Handout

WRITTEN BY M. SHAMEEM A. KARIM

Residential Architecture stripped back

A framework to reduce embodied carbon in Queensland suburban house design.

INTRODUCTION

This handout presents a framework aimed at reducing embodied carbon in mass produced suburban home design in Queensland via the identification of 8 strategies, optimising building systems, material selection and material palette used in such semi-detached houses to ensure a more sustainable future. Research methodology involved the selection of a relevant case study developed by a prominent real-estate organisation in Queensland, followed by the assessment of a Life Cycle Carbon Emission, to thus determine carbon emissions of building components and materials used within the project. Analysis was undertaken in four stages, namely Mass Analysis, whereby mass of materials identified in a building section was calculated and tabulated, calculation of embodied carbon of said materials, identification of carbon hotspots, and finally identification of methods and practices aimed to address critical building materials to thus reduce embodied carbon. The 8 strategies identified propose to address high carbon materials by either replacing them with more sustainable alternatives, or optimising building systems to avoid or reduce usage of such materials. To assess efficiency of research, the total embodied carbon of project is calculated at both initial stage and end stage of research to investigate impact of the strategies used.

BACKGROUND

With the increasing Queensland population, the Department of Housing projects that 380,000 additional homes will be needed by 2027 as the state's population grows to 5.7 million people (Queensland Government, 2017). It is hence projected that the prevalence of mass produced suburban dwellings, which accounts for preferred housing option by Australians at 72.9% in 2016 (ABS, 2016), will undergo significant increase in the near future. Such residential architecture, however, often falls prey to cosmetic and marketable approaches, supporting low quality, disposable designs where little consideration is given to material selection and usage. QDesign identifies material usage as an essential ingredient to sustainable contemporary architectural solutions (Queensland Government, 2018), and this research aims to support that principle, promoting a change in approach in mass-produced suburban dwellings, to thus show more care and thinking to material usage in detached houses. Replicating similar strategies across such large scale projects may hence engender a significant impact on carbon emissions within Queensland's construction industry, aiming for a cleaner, greener future where Material Matters.

CASE STUDY

Characteristics of Case Study building

Building parameter	Specification
Building area:	
Ground floor	182 m²
First floor	175 m²
Outdoor room	14 m²
Total	**371 m²**
Number of floors	Ground + First floor
Building Height	6.5 m
Structure	Reinforced concrete
Walls	Masonry clay brickwork
Roof	Colorbond roof sheeting
Doors and window	Powder coated Aluminium

Building Materials

Building Component	Material
Concrete Slab & Floor	Ready-mixed concrete
	Reinforcement steel
F.C Sheet soffits and infill	Fibre Cement
External brick wall	Masonry clay bricks
	Cement Mortar
Internal walls	Plasterboard sheet
	Paint
Flooring	Ceramic tiles
	Carpet tiles
Windows & Doors	Powder coated Aluminium
	Glass
	Softwood (decorative sill)
Kitchen	Chipboard (Lamimex cabinet)
	Formica (countertop)
Ceiling	MDF ceiling planks
Cornices and plinths	Polyurethane
Roof	Colorbond Steel sheeting
	Hardwood roof trusses

Initial Embodied Carbon Analysis

Material	Embodied carbon coefficients ($kgCO_2/kg$)	Embodied carbon (kg)	% embodied carbon
Ready-mixed concrete	0.123	21,077.3	30.9
Reinforcement steel	1.90	13,406.4	19.7
Fibre Cement soffits	1.09	203.8	0.3
Masonry clay bricks	0.23	13,156.9	19.3
Cement mortar (1:5)	0.146	1,756.5	2.6
Paint	2.42	785.3	1.1
Ceramic tiles	0.74	1790.8	2.6
Carpet tiles	3.9	2,092.7	3.1
Plasterboard (ceiling + walls)	0.38	1,201.2	1.8
Aluminium (openings)	8.16	3,538.2	5.2
Glass (openings)	0.86	916.8	1.3
Chipboard (lamimex)	0.84	197.7	0.3
Formica (countertop)	0.84	87.2	0.1
MDF (ceiling planks)	0.72	582.6	0.9
Polyurethane (cornices + plinths)	3.76	42.5	0.1
Steel sheeting	1.45	2,929	4.3
Hardwood (structural)	0.86	4,394.6	6.4
Softwood (decorative)	0.58	19.1	0.02
Total		**68,178.6**	

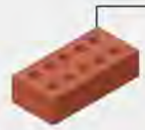
Mass Materials High Carbon Materials

8 STRATEGIES FOR EMBODIED CARBON REDUCTION

1. Use Alternative Wall Materials

Building Component:
Masonry Brick Wall

21.9% of total building embodied carbon



18,453 Clay bricks (mass material)
embodied carbon - 0.23 kgCO2/kg

Cement mortar (mass material)
embodied carbon - 0.146 kgCO2/kg

Alternative
Material:

12,548 Fly Ash bricks
embodied carbon - 0.042 kgCO2/kg

Benefits:
35% reduction in wall dead load
88% reduction in embodied carbon

Material	Volume (m³)	Density a(kg/m³)	Mass (kg)	Embodied Carbon (kg)
Masonry clay bricks (76 x 230 x 110mm)	29.8	1,922	57,204.3	13,156.9
FAB (230 x 110 x 70mm)	22.2	1,700	37,740	1,585.1

Brick wall area in case study: 313.7m²

2. Use Exposed Wall systems

Building Component:
Internal Wall
Plasterboard
covering

1.8% of total building embodied carbon

Alternative
Expose brickwork
in interior living spaces celebrating brute quality of masonry works

Benefits:
58% less plasterboard used
81% reduction in embodied carbon of wall system

Wall type	ECO_2 of main units (kg)	ECO_2 of mortar (kg)	ECO_2 of plasterboard (kg)	ECO_2 of wall (kg)
Clay Brick	13,156.9	1756.5	503.4	15,416.8
FAB	1,585.1	850.4	503.4	2,938.9

Plasterboard volume for walls: 2.07m³

3. Avoid Pastiche detailings

Building Component:
Victorian Cornices

Critical Material:
Polyurethane

Polyurethane emits **14kg** of CO2 per square metre produced

Alternatives:
Adopt **simpler design** to use **less material**
Use **plaster** cornices

Benefits:
48% reduction in cornice material volume
57% reduction in cornice embodied carbon

Material	Volume (m³)	Density a(kg/m³)	Mass (kg)	Embodied carbon coefficients ($kgCO_2/kg$)	Embodied Carbon (kg)
Polyurethane	0.334	34	11.3	3.76	42.4
Plaster	0.176	849	149.42	0.12	17.9

4. Utilisation of Pre-fabricated Materials

Building Component:
Floor slabs

In-situ
770 kg CO2 eq

Precast
692 kg CO2 eq

Critical Material:
Ready-mix concrete
uses timber formwork
(reused 2-10 times)

Alternative:
Pre-fab. concrete slabs
uses steel formwork
(reused 100-200 times)

Benefits:
10% reduction in carbon emission

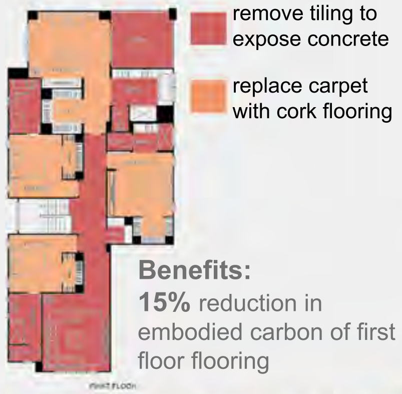
Material	Volume (m³)	Carbon Emission per m³ (kg CO_2)	Embodied Carbon (kg)
Ready-mix concrete	36.4	770	28,028
Pre-cast	36.4	692	25,188.8

Volume of concrete of first floor slab: 36.4m³

5. Optimise Systems for Material Efficiency

Building Component:
First floor slab

Critical Materials:
58m² **Carpet** +
35m² **Ceramic**
= 1802 kg of embodied carbon



Alternative:
Adopt **polished concrete** surfaces in high traffic areas & **Cork flooring** in low traffic zone

Benefits:
15% reduction in embodied carbon of first floor flooring

Building Component	Materials	Mass (kg)	Embodied carbon coefficients ($kgCO_2/kg$)	Embodied Carbon (kg)
First floor slab	concrete	84,000	0.123	10,332
	Carpet (58m²)	316.6	3.9	1234.8
	Ceramic tiles (35m²)	766.5	0.74	567.2
Initial Total				**12,134**
First floor slab w/ alternative materials	concrete	84,000	0.123	10,332
	12mm Cork (58m²)	156.6	0.19	29.7
Alternative Total				**10,361.7**

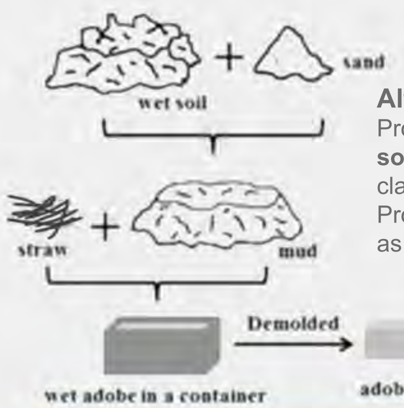
Surface area of first floor slab: 175m², bedrooms: 58m², corridor: 35m²

6. Promote Local & Recycled Materials

Building Component:
Masonry wall, Floor slab

Critical Materials:
Clay Brick, Steel Reinforcement

transportation of materials = **350 x 10^{15} joules** of energy per annum



Alternative:
Promote application of **site sourced mud bricks** to replace clay bricks
Promote usage of **recycled steel** as reinforcement

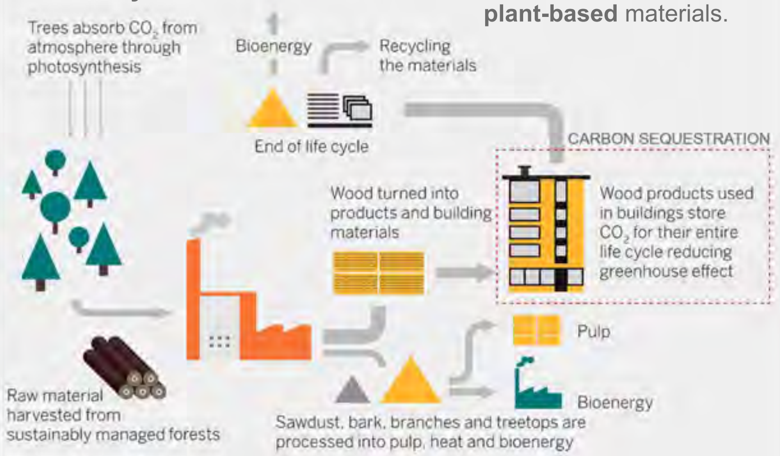
Benefits:
31% reduction in embodied carbon if 58% recycled steel is used

Material	Mass (kg)	Embodied carbon coefficients ($kgCO_2/kg$)	Embodied carbon (kg)
Reinforcement steel	7056	1.9	13,406.4
Reinforcement steel (58% recycled)	7056	1.31	9,243.4

7. Use Materials that Naturally Sequester Carbon

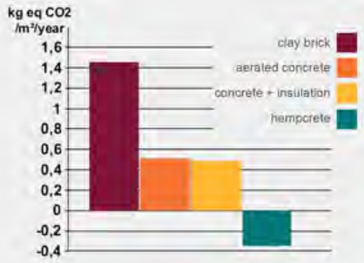
Critical Material:
Ready-mix Concrete

Alternative:
Promote usage of **sustainable plant-based** materials.



Hempcrete as a concrete alternative sequesters approx. **249kg** of CO2 in a 100 yr lifecycle

Benefits: 5,229 kg of CO2 sequestered if hempcrete is used in project



8. Design for Deconstruction

Building Component:
Whole building

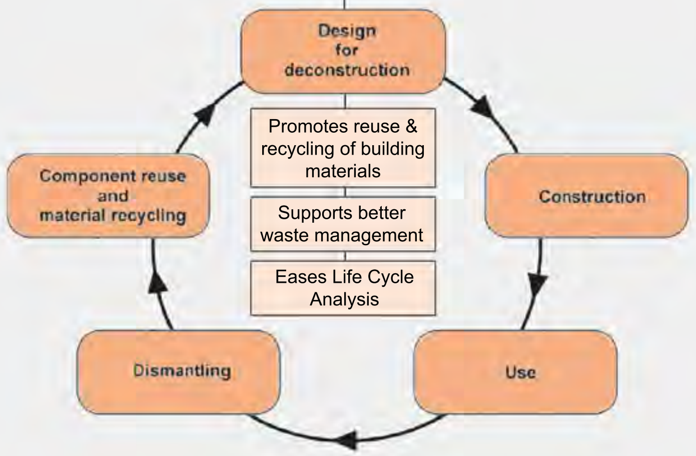
Develop **end-of-life hierarchy** of materials to identify what is **recycled**, **reused**, **incinerated** for energy or **landfilled**

Avoid painting sheet materials and bricks to ease recycling

Avoid permanent fixtures such as nails and adhesives

Avoid materials with **low recyclability** applications such as Formica

Keep material palette at a **minimum** to ease material management



APPLYING STRATEGIES

Selected strategies were applied to the case study, followed by the re-assessment of Embodied Carbon, so as to determine impact value of applied principles and practices. The following amendments have been applied to the selected detached home design:

1 - Reinforcement steel with **58%** recycled content has been implemented, reducing embodied carbon by **4,163kg.**
2 - FAB is utilised as alternative to clay bricks reducing wall embodied carbon by **81%**.
3 - Paint is utilised only on exterior faces reducing mass from **324.5 kg** to **137.8 kg**.
4 - Cork flooring replaces carpet tiles while concrete surfaces replace ceramic tiled floors reducing embodied carbon in flooring by **21%**.
5 - Plasterboard is removed from interior walls in living spaces reducing volume from **4.94m³** to **2.07m³**
6 - Recycled concrete is used as alternative to Formica for kitchen countertop, reducing embodied carbon of said element by **86%**.
7 - Plaster is used for cornices and plinths instead of polyurethane, reducing embodied carbon of said element by **58%**.
8 - Terracotta replaces steel sheeting, engendering a reduction of **675.7kg** in embodied carbon.
9 - Aesthetic additions such as softwood window sill and MDF ceiling planks are removed from design.

Re-assessed Embodied Carbon Analysis

Material	Embodied carbon coefficients ($kgCO_2/kg$)	Embodied carbon (kg)	% embodied carbon
Ready-mixed concrete	0.123	21,077.3	45.7
Reinforcement steel	1.31	9,243.4	20.0
Fibre Cement soffits	1.09	203.8	0.4
FAB	0.042	1,585.1	3.4
Cement mortar (1:5)	0.146	1,756.5	3.8
Paint	2.42	333.5	0.7
Cork	0.19	53.8	0.1
Plasterboard (ceiling + walls)	0.38	503.4	1.1
Aluminium (openings)	8.16	3,538.2	7.7
Glass (openings)	0.86	916.8	2.0
Chipboard (lamimex)	0.84	197.7	0.4
Recycled concrete (countertop)	0.072	12.4	0.0
Plaster (cornices + plinths)	0.12	17.9	0.1
Terracotta	0.23	2,253.3	4.9
Hardwood (structural)	0.86	4,394.6	9.5
Total		**46,103.7**	
Total Initial		68,178.6	
Reduction		**22,074.9**	**32% less**

Recalculated embodied energy total presents a reduction of **22,074.9 kg** within the selected case study, or a decrease of **32%**. Indeed replicating such within the wider industry of suburban real estate ventures would greatly assist in reducing carbon footprint in Queensland's construction industry.

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Handout

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Alternatives to kitchen building materials with negative health implications?

INTRODUCTION

Due to the evolution of technologies in the 21st century, convenience and enhancement of living standard are benefited in our daily life. Conversely, our health are threatened by the harmful chemicals from engineered development and the artificial products. People are suffering from the threat of being vulnerable to against the disease since the resistance against bacteria is weaken by the unhealthy environment we are living and the rise of allergy to different materials. As striving to challenge the limit of current development of technology, maintaining a healthy living environment is as essential as the evolution in science. Since the fruitful financial profit gained from the rapid production of invented building materials, massive production of materials with components of high level of toxicity were revealed in the last decades. The report of being suffered from the sick building syndrome are gradually increasing through a long period of time since the application of toxic materials in our surrounding. As a matter of fact, the awareness of health building materials is provoked by the alarm of threat against our health. The most intimated place in our house in relation to our health is the kitchen. As we survive from gaining energy nutrition of the foods, our health will been directly affected by the foods produced from our kitchen. Adversely, we will suffered from the disease caused from contaminated environment. There is an significance to understand the content of environment of our surrounding in relation to the health issue. In this report, the hazardous components in the kitchen is investigated. The materials with negative health implication are examined as well as the consequence of living in unhealthy environment of the kitchen. Additionally, alternatives for harmful building materials are highlighted and local supply of those materials is sourced. The methodology for creating an sustainable health kitchen is illustrated.

Source: Elemental green, https://elemental.green/how-to-design-and-build-a-sustainable-kitchen/

HISTORY OF UNHEALTHY BUILDING MATERIALS USED IN KITCHEN

Materials used in late decade

During the late 19th century, ways of improving the construction process of buildings were investigated. As the builders are beneficial from the advantages of adopting asbestos in construction process, asbestos are prioritized in the building materials as comparing with other materials. (ARA, 2013) From the production record of the industry, there are over 60% manufactured product containing asbestos fibre still being used in Australia. The materials were durable and cheap. (AIAS, n.d.) Furthermore, it has good performance in sound absorption due to its fibrous qualities as well as a heat resistant and fire retardant agent. (ARA, 2013) There were 70,000 house in New South Wales built with asbestos cement. Besides, approximate 98% of house constructed in Victoria used products with asbestos. However, the setback of this material in relation to human health brought it to prohibition in 1990s as number of people diagnosed with asbestos related diseases keep rising every year. (AIAS, n.d.) Consequently, substitutes of asbestos have been investigated since the late 1990s.

Another dominant toxic materials in building affecting our health is volatile organic compounds (VOC). Volatile organic compounds are carbon-containing solvents, which are widely used in household products and building materials, such as varnishes, cleaning agents, paints, scents, adhesives, sprays and synthetic fabrics. The compounds vaporize into the atmosphere and have odor. They are emitted in the surrounding indoor air as 'offgas' slowly from the new products or dried paint. (CDHA, 2002) Offgassing will decrease over time but it will take up to five years after beginning of utilization. VOC causes negative impacts on human health and certain disease are suffered from inhaling huge amount of these harmful chemicals into our bodies. Up to 16 percent of all VOC emission from paint industry in Australia is reported. As the polymer in VOC, propylene glycol, prevents paints from drying fast after application, paints with high level of VOC is commonly used in Australia with its unique warm climate. (Geraldine, 2014) One of the most commonly used compounds in building materials is formaldehyde. It is used in certain insulation materials and pressed-wood products. (ACS, 2014) The VOC usage levels of products is determined mainly by the Australian Paint Manufacturer's Federation (APMF) and the Green Building Council of Australia (GBCA). (Geraldine, 2014) Suppliers are working closely with engineers to examine the products with lower VOC level in order to salvage the occupants suffering from toxic building materials.

Sustainability trend

Due to the negative implication on human health, evolvement of healthy building materials becomes the current concern of occupants. According to the Smart market report of Australia in 2018, the trends of green building activity in Australia is predicted to accelerate along the rise of market in globe. As a matter of fact, the industry sector are benefited from the green building investments by the significant saving in operating cost, asset value increase and short payback period. On the other hand, the environmental regulations and demands from client are the main factor deriving the growth of market in green building. Occupants are aware of the significance of healthy living environment. Notwithstanding the positive pursue in healthy environment, there are still obstacles for the slow pace in development of Australian. The most challenging factor for them is the higher perceived first cost. Also, green building as for high-end projects is their perception. They concern their affordability of green building. (Stephen, 2018) It is obvious that the increasing demand of healthy building materials is derived from the sick building syndrome revealed in the occupants living in the house with toxic building materials.

Source: Elemental green, https://elemental.green/how-to-design-and-build-a-sustainable-kitchen/

TECHNOLOGIES DEVELOPMENT OF HEALTHY BUILDING MATERIALS USED IN KITCHEN

Due to the rise of awareness in building materials in relation to health, the political force from the governments, the demands of market, innovations of building materials are being sought. Under the endeavor of the engineers and researchers, the VOC level of coating has been reduced to one third of the conventional products used before late 19th century. The VOC level is diminished to 3.5 pounds per gallon in the water- reducible product in the first stage of evolution of the coating industry. Nevertheless, the VOC level of the revised version did not fulfill the regulations dictated with lower VOC level in some sites. Thus, products with 2.0 or 2.15 VOC with high-gloss color are created in order to achieve the prohibitive level. The development of zero VOC and near zero VOC product is being challenged without sacrificing the properties of the product and limitation of color pigment. (Henry, 2001)

KEY HARMFUL INGREDIENTS

Harmful substances in the materials threatens our health in the environment we worked and inhabited. There is no doubt that we have the responsibility to learn what toxic ingredients in the building materials and the health implications. Harmful components of building materials are listed as follow:

Asbestos

Asbestos, as a prohibited building material since 2003, are found in the building built during 1940-1980. It is one of the hazardous chemicals categorized in the list of dangerous goods which has adverse health effects by the Queensland government. (Qld Gov, 2019) It is defined as a group of naturally occurring minerals formed into microscopic fibres. Three common types have been used in Australia, which are chrysotile in white, crocidolite in blue and amosite in brown. Owning to the flexibility and resistance to heat offered by asbestos, the component is used in making the asbestos-cement construction materials and fire resistant insulation, for instance, fibro boards and sprayed' limpet' asbestos, for interior wall, flooring and roofing sheets. In fact, no risk is posed as building materials containing asbestos are utilized under general situations. The asbestos-related diseases can be resulted in case there are airborne asbestos fibres exposed in the air and inhaled into the body of occupant with sufficient amount. As a matter of fact, the risk of suffering from asbestos related disease depends on the whether the asbestos containing materials are broken down and asbestos fibre are released in the air, the type and size of the fibres, the qualities of fibre being inhaled , the length of exposure of the fibres and any pre-existing disease of the occupant. Despite of various factors affecting the possibility of having asbestos related disease, health of occupant with good indoor air quality is essential to get rid of the serious health implications, such as asbestosis, lung cancer, malignant mesothelioma and benign plaques. Whereas the data indicating the huge

Volatile organic compounds (VOC)
Volatile organic compounds are chemicals which vaporize and evaporate with an odour easily in atmosphere at normal temperature. It is a widely chemicals in the building products and new furnishings including adhesives, varnishes, paints, synthetic fabrics and etc. Occupant will suffer from sick building syndrome as inhaling high amount of VOC through offgassing. Symptoms including confusion, headache, collapse or death are revealed by the occupant suffering. Sudden death will occur in serious case as absorption of high level of carbon monoxide. Besides, irritation of eyes, throat, nose and lung will be suffered from exposure to sulfur dioxide and nitrogen dioxide. Other than these, polycyclic aromatic hydrocarbons adhering to the surface of airborne particles are proved to cause cancer. (CDHA, 2002) VOCs can be drawn out from products already stopped offgassing by negative air pressure. Even radon can be drawn up from the basement in negative air pressure. (Andrea, 2007)

Formaldehyde
Formaldehyde is a dominant type of volatile organic compounds used in foam insulation, particleboard, paneling, plywood, adhesive, paint, laminate countertops, medium density fibreboard (MDF), vinyl flooring and other wet applied products. (EG, n.d.) It is usually used in making the cabinet boxes, countertop underlayment and washable, high-gloss paint. High concentration of formaldehyde is used for darker pigments, especially red. (Andrea, 2007) It is broken down quickly in air and easily dissolves into water. Formaldehyde can be absorbed mainly through ingestion and inhalation, even through skin in liquid form. Low concentration of formaldehyde has odour only. But irritation of eye, throat, nose, upper respiratory tract and skin I resulted in exposure of moderate concentration of formaldehyde, 1-3 parts per million. It will cause toxic implications on nervous system with symptoms including headache, sleep disorder, mood disorder, dizziness, impaired memory, impaired equilibrium and dexterity and insomnia as it is a renowned neurotoxin. (Qld Gov, 2017) (Rob, 2018)

1

2

3


1. Asbestos
2. Formaldehyde (in MDF)
3. Polyvinyl chloride (PVC)

For woman, spontaneous abortion, menstrual disorder and impacts on fetuses like DNA and chromosome damage will be found under exposure of high concentration of this toxic chemicals. Other the other hand, the development of asthma in children is increased which is highlighted in the research. Formaldehyde can be harmful to human's health across different generations. (EG, n.d.)

<u>Other names label on products containing formaldehyde:</u> (ACS,2014)

- Formic aldehyde
- Formalin
- Methanal
- Methanediol
- Methylene glycol
- Methylene oxide
- Methyl aldehyde

Polyvinyl chloride (PVC)
Polyvinyl chloride is used in numerous products, not limited in flooring, carpet backing, wall coverings, resilient flooring, window treatments, upholstery textiles, waterproofing membrane, siding, acoustical ceiling surfaces and more. Other chemicals will associated with PVC to enhance the materials properties, such as, phthalates for increasing the flexibility, which will cause endocrine disruption, asthma, obesity, allergies, reproductive problems and etc. Another chemical added in plastic is lead which have negative implication to every system of our bodies. (EG, n.d.)

List of other harmful substances in building materials (tropical, n.d.)

Common toxic chemicals	Application	Health implications
Acetone	• Paints • Adhesives	• Damage of mucosa of the mouth • Irritation and damage of skin • Damage of liver, kidney and nerve • Increase of birth defects • Disability of reproduction of male
Acrylics - paint	• Paints • Resins, varnishes and stains	• Toxic through skin, eye and inhalation routes
Arsenic	• Paints • Preservative and insecticide of timber	• Death from multi-system organ failure
Benzene	• Thinners & solvents of paints • Varnishes	• Liver damage and possibly cancer • Leukemia

Common toxic chemicals	Application	Health implications
Benzene (Cont')	• Solvents for rubber adhesives	
Bromine	• Fire retardant in cellulose insulation • Fabric flame proofing, dyes	• Irritation • Painful blisters produced on exposed skin and mucous membranes • Damage of respiratory system
Chromium	• Primer and enamel paints • Preservative of timber	• Lung cancer- (chromium VI)
Dioxin	• Resins, varnishes and stains • Adhesives • Preservative of timber	• Reproductive disorders and endometrios • Skin lesions • Damage to the immune system • Increased rates of liver and lung cancer • Diabetes • Developmental abnormalities in the enamel of children's teeth • Birth defects
Glass wool	• Weather-proofing • Thermal insulation	• Carcinogenicity
Naphtha-lene	• Paint sol-vent • Resins, varnishes and stains • Adhesives	• Damage of red blood cells • Lack of appetite • Fatigue • Pale skin • Restlessness • Diarrhea • Vomiting • Nausea • Blood in urine • Yellow colour of skin
Neoprene	• Corrosion resistant coatings • Liquid adhe-sives • Noise insu-lation	• Carcinogenicity • Irritation of the eye and of the respiratory tract • Central nervous system depressant • Liver function abnormalities • Cardiovascular system disorders • Immune system depression
Nickel Compounds	• Paint pig-ments	• Carcinogenicity • Dermatitis • Allergy of skin
Polyeth-ylene Tere-phthalate	• Carpets • Fibre fill	• Irritation of the skin and of the respiratory tract • Pneumoconiosis • Menstrual issue
Xylene	• Paints • Resins, varnishes and stains	• Dysfunction of Central Ner-vous System and destruction of other tissues • Irritation of eye, nose and throat

Common toxic chemicals	Application	Health implications
Xylene	• Waterproof-ing of timber and floor	• Headache • Fatigue • Vomiting • Nausea • Dizziness • Abdominal pain • Light headedness • Loss of appetite • Loss of consciousness • Reduced coordination • Brain hemorrhage • Amnesia • Dermatitis • Cardiac stress • Liver and kidney damage and etc.

ALTERNATIVE MATERIALS WITHOUT HEALTH IMPACTS

Alternative materials with low level of toxic chemical components are invented for eliminating the negative implications on health. Health materials are not only designed for sensitive individuals.

Kitchen cabinet

Conventional cabinets used materials with high levels of volatile organic compounds, formaldehyde. Wheatboard, green plywood, wood containing non-toxic adhesives and custom hardwood are alternatives for a health kitchen cabinet. Apart from woods, aluminum will be another option. (KBB, 2015) Wheatboard is made from remained part of plant fibre hardened into a medium density fibreboard. The main component is high quality of wheat fibre lef over after harvests. It is an excellent eco-friendly materials which has no formaldehyde emission. Besides, its physical property is superior to the other plywood or artificial board. (Sutori, n.d.) On the other hand, green plywood is another sustainable products as the VOC emission rate is very low, around 0.17mg/m2/hr- rating E0, which is certificated as green product by the Green Building Council of Australia. The wood panels are certificated from the Forest Stewardship Council (FSC), an independent organization. It indicates that the wood is harvested from the forest under responsible forest management. (MV, n.d.)

Suppliers: Austral plywoods, Matilda Veneer Pty Ltd, Gen-Eco Environmental Wood Products Pty Ltd, Arkie Designs

Countertop
Quartz is the best materials for manufacturing kitchen countertop. (KBB, 2015) It is an engineered material with high performance in stain and heat resistance. The materials is extremely hard as it is manufactured by combining approximate 95 percent ground quartz, natural materials, mixing with polymer resins. Another merit of quartz is the excellent durability. The materials will not damaged by daily tear and wear. It does not require sealing like other natural stones like granite, marble and slate materials. It is a health material without VOC emission. (Deirdre, 2020) Other than quartz, reclaimed or salvaged stone of wood are low VOC emitting materials as an alternative safe natural option for countertops. Only natural oils applied to the reclaimed wood for protection is recommended. (EWG, n.d.)

Another alternative for countertops is concrete. Concrete does not have harmful VOC emitting chemicals and incredibly durable. It is comparatively cheaper than stone. Furthermore, damaged on the surface of concrete can be sanded and resealed. (EWG, n.d.)

In addition, VOC- free stainless steel is one of the good options for countertops due to the high durability and easy maintenance. (EWG, n.d.)

Suppliers:
Quartz- Project Stone Australia, Stoneville Austalia, Southeast stone Pty Ltd
Concrete- Q-crete premix, Lyndons Pty Ltd, Hanson Construction Materials
Stainless steel- Atlas Steels, Australian Stainless Steel Department Association, Metro Steel

Sealant and paint
Paint with zero VOC are invented and supplied in the market. Non- VOC tints and cleaner paints are made by PPG and safecoat. (Andrea, 2017) Linoleum is a greenest product of sealants. It is mainly made from natural materials including linseed oil, chaulk and ground up cork. (TinaK, 2018) Other options for wood sealant are walnut and hemp oil. (KBB, 2015)

Suppliers: Auto West Paint, Economy Paint Supplies, North QLD Chemicals and Paints, Paint & Décor

Flooring
Formaldehyde-free laminate are recommended for flooring of kitchen. Cork is a biodegradable natural material. It is a good heat insulator, high durable, hypoallergenic and antimicrobial. Cork flooring is Fpresented in a new form as laminated planks. (Joseph, 2020)
Bamboo is renewable materials. It is non toxic materials with long life span and requires easy maintenance. (Joseph, 2020) Bamboo flooring with treated to withstand high moisture and formaldehyde-free glue is recommended. Reclaimed woods will be another eco-friendly option for flooring. (Sarah, n.d.)

Recycled glass is recently introduced in the market for flooring. As glass is an non toxic material, the crushed glass from industrial sites are used for manufacturing the green glass flooring. The mix of colorful crushed glass results in an aesthetic stained glass floor pattern. (Sarah, n.d.)

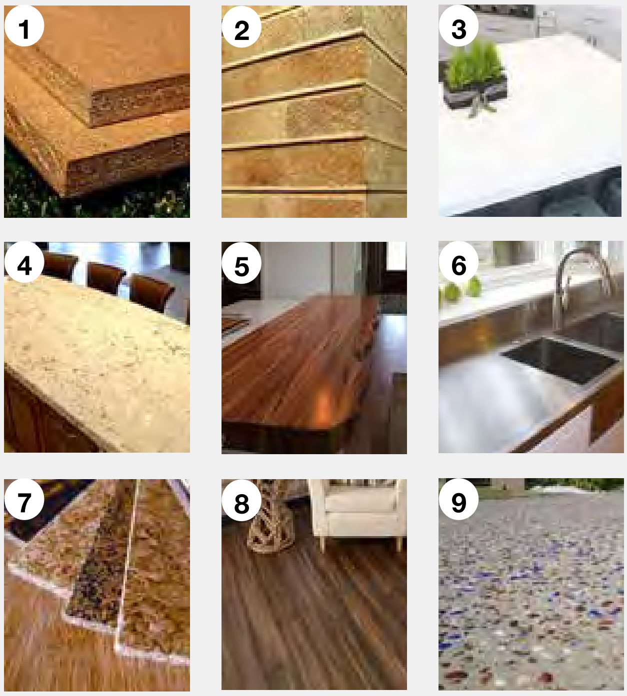
Suppliers:
Cork- Queensland Cork Supplies & Westfloors, Premium Floors Australia, Marques Flooring, Portugal Cork
Bamboo- Right Floors, Bamboo Floors, All Flooring Solutions Pty Ltd, Genesis
Recycled glass- Earp Bros, Schneppa glass

HOW TO DESIGN A SUSTAINABLE AND HEALTHY KITCHEN

Undoubtedly, building materials with negative implications are used in our surrounding, this phenomenon is the results of various factors including financial inadequacy, production of harmful materials with harmful chemicals, selection of materials without careful considerations, lack of supervision in production and selection of materials. (Nil, 2018) The consequence of application of harmful materials will become worse without adequate actions taken to eliminate the negative implications. As studies reported that sensitive people have not been born the way of getting irritated easily. Hence, a sustainable and healthy kitchen is critical to maintain our health. The methodology for maintaining a healthy construction are elimination, separation and ventilation. First, we Have to eliminate major poison chemicals in our surrounding. Materials containing high level of volatile organic compounds and formaldehyde should be avoided. Natural and organic substitutes should be used instead to ensure the environment not being contaminated. When elimination of toxic materials is not feasible for your current situation, then separation of harmful materials is another option for minimizing the negative implications on health. For example, insulation with VOC emission is hidden behind the drywall. The final step to do is to ensure adequate ventilation for the spaces. Nice exchange of air is required for maintaining good indoor air quality. (PB, 1996) Apart from the methodology adopting for creating a healthy and sustainable construction, responsibility in sourcing and resource efficiency are indispensable criteria for achieving the goal. Woods with Green Tag certified are preferable and wood materials with third party certification, FSC, are the best options. Durability and need for maintenance have to be put in consideration as materials with high durability requires less chemicals for maintenance. It will enhance the eco-friendly environment. For the toxicity of building materials, we should insist on choosing zero or low VOC one. For the materials with adhesive or sealant, water-based and low-VOC finishes are better choices. Rather than using new manufactured products, recycling unused materials is another feasible measure to protect our environment. (Kate, n.d.) Furthermore, the carbon impact can be minimized by having the transaction between transportation, manufacturing and subsequent installation of products within 100-mile radius. (Andrea, 2009)

It is understandable that occupants concern the first cost verse the long-term operating costs. In the past, focus of market is value-engineered cost in materials production. Nowadays, the focus is shifted to a sustainable design strategy established which can meet present living requirements and whether enough flexibility is remained for the future. (John, 2009) In spite of the transformation of market focus, force from the government have effects on the development of sustainable and healthy living environment. The industry is moved forward by the energy star standards for enhancing an eco-friendly environment. (John, 2009) Organization for establishing the sustainability standards are taking actions to protect our environment, such as the Green Building Council of Australia, Australian Paint Manufacturer's Federation (APMF), Department of Environment and Heritage. Significantly, key to a healthy kitchen is education. Clients' choices of a healthy, responsible product can be educated by designer and dealers. (Andrea, 2007)

Materials board of non-toxic building materials



1. Wheatboard
2. Green plywood
3. Quartz countertop
4. Granite countertop
5. Reclaimed wood countertop
6. Stainless steel countertop
7. Cork flooring
8. Bamboo flooring
9. Recycled glass flooring

Poster

WRITTEN BY MICHELLE, YUK KING LAM

What are some locally available alternatives for building materials used in kitchen with negative health implication?

Non-VOC paint/ linoleum/ walnut and hemp oil

Suppliers:
Auto West Paint, Economy Paint Supplies, North QLD Chemicals and Paints, Paint & Décor

Wheatboard/ green plywood

Suppliers:
Austral plywoods, Matilda Veneer Pty Ltd, Gen-Eco Environmental Wood Products Pty Ltd, Arkie Designs

Formaldehyde-free laminate (cork)/ bamboo flooring/ recycled glass flooring

Suppliers:
Cork- Queensland Cork Supplies & Westfloors, Premium Floors Australia, Marques Flooring, Portugal Cork
Bamboo- Right Floors, Bamboo Floors, All Flooring Solutions Pty Ltd, Genesis
Recycled glass- Earp Bros, Schneppa glass

Quartz/ reclaimed or salvaged stone of wood/ concrete/ stainless steel

Suppliers:
Quartz- Project Stone Australia, Stoneville Austalia, Southeast stone Pty Ltd
Concrete- Q-crete premix, Lyndons Pty Ltd, Hanson Construction Materials
Stainless steel- Atlas Steels, Australian Stainless Steel Department Association, Metro Steel

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Handout

WRITTEN BY ZIYUAN LI

Analysis of the Recycled Plastic and Applications in Australia

INTRODUCTION

The use of plastic has become an integral part of our lives. Plastic is a kind of organic synthesis or processed polymers materials, which are mainly divided into thermoplastic or thermoset and that can be made into objects, thin films or filaments. The term plastic originally comes from the Greek plastikos meaning fit for molding, the word is quite appropriate to the properties of plastic itself, due to its advantages of low density, high strength, long life, and low cost. In the application area, plastic is often used in construction, clothing, packaging, automobiles, electronics, medical, and other aspects. Moreover, plastics are highly recyclable. Therefore, by establishing a suitable recycling system, the government or relevant institutions can correctly guide companies and the public to establish the awareness of recycling plastic products, so as to recycle waste plastic more efficiently and purposefully. When plastics are recycled after consumption, they can be recycled into new products after sorting, washing, resizing, identification and separation of plastics, and compounding. The reuse, recycle of waste plastics can greatly reduce the dependence on the raw materials for plastic production, such as reduce the need for non-renewable oil resources which can protect the natural resources, reduce greenhouse gas emissions, and promote the development of the circular economy.

Recycled plastics

BACKGROUND

Plastic as the metal, wood, cement and inorganic brick after another important building material, has the following advantages: the energy needed for the production of plastic building materials is lower than the amount of steel construction building materials, the pipe made of energy consumption is lower than the metal pipe, and plastic recycling and recycling performance were higher than brick wood and inorganic materials. This makes plastic building materials not only meet the requirements of national energy conservation and environmental protection but also can provide broader thinking and scope in architectural design and material selection, thus creating a more comfortable architecture space. In recent years, with the increasing demand for plastic building materials and the continuous expansion of the market, the annual production of scrap plastic has increased significantly, and mass construction waste is generated from this, including plastic waste will become an environmental threat that cannot be ignored. Therefore, for building materials in the recycling of scrap plastic and recycled plastic application in building materials research and standardization, is the environmental pollution and resources shortage status under the urgent demand, is also the positive response of the relevant national laws and regulations and standards, at the same time is conducive to the construction of environmentally friendly building materials industry, standardize the order of plastic renewable building materials market.

In terms of plastic recycling, Europe, the United States, Japan, and Australia have different strengths in different areas of plastic waste recycling. In Europe, the average recovery rate for plastics is over 40%; The United States has established a garbage recycling and collection system to achieve an effective recovery rate of no less than 12% of waste plastics. Among all post-consumption plastics for recycling, plastic building materials only account for 18%, which is already a high level in the world.

ANNUAL CONSUMPTION AND RECOVERY OF PLASTICS IN AUSTRALIA

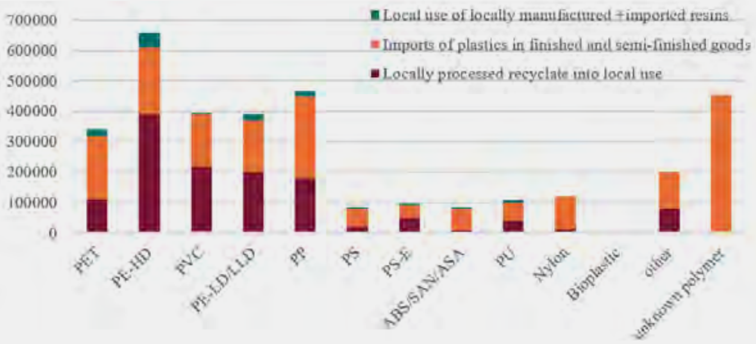
Year	Plastics consumption (tonnes)	Plastics recovery (tonnes)	Plastics recycling rate (%)
2000	N/A	167 700	N/A
2001	N/A	160 900	N/A
2002	N/A	157 300	N/A
2003	N/A	189 400	N/A
2004	N/A	191 000	N/A
2005	N/A	232 000	N/A
2006	N/A	244 000	N/A
2007	N/A	261 100	N/A
2008	N/A	282 000	N/A
2009-10	N/A	287 000	N/A
2010-11	N/A	302 600	N/A
2011-12	N/A	307 300	N/A
2012-13	N/A	313 700	N/A
2013-14	N/A	341 800	N/A
2014-15	3 167 000	341 800	10.8%
2015-16	2 912 000	328 900	11.3%
2016-17	2 955 400	291 000	9.8%
2017-18	3 407 300	320 000	9.4%

The table showed in annual consumption and recovery of plastics in Australia that the total plastic consumption in Australia in 2017-18 contributed 3.4million tons, which represented a huge increase from the 2.96 million tons reported in 2016-17, which is in the previous year. The plastic recovery reached 3.2 million tons in 2017-18, which was an improvement compared to 2016-17, but the output slowly decreased from 2014-15 and 2015-16 by 0.2 million tons and 0.1 million tons, respectively. However, the recovery increased by twice as the 1.68 million tons in 2000. In 2017-18, the recycling of plastics rate was 9.4%, which decreased by 2% compared with 2015-16, and reached its peak value of 11.3%.

