External Research Report ER112 [2025]

Examining Built-in Plastic Components Used in NZ Building Construction and Advice for Alternative Materials and Fixation Methods

Ferdinand Oswald, Jack McGoldrick, Tessa Pook, and Baskoro Laksitoadi

Project LR14389

The University of Auckland, funded by the Building Research Levy

This report was prepared by the **University of Auckland**.

This research is located within the BUILDING CARBON RESEARCH GROUP led by Dr Ferdinand Oswald at the University of Auckland.

This research is located within the Future Cities Research Centre at the University of Auckland

https://www.futurecities.ac.nz/

Funded from the Building Research Levy

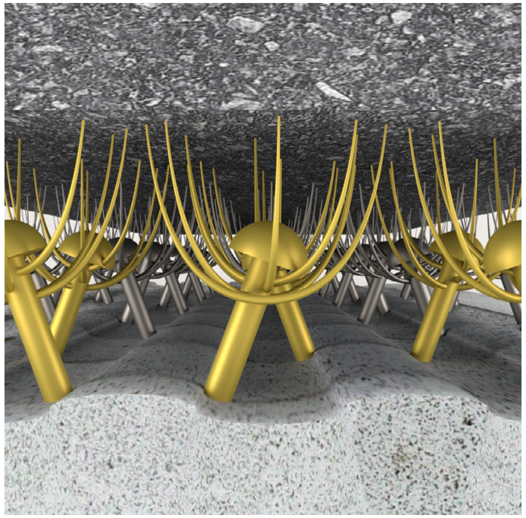
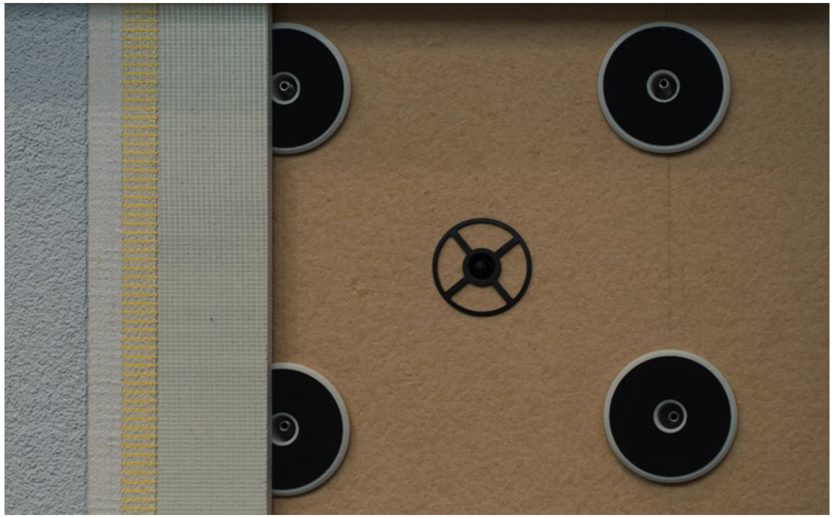
1222 Moonshine Rd, RD1, Porirua 5381

Private Bag 50 908, Porirua 5240
New Zealand

ISSN: 2423-0839

Examining Built-in Plastic Components Used in NZ Building Construction and Advice for Alternative Materials and Fixation Methods

Ferdinand Oswald, Jack McGoldrick, Tessa Pook, and Baskoro Laksitoadi

Faculty of Creative Arts and Industries: School of Architecture and Planning, The University of Auckland

Kindly funded by the Building Research Levy

This research is located within the
BUILDING CARBON RESEARCH GROUP
led by Dr Ferdinand Oswald at the
University of Auckland.

Funded from the Building Research Levy

This research is located within the Future Cities Research Centre at the University of Auckland.

https://www.futurecities.ac.nz/

Project code LR14389

ISSN: 2423-0839

1222 Moonshine Rd, RD1, Porirua 5381
Private Bag 50 908, Porirua 5240
New Zealand
branz.nz

Contents

List of figures

List of tables

1. Acknowledgements

This work was funded by the Building Research levy 2021 as part of the 'Sustainable Management of Plastic Waste on Construction Sites in NZ: A Co-operative Solution to Improve on the Cradle to Grave Approach' project in cooperation with the University of Auckland, Dr Ferdinand Oswald is the Associate Investigator at the University of Auckland and the director of the Building Carbon Reduction Research Group. We extend our heartfelt gratitude to David Dowdell, Principal Scientist of Sustainability at BRANZ, for generously providing us with the LCAQuick data sheets and for regularly meeting with us to discuss project outcomes and objectives. Thanks to Nigel Benton from Benton Ltd for providing the Titirangi Road case study site and all relevant information and feedback. Gratitude is also extended to Gregor Steinhorn, Unitec Institute of Technology who has kindly provided his advice, time, and feedback.

2. Executive Summary

2.1 Introduction

Plastics have been part of human civilisation for the past 100 years (Chalmin, 2019) and each year an estimated 350 million metric tons of it become waste worldwide (Brown, Laubinger, & Börkey, 2023). The wide-spread of plastic can be attributed to its durability, strength, and malleability. These qualities allow for a plethora of forms and applications including building components and fixation methods. In building construction, plastics can be found in the walls, foundation, and roof in the form of insulation, pipes, flashing, tapes, sealants and many more. Many of these can theoretically be recycled, however, once building components have been fixed using glues or foams, the components become contaminated and cannot be separated without being destroyed.

2.2 Project overview

This research examined the plastic components procured for a case study building construction site in Auckland and other commonly used plastic building components. Each component was evaluated in terms of potential for reuse, recycling and landfill using the expertise and information from builders, architects, product manufacturers, and building companies. The information was compiled and formatted to be integrated into the LCAQuick C1 Building End-of-Life Waste Datasheet. Glues and Foams were one of the focal points of this report, as they have a wide variety of applications in building construction (Figure 1).

2.3 Objectives

The research for this report sits within the End-of-Life stage of a building and was guided by four main aims. These involved the compilation of a comprehensive list of plastic components used in typical residential building construction projects in Auckland, each of which was evaluated for potential 'reuse,' 'recyclability,' and 'landfill'. This report aimed to format the research results for integration into LCAQuick Module C1 datasheet through a detailed breakdown of the plastic components identified. Following this, alternative fixation methods and materials for the current practices that are conducive to a closed loop material cycle were suggested.

2.4 Methodology

The nature of the methodology employed in this research is both qualitative and quantitative. The first part is quantitative and involved the compilation of a list of plastic components and the relevant information for each one. The second part of the process was quantitative, as it involved the evaluation of each component's reuse, recycling, and landfill potential. The evaluations were based on a range of sources including publications, product specifications, discussions with builders and other experts in the building construction industry. The final part of the research, also of qualitative nature, proposed additions to the LCAQuick Module C1 in the form of 'best practice' scenarios. In these scenarios, alternative fixation methods and materials that are more conducive to a closed loop material cycle are suggested and explained.

2.5 Findings

1) 5 of the 45 plastic building components analysed were deemed reusable and 12 of 45 were deemed recyclable.

2) When less glue is used to fix building elements, components are more likely to be in suitable condition for reuse after demolition or deconstruction. Furthermore, materials uncontaminated by glues can be recycled.

3) LCAQuick lists plastic as one single component, however 45 separate plastic components were identified by this study

2.6 Conclusion

In conclusion, this report evaluated relevant plastic components and fixation methods found in New Zealand residential buildings. Based on cost estimate documents from the case study site of eight terraced houses at 40 Titirangi Road, a comprehensive list of plastic components used in a typical residential building construction project in Auckland was generated. This report highlighted the linear nature of the lifecycle of fixation methods commonly used today. Five building component systems and materials that disregarded the end-of-life of a building were selected and alternative fixation methods and materials were identified. These examples were formatted for integration into LCAQuick Module C1 through a detailed breakdown of each component system or material. Potential alternatives conducive to a circular economy were found in historic approaches such as the range of mechanical fastenings that were widespread before the use of glue and foam adhesives in New Zealand. Minimising the use of glues and foams allows for better separation at the end of life and, consequently, more effective recycling and reuse opportunities for materials and components.

3. Introduction

Plastics have been part of human civilisation for the past 100 years (Chalmin, 2019) and each year an estimated 350 million metric tons of it become waste worldwide (Brown, Laubinger, & Börkey, 2023). The widespread of plastic can be attributed to its durability, strength, and malleability. These qualities allow for a plethora of forms and applications including building components and fixation methods. In building construction, plastics can be found in the walls, foundation, and roof in the form of insulation, pipes, flashing, tapes, sealants and many more. Many of these can theoretically be recycled, however, once building components have been fixed using glues or foams, the components become contaminated and cannot be separated without being destroyed. Such components are typically discarded in landfills (BRANZ, 2022). This research examined the plastic components procured for a case study building construction site in Auckland and other commonly used plastic building components. Each component was evaluated in terms of potential for reuse, recycling and landfill using the expertise and information from builders, architects, product manufacturers, and building companies. The information was compiled and formatted to be integrated into the LCAQuick C1 Building End-of-Life Waste Datasheet. Glues and Foams were one of the focal points of this report, as they have a wide variety of applications in building construction (Figure 1).

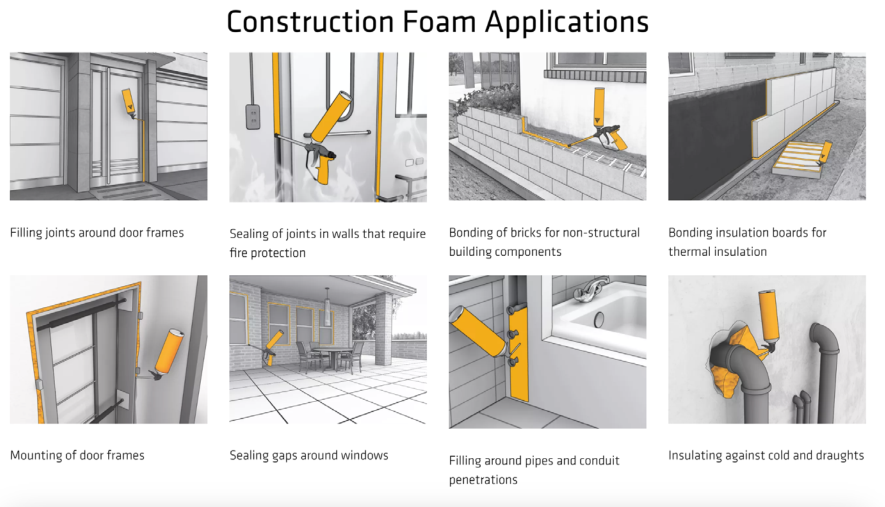


Figure 1 - Construction foam applications. Image by Sika Group, 2023.

4. Aims

The research for this report sits within the design process (fixation methods) and the End-of-Life stage of building construction (Figure 2), and was guided by four main aims:

1. To generate a comprehensive list of plastic components used in typical residential building construction projects in Auckland. This was based on the cost estimate documents for the case study site of eight terraced houses at 40 Titirangi Road. A selection of other commonly used plastic components were added to this to represent a wider range of products and fixation methods used in New Zealand building construction.

2. To evaluate the potential 'reuse,' 'recyclability,' and 'landfill' of each identified plastic component. Evaluations were based on information gathered from the attendants of the builder's workshop, technical guides, publications, and online sources. The complete list can be referred to for future contributions to the LCAQuick tool.

3. To format five selected building component systems for integration into LCAQuick Module C1 datasheet through a detailed breakdown of the plastic components within each one.

