MARK GORGOLEWSKI

RESOURCE SALVATION

THE ARCHITECTURE OF REUSE

WILEY Blackwell
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The notion of using the site and surrounding area as the first place to look for resources is unfamiliar and foreign to most current designers. But in the past, and in some parts of the world even today, discarding materials was not an option, as new materials were expensive or not easily available, and innovation included working creatively with materials that had a past life.

In any urban society there is a massive stock of available materials from demolition and industrial waste that is currently discarded but has potential value. Although the infrastructure to locate and use these resources is currently lacking, some industry leaders are establishing design strategies, material recovery processes, construction management approaches and manufacturing systems to create innovative new ways of using them in the built environment. This book explores the creative opportunities and practical aspects of this gradual move to a more circular way of thinking about material resources in the built environment. In particular, the focus is on reuse of materials and components, including both construction salvage and waste streams from other industries.

In The Science of the Artificial, Herbert Simon describes design as ‘the process by which we devise courses of action aimed at changing existing situations into preferred ones’. If we wish to create a more ecologically based built environment, we need not only to design more sustainable buildings but, more fundamentally, to devise a system and infrastructure that will achieve this. This is what this book is working towards.
ACKNOWLEDGEMENTS

The book is dedicated to my wonderful and supportive family, Grazyna, Krysia, Adam and Stefan – thank you.

Thanks go to all the various architects, designers, builders and others who have provided information, images, comments, edits, ideas and help in compiling the case studies and practitioner examples in this book. I am also grateful to Sandra Wojtecki for her help in compiling some of the case studies.
Circular Economy refers to a closed-loop model of an economy where waste is eliminated and product are sold, consumed, collected and then reused, remade into new products, returned as nutrients to the environment or incorporated into global energy flows.

Cradle to Cradle (also referred to as C2C) models human industry on nature's processes viewing materials as nutrients circulating in healthy, safe metabolisms and separates these into technical and biological nutrients.

Deconstruction describes a process of selective disassembly of a building at the end of its life to recover materials and components or systems for potential reuse or recycling. It is an approach to building removal that can extract resources so they can be used for high value future uses.

Design for deconstruction (or disassembly) describes how a building is designed to be readily taken apart at the end of its useful life so that the components can have a second use. To facilitate this, a design team needs to consider how the major systems can be deconstructed during renovations and end-of-life.

Design for durability considers extending the life of a building and its individual components. This can mean choosing long-life components but also creating adaptability in a building as a means to extend its service life and its potential for repurposing.

Diversion (waste diversion, landfill diversion) is the process of diverting waste from landfills or incinerators through various means such as reuse, recycling, composting or gas production through anaerobic digestion. Waste diversion is a key component of effective and sustainable waste management and a major policy objective of many governments.

Embodied energy/carbon is the energy (and resultant carbon emission) used in all the processes necessary to produce a material or component.

Extended Producer Responsibility (EPR) is a policy approach in which a producer is held responsible (physically and/or financially) for a product in the post-consumer stage of a product's life cycle. EPR makes producers consider what will happen to their products after first use and incentivises them to use resources in a way that allows them to have second lives.
**Life cycle analysis (LCA)** is a comprehensive method for assessing a range of environmental impacts across the full life cycle of a product system, from materials acquisition to manufacturing, use and final disposition. The ISO standard ISO 14040 defines the processes for carrying out LCA calculations.

**Linear Economy** is a consumption model of an economy where a product is sold, consumed and discarded (take–make–waste).

**Reclaim** is to recover something of value from a waste stream.

**Salvage** is typically something extracted from the waste stream as valuable or useful.

**Sustainable Materials Management (SMM)** is an approach to promote sustainable materials use, integrating actions targeted at reducing negative environmental impacts and preserving natural capital throughout the life cycle of materials, taking into account economic efficiency and social equity.

**Virgin materials (also known as primary materials)** are resources extracted from nature in their raw form, such as stone, timber or metal ore that have not been previously used or consumed.