PLATICS CONSUMPTION BY POLYMER TYPE AND SOURCE IN 2017-18 (TONNES) IN AUSTRALIA

Polymer type	Local use of locally manufactured+ imported resins	Imports of plastics in finished and semi-finished goods
PET	114 400	223 000
PE-HD	377 600	253 600
PVC	233 900	172 000
PE-LD/LLD	198 800	172 400
PP	176 300	274 000
PS	12 900	48 700
PS-E	50 500	34 900
ABS/SAN/ASA	9 500	56 900
PU	35 600	44 500
Nylon	10 800	114 500
Bioplastic	<100	<100
Other	75 300	141 900
Unknown polymer	5 800	462 500
Total	1 301 200	1 981 000

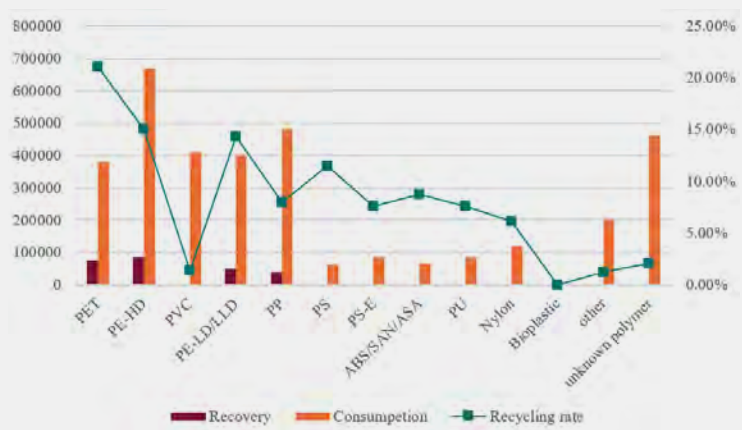
Polymer type	Locally processed recyclate into local use	Australia consumption
PET	18 200	355 300
PE-HD	43 300	656 500
PVC	4 300	410 200
PE-LD/LLD	28 800	399 900
PP	18 500	468 900
PS	1 900	63 600
PS-E	1 700	87 100
ABS/SAN/ASA	800	67 300
PU	6 500	86 600
Nylon	200	125 500
Bioplastic	0	<100
Other	800	218 000
Unknown polymer	0	458 000
Total	125 100	3 407 300



The output of the products obtained by importing finished products and semi-finished products amounted to 1.98 million tonnes in the year 2017-18, and only 42% of the output was made by using the local resin (locally made and manufactured) or the output of the recycled resin in the local production. The value of the tons was 1.3 million tonnes. The recyclate use rate in the local area reached a very low value, and the number was only 0.12 million tonnes. Over the past decade, local resin manufacturers of PET, PVC, PS, and EPS have ceased production, so the only major resin types currently produced in Australia are HDPE, LDPE, and PP.

THE CONSUMPTION OF PLASTICS AND RECOVERY BY POLUMER TYPE IN 2017-18

Polymer type	Recovery	Consumption	Recycling rate
PET	74 900	355 300	21.1%
PE-HD	98 100	656 500	15.0%
PVC	5 900	410 200	1.4%
PE-LD/LLD	57 100	399 900	14.3%
PP	37 500	468 900	8.0%
PS	7 300	63 600	11.5%
PS-E	6 600	87 100	7.6%
ABS/SAN/ASA	5 900	67 300	8.7%
PU	6 500	86 600	7.6%
Nylon	7 700	125 500	6.1%
Bioplastic	0	<100	0.0%
Other	2 600	218 000	1.2%
Unknown polymer	9 800	459 400	2.1%
Total	320 000	3 407 3000	9.4%



The total national recovery rate was 9.4 percent, down slightly from 9.8 percent in 2016-17. The most top recovery rate for PET was found in 2017-18, at 21.1% (mainly from packaging), followed by less than 6% for HDPE (also mainly from packaging).

PLATIC RECYCLING PROCESS

Plastic recycling can be divided into several different steps. (Some of these steps are the same in the majority of recycling facilities, but some steps can be merged or omitted in some different situations.)

1.COLLECTION → 2.SORTING

↓

4.RESIZING ← 3.WASHING

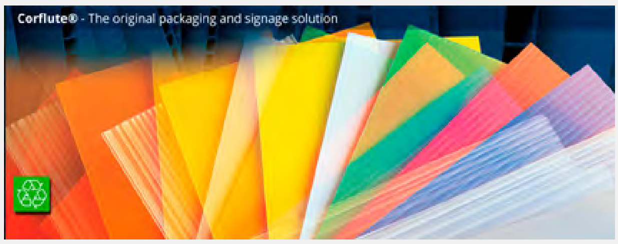
↓

5.IDENTIFICATION AND SEPERATION → 6.COMPOUNDING

APPLICATIONS

1.Closed loop polymer recovery and recycling of solid sheet thermoplastic products

The recycling and reuse of thermoplastic polymer sheets save the disposal cost and natural resources for the enterprise and provides Corex Plastics with economical and reliable sustainable raw materials. While recycling these thermoplastic sheets materials, it saves more space and cost for the landfill. Thermoplastic sheets are not a biodegradable material, which means it could keep in landfills for years, causing unexpected damage to theenvironment. Recycling one tonne of plastic can save an estimated 5.7 cubic meters of landfills space.



Corex Plastics solid sheet thermoplastics

2.Concrete with recycled plastic

The Engineering company Fibercon in Queensland has adopted a new method to produce concrete. This company recycled plastic to mold the steel mesh in reinforced concrete, which recycles more than 50 tonnes of plastic waste.They use PP instead of traditional steel to reinforce concrete, reducing greenhouse gas emissions, water use, and natural resources from fossil fuels.

Reinforcing concrete with recycled plastic

3. PVC windows

PVC Windows has reached a high market use rate, and this is because PVC Windows can have the perfect design, adapt to the needs of styling, easy to maintain. But, more importantly, they can be 100 percent recycled. When a window has a lifespan of 40 years, it means a significant reduction in greenhouse gas emissions. In theory, a window can be recycled and used up to seven times without any negative impact on raw materials or the quality of processing.

4. **Recycled plastic road in Australia**

In Australia, the government decided to conduct a program to remove some 200,000 plastic bags and packaging, and 63,000 glass bottles from landfills and use them to build a Victoria road.

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Handout

WRITTEN BY Jimeyong Park

Community Construction and Demolition Waste Management in S.E Queensland

INTRODUCTION

This handout presents overview of "Construction and Demolition Waste Management Guideline with Community Recycling in South East Queensland". The aim of this paper is to investigate the potentials of C&D wastes at the end of life from the Life Cycle Assessment (LCA), and to verify ways to divert these materials from landfill to a circular economy.

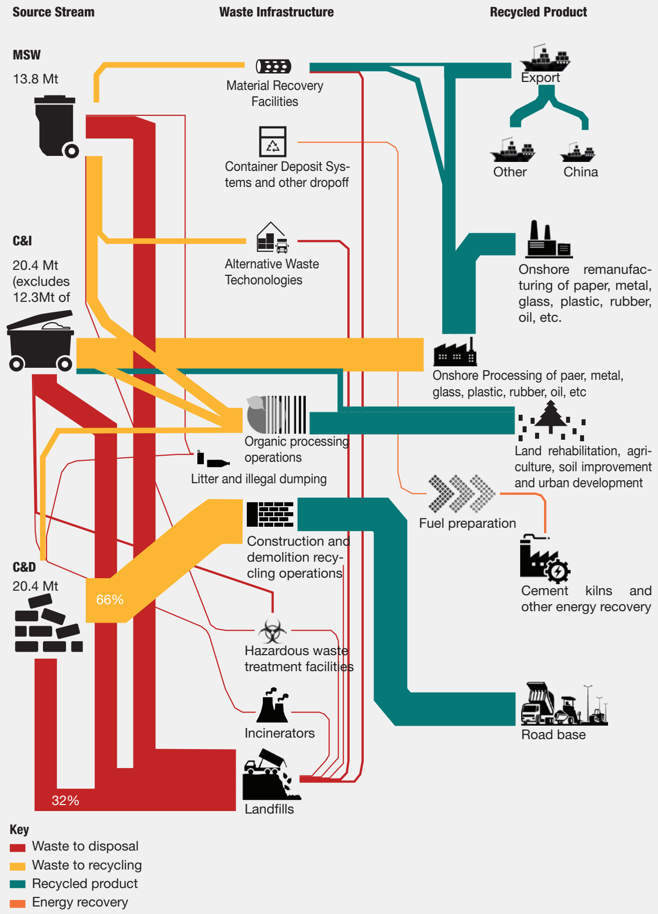
To begin with, it analyses Australia's waste streams to identify the causes of transport interstate and overseas. Second, analysis of the flow of C&D waste generated within Queensland and current recycling facilities demonstrates their capacity. In addition, the recyclable waste going to the landfill is quantified and converted into carbon emission unit to evaluate its environmental impact. The third part presents different cases of C&D waste treatment and management with the method of recycling and reuse, and suggests applicable technology and business models. Finally, the fourth part illustrates a guideline with 4 principles to improve the recyclability in community. Strategies that can be applied from the perspectives of all enablers such as, architects, recycling centres, governments, transport business company, and individual stakeholders are described.

BACKGROUND

Queensland has been the third-largest population growth in all Australian states in the past decade. While the population grew by 1.6% and the economy grew by 3.7%, headline waste generated an additional 1.1 million tonnes (11%) during the same period. The headline waste refers to the sum of MSW (Municipal Solid Waste), C&I (Commercial and Industrial), and C&D (Construction and Demolition). The overall recovery rate increased only 0.9% from 44.5% in 2016-17 to 45.4% in 2017-18, but 4,945,000 tonnes (13% increase over the previous year) of headline wastes diverted from the waste stream. When broken down, 32.4% of MSW, 47.3% of C&I, and 50.9% of C&D recovered from the waste stream. 60% of headline waste was treated and landfilled in private sector waste facilities (landfills, monofills and incinerators), a 3% increase over the previous year. And 95% of C&D waste was disposed of at the aforementioned facilities. In the case of green star certified buildings, masonry waste is often converted to a renewable state at a fairly high rate and reused. However, as materials are mixed during construction and demolition work, they are often mixed and arduous to classify, process and recyle. And public awareness that landfill C&D waste is not a big problem also makes recycling of resources difficult.

Waste generation in Australia

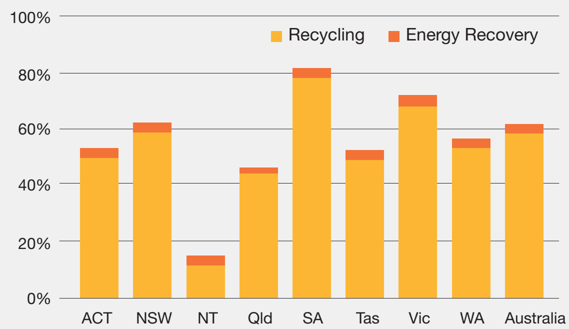
In 2016-17, Australia generated 67 Mt(million tonnes) of waste, including 17.1 Mt of masonry material, 14.2 Mt of organics, 12.3 Mt of ash, 6.3 Mt of hazardous waste, 5.6 Mt of paper and cardboard, and 5.5 Mt of metals. This is equivalent to the amount of waste generated by 2.7 tonnes per person.



Resource recovery and recycling rates by jurisdiction

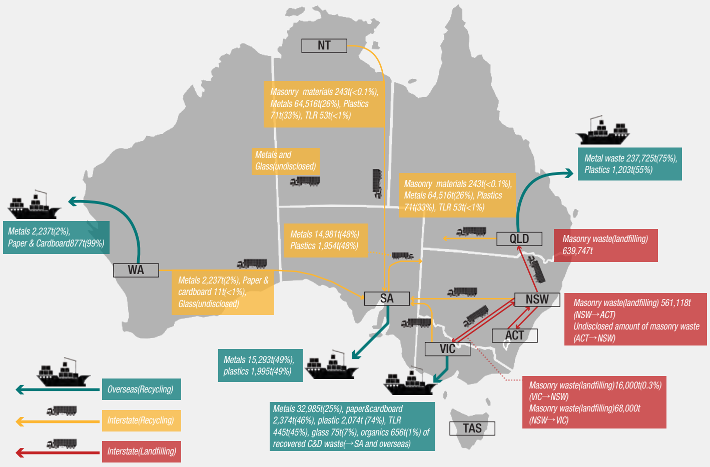
SA(82%) had the highest resource recovery and recycling rates, followed by Vic, NSW, WA, ACT, Tas, Qld and NT. Resource recovery rates across Australia are 62% and recycling rates are 58%.(2016-17)

	ACT	NSW	NT	Qld	SA	Tas	Vic	WA	Australia
Resource recovery rate	53%	62%	15%	47%	82%	53%	72%	57%	62%
Recycling rate	49%	59%	11%	44%	78%	49%	68%	53%	58%



An Inflection point in global waste streams

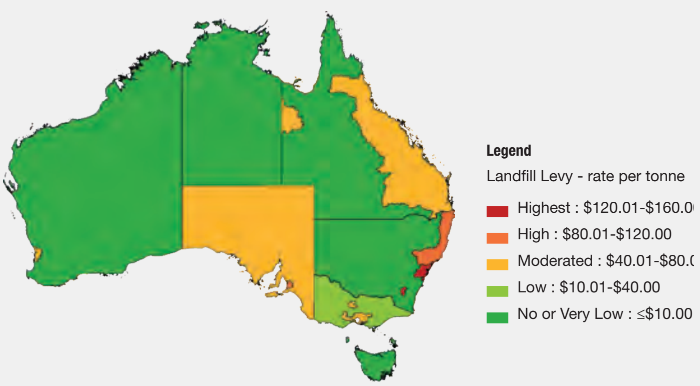
China's "National Sword" policy, enacted in January 2018, has slowed the flow of waste to countries where the world had relied on recyclable waste disposal for over 25 years. As a result, plastic waste imports to China have declined by 99%, and the UK had to burn more than 500,000 tonnes of plastics and household wastes.



Landfill Levies by Regions

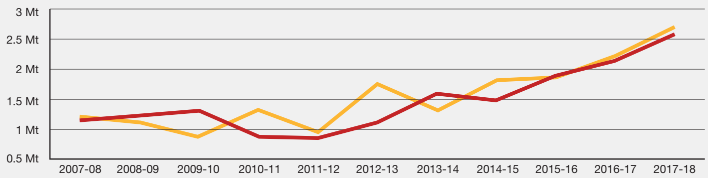
The main cause to landfill in Queensland from other states was the low disposal cost(less than $80 per tonne). Almost all of the waste transported to Queensland comes from New South Wales. This is because the cost of landfilling to Queensland is lower than the cost of disposing of waste in the area where the waste was generated.

Fortunately, the Levy zone policy commenced from June 2019 is expected to reduce this tendency. The introduction of Levy charges has been reducing the amount of waste landfilled since 2019. The effectiveness of SA's Levy levy policy is seen in increased resource recovery rates. It was skyrocketed from about 2 million tons in 2004 (60% of recovery) to 4 million tons in 2016 (81.5% of recovery).



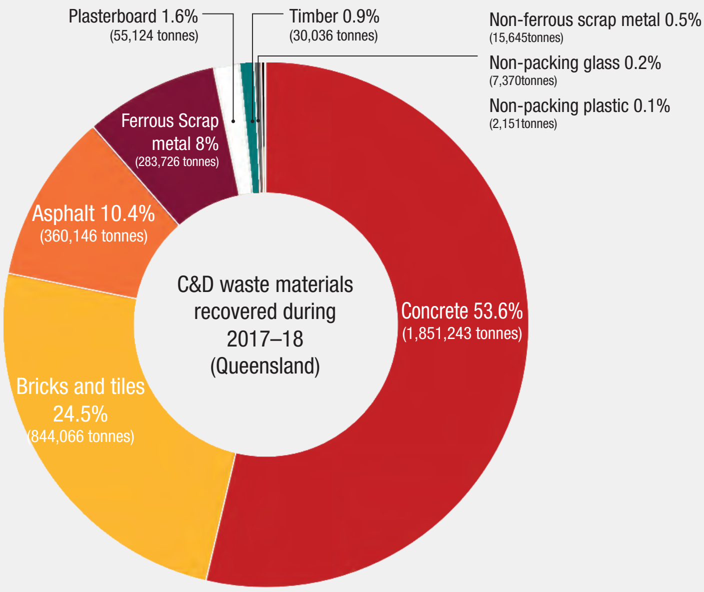
Construction and demolition waste in Queensland

The trend in C&D waste of Queensland shows a continued growth in 2017–18. The 2,592,000 tonnes landfilled was a 446,000 tonnes(24%) increase from previous year. A main factor was a 394,000 tonne increase in the amount of C&D waste transported from other state, which increased from 640,000 tonnes in 2016–17 to 1,034,000 tonnes in 2017–18. In 2017-18, the recovery rate of C&D waste is 21%. This is an increase of 477,000 tonnes compared to 2016-17, reaching 2,690,000 tonnes.12 This includes an increase of 375,000 tonnes of recovered concrete and 42,000 tonnes of recovered bricks and tiles.



C&D waste materials recovered during 2017-18

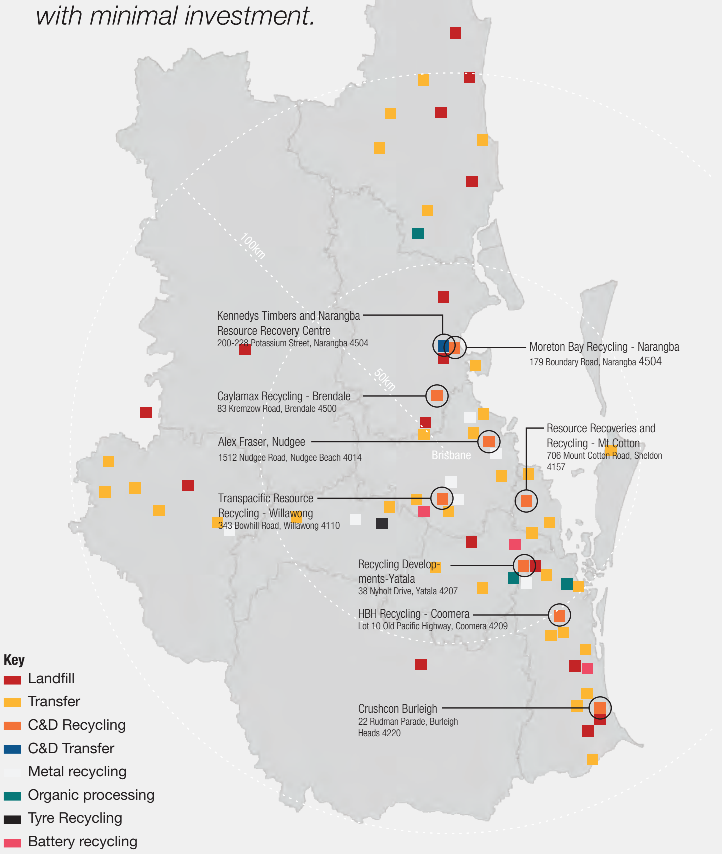
In Queensland, about 2.7 million tonnes (50.9%) of the 5.3 million tonnes of C&D waste were recovered. This is a slight increase from 50.8% reported in 2016-17. In 2017-18, the total volume of the C&D waste increased by 900,000 compared to 2016-17.However, 430,000 tonnes were transported from other states, such as NSW, representing about 8.1% of the total 5.3million. Therefore, the recovery rate for waste produced in Queensland itself may be higher, excluding the amount from outside. Conversely, except for recycled materials shipped overseas, the rate of recovery from purely Queensland itself can also be reduced.



Public waste and recycling facilities (SEQ Region)

Currently, there are 388 public waste and recycling facilities in Queensland. It is classified into landfills, transfer stations, metal recyclers, construction and demolition recyclers, organic processors, battery recyclers, tyre recyclers, and paint recyclers according to each function or waste type. The figure below shows the location of each facility in the SEQ region and the distance from Brisbane, Queensland's capital city, in the range of 50 km and 100 km.

Table below summarizes the main treatment capabilities of the C&D waste facility and information on the wastes being handled. Inert materials (concrete, brick and soils) and scrap metals can be classified to some extent as basic screening and grinding equipment in the field. These primary sorted chunks are then sent back to recycling centres and related companies for secondary processing. According to the Arcadis report, C&D recyclers in the SEQ region now have spare capacity and ability to increase throughput with minimal investment.



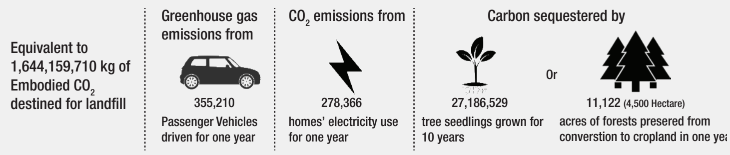
No.	Recycling Centre location	Distance from CBD	Pick up	Drop off	Major Material
1	Kennedys Timbers and Narangba Resource Recovery Centre	38.7km	undisclosed	undisclosed	Timber
2	Moreton Bay Recycling - Narangba	37.7km	undisclosed	undisclosed	Recycled Aggregate
3	Caylamax Recycling – Brendale	23.6km	O	O	Ferrous and non-ferrous metals
4	Alex Fraser, Nudgee	21.7km	O	O	Asphalt & Bitumen
5	Resource Recoveries and Recycling - Mt Cotton	34.7km	X	O	All
6	Transpacific Resource Recycling - Willawong	25.9km	X	O	All
7	Recycling Developments - Yatala	37.3km	undisclosed	undisclosed	Recycled Concrete
8	HBH Recycling - Coomera	50.0km	X	O	Crushed Rock& Concrete Products
9	Crushcon Burleigh	87.2km	X	O	Fines/20mm/20-40mm/40-70mm/road base (Recycled concrete aggregate)

Greenhouse Gas Equivalencies Calculator

The table demostrates estimated GHG emissions (kgCO2 /kg), Embodied energy (MJ/kg), and Embodied Carbon (kg) of chosen resources which represent each category.

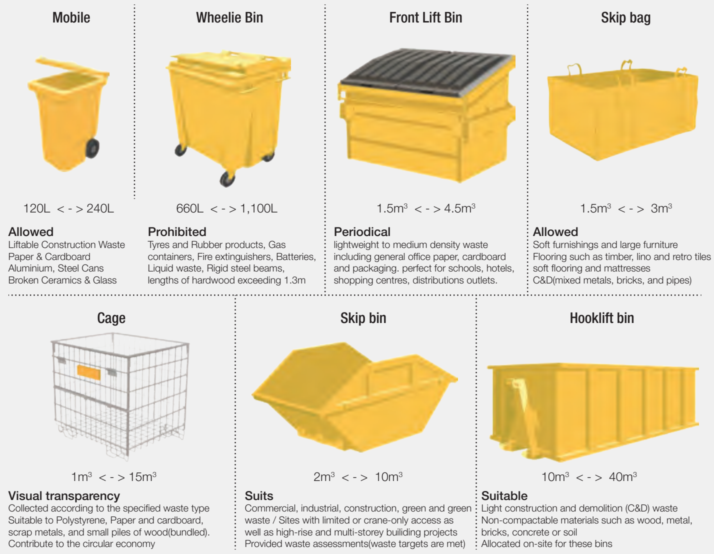
And the figure below illustrates the result when all C&D waste is diverted and salvaged from landfill. This chart allows people to guess that even a third of the landfill waste in the SEQ region has a huge impact.

Disposed materials (Tonnes)	Recovery rate	MSW	C&I	C&D	Total by category	% by category
Masonry materials	47%	37,299	229,233	1,213,081	1,479,613	27%
Metals	82%	62,662	44,443	67,976	175,081	3%
Organics	44%	893,563	531,986	115,289	1,540,838	28%
Paper&cardboard	56%	198,172	207,587	38,938	444,697	8%
plastics	6%	292,501	270,479	48,430	611,410	11%
Glass	34%	98,795	33,878	43	132,716	2%
Other	10%	39,372	103,771	0	143,143	3%
Hazardous	35%	0	556,291	382,062	938,353	17%
Total by stream		1,622,364	1,977,668	1,865,819	5,465,851	100%
% by stream		30%	36%	34%	100%	



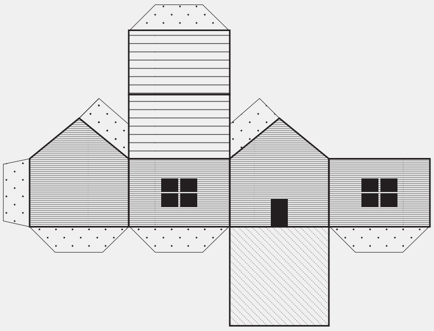
Principle 01. High purity of recyclealbe resource collection with Waste management services

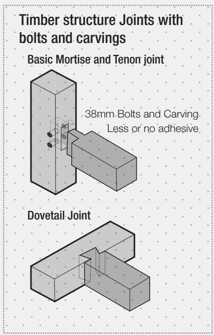
Although many people want to practice recycling, they give up because of the difficulty in classifying mixed waste. It is easier to reuse and recycle materials with higher purity than materials mixed with or coated. The degree of contamination of C&D waste is affected by different stages like production, construction, and management after waste generation. The focal point is to place a waste container suitable for the site condition so that it can be classified in small-scale housing projects and refurbishment projects from the initial stage.

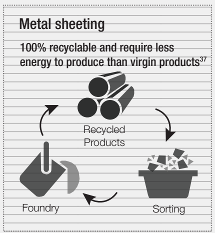


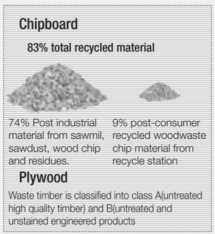
Principle 02. Design for disassembly

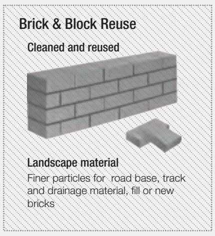
Design for disassembly is an overall design approach, which allows the product to be easily disassembled and subdivided into individual component units for replacement. This approach is a keystone of the circular economy, allowing each component to cycle through a closed material cycle. They are reused, reassembled, and recycled and re-created as new products.





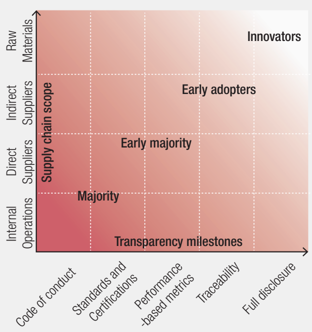


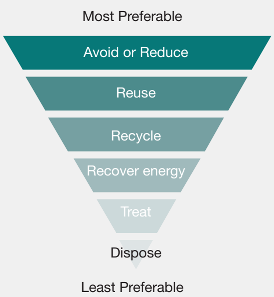




Principle 03. Product procurement with transparent content information

Information about materials of product must be transparent so that the public can easily access it. Related information can be provided as an integrated system using information from institutions such as LCA, EPD, Ecospecifier, Building Transparency, Cradle to Cradle Certified™, and EToolLCD.



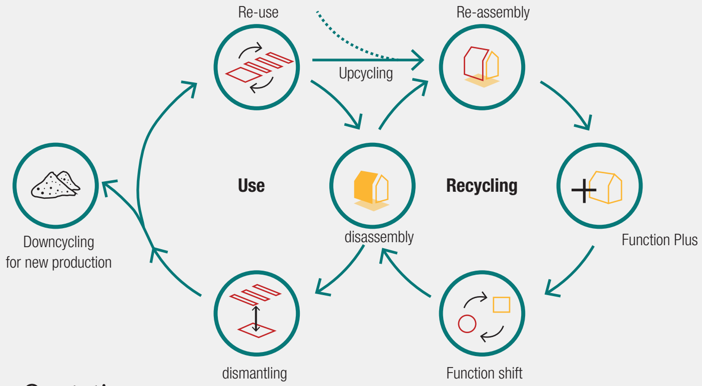


Principle 04. Product life Extension

The community engaged model aims to extend the lifespan of the products and improve the values. It is necessary to develop products that can maintain their long-term effectiveness, taking into account the operating costs of the building.

Conclusion

The relationship between production and purchase needs to be re-established. And all the enablers who involve in Waste stream need to be responsible for transforming into the circular economy



Quotation

"Recycling is the future. Businesses must use sustainable resources to ensure their ongoing success." by David Henderson, Executive Director, D&R Henderson.

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THANKS

Handout

WRITTEN BY M. SHAMEEM A. KARIM

Residential Architecture stripped back

A framework to reduce embodied carbon in Queensland suburban house design.

Handout

WRITTEN BY MICHELLE, YUK KING LAM

Alternatives to kitchen building materials with negative health implications?

Handout

WRITTEN BY ZIYUAN LI

Analysis of the Recycled Plastic and Applications in Australia

Handout

WRITTEN BY Jimeyong Park

Community Construction and Demolition Waste Management in S.E Queensland

Handout

Srinivas Palivela

Designing a process to develop worth out of waste in Austalia

Handout

WRITTEN BY FAHMI BAHMDAN

Designing for Disassembly with concrete

Handout

LIMING ZHENG

Designing with Waste glass in Australia

Handout

NURUL AINA BINTI NADZRI

Environmental Impacts of Australian Premix Concrete Suppliers

Handout

WRITTEN BY QIULIN WANG

Environmental Impacts of Timber Manufacturing in Australia

Handout

WRITTEN BY ANDREW KWOK

facade design for circular economy principles

Handout

WRITTEN BY VIRAJ MHATRE

Good Thatching practice in Australia

Handout

WRITTEN BY ZOE WELLS

Guide to specifying local building materials manufacturers

Handout

HYESU JEON

Recycling carpet in Austalia

Handout

JAMES FERGUSON

How have Queensland's building materials changed over the last century?

Handout

SHRIYA VENKATESH

Impacts of Mould Toxicity on Queensland Homes

Handout

Material durability and disassembly in the Queensland domestic context

Handout

‘Queenslander’ houses and Circular Design

Handout

HYESU JEON

Recycling carpet in Austalia

Handout

WRITTEN BY Emily Richter
s4395500

Refuse, Reuse & Recycle: A Guide to Material Substitutions for Sustainable Concrete

Handout

WRITTEN BY DANNI'ELLE JENKINS

Reusing Construction Materials in New Buildings

Handout

WRITTEN BY KITTIDECH MARAYAT

Simple steps to conduct LCA

Handout

WRITTEN BY NATHALIE BLOOMFIELD

Sustainability and External Cladding Materials

Handout

Srinivas Palivela

Designing a process to develop worth out of waste in Austalia

INTRODUCTION

The handout presents a beginner's overview of the opportunity to use the waste to develop a product that can be used in the construction industry. The paper is focusing on the ways to generate a circular economy in Australia using the commercial and industrial waste that is not being recovered efficiently and are landfilled. The aspect of introducing these wastes to produce viable and cheaper construction material. The process of the waste generation has been linear and needs to generate a loop to benefit the economy, environmental impacts, and resource-saving. The paper will be developing a sense of the material processing using the existing stockpile in Queensland and produce a catalog of viable materials that will cater as a façade screening, masonry, and other structure alternative option. The collection of waste starts in south-eastern Queensland and the recycled material can be used all over Australia as an experiment. Reducing the number of landfills will be the second motive. Hence the use of such a system will benefit most of the industries.

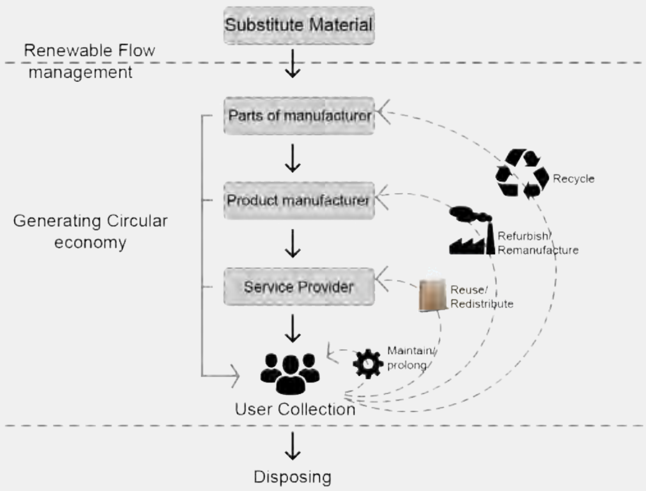
BACKGROUND

The Australia commercial industry is catering people of 25 million population. The Process is quite linear for the commercial sector that is manufactured, supply, and disposed of. The overall waste generated in Australia is 10.9 million Tonnes and has been obtaining an increase since 2016-2017.[1] The rate of recovery of the waste peaked from 0.9 to 44.5 percentage in 2016-2017 and 45.4 percentage in 2017-2018. Comparing the number of Tonnes of waste and recovered waste in Queensland. The recovery rate of the waste in Queensland was 45.4 percentage in 2017-18. The recovered waste overall is 4,944,825 Tonnes and disposed of is 5,947,163 Tonnes overall in Queensland.[2] The recovered municipal waste and commercial &industrial waste is at the lowest level as 870,492 and 1,384,600 tonnes where as the landfill of this categories are 1,814,217 and 1,540,659 tonnes in 2018. The amount of landfill is double the recovery.[3]
While looking at the current Australian recycling industry, it has been facing issue due to the capacity to recycle such a heavy stockpiled waste. The issue of buyers not investing on such waste these wastes are being landfilled due to over stockpiling. Further when dividing the materials under the category of Commercial and industrial Waste the materials that are under focus are Glass, Paper &cardboard, plastic and steel cans. Until year 2018 the landfill has been overpowering the recovery of the waste and Introducing materials that can be used to generate an alternative construction material.

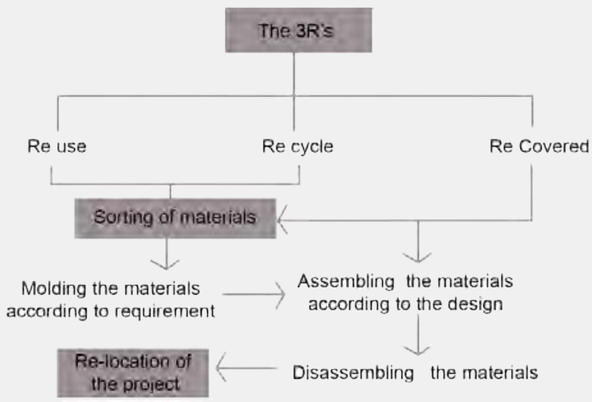
CONTENT

The linear process of developing the product in the commercial and industry sector that leads to the recycling unit but cannot be tracked as how is the waste used. Further this process ends the materials with stock pilling.

The linearity of such process leads to negative leckage of the waste causing environmental impact and waste of embodied energy. This resource needs a loop of renwability that can save the virgin reources and generate economic inflation using waste. Develoing a circular economy process is required While connecting the commercial & industrial sector waste to the construction industry use:



The use of this circular process can develop a new construction material that can follow the princples to easy up the assembley and disassemebly of the materials to have a property of endless use of the product.



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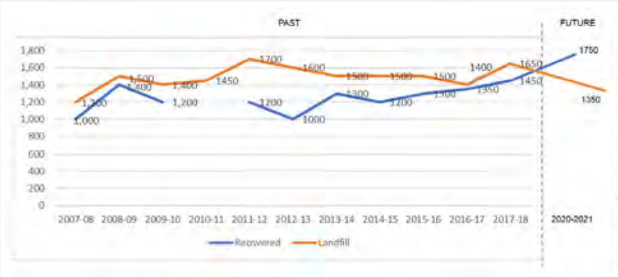
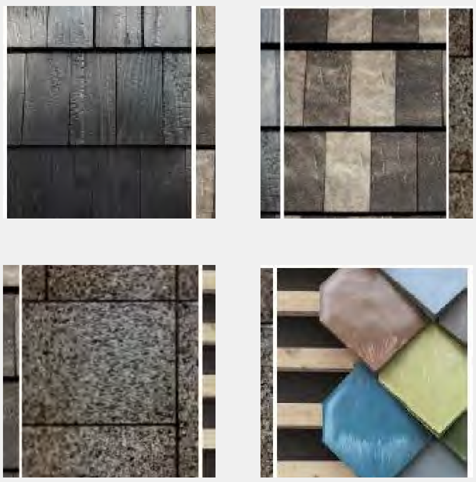
GRAPH OF LANDFILL AND RECOVERED WASTE IN QUEENSLAND OVER YEARS AND FUTURE SCOPE:



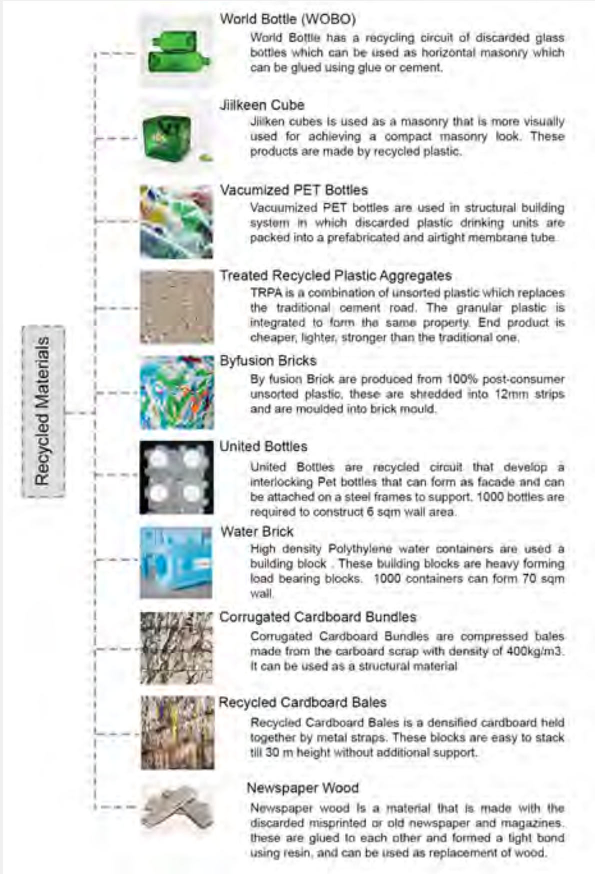
IMAGES

Example of reused and upcycle materials- Case study of A scalable building solution— circle house, Copenhagen by 3XN Architects.[4]

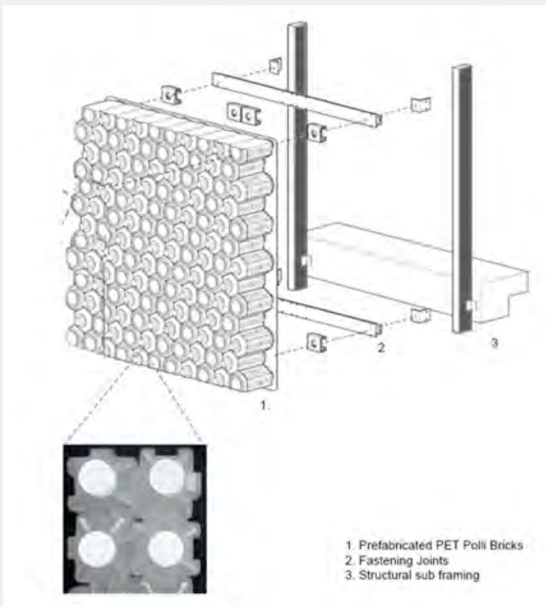
Material Palatte



Catalogue of material :



Example of PET Bottle Interlocking building blocks :
The Polly Brick exhibits the possibility to assemble and dissassemble the components.[5]



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THANKS

Handout

WRITTEN BY FAHMI BAHMDAN

Designing for Disassembly with concrete

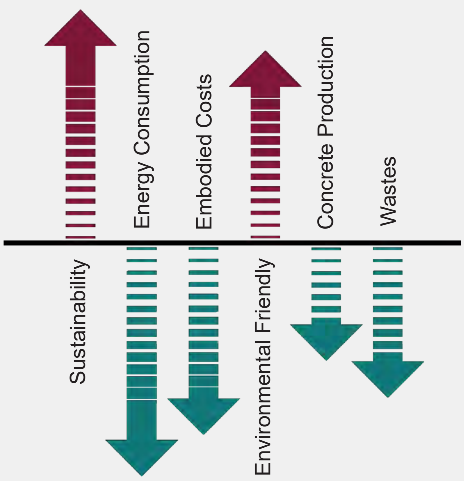
INTRODUCTION

This handout presents a beginner's overview of the opportunities to turn the concrete to flexibility and sustainability, and that by reusing the structural elements (such as columns and beams) of a building will be demolished. Moreover, making analysing and researching to find a type of concrete contributes significantly to reduce consumed energy in manufacturing process and in terms of embodied too.

The beginning of the research was through a complete review of concrete history which is resulted in creation a full image about the material specially in terms of its construction's design concept. The next step was to identify the negative aspects of this material and the causes of that negativity. With the emergence of the sources that cause these negativities, solutions can be identified. Moreover, a similar case study investigation can be helped for effectiveness.

Research Methdology

Expected Results



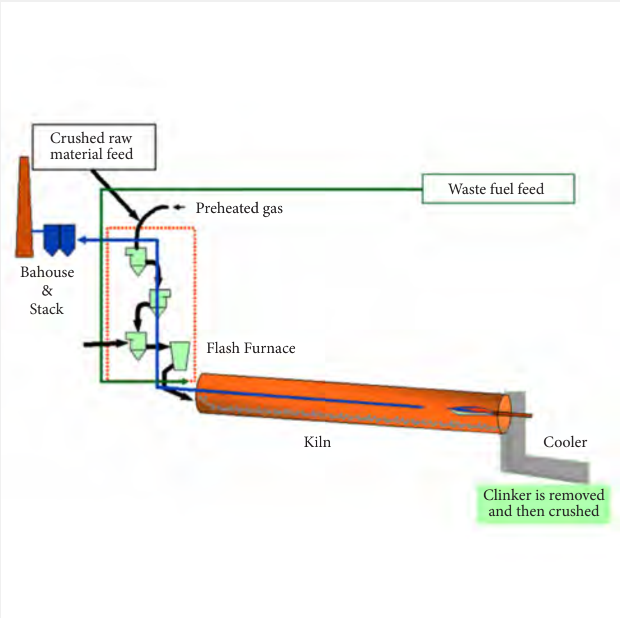
BACKGROUND

The shared opinion about concrete over the time, is a material which has a high average of durability and strengths. This acquired reputation was one of the reasons why this substance spread so widely. With the wide spread of this material, many environmental and health issues appeared. One of the most dangerous outputs from the concrete industries is the carbon dioxide emissions and that emitted in a huge amount during the manufacture of concrete. For instance, the new transport project in London Crossrail Line, if the whole project was constructed in the same time, it will emit 10 million tonnes of CO_2. This amount of CO_2 is equivalent to what a whole city emitted in size of Birmingham.

Moreover, the concrete constitutes approximately 8% of the global CO_2 output. What makes the situation worse is the increasing of cement production which is the main substance of concrete composition. The latest statistics indicate that the rate of increase in the cement industries in a year is quadrupled comparing with the year before. This led to the interest of researchers in the engineering field to study the material from many aspects. As a result, several types of cements have emerged which are considered as a good alternative of using the Portland cement.

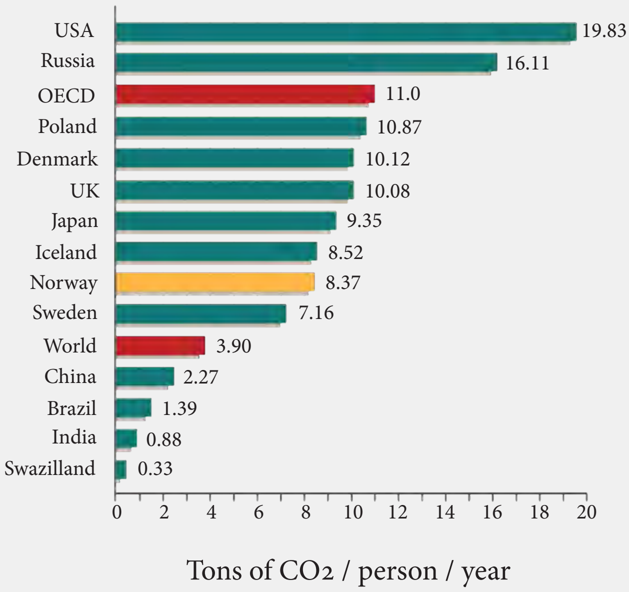
In addition, the current periods are witnessing a sharp increase in the prices of materials and constructions, as well as the wages of workers. This also can be seen through the high rental price of accommodations. Therefore, ownership of housing has become a burden facing most societies. Even on the scale of governments, the projects that will be constructed must be studied under the investment scope and measured by the financial returns which determines the decision of construction a building. Also, this can be observed through the type of newly established projects in most countries which aimed primarily at investment. Undoubtedly, the huge inflation in the prices of construction is considered one of the reasons to these phenomena.

