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Advancing Timber for the Future Built Environment

Fisher & Paykel Global HQ Campus – Mass Timber Diagrid Innovation - delivering so much more than environmental sustainability.

Richard Naish, Adam Dwen

The scope of the project was to rebuild the global headquarters corporate and product development campus of Fisher & Paykel Appliances on a new site in Auckland, New Zealand. The principal building is a 11,380msq mass timber diagrid 2 & 3 story office building suspended above the land and enclosing an oasis of regenerated native New Zealand flora. The proposal develops a repetitive elemental low carbon construction system to demonstrate global innovation consistent with the clients' core values. The project has achieved a fast to build componentized mass timber system delivering a campus wide carbon neutral outcome. It has also employed, biophilic design principles, indigenous people's consultation, and high amenity staff facilities to deliver a socially, culturally, and environmentally sustainable outcome.

KEYWORDS: timber architecture, biophilic design, sustainability

1 – INTRODUCTION

Low carbon, mass timber, timber to timber diagrid jointing system, 2 and 3 story office building construction as part of a 3 building global headquarters campus development for Fisher & Paykel Appliances.

2 – BACKGROUND

Fisher & Paykel are a global home appliance company that have been operating on an existing campus for over 50 years and has come to its end of life. The need became clear to re-build their entire campus and facilities for a future 50 years on a new site closer to the city centre and with nearby public transport connections to make a new campus that more fully reflects the values of the company - sustainability and innovation.

2.1 CLIENT DRIVERS

The company has transitioned from being a domestic appliance manufacturer to a premium global brand which now makes 80% of its sales offshore. As a reflection of this change, Fisher & Paykel's company values now focus on innovation, sustainability, people and cultural awareness, so the brief for this new generation campus was for it to reflect these values in the architectural outcome of both building and landscape.

Fisher & Paykel executives, admired the eco-design credentials of the SCION Innovation Hub in Rotorua, a project designed by RTA Studio in collaboration with Irving Smith Architects, with a similar mass timber diagrid structure. They envisioned a base that would reinforce their deeply embedded commitment to sustainability. While architecture with a light carbon footprint was a priority, they also wanted buildings that would 'nurture and nourish' the occupants – a core philosophy that underpins the development of all Fisher & Paykel appliances. A mass timber structure therefore became a key aspect of the technical brief due to the alignment with their key values of innovation, sustainability, people and cultural awareness.

3 – PROJECT DESCRIPTION

The project involves 3 broad buildings occupying a landscaped campus.

The HOME building (11,380msq) accommodates 1000 staff working on a hybrid model in an office workplace environment. The interior fitout is highly flexible and based on the 'day 1' fitout design allows to accommodate up to 650 staff members at any one time with an upper limit capacity of 800 staff members. This building is designed as a mass timber structure suspended above the regenerated landscape on individual pre-cast concrete piles. The building is wrapped in a curtain wall façade system with extensive glazing and a highly insulated roof and has a mixed mode ventilation system. This building is the main focus of this paper.

The SHED building is a prototyping and product testing facility. This building is concrete and steel to provide optimised structure for minimal movement and vibration.

Richard Naish, Registered Architect, BArch FNZIA, Director RTA Studio, Auckland, New Zealand, rich@rtastudio.co.nz.

Adam Dwen, Registered Architect, BArch ANZIA, Associate Director RTA Studio, Auckland, New Zealand, adam@rtastudio.co.nz.

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The GARAGE building is a carpark building which accommodates 50% of the previous campus carpark numbers due to utilisation of public transport within proximity of the new campus.

The project provides 800MWh/a of electrical generation from photovoltaic cells distributed across the 3 buildings and is intended to provide for 40% of the operational energy demand for the whole development. The project has a sustainability goal to be whole of life carbon neutral based both on upfront and operational embodied carbon.