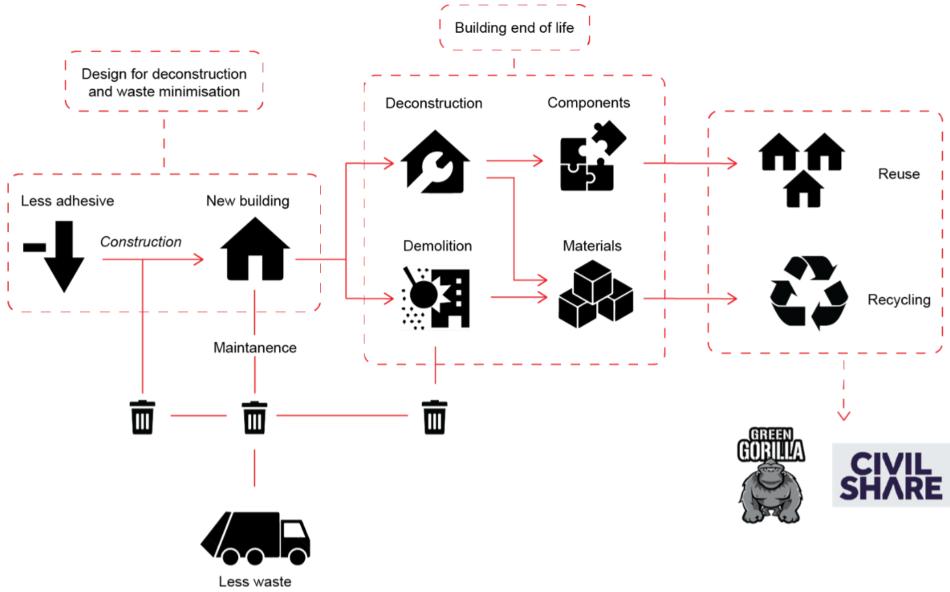


Figure 2 - Diagram of plastic product lifecycle. (UoA).

4. To identify alternative fixation methods and materials for five building component systems that disregard the end-of life of the building. During the design phase of a building, the selection of components, materials, and fixation methods impacts the lifecycle of the building, and its total embodied energy. Once building components have been fixed using glues or foams, the components become contaminated and cannot be separated without being destroyed. Such components are typically discarded in landfills (BRANZ, 2022).

5. Methodology

The nature of the methodology employed in this research is both qualitative and quantitative. The first part is quantitative and involved the compilation of a list of plastic components and the relevant information for each one. The second part of the process was quantitative, as it involved the evaluation of each component's reuse, recycling, and landfill potential. The evaluations were based on a range of sources including publications, product specifications, discussions with builders and other experts in the building construction industry. The final part of the research, also of qualitative nature, proposed additions to the LCAQuick Module C1 in the form of 'best practice' scenarios. In these scenarios, alternative fixation methods and materials that are more conducive to a closed loop material cycle are suggested and explained.

5.1 Identification of Plastic Components

This step involved compiling a comprehensive list of all plastic components used in building construction in New Zealand. This included components such as pipes, insulation, glues, foams, fixtures, and various other plastic building elements. The construction of an eight-unit terraced development, at 40 Titirangi Road, New Lynn, Auckland was the case study for this report. A list of all components for the build were provided by owner Nigel Benton, from which a list of plastic components was extracted. The plastic components were then detailed in a spreadsheet, including their application, location within the building, material content, and fixation method (see complete list in Appendix). To ensure that the report encompassed a broad scope of plastic componentry and their respective fixation methods, additional plastic components were added to the initial list. These were plastic components that are typically found in other New Zealand budlings and developments (see results in Appendix).

Glues and foams were also added to the list, as they are defined plastics. Plastic, as a substance, is defined by Merriam-Webster (n.d.) as:

"Specifically: any of numerous organic synthetic or processed materials that are mostly thermoplastic or thermosetting polymers of high molecular weight and that can be made into objects, films, or filaments)"

Common adhesives and foams are often composed of polyurethane or silicone bases, which fall under the of synthetic thermoset polymers (Chalmin, 2019; Geyer, 2020). This report considers adhesives and construction foams as plastic components in building construction.

5.2 Evaluation of Potential End of Life

Once the list of plastic components was compiled, the research team assessed the potential for three main disposal outcomes: 'reuse,' 'recyclability,' and 'landfill' (Table 1). They examined each plastic component's potential for being reused in other construction projects, recycled into new materials, or ultimately destined for disposal in a landfill. Each component was then assessed for reuse, recyclability, or landfill on a yes/no basis.

The evaluation of 'reuse,' 'recyclability,' and 'landfill' is conducted based on, research consortium meetings, online research on the collective experience of builders, architects, product manufacturers, and building companies. Furthermore, in collecting and analysing research data, the team utilized BRANZ appraisal documents, observed products in the market, and reviewed technical product data sheets. Through this approach, the research team leveraged the combined knowledge and practices of these entities to assess the potential disposal outcomes for the identified plastic components.

Plastic component	Application	Location	Material content	Fixation	Reuse	Recyclability	Landfill
Soft plastics							
Agpac Polythene Black 250 Micron 4mx25m [Slab DPM] (5)	"black polythene sheet for use as a damp-proof membrane (DPM) under floor slabs." (5)	Used to separate site levelling sand from concrete slab foundation system (EXPOL Tuff Pods and poured concrete) (5)	"250-micron thick, black polythene sheet." (5)	"The DPM is loose laid with taped joints" (5)	No (16)	No, contaminated	Yes (16)

Table 1 - Example of information gathered for soft plastics. (UoA)

5.3 Alternative fixation methods and material options

The outcomes of this research were formatted to be integrated into the LCAQuick C1 Building End-of-Life Waste default datasheet to support the continued development of the tool. LCAQuick is a Life cycle assessment tool developed by BRANZ. The tool is designed to support architects, designers, and structural engineers to make informed, sustainable design decisions. Module C1: Building End of Life Waste Datasheet is used to estimate the demolition waste quantities from commercial buildings in New Zealand. The information is divided into 'typical case' and 'best practice' scenarios, each with the subcategories: 'reuse', 'recycling', 'recovery (energy)', and 'landfill/cleanfill'.

This research presents commonly used plastic components found in five systems within a residential building (slab systems, flashings and jointers, interior door frame fixing, fixing plywood floor cover on joists, and EIFS (Exterior Insulation Finishing System)) and their current waste endpoints as 'typical case' scenarios in the format of LCAQuick C1 datasheet and is described in the results section. Additionally, 'best practice' alternatives for each plastic component and suggestions for alternative fixation methods and materials are presented in the same format.

In LCAQuick Module C1, each subcategory gives the percentage of the material that is typically reused, recycled, sent to energy recovery, and discarded in landfills during demolition. The Titirangi Road case study was a new build construction site, not a deconstruction project. Therefore, percentages for the waste endpoint of each component were not able to be determined. This is a potential area for future research. In place of the missing percentage figures, existing data from LCAQuick datasheet (typical case) was input. Assumptions about the end-of-life of each component were made based on research consortium meetings, collective knowledge of practitioners and the research team, site visits to 40 Titirangi Road, and online sources such as technical documents and publications.

6. Limitations

6.1 Durability

Durability is not within the scope of this research. The main reasons for its exclusion are the complexities of durability assessment, involving many factors such as the degradation of plastics due to moisture, chemicals, UV sunlight, movement, weather and so on. A detailed deconstruction case study project by measuring each plastic recycling opportunities after lifetime would be necessary to investigate the durability factor of built in plastic components. In this report, it is assumed that if a building component can be removed from the building without significant damage, then it can be reused in another project. Due to the wide range of materials and plastic product manufacturers identified, durability was an impractical focus for the scope and scale of the research report.

6.2 Economic factors

Another limitation of this paper is the financial impact of switching to more sustainable materials. No cost calculation of the most sustainable "green" material selection possible, or examination into an investment return study was undertaken in this report.

6.3 Alternatives and advice

The results of this research are limited to five systems found in residential buildings and the components within them. This is due to the lack of viable alternatives available on the market. Many of the plastic component systems identified in this research are highly specialised products which limits their potential for recycling. The development of entirely new systems in which each component is separable after life and has its own circular economy would be required to replace these. For example, the window flashing tape system developed by Thermakraft provides a weather-tight seal around the edges of window fenestrations and operates as the industry standard for weather protection and sealing windows for weathertightness. There are no alternative solutions available on the market currently. High strength adhesive tapes in combination with one another cannot be reused after life, nor can the material that the tapes adhere to be reused because the adhesive from the tape contaminates the material. A more sustainable solution to sealing around a window might require the development of an entirely new system of interconnected products that could allow for reuse or recycling of each component in the system, therefore recommendations for the replacement of this system are beyond the scope of this report. Several other plastic components identified in this research also fall under this category.

6.4 Toxicity

Toxicity is not within the scope of this study. Plastics and their associated chemicals can release toxins throughout their life that can be harmful to the environment and to human health. The chemical composition of plastics, including glues and foams are highly complex and often toxic during multiple stages of their lifecycle, including production, installation, during use, demolition, and in landfill. Despite the recognition of these risks, discussion and analysis of these aspects of plastic building components are omitted in this report.

7. Results

7.1 List of all plastic components

24 plastic components were identified in the Titirangi Road case study. 13 additional plastic components were identified through other documentation from the case study site such as photos from the bins on the site that collected waste during construction. 8 more plastic elements were identified by the research team by online research investigation as typical for a construction site in NZ, totalling 45 plastic components identified.

According to the evaluation that was undertaken in this research, all the 45 plastic components identified would typically go to landfill. 42 of the 45 plastic components identified are unable to be reused (Figure 3). However, the three identified that can theoretically be reused, PVC vent strips, PVC jointers and plastic access panels.

12 of the 45 plastic components are recyclable, and 33 are non-recyclable (Figure 4). Like reusability, the plastic components recyclability is dependent on the product material composition, the availability of recycling facilities and the material's state of contamination and condition at the time of demolition or deconstruction. These results are based on BRANZ LCAQuick data, and assumptions informed by the information sources that formed the basis of this report.

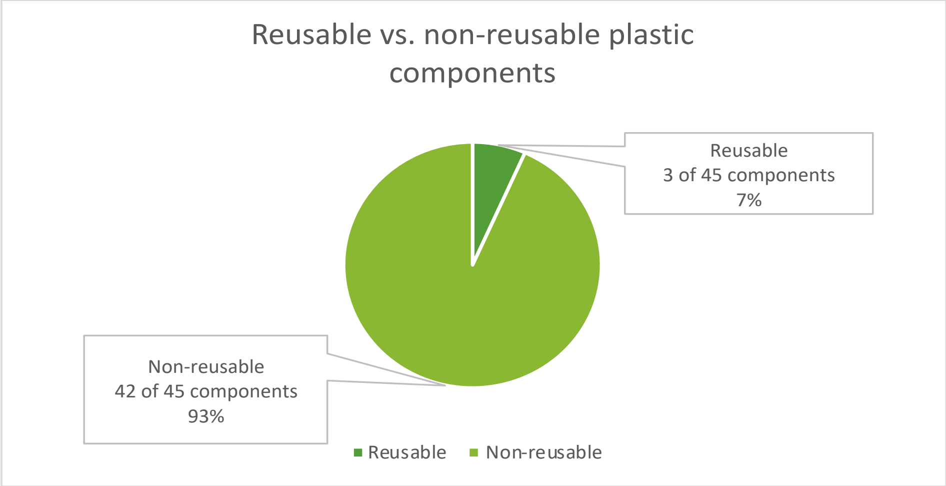


Figure 3 - Total reusable vs. non-reusable plastic components. (UoA)