- Concrete Manufacturing



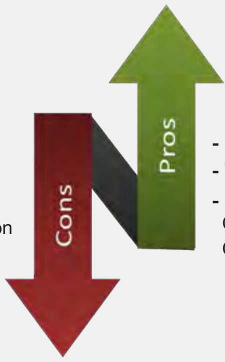
In the process of concrete, the carbon dioxide emissions are resulted from two sources:
- The biggest one is from the operation of the rotary kiln by combustion the fossil fuels.
- The second source of CO_2, is gained during the calcining limestone into lime.

- CO2 Emission per Capita in 1990



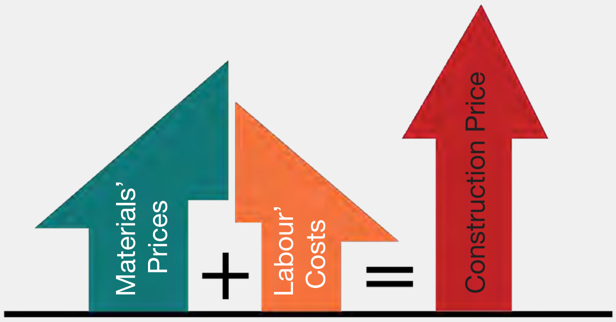
- Portland Concrete

- Carbon Dioxide Emissions
- Difficult to Recycle
- High Energy Consumption
- Water Consumption & Pollution
- High Absorption of Sun Heat & Gases
- Healthy Issues



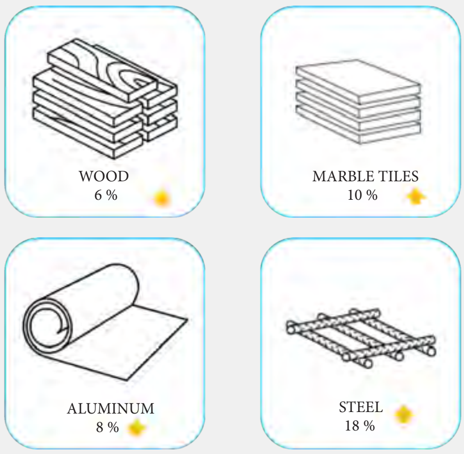
- Durable Material
- Wide Live Span
- Easily Constructed Comparing with Other Construction Materials

THE INCREASING IN EMBODIED COSTS



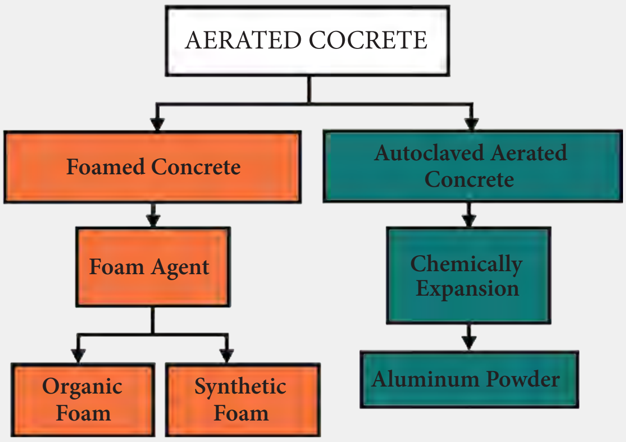
An Example:

The Increased Percentage in The Prices of Some Materials in Saudi Arabia Between 2017- 2018



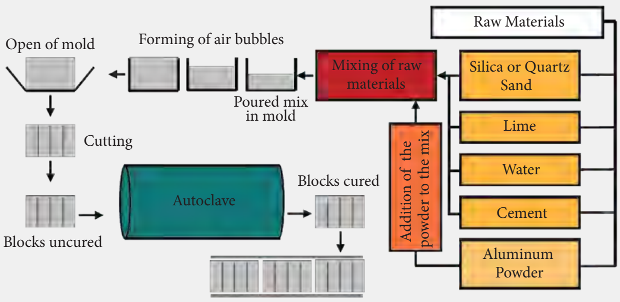
According to the study by Colliers International in Saudi Arabia, they are estimating every 10% increase in the cost of labor will increase construction cost by 3%.

SUGGESTED SOLUTION / REPLACING BY A DEVELOPED CONCRETE



- Foamed concrete proved its high potential in isolation and leveling works.
- Aerated concrete has many advantages, the most important properties of it are the durability and light in weight.

- Manufacturing Process



- The Ability Teasting Between Non-Autoclaved & Autoclaved

THE RESULTS:

1- Testing of Strength

Autoclaved Concrete

Non-autoclaved Concrete

2- The Pressure Test

Autoclaved Concrete

32.7kn

Non-autoclaved Concrete

45.4kn

3- Water Absorption

Autoclaved Concrete

Absorption rate 60%

Non-autoclaved Concrete

Absorption rate 30%

4- The Resilience to Fractures Test

Autoclaved Concrete

Non-autoclaved Concrete

Notice: for further information of the test check this video link:
https://www.youtube.com/watch?v=JYXtkb2q52M.

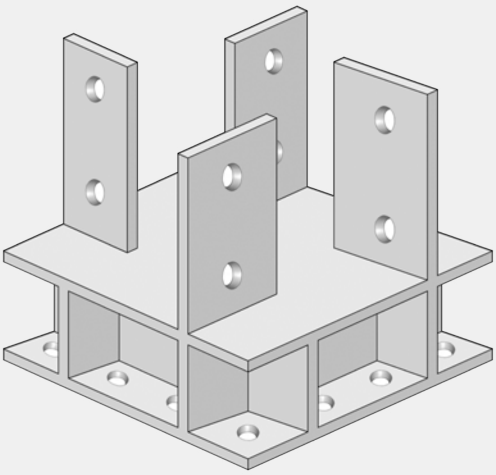
- Comparision Between Aerated & Solid Concrete

CATEGORIES	SOLID CONCRETE	AAC
COLOUR	Light Grey	Grey
WEIGHT	More	Less
PLASTERING	Easly	Hard to Stick
COMPRESSIVE STRENTH	4 to 5 N/mm2	2 to 7 N/mm2
THERMAL CONDUCTIVITY	Heat Transfer Is High	Less Heat Transfer Resulted in Reduc-ing Energy Cost
WATER CONSUMPTION	More for Curing	Required Less Water
TRANSPORTA-TION	Difficult Due to Its Wieght	Easly
GREEN PRODUCT	No	Reduce Industrial Waste
COST	No Savings	Saving: - Steel up to15% - Concrete up to7%

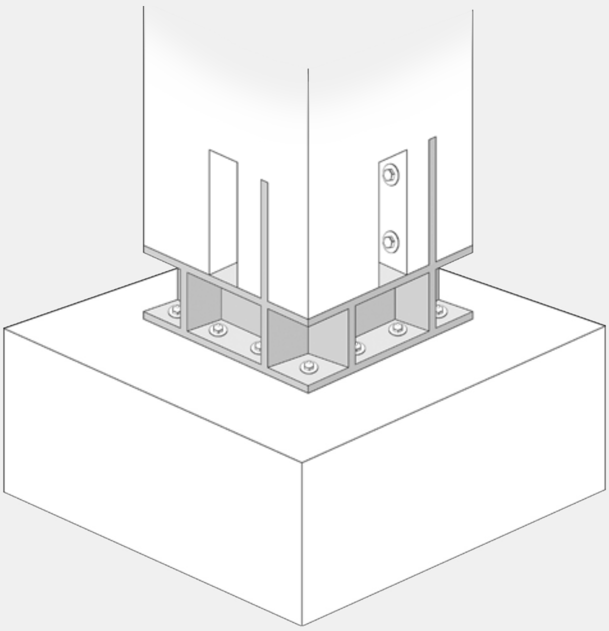
/ DESIGN FOR DISASSEMBLY (DfD)

- Connecting Columns with Bases

THE JOINT:

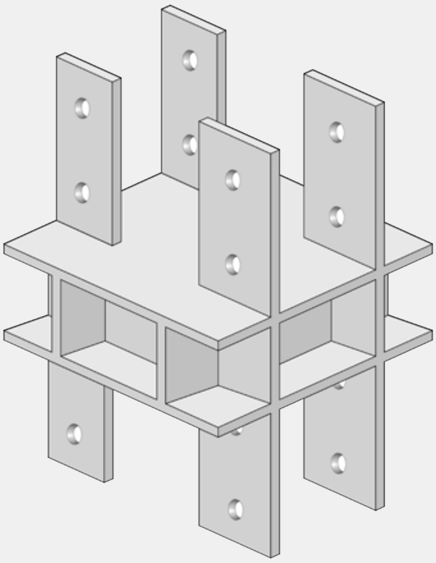


THE JOINT IN THE COMPONENTS:

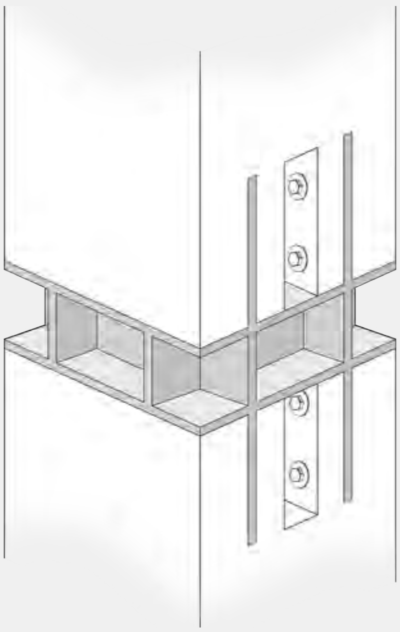


- Connecting Extended Column

THE JOINT:



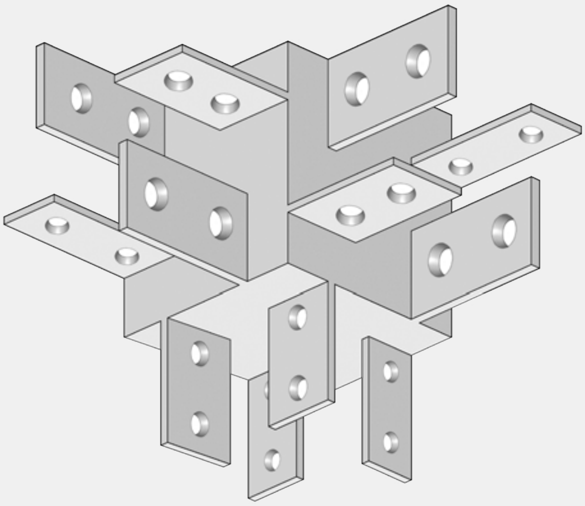
THE JOINT IN THE COMPONENTS:



/ DESIGN FOR DISASSEMBLY (DfD)

- Connecting Column with Cross Beams

THE JOINT:



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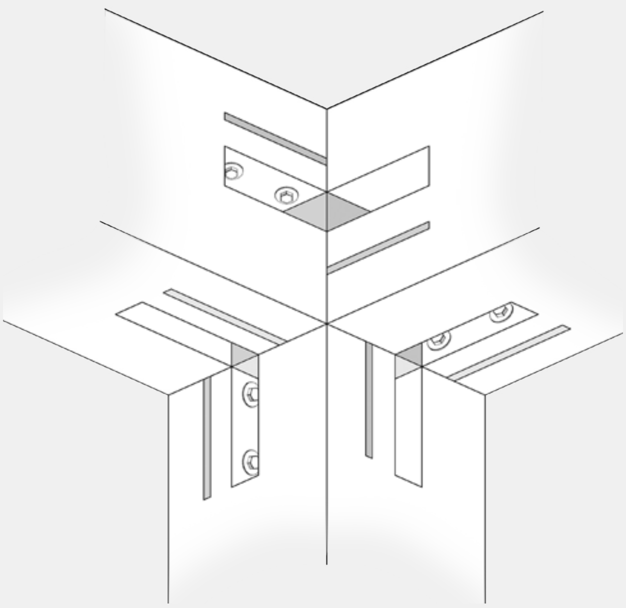
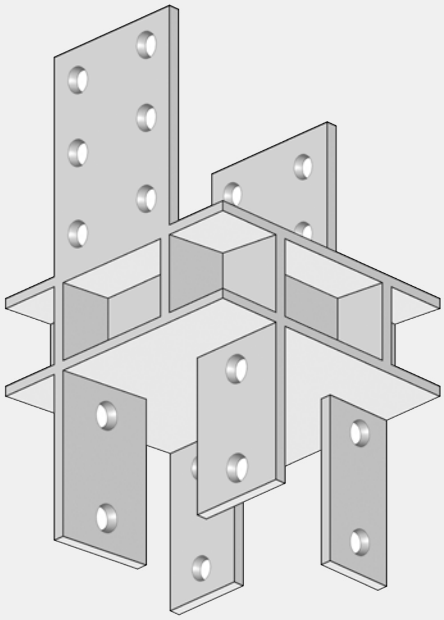
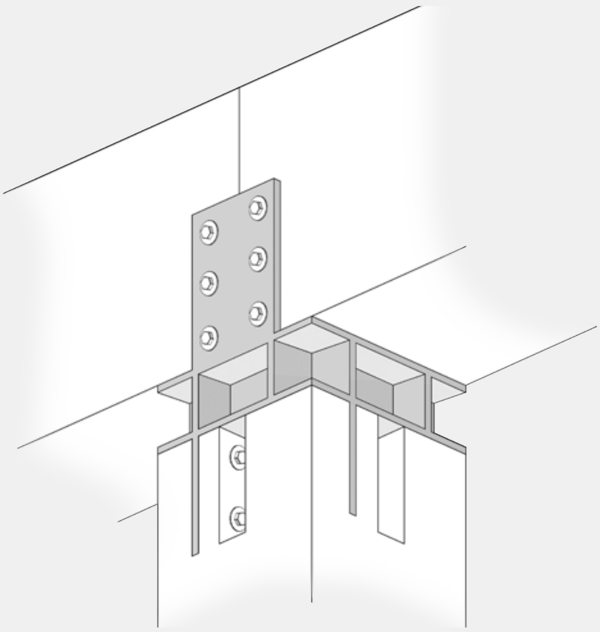


- Connecting Column with Horizontal Beams

THE JOINT:



THE JOINT IN THE COMPONENTS:



Handout

LIMING ZHENG

Designing with Waste glass in Australia

INTRODUCTION

This handout presents a beginner's overview of the opportunities to use waste glass as a construction material in Australia. Did you know that the world generated about 2.1 billion tonnes of solid waste every year? Among them, about 1.2 million to 1.3 million tonnes of glass comes from Australia. The recycling glass mainly happened and collected through the household consumption and commercial consumption. The source of glass material is mainly from glass packaging, where the glass packaging is primarily used in the food and beverage industry. The world's population is growing and urbanisation, thus the amount of glass waste generated will continue to increase. In fact, waste glass is 100% recyclable, it can be reprocessed, and it does not reduce the quality or purity of the glass. Therefore, the glass is a sustainable resource, and it can completely transform waste glass into profit. There are 40% to 70% of the glass product in Australia are recyclable glass. For every 1 million tonnes of waste glass, 0.60 million tonnes can be recovered each year, and the recovery rate can reach to 56%. The energy saved per tonne of glass can be saved up to 75%; hence, the recycling of waste can greatly reduce the environmental pollution.[1]

BACKGROUND

With the increasingly extensive use of glass materials, a large amount of waste glass products is formed, resulting in the waste of resources. Waste glass can be sent to the material recovery facility (MRF), where they can further process the waste glass; thus, the waste glass can be reused. There are two outputs of glass reprocessing in Australia, which are cullet and glass fines. The cullet is waste glass that is added to the raw batch in making new glassware, the glass fines utilising recycled glass as a substitute ingredient for raw materials in other products.

One of the most attractive ways to solve the environmental impact is to use waste glass in the construction industry because they have a wide range of construction sites that require large quantities of construction materials. The glass contains large quantities of silicon and calcium in its chemical composition, and it can be use with glass powder as supplementary cementitious material in construction material. The recycled glass can be substituted for up to 95% of raw materials. Crushed recycled glass that can be use as filler in other construction materials, such as cement, asphalt, ceramic, insulation batts and filtration medium. This will not only have environmental benefits but also economical. [2]

The use of recycled glass can also slow down the mining process, and using recycled glass as raw material will produce the following benefits:

- Reduce landfill.
- Reduce CO2 emission: for every 10% of cullet used in production and it will reduce approximately 5% carbon emission.
- Reduce virgin raw materials usage.
- Energy saving: for every 10% of used cullet, it will save approximately 3% energy, and cullet requires less energy compare to raw materials.

TABLE 1

Material	Product	Application
Cement	Geopolymer cement	Adding glass micro-spheres, or replaced the other raw materials
Asphalt	Glassaphalt	Glass waste as additive, or replaced the other natural raw materials
Cermics	Tiles, Bricks, Porcelain, Stoneware, Glazes	Glass waste as additive, or replaced the other raw materials
Insulation batts	Glass wool batts	Add crushed glass powder into polyurethane foam insulating materials
Filtration medium	Glass filtration media	Glass powder replace-ment for traditional waster filtration media

Table 1 shows that recycled glass can be used as an ingredient to replace the raw materials in construction products or mixed into existing formulas. Adding waste glass as an additive to these materials does not affect its original performance of the product. Instead, it shows better performance in some products. For example, waste glass as an additive in reclaimed tiles. The tile is not strong enough in its machinal properties, by mixing with 20% of waste glass will improve its performance. Same as use glass powder as a replacement for traditional sand water filtration media, the glass is more effective than virgin sand. [3]

"If it can't be reduced, reused, repaired, rebuilt, refurbished, refinished, resold, recycled, or composted, then it should be restricted, designed or removed from production." [4]

– Pete Seeger, Folk Singer & Social Activist

DIAGRAMS

Figure 1: Glass Recycling process

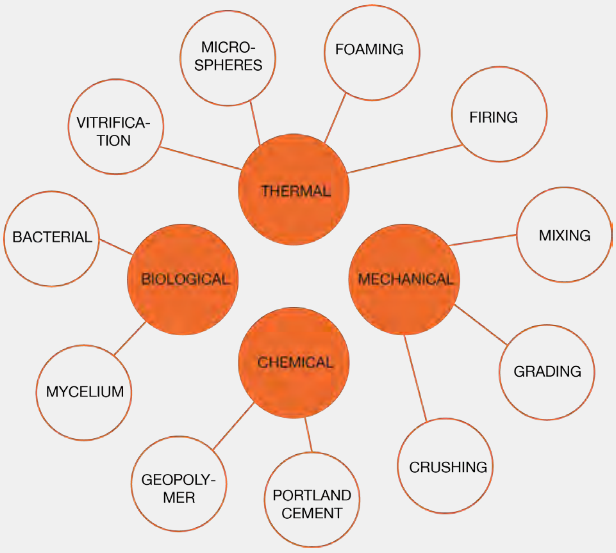


Figure 2: Manufacturing matrix for re-purposed glass fines *(RMIT,2019)*

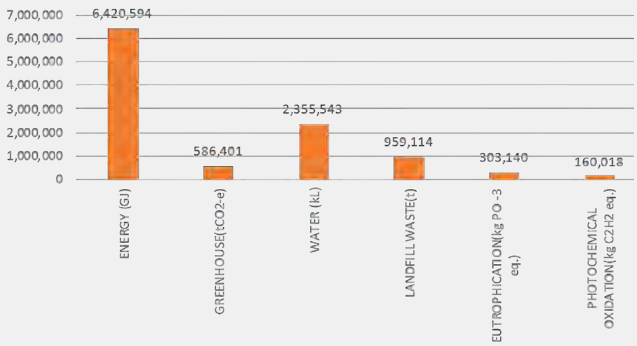


Figure 3: Annual environmental benefited due to recycling waste glass in Australia
(The Australian recycling sector,2012)

CASE STUDY

<u>Use recycled glass into insulation</u>

Fletcher Insulation is one of the leading insulation companies in Australia. Fletcher Insulation is the first insulation company that has obtained Good Environment Choice Australia (GECA) certification for its glasswool batts and unfaced blanket range of products. Fletcher Insulation uses a large amount of recycled materials to produce sustainable products. Their insulation material comes from the waste stream in glass cullet to produce glasswool insulation. Up to 74% of the total raw materials input of glasswool production came from post-consumer waste sources, such as scrapped car glass, residual materials from the glass manufacturing industry, and glass bottles from the packaging industry. Australia produces approximately 80,000 tonnes of insulation materials every year. Up to 70% of them can be recycled glass; hence the industry has the capacity to recover nearly 50,000 tonnes of glass.[5]

There is a challenge for applying glass to glasswool insulation. When producing glasswool insulation, it can only use up to 33% of bottle glass. If it exceed 33%, the product will have a problem because during the manufacturing process, the mixture is contaminated with too much coloured glass, it will increase the risk of sub-standard product. To solve this problem, Fletcher Insulation has established a cooperative relationship with the recycling industry to improve the quality of waste glass.

Using waste glass in glass wool insulation will have following benefits:

- Reduce the cost as the price of using waste glass is cheaper than unused glass material.
- Reduce energy consumption in the manufacturing process of insulation material, raw materials require 1600 °C during the production process, and the use of waste glass can be reduced to 800 to 900 °C.
- Low environmental impact.
- Low product emissions.

Figure 4: Glasswool Insulation *(Nuclear-power)*

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Handout

NURUL AINA BINTI NADZRI

Environmental Impacts of Australian Premix Concrete Suppliers

INTRODUCTION

This handout shows a beginner summary of the environmental impacts of Australian Premix Concrete Suppliers. This research considers the exact situation occurred in the premix concrete industry in Australia and around the world.
The handout also compares the difference and similarities in suppliers' approach to provide sustainability. The use of raw materials and recycled wastes are also important to provide greener options for the clients, architects and builders. The comparison between conventional premix concrete and green premix concrete will provides better understanding of different alternative that is available on the market. The availability of other substitutes allows the clients to have more options in building design. This handout also includes the importance of assessing the life cycle of premix concrete from the extraction of raw materials, manufacturing process, usage of product and the product's end of life. The transparency of each supplier can also be seen based on the availability of product's information, data and annual reports.

BACKGROUND

This research is important to expose how much the impact generated using premix concrete as one of the construction materials towards the environment. The construction and buildings sectors contribute almost 40% of energy-related carbon dioxide productions around the world. The industry plays an important part in the biodiversity loss and climate breakdown while affecting the natural environments. The industry accounts for the third largest carbon dioxide emitter globally, behind China and the United States of America with 7% of globe's total carbon dioxide emissions. However, the manufacturing stage of concrete requires high amount of water and energy use. The supplies of limestones, a raw material in cement, are also getting scarce over the high demand. Disposal of concrete at the end of its construction life also create another environmental issue.
The Cement, Concrete & Aggregates Australia is responsible for the heavy construction materials industry in the country. This industry involved nearly 110 000 Australian workers both directly and indirectly while generating $15 Billion of revenues every year. The members of CCAA are producing more than 90% of Australia's cement output.

This research chooses three of CCAA foundation members in order to produce better understanding about the exact situation happens in Australia's premix concrete industry and how the members of the foundation are dealing with the global crisis and held responsible for its actions on the environment. The three chosen premix concrete suppliers are Hanson Australia Pty Ltd, Boral Australia and Holcim Australia Pty Ltd.
A transparent report of concrete products from the suppliers will create options for clients, architects and builders to choose the best concrete products. The best premix concrete product will generate minimal embodied energy during its lifecycle with slightest environmental affect in Australia and globally.
The results obtained from this report will create a reference for clients, architects and builders for creating sustainable buildings.
The transparency of the cement and premix concrete industry will help clients to choose more cost-effective and sustainable suppliers to contribute towards less harmful chemical and carbon emissions.

CONTENTS

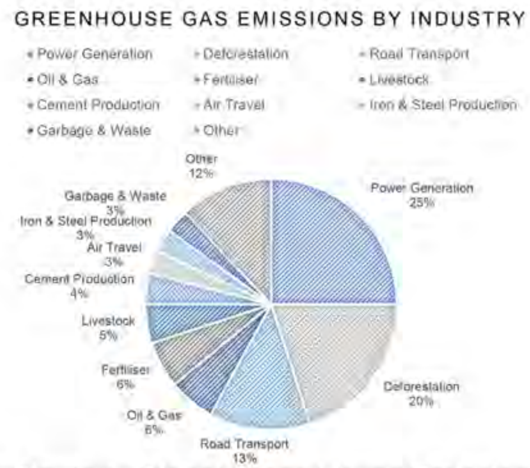

Figure 1. Global Green House Emissions.

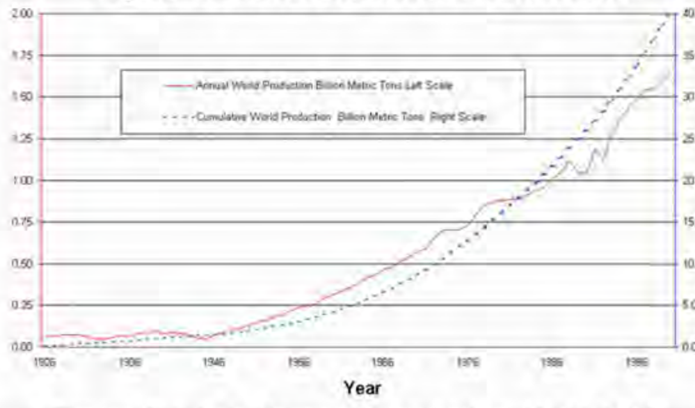

Figure 2. World Cement Production 1926-2000.
(Source: Greenspec, https://www.greenspec.co.uk/building-design/environmental-impacts-of-concrete/.)

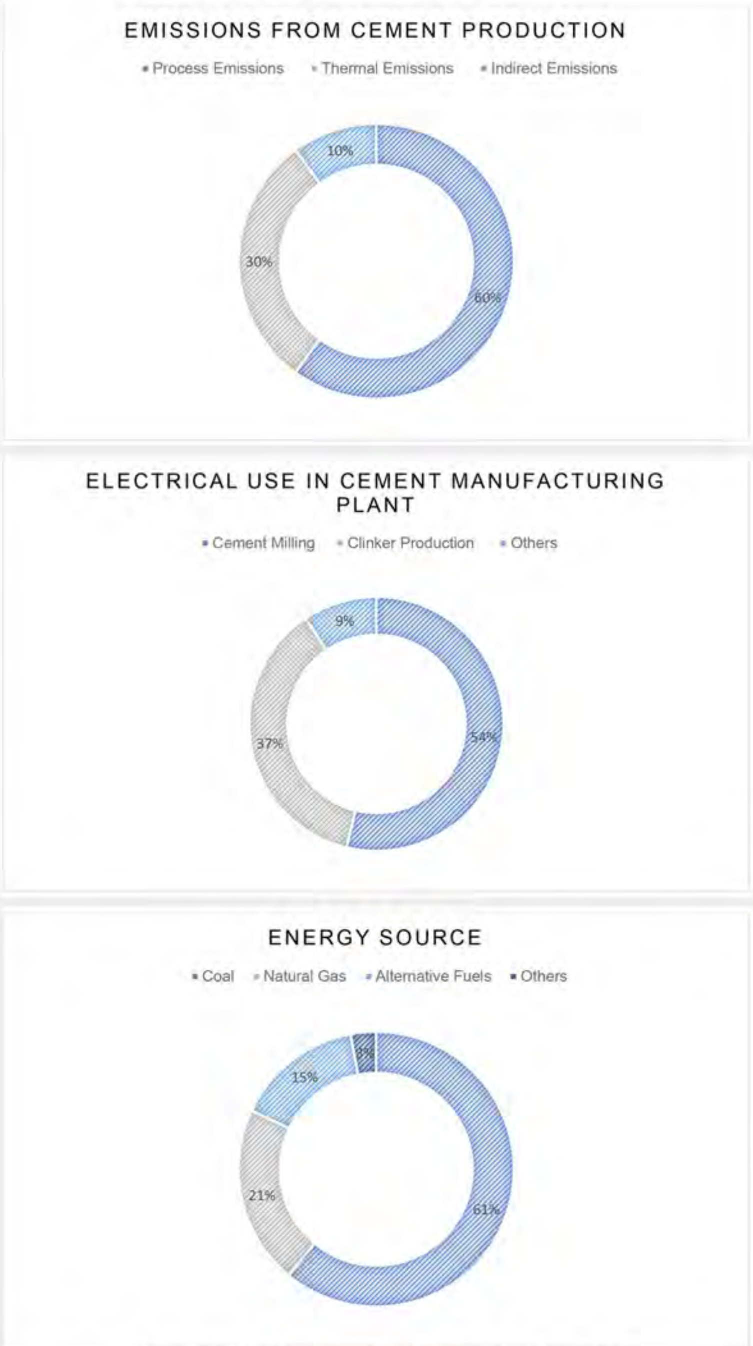

Figure 4. Concrete, Quarry & Cement Industries Report in Australia.

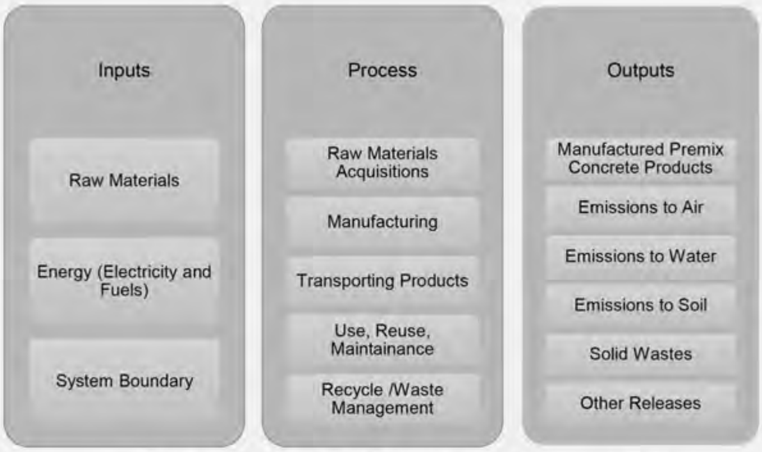

Figure 5. Premix Concrete's Process and Impacts on Environment.

Figure 6. Social, Economic and Environmental Performance to Create Sustainability

Hanson Australia Pty Ltd					
	Premixed Concrete	Concrete Washout (Crystalline Silica)	Recycled Water	Silica Sand	Quarry Products
Ecotoxity (Terrestrial)	No	No	Alkaline slurry with high percentage of water	No	No
Ecotoxity (Aquatic)	No	No	Alkaline slurry with high percentage of water	No	No
Persistence/ Solubility	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Biodegradability	Low / No	Low/ No	Low	No	No
Mobility in Landfill	Low	Low	High	Low	Low

Figure 7. Ecological Information for Hanson Australia Pty Ltd.

Boral Australia					
	Premixed Concrete	Concrete Washout (Crystalline Silica)	Recycled Water	Silica Sand	Quarry Products
Ecotoxity (Terrestrial)	No	No	Alkaline slurry with high percentage of water	No	No
Ecotoxity (Aquatic)	No	No	Alkaline slurry with high percentage of water	No	No
Persistence/ Solubility	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Biodegradability	Low / No	Low/ No	Low	No	No
Mobility in Landfill	Low	Low	High	Low	Low

Figure 8. Ecological Information for Boral Australia.

Holcim Australia Pty Ltd					
	Premixed Concrete	Concrete Washout (Crystalline Silica)	Recycled Water	Silica Sand	Quarry Products
Ecotoxity (Terrestrial)	No	No	Alkaline slurry with high percentage of water	No	No
Ecotoxity (Aquatic)	No	No	Alkaline slurry with high percentage of water	No	No
Persistence/ Solubility	Insoluble	Insoluble	Insoluble	Insoluble	Insoluble
Biodegradability	Low / No	Low/ No	Low	No	No
Mobility in Landfill	Low	Low	High	Low	Low

Figure 9. Ecological Information for Holcim Australia Pty Ltd.

Premix Concrete's Ingredients (Percentage, %)			
	Hanson Australia	Boral Limited	Holcim Australia Pty Ltd
Sand	20-85	30-60	Approx. 20
Crushed Stone/ Gravel	20-85	30-60	Approx. 60
Portland Cement	10-60	10-30	Approx. 10
Water	0-20	>10	<20
Blast Furnace Slag	0-20	10-30	Approx. 60 (in Aggregate)
Fly Ash Pozzolans	0-10	10-30	None
Silica Fume (Amorphous Silica)	0-10	None	<4
Chemical Admixtures/ Activators	0-10	<10	<1
Polystyrene Balls	2-10	None	<10
Polypropylene Fibres	0-60 (by volume)	None	<10
Steel Fibres	0-10	None	<10

Figure 10. Premix Concrete's Ingredients.

Comparison between Conventional Premix Concrete and Green Premix Concrete		
	Advantage	Disadvantage
Conventional Premix Concrete	• Very high durability • Low maintenance cost • Good fire resistance • Good water and wind resistance • High compressive strength than steel	• Reinforcement is required due to low tensile strength • Construction joints are required to prevent cracks • Expansion joints are required in long structures • Efflorescence occurs due to moisture from soluble salt
Green Premix Concrete	• Uses recycled raw materials from local sources • Reduce carbon dioxide gas emission during manufacturing process • Uses less amount of cement • Reduces environmental pollution • Economical and higher workability • Preparation of green premix concrete is almost identical to conventional concrete	• Lower tensile strength than the conventional premix concrete • The use of stainless steel as reinforcement increased the cost of construction • Higher water absorption than conventional premix concrete

Figure 11. Comparison between Conventional Premix Concrete and Green Premix Concrete.

Premixed Concrete's Alternative Building Construction Materials				
	Description	Example	Advantage	Disadvantage
Rammed Earth	• A mixture of aggregates such as silt, sand, gravel, and a tiny amount of clay	• Building blocks • Whole wall	• Aggregate and earth used determined the colour of rammed earth • Very strong in compression • High thermal mass as heavy masonry • Good sound insulation • Very good fire resistance • Very good vermin resistance • Low to moderate embodied energy	• Limited thermal insulation • Low durability when exposed to water • Non-conventional material (Not familiar to builders) • Difficult to create sculptural or rounded shaped walls • Difficult soil selection
Straw Bale	• Grasses like rice and wheat with high tensile strength. • Construction involved stacking rows of bales on raised foundation or footing. • The Bale Walls can be tied with timber or bamboo pins, or surface wire mesh	• Thatch Roof • Wattle and Daub Wall • Mixed with Earth in Cob	• Can be rendered with Earth or Cement • Good Structural Capability for loadbearing wall • Cost effective thermal insulation up to R30 or R35 • Cost effective sound insulation • Good fire resistance than timber frame • 100% Biodegradable and safe • High renewable material (6 months growing cycle) • Low embodied energy	• Very low thermal mass • Low durability when exposed to water • Non-conventional material (Not familiar to builders) • Wall thickness reduced total floor area • High cost of transportation if sourced far from the construction site. • Allergies from straw dust
Bamboo	• Traditionally linked as construction material in Asia, South Pacific and the Central and South America	• Building constructions • Bridges • Structures • Scaffolding	• Cost effective • Durable and strong • 100% Biodegradable and safe • High renewable material (Grow 35 inches daily)	• Low durability when exposed to water than timber • Flammable (Lower fire resistance) • The quality of bamboo may vary
Timber	• A type of wood that has been treated for carpentry and building construction	• Building constructions • Furnitures • Structures	• Good insulator • Durable and strong • Can be recycle • Renewable material • Easy and fast installation	• Changes in different climatic conditions • Flammable (Lower fire resistance) • High maintenance

Figure 12. Premixed Concrete's Alternative Building Construction Materials.

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Handout

WRITTEN BY QIULIN WANG

Environmental Impacts of Timber Manufacturing in Australia

INTRODUCTION

The growing global demand for timber products has led to an unprecedented boom in the timber manufacturing industry. Especially in countries with rich forest resources such as Australia, timber has become an indispensable building material for the construction industry. As a relatively clean and environmental-friendly material, timber has a long-life cycle and requires little maintenance during usage. Most of timber products can be fully recycled and reutilize at the end of its life cycle. The main impact on the environment comes from the production stage, which is the entire supply chain from harvesting, sawmilling to manufacturing. A large number of production and application has brought environmental problems like energy consumption, emissions, and waste production. All of these urge us to consider the possible environmental impacts in the process of timber production, and to seek solutions to minimize the pollution and make it become a veritable "environmental-friendly" building material. Therefore, this handout presents a beginner's overview on the potential environmental problems that may exist in Australian timber manufacturing industry. A step-by-step analysis on the production process and its environmental impact aims to provide readers with a general and correct understanding of the timber industry. Meanwhile, it serves as a wake-up call, reminding people to protect the nature we are in.

Figure1 - Logging of forests
Source: "Clear Cutting," Nelson Star, 4 September 2018, https://www.nelsonstar.com/opinion/letter-standing-up-to-clear-cutting/

BACKGROUND

In Australia, each person can produce about 1 ton of waste annually, of which the construction industry contributes more than 40% of it.[1] Therefore, the choice of materials and the its environmental impacts are particularly important. During growth stage, timber absorbs carbon dioxide from the air, converts it into carbon-based compounds and stores in the body, which making up half of the tree's dry weight. That is to say, the more carbon is left in the wood, whether in the form of trees or timber products, the more time is brought for us to improve the ecological environment. According to David Ellsworth from Western Sydney University, "Whatever you believe, buying us time is always a good thing here. Technologies will advance, treaties will go forward and those will all help with mitigating climate change."

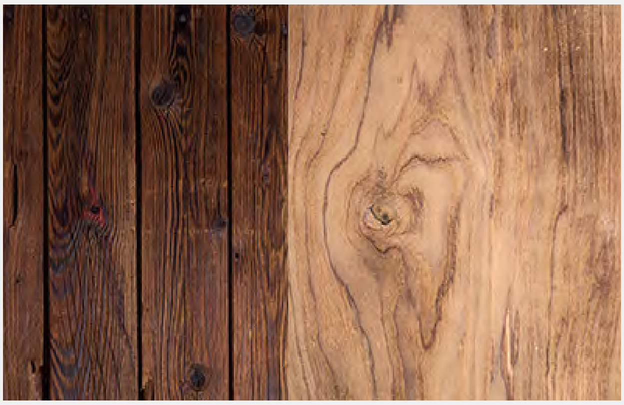


Figure2 - Hardwood and Softwood
Source: "Hardwood Versus Softwood," Forest Polywood, acessed 20 June 2020, https://forestplywood.com/blog plywood/hardwood-versus-softwood/

Timber in Australia is mainly divided into hardwood and softwood. Hardwoods as native species, mostly distributed in coastal and inland areas of the native forest. Softwood is mostly cultivated in commercial plantations as an exotic species. Hardwoods are characterized by dark colors, dense textures, strength and durability features, therefore commonly used as structural components, including floors, wooden beams or fences. In contrast, softwood has light colors, texture and is lightweight, often used as furniture components, decoration panels, etc.[3] The distinctive features determine the subtle differences in the manufacturing stage of the two categories of wood. Being heavier and harder, hardwood may consume more energy during transportation and conversion than softwood. The relatively closed cells also make the drying and preservative treatments become more difficult. Correspondingly, the production process of hardwood has a more significant environmental impact than softwood, which is worth discussing.

ENVIRONMENTAL IMAPCTS EVALUATION

This handout used the method of adding weighs to the factors that may affect the environment to carry out the assessment. 1, 3, and 5 were assigned to different factors, respectively representing the minimum, medium, and maximum contributions.[4] All data are aggregated with information from the EPD of Australian Hardwood issued by Wood Solution.[5]

	Felling	Transport	Conver-sion	Season-ing	Second-ary Pro-cessing
Timber	5	0	0	0	0
Power	1	5	3	1	3
Dust	1	0	5	0	3
GHG	1	3	3	1	3
Harmful Gas	0	0	3	0	0
Chemical	0	0	0	1	3
Water Pollution	0	0	0	0	3
Offcuts	1	0	5	0	1
Solid Waste	0	0	0	0	3

From1 - The contribution of each process in timber production that may affect the environment

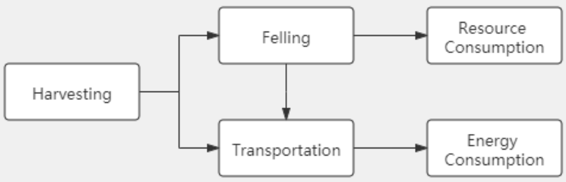
In Form2, ABCDEF represents different environmental impacts, which specifically:

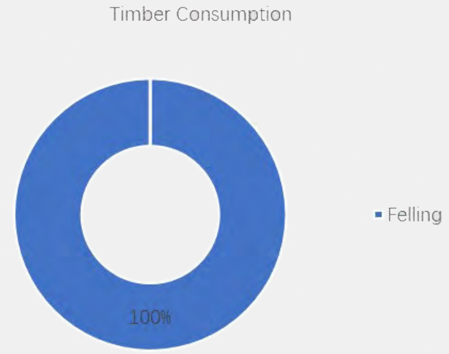
A - Climate effects
B - Ozone layer reducing
C - Acidification
D - Harmful emissions
E - Organic pollutants
F - Impoverishing of nature types, biotypes, etc.

	A	B	C	D	E	F	Load	Sum
Timber	5	0	3	0	0	3	5	55
Power	5	3	1	3	0	0	3	36
Dust	3	0	0	1	0	0	1	4
GHG	5	3	3	3	0	0	5	70
Harmful Gas	5	3	3	3	0	0	5	70
Chemical	0	1	3	1	3	0	1	8
Water Pollution	0	0	0	0	1	1	1	2
Offcuts	1	0	0	0	0	0	1	1
Solid Waste	3	0	0	3	3	0	3	27

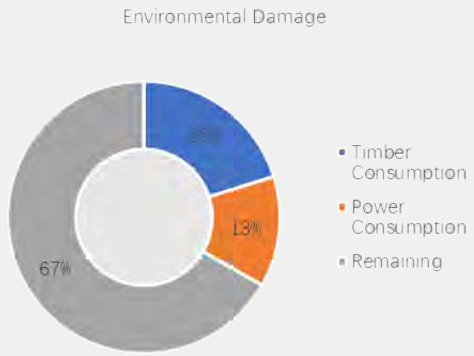
Form2 - The contribution of different factors to the direct consequences of environmental damage

HARVESTING

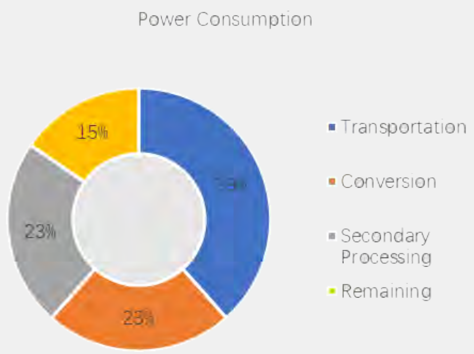




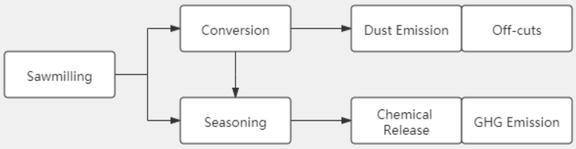
FELLING is the first step in wood production. Workers choose to fell mature trees in the right season. Every tree cut down will be replaced by a seedling to keep the forest sustainable.[6] However, if logging is not carried out in such manner, it will result in the consumption and waste of resources and have an impact on the environment. As can be seen from both charts, the consumption of forest resources in the felling stage causes 20% of the environmental damage, and all the waste of resources comes from unethical logging

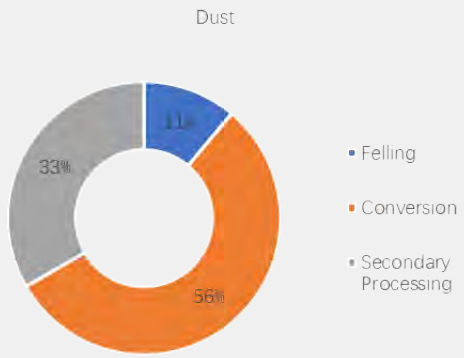


TRANSPORTATION as the second stage, ships timber from remote forests or plantations to sawmills or paper mills.[7] It will consume a lot of fossil fuels and emit greenhouse gases, which will aggravate the greenhouse effect. As can be seen from the chart, although transportation is not the only consumption source of energy, it contributes 39% of it. And there are 13% of environmental damage coming from energy consumption throughout the whole production process (including transportation, conversion, secondary processing and so on).