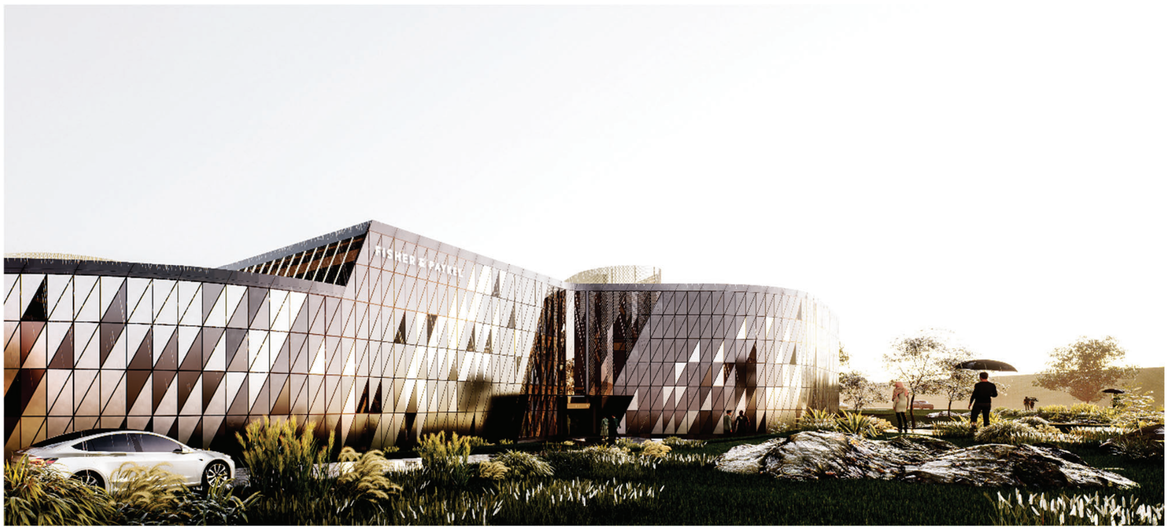

Figure 1. HOME Building – Rendered View - Point of Arrival

4 – DESIGN PROCESS (MAIN TEXT)

The design process for the HOME Building was to evolve our research of novel timber to timber jointed mass timber diagrid construction system to design a 2 and 3 story building aimed to combine innovative architectural design with structural integrity.

Challenges were to take an experimental mass timber diagrid system developed for a 1500msq building and develop a methodology to enable a 10,000msq+ building to be built efficiently within the relatively limited mass timber construction industry of NZ.

Minimising steel connectors reduces embodied carbon and cost in expensive steel joints and post-tensioning systems. It also reduces complex fire engineering issues associated with steel to timber connections. The integration of building services and passive design features, meet the fire design constraints while retaining the architectural expression of the timber structure.

Developing a building design and site erection methodology that minimised the site exposure time of the timber to prevent moisture and UV damage including tolerenace issues caused by swelling and contracting of timber as it gets wet and dries.

While the design development of the timber structure was a key component of the architectural design, to have an overall successful outcome the design needed to incorporate other fundamental project drivers. The building design was also to address issues of occupying post-colonial and post-industrial land, consultation with indigenous Māori tribes of the land, regeneration of pre-European flora and fauna, biophilic design in a post-pandemic modern workplace environment.

4.1 ARCHITECTURAL EXPRESSION MEETS STRUCTURAL INNOVATION

Timber Diagrid at Scale

Fisher and Paykel's are proud of their "Designed in Aotearoa" ethos with their own design philosophy to be inherently "of New Zealand". Therefore an important aspect of the their project brief was to keep the timber design, manufacture and delivery within New Zealand and with locally grown timber. The timber construction industry is expanding slowly, however at the time of this project there is limited capacity. One of the key learnings from the SCION project, where prefabrication in the factory was favoured, the same methodology that suited this smaller scale build would not be suited to deliver a building of a larger scale within feasible timeframes. This lead the design team to consider a development strategy for the diagrid system that was still highly repetitive but

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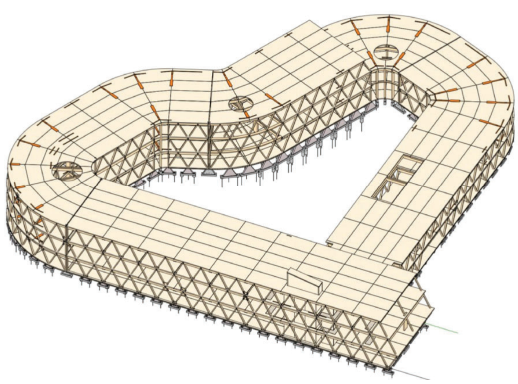
more elemental in nature with individual, easy to assemble components and in particular, simple brace to node connections. This approach was intended to allow individual components to be assembled by a different assembly team separate to the manufacturers, therefore occupying less factory time, allowing them to focus on and prioritise production of individual elements.

