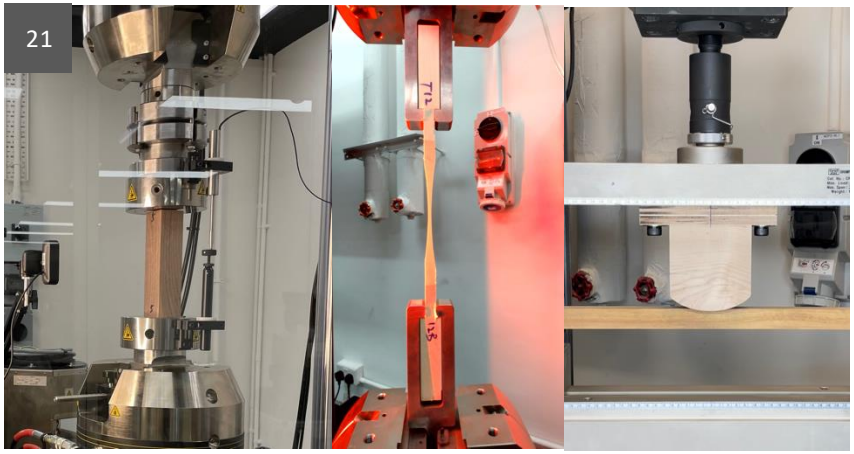


Figure 21. We tested wood samples using the university's facilities, including compression (parallel to grain; left), tension (middle) and static bend tests (right).

Research Dissemination

Yard Waste Recycling Process in Hong Kong

To understand the recycling service system for local yard waste, the team illustrated the process and mapped all actors/ action items through interviews with officers from the government of Hong Kong's environmental protection department. This map is exhibited at Y.Park, and acts as an epistemic object to promote the knowledge, communication and collaboration of stakeholders in future.