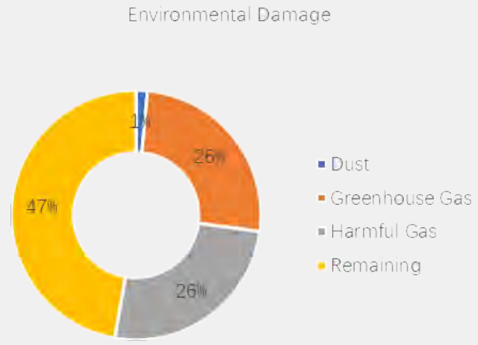


SAWMILLING



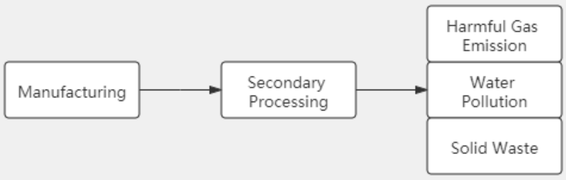


CONVERSION, which the timber is roughly sawed through "breaking down," while the "re-sawing" removes the curved edges and gives a final finish. Now the wood looks more like a board.[8] However, there will be a lot of waste products in this stage, including off-cuts, wood chips, and sanding power. Floating dust in the air could be harmful to the health. As can be seen from above chart, conversion produced more than half of the dust. Although the environmental impact of dust is not as significant as other factors, it does cause serious health damage to sawmill workers and nearby residents.



SEASONING is the process of drying water content contained in the sawnwood, making it hard and difficult to deform. It mainly contains two methods: (1) Air seasoning, in which the water content is carried out by air flow. (2) Kiln seasoning, in which the water content is carried out by thermal energy.[9] Potential environmental problem is that air seasoning may cause a part of water that carrying preservatives to penetrate into the ground, affecting the biodiversity of the land. Kiln seasoning constitutes a stable and easily controlled environment (temperature, humidity and air circulation). However, a large amount of energy is consumed in this process, resulting in greenhouse and harmful gases are emitted.

MANUFACTURING



SECONDARY PROCESSING is the last step in wood production. Sawnwood are shipped to furniture factories, veneer yards, and so on. Any preferred treatments are applied to produce timber products that meet different needs and functions. Once all the treatments have been made, the timber product can be shipped to suppliers for sale.[10] Due to the numerous and complex steps in this stage, it will generate various impacts on different aspects of the environment.

First of all, adhesives and wood coatings release large amounts of chemical gases. Free formaldehyde floats in the air is harmful for human health. In addition, the coatings used in wood panels contains 30% ~ 80% organic solvent. Most of them are flammable, explosive and poisonous, which will endanger human health.

Water pollution is another potential effect. Wood industrial wastewater mainly contains suspended solids, adhesive residues and various soluble chemicals. They spread pollution with the flow, causing serious damage to the river ecosystem.

A large number of solid wastes could be produced during secondary processing. Like other industrial wastes, solid wastes are generally easy to be seen, but often not easy to be aware of. The harmful metal compounds may result in a loss of biodiversity to the land. Through biological decomposition or internal chemical reaction, it could produce a large number of harmful gases, causing air pollution.

Figure3 - Subtle Godzilla
Source: "Subtle Godzilla," Reddit, acessed 20 June 2020, https://www.reddit.com/r/wallpapers/comments/2190q3/my_very_subtle_godzilla_wallpaper_1920x1080/

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3. "Our Industry," Timber NSW, accessed 10 June 2020, https://timbernsw.com.au/our-industry-2/
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Handout

WRITTEN BY ANDREW KWOK

facade design for circular economy principles

The principles of the Linear economy and circular economy.

"Illustrating the flow of bioloical and technical nutrients in the linear vs. the circular economy," Building a circular future (Denmark: 3XN Architects. 3rd ed, 2019),175,176.

INTRODUCTION

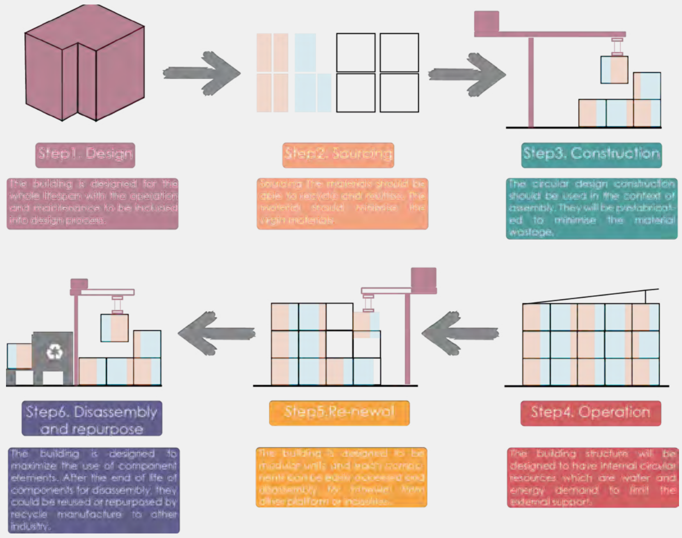
This handout presents to a beginner to understand the Circular Economy apply in the building industry by analyzing how the building industry use building façade to support the Circular Economy principles. A normal building can maintain up to fifty years before demolition to the ground but most of the buildings do not survivor to fifty years due to different reasons. According to Building a Circular Future, a normal building foundation would last up to 100 years of lifespans. If we could find a way to refurbish other elements of building such as structure, Façade, Partitions, and systems and things we could continue the building lifespans. The procedures of maintaining a building façade either changing to a module or carrying a major renovation which would waste a lot of energy and the loss of scarce and valuable raw materials. It is key to design the façade that can be easily altered and regenerated. Circular design principles will allow the building façade to have a longer lifespan due to the design principle of product cycles or reusable design.

BACKGROUND

Nowadays, the increasing use of natural resources had brought a significant problem of a negative impact on our world environment. In the building industry, the problem of using too many resources is the linear model of construction process for the building of which will lead to the demolishing of the last stage of the life cycle. The demolishing of the building will create a massive of waste energy and labor also it left behind enormous of building waste which would create negative impacts on the environment and resulted in resource scarcity.

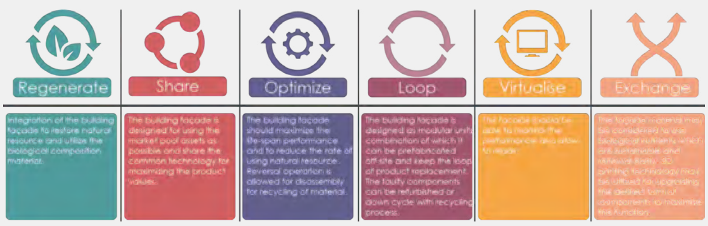
The circular economy principles are the way that could make the future better. The idea of the circular economy principles was to design a product that could be restorative and regenerative from which it allows the components or materials are in the highest values using at any time. Using the modern technology and manufacturing technique to develop a demountable and reusable façade as a strategy for the circular economy is trending for façade development. Design for disassembly had been introduced for contemporary building but not well encouraged and only limited to smaller projects and temporary structures. Developing a multi-level commercial building using the circular design principles needs to meet those design criteria which are design, sourcing, construction, operation, renewal, disassembly, and repurpose. The building façade is one of the elements that can be designed for operation, re-newal, disassembly, and repurpose following the design for circular economy principles. This method could benefit the lifecycle of the building, the cost of the maintenance for the building, and the impact of the environment as mentioned before.The circular design façade system should be able to regenerate, share assets design, optimize the façade performance, loop modular design, virtualize of repair, and ex-change.

BUILDING A CIRCULAR BUILDING



"Application of Circular Economy Principles to Commercial Property," The circular economy in the built environment (London UK: Arup, 2016),44.

CIRCULAR FACADE

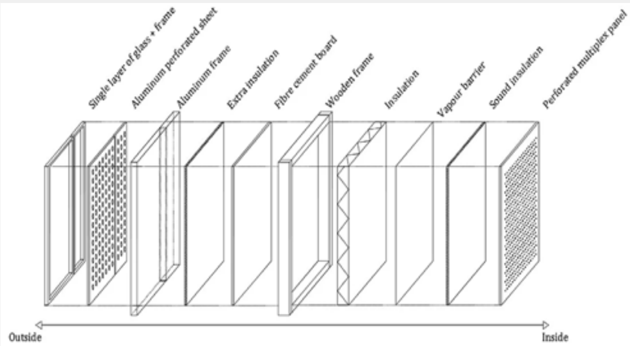


"7S illustrative example (Source: Stuart Brand's Shearing Layers, from How Buildings Learn: What Happens After They're Built," The circular economy in the built environment (London UK: Arup, 2016),66-67.

CASE STUDY 1 AEROPOLIS II

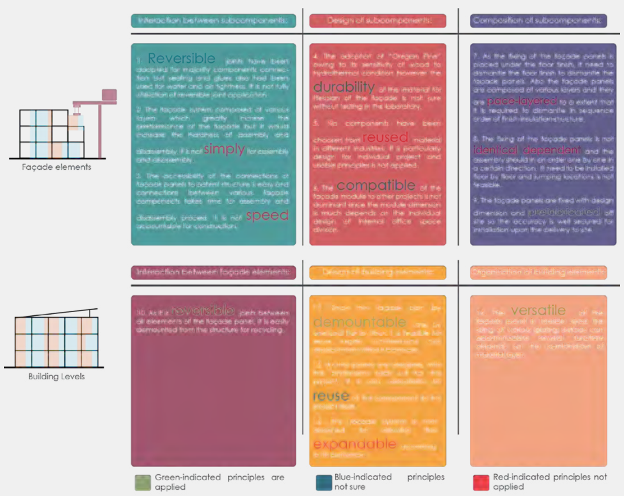
Developer: Groep Arco – KWB – KAV – KAJ
Design by: Architectes Associés

Architectes Associés, Aeropolis II,medium, 1485x 976, Belgium, Schaerbeek, 12/06/2020 accessed , https://www.circularfacades.com/aeropolis-ii.



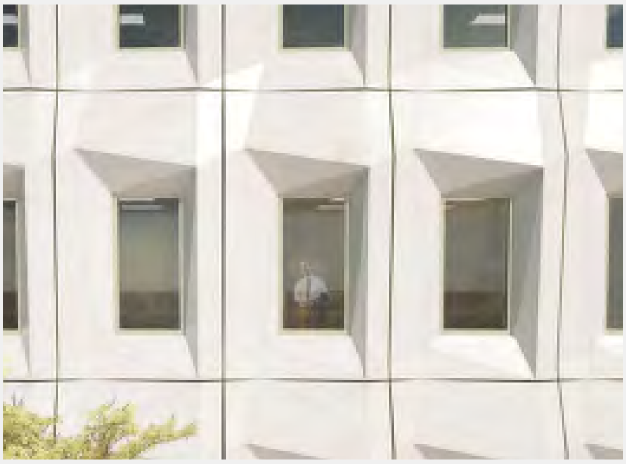
The explooded view of different layers in the façade modules

Architectes Associés, Exploded view of the different layers in a façade modules of Aeropolis II,medium, 1519 x 697, Belgium, Schaerbeek, 12/06/2020 accessed , https://www.circularfacades.com/aeropolis-ii



CASE STUDY 2 BioBuild: structural façade panel in biocomposite materials

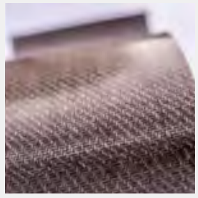
Developer: Guglielmo Carra, Senior Engineer & EU Technical Leader Materials Consulting, Arup



"BioBuild: structural façade panel in biocomposite materials," CIRCULARITY IN THE BUILT ENVIRONMENT: CASE STUDIES (United Kingdom: Ellen MacArthur Foundation, 2016),48.

Natural plants

Natural fibers



Natural resins

The materials used to manufacture the panel

"BioBuild: structural façade panel in biocomposite materials," CIRCULARITY IN THE BUILT ENVIRONMENT: CASE STUDIES (United Kingdom: Ellen MacArthur Foundation, 2016),50.

Circulation of values and resource:

1. The raw material of façade panel is deverived from easy accessible of biologic plants from which the production is having great circulation values from natural resource.

Beneficial to enviroment:

2. As the façade panels are made from biologic plant, it absorbs carbon dioxide from atmosphere as a living façade of a building makes the reduction of carbon dioxide content in the enviroment.

The reducing of embodied energy:

3. The panel form is derived from bio-decomposition such that the embodied energy required can be greatly reduced when comparing with other resource used through processes of mining, factory structural form creating, transportion, maintenance and end-of-life.

Light weight façade system to save structural loading to building:

4. The biocomposite panels are comparative light weight to other metal façade system but they even are having outer and inner layrers as insulation for the building energy comsumption saving.

Prefabrication and design for easy assembly and disassembly:

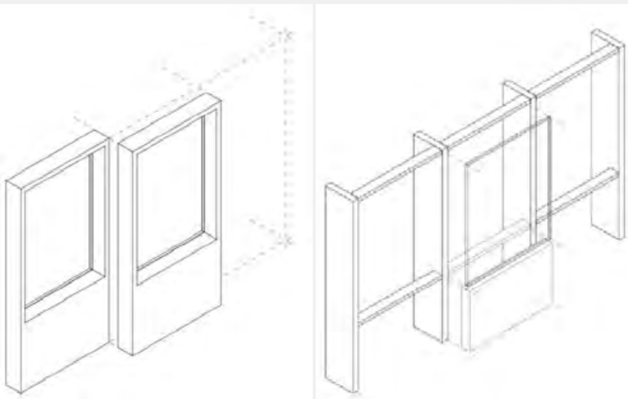
5. The biocomposite can be fully prefabricated off-site according the modular design of panels. The structure panels fixing with interfacing joints are designed for easy assembly/disassembly and easy accessible.

CASE STUDY 3 Municipal office Venlo

Architect: Kraaijvanger architects, Hans Goverde

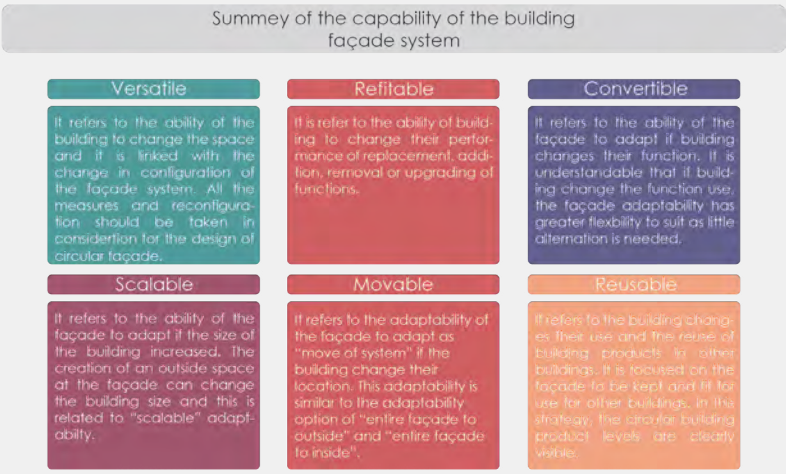
Contractor: Laudy bouw & ontwikkeling Ballast Nedam Bouw & Ontwikkeling

"Artistic impression biological facade (north and east side) municipality office Venlo," Built-to-rebuild (Netherlands: Eindhoven University of Technology, 2015),52.

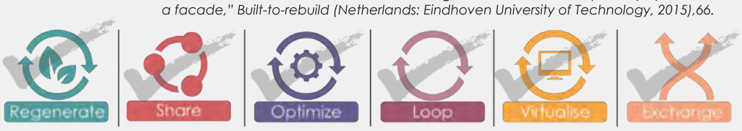


Unitised facade system prefabrication off-site and assembly on site by small labour force and the stick façade system connection.

"Stick facade system, illustrated a post and-beam facade, consisting of storey-high vertical mullions linked by horizontal transoms," Built-to-rebuild (Netherlands: Eindhoven University of Technology, 2015),53.



"Adaptability options overview: Adaptability strategies related to the adaptability options for a facade," Built-to-rebuild (Netherlands: Eindhoven University of Technology, 2015),66.



LINKS

Building-a-Circular-Future

https://gxn.3xn.com/wp-content/uploads/sites/4/2018/09/Building-a-Circular-Future_3rd-Edition_Compressed_V2-1.pdf

The circular economy in the built environment

https://www.arup.com/perspectives/publications/research/section/circular-economy-in-the-built-environment

Built-to-rebuild

https://research.tue.nl/en/studentTheses/built-to-rebuild

Aeropolis II." Circular facades

https://www.circularfacades.com/aeropolis-ii

Municipal offices based on circular principles

http://www.rebus.eu.com/wpcontent/uploads/2019/03/Municipal-offices-based-on-circular-principles.pdf

ADDITIONAL INFO

The circular economy principles are the way to create a circular future allows the building to maintain longer-lifespans and changes the way we construct building from linear mode construction design to a close-loop construction design from which everything can be recycled, reused and regenerate. In the future, building needs to develop a more closed-loop design that allows recycling, reuse, regenerate, assembly, and disassembly to support the Design for Circular Economy, the façade also needs adaptability focused on the modular design of façade panels to allow more versatile, refitable, convertible, scalable, movable. The more circular building design the better of the ecosystem for our future.

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THANKS

Handout

WRITTEN BY VIRAJ MHATRE

Good Thatching practice in Australia

INTRODUCTION

Indigenous Australians namely Aboriginals and Torres Strait Islanders used sophisticated methods of construction for their homes. For many decades their choice of materials for roofing was locally available thatch. In Contemporary Architecture thatch is said to be too primitive and traditional. However, thatch is available abundantly, is waterproof naturally, easy to harvest and ecological as it stores carbon for a long amount of time. It is therefore a sustainable material and can be considered as a building material in present-day constructions. Thatch does have some limitations. It cannot be used in dense areas, in cities and several other places. But thatch as a building material can be used in places like Museums, cultural centers, eco-tourism sites, places of historical and cultural importance, and in housing schemes for the indigenous people. This will serve double duties of promoting the message of historical importance as well as sustainability and green practice. This handout provides a detailed guide, explaining through pictures, how to achieve a high-quality thatching practice in Australia. The intention is to portray how easy it is to build a Thatch roof using some simple tools and a comprehensive guide.

BACKGROUND

For thousands of years before the European invasion, the local Australian Aboriginal community had established ideal environments for their culture and climate. Traditional Indigenous Homes ranged from temporary windbreaks to wiltjas (Shelters), tiny bark shelters constructed over a wooden frame of stringy bark or paper bark to big, oval, thatched-roofed houses for large families. Like every living technology it has been constantly developed and improved. Today, thatching can have much of the benefits of any new roofing tool, as well as the original good points that have rendered it so valuable over the years. Grass or weed re-grow every year, and with the simplest care, abundance of thatching material is provided. Thatching can provide the basis for small businesses where people have few or no resources, and thus may increase economic stability and independence. Farmers and grooming craftsmen will profit both directly and in effect the local economy. Thatch is an environmentally friendly roofing option because it uses natural and renewable materials and does not require much in terms of processing to reach a usable state. If the roof is decent and the stalk correctly installed, thatch is also weatherproof-it is demonstrated by the prevalence of stalk rooms in cold, humid spots, such as Scandinavia and the Scottish isles. In Australia, as an attractive, rustic roofing option for things like pergolas and outdoor shading than it is for house roofing. While thatch has many benefits, the most challenging obstacle is always the refusal of many to use what they see as an old-fashioned, primitive material. Perhaps the only approach to resolve such bias is to demonstrate how well thatch performs in reality.

The handbook looks at how to deliver high quality, long-lasting thatch roof, and demonstrate a fairly easy step by step methodology to lay and sustain thatch.

THE GUIDE TO THATCHING

1.1 Thatching Material

Tailing materials shall conform to the list of the most commonly used grasses and reeds in Australia and their geographic locations unless otherwise stated. This means that the stalk is of a type that has been used successfully as a roof in the geographical sites concerned and must be harvested when growth has stopped or the seed is ripened and dissolved. -- usage of stalk and all fire retardant systems shall not prematurely impact the existence of the stalk material or alter the quality of the substance. Thatch should be stowed so that the stem surface is not damaged, clear from the ground and not unnecessarily exposed to the weather.

1.2 Thatching Specification

A. Common or fine thatching grass (Hyparrhenia) for use shall:

A-1. Have a cut length of not less than 0,8m (measured from the butt end and including tips of seed ends)

Figure 1. Correct cut length longer than 0.8m

A-2. Have a minimum diameter and maximum diameter at the butt end of 1,2mm and 2,5mm respectively;

Figure 2. Correct diameter of butt end between 1.2mm and 2.5mm.

A-3. Be acceptably straight (cut above the first node);

Figure 3. Correct diameter of butt end between 1.2mm and 2.5mm.

A-4. Be free of loose material;

Figure 4. Properly harvested thatch free of any loose material.

A-5. Must not be in the growing season, Must be free of seed heads when cut;

Figure 5. Sample free of any seed heads at harvesting.

B. Storage of Thatch on site.

Figure 6. Thatching materials shall be stored such that:

1. the stem surface is not physically damaged,
2. the bundles are clear off the ground,
3. the bundles are not unduly exposed to moisture and the sun.

C. Cleaning and Bundling.

Each packet is shook to dislodge some loose material after the grass has been cut and loosely wrapped. The packets are washed by going through a sickle and operating from top to bottom.

D. The Roof Structure

The factors below can be used to calculate the pitch length of a roof depending on the roof angle. A = distance, B = height, C = pitch length measurement element.

ANGLE	A	B	C
45 deg.	1.000	1.000	1.414
50 deg.	1.000	1.192	1.556
55 deg.	1.000	1.428	1.734
60 deg.	1.000	1.732	2.000

E. Planting Posts

Figure 7. STAND: If a pole is planted on top of a concrete base make sure the base is completely dry before the pole is planted.

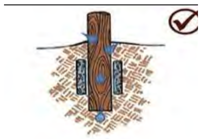

Figure 8. COLLAR: If concrete is used allow the concrete to form a collar with the pole protruding at the bottom to allow moisture to drain.

F. King Posts

FIGURE 9. All king posts are to have plum bobs attached at the top during the entire construction period. This eliminates distorted roofs. Uprights should not be more than 3,500 metres away and the total ring beam width should not be less than 150 mm Ø in every structure. When the building grows in diameter, the thickness of the ring beam must expand (when authorised by the engineer). Poles for use as rafters shall have a diameter of at least 100mm measured at the thin end of the pole.

G. Rafter Spacing

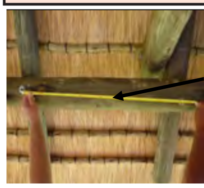

Figure 10. Showing 800 mm Correct rafter spacing, max is 900mm centre to centre

H. TRUSS Spacing

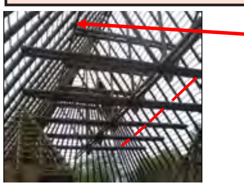

Figure 11. Intermediate Ring-beam

Trusses spaced correctly no more than 2.700m apart.

I. Ring Beam Connections

There are numerous failures in the ring beam and three main reasons:
1. The ring beam size is too small. 2. The uprights are well back. 3. There are no sufficient tie points on the ring beam adding additional tension.

Minimum ring beam thickness measured at the thin end of the pole, not less than 150 mm diameter. With building width raise the ring beam thickness (subject to the specification of the engineer)

K. Wind Braces

Figure 12. Shows braces fixed at the edge of the rafter posts.

L. Valleys

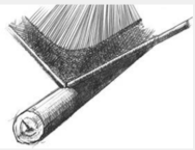

Figure 13. Section through a grass valley showing the thickening of the thatching layer over the valley.

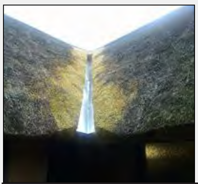

Figure 14. Showing Completed valley liner installation.

M. Hips

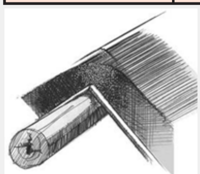

Figure 15. Section through hip showing a single pole and the thinner thatch layer over the corner.

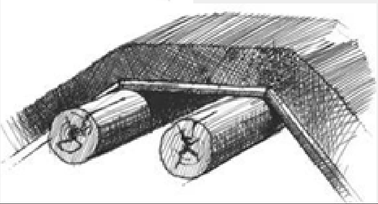

Figure 16. Section through a grass valley showing the thickening of the thatching layer over the valley.

N. Chimneys

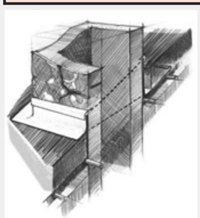

Figure 17. Cross-section through chimney, showing secret gutter and flashing details.

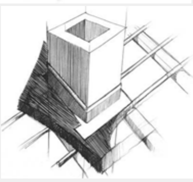

Figure 18. Preventing the thatch from sliding down.

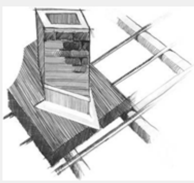

Figure 19. Alternative chimney detail to minimize water leaks.

1.3 Thatching

A. Spray layer "Spreilaag"

A coat of selected reed, cleaned stalks of stalk or cap stalk, called the spray layer (spreilaag), is evenly spread to the roof battens up to a thickness of about 5 to 8 mm before stalking. For grass, the comb is made by driving several round wire nails in a horizontal pole with a diameter of 75 x 3.5 mm about 300 mm. The nails are arranged in a straight line about 12 mm apart. The grass bundles are placed at the top of the comb and pressed down to separate the stalks by the nails. The packet is then drawn from top to bottom via the comb.

Figure 20. Good example butt and seed ends are not visible. The butt ends are concealed. Twine is tight around the lath.

Figure 21. Neat finish to sprei layer

B. Thatch Binding

The components used are tar-treated twin sisal or stainless steel wire, or galvanised wire of 0.9 mm in diameter, with the thickness between 1 mm and 1.2 mm. Stitching with a maximum spacing of 110 mm.

Figure 22. Sisal tar twine binding

C. Binding Spacing

The materials used shall be tar-treated sisal twine or stainless steel wire with a diameter of between 1mm and 1,2mm or galvanized wire with a diameter of 0.9mm. Stitching spaced at a maximum of 110 mm.

Figure 23. Correct binding spacing at 110mm. Note the twine is tightly around the lath.

D. Binding Tension

The materials used shall be tar-treated sisal twine or stainless steel wire with a diameter of between 1mm and 1,2mm or galvanized wire with a diameter of 0.9mm. Stitching spaced at a maximum of 110 mm.

Figure 24. Correct binding tension.

E. Sway

Sways compose of either: Sways

1. Galvanized wire of at least 3,15 mm diameter
2. Cape reed in at least 10 mm bundles.

Figure 25. Galvanised wire sway of min 3.15mm

F. Laying of Thatch

Thatching starts from the edge at the base of the roof which is placed parallel to the rafters or trusses. At the end of the hip plane it shall extend parallel to the hip rafters. The maximum length of the stalk is held along the hip 's curve.

Figure 26. Displaying thatch wraps around laths when thatching. Pack length for at least three gaps, i.e. the tip must reach at least four laths.

1.4 Details

A. Ridges

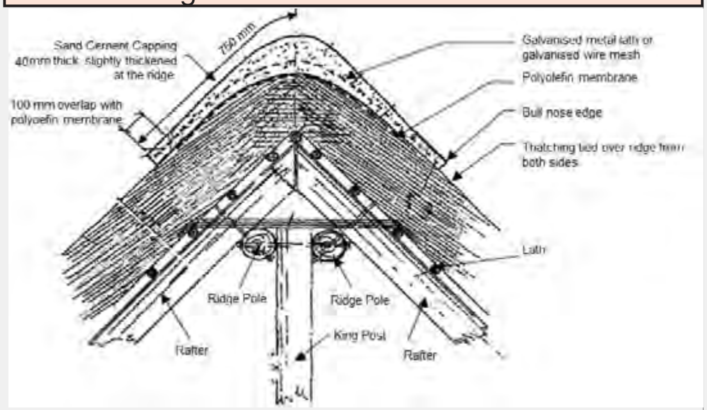

Figure 27. The capping of the ridge shall be a 40 mm (minimum) thick sandstone-ceiling (one-part common cement to four parts of sand) covered by a galvanated lath, or galvanised wire mesh, spread at least 750 mm from each side of a strip, placed on the single polyolefin membrane layer, and shall have a lath cover of not less than 20 mm and shall be suitably shaped and thickened on a strip.

1.5 Additional Information- General Installations

A. Flashing Installations

Flashes often lead to waterproofing areas. Devices that intrude through the roof plane will also be prevented to the fullest degree practicable.

Figure 28. The best way to mount wall flashes and silicon used for scrubbing grass under the flashing plus less than 10 mm thick and 200 mm of thatching grass over the flashing.

B. Bird Mesh Installations

Correct way to fit bird mesh for baboons (maximum size of holes: 25 mm)

Figure 29. Bird mesh fitted around 'voetlaag' stitch around first batten with thin galvanize wire.

C. Box Gutter Installations

It is preferable to not have valleys discharging rain water over the front door.

Figure 30. A steel box gutter can be made to fit this problem area over a front door and concealed by using poles and laths.

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THANKYOU

Handout

WRITTEN BY ZOE WELLS

Guide to specifying local building materials manufacturers

INTRODUCTION

This handout presents a beginners guide to specifying local building manufacturers by assesing the environmental, economic and social sustainability of a manufacturer. Using a simple yes/no point score system individuals can begin to compare manufacturer's against each aspect of sustainabiliity.

This handout will hopefully raise awareness and educate people, both industry professionals and the general population about the importance of sourcing and supporting locally building material manufacturer's as it contributes to a more wholesome approach to sustainability.

BACKGROUND

The construction industry is one of the biggest responsible for environmental impacts on the world and also impacts almost every other industry. Globalization has led to the minimisation of trade barriers has enabled both manufacturing to occur on a global scale and but also has enabled manufacturers to be more productive through the exploitation of natural raw sources.

However, this could have a detrimental effect on the world's natural resources and also has the potential to significantly impact the wellbeing of local communities and economies. We are living in a society where people's relationship to their environment truly matters and there are a growing number of people who are paying more attention to how everything impacts their community.

in order to build a truely sustainable environment within the industry sustainability must be considered more holistically. By approaching sustainability more holistically it can be broken down into the "Three Pillars of Sustainablity." These three pillars are environmental, economic and social and to develop a truly sustainabile outcome each aspect must be considered to be of equal importance.

ENVIRONMENTAL SUSTAINABILITY

1. Are your raw materials sourced within a 500km radius of your manufacturing location?

2. Do you have any recycling intiatives in place during manufacturing?

3. Do you have recycling initiatives in place for a buildng products End of Life Cycle?

4. As a manufacturer, do you offer transparency around your supply chains and manufacturing processes?

SCORE ____/4

ECONOMIC SUSTAINABILITY

1. Do you keep control of all aspects of the business in an attempt to be economically sustainable?

2. Where you source your raw material from, does it employ people within the local community?

3. Do you employ people within the local community at the manufacturing location?

4. Do you attempt to structure your manufacturing processes around supply and demand of your building material?

SCORE ____/4

SOCIAL SUSTAINABILITY

1. Have you developed lifelong relationships with local industry professionals?

2. Do you support the growth of people within the company?

3. Do you actively engage with the local community and engender trust by being open about your product and manufacturing process?

4. Do you actively educate the community about your product?

SCORE ____/4

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Handout

HYESU JEON

Recycling carpet in Austalia

INTRODUCTION

This handout examines a beginner's overview of the available opportunities in the waste carpet recycling industry across Australia. The primary objective of this handout is to inform a deeper understanding of the possibilities from recycled carpet that are simply being dismissed. The use of carpet in construction is gradually increasing in Australia, yet there are scarce resources which educate consumers about the end-of-life process of carpets. Given that the average life cycle of carpet is only between five to ten years, it is crucial to approach sustainable procedures of recycling old carpet. As a country lacking in manufacturers which sustainably recycle old carpet, it is becoming increasingly pivotal to integrate the systems into our construction industry.

The research will underpin the methodologies which enable textile industries to decrease their dependence on virgin raw materials, lower production costs, and ultimately, minimise their environmental impact. With this handout, it is important that manufacturers and consumers become aware of the detrimental effects carpet disposal in landfills have on the environment.

BACKGROUND

For manufacturers, a considerable amount of time and energy is spent on managing their supply chains varying from raw material suppliers to manufacturers, wholesalers, suppliers and consumers. With the focus being predominantly placed on the supply chain's forward action, scarce amounts of manufacturers have properly addressed the concern on how the supply chain can and should operate in reverse.[1] The consideration in presenting this rising issue is crucial in order to educate consumers and suppliers in recovering the products at the end-of-life cycle and return them for decomposition, disposal or for the re-use of key components, and thus re-entry into the chain. The vitality of adopting a life-cycle approach to product distribution is gradually becoming essential, as well as its implementation into educational programs for customers, suppliers, vendors and others within the supply chain.

Unlike many other construction materials, waste carpet is commonly disregarded and simply disposed in landfills. Standing at second place in the global textile consumer sector, Australia is significantly falling behind other countries in regards to the initiative taken in the carpet recycling industry (figure one).[1]

BACKGROUND CONTINUED

501,000 tonnes of textiles, including carpet, are discarded into Australian landfill on an annual basis, yet a mere 15 percent of the discards are being recycled (figure two). [2] The face fibres of carpets produced in Australia are generally comprised of synthetic fibres, including nylon and polypropylene, or natural fibres such as wool. However, these synthetic fibres are not decomposable, and wool, although it does decompose, it emits methane gases during the process. [3] As a result, more greenhouse gases are released into the environment.

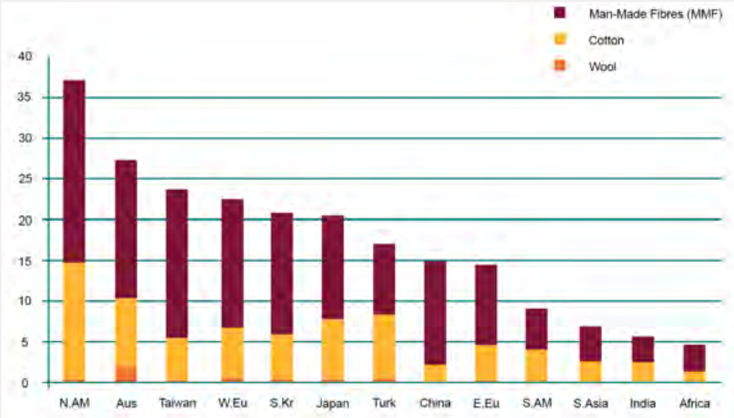

Figure one Global Final Consumer Demand for Textiles (kg/ Capita).

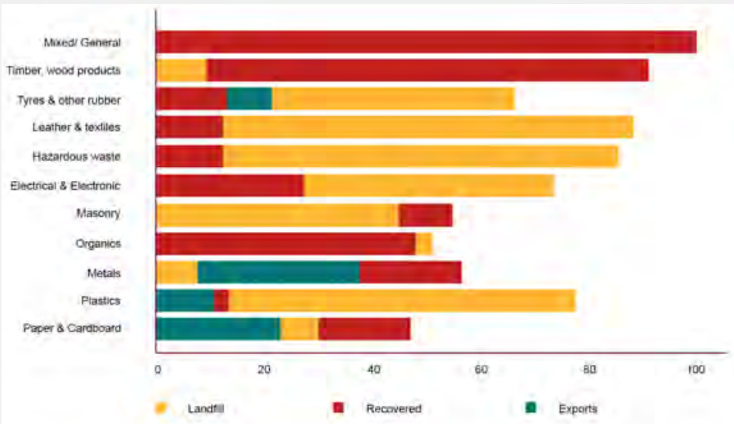

Figure two Waste Management by Material (% of Material Generation), from 2009 to 2010.

WHAT IS BEING DONE IN AUSTRALIA?

While most carpet fibres are recyclable, there are currently **no commercial recycling plants** specific for carpet within Australia.[4] Interface is one organisation which has developed a new carpet recycling facility; the first of its sort in Australia.

WHAT IS BEING DONE IN AUSTRALIA? (cont.)

The company provides two different forms of recycling, whereby ‘ReUse’ is a program in which old carpet is refurbished and used for flooring again, and ‘ReCycle’ partakes in the separation of all old carpet component and then reused for new flooring.[5] Interface estimates a total of 500-600 tonnes of carpet is processed annually, with the prevention of 2 million square meters of carpet from appearing in landfill around the world in 2016-2017.[6]

The company introduced the program called **ReEntry**, accepting old carpets to reproduce it into new carpet. Nylon, a Man-Made Fibre (MMF), is derived from oil and is non-biodegradable, yet it constitutes a major portion in carpets.[7] Thus, Interface is attempting to reclaim and recycle as much of the used carpet as possible. Two things are achieved through the reuse and recycle program: reduced amounts of virgin or raw materials and diverting carpet away from landfill. The content of the fibres used in their carpets include those from post-consumer Type 6 and 6,6 Nylon Fibres provided through the ReEntry process. As a new innovative method of recycling, the company works with Aquafil, incorporating **salvaged commercial fishing nets** into the 100 percent recycled content Type 6 Nylon.[8] Consequent of the creative reuse of commercial fishing nets, Interface introduced a new program called **Net-Works**, which aspires to gather discarded fishing nets to both protect marine life and for reuse in their recycled contents. (Please refer to Interface: ReEntry for additional information).

CASE STUDIES

America has taken upon various schemes within the carpet recycling industry, taking initiative in the case of the market-based Extended Producer Responsibility (EPR) implementation within the country.[9] The approach envisages in reducing the environmental burden by placing financial and physical responsibility on the manufacturers to recycle their products. Private companies have actively implemented the concept of EPR as part of their strategic management of sustainability and the supply chain.[10] Carpet America Recovery Effort (CARE) is a program operating to divert a significant quantity of carpet from landfill (please refer to CARE for additional information). In 2012, CARE achieved a 10 percent diversion rate, amounting to approximately 159,000 tonnes of discarded carpet.[11] Despite a decline in diverted waste carpet from 242,000 tonnes in 2013 to 221,000 tonnes in 2016, **Australia has failed** to achieve any results like these.[12] According to CARE, in 2016, 33 percent of diverted carpet waste was sent to recycling, 20 percent was used as alternative fuel, and 11 percent towards energy alternatives.[13] Mohawk Industries, like interface, has created their ‘Everstrand residential carpet,’ which is constructed of 100 percent **post-consumer carpet fibre from plastic bottles**.[14] The company retrieved over **three billion plastic bottles** and recycled them into approximately 73,000 tonnes of polyester fibre for their carpets.[15]

United Kingdom (UK) is another country taking initiative within the industry. During 2013, UK processed carpet wastes diverted from landfill through five different processing options including energy recovery, equestrian surface application, plastics reprocessing, fibre reprocessing and carpet re-use. (figure three).[16]

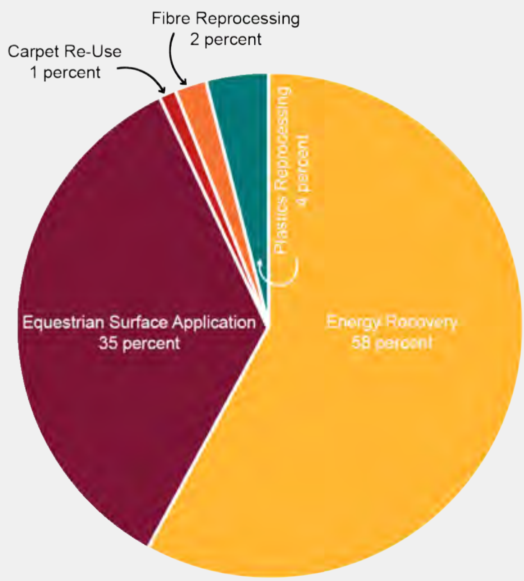

Figure thee Five different types of applications of waste carpet in UK.

ADDITIONAL INFO

MORE ABOUT THE FIVE PROCESSING OPTIONS

Energy recovery-
(Via incineration) Involves shredding waste carpets, which are then utilised in cement kilns or boilers, as a replacement of the traditional means of fuel, such as coal. Fuel produced from carpet wastes is known as Carpet Derived Fuel (CDF).[17] (Please refer to CDF for additional information).

Carpet waste in equestrian surfaces-
The separation of natural and syntenic fibres.[18] The separated carpet waste fibres are then pulverised and mixed with sand and rubber crumbs (obtained from waste tyres).[19]

Plastics reprocessing-
The reproduction of carpet waste into engineered plastic solutions.[20]

Fibre reprocessing-
Pertains to depolymerisation, separating the face fibres from the other components.[21] Nylon can also be recovered through different systems of depolymerisation, involving the recovery of caprolactam (nylon monomer), which are then re-polymerised into new nylon products.[22]

Carpet re-use-
The cleaning, trimming and re-colouring of old carpets. Although the most cost-effective approach, refurbishing carpet is rarely done successfully. [23]

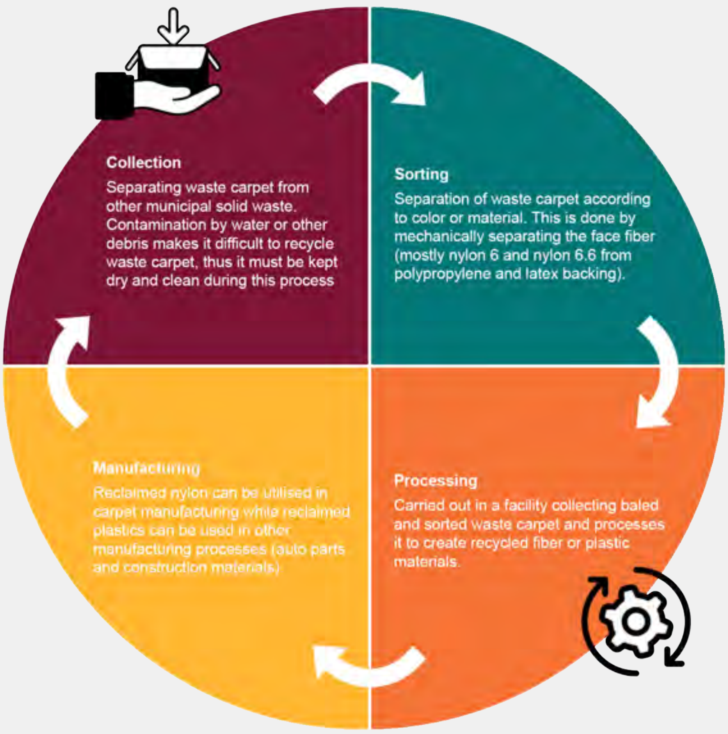

Figure four Four Stages in the Waste Carpet Recycling Scheme.