Timber to Timber Connections

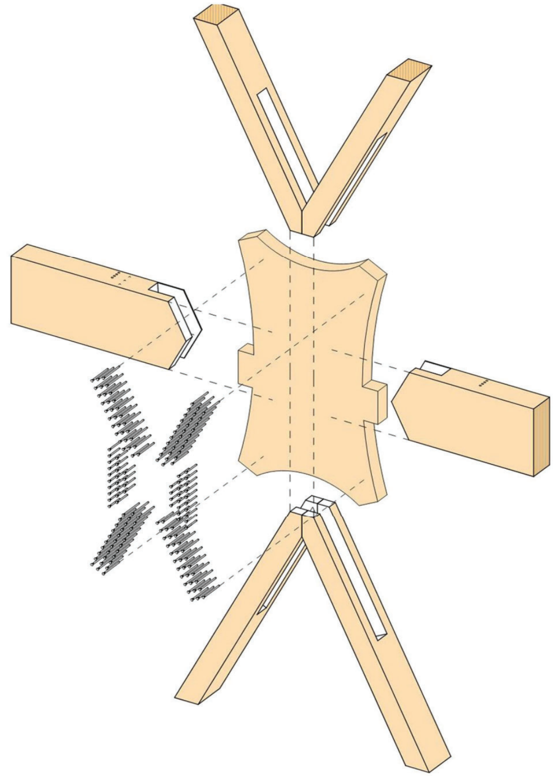
With a diagrid geometry design established that prescribed the overall volume of the building with floor plans, section heights, python script modelling was utilised to create a consistant setout of individual elements. This was particularly useful for achieving accuracy where the building geometry was curving in plan and efficiency of modelling where minor adjustments were required through design development.

Repetition of elements was key with the intent to limit the amount of "special" connection details in order to achieve as much simiplicty in the system as possible for the sake of quality assurance, economy and efficiency. All connection details were derived of two "master" details, straight and tapering, from which minor variants could be made to suit structural requirements or minor changes in geometry to suit their location.



Home Building – Structural Axonometric

Optioneering was carried out for various ways of achieving a brace to node connection. Developed by the structural engineers and architects, the optioneering process also had input from the timber manufacturers who were engaged early in the design process to assist in steering the design process toward a solution that achieved efficient manufacturing processes.



HOME Building – Strucutral Node & Brace Junction

The preferred option was refined and developed to a point of resolution with prototyping carried out to test manufacture processes and times, to benchmark quality, finish and to better understand assembly methodology.

Fire integrity was typically achieved utilising the char method with all steel screws embedded and timber plugged. A minimal amount of steel strapping was required for tying together of CLT floor and roof panels which were fire protected by encapsulating with industry standard non-combustble fire protection systems. The overall fire load to the building was carefully considered as part of the fire engineers combustion calculation. Non combustible linings were applied to the CLT to keep the fire load to an acceptable level with prioritisation of exposed timber given to higher profile areas where it was important to expose as much structural timber as possible in support of the projects biophilic aspirations. More specifically, the flooring substrate of the raised acoustic floor was non-combustible and approximately 60% of the underside of CLT floors were also lined to encapsulate the timber. LVL beams, columns and diagrid frame were therefore able to be left exposed.

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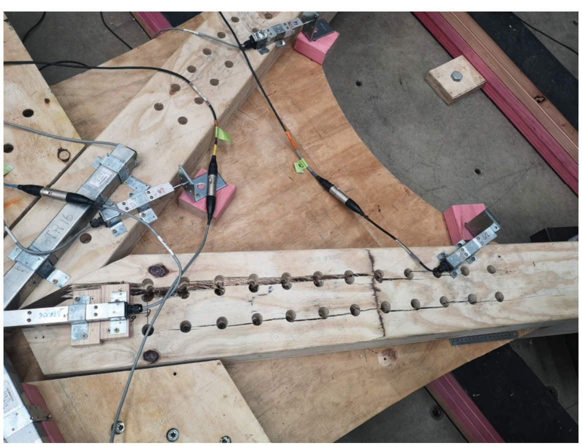
Full-scale structural testing was carried out at the BRANZ testing facility which was implemented to test and confirm design assumptions around movement under load (compression and tension), the overall rigidity, and breaking points of the structural assembly that were up to



HOME Building – Prototype Strucutral Testing

that point, based on calculations and not physical data that would otherwise typically be available for other more commonly used materials/structural assemblies. This successfully served to reduce risk by testing structural performance and reliability of the complex LVL diagrid.

