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REGENERATIVE PRACTICE IN STRUCTURAL ENGINEERING A CASE STUDY: SOUTH DUNEDIN LIBRARY

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ABSTRACT

Regenerative Practice in building design is about creating facilities that build capacity in people, communities, and natural systems to allow them to renew and thrive. This way of thinking goes beyond sustainability, and is not about being ‘less bad’ but creating something that will continue to create. As a structural engineer this can be a daunting and unfamiliar task. This case study discusses how regenerative thinking was applied to the Structural Engineering concept design for the proposed South Dunedin Library by supporting other design disciplines and using the five regenerative principles developed by the Lenses framework.

A regenerative design was achieved by designing a resilient structure that also provides future flexibility. Flooding is an issue in South Dunedin, raising the floor level will mitigate the flooding risk and create a zone to build on above the existing concrete slab, limiting the need to excavate in potentially contaminated ground, in this zone a ground beam grillage has been designed to spread the building loads to the soft ground. The space between the ground beams will be filled with insulation that also reduces the amount of concrete required for the project. The structure has been designed for future flexibility with column free spaces, so when the need to renovate the building arises the structure can be re-used. This reduces the cost of future alterations meaning the renewal of the facility is more likely to be feasible. The roof has also been designed to support solar panels in the future. It is hoped that once technology improves, this will allow the building to generate more electricity than it uses.

INTRODUCTION

WSP with Baker Garden Architects were engaged by the Dunedin City Council in October 2019 to complete the Concept Design for a new library and community complex in South Dunedin. The project is currently at the preliminary design stage.

Dunedin City Council (DCC) wished to have the community integrally involved in the project and the facility’s design. They embarked on a regenerative co-design process that was facilitated by Flatfish Projects. The South Dunedin Library and Community Centre (SDLCC) will be a community facility that is designed by the community for the community.

Site Location

The site was acquired by Dunedin City Council following a wide-ranging search for a suitable location. The SDLCC site is perfectly positioned to act as a flagship building along King Edward Street, the main shopping avenue and cultural precinct of South Dunedin. Refer figure 1 below.

South Dunedin was built on land reclaimed from a coastal wetland. The low level of South Dunedin, along with high groundwater and the effects of climate change make the area prone to flooding.

Figure 1. South Dunedin Library Site Location

Project Brief

To develop a South Dunedin Library and Community Complex. The facility will provide DCC library and customer service agency services, public meeting and gathering space. The facility is intended to become a focus for community activity in South Dunedin.

Project Team

Principal / Project Manager: Dunedin City Council

Regenerative Facilitator: Flatfish Consulting

Enginers / Lead Consultant: WSP

Architect: Baker Garden Architects

CO-DESIGN

Co-design is where a facility is designed not just *for* users but *with* them in a partnership to ensure it meets their needs. Dunedin City Council selected a diverse panel of representatives from community stakeholder groups for the co-design.

The co-design was facilitated by a team from Flatfish Projects using the Living Environments in Natural, Social and Economic Systems (LENSES) regenerative framework. In parallel with the start of the concept design the project team participated in a LENSES regenerative training course delivered by Flatfish and the Center for Living Environments and Regeneration (Clear). LENSES is a structured process where facilitators guide individuals and groups in exploring the full potential of a project. The course was heavily participant led, with guidance towards realisation and learning, this ensured lessons learnt were powerful and reinforced. Completing this course in parallel with the start of the concept design provided an opportunity to practice regenerative design as we went. The five key principles of regenerative design explored in the course were:

- Working in wholes not parts
- Being of service
- Account for uniqueness
- From separate to aligned with nature
- From problems to potential

Co-design doesn't mean the public is sizing beams or specifying concrete mixes, rather it is a high-level view of what is essential for the project to achieve. During the co-design initiatives were conceived and developed with the community until these were refined down to 13 key initiatives. The initiatives are summarised in figure 2 below.