**Zero Waste** is a policy concept that focuses on creating a cyclical system, reducing waste, reusing products and recycling and composting/digesting the rest, with the ultimate goal of eliminating all waste and achieving zero waste to landfill.
Today buildings are a graveyard for materials – once used they rarely have a further life. We hear that increasing percentages of demolition waste is ‘recycled’, but what value comes from this? Most recycling actually means crushing and use as road base or for other low value uses. Much of the usefulness and financial value is lost. Yet existing buildings and industrial waste streams are huge reservoirs of materials and components that can potentially be mined to provide much needed construction resources. There is increasing recognition that a building at the end of its life is an asset to be valued and that innovation and imaginative design can offer new opportunities for using discarded materials and components as valuable parts of buildings. In the developed world we can learn from ecological systems and from resource strategies in poorer parts of the world, where materials are more precious and salvaged items are more highly valued. This may help to create material systems for construction that replicate and integrate with the cyclical features of nature.

But what would our cities look like if our buildings were to be built from locally available, renewable and salvaged resources? What sort of new urban vernacular may emerge if we focus on previously used materials and components that come from the local area and do not need large amounts of energy and other primary resources? How does value in old materials get transformed and reconceptualized into new value? How can we transfer heritage value in components and not just whole buildings? Will the process of designing and constructing buildings need to change if it is based on a harvest of local, salvaged materials? What infrastructure is required to make this happen?

Today there is increasing interest in exploring how buildings are made and un-made, and in finding new business models that make use of discarded materials, components, and buildings (Figure 1.1). The above questions are addressed in this book.
Figure 1.1 The TAXI building in Denver, CO, was entirely modernized by tres birds workshop using reclaimed materials, including a thermal exterior wall system fabricated from 21,000 recycled PET plastic water bottles.
which draws on the experience of practitioners and case study projects to explore the potential for a new type of architecture that places a high economic, social and ecological value on existing materials and treats the urban environment as a transient store of resources that should be redeployed once their initial use is complete. The book focuses on the experience of designers who have started to explore ways to close resource loops, attempting to create systems where less is wasted. Materials destined for landfill are put back to use, with positive effects on the economy, society and the environment. As architect Jeanne Gang put it, they have begun to explore an ‘architecture originated in the material itself rather than in a formal language or design concept’. 

Box 1.1 Venice Architecture Biennale 2016

For the 2016 Venice Architecture Biennale, Chilean architect Alejandro Aravena created two introductory rooms using over 90 tonnes of waste generated by the previous year’s art biennale in Venice. Short lengths of previously used crumpled metal channelling were suspended vertically, creating a unique ceiling using waste. Also, the walls were covered by 10 000 m² (100 000 sq. ft.) of multicoloured leftover plasterboard (drywall) pieces which were stacked to create a moulded surface that included protruding display shelves.
1.1 BACKGROUND

Architecture in its traditional role is probably a dying profession. Today, architects must work with systems; they must design new ways of living and working in which buildings play a key role. We desperately need mediators between human need and the enduring cycles of nature. Architects can, and must inhabit this new role. (Paul Hawken³)

Architecture is created from a fusion of concept and matter, what Louis Kahn called ‘the measurable and the unmeasurable’, and throughout history architecture has been shaped by a dialogue between ideas and materials. Kieran and Timberlake in their book Refabricating Architecture state that ‘architecture requires control, deep control, not merely of the idea, but also of the stuff we use to give form to the idea.’⁴ Traditionally this has led to a fascination with the newest and most innovative materials, and the evolution in architectural history has a strong association with new technology. Today the vast majority of materials used to create the built environment are new and pristine, and our consumer culture leads us to assume that new is best. At the same time, most materials are unrelated to place, and predominantly come from all over the world – aluminium may come from South America, steel from Russia, glass from China, timber from Canada and so on.

Material and component selection is a vital part of architecture because it holds such potential to communicate meaning in our built environment. In the developed world today we do not normally conceive of buildings as being made from local, salvaged, pre-used materials. We are used to the off-the-shelf method of choosing materials (and technologies). But up until the twentieth century many building components were custom designed by architects. Windows, columns and so on were not standardized. More recently, architects have come to rely on a readily available architectural palette of standardized components from catalogues or web sites. Information such as specifications, dimensions, and standard details for globally produced building components are readily available and their use is facilitated by digital technologies. Design and construction for most buildings is organized as a process of integration of appropriate components. This has isolated designers from a better understanding of materials and their tectonic potential and has removed some creative possibilities and discovery from design.
Furthermore, the quantity of these materials that we use has grown hugely. In the last 50 years the world population has doubled yet our use of some engineering materials has grown by 4–15 times. This huge increase has enabled us to increase our living standards, creating and servicing a huge urban infrastructure connected by extensive transport networks. But, as architect Thomas Rau has pointed out, unlike energy, which is widely available from the sun (we just need to implement appropriate technologies for harvesting it), access to materials is effectively limited by what is available on earth, and for some materials we have consumed most of the easily obtainable supply.