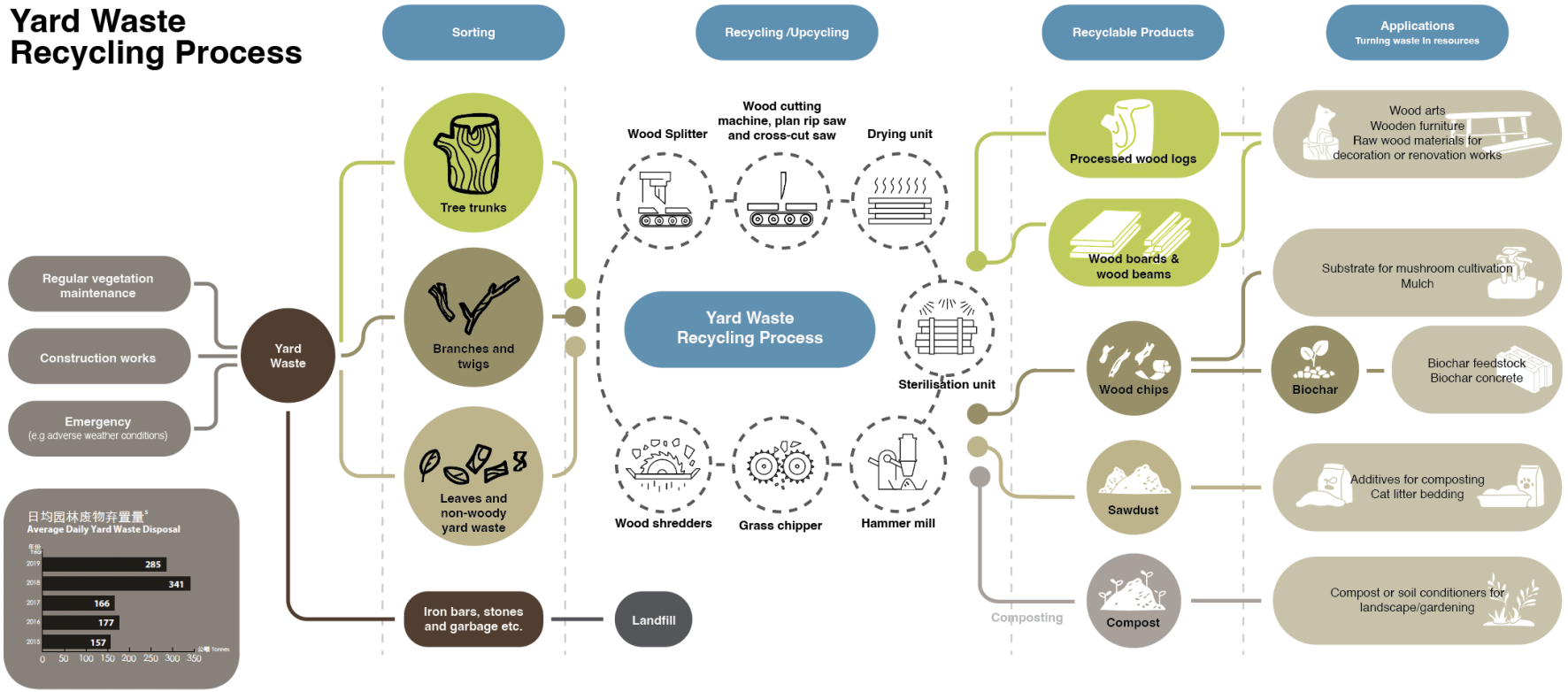


Figure 22. Yard waste recycling process in Hong Kong (illustrated by the research team)

Research Dissemination

Experiential Exhibition and Local Wood Archive (for the Public in Hong Kong)

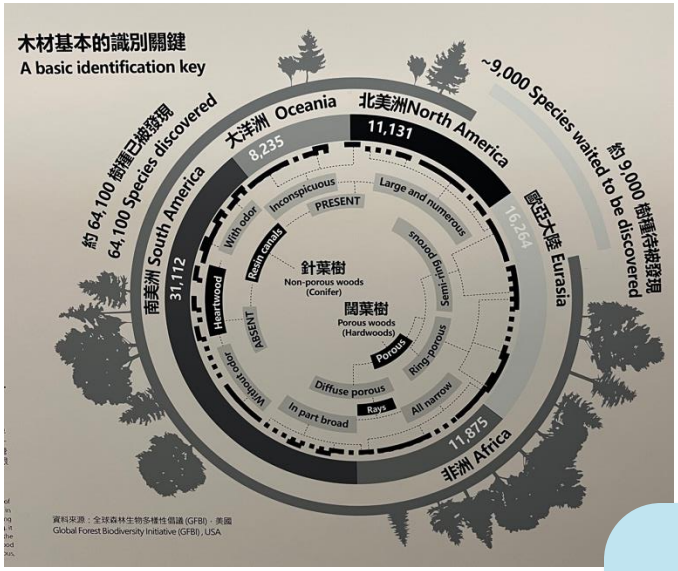
- Since January 2023, the project has been exhibited at Y・PARK, the first and only public facility for collecting and recycling yard waste in Hong Kong. It is a permanent installation intended for educational and promotional purposes.
- Location: Y・PARK (Tuen Mum, Hong Kong). Official website: https://www.ypark.hk/en/
- Design researcher and content provider of the exhibition: Prof. Brian Lee (PI) and Miss Ada Chan (Research Associate)

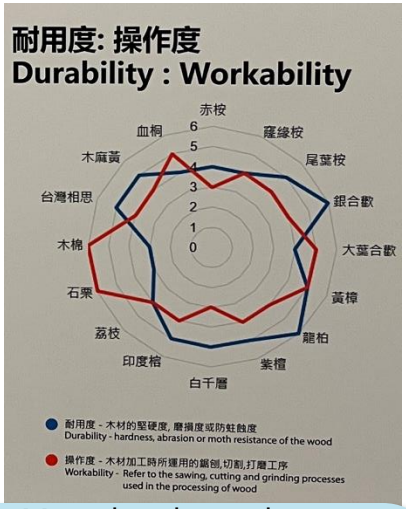
First local wood archive and exhibition for knowledge sharing, providing a tangible experience of wood materials, their properties and their design applications in Hong Kong.