In addition to the node and braces of the diagrid, LVL was also selected as the predomonent structural product for the frame including primary and secondary beams, and central columns that act as a spine throught the centreline of the building footprint. CLT was utlised for floors and roof with a small amount of glulam beams where a curving geometry was required.

Digital Modelling & CNC Fabrication

Design models were provided to the manufacturer to aid them in understanding the structural geometry of the structure and key relationships to architectural elements. The production team implemented an advanced 3D modelling workflow in a similar manner to the original design model, developing centreline-based models that operated independently from traditional "master" connection details. This allowed for a more adaptable and streamlined modelling process. Custom scripts were employed to map each master connection to designated points within the centreline framework and to automate the insertion of screw patterns into structural elements. This method not only cut down on drafting time but also enhanced inter-team coordination and offered greater adaptability throughout both design and fabrication phases.

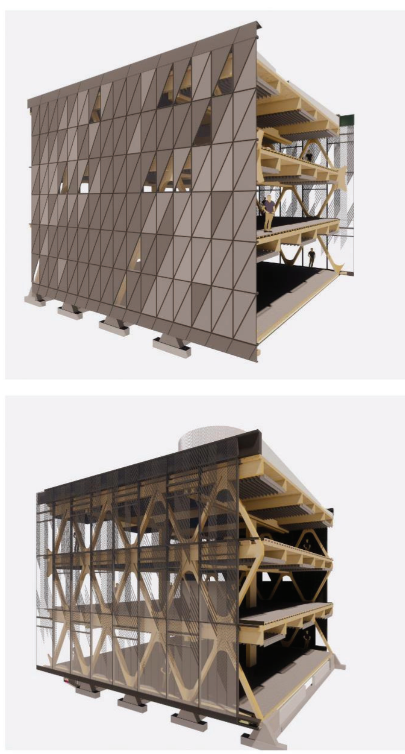
Off-site Pre-Assembly

All timber elements were precisely CNC-fabricated off-site to a tolerance of ±2mm and coated with a protective oil coating before being transferred from the manufacturer to the off-site assembly team. More than 54,000 screws had to be installed into the LVL components with high precision which favoured an installation process in a controlled environment. The main contractor organised a secondary off-site facility which was used for the pre-assembly stage, where diagrid components were factory-built into sizable modular sections typically with pre-drilled holes by the manufacturing team for better accuracy. These modules were systematically stacked and sequenced to enable an efficient, just-in-time delivery to site, optimizing crane operations during installation and minimising site exposure time. Due to timber's lightweight nature, transporting and installing large assemblies proved relatively straightforward. Prefabrication also included the integration of brackets and connectors, further streamlining on-site construction.

Making use of the shop drawing models, the manufacturer and pre-assembly team developed a digital QA system. The system allowed users to embed information—such as RFIs, photos, QA approvals, and shop drawings—directly into precise locations within the model. This functionality supports real-time, location-specific communication and coordination, streamlining review processes and enabling issues to be flagged and resolved early within the digital environment, enhancing site quality assurance.

4.2 PASSIVE DESIGN MEASURES & SERVICES INTEGRATION

The Home Building employs a number of passive design features to reduce energy use. The planning of the building is a deformed circle, 2-3 stories high and only 16m wide to achieve adequate natural light from both sides of the building. It encloses a planted oasis also containing a natural pond.

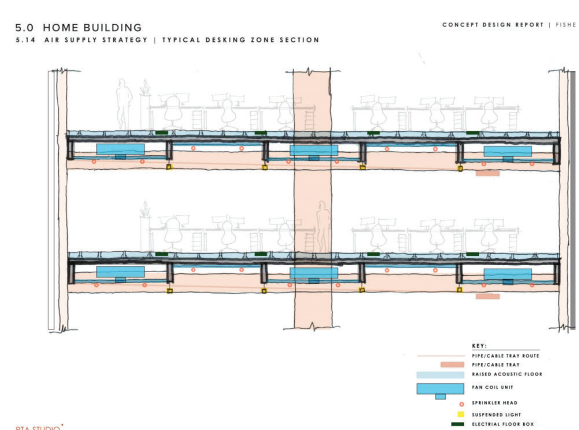


HOME Building – Enevelope

This oasis facing façade is a fully glazed curtain wall system to maximize views and solar gain, however ingress of solar heat and glare is moderated by a glass fritting pattern that varies in density depending on its orientation to the sun. A curtain wall façade system is also utilised to the outer elevations as a combination of insulated panels and glazed windows. Façade systems were shop drawn in parallel with timber structure shop drawings and prefabricated offsite. This allowed the building eneveloped to be clipped on shortly after the timber structure was erecented on site therefore minimising the timbers site exposure time. The roof system was designed as a highly insultaed warm roof with tapered PIR insulation and a double layer membrane. A vapour control layer was installed to the CLT roof structure to control moisture through the life of the building, however this also double as a temporary protection layer during the site phase and was installed in the factory prior to site delivery giving the timber an element of protection as soon as it landed on site.