In a world faced with climate change, increased resource scarcity, and other environmental, social and economic challenges, access to new material resources and disposal of waste are becoming far more costly and constrained. Growing concerns about the loss of useful resources and physical limits of the earth’s capacity to provide new resources and absorb the mountains of waste accumulating in landfills, as well as the increasing cost of disposal, are leading some to a rethink how we deal with resources. The United Nations Environment Programme (UNEP) has noted that ‘As global population continues to rise, and the demand for resources continues to grow, there is significant potential for conflicts over natural resources to intensify in the coming decades’.

The work of photographers such as Edward Burtynsky, Timo Lieber and Vik Muniz (Figure 1.2) brings to light the vastness of the process of dealing with materials throughout their linear life cycle and highlight some of the impacts this has on individuals, society and the natural world. As buildings gradually become less carbon intensive for operating energy use, the impact of extracting, processing and installing the materials used to create the built environment become increasingly important and the embodied energy and carbon that occurs from this becomes progressively more of a concern.

It is now commonly recognized that a linear economy, which focuses on maximizing ‘throughput’, is wasteful because it permanently disposes of valuable resources after their first use. There is an increasing awareness of the need to move towards a circular economy, based on cyclical systems as observed in nature, which aims to transform the value of existing resources that have come to the end of their usefulness in their current form. Many governments around the world are beginning to consider resource efficiency, resource productivity and waste reduction, in addition to climate change and other development issues in their policies. In 1999, John Prescott MP (then UK Deputy Prime Minister and Secretary of State for the
Environment, Transport and the Regions) stated that ‘In the past, focus has centred mainly on improving labour productivity. In the future, greater emphasis will be needed on resource efficiency. We need to break the link between continued economic growth and increasing use of resources and environmental impacts’. These factors will, in future, have significant repercussions for materials availability and, thus, architectural design and building construction. Supply of bulky, low value, construction materials may in future be far more dependent on local proximity and local availability. The need to design and build using local, readily available, renewable or reused resources, and to develop closed-loop systems for the life cycle of building materials are likely to become major drivers for the design of the future built environment. And this will create new design opportunities, but will also change the design and construction processes.

Figure 1.2 ‘Atlas (Carlão)’ is one of several amazing portraits created by photographer Vik Muniz and the catadores – self-designated pickers of recyclable materials, using waste from Jardim Gramacho waste dump located on the outskirts of Rio de Janeiro.

Environment, Transport and the Regions) stated that ‘In the past, focus has centred mainly on improving labour productivity. In the future, greater emphasis will be needed on resource efficiency. We need to break the link between continued economic growth and increasing use of resources and environmental impacts’. These factors will, in future, have significant repercussions for materials availability and, thus, architectural design and building construction. Supply of bulky, low value, construction materials may in future be far more dependent on local proximity and local availability. The need to design and build using local, readily available, renewable or reused resources, and to develop closed-loop systems for the life cycle of building materials are likely to become major drivers for the design of the future built environment. And this will create new design opportunities, but will also change the design and construction processes.
Some designers and building owners have begun to explore alternatives to the produce–use–dispose linear model of resource use in the built environment and to consider closed-loop approaches that aim to find use, value and inspiration in what was previously classified as waste (Figure 1.3). Materials destined for landfill can be put back to use, with positive effects on the economy, society and the environment. Such an approach has potential to alter the design and construction processes in ways that may lead to more place-based architectural solutions. It is also important to differentiate between reuse today, which has to deal with material that is already in use, and future reuse of materials that we can now ensure will be more readily reusable.

Although green building rating systems such as LEED and BREEAM encourage a move towards closed-loop systems through strategies such as choosing recycled materials and reused components, at present in the developed world the reused building material sector is fragmented. There is an absence of a clear system or infrastructure with recognized business models and processes aimed at reuse. There is a need to establish a supply chain and inform designers about the

Figure 1.3 The Mountain Equipment Coop explored the potential for material reuse in several of its stores such as this one in Winnipeg, Canada.
potential of such materials and components, and to create a demand that will encourage demolition contractors to deconstruct old buildings due to the value they can get from them. Inventories are needed of salvaged products to enable designers and their clients to have confidence in the availability of materials. And certification processes for materials are needed to facilitate their use without concern.