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Handout

JAMES FERGUSON

How have Queensland's building materials changed over the last century?

How have building materials changed over the last century within Queensland's stand-alone housing typology? The following is a summary of a paper that analysed two case studies from the start and end of the 20th century, revealing how and why timber building materials are increasingly being substituted with steel alternatives. Findings reveal that the socio-economic environment of Queensland at both the start and end of the 20th century has been the primary influence of material selection. The following is an summary of the socio-economic environment of Queensland over the last decade and a comparison of two stand-alone predesigned and ready to assemble residential dwellings from either side of the century.

The case studies under analysis include a 'redicut' home from one of Brisbane's earliest housing merchants, Campbell & Sons. The two-bedroom house named 'The Warra', was advertised throughout Queensland in the 1920's (house histories). The contemporary equivaled under analyses titled, 'The Aussie Retreat' is a kit home by a South East Queensland supplier 'Sheds n Homes'. By using the written specification provided by Campbell & Sons for their 'redicut' home 'the Warra', a catalogue of building components and specified material has been created and compared with the contemporary equivalent dwelling in order to identify any material changes of standard building components over the last one hundred years. The identified changes are deemed to be entirely based on socio economics influences that have occurred over the last century. These changes possess certain pros and cons for the two material types such as strength, environmental impact, and lifespan.

Queensland early 20th century

The evolution of the Queensland house with its diverse forms and building materials has been taking place since the 1820s as a continuously evolving product of geographical, social, and economic forces.

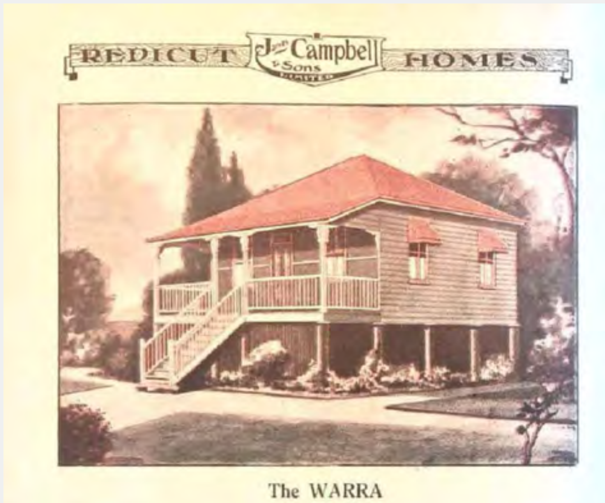
Agriculture and mining were the primary forms of economic trade that occurred in Queesnsland once free trade was established with the closing on the convict settlement in 1842 (Bell 2002, 4).

During the period of convict settlement, buildings were built using stone, brick, and timber with little regard for cost, as the building industry did not conform to free market economics, hence utilised free labour from an unpaid workforce (Bell 2002, 1).

This expansion into the north of the state with the proliferation of mining fields saw a significant drop in transport costs due to the increase of transport infrastructure and subsequent availability of imported goods (Bell 2002, 10). Sawn timber and corrugated iron become the preferred construction material within these mining towns (Bell 2002, 15).

The timber stud frame and corrugated iron roof became the quickest and cheapest way to build a house in the late 19th century as these industrialized materials became available to the domestic market soon after being introduced by the mining boom (Bell 2002, 16).

The building industry was growing in parallel with the mining boom and saw the emergence of many large vertically integrated building businesses such as Campbell & Sons. One outcome of this scenario was the prefabricated house, a standardised housing type that flooded the Queensland market.



House Histories, *James Campbell & Sons, The Warra.*

Sheds n Homes, *The Aussie Retreat.*

Queensland early 21st century

The socio-economic and geographical environment of Queensland in the 21st century is not dissimilar to that of the 20th century with mining and agriculture being primary industries.

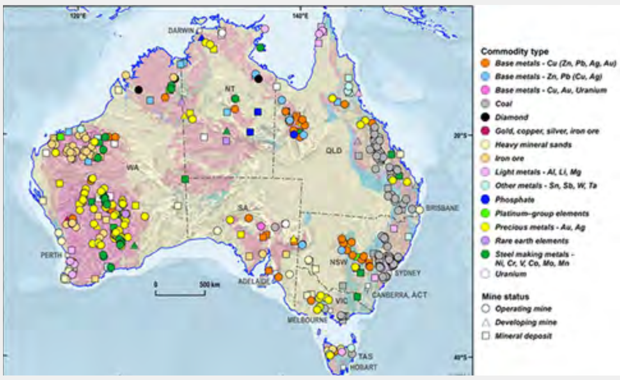
Queensland is best observed firstly as part of the country as a whole when looking at its socio-economic environment in the 21st century.

Australia is the number one global exporter of iron ore, coal, gold, and uranium, and is the world's third largest exporter of mining and fuel resources (austrade 2020).

Mining employs only 2.6% of the working population however contributes disproportionally to the state's economy by making the largest contribution at 11.8% followed by the construction industry at 8.8% (dfat 2019).

As in the early 20th century, Queensland is still significantly contributing to the Australian timber market, supplying 13% of total national hardwood production and 15% of softwood production. It is also the largest producer of native cypress pine sawlogs, accounting for approximately 75% of Australia's production (Queensland Forest and Timber Industry 2016).

Queensland has continued to rely on mining as its primary means of economic stimulation since free settlement was establish in the mid 19th century.



Geoscience Australia, *Major mining and mineral deposists in Australia 2016.*

Comparison of Case Studies by Material

Building Component	Material by Campbell & Sons	Material by Sheds n Homes
Bearers	4 x 3 hardwood	Steel by Bluescope
Top plates	3 x 3 hardwood	Steel by Bluescope
Studs	3 x 3 and 3 x 2 hardwood	Steel by Bluescope
Floor Joists	4 x 2 hardwood	Steel C section by Bluescope
Ceiling joists and rafters	4 x 2 pine	Steel truss by Bluescope
Roof battens	4 x 1.1/2 pine	Steel by Bluescope
Flooring to verandah	4 x 1 dressed hardwood	*Spotted gum or Modwood*
Flooring to rooms	6.1/2 x 1 T&G pine	Polished concrete slab
Eternal exposed walls	6.1/2 x 1 pine chamfer boards	Horro Corro wall cladding by Colorbond
Internal lining to walls and ceilings	4.1/2 x 22 T.G.V pine	*Direct fix 10mm unispan plasterboard*
wall under verandah & partitions	4.1/2 x 1 T.G.V pine	N.A.
Roof fascia	8 x 1 dressed pine	Steel by Colorbond
Windows	Timber framed with clear glass	*Aluminum or timber*
Doors	Timber framed 4 panel and ledged.	*Aluminum or timber*
Window sills	7 x 2 dressed hardwood	*Aluminum or dressed pine*
Door sills	6 x 1.1/2 dressed hardwood	Dressed pine
Roofing, ridge capping, down pipes	galvanized iron	Steel by Colorbond
Stump caps	galvanized iron	N.A.
External finishes	Berger's B.P. paint	Not required
Verandah bottom plates	7 x 2 hardwood	Steel by Bluescope
Verandah posts	4 x 4 dressed hardwood	Steel by Bluescope
Verandah railings	3 x 2 dressed hardwood	Dressed pine or hardwood
Verandah top plates	6 x 2.1/2 dressed pine	Steel by Bluescope
Verandah purlins	3 x 2 dressed pine	Steel by Bluescope
Nails and anchor bolts	steel	*Steel*

Summary

Perhaps Australia's ever-growing and dependent relationship with mineral mining has resulted in an environment where steel can be produced at a cost that it can be marketed as an affordable, superior alternative to timber. With Australia being the world's largest exporter of both iron ore and coal 'the two primary ingredients in the production of making steel' (world steel 2019), perhaps it is no surprise that steel is quickly becoming a popular alternative to timber for house framing.

A description of Queensland in the early 20th century by F. Corkling (Hancock 1970, 169).

“The Australian may live in a wooden house, in a wooden town, walk on a wood paved street, travel in a wooden carriage over wooden sleepers and wooden bridges; ship his goods from wooden wharves, shear, refine and manufacture in wooden sheds, enclose his land in wooden fences, and look forward to making his exit in a wooden coffin”

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THANKS

Handout

SHRIYA VENKATESH

Impacts of Mould Toxicity on Queensland Homes

INTRODUCTION

In today's modern society, people spend 80-90% of their time indoors. Most of that time is spent either in their homes or workplaces. Hence it is essential to have access to clean and fresh air that ensures a safe and healthy environment for the everyone.

This handout discusses the implications of mould contamination on indoor air quality and its adverse impacts on occupant health. It also provides an overview of the impact of mould and dampness on interior building materials in Queensland homes.

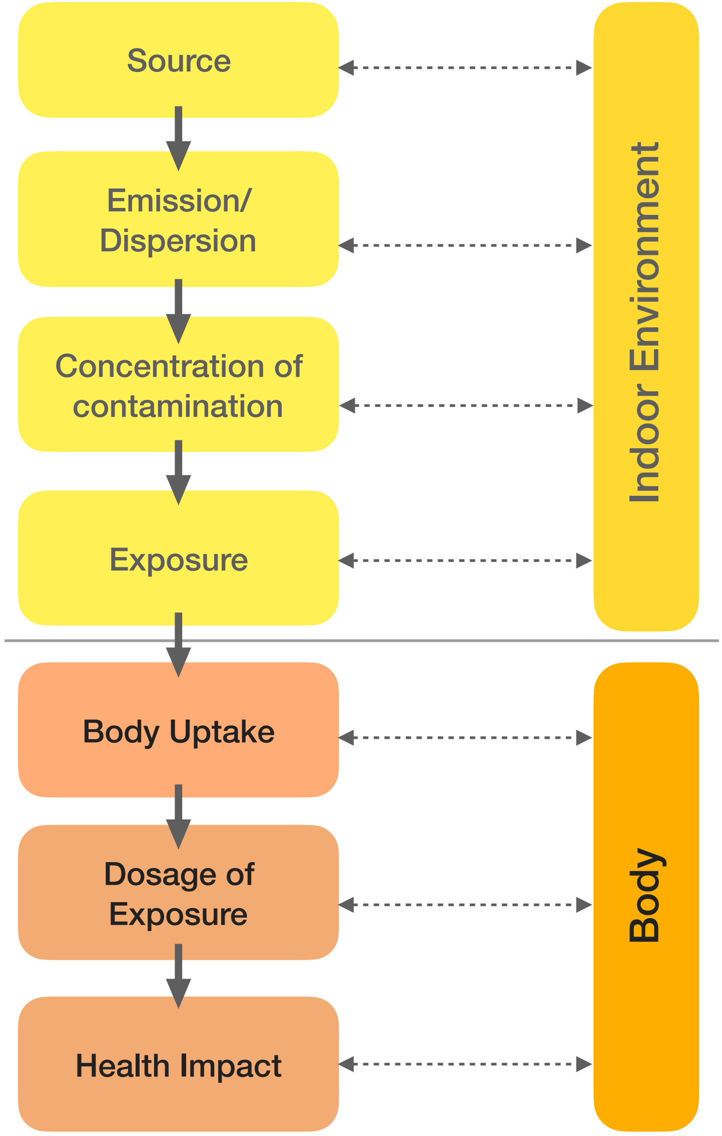
BACKGROUND

Dampness and moulds

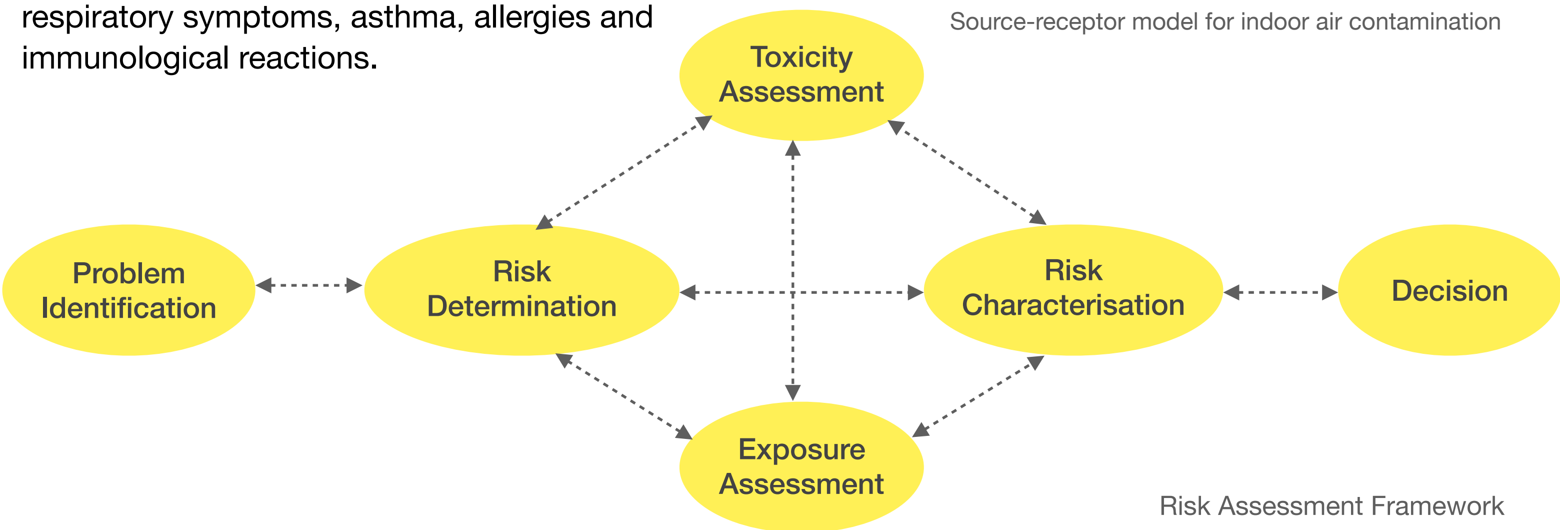
Filamentous fungi, also known as moulds, are microbial pollutants that are commonly found in interior surfaces around the world.

Impact on health

Places like residences, hospitals and day-care centres have people of different age groups that could be vulnerable to many health issues and complications arising out of poor quality of indoor air. Microbial pollutants such as bacteria and fungi grow indoors when in contact with enough moisture and can cause a host of problems such as respiratory symptoms, asthma, allergies and immunological reactions.



Source-receptor model for indoor air contamination



Risk Assessment Framework

Impact on building materials

Prolonged exposure to moisture and fungal contamination on surfaces also results in physical and chemical degradation of the building materials. The harmful Volatile organic compounds (VOCs) released by the fungi can be identified by the musty odour emanating from mouldy building materials. When left unchecked, mould can spread rapidly and affect the indoor building materials causing eventual degradation of the structure.

Identifying all the mould infected surfaces in the house is crucial, since it can spread from the source to all nearby surfaces.

The materials that are non-porous such as plastics, glass and metals are usually not affected by mould and can be cleaned.

Porous materials such as timber, carpets, tiles, gyprock etc are highly susceptible to mould growth. Moulds from these porous materials can spread and contaminate other interior surfaces in close proximity to the source.

REMEDIATION

Mould contamination can be classified as Simple level contamination and Complex level contamination based on location and extent.

Simple level mould contamination

Small and isolated areas of contamination ($<1m^2$) which can be cleaned appropriately by the building occupant.

Complex level mould contamination

If the contaminated area is spread out ($>1m^2$) or there there are signs of damage to the building structure.

Basic remediation procedures:

- Containment - Keeping the contaminated area isolated from other areas of the house.
- Identifying and fixing the source of contamination.
- Fixing the source of moisture or dampness.
- Completely cleaning or getting rid of all surfaces contaminated with mould.
- Ensuring that all building materials, furnishing, carpets etc are dry and well ventilated.

Occupant safety precautions:

- Face masks - P2 or N956 respirator face masks help shield the face from airborne fungal spores.
- Gloves - Protective gloves that extend till the forearm should be worn. Rubber or neoprene gloves are recommended when working with chemical disinfectants or bleach.
- Safety goggles - Goggles or glasses are to be worn to protect the eyes from airborne spores and dust.

Environmental controls:

Close the door between infected room and the rest of the house.

- Keep the room well ventilated while avoiding direct access to high-speed winds from outdoors as its may spread the spores within the interior space.
- Avoid use of any HVAC systems before fixing the problem.
- Keep the infected area isolated and enter only with protective equipment.

The choice of materials has a huge impact on the quality of indoor air quality and occupant health. The table below offers a list of safer alternatives for indoor building materials and finishes with lower/nil emission levels of harmful volatiles gases (VOCs and MVOCs) which can be used instead of the traditional material choices.

Interior Materials	Recommended materials and finishes
Caulk and Adhesives	Epoxy adhesives are safer than solvent-based adhesives. White glue (polyvinyl acetate) and carpenter's glue (yellow aliphatic resin) are safe when dry.
Cabinets, doors, shelving, furniture	Use solid wood, formaldehyde-free wheat board, finished with a low-VOC paint or stain. Modwood is an Australian company that uses recycled and reconstituted timber products.
Paints	Choose water-based paints with low VOC-content of 150 gram/litre or less. Ecocolour and Livos have a range of No-VOC paints. Dulux and Wattyl have a range of low VOC paints
Flooring	• Recycled timber, bamboo, coir, sisal, seagrass, hemp, jute, pure wool carpet are sustainable alternatives. Use no VOC glues and sealants. Livos have a good range of products. • Avoid vinyl flooring. (vinyl chloride fumes are carcinogenic and also traps moisture with promotes mould growth) Instead consider true linoleum or marmoleum flooring. • If using hardwood floor, use Forest Stewardship Council (FSC) wood. Avoid formaldehyde in underlayment. Use installation with no glue or use water-based glue
Floor	For a concrete slab, use high recycled content concrete like Boral's Eco-crete with suitable insulation (foil or polystyrene). Avoid using insulation with formaldehyde.
Subfloor, sheathing, underlayment	Use low-emission boards such as wheatboard, strawboard, isoboard, exterior-grade plywood. Seal with low-VOC vapour barrier and finish with low-VOC paint.
Weather-proofing and insulation	All external walls should be weatherproofed. For example sarking product from DCT - Proctor breathable membrane provides good weatherproofing. Kingspan also have good products with high R-value thin insulation and roof panels.

MOULD PREVENTION CHECKLIST FOR HOMEOWNERS

Materials and Surface Finishes

- ○ Is the finishing surface sealed and easily washable?
- ○ Are the finishing materials durable? Can they be easily replaced?
- ○ Have you ensured that exposed concrete is avoided as finishing surface in humid spaces (parking, OHT room)? Have the floors been painted and sealed?
- ○ Is the selected carpeting easy to clean and maintain?
- ○ Did you avoid using building materials and finishes with high VOC content? (Check for emission levels compared with accepted criteria in material safety data sheets MSDS)
- ○ Did you avoid rough and porous surfaces which accumulate dust and difficult to clean?
- ○ Are all paint finishes water resistant and easy to wipe clean?
- ○ Are all materials used for food storage water resistant, durable and easy to keep clean?

Layout and Design

- ○ Are the building materials covered (shielded from sun and rain) on site during construction?
- ○ Does the house layout ensure adequate ventilation in all spaces?
- ○ Has the design ensured access to all service areas and water tanks for cleaning and maintenance purposes?
- ○ Are the humid spaces such as bathrooms, kitchen, parking fitted with exhaust fans?

Maintenance

- ○ Is the building fabric effectively weatherproofed?
- ○ Are the doors and decks that are exposed to the exterior waterproofed?
- ○ Are the intake ducts fitted with bird and insect screens prior to occupation?
- ○ Is the drainage for the house away from the main building (including roof down pipes)
- ○ Are the water sprinklers at a good distance from the building?
- ○ Is the roof waterproofed and free of pooling water?
- ○ Are the drain pans cleaned regularly and free of mould or mildew?
- ○ Is the waterproofing membrane properly sealed?
- ○ Are the exterior walls, window sills and window frames free from signs of dampness?
- ○ Do any interior walls, ceiling and floors show signs of damage and mould?
- ○ Are the HVAC ducts and filters regularly cleaned?

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THANKS

Handout

Material durability and disassembly in the Queensland domestic context

Current domestic deconstruction process Figure 1

Title
Material durability and disassembly in the Queensland domestic context

Author
Lindsay Taylor

Research Question
How can a hardwood framed domestic structure in the Queensland context be designed for both longevity and disassembly? In order to reduce the amount of materials going to waste.

Aim
Identify and research previous precedents of timber structures designed for disassembly and identify and research factors effecting the durability of lifecycle of Australian hardwood timbers. Through the analysis of these findings suggest typical details designed around increasing the service life of the hardwood in a domestic building and suggest details that allow for ease of dissasembly. This will then prove a value in the consideration of life cycle analysis in the design of buildings.

Methodology
The identification of a serious issue in the building and construction industry is first to be noted, where by a unilateral approach to the construction and demolition of buildings is the current model. This drives demand for the energy intensive process of material manufacture, and is continuing to increase the amount of building waste the industry disposes of every year into landfill. The method of conducting this research will firstly analyse the inherent qualitites and durability of Australian hardwood timber. The vernacular houses of Queensland will inform how the timber responds to local conditions. Previous research around the topic will also been drawn on as a gateway into this research.

The findings from that research will inform an argument based around the durability and ability for hardwood to be reclaimed, recycled and reused. The hazards to the logevity of timber as a material will be analysed, and preventative measures will be presented.

An already established body of research raises a discourse based around the disassembly of structures, particurly domestic.

Figure 1. sourced from The Cairns Post

the thinking of building assembly whilst simultaneously thinking about buidling disassembly leads to a number of potentially interesting lines of enquiry. Including a new diagram of building lifecycles based around findings from this research.

Finally a typical detail wall section will be analysed in order to prove the problematic approach that mainstream domestic buildings take towards materials. From here a potential domestic wall section will be proposed as a possible introduction into a new way of thinking, taking a position on material use.

Background

The Australian Government - Department of Sustainability, Environment, Water, Population and Communities, in 2011 released a paper titled ‘Construction and Demolition waste guide - Recycling and Re-use across the supply chain’. This was prepared for the department by Edge Environment Pty Ltd. Within they identify the large scale impact that the construction industry and associated material manufacturers are having a negative environment impact at ever stage of the building process. The aim of the guide therefore is to assist in the development of “effective markets for materials diverted or derived from the C&D (construction and demolition) waste stream”[1]. On the case of timber, for the most part their is currently a very low market demand for most recovered timber products. However there high value market for quality Australian Hardwood timbers, with prices in excess of $\$1000/m^3$. The difficulty in order to recover this timber means that the volume recovered is quite low. Edge Environment recognises “A barrier to growing the reuse of market is the increasing mechanisation of demolition works (primarily due to time pressures and occupational health and safety requirements), which makes it more difficult for salvage operations to take place, and increases the potential for high-value timbers to be damaged”[1]. The body of research conducted here is an attempt to propose a new way of thinking around architecture and building design, to foster a value in designing for disassembly, rather than demolition. John Winter comments “We are not good at designing for time and the changes that come with time. The structure of our profession is organised around a big bang approach to our clients’ needs, not gently advising over the years like doctors or accountants”[2]. The life cycle of buildings are, for the most part not currently being considered in architectural discourse.

A life cycle of any given building is dependent upon the structures components, in some cases when these components break or reach the end of their functional lives they are able to be easily replaced without effecting any other components of a building, a light bulb for example. However critical components and critical structural components such as structural timber members typically require partial demolition of the building in order to be replaced. Further in some cases it becomes infeasible economically to partially demolish and replace a number of components, so in which case the building will be completely demolished. Between 2013 and 2018 the Brisbane City council approved 139 pre-1946 timber dwellings to be completely demolished in the suburbs of Brisbane. The city council’s planning chairman, Matthew Bourke said that pre-1946 houses are able to be approved for demolition “where they are found to be structurally unsafe and unable to be repaired”[3].

This research recognises the fact that all buildings are ephemeral, but will argue that most building materials have a durability that allows them to be used over and over again in several buildings.

Current domestic deconstruction process Figure 2

Figure 2. sourced from The Cairns Post

1. Environment Pty Ltd for the Australian Government. 2011. “Construction And Demolition Waste Guide - Recycling And Reuse Across The Supply Chain”. Canberra: Australian Government - Dpt, Sustainability, Environment, Water, Population & Communities.
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Findings

The Queensland house

A vernacular building is that which can be described as indigenous or traditional to a region, having been constructed with directly available building materials in response to the local climate and needs of the occupant. Ray Kerkhove and Cathy Keys raise the idea that the bush or bark huts of the early colonial settlers in Australia were influenced by an indigenous building practice, where large sheets of bark, stripped from trees were used as shelter[4]. By the mid-19th century however, the European response to the vernacular, particularly in Queensland was constructed of timber and iron[5]. Out of all the states and territories in Australia, the houses of Queensland are perhaps the closest to the creation of native indigenous style[6]. This can be seen as the classic 'Queenslander' style, that is perhaps the most recognisable building type in Australia to date (Figure 3). The Queensland house is that which is constructed on an elevated platform to deal with the hilly and frequently flooded terrain of Brisbane, and sheltered by a large sheltering tin roof[7]. Typically they were wrapped around all four sides with a generous verandah roof to shade the building from the sub tropical sun, to shelter the building from driving rain and to protect the primary structure from the effects of weathering. The approach the Queensland house took to this region has number of advantages, but probably the most noteworthy for this body of research is ability for the lightweight timber frame to be assembled and disassembled, and transported as a whole building to another site.

During a previous Master of Architecture research course with the University of Queensland (ARCH7072 - Materials and Making) coordinated by Dr Catherine Keys, the recyclability of Australian hardwood timbers from a 1940's Queensland house was explored. After an unfortunate partial demolition of the original 1942 Farmhouse of the suburb of Eatons Hill (Figure 4), lengths of hardwood timber waste were reclaimed that would otherwise been dumped into the site skip bin. It was found through making and playing with 80 year old hardwood timbers, the incredible durability the material provides. This was then constructed into a self supporting timber screen in order to prove the value of the timber that would otherwise of ended up in landfill (Figure 5). The lifespan of the material was therefore extended, and the lifespan of building materials in construction was better understood.

Queensland House Figure 3

1942 Farmhouse Figure 4

Self supporting recycled hardwood screen Figure 5

Figure 3 sourced from 'Queensland Places
Figure 4 & 5 photographed by author

4. Kerkhove, Ray, and Cathy Keys. "Australian Settler Bush Huts and Indigenous Bark-Strippers: Origins and Influences." Queensland Review 27, no. 1 (2020): 1–20. doi:10.1017/qre.2020.1.
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Durability of Australian Hardwood Timbers

Philip Cox and John Freeland speak on the rich history timber has had on building Australia in there book ‘Rude Timber Buildings in Australia “they are made of a material with which everyone has a deep-rooted harmony, because they are put together in ways that are easily understood and because their forms are readily comprehended, they are universal buildings whose roughness and even whose frequent dilapidation give them a powerful emotional appeal and impact. They are buildings to be felt rather than reasoned”[8].

The durability of any material and the expected lifespan of any material, are all important aspects that should be considered during the design of buildings. In simple terms the role of the architect is to specify what material a building is to be constructed of, where it will be used, how it will be used and how will it be fixed to other materials. Through this process the architect can then make a reasonable prediction of the buildings lifespan. A estimate of the average lifespan of domestic building in Australia by CRC for Greenhouse Accounting is 44 years[9]. Ximenes, Kapambwe and Keenan uncovered through there research into the longevity of domestic dwellings in Australia, the main reasons these buildings reach the end of there life. Stated, “The primary reasons for demolition included site redevelopment (58%), the building ceasing to reach owners requirements (28%), the dwelling becoming unserviceable (8%), and for other reasons such as damage by fire, storms, etc (6%). Few dwellings were demolished due to the failure or decay of wood products. Most buildings were demolished for reasons other than the state of the structural systems”[10]. Therefore in almost all cases of domestic demolition the timber or wood products were still sound after 44 years or longer.

The National Association of Forest Industries (NAFI) identify a number of hazards that directly effect the project lifespan of a timber member. Outlined in Table 1 below.

Hazard	Caused by	Methods of protection
Weathering	Rain (wetting and drying) Sun (ultraviolet radiation) Freezing	-Application and maintenance of finishes -paints -stains -water repellants -preservatives
Insect attack	Termites Lyctine beetles Anobiid borers	-Eliminate cracks in concrete slabs and foundations -Minimise soil and garden contact to building -Use termite barriers and regularly inspects
Fungal attack	Moulds Rot fungi	-Eliminate timber contacting water -Use appropriate durability rating for specified use -Use preservative treatments -boron compounds -light organic solvents -copper chrome arsenate (water-borne) -Creosote (oil-borne
Chemical degradation	Exposure to chemicals present in other building typologies	N/A
Corrosion	Contact to corrosive fixings	-Use non corrosive metal fixings -Countersink and plug fasteners -Seperate fasteners from CCA treated timber with another material (rubber washer)
Marine organisms	Molluscs Crustaceans	N/A
Fire	Bushfire House fire	Fire resistance
Mechanical degradation	High mechanical stresses	Design considerations needed where timber is heavily trafficked

Table 1

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Table 1 - information sourced from 11

Designing for disassembly

The discussion based around the lifecycle of a building tends to lead to the thinking of the building as a single object on a site. This leads one to perceive the building as one whole that is “designed, constructed, used, and then disposed of as complete entities”[12]. However when understanding the assembly of a building its becomes thought of as a large number of parts or layers that make up the whole. Layers and parts that are assembled in particular and specified ways to make the building. The parts of the Queensland house can be understood as timber and tin, put together as a number of small pieces to make the whole house. This line of thinking of building assembly becomes problematic when the assemblage of materials becomes unidirectional, that is to only think of a material as serving one purpose over it’s lifecycle, and once that service is complete, the material becomes useless and is disposed of. However a thinking of any material in terms of assembly and disassembly simultaneously, leads to the thinking of that material being able to perform a number uses over it’s functional life cycle. John Habraken, identifies a building as that which has two distinct layers[13]. The first being the structure, that in a timber context is constructed as a frame, this has a long functional lifecycle as it is typically well protect from environmental factors. The second layer is the space making elements, that are able to be moved, removed and replaced over time without compromising the structural frame. Assuming the long lifecycle of a timber structural frame, a building such as one Habraken identifies can change over time and be disassembled to replace components that have a shorter life expectancy.

The idea that a building is constructed using many different materials and assembled in a way that recognises the particular service lives of different parts, was one in which was explored in the 1960’s by various architects. The metabolism architectural movement in Japan during this time sought to begin a line of thinking about buildings and cities as emulating a living being. Architects including Kisho Kurokawa “believed that cities and buildings are not static entities, but are ever-changing”[14]. The architecture is that which has cellular type parts, that can be removed and replaced when the lifecycle of that component or material is over. In ‘Project Japan, Metabolism Talks’, Rem Koolhaas states “Once you’re interested in how things evolve, you have a kind of never changing perspective, because it means you’re interested in articulating the evolution”[15]. The architecture therefore is constantly being pulled apart and reassembled, juxtaposing a conventional building that is constructed and demolished, adding to a cycle of construction-demolition.

‘How Buildings Learn - What happens After They’re built’ was a book written in 1994 by Stewart Brand, an American writer. He was particularly interested in the evolution of buildings over time, and broke the understanding of buildings down into a number of built layers, each with different life spans. Questions were asked in this book such as; how do different owners adapt spaces? How are buildings able to facilitate to the changing requirements over periods of time? The layers Brand identifies are set out in Table 2, each layer exists as a part of the building for a certain amount of time. Brand argues the benefits of designing buildings in a layered arrangement that allows for disassembly, and adaption over the life of the building[16]. The life span of layers that were proposed in this book, were based off an American context, so the figures would change depending on the location of the building, the materials used, how well the materials are protected from weather. Australian hardwood timber is capable of lasting 40+ years as an external building skin[11].

Layer	Life span (years)
Site	Eternal
Structure	30-300
Skin	20
Services	7-15
Space plan	3-30
Stuff	Daily

Stewart Brand’s buildng layers Table 2

It could be argued however that the materials used in a layer such as ‘space plan’ could be disassembled and reassembled in various ways. Meaning that the lifespan of any particular spatial arrangement may only last ‘3-30 years’ but the material is able to last a great deal longer.

12. Crowther, Philip. 2005. “Design for disassembly - themes and principles”. DES 31. BEPD Environment Design Guide.
13. Habraken, NJ, 1998, The Structure of the Ordinary, MIT Press, Cambridge.
14. Hobson, Benedict. 2020. “”There Is A Practical Side To Archigram, It’s Not Just Funny Drawings,” Says Dennis Crompton”. Dezeen. https://www.dezeen.com/2020/05/14/archigram-monte-carlo-dennis-crompton-video-interview-vdf/.
15. Koolhaas, Rem. 2011. “Talking Metabolism With Rem Koolhaas”. The Architectural Review, , 2011.
16. Brand, S, 1994, How Buildings Learn: What Happens After They’re Built, Viking, New York.

Life cycles

Set out below are two material lifecycles that can occur in the construction industry. The unilateral construction material approach is the common practice in today's economy.

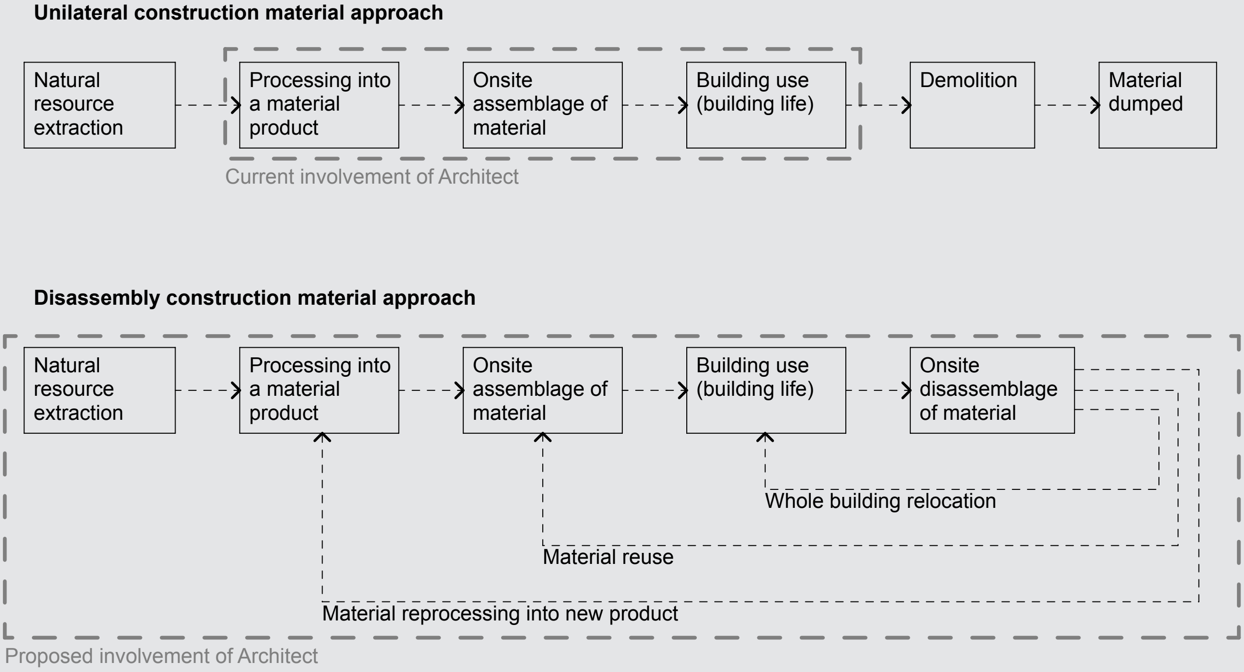


Figure 5

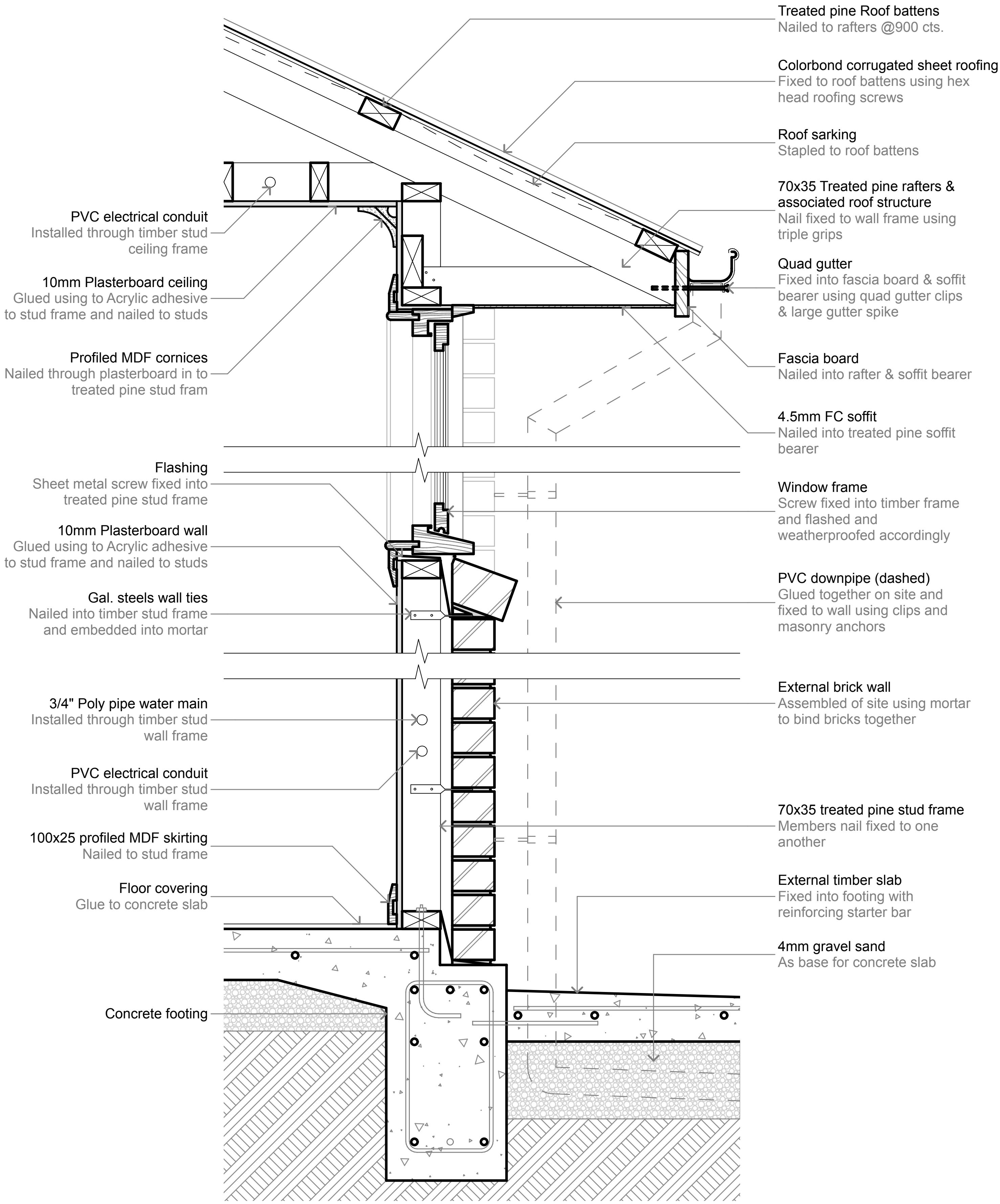
Principles of disassembly

The principles for disassembly set out here are one of many that can be adopted for a range of different materials. These principles here are based off the workability, opportunities and constraints of Australian hardwood timber.