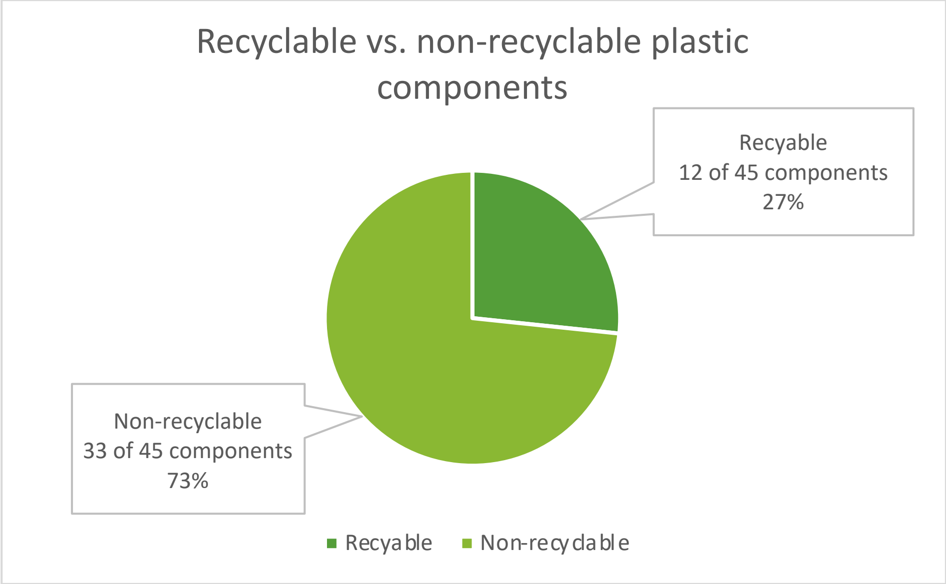


Figure 4 - Total recyclable vs. non-recyclable plastic components. (UoA)

7.2 Alternative fixation methods and material choice examples

The following subsections include analysis and advice for commonly used plastic components found in five systems within a residential building: slab systems, flashings and jointers, interior door frame fixing, fixing plywood floor cover on joists, and EIFS (Exterior Insulation Finishing System). The 'typical case' and 'best practice' scenarios are described in terms of application/material content, location/fixation, and reuse/recycling. The corresponding advice for alternative fixation methods and materials is composed of recommendations that are both historic, but now out of fashion, like mechanical fastening, blocking, and nailing, and innovative products found on the market such as Cleva Pod and Stosystain. Recommendations for the inclusion of each plastic component in LCAQuick are detailed at the end of each subsection.

The criteria for best practice scenarios were used for the alternative solutions, which is that materials and components will be installed correctly, and thus free of contamination and properly separated at end of life and are able to be reused or recycled.

7.2.1 Slab Systems

7.2.1.1 Typical case: Foundation systems

Application/ Material content

The RibRaft foundation system is often used in combination with EPS blocks such as the Expol Tuff Pod system, to form a concrete reinforced slab foundation for a common residential build. Components include rebar mesh chairs, EPS internal spacers, EPS edge spacers, EPS centre spacers, EPS pods, steel rebar as well as the poured concrete itself.

Location / Fixation

Blocks of EPS are laid out in specified the grid pattern. Centre, internal, and edge spacers are laid out to hold the EPS blocks in place, as well as providing support for the placing of steel rebar between and on the edges of the slab. Mesh chairs are arranged on top of the EPS blocks to support the top layer of rebar before concrete is poured, creating the foundation slab.

Reuse/ Recycling

In a typical case scenario, when the foundation slab of the building is demolished each aspect of this foundation system is contaminated and is unable to be reused. This includes rebar mesh chairs, internal rebar spacers, EPS edge spacers, EPS centre spacers, EPS blocks as well as the concrete itself. For each of these components recycling of the materials is possible but highly unlikely to occur due to the contamination and the labour-intensive process of removing concrete from plastic and EPS. Thus, in a typical case each of the components will be diverted to landfill.

Figure 5 - Rebar chairs in the RibRaft System. (Firth Industries, 2019).

Figure 6 - RibRaft installation closeup. (Firth Industries, 2023).

Figure 7 - Solid Bearing Concrete RibRaft Foundation. (Construction Specialists Ltd, 2023).

version 1 9/5/16	Module C1					
Main materials/products (alphabet-ical)	**Typical (current)**					
	Fate of building waste (% material by mass)				**Recycling route/ technology**	**Source**
	Reuse	**Recycling**	**Recovery (En-ergy)**	**Landfill/ Clean-fill**		
Rebar mesh chairs	0	0	0	100	Difficult to recover as binds to concrete	*
EPS pod internal spacers	0	0	0	100	Difficult to recover as binds to concrete	*
EPS pod edge spacers	0	0	0	100	Difficult to recover as binds to concrete	*
EPS pod centre spacers	0	0	0	100	Difficult to recover as binds to concrete	*
EPS pods	0	0	0	100	-	*
Stainless steel rebar	0	20	0	80	Recycled back into steel	**
Concrete (in situ)	0	20	0	80	20% reclaimed and crushed for aggregate in Auckland.	**

Table 2 - Proposed addition to LCA Quick: Typical - foundation systems. Adapted from (BRANZ, 2022).
*Sources: * UoA Data ** LCA Quick default data (BRANZ, 2022)*

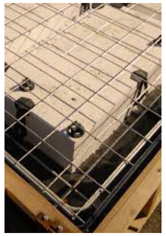


Figure 8 - The RibRaft System (Firth Industries, 2020).

Figure 9 - RibRaft installation. (Firth Industries, 2012).

Figure 10 - Polystyrene contaminated by concrete. (ClevaCo, 2023).

7.2.1.2 Best practice: Foundation systems

Application/ Material content

The Cleva Pod system can be used to replace the plastic componentry and EPS blocks required for a reinforced concrete slab foundation. It is manufactured from recycled and waste polypropylene plastic.

Location/ Fixation

The Cleva Pods are placed in the same grid pattern as EPS blocks would be for a reinforced slab foundation. They can be cut on site to fit irregular floor plans, and can have their own spacer system. Once the grid is locked in, rebar can be installed in a similar way to a traditional foundation system, and concrete poured on top.

Reuse / recycling

The Cleva Pod system eliminates the use of single use plastics, and is recyclable at the end of the foundations life (CLEVACO, 2022). The crucial difference of the ClevaPod system is that it does not use EPS as insulation material. With its plastic pods, it creates air cavities that serve for insulation properties. The problem with the conventional EPS system is that EPS cannot be separated clearly when it is connected with concrete, and ClevaPod solves this issue.

The task and opportunities for the separation of the steel rebar from the concrete slab remain the same. For the stainless steel rebar and concrete, we assumed the same data found in the LCAQuick C1 Datasheets, which is 100% recycling and 0% cleanfill in the best practise scenario.

Figure 11 - Cleva Pod 220 waffle foundation pod. (Clevaco, 2023).

Figure 12 - Reinforcing bars on the CLEVA POD® spacers™. (Clevaco, 2022).

Figure 13 - Clevaco full foundation Warkworth Auckland. (Clevaco, 2022).

Figure 14 - CLEVA POD® recycling. (Clevaco, 2023).

Figure 15 - Cleva Pod spacer. (Clevaco, 2023)

version 1 9/5/16	Module C1					
Main materials/products (alphabetical)	**Best practice (case studies/future)**					
	Fate of building waste (% material by mass)				**Recycling route/technology**	**Source**
	Reuse	**Recycling**	**Recovery (energy)**	**Landfill/ Cleanfill**		
Plastic foundation pods (Cleva Pod)	0	60	0	40	Assume correct separation and recycling	1
Pod spacer	0	60	0	40	Assume correct separation and recycling	1
Stainless steel rebar	0	100	0	0	Recycled back into steel	*
Concrete (in situ)	0	100	0	0	Assume reclaimed and crushed for aggregate	*

Table 3 - Proposed addition to LCA Quick: Best Practice - Cleva Pod foundation system. Adapted from (BRANZ, 2022).

*Sources: 1) Cleva Pod TDS, * LCA Quick default data (BRANZ, 2022)*

7.2.2 Flashings & jointers

7.2.2.1 Typical case: PVC Vent Strip, Jointers and Flashings

Application/ Material content

Vent strips, jointers and flashings are perforated, moulded lengths of polyvinylchloride (PVC). Vent strips are used to close the bottom edge of cavities, protecting the cavity from vermin and allow ventilation while protecting the bottom of the cladding. Jointers fill gaps between sheets, for example between fibreglass sheets. Flashings assist with weather-tightness of the building envelope and can be used for straight joins and Z flashings as well.

Location/ Fixation

Vent strips are fixed to framing using nails or staples wherever there is an opening in the bottom of wall cladding, to allow the cavity to drain. Jointers are nailed to joists, and flashings are nailed or taped at internal and external corners.

Reuse/ Recycling

For each of the PVC vent strips, jointers and flashings, reuse is possible if the material is undamaged, and the material can be recycled. However, all of these components are typically disposed of in landfill unless specific recycling bins are provided on site.

Figure 16 - James Hardie 302490 PVC Vent Strip 75mm x 18mm x 3000mm. (GFC Fasteners, 2023).

Figure 17 - Slimline Soffit. (Soudal, n.d.).

Figure 18 - DynaFlash 75 x 75mm Universal Back Flashing. (Dynex Build, n.d.)

version 1 9/5/16	Module C1					
Main materials/products (alphabet-ical)	Typical (current)					
	Fate of building waste (% material by mass)				Recycling route/ technology	Source
	Reuse	Recycling	Recovery (En-ergy)	Landfill/ Clean-fill		
PVC vent strips	0	0	0	100	-	*
PVC jointers	0	0	0	100	-	*
Corner flashing	0	0	0	100	-	*

Table 4 - Proposed addition to LCA Quick: Typical PVC Vent Strip, Jointers, and Flashings. Adapted from (BRANZ, 2022).

*Sources: * LCA Quick default data*

7.2.2.2 Best practice: Metal Vent Strip

Application/ Material content

Metal, usually aluminium, vent strips, jointers and flashings are available in the New Zealand market. They serve the same purpose as their respective products made of PVC, though with greater durability.

Location/ Fixation

Aluminium vent strips and jointers are used in the same way their PVC counterparts are. Aluminium flashing in the form of Z flashing and straight flashing is also used in the same way are also available in aluminium.

Reuse/ Recycling

Aluminium has a higher durability than PVC and therefore can be reused more easily at the end of life. Recycling facilities for aluminium are readily available in New Zealand.

Figure 19 - James Hardie 305431 Stria Aluminium Cavity Closure 3000mm. (GFC Fasteners, 2023).

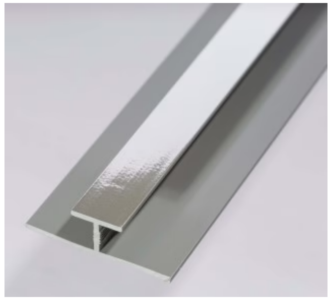


Figure 20 - 10MM ALUMINIUM CLADDING H JOINER. (Plastics Hub, 2023).

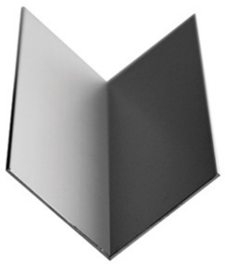


Figure 21 - Internal 90 Angle Aluminium Flashing 3.0m. (Shawdowclad, n.d.)

version 1 9/5/16	Module C1					
Main materials/products (alphabet-ical)	Best practice (case studies/future)					
	Fate of building waste (% material by mass)				Recycling route/technology	Source
	Reuse	Recycling	Recovery (en-ergy)	Landfill/ Clean-fill		
Aluminium vent strips	50	50	0	0	Assume correct separation, reuse/recycling available	**
Aluminium jointers	50	50	0	0	Assume correct separation, reuse/recycling available	**
Aluminium corner flashing	50	50	0	0	Assume correct separation, reuse/recycling available	**

Table 5 - Proposed addition to LCA Quick: Best Practice - PVC Vent Strip, Jointers, and Flashings. Adapted from (BRANZ, 2022).

*Sources: ** UoA data*

7.2.3 Interior door frame fixing

7.2.3.1 Typical case: Expanding foam

Application/ Material content

Expanding foam is Polyurethane (PU) based self-expanding foam used for a variety of purposes, usually to close and fill gaps in building construction and assist with weathertightness to prevent thermal transfer, air movement and acoustic transfer, as well as being used for adhesion and bonding materials.