A mixed mode HVAC system allows natural ventilation by auto-opening sashes drawing freshened air only from the oasis façade and exhaling the stale air through 4 atria which act as “lungs” for the building, utlising the stack effect due to the increased height of the atriums. The Building Management System (BMS) controlled automatic opening window system operates through shoulder seasons when temperatures are mild, with temperature set points configured at 20-24°C, intended to achieve comfort for a minimum of 90% of occupants. The outer façade faces the industrial neighborhood and protects against polluted air.

Individual fan coil units are distributed throughout the interior, located within the structural bays of the ceiling space. Early in the design process, an allowance of services reticulation was factored into the structural design,



HOME Building – Concept Section

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whereby primary and secondary beams were designed with a substantial offset, making room for the running of services through the long building footprint back to services cores. An acoustic floor was also specified to meet Impact Insulation Class rating requirements which was also utlised for running of electrical services through the floor cavity. Toegether with the beam offset strategy, the amount of services penetrations required in the structural beams were minimised and allowed the timber structure above to be exposed to view in a tidy manner, showcasing the timber and enhancing biophilic aspect of the design.

Holistic View Toward Environmental Sustainability

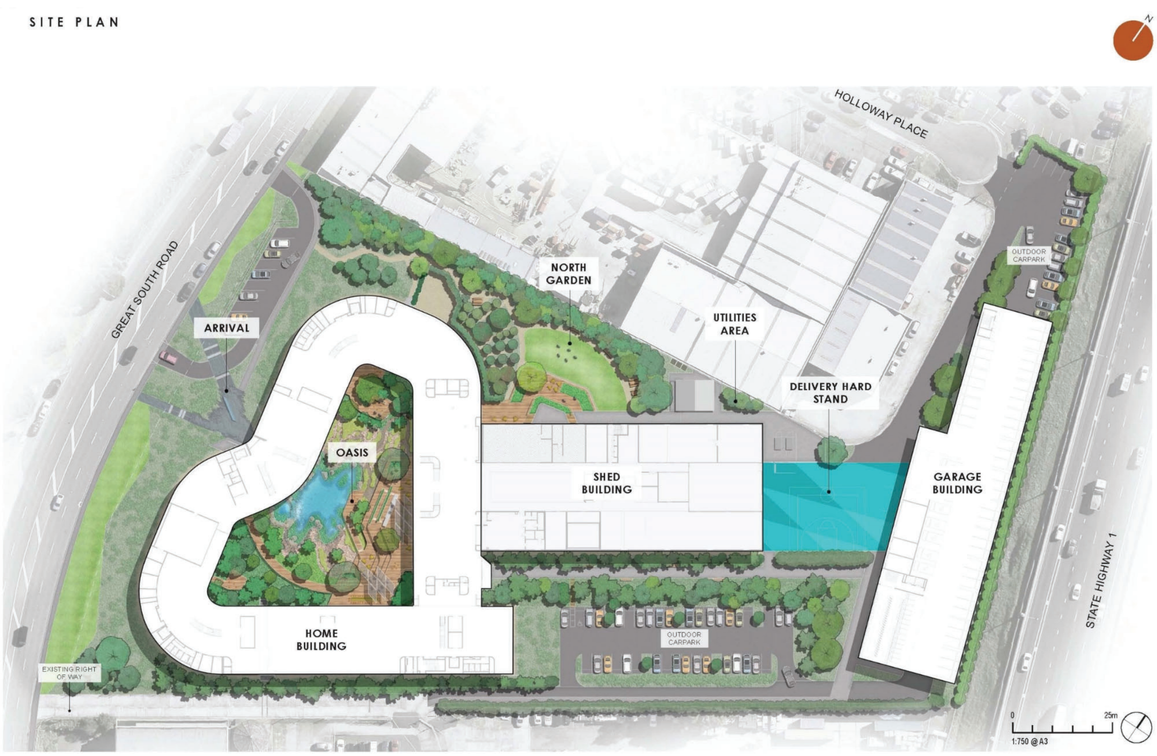
This project redefnes sustainable architecture through innovative, regenerative strategies. Its mass timber diagrid frame (NZ plantation grown certifed sustainable pine) achieves a negative embodied carbon footprint.