10 Principles of assembly/ disassembly	
1. Specify and use recyclable materials and where possible materials that are recycled	to further add to supply and demand of recycled materials, always use materials that are anticipated to have a use after the building has been disassembled.
2. Do not use permanent material binding agents such as adhesives	where two materials are permanently bound together, both materials therefore only have the single service life and become useless after disassembly.
3. Use mechanical fixings that can be pulled apart and put back together again	nuts and bolts can be easily removed from a material without damaging itself or the host material, nails however typically can only be used once and risk extensive damage when being removed.
4. Following engineers specifications limit the number of fixing holes through materials	nuts and bolts can be easily removed from a material without damaging itself or the host material, nails however typically can only be used once and risk extensive damage when being removed.
5. Attempt to keep building simple and minimal, structure set out on a grid where possible	the more complex a building is to construct, the more difficult it becomes to deconstruct and disassemble whilst avoiding damage to materials, leading to it not being economically viable to disassemble.
6. Systematically label materials	document and label all materials within the building, include date of install, expected service life, etc.
7. Where possible seperate structural elements from non-structural elements	seperate critical structural elements from other elements that are likely to be disassembled prior to structure.
8. Allow inspection access to all components in the building	design the building to allow inspection to all fixings and elements
9. Use lightweight materials	allow for building to be assembled and disassembled by hand on site
10. Leave services exposed	allow for building to be assembled and disassembled by hand on site

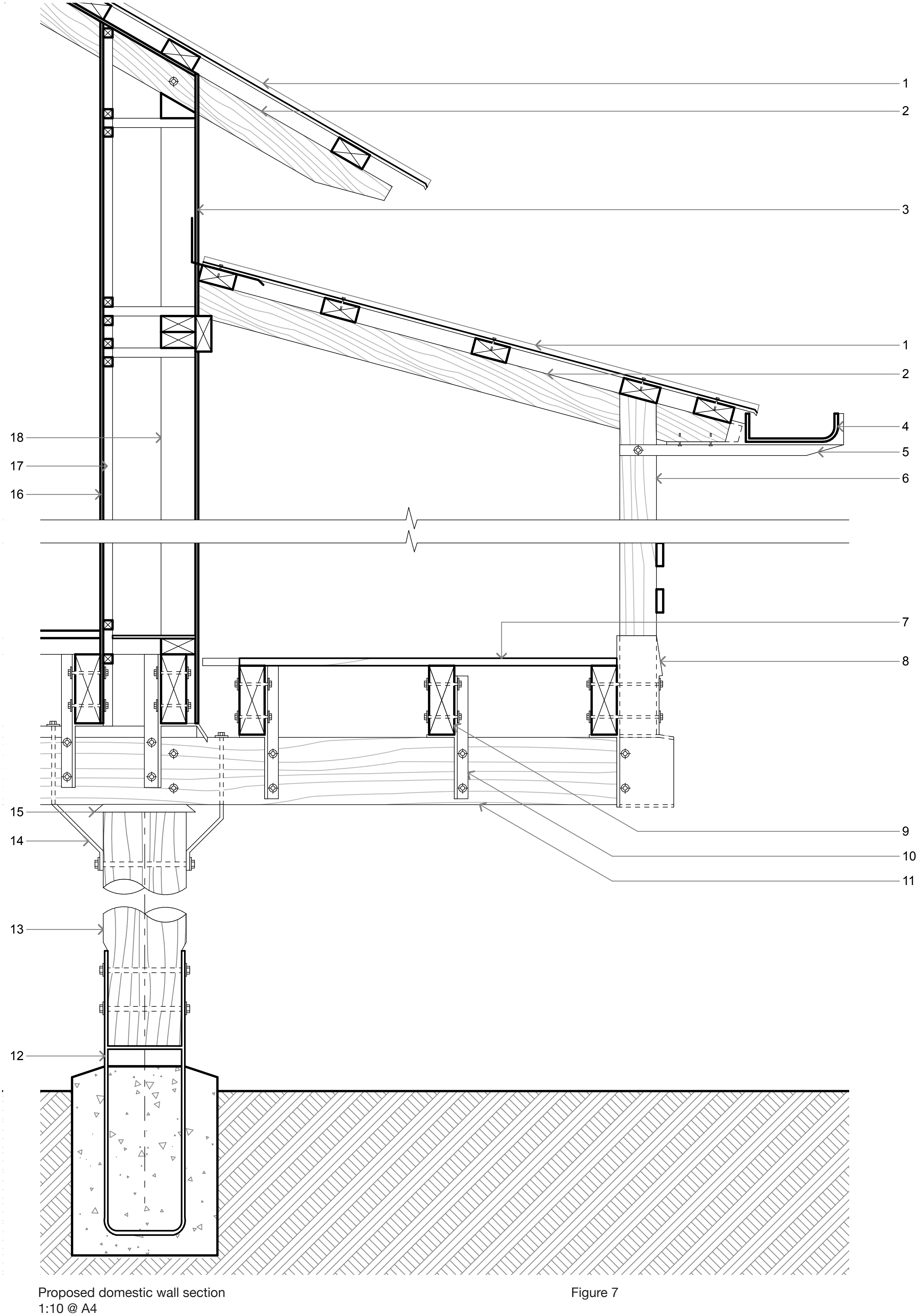
Table 3

Figure 5 - by author, based on ideas set out in source 12
Table 3 - by author, based on ideas set out in source 12



Typical domestic brick veneer wall section
1:10 @ A4

Figure 6



Proposed domestic wall section
1:10 @ A4

Figure 7

Legend

1. Colorbond corrugated sheet roofing
Fixed to roof battens using hex head roof screws

2. Grey Ironbark rafter
Sizing dependent upon engineers specifications. Back cut to reduce exposure

3. Aluminium sheet cladding
Cladding fixed to structural frame using stainless steel (316) screws

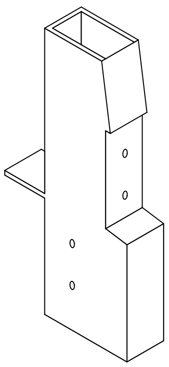
4. Custom profiled aluminium gutter

5. Custom gutter bracket
Galvanised steel fixed to rafter and external post

6. Grey Ironbark post
Bolt fixed into custom bracket at bottom, bolt fixed to rafter at top

7. Spotted Gum decking
16mm deck boards screw fixed to joists

8. Custom galvanised steel bracket
to protect end grain of bearers and posts, and to assist in bolt fixing elements (see axo below)



9. Grey Ironbark joist
Sizing to engineers specifications, bolt fixed to galvanised 30x5.0EA

10. 30x5.0EA Galvanised

11. Grey Ironbark bearer
Sizing to engineers specifications, bolt fixed to galvanised 30x5.0EA. Supported atop 13

12. Galvanised steel seat to support 13

13. Hardwood stump
Sizing to engineers specifications, potential to be recycled power pole

14. Galvanised steel tie-downs
Bolted through internal and external bearers

15. Termite cap
To be regularly inspected

16. Internal plywood wall sheet
Screw fixed to 17

17. 25x25 spotted gum frame to support 16
Fixed back to 18 to allow for structural inspection

18. Wall structure
spotted gum wall frame, sizing to engineers specification

Conclusions

The current construction practice that sees the assembly of materials and components as unidirectional with an end goal of producing a final building. This researches proposes that the construction industry could do more in understanding materials and there lifecycle over a period that extends beyond a finished new building. Through the better understanding of a particular material it is possible to understand the durability and the ability for the material to serve a number of functions over its lifetime is understood. A thinking of a design process of assembly and disassembly simultaneously, promotes the discourse around material resuse. Looking at the 2 wall sections, one can understand that in the conventional section nearly no materials can be salvaged from the building due to the way the building is constructed. However in the proposed wall section, close to 100% of the materials could be salvaged and repurposed.

"A barrier to growing the reuse of market is the increasing mechanisation of demolition works (primarily due to time pressures and occupational health and safety requirements), which makes it more difficult for salvage operations to take place, and increases the potential for high-value timbers to be damaged"[1]

This research hopes to propose a new way of thinking about the construction industry through the lense of materials lifespans, in order to reduce natural resource extraction and reduce the amount of building waste going into landfill.

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Handout

‘Queenslander’ houses and Circular Design

Queenslander house relocation [1]

Title
Can 'Queenslander' houses can be considered as 'Circular Future' model since they are portable, re-usable and adaptable?

Authors
Atee Moazen Safaei

Research Question

Global warming and other ecological issues which have been loudly expressed in media these days, makes one to wonder if construction industry and, in particular, the residential sector has done enough to help addressing the environmental problems. It has been argued in the literature that slightly over half of planet's energy are being consumed in construction industry and its verticals such as transportation, manufacturing, etc [2]. The sheer amount of precious and scarce fossil energy, which we all know it is going to be exhausted in near future, being consumed in this area makes one to wonder if there is anything can be done to reduce that volume or maybe use it more wisely. Any attempt towards this goal such as re-adaptation, renovation and re-use of materials are highly welcomed by researchers who are actively seeking novel and environmentally sustainable solutions in this realm.
Speaking of portability and re-use of construction materials brings a unique housing style in mind particularly if one has lived in the state of sunshine: The Queenslanders. For the sake of definition, this research agrees with how 2 have defined the commonly used term Queenslander house in their study: A wooden house with corrugated iron pyramid type roof surrounded by veranda elevated off the ground with the aid of stumps and suitable for hot sub-tropical climates which were initially originated from Indian 'Bungalow' during Australia's colonial times. It is especially interesting to know that Queenslander houses were not meant to be portable at first when they emerged back in 1840.3 The residents of these houses did not have nomadic lifestyle with the mindset of relocating their habitat by attaching their house to the back of a caravan and move from one place to another. On the contrary, cultural and social studies show, amid the Australia's population growth in the past 200 years or so, farmers who needed permanent roof on top of their heads were amongst the group who opted living in such houses the most for simple reasons. Hoop pine and eucalypt hardwood were cheap as they were in abundance, the entire family were safe from Queensland's torrential summer rains as were elevated off the ground, and their children had lots of space to play in surrounding veranda enjoying the drumming music played by raindrops landing on iron rooves.4

1. Wright, David. "Home Removal & Demolition." http://davidwright.com.au/image-gallery-removals/.
2. Walker-Morison, Andrew, Tim Grant, and Scott McAlister. "The Environmental Impact of Building Materials." Environment Design Guide (2007): 1-9. www.jstor.org/stable/26148741.
3. Evans, Ian. The Queensland House : History and Conservation. Edited by Queensland National Trust of. Mullumbimby, NSW: Flannel Flower Press, 2001.
4. Ximenes, Fabiano, Misheck Kapambwe, and Rodney Keenan. "Timber Use in Residential Construction and Demolition." Environment Design Guide (2008): 1-8. www.jstor.org/stable/26148968.

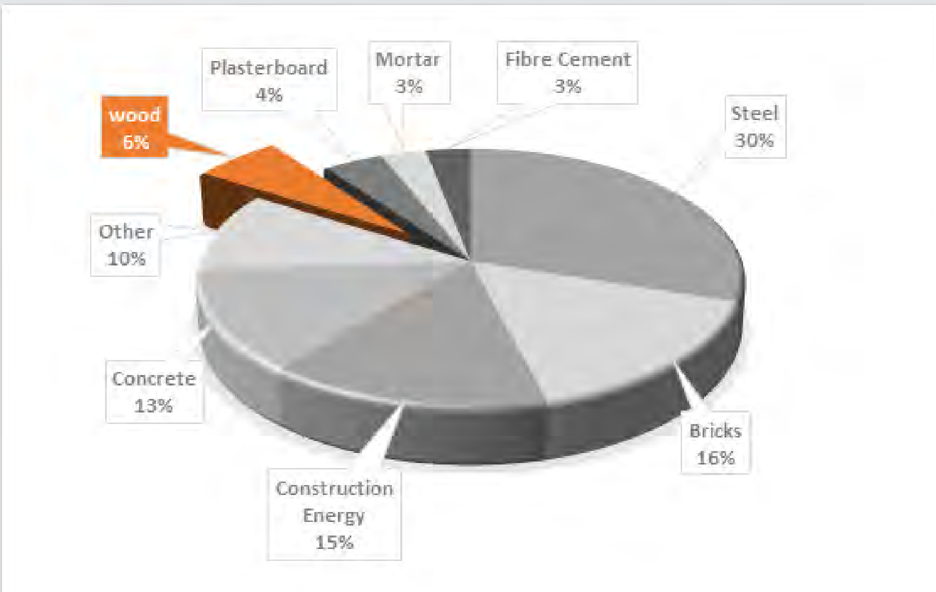
Aim

looking backwards to go forward

This research tries to investigate any possibility to establish a link between modern architecture and Queenslanders, from construction point of view, by focusing on the structural elements details and the fact that they are portable and can be adapted to the new site, re-configured for a new user based on new owner needs without losing construction materials values. Popularity of such houses are as such that they have caused 'house removal' businesses to boom. Apparently, the process of house transportation is relatively efficient and environment friendly, with low carbon emission footprint, that this research finds it worthy to analyse different aspects of Queenslander houses and perhaps inspire from their construction theme in modern architecture designs. In other words, the intent of this research is to investigate whether Queenslanders can be considered as an example for 'Circular Future' houses or not.[1]

Background

To depict a picture of what is the contributing role of house construction in global warming and appreciate why it is crucial to pull reader's attentions to this topic, perhaps it is best to look into some figures and statistics provided in the literature. A natural survey[2] mutually conducted by university of Melbourne and New South Wales department of primary industries has found out that since 1945 the average usable floor area in residential houses has grown 300% while the use of timber materials have plummeted to 20% noting such sharp plunge in usage of wood products are for reasons other than failure in timber structural frames. Motives like replacement of suspended floor systems with concrete slab, or designing houses with more open plans resulting less internal wall frames and finally the less use of timber for cladding could potentially be some reason for drop in hardwood usage in housing industry.[2]
Not only usage of timber frames in houses (if maintained systematically) can result in re-using them over time but also the waste of wood products created during the process of manufacturing, is itself recyclable and can be transformed into other types of energy (e.g. heat) in other industries. Moreover, ecologically speaking, as 5 has listed in his paper timber products have several advantages over other construction materials such as: being renewable resource, absorbing carbon dioxide off the air, and manufacturable with lower amount of fossil energy compared to something like steel. As depicted in diagram below, which shows building materials contribution in carbon footprint, [3] has appraised wood in terms of producing less carbon emission during its manufacturing with a humble 6%. involvement in total greenhouse emission amongst other construction materials. The authors have argued Australia could save up to six hundred thousand tonnes of carbon dioxide per year if 60% of new dwelling are shifted from using concrete slabs to timber flooring systems. But acknowledging all the aforementioned wood products benefits and also the recent lack of motivations from builders and architects towards using them, how can this trend be reversed?



Building Materials Contribution to greenhouse Emission in Australia.[3]

1. Jensen, K.G., and J. Sommer. Building a Circular Future. GXN Innovation, 2016. https://books.google.com.au/books?id=8SepAQAACAAJ.
2. Ximenes, Fabiano, Misheck Kapambwe, and Rodney Keenan. "Timber Use in Residential Construction and Demolition." Environment Design Guide (2008): 1-8. www.jstor.org/stable/26148968.
3. Walker-Morison, Andrew, Tim Grant, and Scott McAlister. "The Environmental Impact of Building Materials." Environment Design Guide (2007): 1-9. www.jstor.org/stable/26148741.
4.

Methodology

This research has been conducted using qualitative methods namely interviews with some of building designers who are actively involved and specialised in renovating, modifying and building Queenslander houses and also analysing Queenslander houses in detail. For the interview part, the researcher prepared some predefined and well-thought questions beforehand and asked them from interviewees in an open-end question forms during the interview. Questions were mainly about the interviewee's reasonings for opting Queenslanders to be their dwelling of interest amongst other modern housing styles, the challenges they deal with when trying to re-use a Queenslander house on a new site (e.g. relocation, re-adaptation, the scope of changes, etc). During interviews, the researcher found good insight of the construction method of Queenslander houses and their main structural elements and finally got invited for a site visit with one of the building designers who generously shared his 40 years of experience during a two hour site trip. Unfortunately, time limitations did not allow for a brief interview with the new house owners and asking about their motives for relocating their house instead of constructing a new one from scratch.

For analysing part of the research, the researcher scrutinised the Queenslanders in depth to find out what feature of them specifically allow them to be such adaptable, flexible, relocatable and reusable. In fact their portability factor was the key factor which brought this research topic into researcher's mind as having a very long life cycle can potentially make Queenslanders an example of 'circular future'

Conclusions

Summery of your topic and research.

1. References
2.
3.
4.

Findings

Queenslander House - Features

This section of research tends to list some of the typical features of Queenslanders houses which make them to stand out:

- Isolated on their own allotment
- Generally single story
- Construction materials were completely mechanized
- corrugated galvanized iron rooves
- walls were generally made from sawn timber (light studs)
- Visible bare frame from exterior
- Elevated using timber posts (approximately to 3m above ground)
- Straightforward plans for the core part of the house
- Symmetrical floor plan and front façade
- plain, simple and mass-produced embellishment for the house
- Definite one veranda, with more possible verandas around the house [1]

Typical Queenslander style house[2]

Queenslander House's Materials

As mentioned earlier in this document, Queenslander houses were mostly built from hardwood timber and iron. Hardwood timber was preferred choice for housing because they were produced out of slow-growing trees meaning the flesh have very high density and therefore the final product can have longer life cycle and enhanced firmness. Coincidentally, wood products have certain ecological advantages which the initial Queenslander builders might not have cared about but nonetheless the planet benefited from them. Things such as absorbing carbon, possibility of mass production with less energy compared to other construction materials, being sustainable resource and producing useful residue during manufacturing which could be used to generate energy for other industries.3

The other imminent material used in Queenslanders was iron (used in the rooves) which had couple of benefits compared to other alternatives (such as slate) namely reliability, waterproofing, easy mounting and lastly providing a supply of clean rainwater.[2]

1. Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
2. Bell, Peter. A History of the Queensland House / Peter Bell. Adelaide: Historical Research, 2002.
3. Ximenes, Fabiano, Misheck Kapambwe, and Rodney Keenan. "Timber Use in Residential Construction and Demolition." Environment Design Guide (2008): 1-8. www.jstor.org/stable/26148968.
4.

Queenslander houses structure

The construction technique used in most of these houses was the light stud frame, in which each wall of the house was formed of a row of light vertical posts or studs, with horizontal boards nailed to them. The technique had been developed in England a hundred years earlier for lightweight farm sheds and cricket pavillions, and adopted enthusiastically in Australia and New Zealand in the early nineteenth century to provide cheap colonial housing.
The use of external framing required a lining board that lay flush against the studs, and was weather-lapped by milled chamfers at the top and bottom of each board, giving them the local name of chamferboards. Internal partitions in timber houses were usually very light walls consisting of a single layer of vertical tongue-and-groove boards secured to one or two horizontal rails.
The structure of most houses is the stud frame, lined with boards on the Inner face, and left exposed
externally. this boards can be disassemble and fix easilly. Because the product can be easily disassembled, it is easier to remove things that are broken and repair them, change or upgrade outdated
technology, making it easier and cheaper to maintain and operate. When a broken part is removed, it can be disassembled into all its smaller components, enabling all of the parts to be upcycled to new products in the best possible way.
Construction of houses was highly industrialised and centralised, the majority being prefabricated, or at least precut, at builders' yards. The practical explanation for the adopting of exposedbframing in Queensland Is obviously that it saves a third or more of the wall's cost, in a region where insulation Is not essential.
The most conspicuous architectural legacy of the tropical planter economy was the highset house. The practice of raising houses three metres or more off the ground is one of the more distinctive features of Queensland's domestic architecture, and a number of authors have devoted space to explaining the reasons for it, variously proposing flooding, hillslope sites, defence against mosquitoes or termites, or in one case, crocodiles. There has never been a standard term for the posts which elevated the house; they have been variously called posts, piles, piers, blocks or stumps. Traditionally they were round tree trunks, which gave them the most popular name, stumps. They also became an important part of the timber house's defence against termites. As early as the 1860s, stumps under low-set houses were being capped with a piece of sheetmetal as a termite barrier, and by the early 1880s this had become standardised as a massproduced dish-shaped stump cap Later in the century, the use of stumps allowed a house to adapt to a different topography; the old stumps could be cut to the requisite height or new ones procured for levelling all around.

'SQUARE WOODEN BOXES ON LONG LEGS' Peter Bell

A workers' house at Thomas Swallow's Hambledon plantation, south of Cairns.[1]

1.Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
2.
3.
4.

for example this house in Mitchelton, Brisbane has been relocated to Dalby and the relocation process is:

1. Structural movers slide steel beams under the ground floor to lift it;
2. The house removal team will support the house on hydraulic jacks and carefully take the weight off the existing old house stump.
3. Then the house is raised on jacks,
4. Dollies are maneuvered beneath it, and the beams supporting the house are lowered onto the dollies, which have an integrated hydraulic suspension system that adjusts to the road, so that no part of the house is unduly stressed on the way.[1]

Mitchelton house originaly in Brisbane.1

Mitchelton arriving in Dalby.[1]

Mitchelton relocating to new site in Dalby.[1]

Mitchelton positioning in Dalby.[1]

Joining Mitchelton on site in Dalby.[1]

Mitchelton joined up in Dalby.[1]

Mitchelton being stumped on site in Dalby.[1]

Mitchelton finished on site .[1]

1. "Dalbyremovalhomes." http://www.dalbyremovalhomes.com.au/asp/images002.asp.
2.
3.
4.

or Millwood house has been rolacated from Tummaville to Boonah.

Millwood from Tummawill to Boonah.[1]

Millwood loaded at Tummawill.[1]

Millwood loaded to go to Boonah.[1]

Millwood loaded to go.[1]

Millwood loaded undergoing removal works.[1]

Millwood relocating to Boonah.[1]

Millwood at boonah.1

Millwood new roof and restumped at Boonah.[1]

1. "Dalbyremovalhomes." http://www.dalbyremovalhomes.com.au/asp/images002.asp.
2.
3.
4.

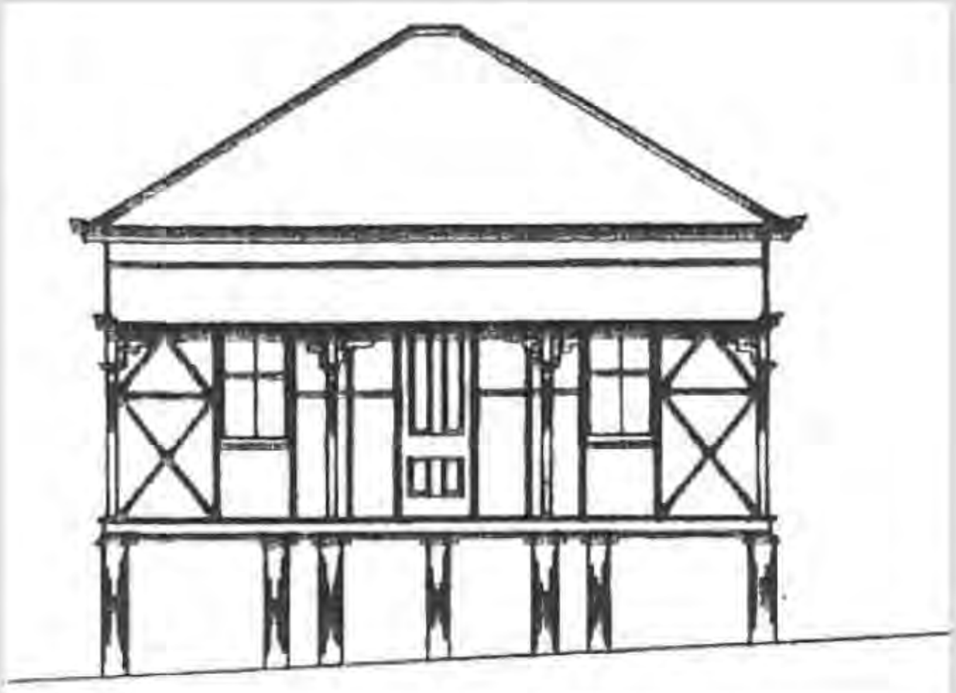
The majority of wood used in houses in Australia is used for framing applications (nearly 52 per cent, according to estimates of wood usage from BISShrapnel (BIS-Shrapnel, 2008)). Construction, renovation and demolition of buildings are responsible for approximately 40 per cent of waste deposited in landfills in Organisation for Economic Co-operation and Development (OECD) countries (OECD, 2003). Significant volumes of waste are generated as a result of construction and demolition activities in Australia. The Department of Environment so Removal homes save time, money and the environment by reducing demolition costs, avoiding the waste of new construction resources, and conserving the embodied energy of the building. and Heritage (DEH) estimated that of the 14 million tonnes of construction and demolition waste produced. Removal homes save time, money and the environment by reducing demolition costs, avoiding the waste of new construction resources, and conserving the embodied energy of the building.

1. "Dalbyremovalhomes." http://www.dalbyremovalhomes.com.au/asp/images002.asp.
2.
3.
4.

Single Skin

The climate played a part in shaping the Queensland house. a single skin of boards was enough. Hence the practice arose of reducing costs by leaving the timber frame exposed on the outside of the house (of course the option of later cladding remained open).[1]

single skin timber wall is much more flexible than brick work due to it being a light weight construction you can design and build almost anything you wish, Timber can easily obtain very high energy ratings due to lightweight construction having low thermal mass and therefore with the right insulation can change from cool to hot in an efficient and timely manner to adapt to the weather conditions. Timber has a much lower embodied energy than clay bricks, most of the embodied energy in bricks is from the in-depth manufacturing process. Therefore, timber is much more sustainable and has a better impact on the environment.[2]



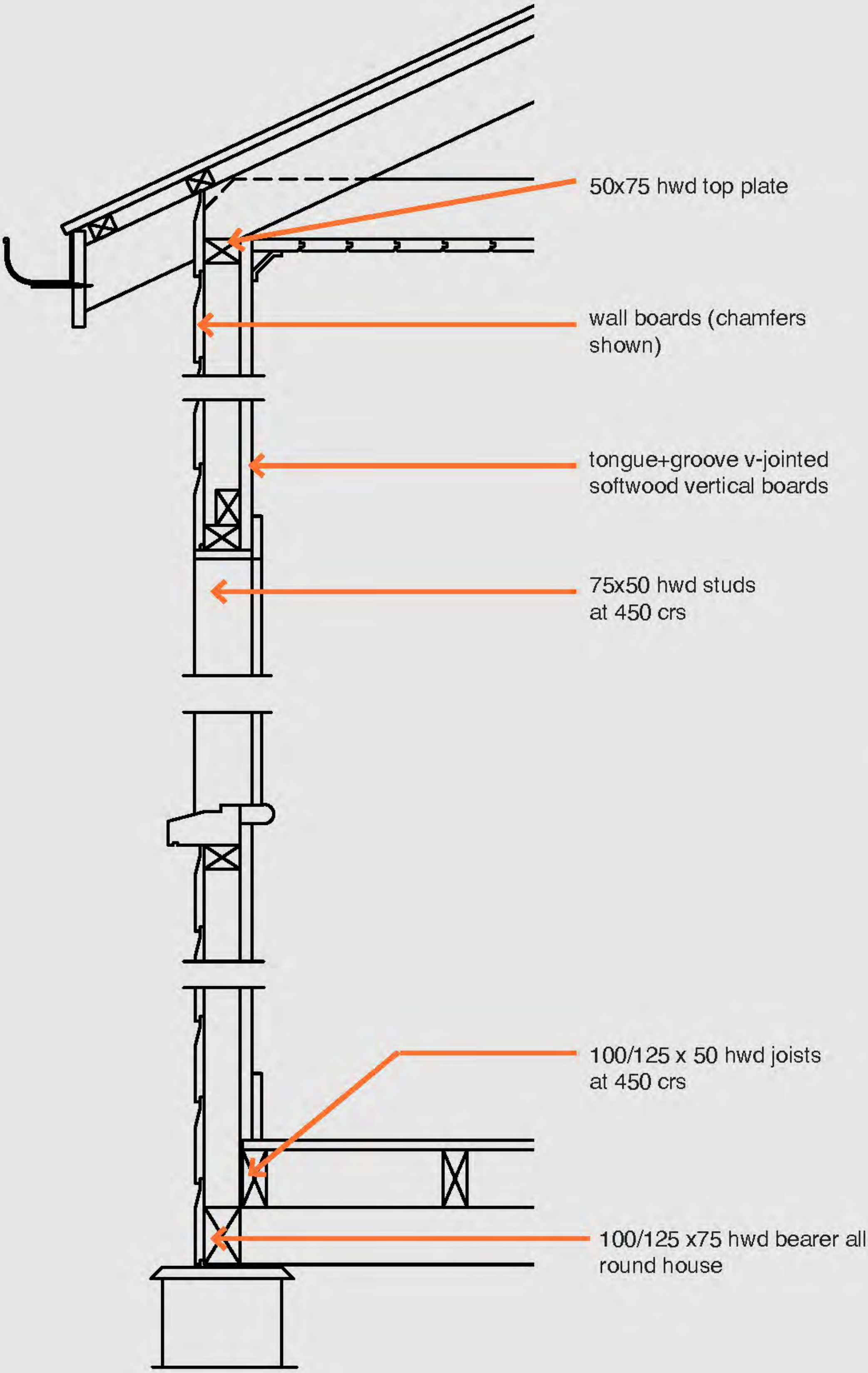
The legacy of the Federation era: a nineteenth century Queensland house facade.[1]

The legacy of the Federation era: a twentieth century Queensland house facade.[1]

1. Bell, Peter. A History of the Queensland House / Peter Bell. Adelaide: Historical Research, 2002.
2. "Double Brick Vs Timber Framed Construction." 2017, https://www.distinctrenovations.com.au/blog/double-brick-vs-timber-framed.
3.
4.

Single Skin

the following drawings are the construction details of typical Queenslander houses and their specific way of construction which is making them durable.

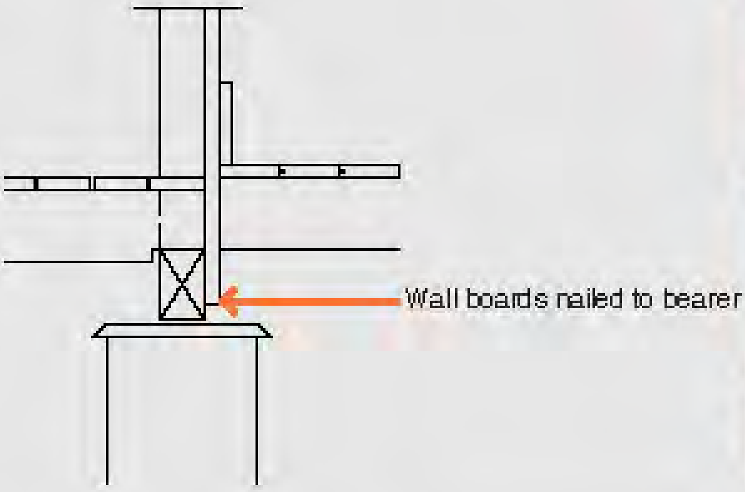


Detail section at external wall.[1]

Verandah exposed timber frame.[1]

1. “Queenslanders Design + Documentation.” http://latemoredesign.com.au/brochure/.
2.
3.
4.

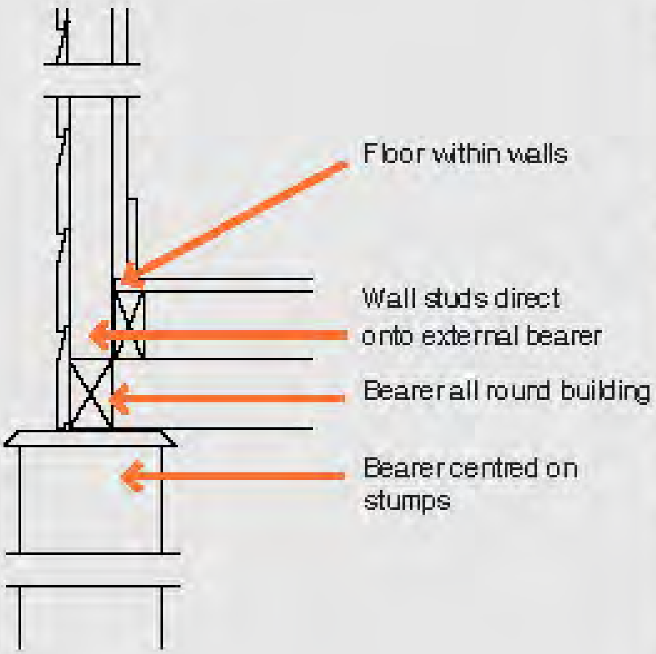
Elements - VJ's onto bearer.[1]



Scott House Windsor 1920s.[1]

The vertical wall studs were not supported by a bottom plate (later framing) but instead extended down to the bearers supported by the stumps (piers).[3]

Elements - Walls onto bearer.[1]

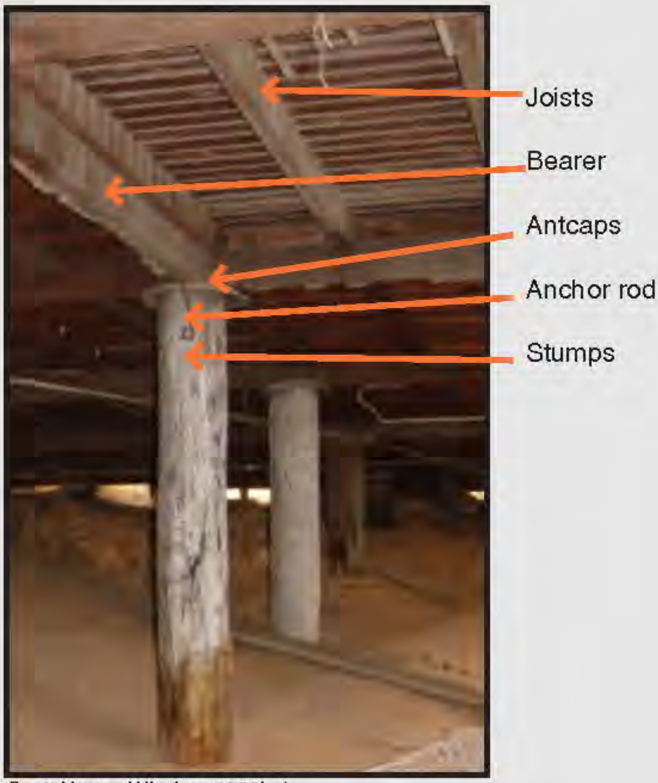


The foundations of the Eureka hotel show the use of a round stump squared down to become a wall post Shorter stumps support the floor bearers.[2]

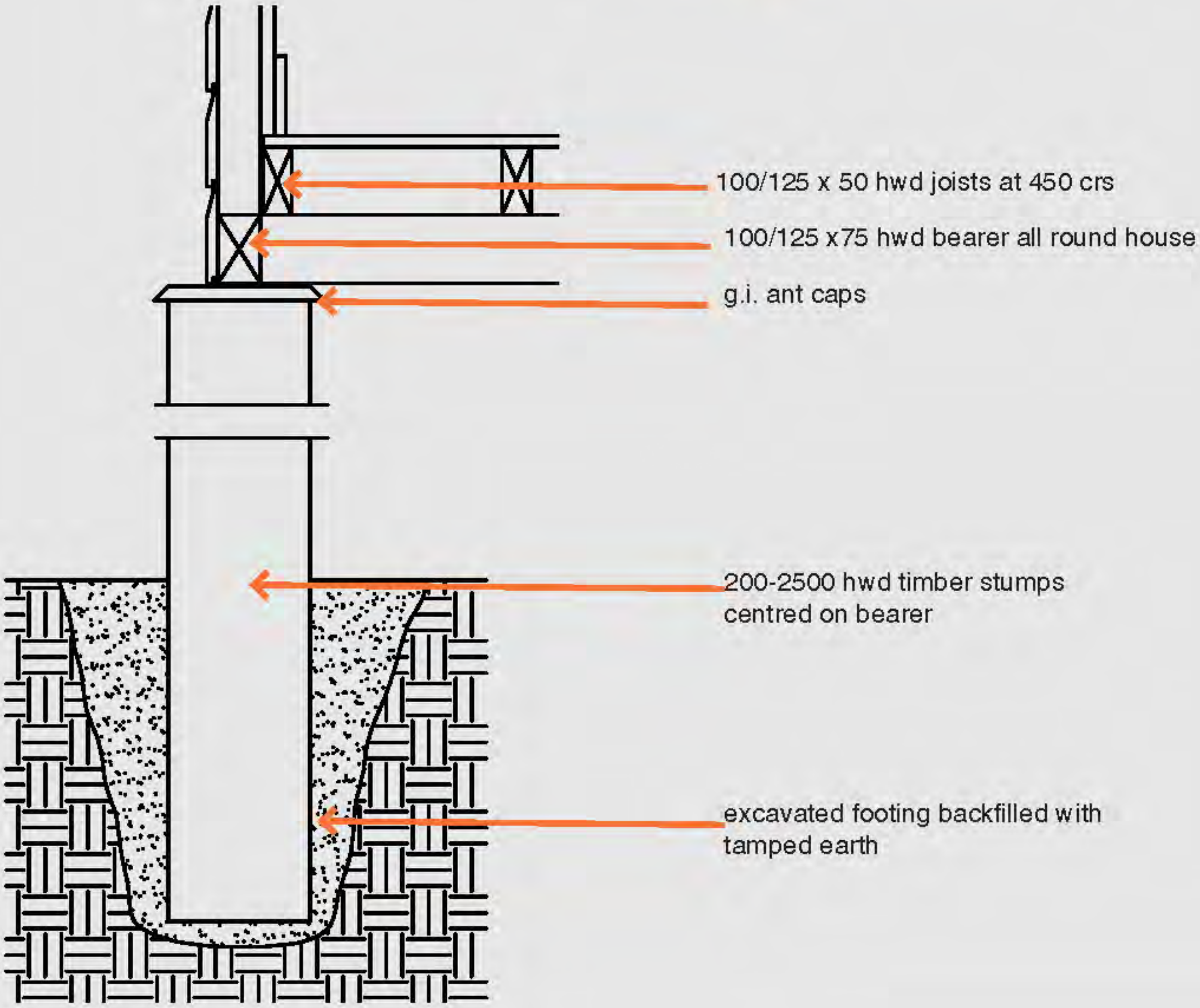
1. "Queenslanders Design + Documentation." http://latemoredesign.com.au/brochure/.
2. Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
3. "Queenslander Frame Components." 2020, https://qbis.com.au/queenslander-frame-components-2/.
4.

Elements - undercroft.1

- Stumps provide bracing
- Anchor bolts are also tiedown.[1]



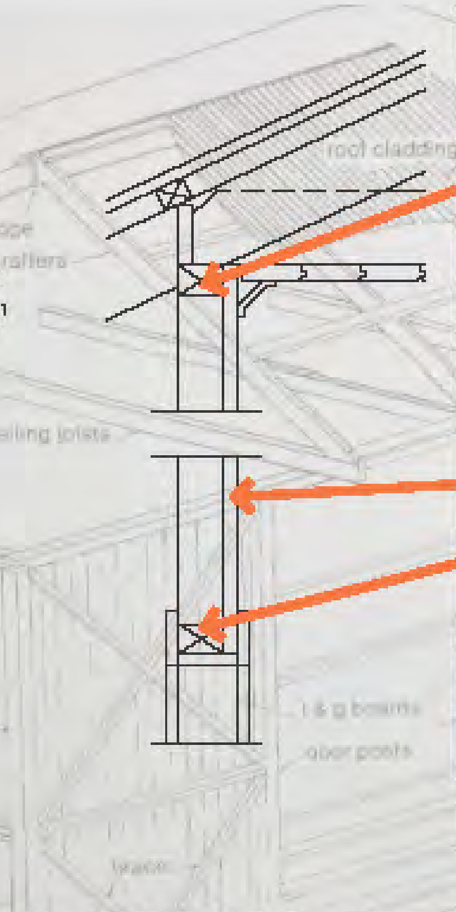
Scott House Windsor 1920's.[1]



1. "Queenslanders Design + Documentation." http://latemoredesign.com.au/brochure/.
2.
3.
4.

Elements - External VJ Walls.[1]

- Single skin withposts
- Roof/ceiling loadnbearing
- Joinery within posts
- Braces on older houses
- External stud +vj walls are load bearing
- Internal vj walls often support ceiling
- VJ walls provide bracing
- VJ's are the main wall tie-down element
- Nailed into sides of top plates + bearers[1]



117 Kendalls Road. 1

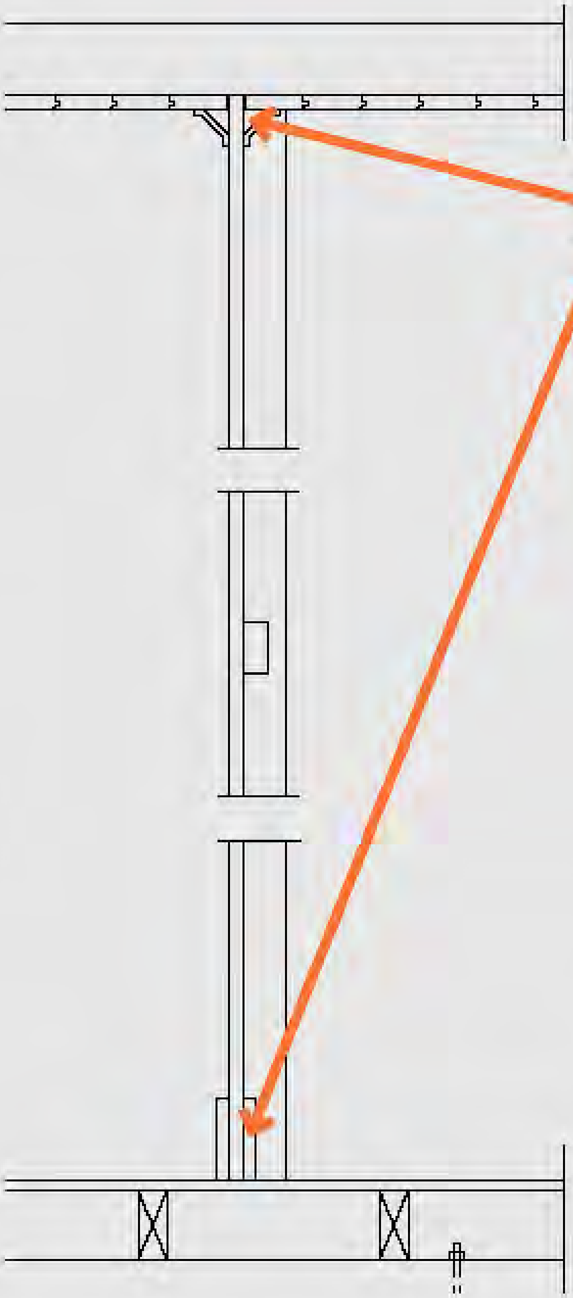
- Single skin can be horizontal
- Double belt rails some houses

Stamped sheet-metal brackets in Bowen.[2]

1. "Queenslanders Design + Documentation." http://laterrordesign.com.au/brochure/.
2. Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
3.
4.

Elements - Internal VJ Walls[1]

VJ or vertical joints (also known as tongue and groove) run vertically to create a wall and were very common in old Queenslanders. Tongue and groove is a method of fitting similar objects together, edge to edge, used mainly with wood paneling. It allows two flat pieces to be joined strongly together to make a single flat surface. Each piece has a slot (the groove) cut all along one edge, and a thin, deep ridge (the tongue) on the opposite edge. The tongue projects a little less than the groove is deep. Two or more pieces thus fit together closely. The joint is not normally glued, as shrinkage would then pull the tongue off. Gaps between boards tended to be sealed with beading. Tongue and groove boards have been rendered obsolete by the introduction of gyrock and other wall sheeting.[2]This type of wall lining can be renovate or fix easily in comparison with plasterboard becoase all board should be change and remove for fixing plasterboard but we can only fix one board without damaging the rest of the lining in VJ boards.

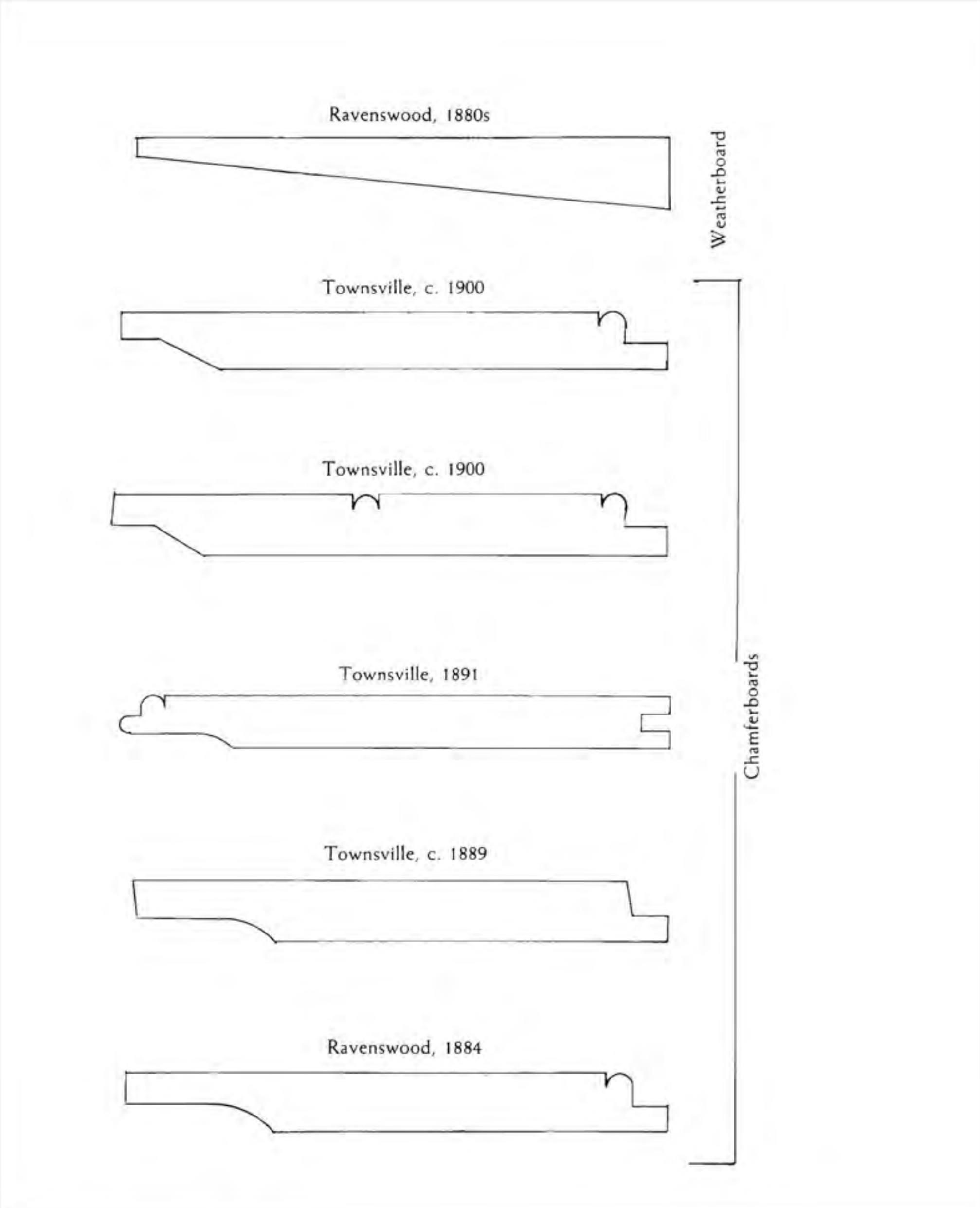


- Single skin with posts
- Ceiling load bearing
- Doors within posts
- Direct onto floor
- Belt rail one side
- Skirtings structural.[1]

1. "Queenslanders Design + Documentation." http://latemoredesign.com.au/brochure/.
2. Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
3.
4.