Location/ Fixation

Expanding foam is used around the edges of window and door fenestrations, filling gaps around holes for piping, fixing window and door frames, filling and sealing around pipe and ductwork penetrations, as well as bonding insulation components such as XPS and EPS sheets, wood fibre boards and fibre cement boards. It is sprayed with a gun accessory or tube supplied with the product. The product itself is adhesive so no further fixation is required.

Reuse/ Recycling

Neither reuse nor recycling is possible. The material is single use and is also damaging to other products, it is possible to remove expanding foam with a solvent though unlikely to occur to reuse or recycle other materials or products as the process is labour intensive.

Figure 22 - Mounting of door frames. (Sika Group, n.d.).

version 1 9/5/16	Module C1					
Main materials/products (alphabetical)	Typical (current)					
	Fate of building waste (% material by mass)				Recycling route/ technology	Source
	Reuse	Recycling	Recovery (Energy)	Landfill/ Cleanfill		
Expanding foam	0	0	0	100	-	**

Table 6 - Proposed addition to LCA Quick: Typical Expanding foam. Adapted from (BRANZ, 2022)

*Sources: ** UoA data*

7.2.3.2 Best practice: Blocking, nailing, screwing and loose fill insulation

Application/ Material content

Many scenarios in which expanding foam is used can be replaced by loose fill insulation. For example, this could be around the edges of window frames, door frames or external pipe penetrations, for which insulation could either be cut to size or have loose fill pushed into the gap.

Blocking and nailing around the edges of internal doors is another viable alternative for avoiding the use of expanding foams in construction. Small pieces of wood can be used to secure the door frames without using expanding foam.

Location/ Fixation

As above, many of the places in which expanding foam is used could have loose fill wool insulation pushed into gaps as required. Alternatively, blocking and nailing can be put around the edges of internal door frames.

Reuse/ recycling

Provided that the loose fill wool insulation is installed correctly, maintained and as well as the house being deconstructed correctly with no contamination of the material, reuse and recycling is possible.

Using either nails or screws makes a crucial difference in terms of recycling and reuse. As nails are not reversible connectors, removing them becomes challenging without causing damage. In examples of demolitions, nail connections in timber-frame construction have been chain sawed, cutting both the timber and nails, making it very difficult to separate the nails from the timber for recycling. On the contrary, screws can be unscrewed without sustaining damage.

NZS 3604, which regulates timber-framed buildings, specifically mandates the use of nails and glue in construction (Standards New Zealand, 2011). This contradicts the characteristics of reversible joints, such as screws. Information received from demolition contractors suggests that newer buildings are more challenging to deconstruct than older ones due to the extensive use of multiple nailed joints, hidden fixings, and composite construction materials (Storey et al., 2003). Removing nails without damaging the timber proves to be time and manpower-consuming.

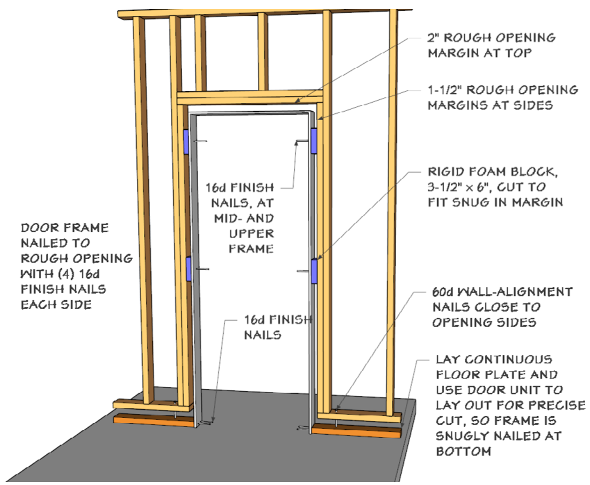
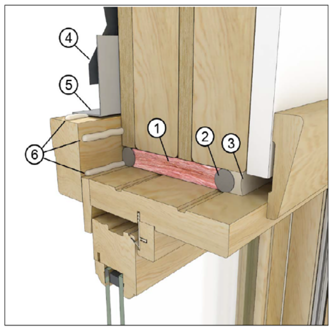


Figure 23 - Door frame set in floating wall. (Twinsprings Research Institute, 2016).



1	Loose fill fiberglass insulation
2	Backer rod
3	Continuous air seal (sealant)
4	Flashing
5	Rigid head flash
6	Sealant

Figure 24 - Loose Fill Fibreglass Insulation. (Marvin Doors, 2019).

version 1 9/5/16	Module C1					
Main materials/products (alpha-betical)	Best practice (case studies/future)					
	Fate of building waste (% material by mass)				Recycling route/technology	Source
	Reuse	Recycling	Recovery (en-ergy)	Landfill/ Cleanfill		
Loose fill insulation	100	0	0	0	Assume uncontaminated	1
Timber blocking	10	50	15	25	Assume some re-use as timber framing (treated or untreated). Untreated recycled into smaller pieces by cutting or to form mulch. Some chipped for fuel.	2
Screws	80	20	0	0	-	3
Nails	0	20	0	80	-	*

Table 7 - Proposed addition to LCA Quick: Best Practice - Blocking, nailing and loose fill insulation. Adapted from (BRANZ, 2022).

Sources: 1: BRANZ 'What products can be salvaged?' https://www.branz.co.nz/sustainable-building/reducing-building-waste/assessing-waste/salvaged/

2: Adapted from BRANZ LCA Quick data; Timber (solid)

3: Storey et al., 2003

** UoA data*

7.2.4 Fixing plywood floor cover on joists

7.2.4.1 Typical case: Adhesives

Application/ Material content

Adhesives are very common in building construction in New Zealand. Silicone is a common base for a sealant/adhesive, as well as moisture-cured or hybrid silyl modified polymer, polyurethane, or synthetic rubber, varied per the performance requirements for each product.

Location/ Fixation

There are many applications, such as bonding common construction materials (metals, timber, concrete), installing fibre cement or other types of panel bonding, and attaching skirting boards, architraves, and trims to walls.

Reuse/ recycling

As the material is a fixative, neither reuse nor recycling is possible. Furthermore, the product, once dried is very difficult to remove and can often be the cause of other materials' contamination and therefore inability for other materials to be recycled.

Figure 25 - Adhesive applied to floor joists. (ConstructionMentor.net, n.d.)

version 1 9/5/16	Module C1					
Main materials/products (alphabetical)	Typical (current)					
	Fate of building waste (% material by mass)				Recycling route/ technology	Source
	Reuse	Recycling	Recovery (Energy)	Landfill/ Cleanfill		
Adhesives	0	0	0	100	-	*

Table 8 - Proposed addition to LCA Quick: Typical Fixing plywood floor cover on joists. Adapted from (BRANZ, 2022).

*Sources: * UoA data*

7.2.4.2 Best practice: Mechanical fastening

Application/ Material content

Instead of using adhesive, several mechanical fastening solutions are possible.

Location/ Fixation

Mechanical fixing with screws, self-drilling screws and nails can be used to secure materials without the need for silicone/adhesives. Metal panelling clid, connectors or angle brackets designed to hold panelling, architraves, skirting or trims in place can be used instead of silicone. There offer additional support and can be used in combination with mechanical fixing.

Reuse/ recycling

Like expanding foams, adhesives are often the cause for another materials' inability to be reused or recycled, and as they are also a fixative, they are inherently unable to be recycled or reused themselves. The use of mechanical fixings may allow for reuse dependant on the product (such as brackets, but unlikely for screws or nails), and recycling is possible, dependant on the quality and care taken during a building's deconstruction.

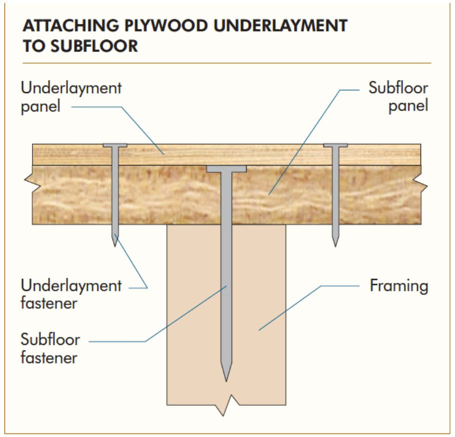


Figure 26 - Attaching Plywood Underlayment to Subfloor. (The Engineered Wood Association, 2013).

version 1 9/5/16	Module C1					
Main materials/products (alphabet-ical)	**Best practice (case studies/future)**					
	Fate of building waste (% material by mass)				**Recycling route/technology**	**Source**
	Reuse	**Recycling**	**Recovery (en-ergy)**	**Landfill/ Clean-fill**		
Nails	0	0	0	100	-	*
Screws	80	20	0	0	-	1

Table 9 - Proposed addition to LCA Quick: Best Practice - Mechanical fastening. Adapted from (BRANZ, 2022).

*Sources: * UoA data, 1: Storey et al., 2003*

7.2.5 EIFS (Exterior Insulation Finishing System)

7.2.5.1 Typical case: Adhesives

Application/ Material content

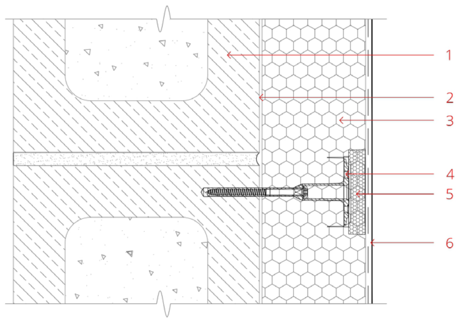
In New Zealand, there are several façade systems where EPS is used as a composite façade. One is termed Exterior Insulation Finishing System (EIFS), where EPS is glued onto the loadbearing façade structure. There are other similar systems which also can be installed on timber-framed systems. Stucco is a cement-based plaster applied over a variety of backings including fibre-cement and plywood sheeting, which is then painted. This is the oldest of monolithic cladding and has been used in New Zealand since the 1920s. EIFS is glued on the loadbearing façade structure and covered with glued mortar, render, plaster, and paint finish. EIFS has been popular in New Zealand since the 1980s (ConsumerBuild, 2022) (Oswald, 2024).

Location/ Fixation

The StoTherm Masonry Insulation System is an example of EIFS on a solid loadbearing structure such as masonry or concrete (Figure 3). The different components are glued together, and several different material layers are part of EIFS, as shown in the Sto product system in Figure. An additional fixation is an anchor system. The figure illustrates the typical system detail of a StoTherm Counter Sunk Anchor. This example anchor system can be applied for different insulation thicknesses (60mm, 80mm, or 100mm insulation panels) (StoTherm , 2022).

Reuse/ recycling

Where options for energetic reutilization are absent, EPS waste is typically disposed of in the landfill. Annually, 8500 tonnes of expanded polystyrene is manufactured in New Zealand. EPS building products including thermal insulation and packaging currently accounts for three quarters of this volume. Despite the lightweight properties of EPS products, the waste occupies a large amount of space in landfills (Plastics New Zealand, 2022).69F Possessing durable properties like other plastic products, it takes at least 500 years for EPS to decompose in landfills. With concerns of high quantities of construction waste entering landfills, some councils in New Zealand have encouraged seeking alternative recycling solutions by introducing a high minimum charge or a volumetric price for waste disposal (Plastics New Zealand, 2022). In general, EIFS has limited reusable and recyclable opportunities because the different layers are glued together and hence, the single, independent materials cannot be separated.