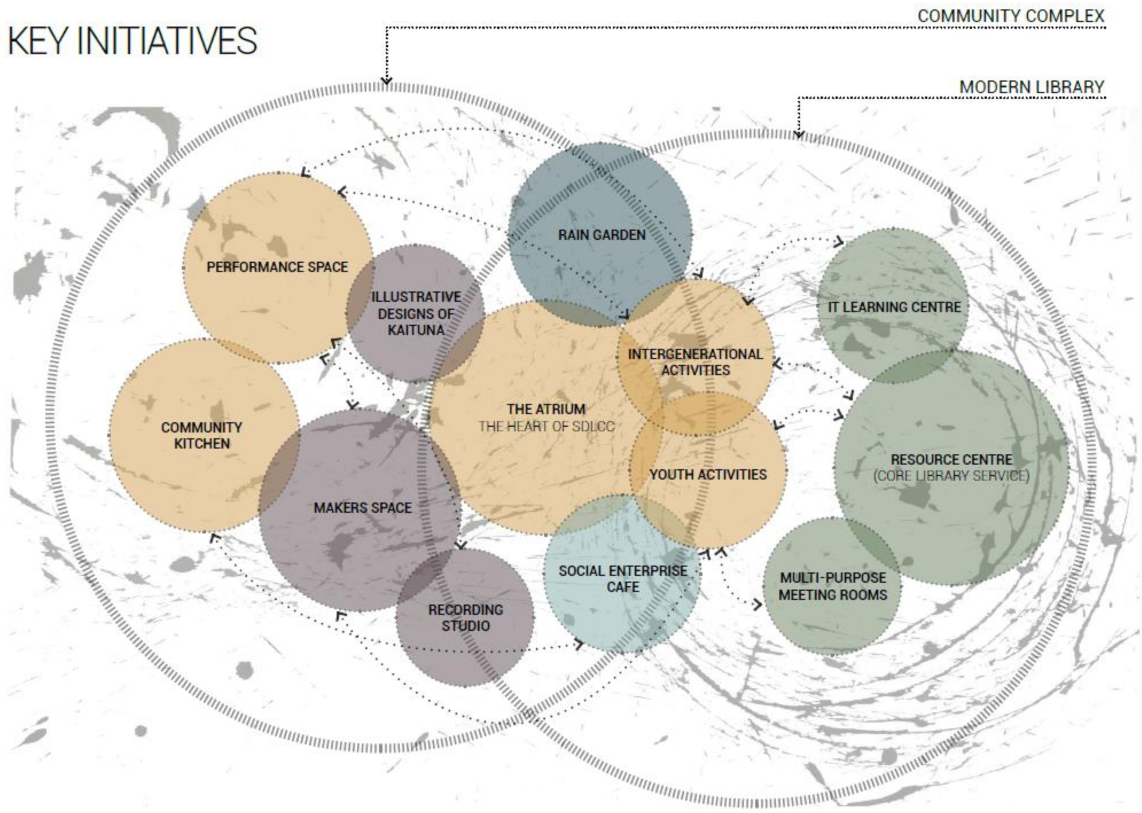

Figure 2. Co-design key initiatives

As an engineer being involved from the start it was possible to guide the initiatives to ensure the project is cost effective and remains within its restraints such as the budget. In regenerative practice the aim is to do this without compromise. An example of this was the 'Rain Garden' initiative. Originally a green roof was proposed to provide a connection to nature, filter stormwater, provide stormwater retention and a visual education opportunity about storm water retention in a flood prone area. The issues with a suspended garden included:

- Significant additional structure required to support the soil weight.
- Increased load on the foundations and the soft soils below.
- Increased seismic weight requiring more bracing.
- Waterproofing to a habitable space below and the ongoing maintenance.

As consultants, we can then utilise our skills and experience to bring this vision to life. It was an empowering experience to be let out of our structural engineering box and to be able to participate in this front of project process. It helped to see the 'bigger picture' of not just the project but the natural, economic and social systems the project can influence. A regenerative practitioner is encouraged to consider the largest system affected by the project to get the maximum benefit from initiatives. As an engineer the lessons learnt included:

- The community values resilience in the built environment.
- The best structural solution is not always the best project solution.
- Buildings can provide benefits to much larger systems well beyond their legal boundaries.
- A high level of trust can be built up with stakeholders through active listening and learning from others.
- How important this project is to the local community.

Through discussion this initiative was developed to become a rain garden at street level. Water from the roof will flow through the rain garden and into the stormwater system. This provided all of the benefits of the green roof with the following additional benefits:

- Much lower cost by eliminating the structural and architectural issues identified
- A more accessible feature on the ground floor that will be seen by more people

Throughout the workshops South Dunedin's history, ecology, society and economy were explored. Stories of South Dunedin were heard with the aim of discovering how the library will help realise South Dunedin's life-generating potential. Kaituna is currently being adopted as the name to represent South Dunedin's broader living environment or its inherent nature.