Elements - Cross-sections of some characteristic cladding boards.

Chamferboards were nailed flush to the inner surface of the frame. The chamferboard was usually a 25 x 200 mm dressed board with its upper and lower edges rebated to form a weather overlap. A variety of profiles are encountered, with curved or angular rebates and square or angled edges. Most chamferboards were beaded internally along either the upper or lower edge, and many have a second bead incised along their mid-line. On better quality houses the inner face of the chamferboards used for the exterior walls exactly matched the tongue and groove boards used for partitions.[1]



Cross-sections of some characteristic cladding boards.[1]

1. Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
2.
3.
4.

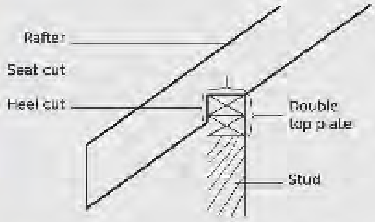
Jointing

The building construction of Queensland vernacular timber houses relied on carpentry for fixings and tie down resulting in a robust, integrated structure. timber stud wall framing, morticed to the floor structure, timber joist floor frame with tongue and groove flooring,The junction details and integrated bracing provide a strong, light structure, which is capable of some movement and deflection when stressed, as occurs in the removal and transportation journey. [1]

Birdsmouth

The joint is formed by cutting an angular notch called bird mouth in the main member, to which the other member is inserted and fitted.[2]

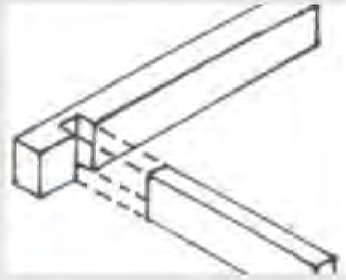
Birdsmouth.[2]



Housing joints

When the end of a board is to be joined to the face of another, the housing joint provides a solid and durable method of attachment. wall-plate [2]

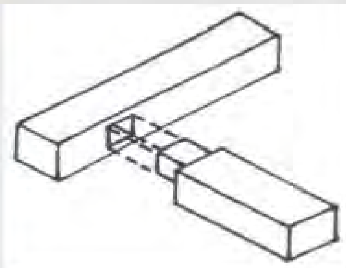
Housing joints.[2]



Mortise and tenon joints

A mortise (or mortice) and tenon joint connects two pieces of wood or of other material. Wood-workers around the world have used it for thousands of years to join pieces of wood, mainly when the adjoining pieces connect at right angles.[2] this joint have used in Belt railsHand rails in Queenslander Houses.

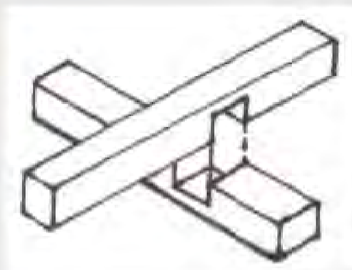
Mortise and tenon joints.[2]



Halving joint

The halving joint is mainly used in framework and is moderately difficult to construct because it consist of two channels that interlock and are bonded together with adhesives and sometimes a nail or screw is added for extra strength. Verandah Purlin[2]

Halving joint.[2]



1. Case, Joanne and Spanbroek, Nancy (2001) The Relocatable House, in Dreaming for the Future, UIAH Future Home Conference, pp. 2-11, Helsinki, Finland, May 7-19 2001. University of Art and Design, Helsinki.
2. "A Guide to All Things Woodwork" (2019). http://www.woodworkbasics.com/halving-joint.html#:~:text=The%20halving%20joint%20is%2 mainly,is%20added%20for%20extra%20strength.
3.
4.

Modern Houses

Currently, the detached house represents the majority of the built environment in suburban Australia. Many new project homes adopt generic designs regardless of local topographical or climatic conditions, resulting in a homogeneous housing stock proliferating across widely varying climate zones. In Queensland, these types of designs have marginalised local design knowledge and building practice, and often result in inappropriate outcomes that rely on energy-consuming appliances such as air conditioning for comfort. Since the 1960's the majority of houses constructed in South East Queensland have been timber framed and brick veneer construction on concrete slab on ground. Due to costs and the speed of construction, concrete slab on ground has been widely preferred by the building industry over the low set raised timber floor system. The stud frame in modern houses which no nineteenth century carpenter would have recognised it. During the wartime emergency, joinery had shrunk to the absolute minimum needed to keep two pieces of timber in contact. Mortice and tenon joints had vanished, and studs were merely housed into a slot cut a few millimetres into the top and bottom plates (a joint requiring two brief sawcuts and two chisel blows) and then skew-nailed. In the cheapest construction, the joinery was omitted and skew-nails did the entire job.[1]

As we can find from following table there is vvariaty of construction systems in Australia but all of them are not suitable for designing for circular future based on the construction details and embodied energy in the material and construction system. they are far away from being relocatable or easilly be renovated like Queenslander houses. in the nex part of the research the aim is to analyse the timber frame detache house and it's material to find best construction system for modern houses to make them as much as close to Queenslander houses construction system.

The Austerity house[1]

1. Bell, Peter. Timber and Iron : Houses in North Queensland Mining Settlements, 1861-1920. University of Queensland Press, 1984.
2.
3.
4.

Construction systems and their most applicable buildings.[1]

Construction systems		The two storey class 1a house	The two storey class 1a townhouse	The two storey class 2 apartment
Footing	Strip footing	✓	✓	✓
	Pad footing	✓	✓	✓
	Small diameter piles	×	×	✓
	Screw piles	×	×	✓
Retaining wall	Concrete masonry retaining wall	✓	✓	✓
	Treated timber sleeper retaining wall	✓	✓	×
Sub floor	Timber stump	✓	✓	×
	Steel stump	✓	✓	✓
	Masonry piers	✓	✓	✓
Structural floor system	Slab on ground	✓	✓	✓
	Suspended concrete	×	×	✓
	Full timber framed floor	✓	✓	✓
	Timber framed with steel beam floor	✓	✓	✓
	Timber framed with engineered beams	✓	✓	✓
	Light weight steel framed floor	✓	✓	✓
flooring	Timber strip flooring	✓	✓	×
	Particleboard flooring	✓	✓	×
	Ply flooring	✓	✓	✓
	FC sheet flooring	✓	✓	✓
walls	Prefab timber frame wall	✓	✓	✓
	On – site built timber framed wall	✓	✓	×
	Steel framed wall	✓	✓	✓
	Veneer brick wall	✓	✓	✓
	Cavity brick wall	✓	✓	✓
	Block wall	✓	✓	✓
Roof	Timber trusses	✓	✓	✓
	Cathedral roof construction	✓	×	×
	Steel beams/purlins	✓	✓	✓

1. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
2.
3.
4.

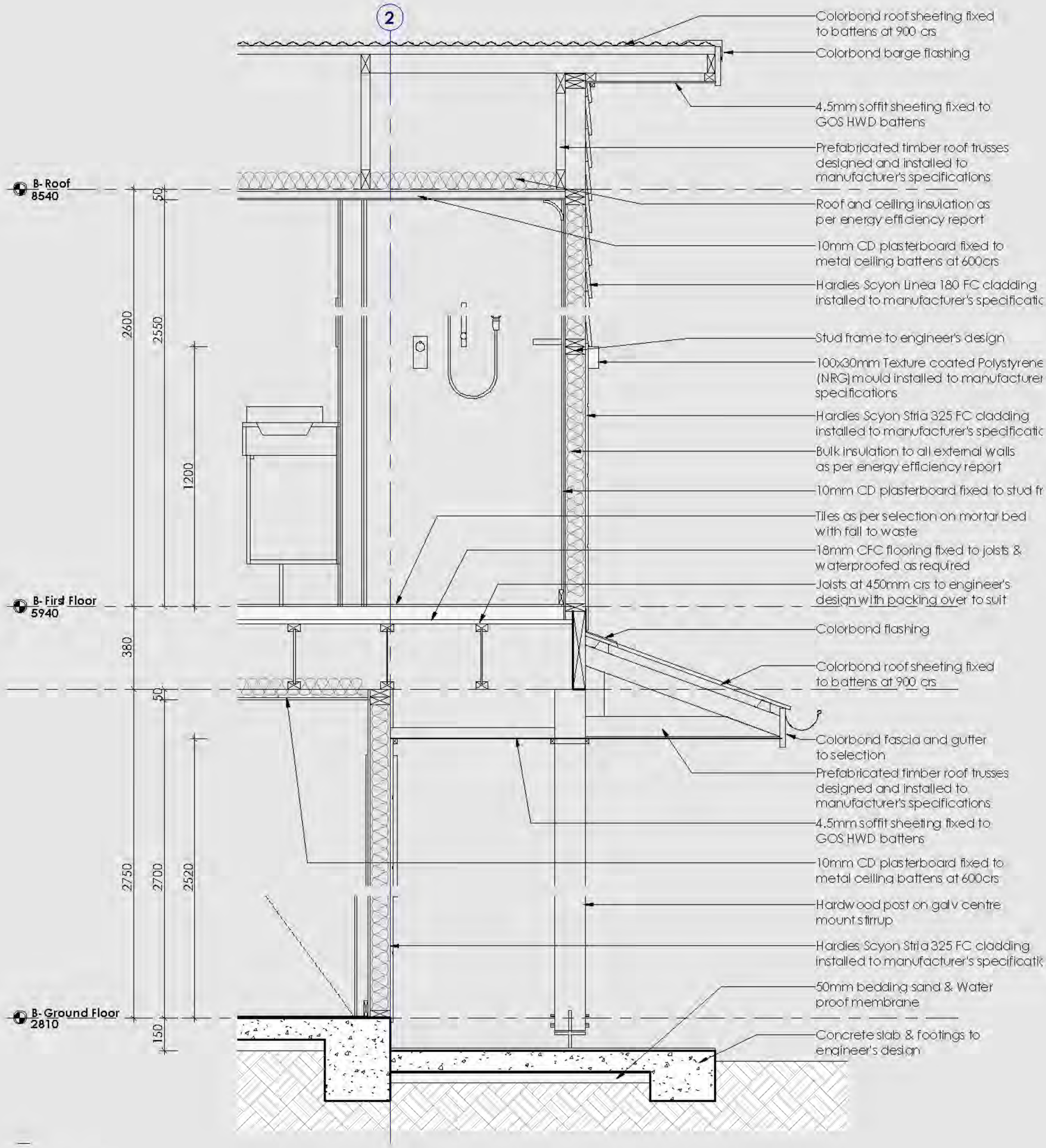
For example the detached house in Thomsonn street has been built with timber frame and concrete slab. the internal lining is with plasterboard and cladding is mostly with Haardies Skyon Stria FC sheets .[1]

Concrete slab
This house won't be relocatable because of concrete slab. it would be very difficult to access underneath concret footing and the Concrete slab-on-ground construction requires extensive cutting and filling of land and causes loss of habitat, interruptions to overland water flow and results in dramatically altered microclimatic conditions. [2]

Embodied energy for assembled floors[3]

Assembly	PER embodied energy MJ/m²
Elevated timber floor	293
110mm concrete slab-on-ground	645
200mm precast concrete, T beam/infill	644

1. "Thomson Strret House." 2019, https://www.mercury-design.com/thomson-street-residence.
2. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
3. "Embodied Energy." 2013, https://www.yourhome.gov.au/materials/embodied-energy.
4.



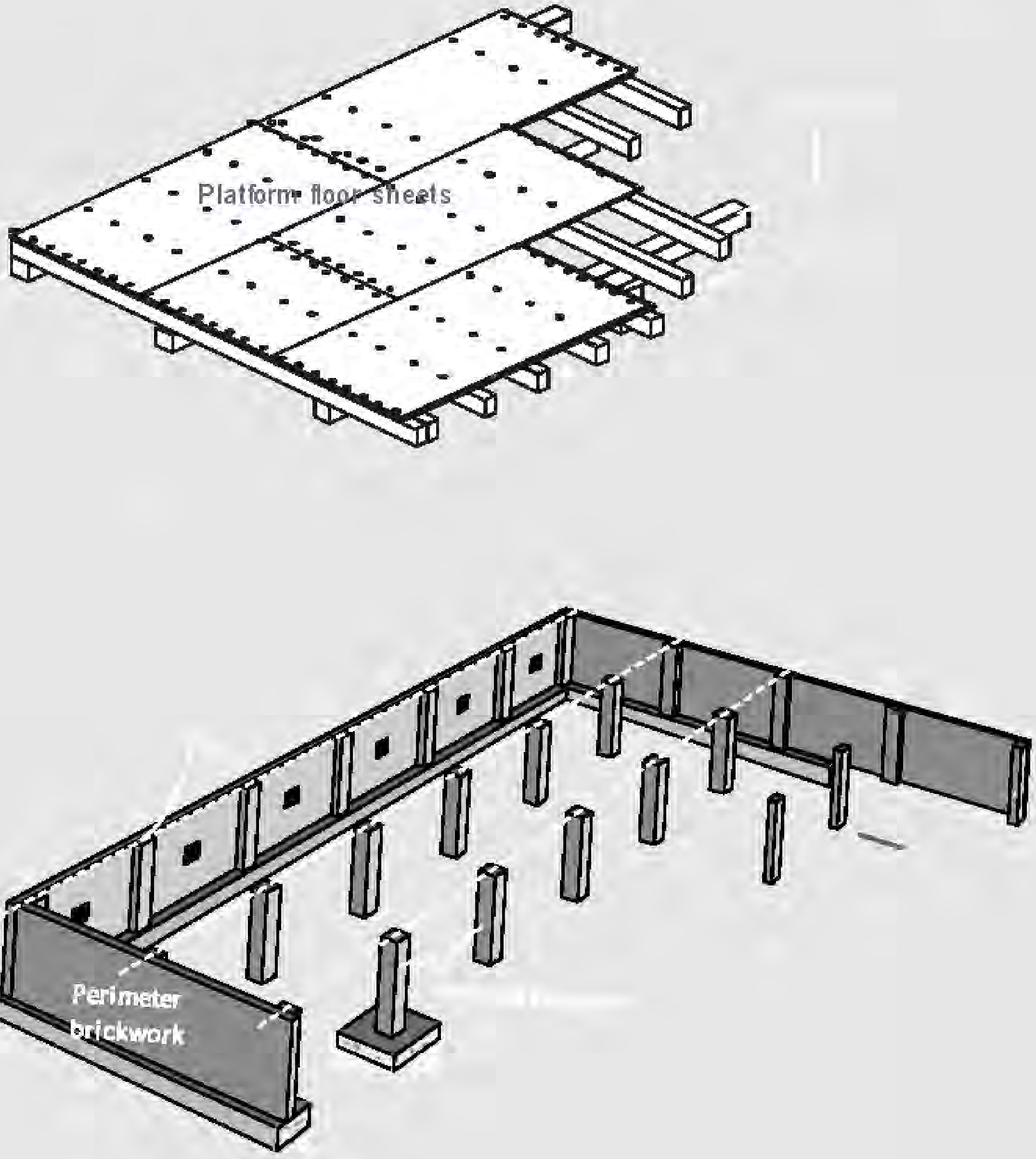
Wall Section[1]

1. "Thomson Strret House." 2019, https://www.mercury-design.com/thomson-street-residence.
2.
3.
4.

Suspended Timber Floor Construction

We can use suspended timber floor construction system instead of concrete slab because this system is similar to Queenslanded houses construction system and is on pierer so the house can be relocate in the future and Lightweight timber framing using sustainably sourced plantation timber is a carbon sink efectively minimising embodied energy. Engineered timber bearers and joists allow for highly efficient use of materials but glues can have a detrimental effect on indoor air quality and human health. Timber is subject to termite attack and, while termite proofing reduces this risk, it often relies on chemical treatments that have other environmental implications. It is relatively low cost. The raised floors possible with timber construction techniques are much better able to accommodate sloping and 'difficult' terrain without major interventions on site.

- A "Platform floor" made from plywood or particleboard sheets suports walls above
- "Joists" support the platform floor "Bearers" support the joists
- A grid of subfloor supports, support the bearers
- If required, perimeter brickwork can be used to enclose the subfloor and contribute to the supports
- Footings support brickwork and the subfloor supports – the loads are then distributed to the ground.[1]

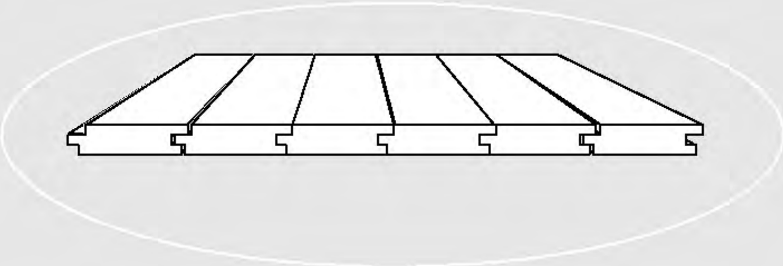


Suspended Timber Floor.[1]

1. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
2.
3.
4.

Constructing Fitted Flooring

- An alternative to the platform approach is a "Fitted floor" (or "Cut in" floor)
- These floors are cut in after the walls have been placed
- Though the same sheeting material as platform flooring may be used, tongue and groove floorboards are more common. They usually serve a decorate as well as functional role
- They are nailed directly to the joists and glue isn't normally used
- These boards can also be used as a decorative overlay to platform flooring, but different fixing methods apply.[1]



Advantages of Timber Floors

- Suspended timber floors are good for steeply sloping sites and for obtaining ground clearance. They are even more beneficial where utilising "open" subfloor construction. This removes the need for perimeter subfloor walls and associated advantages include:
- No strip footings required
- Less footing excavation
- Less concrete usage
- Reduced number of trades involved
- Better at dealing with reactive and problem soil types
- Easier to use on sites with limited access
- Better for environmentally sensitive sites
- Better for termite management
- Less cost.[1]

Suspended Timber Floor.[1]

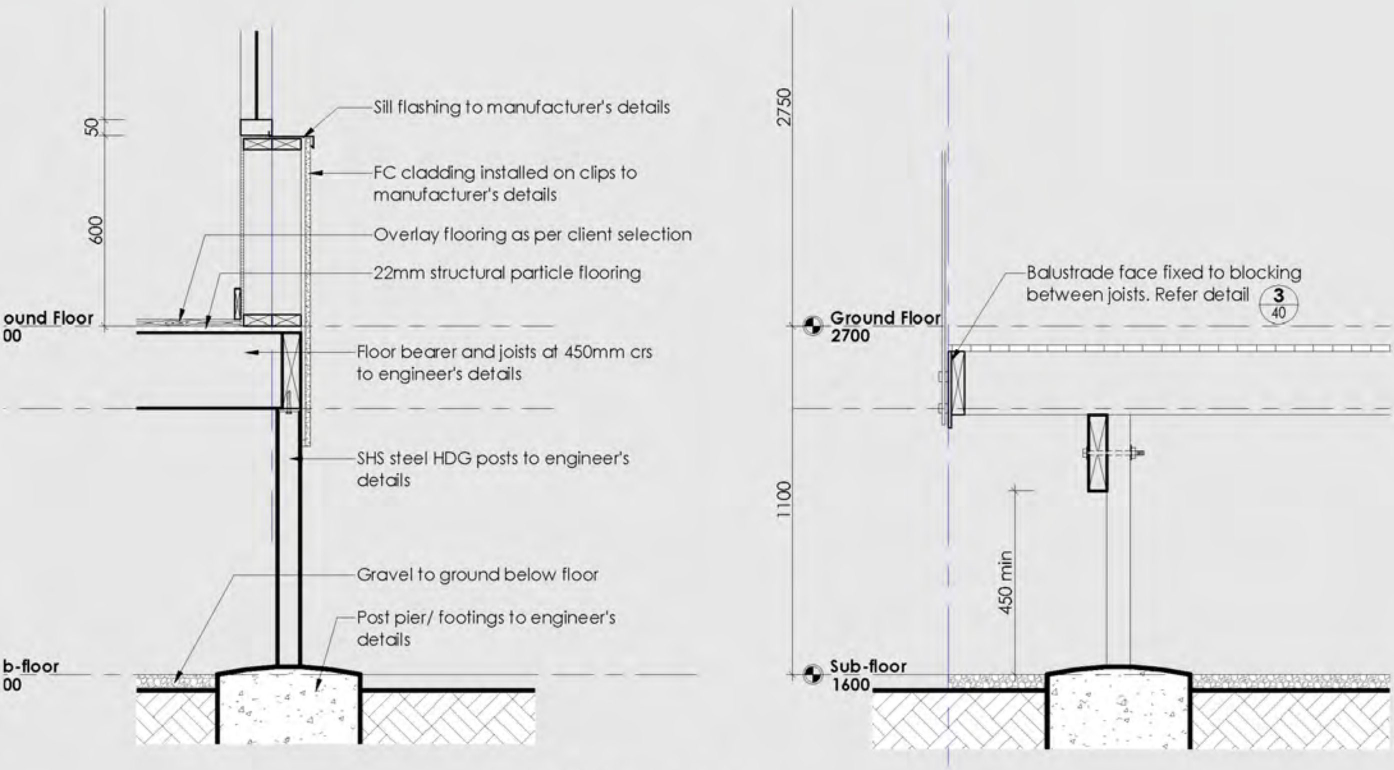
1. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
2.
3.
4.

Screw-in steel piles can be used as an alternative to pad footings and can also be used to provide deep support for strip footings i.e. where founded on poor or highly reactive soils.[1]

Process:

- Piles consist of a metal tube with a helix configuration at the end
- Piles are screwed into the ground until sufficient (torque) resistance is met
- No spoil or concreting is involved
- The installation process is fast and relatively accurate
- The tops of piles can be cut if being embedded in strip footings, otherwise they can extend as high as necessary to act as a support post to the bearer (thus contributing to the subfloor support) [1]

Screw-in steel piles[1]



Wall Section[2]

1. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
2. “Thomson Strret House.” 2019, https://www.mercury-design.com/thomson-street-residence.
3.
4.

Timber Wall FrameConstruction

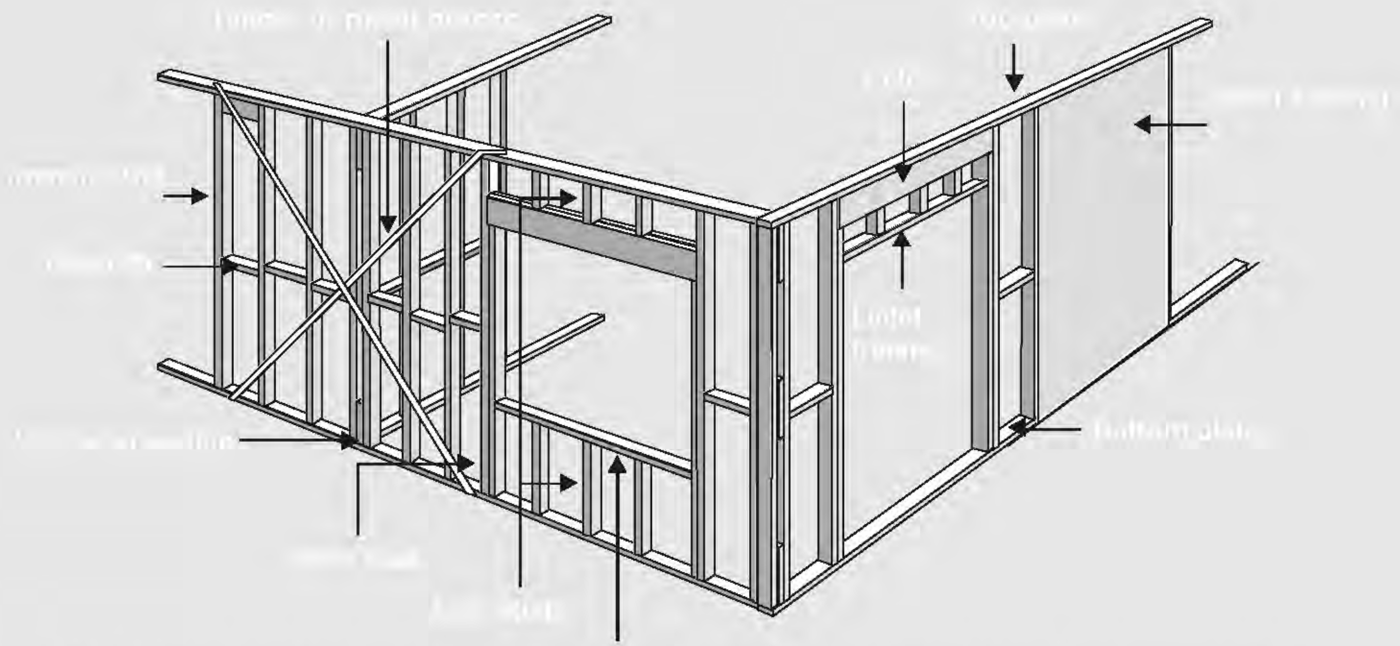
This building is going to be with lightweight timber construction system that has the low embodied energy. Embodied energy content varies greatly with different construction types.[1]

Embodied energy for assembled walls2

Assembly	PER embodied energy MJ/m²
Single skin AAC block wall	440
Single skin AAC block wall gyprock lining	448
Single skin stabilised (rammed) earth wall (5% cement)	405
Steel frame, compressed fibre cement clad wall	385
Timber frame, reconstituted timber weatherboard wall	377

Timber Wall FrameConstruction

The figure below depicts the members in wall frame construction. Each must be designed in accordance with AS1684.[1]



- Top plates take roof loads and transfer them to studs - top plates also hold the top of the frame together
- Common studs act like columns taking loads from the top plate and transferring the loads to the bottom plate - studs are typically 450 or 600mm apart
- Noggings are placed in the mid region of the wall height to strengthen studs by stopping them from bowing under load i.e. a form of lateral restraint
- Bottom plates take loads from the studs and transfer the loads to the floor structures - bottom plates also hold the bottoms of the frame together
- Lintels carry the load over window and door openings, and distribute the loads to jamb studs on either side. The larger the span and load, the larger the lintel
- Jamb studs take the load from lintels an transfer it to the bottom plate
- Bracing provides rigidity and stability to the wall frames thus resisting lateral loads (e.g. wind)[1]

1. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
2. "Embodied Energy." 2013, https://www.yourhome.gov.au/materials/embodied-energy.
3.
4.

Nailing

The stud frame in modern houses which no nineteenth century carpenter would have recognised it. During the wartime emergency, joinery had shrunk to the absolute minimum needed to keep two pieces of timber in contact. Mortice and tenon joints had vanished, and studs were merely housed into a slot cut a few millimetres into the top and bottom plates (a joint requiring two brief sawcuts and two chisel blows) and then skew-nailed. In the cheapest construction, the joinery was omitted and skew-nails did the entire job.[1]

Screw instead of nail

Piercing nails through structures and materials to make connections is very common find in the construction industry. Unfortunately, the downside to this is that nails damage the material and cannot be retrofitted to other uses. Instead, it is better to practise using screws, nuts and bolts because of easier design for disassembly allow for reuse of materials.[2]

1. Bell, Peter. A History of the Queensland House / Peter Bell. Adelaide: Historical Research, 2002.
2. "Jensen, K.G., and J. Sommer. Building a Circular Future. GXN Innovation, 2016. https://books.google.com.au/books?id=8SepAQAACAAJ.
3.
4.

Claddings in Wall Frame Construction

Insulated lightweight walls reduce heat loss and can have minimal embodied energy, depending on the cladding material used. Fibre cement sheet, plywood and other sheet cladding systems have low embodied energy and generally low environmental impact. They are very durable, although maintenance is required for any painted surface. Cladding can be fixed directly onto the timber framing thus offering an alternative to brick veneer construction [1]

- Associated advantages include:
- Lightweight construction - less footing construction
- Easy to handle materials onsite
- Cladding can be utilised as wall bracing
- Cladding is more flexible to foundation movement than brickwork i.e. less likely to suffer movement cracks from reactive soils
- Particularly compatible with suspended timber floor construction[1]
-

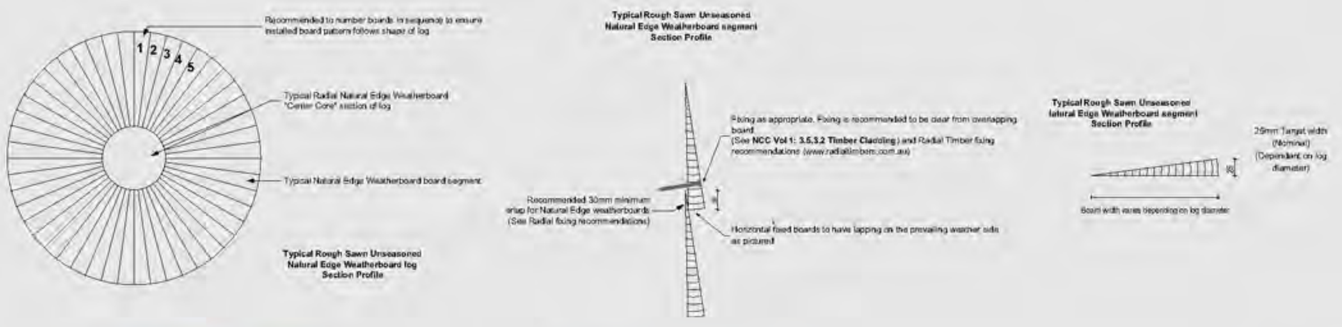
For example Natural Edge Weatherboards could be used as the sustainable and durable cladding

Natural Edge Weatherboards[2]

- Weatherboards are typically ship lapped or splayed overlap to keep weather out
- Hidden nailing possible
- Paint or stain finish needed for appearance/durability

PRODUCT[3]

- Natural edge weatherboards are produced by a patented sawing method that produces perfectly quarter sawn boards. Quarter sawn boards are very stable and can be identified by the alignment of growth rings which are generally at right angles to the broad face of the board. Natural Edge Weatherboards are sawn from strong hardwood timber and are supplied unseasoned, shrinking with virtually no distortion and minimum checking on the exposed face.[3]



1. Staines, A. The Australian House Building Manual. Pinedale Press, 2014. https://books.google.com.au/books?id=96KVAAAACAAJ.
2. "Embodied Energy." 2013, https://www.yourhome.gov.au/materials/embodied-energy.
3."Radial Timber Natural Edge Weatherboards." 2020, https://radialtimbers.com.au/products/natural-edge-weatherboards/.4.

Claddings in Wall Frame Construction

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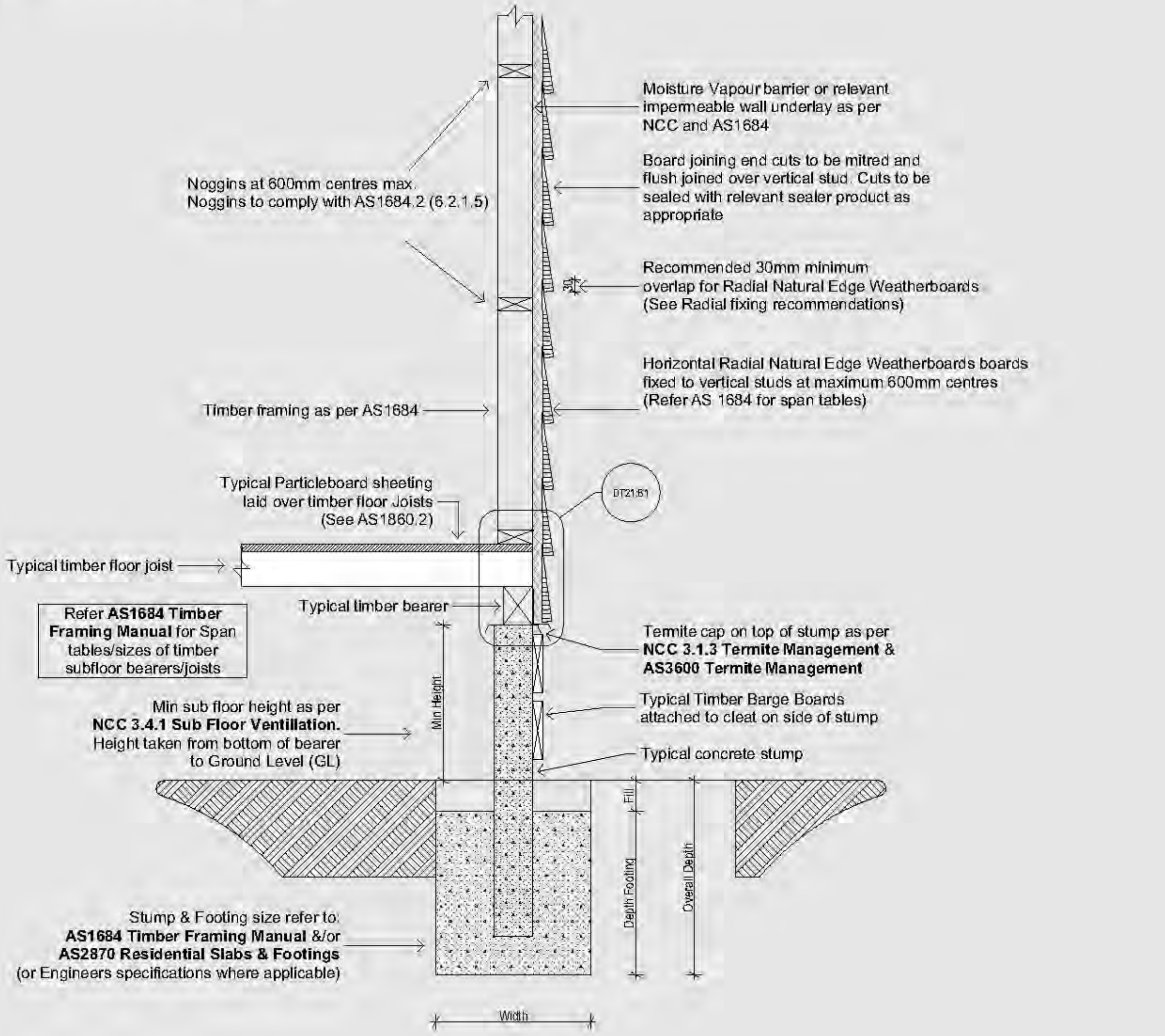
Natural Edge Weatherboards [1]

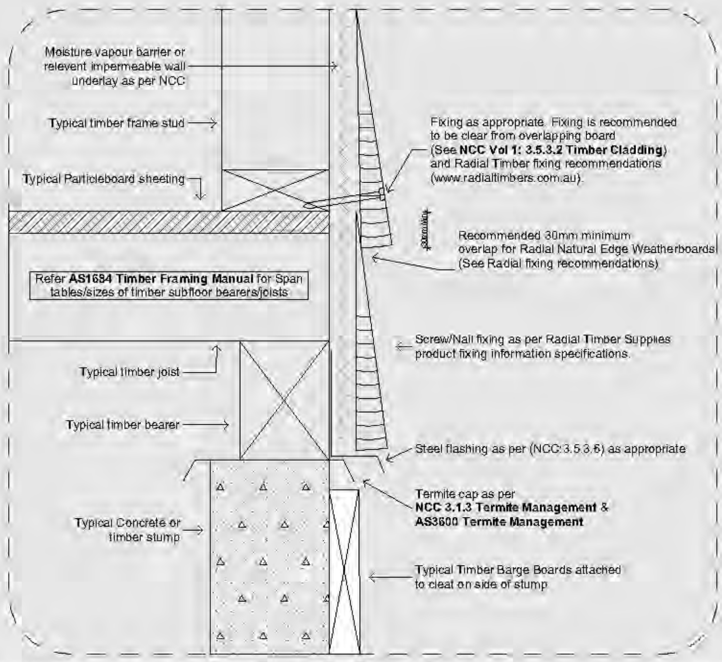
Natural Edge Weatherboards [1]

1.Radial Timber Natural Edge Weatherboards." 2020, https://radialtimbers.com.au/products/natural-edge-weatherboards/.4.

Natural Edge Weatherboards Detail [1]



2.0 NE02:B - Horizontal Radial Natural Edge Weatherboard - Stud Frame: Timber Sub-Floor
1:15



1.Radial Timber Natural Edge Weatherboards." 2020, https://radialtimbers.com.au/products/natural-edge-weatherboards/.4.

Conclusions

This research tried to establish a link between Queenslander's construction methods and modern architicture in hosing design. For that, the Queenslanders structural elements, their main materials and construction techniques were analysed, several professionals in this area were interviewed and the findings were detailed throughout this document.

As discussed in the text and based on the findings described earlier, Queenslanders can be considered as a sample of Future Design as they are portable, re-usable and adaptable. Moreover their materials are sustainable, have long life and consume less energy to be manufactured compared to other elements. This research also found more education and marketing campaign is required to promote using the construction methods used in Queenslanders.

Handout

HYESU JEON

Recycling carpet in Austalia

INTRODUCTION

This handout examines a beginner's overview of the available opportunities in the waste carpet recycling industry across Australia. The primary objective of this handout is to inform a deeper understanding of the possibilities from recycled carpet that are simply being dismissed. The use of carpet in construction is gradually increasing in Australia, yet there are scarce resources which educate consumers about the end-of-life process of carpets. Given that the average life cycle of carpet is only between five to ten years, it is crucial to approach sustainable procedures of recycling old carpet. As a country lacking in manufacturers which sustainably recycle old carpet, it is becoming increasingly pivotal to integrate the systems into our construction industry.

The research will underpin the methodologies which enable textile industries to decrease their dependence on virgin raw materials, lower production costs, and ultimately, minimise their environmental impact. With this handout, it is important that manufacturers and consumers become aware of the detrimental effects carpet disposal in landfills have on the environment.

BACKGROUND

For manufacturers, a considerable amount of time and energy is spent on managing their supply chains varying from raw material suppliers to manufacturers, wholesalers, suppliers and consumers. With the focus being predominantly placed on the supply chain's forward action, scarce amounts of manufacturers have properly addressed the concern on how the supply chain can and should operate in reverse.[1] The consideration in presenting this rising issue is crucial in order to educate consumers and suppliers in recovering the products at the end-of-life cycle and return them for decomposition, disposal or for the re-use of key components, and thus re-entry into the chain. The vitality of adopting a life-cycle approach to product distribution is gradually becoming essential, as well as its implementation into educational programs for customers, suppliers, vendors and others within the supply chain.

Unlike many other construction materials, waste carpet is commonly disregarded and simply disposed in landfills. Standing at second place in the global textile consumer sector, Australia is significantly falling behind other countries in regards to the initiative taken in the carpet recycling industry (figure one).[1]

BACKGROUND CONTINUED

501,000 tonnes of textiles, including carpet, are discarded into Australian landfill on an annual basis, yet a mere 15 percent of the discards are being recycled (figure two). [2] The face fibres of carpets produced in Australia are generally comprised of synthetic fibres, including nylon and polypropylene, or natural fibres such as wool. However, these synthetic fibres are not decomposable, and wool, although it does decompose, it emits methane gases during the process. [3] As a result, more greenhouse gases are released into the environment.

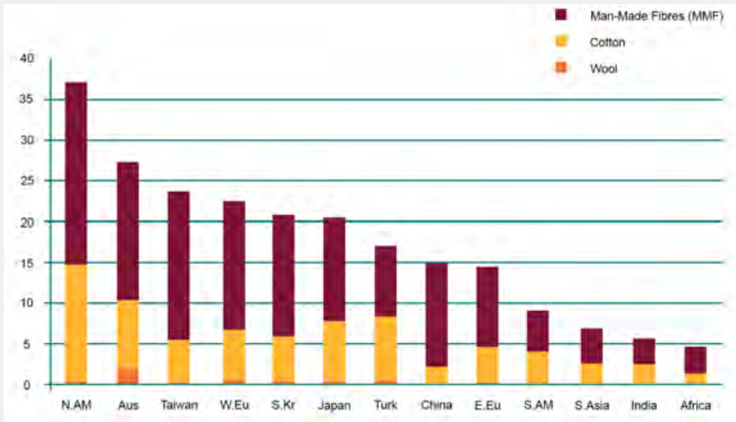


Figure one Global Final Consumer Demand for Textiles (kg/ Capita).

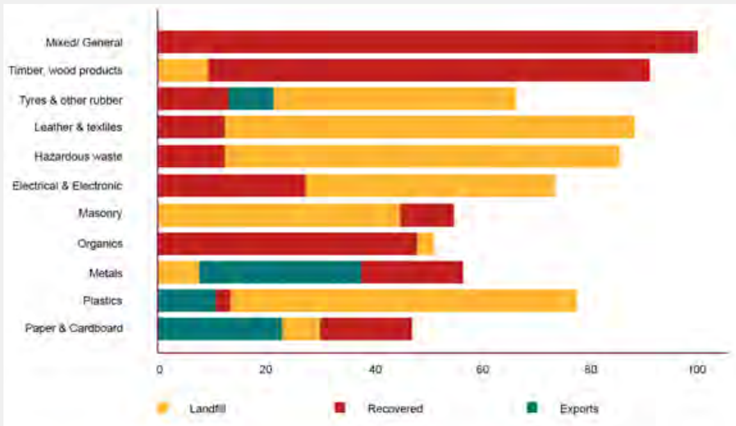


Figure two Waste Management by Material (% of Material Generation), from 2009 to 2010.

WHAT IS BEING DONE IN AUSTRALIA?

While most carpet fibres are recyclable, there are currently **no commercial recycling plants** specific for carpet within Australia.[4] Interface is one organisation which has developed a new carpet recycling facility; the first of its sort in Australia.

WHAT IS BEING DONE IN AUSTRALIA? (cont.)

The company provides two different forms of recycling, whereby 'ReUse' is a program in which old carpet is refurbished and used for flooring again, and 'ReCycle' partakes in the separation of all old carpet component and then reused for new flooring.[5] Interface estimates a total of 500-600 tonnes of carpet is processed annually, with the prevention of 2 million square meters of carpet from appearing in landfill around the world in 2016-2017.[6]

The company introduced the program called **ReEntry**, accepting old carpets to reproduce it into new carpet. Nylon, a Man-Made Fibre (MMF), is derived from oil and is non-biodegradable, yet it constitutes a major portion in carpets.[7] Thus, Interface is attempting to reclaim and recycle as much of the used carpet as possible. Two things are achieved through the reuse and recycle program: reduced amounts of virgin or raw materials and diverting carpet away from landfill. The content of the fibres used in their carpets include those from post-consumer Type 6 and 6,6 Nylon Fibres provided through the ReEntry process. As a new innovative method of recycling, the company works with Aquafil, incorporating **salvaged commercial fishing nets** into the 100 percent recycled content Type 6 Nylon.[8] Consequent of the creative reuse of commercial fishing nets, Interface introduced a new program called **Net-Works**, which aspires to gather discarded fishing nets to both protect marine life and for reuse in their recycled contents. (Please refer to Interface: ReEntry for additional information).