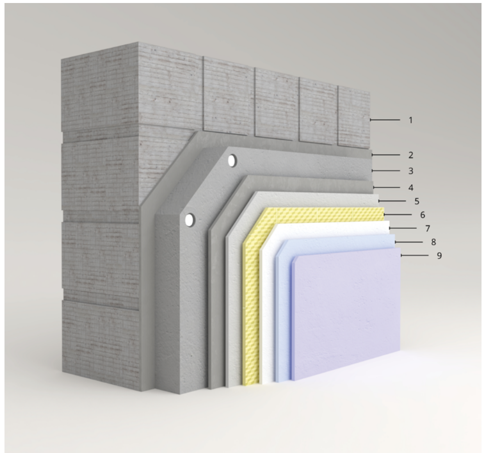
1. Concrete / Masonry Block
2. Sto Adhesive Mortar
3. StoTherm Panel
4. StoTherm Counter Sunk Anchor
5. StoTherm Insulation Cap
6. StoArmat Miral Render System

Figure 27 - StoTherm Countersunk Anchors, Sto product system illustration reworked by Ferdinand Oswald (Oswald, 2024) (StoTherm , 2022).

version 1 9/5/16	Module C1					
Main materials/products (alphabetical)	**Typical (current)**					
	Fate of building waste (% material by mass)				**Recycling route/ technology**	**Source**
	Reuse	**Recycling**	**Recovery (Energy)**	**Landfill/ Cleanfill**		
EPS insulation panel	0	0	0	100	-	*
Panel anchor (countersunk)	0	0	0	100	-	*
Adhesive: glue, mortar	0	0	0	100	-	*
Reinforcing mesh	0	0	0	100	-	*
Reinforcing render	0	0	0	100	-	*

Table 10 - Proposed addition to LCA Quick: Typical EIFS (Exterior Insulation Finishing System). Adapted from (BRANZ, 2022).

*Sources: * UoA data*



1. Substrate: Solid Masonry
   Such as concrete blocks, precast, brick & insitu concrete
2. Adhesive: Gluecoat Mortar
3. Insulation (EPS): StoTherm or StoTherm+ Panel
   50/100mm self-extinguishing panel, manufactured to AS 1366 Pt 3 by an approved manufacturer.
4. Fixing: StoTherm Masonry Anchors
   Drill, install, countersunk, and capped with an ST Insulation Cap to avoid thermal bridging.
5. Basecoat: StoLevell Novo / LevelLite Render
   Lightweight, EPS bead mineral render with good build properties, water retention agents, and machine application properties.
6. Reinforcement Render: StoArmat Render
   An organic, weather resistant, cement-free and breathable, high-impact render, with a crack resistance six times higher than that of standard cement-based plasters.
7. Mesh: Sto Glass Fibre Mesh
   Easy-to-install, meets the highest requirements for crack, stress, and alkalinity resistance.
8. Coloured Finishing Renders: Stolit Renders
   Organically bound, highly weather resistant, strong, hard-wearing, impact-resistant, pre-coloured finishing renders.
9. Facade Paint: StoColor
   StoColor coating based on IQ Net Technology for functional façades.

Figure 28 - StoTherm Masonry Insulation System Sto product system illustration. Image reworked by Ferdinand Oswald (Oswald, 2024) (StoTherm , 2022).

7.2.5.2 Best practice: Fastener Fixation

Application/ Material content

As noted above, a common use of adhesives in building construction is to bond panels together. Adhesives are often used in the creation of external insulation finishing systems (EIFS), for which StoSystain is viable solution. The system uses a reclosable hook fastening system made of polyester and polypropylene to secure EIFS panels to loadbearing walls.

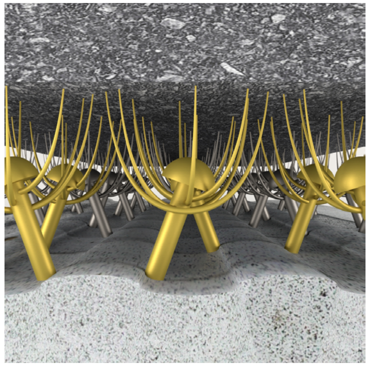


Figure 29 - toSystain R façade grip fixing system with mushroom-shaped heads and loops. (Oswald, 2024)

Location / Fixation

The idea of a recyclable façade insulation system that can easily be dismantled after its lifetime and reused is realisable thanks to an innovative grip fixing system consisting of mushroom-shaped heads and loops-grip fixing instead of adhesive. The newly developed façade system StoSystain is designed for deconstruction. Connections are created without the use of connection materials like adhesives, which damage the main material during deconstruction. All materials can be returned undamaged after deconstruction. In terms of joining technology, the hook and loop fastener connections can be undone; thus, avoiding inseparable composites such as EIFS. A grid array of connectors joins the constituent parts together.

Reuse/ recycling

The dismantling is simple, dust- and noise-reduced and it has nearly unmixed separation as well as reuse and recycling of the system components. The development of the StoSystain R product system has relevance to both architects and designers. The system was released in German-speaking countries and represents an opportunity to use an alternative façade insulation system in future buildings that considers the embodied carbon footprint (recycling & reuse) – of especial relevance for highly insulated buildings such as Passive Houses (Oswald, 2024).

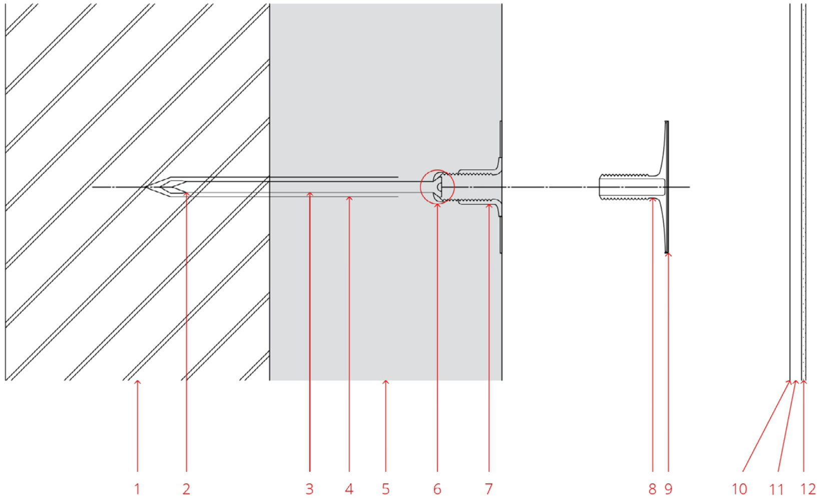


Figure 30 - System structure StoSystain R. (Oswald, 2024)

Legend:

1) Wall
2) Anchor
3) Screw
4) Anchor Shaft
5) Insulation
6) Compensation
7) Internal Thread Stud
8) External Thread
9) Hook (Mushroom shaped gripping elements)
10) Velour Fleece (Loopes) on Carrier Plate
11) Carrier Plate
12) Plaster Surface

version 1 9/5/16	Module C1					
Main materials/products (alphabetical)	**Best practice (case studies/future)**					
	Fate of building waste (% material by mass)				**Recycling route/technology**	**Source**
	Reuse	**Recycling**	**Recovery (energy)**	**Landfill/ Cleanfill**		
Panel anchor (countersunk)	100	0	0	0	StoSystain R system is reusable	1
EPS Insulation panel	100	0	0	0	StoSystain R system is reusable	1
Insulation carrier plate	100	0	0	0	StoSystain R system is reusable	1
Reinforcing mesh	100	0	0	0	StoSystain R system is reusable	1
Reinforcing render	100	0	0	0	StoSystain R system is reusable	1

Table 11 - Proposed addition to LCA Quick: Best Practice - Fastener Fixation. Adapted from (BRANZ, 2022).

Source: 1 (Oswald, 2024)

Figure 31 - StoSystain R Grip fixing system. The mechanical fixation element is round shaped (rotunda) with a hook fastener and has a screw thread for adjusting the irregularities in the load-bearing wall by moving the façade panel forward and backwards. (Oswald, 2024)

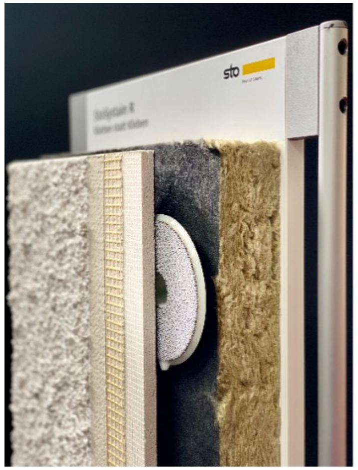


Figure 32 - Photo of demonstration setup StoSystain R. Photo: Ferdinand Oswald. (Oswald, 2024)

8. Conclusion

In conclusion, this report evaluated relevant plastic components and fixation methods found in New Zealand residential buildings. Based on cost estimate documents from the case study site of eight terraced houses at 40 Titirangi Road, a comprehensive list of plastic components used in a typical residential building construction project in Auckland was generated. A selection of other commonly used products were added to represent a wider range of fixation methods and products.

Information gathered from builder's workshops, technical guides, publications, and online sources were used to form evaluations for the potential 'reuse', 'recyclability' and 'landfill' of each plastic component. All 45 plastic components identified in this research would typically go to landfill after life. 42 of the 45 plastic components identified are not reusable (Figure 3). However, three can theoretically be reused: PVC vent strips, PVC jointers and plastic access panels. 12 of the 45 plastic components were deemed recyclable, and 33 are non-recyclable (Figure 4). Like reusability, the plastic components recyclability is dependent on the product material composition, the availability of recycling facilities and the material's state of contamination and condition at the time of demolition or deconstruction. The complete list of plastic components can be referred to for future developments of the LCAQuick tool.

This report highlighted the linear nature of the lifecycle of fixation methods commonly used today. Five building component systems and materials that disregarded the end-of-life of a building were selected and alternative fixation methods and materials were identified. These examples were formatted for integration into LCAQuick Module C1 through a detailed breakdown of each component system or material. Potential alternatives conducive to a circular economy were found in historic approaches such as the range of mechanical fastenings that were widespread before the use of glue and foam adhesives in New Zealand. For example, fixing plywood floor covers to joists using silicone or moisture-cured or hybrid silyl modified polymers, can be replaced with mechanical fixing like screws, self-drilling screws and nails. In conjunction with this, metal panelling clips, connectors or angle brackets designed to hold panelling, architraves, skirting or trims in place can be used instead of silicone. There offer additional support and can be used in combination with mechanical fixing.

The less glue used in building construction, the more likely reuse and recycling is possible. Materials and components that come into contact with glue and foam adhesives become contaminated, which limits their potential for reuse in new buildings, as well as their suitability for material recycling. Minimising the use of glues and foams allows for better separation at the end of life and, consequently, more effective recycling and reuse opportunities for materials and components. Other potential alternatives included in this report looked to innovative new products, also conducive to a circular economy. Cleva Pod is a viable alternative to the use of EPS blocks in foundation systems, which, with the correct separation at end of like is a fully recyclable system. StoStystain was also highlighted as a potential alternative solution to the use of glues in EIFS.

9. Key Points

1) *3 of the 45 plastic building components analysed were deemed reusable and 12 of 45 were deemed recyclable.*

2) *When less glue is used to fix building elements, components are more likely to be in suitable condition for reuse after demolition or deconstruction. Furthermore, materials uncontaminated by glues can be recycled.*

3) *LCAQuick lists plastic as one single component, however 45 separate plastic components were identified by this study.*

10. Strengths and Weaknesses of Study

10.1 Strengths

- The detailed built-in plastic component list was developed from a case study, representing a realistic example of the use of plastic in building construction in New Zealand.
- The list was developed in detail, providing the foundations for a more accurate version of LCAQuick.
- This list was expanded upon to encompass a wider range of materials and fixation methods.
- There is missing data for end of life of plastic components regarding reuse and recyclability BRANZ LCAQuick data is using estimates in absence of data for the typical end of life of plastics. Studies need to be conducted to evaluate the reuse and recyclability potential of each plastic component.
- This report identified five instances of alternative solutions in materials and fixation methods.
- LCAQuick Module C1 is intended for use on commercial projects whereas the case study project used in this research was a residential build. The addition of data on residential builds could potentially expand the user group of the LCAQuick tool.