At present, such factors are preventing the construction industry in most countries from embracing a more long-term view of the value and potential of existing materials and components, and this is hindering the establishment of mechanisms for their widespread reuse. However, in future, when choosing materials, it will be necessary to consider the social, ecological, and technical relationships and the networks that materials are part of. Identifying new business models that make such strategies profitable, and using appropriate design approaches that address consumer needs and create unique buildings, can overcome industry hesitance to embrace new material ecologies.

Successful case studies of reuse of components and materials in building projects discussed in this book are gradually becoming accepted in the mainstream. Although the designers featured are innovators and leaders in this field, they present a foretaste of a potential future that recognizes the value of existing resources, how they can be transformed and the resulting environment that can be created. They also offer some ideas about the infrastructure that will be necessary to establish reuse as a common feature of the built environment.

Box 1.2 Current Resource Use

It is estimated that as much as 40% of the raw materials consumed in North America is for construction.

The European Union (EU) uses 8 566 million tonnes of material resources, of which 7 654 million tonnes (89%) are non-renewable.

From 1980 to 2010 worldwide metals and minerals use increased 66% from 19 billion tonnes to 31.5 billion tonnes (and is expected to grow to 53.7 billion tonnes by 2030).

Typically we still use materials on average only once.

People in rich countries consume up to 10 times more natural resources than those in the poorest countries. On average an inhabitant of North America consumes around 90 kilograms (kg) of resources each day. In Europe, consumption is around 45 kg per day, while in Africa people consume only around 10 kg per day.

Sixty percent of discarded materials is either put in a landfill or incinerated, while only 40% is recycled or reused, but usually for low value uses.

Ninety-five percent of the value of material and energy is typically lost at the end of the first use. Material recycling and waste-based energy recovery captures only 5% of the original raw material value.
1.2 SCARCITY OF RESOURCE
Scarcity appears to be a simple concept based on the notions of availability and shortage. However, it is a term that encompasses economic, political, social and ecological domains each with different associations to resource allocation and material use. Systems-theorists, such as Donella Meadows and others, suggest that scarcities occur when resource flows are in some way constrained or exhausted. Economic doctrine encourages us to dismiss such concerns, relying on the market to achieve optimal flows. In the 1970s, economist Georgescu-Roegen was the first to apply the thermodynamic law of entropy (which states that energy tends to be degraded to ever poorer qualities) to mineral resources, arguing that resources are irreversibly degraded and will eventually be exhausted when put to economic use.11 His work inspired the field of ecological economics and the study of natural resource flows in economic modelling and analysis. He claimed that the economic process irreversibly transforms low entropy (valuable natural resources) into high entropy (valueless waste and pollution), thereby providing a flow of natural resources for people to live on but at the same time degrading the value of these resources.

Others argue that scarcity is a socially and economically constructed condition – there is enough food in the world, it is just in the wrong place. There is enough housing in the developed world, just in the wrong ownership. In the developed world of seeming abundance it is difficult to comprehend the relevance of the concept of resource scarcity. Thus, in reality, scarcity is extremely complex and mutable, and fundamental to the essential question of whether we can really have continual growth on a bounded and limited planet.

There is growing consensus that material availability in the future will be significantly constrained compared to the recent past. This may be due to physical exhaustion of supply of some materials (such as rare metals or platinum) but in many cases scarcity is linked to ease of availability, energy intensity of processing, cost of extraction and processing, and transport. There may be a lot of iron ore or aluminium ore in the earth but it may not be realistic to extract such large amounts of it in future. Conversely, as we have seen with the recent advent of fracking and tar sands oil extraction, sources become more or less economically and politically viable due to price changes for a particular resource and government policies and ideologies.

Nevertheless, there is mounting evidence for all the major resources – energy, water, food and materials – that our existing global industrial models are leading to a series of persistent shortages and/or uncertainties. The Stockholm Resilience Centre has shown that using the concept of planetary boundaries, of the nine boundaries that the Centre has identified, by 2015 four have already been breached and several others are close to the
In 2007 the New Scientist magazine looked at the availability of many key minerals and calculated how many years these minerals would last based on various use scenarios. They speculated that material scarcity will call into doubt the aim that the planet might one day provide all its citizens with the sort of lifestyle now enjoyed in the west. Researchers at Yale University suggest that ‘virgin stocks of several metals appear inadequate to sustain the modern “developed world” quality of life for all of Earth’s people under contemporary technology’. The Worldwatch Institute has estimated that by the year 2030 the world will have run out of many raw building materials and we will be reliant on recycling and mining landfills. Increasingly, questions are being asked about whether we have the resources to deliver?