CASE STUDIES

America has taken upon various schemes within the carpet recycling industry, taking initiative in the case of the market-based Extended Producer Responsibility (EPR) implementation within the country.[9] The approach envisages in reducing the environmental burden by placing financial and physical responsibility on the manufacturers to recycle their products. Private companies have actively implemented the concept of EPR as part of their strategic management of sustainability and the supply chain.[10] Carpet America Recovery Effort (CARE) is a program operating to divert a significant quantity of carpet from landfill (please refer to CARE for additional information). In 2012, CARE achieved a 10 percent diversion rate, amounting to approximately 159,000 tonnes of discarded carpet.[11] Despite a decline in diverted waste carpet from 242,000 tonnes in 2013 to 221,000 tonnes in 2016, **Australia has failed** to achieve any results like these.[12] According to CARE, in 2016, 33 percent of diverted carpet waste was sent to recycling, 20 percent was used as alternative fuel, and 11 percent towards energy alternatives.[13] Mohawk Industries, like interface, has created their 'Everstrand residential carpet,' which is constructed of 100 percent **post-consumer carpet fibre from plastic bottles**.[14] The company retrieved over **three billion plastic bottles** and recycled them into approximately 73,000 tonnes of polyester fibre for their carpets.[15]

United Kingdom (UK) is another country taking initiative within the industry. During 2013, UK processed carpet wastes diverted from landfill through five different processing options including energy recovery, equestrian surface application, plastics reprocessing, fibre reprocessing and carpet re-use. (figure three).[16]

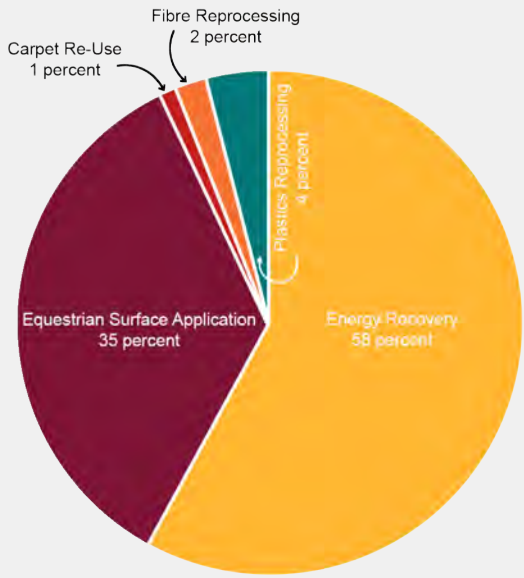


Figure thee Five different types of applications of waste carpet in UK.

ADDITIONAL INFO

MORE ABOUT THE FIVE PROCESSING OPTIONS

Energy recovery-
(Via incineration) Involves shredding waste carpets, which are then utilised in cement kilns or boilers, as a replacement of the traditional means of fuel, such as coal. Fuel produced from carpet wastes is known as Carpet Derived Fuel (CDF).[17] (Please refer to CDF for additional information).

Carpet waste in equestrian surfaces-
The separation of natural and syntenic fibres.[18] The separated carpet waste fibres are then pulverised and mixed with sand and rubber crumbs (obtained from waste tyres).[19]

Plastics reprocessing-
The reproduction of carpet waste into engineered plastic solutions.[20]

Fibre reprocessing-
Pertains to depolymerisation, separating the face fibres from the other components.[21] Nylon can also be recovered through different systems of depolymerisation, involving the recovery of caprolactam (nylon monomer), which are then re-polymerised into new nylon products.[22]

Carpet re-use-
The cleaning, trimming and re-colouring of old carpets. Although the most cost-effective approach, refurbishing carpet is rarely done successfully. [23]

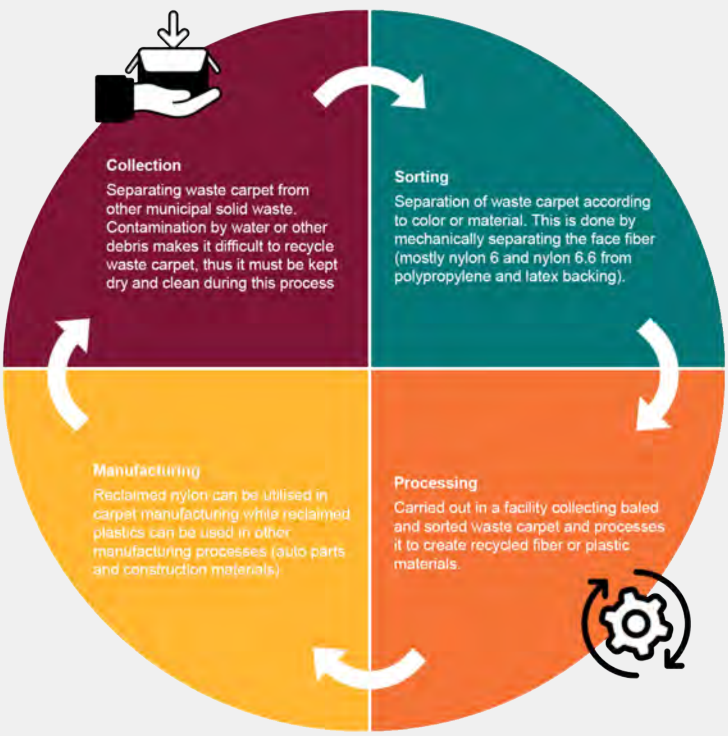


Figure four Four Stages in the Waste Carpet Recycling Scheme.

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Handout

WRITTEN BY Emily Richter
s4395500

Refuse, Reuse & Recycle: A Guide to Material Substitutions for Sustainable Concrete

INTRODUCTION

This handout presents a novice framework for methodologies in reducing, reusing and recycling commonly discarded waste products. By utilising such problematic waste as substitutions to conventional concrete materials. The aim is to outline the possibilities that this can offer to create eco-friendly alternatives within Australia and compare to abroad. Australian companies were contacted to establish what the industry is currently doing to achieve sustainable concrete by utilizing waste during production.

BACKGROUND

“70% of the world’s population lives in a structure that contains concrete.” [1]

Concrete is no new revolution. For many years it has been an integral material for our built environment, with strong links to economic and social security by provides jobs and shelter. It shapes our cities, taking many forms including bridges, roads, hospitals, schools, homes, businesses, and water and energy infrastructure. It is low cost, strong, durable, versatile, flexible in application, fire resistant and provides thermal mass. [2] It comes as no surprise that it is the second most widely used building material in the world, following water. [3] In recent decades, concrete use has shown resurgence, facing the pressures from growing demands in property development to offset the extreme growth in population that is still relentless. [4] Despite its many benefits, manufacturing concrete has had significant environmental impacts that contribute to greenhouse gas emissions and global warming, ranking third place; cement production alone contributes to 4-5% of worldwide CO_2 emissions. [8] Aggregates (coarse and fine) alone make up roughly 60-75% of a concrete batch and Australia is estimated to be extracting roughly 200 million tonnes of aggregates yearly and rising (refer figure 2). [9] Although impressive, this causes land degradation that impairs natural environments and has a history of habitat destruction, including exacerbating the already depleting natural resources, such as sand and water. [10]

Concrete manufacturing involves an enormous amount of embodied energy and creates various pollutant by-products, such as noise, dust and emissions from fuel transporting the materials. [11] Cement, the binder in concrete is a dry combination of limestone, clay, shells and silica sand. [12] Limestone is the predominant ingredient, and when intensely heated to combine the materials it produces high levels of CO_2 emissions. Estimating that for every tonne of clinker (nodular material produced in the kilning stage), 700-1000kg of CO_2 is emitted. [13] Finally, concrete contributes to waste accumulation which puts significant pressures on limited space left in landfill, to no surprise governments are incentivised to introduce levies in order to reduce waste being sent to landfill. [14]

Figure 1: Limestone quarry illustrating the impact that excavating for materials used in concrete production has on the environment, such as land depletion. Source: Davalle, Sofia, “The growth in the mining sector and the use of limestone guide the performance of the lime market in Australia.” (Australia Heavy Quip Journal, Nov 18, 2019), https://www.australiahqj.com/2019/11/18/the-growth-in-the-mining-sector-and-the-use-of-limestone-guide-the-performance-of-the-lime-market-in-australia/.

RECYCLING IN AUSTRALIA

"By 2050, 95% of all sea birds will have plastic in their gut." - CSIRO [15]

The need for appropriate long-term solutions could not be more urgent - Australia is in a waste crisis, especially after China placed restrictions on waste imports and tightened limits on contamination. [16] This has effectively forced Australia to find alternative means of discarding its own waste, with the hopes that alternatives to exporting or landfill can be realised. [17] In 2017, Australia exported almost 600,000 tonnes of plastic; a short-sight and unsustainable practice that allowed the complete absence of a domestic plastics recycling industry. [18] Australia's construction industry generated 20.4 million tons of construction and demolition waste in 2017, contributing to 40% of the total waste accumulation.[19] Queensland has been reported as the highest source of waste, 41% higher than the national average with over 430,000 tonnes from plastic alone in 2013. [20]

The question is, what are we really doing about it? Currently Australia has 193 material recovery facilities with the vast majority hand-sorted; only 18 are automated or semi-automated. [21] This is far from sufficient to deal with Australia's accumulating waste problem. The other common waste solution is the establishment of kerbside collection, which mixes the waste and takes it to sorting facilities – proving to be one of the least successful solutions, only a marginal improvement on dumping directly at landfill. Other forms of recycling have shown more promise, such as deposit systems where people are rewarded small change for recyclables. This is still simply sorting however, and the effectiveness of such systems ultimately relies on how the sorted waste is processed (which in Australia is extremely limited and difficult to track and quantify). [22] Several construction companies have established a take-back scheme, in which helps decreasing the amount of construction waste being sent to landfill.

What are Australian concreting companies currently doing and what is the progress on sustainable concrete?

CONCRETE MANUFACTURING IN AUSTRALIA

What are Australian concreting companies currently doing and what is the progress on sustainable concrete?

Company	Recycled Aggre-gates	Industrial By-prod-ucts	Manufac-tured Agg.	Chemical Additives
Hanson	NO.	YES	YES	YES
Holcim	YES	YES	YES	YES
Boral	NO.	YES	YES	'Would not disclose'
Zeobond	YES	YES	YES	YES

Table 1: What waste materials Australian companies are using.

RECYCLED AGGREGATE SOURCES

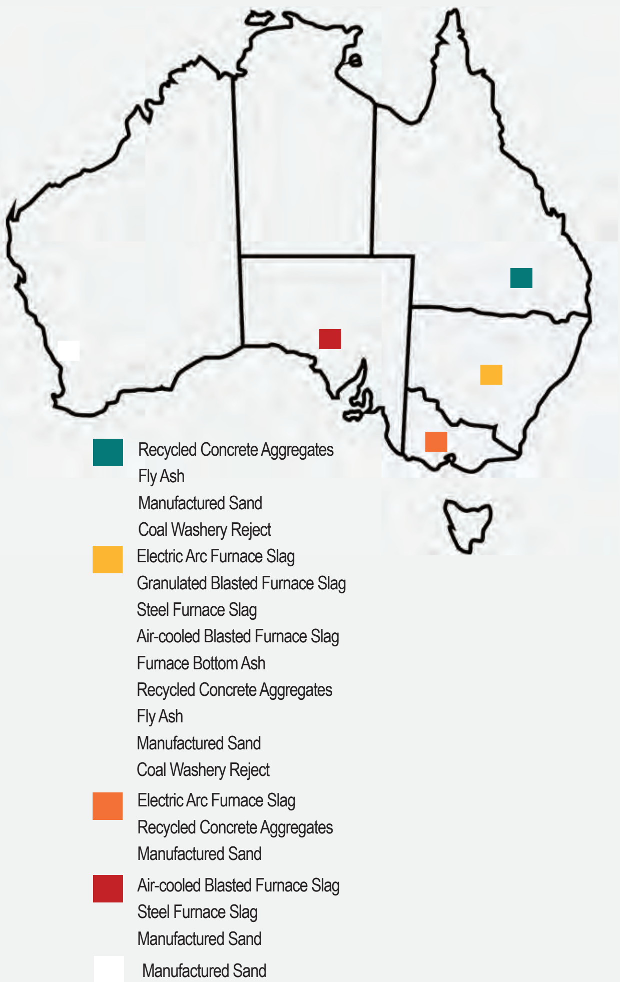

Figure 2: Representing the locations for various recycled aggregates, manufactured aggregates and waste by-products within Australia. Designed by Richter, E. Original/ Information source: Use of Recycled Aggregates in Construction. Cement Concrete & Aggregates Australia (2008).

CONCRETE MANUFACTURING IN AUSTRALIA

Many efforts using recycled aggregates, particularly in Australia have proven practicality for low-strength concrete applications and to a limited degree some structural grade applications. Australian companies were surveyed and the results showed little interest in implementing recycled aggregates in concrete. There were various reasons given for this disinterest, with one company citing the 'lack of reliable and consistent source at this stage,' for recycled aggregate to be worth the time or money invested. On the other hand, pure disinterest was justified as 'not much demand for recycled aggregate use in concrete' and that the 'high-water absorption makes their use problematic and requires extra cement use.' In contrast to this, Holcim appealed this statement, affirming there is in fact 'a market for the use of recycled aggregates.' The level of transparency these companies have shown is commendable, with only minor details exempt from the findings, mostly economic factors or chemical additives were 'not disclosed.' The most common sustainability measure in concrete production is the use of waste by-products, greatly exceeding the use of recycled aggregates. Consistently, by-products like fly ash and blasted furnace slag are commonplace for concreting companies, as they are celebrated for success in reducing CO2 emissions, acting as a partial substitution to Portland Cement.

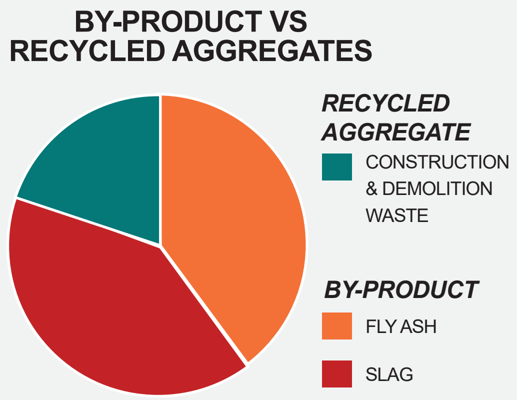

Figure 4: Percentage reflects what waste products are currently observed in the Australian concreting industry. Designed by Richter, E.

CONCRETE MANUFACTURING IN AUSTRALIA

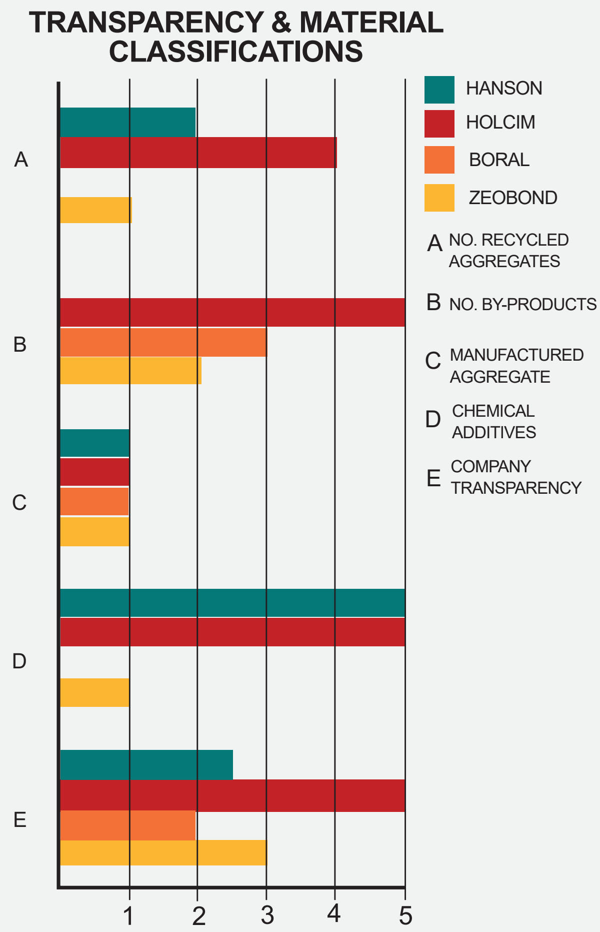

Figure 3: Illustrates the level of transparency the concreting company showed based on a number of responses. Additionally the number of materials under classifications used in each companies concrete. Designed by Richter, E.

CONCRETE 'PRIOR ART'

WHAT DOES THE PRESENT AND FUTURE OF CONCRETE LOOK LIKE?

Recycled roads are on the rise in Australia, becoming almost commonplace as governments desperately find ways to increase material recovery and divert stockpiles of recyclables from landfill. This application uses construction and demolition waste, which contributes to 40% of overall waste. It is withdrawing to think that with all the promising results from ongoing research on recycled aggregates in concrete (addressed below) ramming waste into roads is the only widely practiced outcome.

AUSTRALIAN INNOVATION
RECYCLED GLASS

“Lightweight concrete with glass fines is cost-effective and has a high strength-to-weight ratio, which is very important for the prefab industry.” - Prof. Tuan Ngo, The Project Manager at The University of Melbourne.

Australian researchers from the University of Melbourne effectively produced eco-friendly concrete with glass waste, showing promising results that could potentially be superior to traditional concrete.

Figure 5: Glass waste. Source: “Eco-friendly concrete made from glass waste? Sustainable Building.” TPM Builders (2017), https://tpmbuilders.com.au/concrete-made-glass/

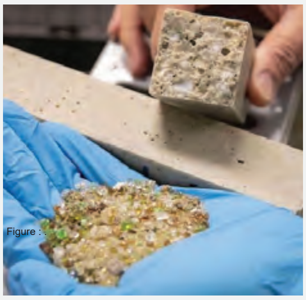

Figure 6: Australian researchers from the University of Melbourne produced eco-friendly concrete from glass waste. Source: Ngo, Tuan; Kashani, Ali; Hajimohammdi, Ailar; and Crough, Damien, “Case study – Using recycled glass fines in light weight concrete,” Published by Sustainability Victoria, (April, 2018)

AUSTRALIAN INNOVATION
RECYCLED RUBBER

Researchers from the University of South Australia were approached by Tyre Stewardship Australia (TSA) to develop and test Crumbed Rubber Concrete (CRC) for potential use in residential construction.

Figure 7: Researchers from the University of South Australia developing crumbed rubber concrete, after being approached by Tyre Stewardship Australia (TSA). Source: “Recycled rubber looks promising for residential construction,” (Architecture & Design, 2019), https://www.architectureanddesign.com.au/news/recycled-rubber-looks-promising#

INTERNATIONAL INNOVATIONS
RECYCLED TIMBER, PLASTIC AND PAPER

Researchers from the Swiss National Forrest Programme have established an approach for greener, lighter and easier to recycle concrete by substituting gravel and sand with more than 50% of sawdust .

Research conducted by The University of Bath in India demonstrated favourable results for reducing excessive amount of plastic waste, with a partial replacement to sand in concrete production; which would potentially save up to 820 million tonnes of sand annually.

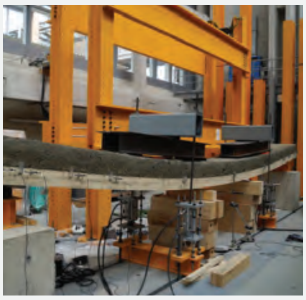

Figure 8: Researchers from the Swiss National Forrest Programme developing a concrete that substitutes conventional aggregates with more than 50% sawdust. Source: Aliento, Willow, “Concrete made from wood. How about that!” The fifth state, (July, 2017), https://www.thefifthestate.com.au/innovation/materials/concrete-made-from-wood-how-about-that/

Figure 9: Plastic waste (resin pellets) in reference to the research being conducted by the University of Bath in India by incorporating plastic aggregates in concrete. Source: “Cement’s solution to plastic waste,” (2018)

The Carriage House by Kelly Hart located in New Jersey, this project substituted traditional aggregates with large pulped paper fibres (waste) in concrete production (papercrete).

[For more information on the project refer to: Kelly Hart (Director, Producer, Writer), Kelly Hart, Rosana Hart, Peter B. Rice (Actor) , Building with Bags: How We Made Our Experimental Earthbag / Papercrete House, 2010]

Figure 10: Papercrete - The Carriage House by Kelly Hart located in New Jersey. Source: Hart, Kelly, "Papercrete," (Kelly Hartworks LLC, established in 2001), http://www.greenhomebuilding.com/papercrete.htm

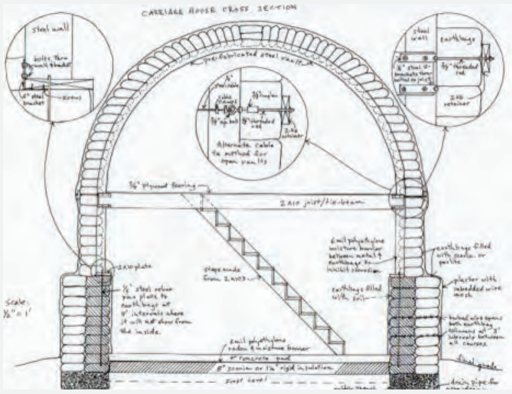

Figure 11: Detailed section through The Carriage House by Kelly Hart located in New Jersey, design utilizes earth-bags plastered with papercrete. Source: Hart, Kelly, "Papercrete," (Kelly Hartworks LLC, established in 2001), http://www.greenhomebuilding.com/papercrete.htm

Conclusion

In conclusion, concrete has remained largely unchanged since the introduction of Portland cement. Traditional processes significantly contribute to greenhouse gas emissions, degrade and destroy habitats and consume large quantities of natural resources such as sand and water. While there has been some progress towards the use of recycled materials in concrete, primarily as substitutes for the traditional quarried aggregates, this avenue is only beginning to be explored, and there is still significant potential for progress in the near future.

Conclusion Cont.

With a poor sustainability record (especially with respect to sand mining), a rapidly growing waste/recyclables problem, and an innovative construction industry capable of utilising these advanced hybrid concrete materials Australia is in a position to see major benefits from the use of waste products in concrete production. Multiple Australian companies and universities are currently researching, trialling and beginning to implement more sustainable concrete products, and these trials as well as personal experimentation demonstrate the feasibility of the process. Further, some of these ingredient substitutions are able to change and even improve the material properties of concrete, showing that sustainability does not have to come at the cost of function. The primary contemporary use of recycled aggregates in Australia is in roads, however even in standard concrete, up to 3% recycled construction materials in the place of aggregates are already in commercial use. Promising results have been shown using up to 50% substitution with materials such as sawdust and glass, although these have yet to see commercial use.

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Handout

WRITTEN BY DANNI'ELLE JENKINS

Reusing Construction Materials in New Buildings

The Renovators Barn, Salisbury, QLD
Image by Auhor

INTRODUCTION

This handout presents a beginners overview of the challenges and opportunities of reusing materials in new buildings, and designing for future disassembly. This overview is designed to empower Brisbane architects, builders and building owners to consider reusing materials as a first choice, and to design for disassembly to allow for future reuse of materials. By reusing materials, we can decrease the environmental impact of construction by reducing the requirement for new resource extraction and processing, reducing embodied energy of materials and buildings, and reducing reusable waste going into landfill.

BACKGROUND

The construction industry is being pressured by the global focus on climate change to adapt its ways of materials extraction, processing and material usage.[1] The consumption of resources in the building and construction industry has major impacts on the environment including, but not limited to, contributing to greenhouse gas emissions, decrease in biodiversity, a decreasing supply of raw resources, and increasing waste of reusable materials going into landfill.[2] Globally, the construction industry consumes 30-50% of raw resources and produces 40% of waste.[1] In Australia, construction waste constitutes to one third of all waste going to landfill.[3] In order to combat and minimise the impact of construction waste, there are five strategies that should be in place when designing, building and demolishing buildings; Avoid, Reduce, Reuse, Recycle, Treat or Dispose.[4] TAfter avoiding and reducing material use, material reuse is the preferable option to minimise waste, as this requires minimal processing and energy consumption.[4]

CHALLENGES OF REUSING MATERIALS

In order to reuse materials, they first need to be retrieved from demolition site in an appropriate manner; unfortunately most buildings are demolished and materials are sent to landfill.[6] The main challenges for demolishing buildings for material reuse are the cost of dismantling by hand, and the labour involved. It's cheaper for builders to demolish with a machine, where as it's more expensive to hire labourers to pull materials apart by hand in a manner that is appropriate for reuse.[7] Builders will always look at cost and time before the benefits of reusing materials - the demolition trade is being decided by cost and time.[8] Another factor is workplace safety, especially when considering the risks of asbestos. It's much easier and cost effective to crush the material up and throw it in landfill rather than dealing with the risks of time, cost and workplace safety.[8] There also needs to be a method of works plan in place prior to beginning demolition for material salvaging.[8]

The hardest part of pulling down buildings for material reuse is the asbestos.[7] Any glues also make it difficult or impossible to reuse existing materials.[7] Older houses are easier to take apart, new houses contain a lot of glue and concrete, which make materials almost impossible to reuse.[7] From a Queenslander, you could probably reuse about 99% of the material.[6] The materials are also usually better quality and built to last.[7] Queenslanders are also built in such a way that it is easy to dismantle, new buildings are too difficult to dismantle.[9]

Another challenge is changing the perception the general public have on reusing materials.[7] Recycling, or using products with recycled content, seems to be the norm, however, when it comes to reusing items in their original form people aren't as well informed.[10] Many believe that used materials are of lesser quality, when often the opposite is true.[7]

Consumers are choosing to buy new building products from mass producers and suppliers, or even buying flat packs where they can.[10] These products are made and ready for immediate use, however, modern products are not always better quality.[10] Old materials are made to last, especially when it comes to old timber which is seasoned and won't shrink.[10] There is also a significant cost saving when buying used materials.[8] Not only are the materials cheaper, but when you buy quality materials that are durable, they will last much longer, reducing the need to repair or replace materials over time.[7] The end product will more often than not be better quality, more affordable and better for the environment when you reuse materials.[8]

When it comes to convincing consumers, designers and specifiers, the challenge comes down to the time and effort involved with finding, repairing and using existing materials that are appropriate for their new use. There is always repairs that are required for existing products to make them reusable, and even though it is cheaper than buying new, it takes more time to achieve the end result.[8] Although renovators and designers are often looking for used items in salvage warehouses, like Woolloongabba Demolitions and The Renovators Barn, it is usually for items to repair heritage buildings or Queenslander houses.[10] Few are looking for materials with the intent to design and build contemporary buildings from existing materials. If a design is already in the works, it is difficult to find all the elements to work within a design, and to find the quantity of consistent materials required.[6] Designers and architects, especially when it comes to the design of commercial buildings are constricted by time, costs and approvals.[11] The time it takes to source and repair existing materials in their original form render the endeavor impossible unless requested in a client's brief.[11]

DESIGNING USED MATERIALS INTO NEW BUILDINGS

When repairing existing buildings, such as Queenslanders, it is easy to incorporate used materials, however, when reusing materials for contemporary buildings, it is much harder to find materials that fit within the design.[1] It may be possible to incorporate the old with the new, but would require finding consistent materials of a particular style and the quantity required to complete the job.[2] Case study projects, Resource Row and Upcycle Studios by Lendager Group, Recycled House by Juan Luis Martínez Nahuel, and Reuse Flat by Arboreal all began the design process with the intent to reuse materials. In order to successfully incorporate a high quantity of reused materials in a contemporary building, the design phase must begin with the material and the intent to design with the materials available. Trying to fit salvaged materials into a completed design will be much more difficult. The reuse of highly durable materials such as steel, timber and bricks, especially when used for finishes and facades, should always be first choice before specifying new.[3]

DESIGN FOR DISASSEMBLY (DFD)

Design for Disassembly refers to applying building assembly and construction techniques to support the recovery of materials for future use.[12] Some principles for DFD include:

- Using recycled and recyclable materials
- Minimising different types of materials and components used[12]
- Avoiding toxic materials[12]
- Avoiding composite materials and secondary finishes[12]
- Using mechanical connections, avoiding chemical connections such as glues and sealers[12]
- Applying grid, modular and interchangeable design techniques[12]
- Using common, low tech, construction techniques[12]
- Separating cladding/lining from structure[12]
- Allowing for parallel disassembly as opposed to sequential disassembly[12]
- Providing permanent identification of material type and retaining all design and construction information[12]

SOURCING MATERIALS FOR REUSE

International: Belgian company, Rotor DC, offer unique services in the field of salvaging building materials.[13] There is opportunity within Australia to form an initiative offering similar services, including reuse assessments of existing buildings, advice to builders for disassembly for materials reuse, demolition and removal services, resell services including online store, consultancy and design assistance for builders, designers, architects and building owners, literature and workshops.[13]

Brisbane: Many builders and demolition companies in Brisbane sell used materials through online channels such as Facebook, marketplace, Gumtree and Ebay. There are also a number of warehouses in Brisbane selling used materials and goods. For the purpose of this study, interviews were conducted at two Brisbane demolition sale warehouses; Mark Christensen, owner of Woolloongabba Demolitions, and Alf Liseo, owner of The Renovators Barn. Both warehouses offer a range of used materials.

Woolloongabba Demolitions, Rocklea, QLD
Image by Auhor

CASE STUDY PROJECTS

The following projects were chosen to display a series of new and renovated buildings that use existing or recycled materials, and/or apply design for disassembly strategies. Click on image hyperlinks for more information.

INTERNATIONAL PROJECTS

1. Reuse Flat by Arboreal Architecture
2. Recycled House by Juan Luis Martínez Nahuel
3. Resource Row by Lendager Group
4. Upcycle Studios by Lendager Group

AUSTRALIAN PROJECTS

1. Charlotte Shack by Ian Sercombe Architect
2. The Recyclable House by Quentin Irvine
3. Arkadia by DKO Architecture and Breathe Architecture
4. CH2 Melbourne City Council House 2 by DesignInc

BRISBANE PROJECTS

1. Petrie Terrace by Skyring Architects
2. Recycle House by BA Architects
3. QLD Emergency Operations Centre by Architectus

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Handout

WRITTEN BY KITTIDECH MARAYAT

Simple steps to conduct LCA

INTRODUCTION

This handout present a beginners overview of the simple step to conduct LCA. LCA is applied as a method helping to make decisions and determine ways to use energy more efficiently. Nowadays it is used with the construction industry to evaluate in various fields. Nevertheless, it is complicated and quite difficult to understand at the beginning, resulting in it being often neglected. Therefore, this research aims to provide a simply step guide for anyone, ranging from the architect to the householder, who want to start conducting life cycle assessment to measure the impact of a building materials

BACKGROUND

ARCH7071 is the subject that focuses on the significance of materials used in building. I have learned and completed assignment 1 which encouraged me to explore many of the interesting aspects of various materials. Then, study in section drawing of the provided precedent project and trying to create the materials supply chain map according to materials from the section drawing. It expanded my horizon in term of where each material come from and the travel of raw materials from many regions around the world. Obviously, there is an input and output energy following by the emission throughout the process. This learning makes me an ambition to research a bit more advanced in the environmental impact created by material manufacturing. In doing so, it is necessary to understand the Life cycle assessment methodology which I found that it is complicated and have several small steps to understand and conduct. So, I decided to find out more in detail about conducting LCA.

Life cycle assessment is the comprehensive analysis products life cycle when it comes to sustainability and its effects on the environment. The main problem is that we do not know how everything functions, and from the very beginning, we tend to think that this particular process is challenging and only for experts[1]. So in this report, there is a need to create a simple guide for those who want to start studying LCA. This report will examine the example material from assignment 1 ARCH7071 in further advance due to creating materials supply chains map in assignment 1 is not enough for understanding the environmental impact of the material life cycle. In this case, material that will be focused on in is Easylap panel (concrete external cladding) compared with another product from the same supplier.

What is LCA

"A Life Cycle Assessment (LCA) is an analysis of the impact one object has on the world around it"[3]. The main goal of industrial ecology is to redefine the idea of a global economy to avoid the open-loop system. In this case, the open-loop system includes the materials flow in each resource are extracted, production process and waste products. They try to choose the closed-loop model in order to remove excessive waste form one product to create raw materials for another, including recycling. LCA includes the creation process and disposal process that affect the environment. If we want to conduct the LCA, we will need to combine all energy, materials input as well as disposal of products. Also, we have to summarize all output (emission, waste, materials, water,) and interpret the result. However, the limitation of LCA also exist, and we have to bear in mind throughout the process that the primary goal of ISO standard is to create consistent definition and data so that we can apply in many scenarios. The main problem is that methodological choice tends to be inconsistent such as system boundaries and functional units, which mean that it is highly challenging to compare various studies[3]. On a bigger scale, for example, when the company want to improve their product, they can choose more sustainable raw material for one product, but actually, the supply chain of a completely different product may make the bigger impact. In addition, conducting LCA normally rely on industry average because of lacking the actual data, so that the LCA would be argued in terms of accuracy. Moreover, social implications do not be incorporated in LCA because it is not interconnected with the environmental aspects of sustainability. LCA studies always focus on the environment without thinking that social impact may equally significant also.

The Product Life Cycle

It is necessary to know what the lifecycle actually consists of when we want to conduct the life cycle of the product. There are normally have 5 phases of the product life cycle.

1. Raw material Extraction
2. Manufacturing & Processing
3. Transportation
4. Usage & Detail
5. Waste Disposal

According to the cradle-to-gave concept, the cradle is the outset of the product with the supplying of raw materials, the grave is the disposal of the product. Nevertheless, there are other concepts of the product life cycle such as Cradle-to-gate, Cradle-to-cradle and Gate-to-gate

The 4 Stage of an LCA

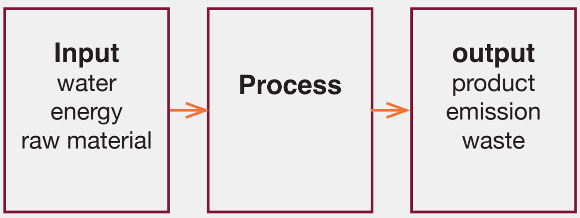
1. Goal & scope Definition

In the beginning, we have to set the goal in mind about what we want to know and how deep our analysis. In this stage, it can be divided into three keys point we have to know before jumping to the next stage.

- Define Fucntional Unit
- Define System
- Define Limits of analysis

2. Inventory analysis

This is the stage that focuses on the collection of data for our LCA. It can be done by getting the data collection sheets from the companies, online database such as Epic database - Please refer to https://msd.unimelb.edu.au/research/projects/current/environmental-performance-in-construction/epic-database for additional information.Throughout this process, it is typically shown with a flow model to make it cleared to understand the overall system.



3. Impact Assessment

Once we have got enough data to be analyzed, then we can evaluate the impact of it, based on our Life cycle inventory flows from stage 2. In this stage, there are three small steps we have to go through.

1. Selection of indicators and models
2. Classification
3. Impact Measurement

4. Interpretation

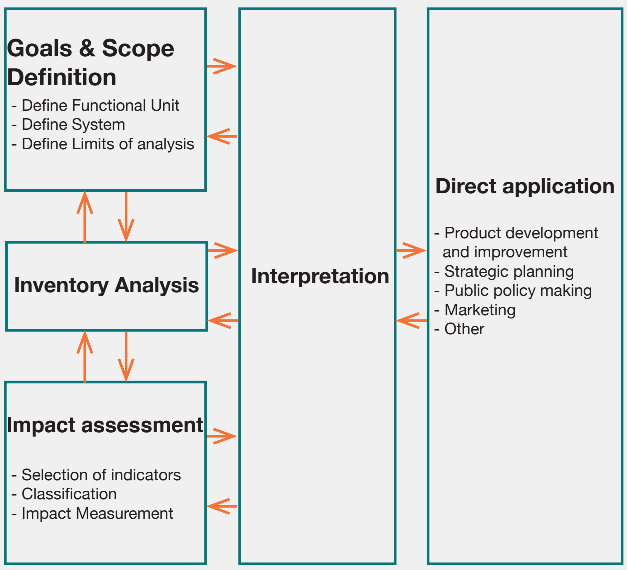
In reality, interpretation can always happen during the assessment. Interpretation doesn't need to be the end of the assessment. However, we can make the conclusions and recommendation of our assessment in the stage according to ISO 14044:2006. This process has to be done cautiously. The ISO norms defined what we need to interpret should include:

- Identifying significant issues based on our LCI and LCIA stage

- Evaluating the study itself, how complete it is, if it is done sensitively and consistently

- Conclusions, recommendations

Here is the summary framework showing the LCA assessment from the first step.



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THANKS

Handout

WRITTEN BY NATHALIE BLOOMFIELD

Sustainability and External Cladding Materials

External cladding is important for the placemaking identity!

This handout demonstrates an overview on the variations within commonly specified external cladding types:

1. Scyon Axon Fiber Cement Cladding – James Hardie
2. Hardwood Timber Weatherboard - Weathertex
3. Architectural Steel Panels - Colourbond
4. Aluminium External Cladding Panels - Alucobond

And a breif description of how to go about specifying green building materials!

WHY IS THIS IMPORTANT?

Building materials count for half of the solid waste generated worldwide, it is increasingly important to consider the life cycle of buildings materials and convert from a linear manufacturing system to a circular system that considers the sourced materials, manufacturing process and end of life cycle of building materials. Not only can the extraction, manufacturing and deterioration of products be harmful to the natural environment throughout its life cycle but toxic chemicals used in construction materials can leech toxins into our bodies. The materials we surround ourselves with can either negatively or positively impact our health and wellbeing. It is through transparency in supply chains and manufacturing processes that we can understand the contents of the building materials that surround us in everyday life and become more informed in the selection of materials that have an environmentally friendly impact.

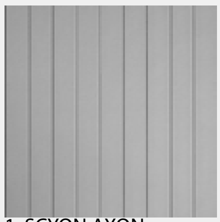
Weathertex profile

STEPS FOR GREEN PRODUCT SELECTION

1. Research
Of the product to be specified for construction, proper research should be conducted to determine its environmental impact. This can be done through MSDS and product specifications, Indoor Air Quality (IAQ) test data, warranties, recycled content, durability, environmental certifications, codes and regulations.

2. Evaluation
When similar materials occur, consider and compare their quantitative and descriptive data through the product's life cycle assessment (LCA) from beginning to end of life.

3. Selection
Through the creation of an evaluation matrix of a variety of materials can they be scored against the environmental goals of the intended project, producing an ease of selection.



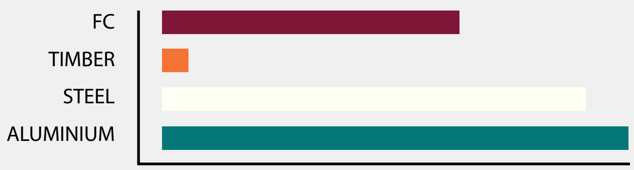
1. SCYON AXON

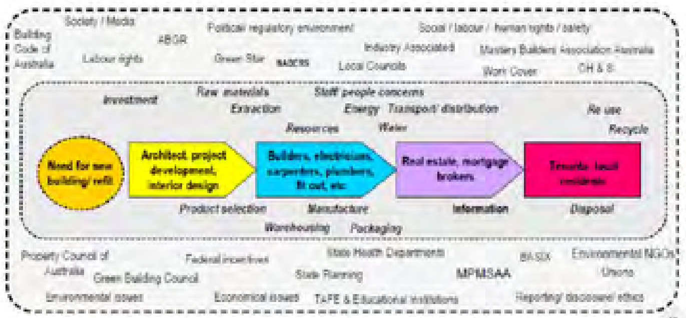
2. TIMBER WEATHERBOARD

3. STEEL PANELS

3. ALUMINIUM PANELS

HIGHEST EMBODIED ENERGY PER CLADDING MATERIAL



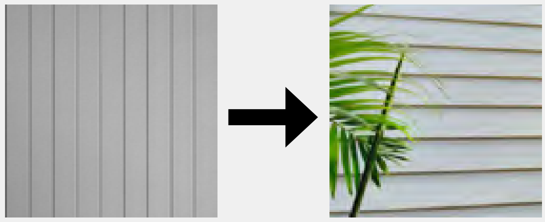


The building Roadmap with its complete external environment (TEC, 2009)

EASY SWAPS – A Conventional Cladding substitute

An alternative to fibre cement and plasterboards > UBIQ light weight INEX Weather Boards. Made from low carbon fibre reinforced engineered cementitious composite (ECC) technology creates boards that are 100% recyclable, BAL-FZ fire rated, termite resistant, mould resistant and can be used for any domestic application.
Total embodied energy of 1.92 MJ/kg, which is on average only 40% the energy used per kg of fibre cement boards (which average 4.8MJ/kg).

- Cost effective and safe solution
- Higher fire resistance than FC boards.



Fibre Cement alternative > INEX Weatherboards

GENERIC SUSTAINABILITY SPECIFICATIONS OF POPULAR CLADDING TYPES IN AUSTRALIA						
	Reconstituted Timber Products	Fibre Cement	Timber weatherboards	Plywood Sheeting	Steel	Aluminium
Availability	Most locations	Available due to high level transport	Available, various products and profiles	Widely available	Available in all regions	Available in all regions
Embodied Energy	Very low, Sequesters Carbon	Generally low, varies with content and manufacturing efficiency	Low to very low, varies with manufacturing, preservatives, termite treatment, can sequester carbon	Low to moderate	High	Highest of any cladding, appropriate usage in highly corrosive environments
Maintenance	Moderate, finishes	Low	High, subject to shrinking, swelling, cracking and rot	Moderate to low	Very low	Low
Durability	High, survives seismic and geotechnical movement	High, survives seismic and geotechnical movement	Low to moderate, depending on timber species and maintenance	Moderate to High, depending on grade, species, glues and maintenance	Very high, must be installed carefully with compatible fixings and flashings	Very high, corrosion resistance, lifespan and corrosion compatibility of fixings and flashings essential
Breathability	Good, low condensation risk	Good, low condensation risk	High, decrease with paints and finishes	Generally low, varies with finish	None, it is a vapour barrier and should be fixed via a breathable cavity	None, it is a vapour barrier and should be fixed via a breathable cavity
Waterproofness	High	High, varies upon thickness and finish	Generally good, horizontal moreso	High, varies with finish and joint detailing	Among most waterproof of cladding materials	Among most waterproof of cladding materials
Insulation	Negligible	Poor	Varies with thickness, seal and density	Limited	None	None
Fire Resistance	Good	High	Poor, exception of a few hardwood species	Poor to Average	High, both roofing and wall applications	Good
Toxicity	Non-toxic	Non-toxic	Non-toxic if untreated	Potentially toxic coatings	Non-toxic	Non-toxic
Finishes	Must be painted	Range of patterns, shapes and finishes	Painted, oiled or stained	Painted, oiled or stained	Range of colours and finishes, including galvanised, zinc, aluminium corrosion treatments, baked enamel pre-finish colours	Range of powder-coated colours
Resource Depletion	Nil when made from forest waste	Cellulose is renewable, cement is not renewable and a finite resource with high embodied energy, sand is abundant but not renewable	Renewable when plantation grown, contributes to high biodiversity loss when sourced from growth forests	Renewable when plantation grown	Non-renewable resource	Abundant but non-renewable resource
Recycling / reuse	Generally not due to finishes, no need due to low cost	Generally not due to finishes, no need due to low cost	Difficult to reuse due to fixings and additional joins	Highly reusable, unable to be recycled, preferably screwed not glued	Highly reusable, 100% recyclable, new products can include up to 40% recycled content	Highly reusable, 100% recyclable if screw fixed
*Important to know supplier and manufacturer company processes to be a sustainable and viable source.						

Table adapted from research conducted by Chris Reardon.[1]

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