The mass timber of the Home building offsets the heavy carbon materials of the Shed and Garage buildings making the whole site low embodied carbon. The ground foor is also timber, suspended off the ground to allow storm event overland flow, but also increasing the low embodied carbon materials. Passive design and low energy building operation systems (described above) coupled with solar systems, generating nearly agigawatt, minimize resource use. The contractor is employing a construction waste recycling policy.

4.3 HEALING THE LAND THROUGH BIOPHILIC DESIGN

Landscape & Biodiversity Integration

The existing site, prior to construction, was a brown field post-industrial piece of land. It was contaminated by industrial uses over the last 100 years. Mostly covered with buildings and paved surfaces it supported very little bio-diversity. Post intervention, new buildings will occupy only 40% of the site with most of the balance being regenerated with pre-European native planting to restore a new bio-diverse ecosystem. This will enable native insects, birds and reptiles to proliferate. This region of Auckland has a number of small extinct volcanic cones, each with a small native vegetation zone. This new pocket of nature will form an additional steppingstone in the surrounding network of natural vegetation nodes within the city.



Site Plan

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Land use & Transformation

We have consulted with local Māori (indigenous) to research the pre-colonial use of the site. In those times the land was forested. It was used for productive food growing close to the coast where fish were gathered. The regeneration planting will be within the oasis & over the balance of the site, including a natural pond with a sponge-based approach to stormwater management through increased infltration, storage & natural drainage. Storm event overland fow is enabled by the suspended building. This regeneration of an ecosystem will provide a natural biophilic environment supporting the well-being of the working community. This holistic approach refects commitment to stewardship, setting a benchmark for sustainable development.

Participatory Design

Ngati Whatua (local Māori tribe) have been actively consulted as the original people of the land. Their narratives & values of sustainability & stewardship have been interwoven into the project. A diverse staff of over 1000 were engaged with followed by sequenced workshops spanning from briefng, through design stages. Briefng policies enabled equality, health & well-being to be embedded into the project. The resultant campus supports a hybrid work model including staff amenities like parent's rooms, pet zones, and chill spaces. A "Social Kitchen" & outdoor boardwalks and seated areas encourage inclusiveness & connection with nature and social well-being through biophilic design. We believe this has set a new standard for post-pandemic workplaces.

HOME Building – Oasis & living Pond

Aesthetic Qualities and Cultural Integration

The campus blends cultural heritage with biophilic design, fostering a contextually rich & inspiring environment. A timber diagrid frame & triangulated cladding pattern refect a Māori narrative of the pātiki (native fish portrayed in traditional artform) and inter-weave Māori concepts of protection (fish scales) & nourishment (nature's bounty). Entry access is oriented toward a sacred volcano with the volcanic rock of the site revealed and displayed. Outdoor spaces, include a living pond & gardens, connect users to nature and celebrate native flora & volcanic geology, strengthening the connection of people to their local natural environment. This thoughtful integration of culture, sustainability, & beauty uplifts the spirit, refecting Fisher & Paykel's forward-thinking ethos.

HOME Building – Biophillic Design Approach

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5 – RESULTS

The project is about 60% constructed at the time of this paper. This new generation diagrid timber to timber connection design has allowed fast componentised construction system to be achieved to facilitate large scale construction. Services and fire design has been in such a way as to maximise the display of the timber structure in support of the biophilic design approach. The design metrics of the carbon content show very low carbon whole of life analysis. The project balances short-term feasibility with long-term value creation, aligning with circular economy principles. Solar power, natural ventilation & low power operational systems are utilised and the masterplan, space-planning & services infrastructure supports future growth, adaptability, and regenerative practices minimize environmental impact.

The suspended ground floor of the building allows cyclonic inundation overland flow events to pass under the suspended building. Landscape regeneration of indigenous planting has been enabled to provide biophilic design, air filtering and stormwater management. The project has in part way redressed colonial disrespect of the land and the indigenous people of the land.

HOME Building – Social Kitchen Atrium Under Construction

6 – CONCLUSION

This project exemplifies an environmentally, socially and culturally sustainable approach to a corporate innovation campus development. It exhibits a globally innovative approach to a structural timber diagrid system, low carbon, mass timber construction, utilising novel timber to timber jointing in a high seismic, high wind, high rain event geo-location.