Consequently, consideration of building materials scarcity goes beyond simple availability and cost, to include engagement in the whole supply process from extraction, through processing, delivery, technologies used, skills required, assembly on site, use, maintenance and end-of-life disposal methods. It requires consideration of all the tangled social, economic, environmental and technical networks that are necessary to make a resource useful, and their consequent impacts. As Till and Schneider suggest, scarcity in an architectural context is much more than just an actual lack of material, space or energy. Rather, scarcity is revealed as socially, economically and politically constructed and requires a discussion of patterns of creation, consumption and behaviour. They also suggest that scarcity presents a radical challenge to the architectural community as the most appropriate solution to a spatial problem under conditions of scarcity may often be the avoidance of new building.

A changed approach to materials, or a ‘new materialism’ based on ecological principles and recognizing limits, demands a rethinking of the nature of material processes in architecture, leading to a

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**Box 1.3 Resource Use In Construction**

In England, the Construction Resources Roadmap states that around 380 million tonnes of resources are consumed by the construction industry each year. The table below provides estimates of global use of five principal construction materials.

<table>
<thead>
<tr>
<th>Material</th>
<th>Global production (Mt/yr)</th>
<th>Use per person – based on world average (tonnes person/yr)</th>
<th>Carbon intensity (kgCO₂e/kg)</th>
<th>Approximate % used in building construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>1400</td>
<td>0.2</td>
<td>1.5</td>
<td>42</td>
</tr>
<tr>
<td>Cement</td>
<td>4000</td>
<td>0.57</td>
<td>0.7</td>
<td>75</td>
</tr>
<tr>
<td>Aluminium</td>
<td>70</td>
<td>0.01</td>
<td>9.2</td>
<td>24</td>
</tr>
<tr>
<td>Plastic</td>
<td>299</td>
<td>0.04</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Timber</td>
<td>534</td>
<td>0.075</td>
<td>0.31</td>
<td>40</td>
</tr>
</tbody>
</table>

Note – these data are a best estimate based on a variety of sources.
The increase in waste generation is inextricably linked to urbanization and economic development. As countries urbanize and standards of living increase, consumption of goods and services increases, so waste generation typically increases. In recent years there have been increasing concerns about the vast garbage dumps that are necessary to service urban areas, and the huge amounts of waste (particularly plastics) that accumulate in the world’s oceans, endangering humans and wildlife and taking hundreds of years to degrade.

Waste has become a significant concern, having major impacts on people’s health, the environment and national economies. Waste disposal has significant costs to municipal governments, pollutes the local and global environment and contributes to climate change in the form of greenhouse gas emissions from transport and processing. Yet, much of this discarded material has significant potential value and usefulness. Discarding it is therefore negligent. In developed countries, construction and demolition waste typically contributes about 35–40% of the total waste stream. It is estimated that about 75% of this demolition waste (by weight) has residual value that can be utilized by reintroducing it into the urban fabric through reuse or recycling.

The problem of waste as a concept is reflected in the difficulty of defining waste and the assumption that it is a burden that requires discarding. Often definitions are not useful and reflect the current linear attitude to resource use. In many countries complex rules define different types of waste and how they can be treated, with legal implications. Sometimes these can prevent legitimate reuse of potentially useful materials. The UK government rules for defining waste state that ‘A material is considered to be waste when the producer or holder discards it, intends to discard it, or is required to discard it’. This ignores any useful value the material may have. Zero Waste America defines waste as ‘a resource that is

1.3 WASTE AND OBSOLESCENCE

The way we see it, waste is what you call something when you have no idea what to do with it. The fact that waste exists anywhere is more a testament to our lack of imagination than it is to the inherent value of any material. If you have a purpose for it, it’s no longer waste. (Omar Freilla)
not safely recycled back into the environment or the marketplace.\textsuperscript{19} A new and evolving ecology of material sees waste streams not as a burden but rather as a valuable resource. In the book *Wasting Away*, Kevin Lynch suggested that ‘Architects must begin to think about holes in the ground and about flows of materials’. A new type of infrastructure of valuing, recovering, sorting, processing, managing and using is beginning to evolve to exploit discarded materials. A new aspirational target of ‘zero waste’ (along with zero energy and zero carbon) has been proposed for new and existing buildings and urban areas which will require the redesign of urban systems and material flows.\textsuperscript{20} As with zero carbon buildings, a discussion is needed about the appropriate scale and strategy for achieving zero waste – should we address waste at the level of the component, building, district or city? Most likely all should be considered.