INTEGRATIVE PROCESS

Integrative Process (IP) actively seeks to design and construct projects that are cost-effective from an initial capital cost perspective and on a whole of life cost basis. This is done by engaging all project team members in a process of discovering mutually beneficial interrelationships between systems and components. This is done in a way that unifies technical and living systems, so that high levels of building performance and environmental benefits are achieved.

This is being achieved on the project by a series of workshops, combined with research and analysis, in a cycle that progressively optimises and refines the design solution during the concept and preliminary design phases. An IP roadmap for the project is being developed and continually refined as the project evolves.

STRUCTURAL CONCEPT

<u>Gravity system</u>

Steel DHS purlins are proposed to support the roofing. These purlins span between internal glulam beams and perimeter steel beams. Glulam columns and steel SHS posts support the roof framing. The living street canopy will be supported by steel beams that cantilever off the Grid B columns. The foundation consists of a shallow ground beam grillage built on top of the existing slab on grade.

Lateral system

Steel cross bracing in the roof between the beams will provide the main roof diaphragm. Sections of ply ceiling diaphragms get the load back to the main diaphragm. The structure will be braced by ply lined timber shear walls of nominal ductility. Steel cross bracing will provide the bracing inside the canopy. The structure will be designed to Importance Level 3 loading as per AS/NZS1170.