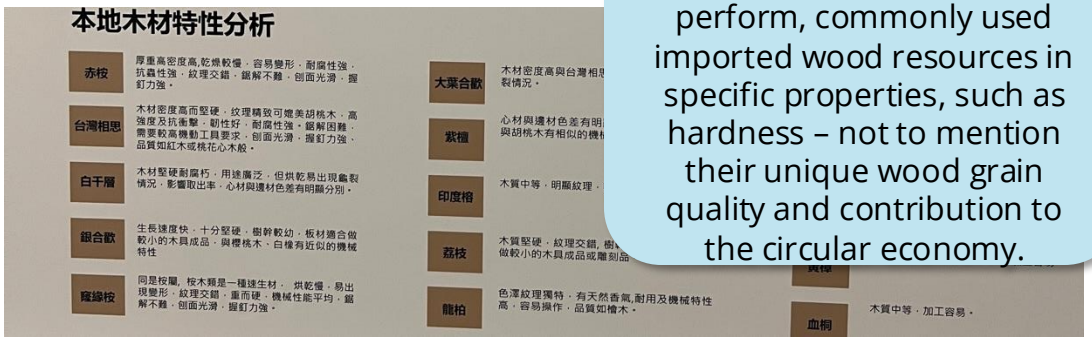
Research Dissemination

Experiential Exhibition and Local Wood Archive (for the Public in Hong Kong)

The exhibition presents the research process, including the identification of tree species, a comparative study of the mechanical properties tests of locally collected and imported trees and highlights from the local wood study showcasing **valuable uses and special aesthetic qualities**.







Many local woods are compatible with, or out-perform, commonly used imported wood resources in specific properties, such as hardness – not to mention their unique wood grain quality and contribution to the circular economy.

Research Dissemination

Experiential Exhibition and Local Wood Archive (for the Public in Hong Kong)

The exhibition showcases both local and imported wood species and demonstrates their differences and similarities and the existing and potential applications of local wood. Exhibition partners include architects, carpenters, designers, woodwork artists and students.

An example of engagement and testing the quality of local wood: Our team invited a senior wood artisan to craft a Ming-style wooden stool using local hardwood. The quality of the local wood is comparable to that of the traditional sources from overseas (e.g. rosewood from other Asian countries).

Research Dissemination

Experiential Exhibition and Local Wood Archive (for the Public in Hong Kong)

Exploration of different local wood species and promotion of responsible design, production and use of renewable and reusable resources.

Research Dissemination

Exhibition (Mainland China)

The project was featured at the ***4th China Design Exhibition & Public Art Thematic Exhibition*** in Shenzhen from 20 February 20 to March 16, 2023.

Venues: 1) The main exhibition at Guan Shanyue Art Museum
2) The Great Bay Area Special Exhibition at the Shenzhen Museum of Contemporary Art and Urban Planning

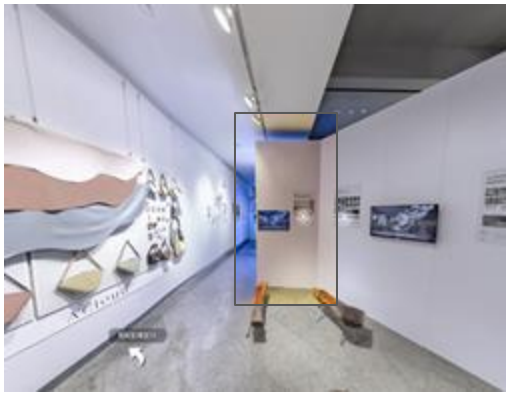
Organised by:
- Ministry of Culture and Tourism of the People's Republic of China
- The Guangdong Provincial Government
- The Shenzhen Government

Virtual exhibition access: https://dmt.silkroadcg.com/austin/start/dist/#/
Media report: https://mp.weixin.qq.com/s?__biz=MjM5MDc5NzY4MQ==&mid=2652486126&idx=1&sn=8d5e65a1a057a92b52eda22d1c5cd68f&chksm=bd5243f08a25cae6520f29d7a5eb402f9ba3a2523c7cde5cfba9f90fb4e7c64c4b1d64b5d294&scene=27

Research Dissemination

Exhibition (Mainland China)

Photographs from the Great Bay Area Special Exhibition at Shenzhen Museum of Contemporary Art and Urban Planning.