Although in recent years waste management and recycling schemes in some countries have reduced the volume of waste going to landfill, to achieve fundamental change in our approach to waste we need to rethink our approach to design, component life cycles and building life cycles. This requires reconsideration of the concepts of obsolescence and decay. Since the built environment uses a lot of materials and lasts a long time, there is a need to carefully reconsider how a material, component, or building decays and when it becomes obsolete. Extending the life of resources (not necessarily buildings) should be an essential aspect of design and management of the built environment.

Obsolescence is defined as when something becomes no longer useful, is outdated, out of date, or falls into disuse. In construction, a component or building is regarded as obsolete at the point when it is discarded for whatever reason. Conversely, decay is the process of rotting or decomposition and is closely related to physical effects. It has been noted that obsolescence occurs for many reasons and is strongly connected with economic value, regulations and market forces, and less with physical decay; thus, architectural design has a limited impact on building obsolescence. A study by the Athena Institute into the reasons for the demolition of 227 buildings in Minnesota, USA, showed that only one-third of the buildings were demolished due to decay and, thus, their physical condition. The study highlighted urban issues and site planning as well as aspects of building construction and maintenance as ways to increase building longevity and avoid obsolescence. Various researchers have presented obsolescence as the divergence over time between declining performance and rising expectations. For building stocks, Thomsen and van der Flier have defined obsolescence as a process of declining performance resulting in the end of the service life. But the reasons for this can be many and are often not technical. They claim that ‘obsolescence of building stocks is only partly a physical phenomenon. It is
essentially a function of human action or disregard. Therefore a distinction should be made between actual and potential performance’. A variety of causes have been suggested for obsolete buildings, including: physical, economic, financial, functional, location, environmental, political, market and fashion. Figure 1.4 shows a conceptual model for building obsolescence as proposed by Thomsen and van der Flier.\textsuperscript{21}

Abramson has explored architectural obsolescence and the idea that buildings and cities can suddenly lose their value and utility. He claims that our current concept of architectural obsolescence evolved out of early-twentieth-century US capitalist real estate development and spread globally in the mid-century urban and social realms before impacting architecture directly.\textsuperscript{22} He states that ‘a building’s value was represented in time and money, inextricably declining and rendering demolition inevitable’. Abramson also identifies obsolescence related to urban renewal and the resulting removal of many technically usable buildings, and related to the corporate strategy of planned obsolescence and the general infusion of a culture of short term-ism. In this context, issues of physical or technical obsolescence become less important as financial concerns dominate.

Some designers have embraced obsolescence’s liberating promise of expendability and short-life buildings. Others object
The World Bank estimates that urban waste generation worldwide will increase from about 1.3 billion tonnes of solid waste per year in 2012 to 2.2 billion tonnes by 2025.

Construction and demolition waste typically constitutes about 25–30% of the total solid waste stream in developed countries.

Construction and demolition waste (CDW) consists of numerous materials, including concrete, bricks, gypsum, wood, gypsum drywall asphalt roofing glass, metals, plastic, cardboard solvents and excavated soil, many of which can be recycled or reused.

In the United States, annual construction and demolition (C&D) debris from buildings (not including roads and bridges) was estimated to be around 162 million tons in 2013 – or about 0.5 t/person/yr.

In the European Union, construction and demolition waste from buildings is estimated 180 million tonnes/yr or about 0.5 t/person/yr.

The Construction Resources and Waste Roadmap in the United Kingdom estimates that total construction and demolition waste in England, including road building, was at 120 million tonnes.

The US Green Building Council (USGBC) estimates that only about 10% of construction waste is diverted from landfills in North America. The European Union has a target of 70% diversion.

Researchers in the United States estimate that the ‘typical’ North American home generates about 1600 kg (3500 pounds) of wood waste during its construction.

Repair and remodelling tends to generate more waste than new construction because many repair and remodelling projects involve both demolition and construction activities, both of which generate waste.

Many countries have established recycling strategies that prevent much C&D waste going to landfill but much is downcycled as low grade road fill products.

Note – these data are a best estimate based on a variety of sources.

### 1.4 PERMANENCE AND REPAIR

Permanence is not a matter of the materials you use. Permanence is whether people love your building. (Shigeru Ban)