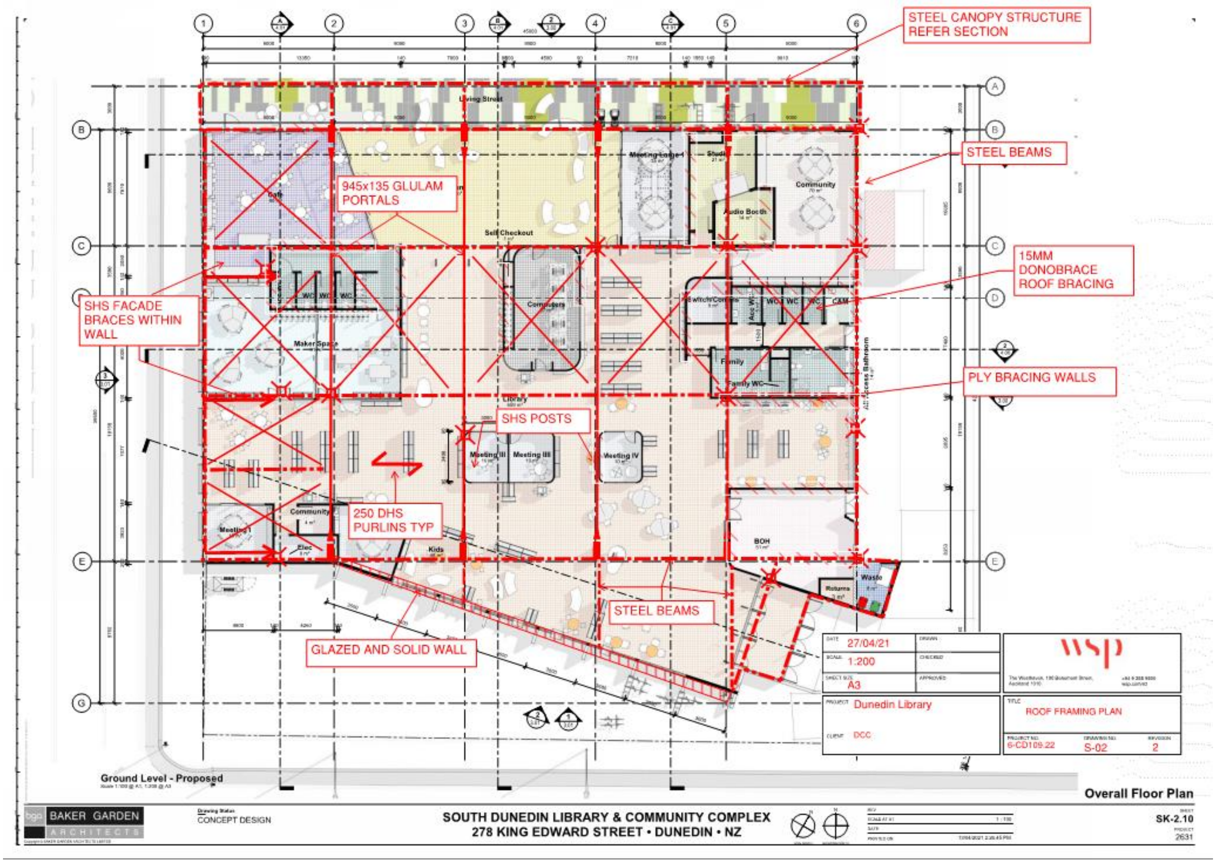

Figure 3. Concept roof framing

SOLAR PANELS

Photovoltaic (PV) panels align well with regenerative practice as they generate energy for the facility and potentially other buildings in years to come. The panels will likely not be installed initially due to budget restraints. Provision is being made for their installation in the future. It is hoped that as technology continues to improve the capital cost of the panels will continue to reduce. This fits well with the DCC's 2030 carbon zero goal. Structurally, an additional 0.2kPa loading has been allowed for in the roof design to cater for the panels.

COLUMN FLEXIBILITY

Regenerative development is about creating capacity and capability to renew, evolve and thrive. Traditionally buildings are built and then maintained over time, with a gradual degradation until they are eventually demolished or a natural hazard event damages them beyond repair. The prospect of creating a facility that will continue to evolve is a challenging prospect for engineers and architects. One way that a structural engineer can contribute to the continual growth and evolution of the facility over time is making it simpler to carry out future alterations.

A column free layout would provide the ultimate in flexibility to allow partitions to be shifted without structural consequences. However, this would have concentrated the load from the roof on to fewer points resulting in higher loads. An expensive piled solution would have then been required to achieve this. Also the longer spans would require a deeper structural roof support system, more expensive in itself and this also increases the height of the building requiring more cladding and increasing the project cost.

To create future flexibility without increasing the project cost significantly an innovative approach was used. As the lateral system is not integral with the gravity system this allows the internal gravity only posts to be relocated without consequences for the lateral system. The ground beam grillage also means there is support for a post everywhere along each grid line. This means that in future alterations posts can be shifted along beam lines provided the maximum span of the glulam roof beams is not exceeded, which also limits the load on the foundations.

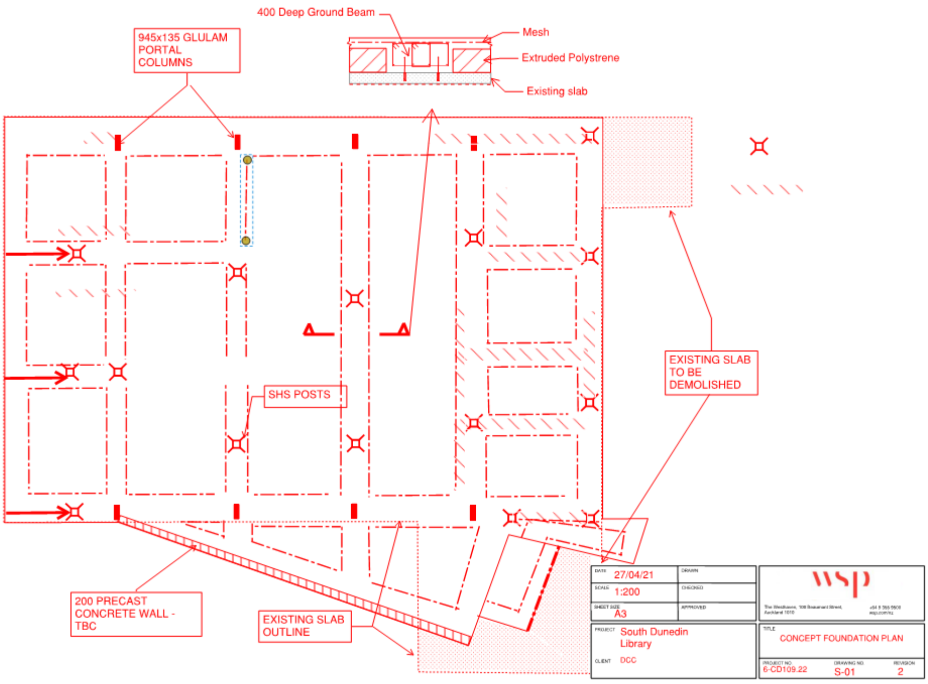

Figure 4. Concept foundation plan

RESILIENCE

One way that structural engineers can contribute to regenerative development is by providing resilience against natural hazards to enhance the buildings ability to survive these events and extend its life. A resilient building will last longer, providing the opportunity for it to be redeveloped to allow it to evolve. This avoids the need to demolish it and the extra cost associated with demolition and starting again. Ideally design should align with nature as much as possible, emulating and enhancing it where possible.