Media Exposure

[Media report]

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http://paper.people.com.cn/rmrbhwb/html/2023-02/21/content_25966218.htm

https://www.chinadaily.com.cn/a/202302/13/WS63e9ad90a31057c47ebae775.html

Research Dissemination

Archive at the Material Resources Centre, PolyU (for Hong Kong Academics, Students and Public)

The CRAFT is displayed at the Material Resources Centre of the PolyU School of Design, where all academics and students from PolyU and other schools, as well as the public, can access it freely.

Since 2014, the Material Resources Centre at the PolyU School of Design has showcased material samples from overseas. To better support the circular economy (e.g. a cradle-to-cradle model in the local region) and address the limitations of materials sourced from outside Hong Kong, the team has begun mapping, collecting and classifying local/regional eco-materials that can be accessed locally or from nearby areas to promote local resources, local production, local consumption and local recycling.

Research Dissemination

Exhibition – At The Hong Kong Polytechnic University

- The exhibition *Material Narratives – From a Point to Infinite Possibilities* Exhibition at the School of Design at The Hong Kong Polytechnic University was opened to the public from April 2 to May 15, 2025.
- The research project was showcased together with 22 innovative material-driven design projects from Hong Kong, Japan and Taiwan.

Figure 23. The project demonstrated the integration of biochar into sustainable renovation, exploring eco-friendly material applications.

Figure 24. Samples showing 3D biochar concrete tiles casted by the newly developed tension-adjustable membrane technique.

- Event website: https://www.polyu.edu.hk/sd/news-and-events/events/2025/4/2-material-narratives-exhibition/?sc_lang=en–
- Promotion (Instagram): https://www.instagram.com/p/DIgN32GSjW5/?utm_source=ig_web_button_share_sheet

Research Dissemination

Exhibition – At the Convention and Exhibition Centre, Hong Kong

- The biochar concrete design research project was nominated by the Environmental Protection Department of the Hong Kong Government and exhibited at the Biochar Application Exhibition, part of the *Conference and Expo for the Food and Beverage Trade 2023 – Towards Carbon Neutrality*, held at the Hong Kong Convention and Exhibition Centre on December 11–12, 2023.

Figure 25. The research outcomes were exhibited at the Hong Kong Convention and Exhibition Centre. The target audiences were industry figures and government organisations.

Research Dissemination

Demonstration – At The Hong Kong Polytechnic University

A set of biochar-concrete benches will be installed on campus in the last quarter of 2025. The images below show the pre-installation evaluation by the project team and the Campus Development Office of PolyU in November 2024.

Promotional video: *LiquidStone – Design for a Sustainable Future*
https://youtube.com/shorts/SP1aUVrS3Iw

Research Dissemination

Public Discourse

- Organiser: Environmental Protection Department of the Hong Kong Government. The PI was invited to give a speech at a public seminar ***Artisanal・Heritage*** (「匠心・傳承」研討會) on October 23, 2021. This knowledge-sharing activity was the first Hong Kong Government initiative to promote the concept of locally produced recycled timber to the public. It also highlighted how reclaimed wood can be upcycled into furniture, ornaments and art sculptures, integrating it into everyday life. In addition, the use of reclaimed wood helps preserve and advance local wood art. The PI was invited to present the study of local wood properties and the concept of a local wood archive to the public.

- Organiser: Hong Kong Design Centre; The PI was an invited speaker at a public seminar *Designing Circularity*, held jointly with international sustainable product designer Ms Ineke Hans on June 15, 2023. (https://designing-circularity.org/en/)

Reference

Websites

a) Y・PARK: https://www.ypark.hk/en/
b) Public seminar to promote the materials archive by the PI on Oct 23, 2021: https://www.instagram.com/p/CUrog4VP5Ai/

Remarks