10.2 Weaknesses

- There is missing data; the potential of reuse and recycling was based upon assumptions. This data could be provided by a future deconstruction case study project.
- LCAQuick Module C1 is intended for use on commercial projects whereas the case study project used in this research was a residential build. Despite this, we integrated data from Module C1 into our proposed additions where no other data was available.
- The criteria for best practice scenarios was used for the alternative solutions, which is that materials and components will be installed correctly, and thus free of contamination and properly separated at end of life and are able to be reused or recycled.

11. Future Work

11.1 Deconstruction study

There is missing data for end of life of plastic components regarding reuse and recyclability BRANZ LCAQuick data is using estimates in absence of data for the typical end of life of plastics. Studies need to be conducted to evaluate the reuse and recyclability potential of each plastic component. This study would be a deconstruction study, assessing the quality and the ability to reuse or recycle each plastic component at end of life. This could also include international case studies of the effective integration of deconstruction methods and recycling / waste separation.

11.2 Historic approach study

This report identified several approaches to material and fixation methods that were employed before the widespread use of plastic components in building construction in New Zealand. A further study could be done with a deeper evaluation of the previous (historic) approaches and comparing advantages and disadvantages of this to current typical practices. This could include an embodied carbon assessment comparison of an old house using mechanical fastenings (nails and screws) and a new house using plastic adhesives (glues and foams) as case studies.

11.3 Economic viability study

The use of glues and foams is assumed to be widespread practice as it is a cost effective and efficient approach (i.e. reduced construction times) to building construction. A study is necessary to evaluate and compare costs between current typical practices and best practices for alternative plastic component material and fixation methods. This could include assessment and comparison of the cost of material transport, recycling, on-site waste separation, cleanfill and landfill costs in New Zealand, as well as overseas.

11.4 Regulatory study

A study to inform building regulations for the ability of materials to be reused is necessary for effective integration of a circular economy in building construction in New Zealand. This is especially important regarding New Zealand's goal of net-zero carbon emissions by 2050.

12. References

BRANZ. (2022). Module C1 Building-End-of-Life Waste Datasheet - Default Datasheet (recieved by David Dowdell in 2022). Auckland: BRANZ.

Brown, A., Laubinger, F., & Börkey, P. (2023). Monitoring trade in plastic waste and scrap. OECD Environment Working Papers, (210): 1-27. https://doi.org/10.1787/39058031-en.

Chalmin, P. (2019). The history of plastics: from the Capitol to the Tarpeian Rock. Field Actions Science Reports: The Journal of Field Actions, Special Issue 19: Reinventing Plastics, 6–11.

ConsumerBuild. (2022, Accessed March 24). Exterior walls : Monolithic cladding 24 March 2022 at . Retrieved from ConsumerBuild: https://web.archive.org/web/20120827224136/http:/www.consumerbuild.org.nz/publish/maintenance/ext-monolithic.php

Geyer, R. (2020). A Brief History of Plastics. In Streit-Bianchi, Cimadevila, & W. Trettnak, Mare Plasticum - The Plastic Sea: Combatting Plastic Pollution Through Science and Art (pp. 31–47 DOI:https://doi.org/10.1007/978-3-030-38945-1). Springer Cham.

Merriam-Webster. (2023, Accessed December 7). Plastic Definition & Meaning. Retrieved from Merriam-Webster: https://www.merriam-webster.com/dictionary/plastic

Oswald, F. (2024). Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System). In E. K. Petrović, M. Gjerde, F. Chicca, & G. Marriage, Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition (pp. Book ISBN: 9780323983365,). Woodhead Publishing.

Plastics New Zealand. (2022, Accessed December 13). EPS Recycling. Retrieved from Plastics New Zealand: https://www.plastics.org.nz/environment/recycling-disposal/EPS-recycling

Sika Group. (2023, Accessed December 13). Construction Foams. Retrieved from Sika: https://www.sika.com/en/construction/construction-foams.html

Storey, J., Gjerde, M., Charleson, A., & Pedersen, M. (2003). The State of Deconstruction in New Zealand 2003 - Synopsis. December, 1–13.

StoTherm . (2022, Accessed March 22). StoTherm Masonry Insulation Energy-efficient insulation for solid masonry construction. Retrieved from Sto New Zealand: https://www.sto.co.nz/03_building/02_concrete_block/sto-therm-masonry-insulation.php

13. Image References

Figure 1 - Construction foam applications. Image by Sika Group, 2023.

Figure 2 – Diagram of plastic product lifecycle. Building Carbon Reduction Research Group, University of Auckland.

Figure 3 - Total reusable vs. non-reusable plastic components Building Carbon Reduction Research Group, University of Auckland.

Figure 4 - Total recyclable vs. non-recyclable plastic components Building Carbon Reduction Research Group, University of Auckland.

Figure 5: Firth Industries. (2019). The RibRaft System [Photograph]. RibRaft Technical Manual. https://encrypted-tbn3.gstatic.com/images?q=tbn:ANd9GcRTacC6vW-_z2oCB2sgMknKMZeHa44U-4NxO4lmPXFsmaErgn84

Figure 6: Firth Industries. (2023). [RibRaft installation closeup] [Photograph]. Firth Industries. https://www.firth.co.nz/concrete/foundations/ribraft/

Figure 7: Solid Bearing Concrete Construction Specialists Ltd. (2023). RibRaft Foundation [Photograph]. Solid Bearing Concrete Construction Specialists Ltd. https://www.solidbearing.co.nz/concrete-foundations/rib-raft/

Figure 8: Firth Industries. (2020). The RibRaft System [Photograph]. RibRaft Technical Manual. https://encrypted-tbn2.gstatic.com/images?q=tbn:ANd9GcQazTuLqW6Y6ToNNaRRA_WsmU5FcPHWmPmlenv_ZsTDq9ooTPu5

Figure 9: Firth Industries. (2012). [RibRaft installation] [Photograph]. Firth Industries. https://encrypted-tbn1.gstatic.com/images?q=tbn:ANd9GcQcixpeSw87AtMKm5FCpvCm2mDVzpb6ZrAQyxk41U-NTiUain-A

Figure 10: Clevaco. (2023). [Polystyrene contaminated by concrete] [Photograph]. Presented by Clevaco at "Leveraging the power of design to build out waste" seminar at UNITEC Auckland, on 10 Oct 2023, organized by Sustainable Business Network, New Zealand.

Figure 11: Clevaco. (2023). [Cleva Pod 220 waffle foundation pod] [Photograph]. Clevaco. https://clevaco.co.nz/wp-content/uploads/2022/04/cleva-pod-top.webp

Figure 12: Clevaco. (2022). reinforcing bars on the CLEVA POD® spacers™ [Photograph]. Clevaco. https://clevaco.co.nz/wp-content/uploads/2022/09/reinforcing-bars-on-the-CLEVA-POD%C2%AE-spacers%E2%84%A2-scaled-1-768x1024.jpeg

Figure 13: Clevaco. (2022). Clevaco full foundation Warkworth Auckland [Photograph]. Clevaco. https://clevaco.co.nz/wp-content/uploads/2022/09/IMG_3186-scaled-1-1024x768.jpeg

Figure 14: Clevaco. (2023). [Cleva Pod recycling] [Photograph]. Presented by Clevaco at “Leveraging the power of design to build out waste” seminar at UNITEC Auckland, on 10 Oct 2023, organized by Sustainable Business Network, New Zealand.

Figure 15: Clevaco. (2023). [Cleva Pod spacer] [Photograph]. Clevaco. https://clevaco.co.nz/wp-content/uploads/2022/04/cleva-pod-spacer-thumb.webp

Figure 16: GFC Fasteners. (2023). James Hardie 302490 PVC Vent Strip 75mm x 18mm x 3000mm [Photograph]. GFC Fasteners. https://www.gfcfasteners.co.nz/assets/full/ZZ208.png?20201124134409

Figure 17: Soudal. (n.d.). Slimline Soffit [Photograph]. Soudal. https://soudal.co.nz/hardware/slimline/slimline-pvc-soffit/

Figure 18: Dynex Build. (n.d.) DynaFlash 75 x 75mm Universal Back Flashing [Photograph]. Dynex Build. https://www.bunnings.co.nz/dynaflash-75-x-75mm-universal-back-flashing_p0318751

Figure 19: GFC Fasteners. (2023). James Hardie 305431 Stria Aluminium Cavity Closure 3000mm [Photograph]. GFC Fasteners. https://www.gfcfasteners.co.nz/assets/full/JH305431.png?20201124131431

Figure 20: Plastics Hub. (2023). 10MM ALUMINIUM CLADDING H JOINER [Photograph]. Plastics Hub. https://www.plasticshub.com/wp-content/uploads/2020/04/h-trim-silver.jpg

Figure 21: Shawdowclad. (n.d.) Internal 90 Angle Aluminium Flashing 3.0m [Photograph]. PlaceMakers. https://pimstorageaueprod.blob.core.windows.net/placemakers/media-assets/1017968_Internal%2090%20Angle%20Alum%20-%208.jpg

Figure 22: Sika Group. (n.d.). Mounting of door frames [Digital illustration]. Sika. https://sika.scene7.com/is/image/sika/glo-sika-boom-02?fit=crop%2C1&wid=480&hei=360&fmt=webp-alpha

Figure 23: Twinsprings Research Institute. (2016). DOOR_FRAME_SET_IN_FLOATING_WALL [Digital illustration]. Twinsprings Research Institute. https://blog.twinsprings.com/2016/03/09/a-door-in-the-wall/door_frame_set_in_floating_wall/

Figure 24: Marvin Doors. (2019). Figure 25 Loose Fill Fibreglass Insulation [Digital illustration]. Marvin Doors, General Installation Instructions. https://www3.marvin.com/WebDoc/Door%20General%20Installation%2019970479.pdf

Figure 25: ConstructionMentor.net. (n.d.) [Adhesive applied to floor joists] [Photograph]. ConstructionMentor, Subfloor Sheathing. https://constructionmentor.net/subfloor-sheathing/

Figure 26: The Engineered Wood Association. (2013). Figure 2: Attaching Plywood Underlayment to Subfloor [Digital illustration]. APA - The Engineered Wood Association, Builder Tips. https://www.apawood.org/buildertips/pdfs/S300.pdf

Figure 27: Ferdinand Oswald. (2024). StoTherm Countersunk Anchors, Sto product system illustration reworked by Ferdinand Oswald [Digital illustration]. Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System).” In Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition, by Emina, K. Petrović, Morten Gjerde, Fabricio Chicca and Guy Marriage

Figure 28: Ferdinand Oswald. (2024). StoTherm Masonry Insulation System Sto product system illustration [Digital illustration]. Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System).” In Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition, by Emina, K. Petrović, Morten Gjerde, Fabricio Chicca and Guy Marriage

Figure 29: Ferdinand Oswald. (2024). StoSystain R façade grip fixing system with mushroom-shaped heads and loops. [Digital illustration]. Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System).” In Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition, by Emina, K. Petrović, Morten Gjerde, Fabricio Chicca and Guy Marriage

Figure 30: Ferdinand Oswald. (2024). System structure StoSystain R. [Digital illustration]. Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System).” In Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition, by Emina, K. Petrović, Morten Gjerde, Fabricio Chicca and Guy Marriage

Figure 31: Ferdinand Oswald. (2024). StoSystain R Grip fixing system. The mechanical fixation element is round shaped (rotunda) with a hook fastener and has a screw thread for adjusting the irregularities in the load-bearing wall by moving the façade panel forward and backwards [Digital illustration]. Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System).” In Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition, by Emina, K. Petrović, Morten Gjerde, Fabricio Chicca and Guy Marriage

Figure 32: Ferdinand Oswald. (2024). Photo of demonstration setup StoSystain R. Photo: Ferdinand Oswald [Photo]. Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System).” In Sustainability and Toxicity of Building Materials - Manufacture, Use and Disposal Stages, 1st Edition, by Emina, K. Petrović, Morten Gjerde, Fabricio Chicca and Guy Marriage