<u>Flood protection</u>

Following the 2015 South Dunedin flood and concerns over sea-level rise, there is a strong desire from the community and the DCC to have a facility that is resilient against flooding. As such raising the ground floor slab by 400-500mm above street level is proposed. This achieves resilience and provides potential for other initiatives.

Figure 5. Flooding on the South Dunedin plain, 4 June 2015. Source: Otago Daily Times

If this extra depth were to be created with hardfill and concrete the additional weight would cause settlement on the soft ground. As such a waffle type slab with a ground beam grillage and polystyrene in the voids is proposed. This has the following benefits:

- Limits the weight on the soft soils
- Polystyrene infill provides insulation increasing the building's energy efficiency
- Allows space for an above ground foundation
- Retaining the existing slab avoids the risk of exposing contaminated ground

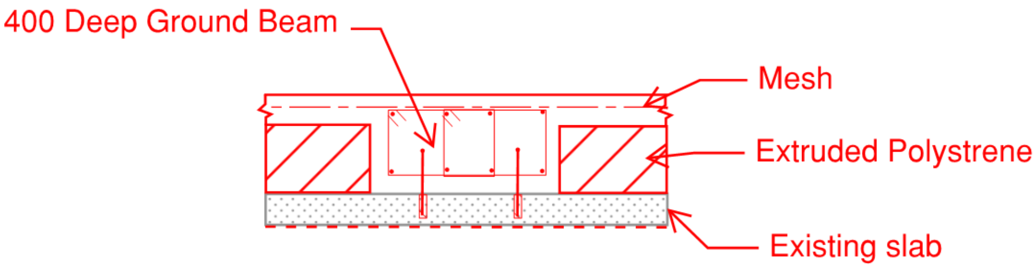

Figure 6. Preliminary typical foundation detail

Earthquake

The building is an Importance Level 3 structure as defined in AS/NZS1170.0. Plywood lined timber bracing walls have been chosen as an affordable means to provide a relatively stiff structure to limit deflections in an SLS event earthquake. By limiting the structures deflection, this limits the amount of damaging movement that non-structural elements such as cladding and wall linings experience in an earthquake. Using a common nail size and spacing the amount of wall required in each direction was calculated for nominally ductile forces (μ=1.25, Sp=0.925). This low level of ductility means that the building is less likely to experience an earthquake that will cause damaging yielding to the primary structure. Capacity design will be used to ensure the hold-down brackets and foundations will have overstrength on the nails to ensure a ductile mechanism (nail bending) under earthquake overloads.

FOUNDATION DESIGN AND TUNNELLING THROUGH THE COST BARRIER

A borehole, consolidation test and cone penetration tests (CPT's) carried out during the Geotechnical investigation revealed soft soils prone to settlement, but a low risk of liquefaction. The settlement was also evident during site walkovers through the existing buildings. Whilst structurally a piled solution is preferred, 30m deep piles would have been required to reach the dense gravel layer making them prohibitively expensive for a single storey structure.

The existing structures on the site are relatively heavy including a two-storey unreinforced masonry structure and a two-storey reinforced concrete structure both with shallow foundations. Whilst these buildings have suffered settlement they have effectively been pre-loading the ground for 60 to 100 years.

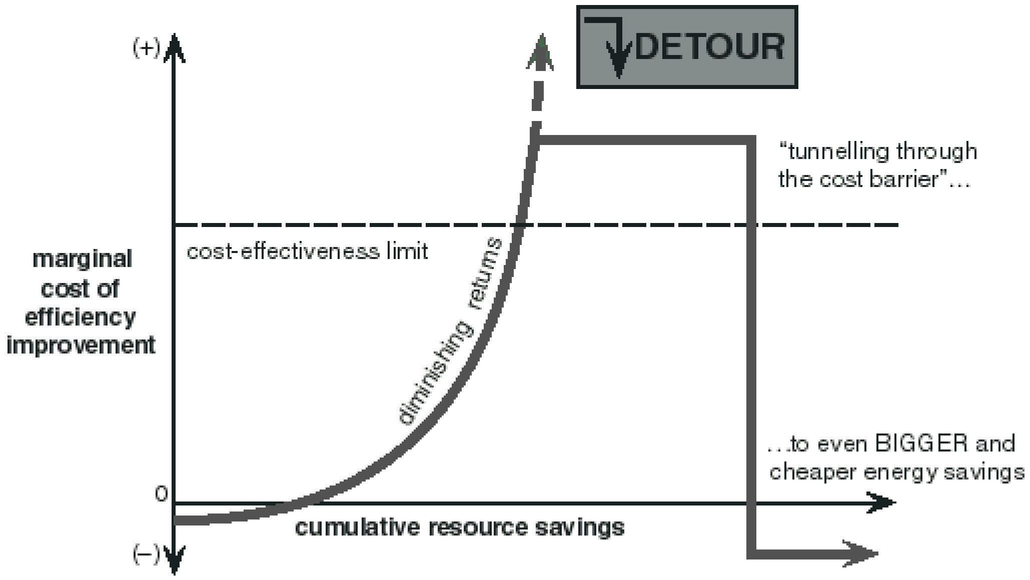

Figure 7. Cost savings

To enable shallow foundations to be used the following has been conceptualised:

- Single storey structure with a lightweight roof
- No precast panels or blockwork to limit the weight
- Polystrene infill between ground beams to reduce weight
- Ground beam grillage to spread the load to existing pads
- Retention of the existing slab where possible to further spread the load

The graph in Figure 7 highlights how reducing the weight of the structure provides minor efficiencies until it reaches a point where the foundation system can be changed to a shallow foundation and a large step change down in cost is realised.

By calculating the weight of the existing structure on each existing foundation pad this gave an upper limit for the weight of the new structure to avoid future settlement. The ground beam grillage will then spread the new superstructure load to these existing points.

In the next design stage a 3D model of the foundation will be created with support points at the existing pad locations to confirm the distribution of load to each existing pad is less than it currently experiences. In parallel with the design, survey monitoring of the existing structure is ongoing to confirm that the existing structure has stopped settling. The possibility of rebound from the silty clay is also being explored by the Geotechnical team with aim of factoring this into the foundation design. The ability to re-level the structure is also being explored with either a timber floor overlay or allowing for grout injection between the existing and new slabs.

CONCLUSION

Regenerative practice provides structural engineers with an opportunity to collaborate more with others leading to better project outcomes and increased job satisfaction. Whilst regenerative design can be a challenging prospect for a structural engineer on their own by supporting others regenerative opportunities can be realised as a design team. Regenerative design also provides engineers with the opportunity to contribute ideas from outside their own formal area of expertise as well. Often structural engineers would not be involved in this part of the design process but given we understand the structure we can add significant value by joining the project earlier.

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REFERENCES

Clear (2018), “Lenses Facilitator Manual – How to Create Living Environments in Natural, Social and Economic Systems”, *Center for Living Environments and Regeneration*

Hawken, P., Lovins, A., Lovins, L.H., (1999), “Natural Capitalism – Creating the next industrial revolution”, pp. 111-124.

Neville, J, Nairn, B. (2019) “Scope of Work – South Dunedin Library & Community Complex Design”, *Dunedin City Council*

Hes, D., Du Plessis, C, (2015) “Designing for Hope”, *Dunedin City Council*

Reed, B., (2007), “Shifting from sustainability to regeneration”, *Integrative Design Collaborative and Regenesis, Arlington, MA, US*

WSP, Baker Garden Architects (2021), “South Dunedin Library & Community Complex Concept Report”.

Goldsmith M., Hornblow, S., Palmer G., (2016), “The Natural Hazards of South Dunedin”, *Otago Regional Council*

Robison, A., Garbarczyk, M., Baker, N.,Kingdon-Diaz, D.,(2020), “South Dunedin Library & Community Complex Vision Plan”, *Flatfish Projects, Baker Garden Architects, CZYK Studio and Dunedin City Council*