14. Appendix

Build in Plastic Components - Residential Building					**Typical Case**		
Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Slab system							
Ribraft Mesh Chair 25/40mm [Slab Mesh Chair] (1)	"The entire floor slab shall be reinforced with 665 or SE62 mesh supported on 40mm mesh chairs sitting on the polystyrene pods." (1)	On top of EXPOL EPS Pods supporting rebar rods. (1)	Plastic (1)	Poured concrete (1)	No, contaminated	No, not practicable, but possible	Yes
Expol Tuff Pod 300mm Spacer [Edgebeam Rod Spacer] (2)	"Only suitable for 220mm PODS for slab edge beam and thickenings." (3) Supports rebar around the perimeter of EXPOL EPS Pods to form edge beam. (1)	Perimeter of EXPOL EPS Pods (1)	Plastic (1)	Poured concrete (1)	No, contaminated	No, not practicable, but possible	Yes
REQUIN WJ 100 CENTRE SPACER [Centre Spacers]	"Used internally and externally throughout the Pod floor." (3) Supports under floor insulation	Spaced around insulation centre (1)	Plastic (1)	Poured concrete (1)	No, contaminated	No, not practicable, but possible	Yes
Expol Tuff Pod 100mm Spacer [Rib Rod Spacers] (2)	"Only suitable for 220mm PODS for internal ribs." (2). Supports rebar between EPS Pods.	"Except where a 300mm wide rib is required, each pod or part pod shall always be separated by 100mm using a minimum of one Firth approved 100mm spacer along each edge of each pod or part pod." (1)	Plastic (1)	Poured concrete (1)	No, contaminated	No, not practicable, but possible	Yes
Expol Tuff Pod 1100x1100x220mm [Pods]	"EXPOL Tuff Pods are extremely strong expanded polystyrene (EPS) blocks designed to provide a quick method for creating a concrete slab floor" (4)	Under concrete foundation slab, on top of Polythene DPM Slab Membrane (4)	Expanded polystyrene (1)	Spacers (1)	No, once set in concrete it is unable to be reused	Recycling available (Expol)	Yes

Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Soft plastics							
Agpac Polythene Black 250 Micron 4mx25m [Slab DPM] (5)	"black polythene sheet for use as a damp-proof membrane (DPM) under floor slabs." (5)	Used to separate site levelling sand from concrete slab foundation system (EXPOL Tuff Pods and poured concrete) (5)	"250-micron thick, black polythene sheet." (5)	"The DPM is loose laid with taped joints" (5)	No (16)	No, contaminated	Yes (16)
Tekton Universal Bldg Wrap 2740mm X 37M [Building paper] (9)	"Synthetic breather-type flexible wall underlay and air barrier" Protection against rain and outside humidity. (9)	"Under direct and non-direct fixed wall cladding on tinder and steel framed buildings." (9)	"Coated spin-bonded polypropylene." (9)	"Fixed to all framing members at a maximum 300 mm centres with hot-dip galvanised, large-head clouts 20 mm long, zinc plated 6-8 mm staples, self-drilling screws, or proprietary wrap fixings" (9)	No	No	Yes
Plascourse Dpc 90mm X 30m Roll Dpc90 [90mm Wall Plate DPC] (7)	DPC is a "permanent Moisture Barrier" used as flashing, as a moisture barrier or separation layer between different materials. (7)	"Plascourse DPC (Damp Proof Course) is designed to use on brick, block, timber, window frames and door frames." (7)	"Low density polyethylene," "Plascourse is manufactured in New Zealand by DLM, made from 100% locally sourced, recycled plastic." (7)	Stapled (8)	No	Offcuts recycled in facility - no information about post construction	Yes
Kingspan Thermakraft Covertek 407 Roof underlay	Heavy duty self-supporting roof and wall underlay (24)	Fixed to wall or roof framing, or on top of mesh (steel construction) (24)	"Micro-porous water-resistant film laminated between two layers of non-woven spun-bonded polyolefin." (24)	Fixed with staples or clouts (24)	If undamaged	No	Yes

Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Kingspan Thermakraft Thermathene Orange Damp Proof Membrane (DPM)	Concrete underlay DPM (30)	Used to separate site levelling sand from concrete slab foundation system (EXPOL Tuff Pods and poured concrete) (30)	300 micron thick polythene sheet (30)	Loose laid with taped joints (30)	No (16)	No, contaminated	Yes (16)
Jointers / flashings							
PVC Vent Strip 75mm x 18mm x 3m [Vermin Strip to Cavity]	Strips of moulded PVC for cavity closers, vermin protection and allowing airflow. (31)	Vent strips are installed “Wherever there is an opening in the wall cladding to allow the cavity to drain” (22)	PVC (31)	Nailed / stapled (22)	Yes, if undamaged	Yes (16)	Yes
Hardijointer Pvc 5x2400mm [Hardiflex Jointer]	Plastic joiner (32)	Facade: to fill gaps between sheets (e.g. fibre cement, HardieFlex), nailed to joists (32)	PVC (32)	Product slotted into sides, nailed to joist (32)	Possible if undamaged (8)	Yes	Yes
Dynaflash 75 X 75 Mm White 25m Dyna150wht25 [Corner Flashing]	Internal/external flashing, over raboard, under cavity flashing (33)	Internal, external corners, straight joins and Z flashings (33)	“Extruded from 1mm thick white polyethylene with co-extruded black EDPM rubber seals along each edge” (33)	Nailed / stapled (33)	No	No	Yes
Insulation system							
Mammoth R2.2 560mm 2.55m2 Wall Sections [Wall Insulation]	Wall insulation “Thermally bonded polyester fibres” (18)	Packed between wall studs (18)	Polyester fibres (18)	Strapped if necessary (18)	No	No	Yes
Mammoth R3.2 Ceiling Blanket 870mm 15m2 [Ceiling Insulation]	Ceiling insulation “Thermally bonded polyester fibres” (19)	Packed between ceiling beams & joists (19)	Polyester fibres (19)	Strapped if necessary (19)	No	No	Yes
Mammoth R1.9 Polyester Multi 370mm 6.75m2 [Mid Floor Insulation]	Mid floor insulation “Thermally bonded polyester fibres” (20)	Packed between flooring beams & joists (20)	Polyester fibres (20)	Strapped if necessary (20)	No	No	Yes

Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Thermastrap 201 19mmx300m [BP Strap] (11)	Rigid strapping to fix wall underlay or insulation. (11)	Applied on top of insulation or building wrap (11)	"Polypropylene embossed strap" (11)	Fixed at maximum 800mm centres horizontally (strap to strap spacing) and with min 8mm staples at 300mm centres. (11)	No, must be cut to size	Yes	Yes
Expanded Polystyrene (EPS)	EIFS (exterior insulation finishing system) (47)	Façade (47)	Expanded polystyrene (47)	Fixed with glue and plastered (47)	No	No	Yes
Piping							
Low Density Pipe LDPE 50mm P/m [Donkey / Services]	Low density polyethylene piping for services (34)	Throughout building walls and floors to required services (34)	Low density polyethylene (34)	Fixed with plastic strapping (34)	No	Reuse possible if undamaged	No
PE Water Pipe	fresh water supply to and within house (35)	fresh water supply to and within house (35)	PE (Polyethylene) (35)	Metal / plastic clamps or expanding foam	No	Reuse possible if undamaged	No
Novadrain PVC-U DWV Pipe 65mm x 6m	Piping for vent applications, discharge, gravity sewer mains . Pictured with 88° bend (36)	Wet areas, bathroom, kitchen or laundry. Leads to sewage mains (36)	PVC (36)	Plastic or metal clips (36)	No	Reuse possible if undamaged	No
Deta 20mm x 20m Corrugated Conduit Medium Duty	General application electrical conduit for concealing wiring (37)	Buried underground for connection to mains, concealing wiring for services e.g. external power meter or HVAC systems (37)	High-density Polyethylene (HDPE) (37)	Loose laid in trenches, fixed to external walls with plastic 'saddles' (37)	No	Reuse possible if undamaged	No
Zipties	Fixing together pipes (38)	Pipes (38)	Nylon (38)	Ziptie is fixation (mechanical) (38)	No	No	Yes

Tapes, adhesion and sealing systems							
Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Agtape Black 48mmx30M [DPM Tape] (5)	“Agtape – is a black tape used for sealing joints between sheets and small areas damaged during installation of the reinforcing.” (5)	Sealing edges of DPM sheets. (5)	“PVC film joining tape.” (6)	Adhesive (6)	No	No	Yes
Tekton Seam Tape 48mmx50m [BP Joins] (10)	Tape to seal edges and ensure continuity of building wrap. (10)	“Over the seams of the installed Wall Underlay,” “Can also be used to repair small rips, punctures or tears in Tekton. [Bldg Wrap]” (10)	“White polypropylene film coated with a cold weather acrylic adhesive.” (10)	Adhesive (10)	No	No	Yes
Thermakraft Aluband Sealing Tape 75mmx25m [Openings]	“Bituminous adhesive flexible window flashing tape.” (13)	“Thermakraft Aluband Window Flashing Tape in conjunction with the Thermakraft Corner Moulded Piece is a flexible flashing tape system for use around framed joinery openings as a secondary weather resistant barrier.” (14)	“Polymeric faced, bituminous modified, self- adhesive tape with a release backing paper.” (14)	Adhesive surface (14)	No, “Difficult to remove as [bitumen] binds to substrates” (17)	No	Yes
Thermakraft Aluband Flashing Tape 150mmx25m [Openings]	“Bituminous adhesive flexible window flashing tape.” (13)	“Thermakraft Aluband Window Flashing Tape in conjunction with the Thermakraft Corner Moulded Piece is a flexible flashing tape system for use around framed joinery openings as a secondary weather resistant barrier.” (14)	“Polymeric faced, bituminous modified, self- adhesive tape with a release backing paper.” (14)	Adhesive surface (14)	No, “Difficult to remove as [bitumen] binds to substrates” (17)	No	Yes
Thermakraft Corner Mould - 50 Units/ pack [Openings]	Secondary protection at flashing tape corners (13)	Creates second layer of protection at flashing tape corners (12)	Polyethylene (13)	Aluband sealing tapes (13)	No, “Difficult to remove as [bitumen] binds to substrates” (17)	No, contaminated	Yes

Sealants / adhesives							
Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Plumbing Plus Roof & Gutter Silicone	Weatherproof silicone sealant for sealing and adhesion in roofing and plumbing (39)	Weatherproof silicone sealant for sealing and adhesion in roofing. (39)	Silicone (39)	Adhesive material, n/a (39)	No	No	Yes
		Weatherproof silicone sealant for sealing and adhesion in gutters. (39)			No	No	Yes
		Weatherproof silicone sealant for sealing and adhesion in plumbing. (39)			No	No	Yes
Plumbing Plus Kitchen & Bathroom Silicone	Anti-fungal and mould silicone sealant for sealant and adhesion in kitchens and bathrooms (40)	Wet areas to seal around sinks, taps, baths, basins etcetera (40)	Silicone (40)	Adhesive material, n/a (40)	No	No	Yes
Allfast Solutions Roof & Gutter Silicone	Weatherproof silicone sealant for sealing and adhesion in roofing and plumbing (41)	Gutter, roofs, flashing, downpipes, sealing (41)	Silicone (41)	Adhesive material, n/a (41)	No	No	Yes
Sika Sikaflex MS Black	General purpose adhesive / sealant (27)	Sealing joints around windows and doors. (27)	Moisture cured Silyl Modified Polymer (SMP) (27)	Adhesive material, n/a (27)	No	No	Yes
		Sealing joints in and around concrete, brick, masonry, pre-cast panels and stone cladding. (27)			No	No	Yes

Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Soudal Gorilla Grip 1 Hour Cure Construction Adhesive	Construction adhesive - With a 1 hour curing time it is ideal for wooden flooring systems. (23)	"Various porous substrates such as wood, concrete, bricks and other common materials in construction" (23)	Polyurethane based adhesive (23)	Adhesive material, n/a (23)	No	No	Yes
SabreBond SMP60 High Grab Adhesive	High-performance Silyl Modified Polymer (SMP) adhesive/sealant (42)	Bonding metals, timber and concrete. Panel Bonding, Structural elastic bonding, General industrial bonding and sealing, Backfilling/seaming, Exterior Sealing, Control joint sealing, Anti-pick joint sealing. (42)	Hybrid Silyl Modified Polymer (SMP) (42)	Adhesive material, n/a (42)	No	No	Yes
Plastic component	Application	Location	Material content	Fixation	Reuse	Recyclability	Landfill
H.B. Fuller Max Bond Original Construction Adhesive	Construction adhesive (43)	Installing particle board, fibre cement, plasterboard, plywood and strip flooring to joists. Compatible with: Concrete, Fibre cement sheeting, Masonry/Brick, Metal, Steel inc. stainless, Zinc/Galvanised steel, Plasterboard, Timber, Plywood, Particleboard. (43)	Synthetic rubber based adhesive (43)	Adhesive material, n/a (43)	No	No	Yes
		Bonding cement sheet and plaster board to timber or metal studs and joists. (43)			No	No	Yes
		Skirting boards, architraves and trims to walls. (43)			No	No	Yes
		Installing interior timber wall panelling to timber and metal studs and joists. (43)			No	No	Yes

Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
H.B. Fuller Sturdi-bond Heavy Duty Construction Adhesive	Construction adhesive (44)	Same applications as above plus: Replacing loose tiles on walls (not recommended for floor tiles). Compatible with: Concrete, Fibre cement sheeting, Metal, Steel inc. stainless, Zinc/galvanised steel, Plaster-board, Timber, Plywood, Particleboard, Ceramic Tiles. (44)	Synthetic rubber based adhesive (44)	Adhesive material, n/a (44)	No	No	Yes
Miscellaneous							
Sika Pef Rod M12 50m Box [Open-ings] (12)	“Backing rods for jointing requirements” (12)	“Pushed into joint gaps to form uni-form and firm base for controlling the depth of gun applied elastomeric sealants.” (12)	“Closed cell polyethylene” (12)	“Pushed into joint gaps,” sealant applied over top (12)	No, con-taminat-ed	No	Yes
Maxihatch Access Square Hatch 600x600 White [Hatch]	Access hatch (21)	Fixed and positioned as required for ceiling access. (21)	“White Aluminium Powder Coated Frame, Prefinished Melamine Door” (21)	Multiple fixing points for screws on aluminium frame (21)	Possible if undam-aged	No	Yes
Above: Titirangi Road Case study Plastic Components							
Below: Other Plastic Components in Buildings in NZ							
Sheets of polycar-bonate roofing	Roof sheets, screwed (45)	Roof cladding (45)	Thermoplastic polycar-bonate (45)	Screwed (45)	No	Yes, if cleaned	Yes
Vermin stoper	Stopper for ends of waste pipe to restrict rubbish or ver-min entry but allow for liquid discharge (46)	Ends of downpipe (46)	PVC (46)	Attached with PVC solvent based glue (46)	No	No	Yes

Expanding foams							
Gap filling foams							
Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Gorilla Pro Expanding Foam Aerosol	Self-expanding polyurethane foam air seal[s] used around window and door penetrations and other cladding fenestration trim cavities to assist with weathertightness and energy efficiency. (25)	Gaps around the edges of window / door fenestrations, filling gaps around holes for piping (25)	Expanding polyurethane foam (25)	Adheres to common porous building materials; wood, concrete, stone. Does not adhere to polyethylene or polypropylene (25)	No	No	Yes
Foam adhesives							
Sika Boom®-562 Foam Fix Plus	Polyurethane based self-expanding foam for adhesion to insulation and plasterboard (27)	Gluing gypsum boards, XPS & EPS sheets, wood fibre boards, cork insulation boards, non-structural building components (27)	Polyurethane (PU) foam	Sprayed with gun accessory or tube (supplied), product is adhesive	No	No	Yes
Low isocyanate and isocyanate-free foams							
Gorilla MS Expanding Foam (28)	Self-expanding “isocyanate free” expanding foam. (28)	Used for filling cavities, mount and sealing of windows and doorframes and creation of soundproof screens. (28)	Isocyanate-free Polyurethane (PU) foam (28)	Sprayed with gun accessory or tube (supplied), product is adhesive (28)	No	No	Yes
Rigid foams							
Sika Boom -156 2C (29)	2 part polyurethane foam, fast curing (29)	Interior door installation, fixing pipes, penetrations etc. (29)	2 part polyurethane (PU) foam (29)	Sprayed with gun accessory or tube (supplied), product is adhesive (29)	No	No	Yes

Fire resistant foams							
Plastic component	*Application*	*Location*	*Material content*	*Fixation*	*Reuse*	*Recyclability*	*Landfill*
Gorilla Fire Rated Expanding Foam Aerosol (30)	Single component PU foam with fire rating of 360 min-utes. (30)	Fire retardant installation of window and door frames, between partition walls, ceilings and floors, same applica-tions as regular gap filling foams. (30)	Polyurethane (PU) foam (30)	Sprayed with gun acces-sory or tube (supplied), product is adhesive	No	No	Yes

15. Appendix 2: Sources

In-text	Reference
1	Firth Industries, Ribraft Technical Manual, Page 11, 2019
2	EXPOL, Expol Tuff Pods: Building Product Information Sheet (Class 1), 2023
3	EXPOL, Technical Product Guide: Solid Insulation and Lightweight Polystyrene Construction Solutions, Page 16-17, n.d.
4	EXPOL, Concrete Floor Solutions Guide, Page 11, 2022
5	BRANZ, BRANZ Appraised: Appraisal No. 1030 [2018] Rhino Building Polythene, 2018
6	Agpac, Agpac PVC Tape. Accessed 23 August 2023. https://agpac.co.nz/product/agtape-pvc-tape/
7	DLM Wallace, Plasticourse DPC. Accessed 23 August 2023. https://dlmwallace.co.nz/products/plascourse-dpc
8	Building Carbon Research Reduction Group applied knowledge
9	BRANZ, BRANZ Appraised: Appraisal No. 548 [2013] Tekton Building Wrap, 2013
10	Marshall Innovations, Tekton Seam Tape. Accessed 23 August 2023. https://www.mwnz.com/product/tekton-seam-tape
11	Kingspan, Data sheet & Install Guide: Thermakraft Stud Strap & Thermastrap, 2022
12	Sika NZ Limited, Product Data Sheet: Sika PEF Rod, 2019
13	Kingspan, Installation Guide: Thermakraft Aluband Window Flashing Tape, 2022
14	BRANZ, BRANZ Appraised: Appraisal No. 878 [2019] Thermakraft Aluband Window Flashing Tape, 2023
15	BRANZ, BRANZ Appraised: Appraisal No. 913 [2021], Dynaflash Flashings, 2021
16	Benton Report V7
17	BRANZ, Building End of Life Waste Datasheet - Waste from NZ commercial buildings by CBI code, 2023
18	Mammoth, Wall Insulation Sections Product Data Sheet, 2023
19	Mammoth, Ceiling Blanket Insulation Product Data Sheet, 2023
20	Mammoth, Underfloor Insulation Blanket Product Data Sheet, 2023
21	Unihatch, Maxihatch Technical Product Datasheet, n.d.
22	Burn, Greg, Drained Cavity Basics, BRANZ BUILD February/March 2009, p19-20 https://www.buildmagazine.org.nz/assets/PDF/Build110-19.pdf
23	Soudal, Gorilla Grip 1 Hour Cure Technical Data Sheet, 2019
24	Kingspan, Installation Guide: Thermakraft Covertek 407, 2022

25	BRANZ, BRANZ Appraised: Appraisal No. 440 [2022] Gorilla Expanding Foam Air Seals, 2022
26	SIKA Norway, Sika Boom -562 Foam Fix Plus, Sika Norway. Accessed 4 October 2023. https://nor.sika.com/no/losninger-innen-bygg/ferdigstille/fug-og-lim/skum/fuge-og-montasjeskum/sika-boom-562-foamfixplus.html
27	Soudal, Gorilla MS Expanding Foam Technical Datasheet, Soudal, 2022
28	Sika, Sealing & Bonding: Sika Boom Construction Foams, Sika, n.d. Accessed 4 October 2023 https://www.sika.com/content/dam/dms/corporate/q/glo-sika-boom-construction-foams.pdf
29	Soudal, Gorilla Fire Rated Expanding Foam Aerosol Technical Datasheet, Soudal, 2022, https://soudal.co.nz/wp-content/uploads/20169-Gorilla-FR-Expanding-Foam-2022June10.pdf
30	Kingspan, Thermakraft Thermathene Orange Damp Proof Membrane (DPM) Product Data Sheet, 2022
31	James Hardie, Hardie™ 18mm PVC Cavity Vent Strip 3000mm. Accessed 15 December 2023. https://www.jameshardie.com.au/accessory/james-hardie-18mm-pvc-cavity-vent-strip
32	James Hardie, Hardie™ 4.5mm PVC Straight Jointer 2400mm. Accessed 15 December 2023. https://www.jameshardie.com.au/accessory/james-hardie-pvc-straight-jointer
33	Dynex, Dynaflash Technical Summanry, 2021
34	Hynds, R2.1 Low Density Polyethylene Pipe & Fittings Technical Guide, n.d.
35	Marley, Marley Polyethylene Systems, n.d.
36	Iplex, Novadrain PVC-U DWV Pipe 65mm x 6m SOE 100.65.6 SOE. Accessed 15 December 2023. https://www.placemakers.co.nz/online/bathrooms-plumbing/plumbing/pvc-pipe-fittings/dwv-fittings/novadrain-pvc-u-dwv-pipe-65mm-x-6m-soe-100656-soe/p/3654704
37	Deta, DETA 20mm Corrugated Conduit Medium Duty – 20M Grey. Accessed 15 December 2023. https://detaelectrical.com.au/product/deta-corrugated-conduit-medium-duty-2/#:~:text=Medium%20Duty%2020mm%20Diameter%20Corrugated,job%20time%20and%20fittings%20required.
38	Construction Products NZ. Cable Ties, 4.8x300mm, 100pcs, Black. Accessed 15 December 2023. https://constructionproducts.co.nz/collections/cable-ties-zip-ties/products/cable-ties-4-8x300-black
39	PlumbingPlus, Roof & Gutter Silicone 300g - 241008. Accessed 15 December 2023. http://www.plumbingplustrade.co.nz/index.php?route=product/product&product_id=4662
40	PlumbingPlus, Kitchen & Bathroom Silicone 300g - 241563. Accessed 15 December 2023. http://www.plumbingplustrade.co.nz/index.php?route=product/product&product_id=4655
41	Allfast, Plumbers & Roofers Silicone. Accessed 15 December 2023. https://www.allfast.co.nz/products/plumbers-roofers-silicone
42	Sabre Adhesives, SabreBond SMP60 High Grab Adhesive. Accessed 15 December 2023. https://www.sabreadhesives.com/product/sabrebond-smp60/

43	H.B. Fuller, Technical data sheet: maxbond ORIGINAL CONSTRUCTION ADHESIVE, 2021
44	H.B. Fuller, Technical data sheet: Sturdibond Heavy Duty Construction Adhesive, 2015
45	Supreme Plastic Roofing Ltd., Calypso Polycarbonate Roofing Technical Information, n.d.
46	Iplex, Iplex Novadrain PVC-U Vermin Stopper Solvent Cement F. Accessed 15 December 2023. https://www.iplex.co.nz/products/novadrain-pvc-u-vermin-stopper-solvent-cement-f/
47	Oswald, Ferdinand, "Recycling and reutilization opportunities and techniques of the insulation material EPS (Expanded Polystyrene) after the lifetime of EIFS (Exterior Insulation Finishing System), 2024