BUILDINGS THAT LAST: DESIGN FOR ADAPTABILITY, DECONSTRUCTION, AND REUSE

The American Institute of Architects

CONTENTS

INTRODUCTION

The built environment is an archive of culture and history. It manifests the aspirations and needs of society in a particular time and place, creating a record of who we are.

But the best architecture does more: It accommodates change. Because of the dynamic nature of commerce and culture—and simple wear and tear—any building will undergo repair, renovation, and potential demolition and replacement. We are also experiencing new forces of climate change to add to the normal forces of the natural environment on buildings. Designing buildings as long-term cultural assets is ever more challenging yet ever more important.

Add to this the fact that constructing buildings in the first place can take a heavy toll on the environment and on communities. We mine raw materials and burn coal to make steel and concrete. We disturb forest ecosystems to cut down trees for lumber. Pollution and other disruptions from construction can degrade quality of life in neighborhoods for years on end.

It's one thing to do all this for a building that will stand for a hundred years or more. But too often our buildings are torn down before they reach the end of their intended design life—and precious materials are hauled away to landfills—to make way for yet more new construction. According to the U.S. Environmental Protection Agency[1], the United States building industry generated 169 million tons of construction and demolition debris in 2015 (the most recent year for which data are available). Some 88 million tons of concrete, 38 million tons of wood products, and 5 million tons of steel from building construction and demolition were generated in that year. (The vast majority of construction and demolition debris—90 percent—was from demolition). This is equivalent to a solid mass 16 stories high covering the entire area of Central Park.

It doesn't have to be this way. Good architecture is worth preserving: It can hold neighborhoods together, encourage economic vitality and social equity, and contribute to community resilience. But in order to be preserved, the built environment needs to be responsive to change. Architects have a major role to play in preventing our buildings from being treated like short-term conveniences.

In this practice guide, we look at design strategies for buildings and materials that last, covering design for adaptability, deconstruction, and building and material reuse.

KEY TERMS

Adaptability The ability of a space to be modified for uses beyond the one originally designed for.

Adaptation Not to be confused with adaptability, this involves preparation for climate change. The United Nations' Intergovernmental Panel on Climate Change defines adaptation as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities."

Adaptive reuse Redesign and alteration of a building to support a new function it was not originally intended to serve

Circular economy An economic model supporting a closed-loop system of material reuse through market-based means.

Deconstruction The careful removal of building materials to retain their integrity and value at the end of a building's service life (as opposed to demolition, which typically destroys the materials)

Embodied environmental impacts The environmental costs of creating materials.

Material reuse Use of materials salvaged during construction, deconstruction, or renovation for either the same or different purposes; design for material reuse involves unique constraints and opportunities.

1 U.S. Environmental Protection Agency, Advancing Sustainable Materials Management Fact Sheet: 2015.

DESIGN FOR ADAPTABILITY

In all the excitement of creating a new building, it's easy to get wrapped up in programming the space for the intended use. That's the designer's job, after all.

But will the building still be needed for the exact same use or the same programmatic requirements a couple of decades down the road? And what happens if it won't? Possibly abandonment or demolition. It's worth giving future uses some thought during initial design to help delay that eventuality for as long as possible. That's where design for adaptability—intentional strategies for supporting multiple potential uses—comes into play.

BENEFITS OF DESIGN FOR ADAPTABILITY

The primary goal of design for adaptability is to lengthen a building's lifespan by making it possible to adapt the space with minimal disruption. This has many advantages, most notably the preservation of the building's cultural and economic value.

Environmental benefits

Design for adaptability avoids the significant impacts from demolition and landfilling of existing materials, and from sourcing of new building materials. It also keeps in place all the natural resources that have been withdrawn to produce and install new materials as well as all the environmental releases to water, air, and land generated by the extraction, manufacturing, construction, and installation of those materials. All the withdrawals and releases associated with a material's upstream supply-chain processes are the integral burden of that material. Each time a material is thrown away, those embodied resources are wasted; and each time a new material is used in place of an older usable material, environmental burdens are duplicated. Design for adaptability has the potential to mitigate the wasting of resources and the pollution and global warming associated with the creation of new materials and buildings.

Extending the life of materials and buildings conserves resources and avoids environmental pollution associated with new manufacturing and construction, including global warming potential.

Resilience benefits

The use of simple, durable, low-maintenance materials such as stone and brick also helps buildings stand up to the forces of nature, which are becoming stronger in many areas due to climate change. Making systems easier to repair and replace is also a benefit, in the event of damage from the elements. Having a more robust structural system can also provide greater resilience.

Community benefits

Design for adaptability is good for communities. Because building demolition and new construction can affect the quality of local life for years with noise pollution and disruption of sidewalks and streets, reducing the need for new construction can be a win for neighborhoods. Overall, building adaptation takes less time and causes less disruption than demolishing and building new. And when buildings are demolished and not replaced, the vacant lots can attract criminal activity and litter.

Not all obsolete buildings are demolished to make way for new buildings; some are simply abandoned, often because they are no longer seen as cultural assets or because the economics of major modifications discourage repurposing. Design for adaptability reduces the risk of blight—which can have far-reaching consequences such as depressed property values and increased risk of crime—and supports continued use of community infrastructure and resources (Figure 1). Adaptable buildings invite new uses to move in more quickly and generate housing or economic activity. When buildings have some architectural significance for the neighborhood, design for adaptability helps preserve their cultural value, contributing to vibrant, healthy communities and protecting historic heritage for all.

Figure 1: Before and after of pre-development blight and redevelopment of Exploratorium at Pier 15, 2016 COTE Top Ten Award recipient by EHDD - Photo Credit: Photo by Bruce Damonte

Economic benefits

Adaptable buildings also have more inherent financial value because they can be economically adapted and renovated as occupant needs change. The durable high-quality materials used to support design for adaptability can also provide long-term savings by avoiding basic repairs and replacement.

SOME POTENTIAL PITFALLS WITH DESIGN FOR ADAPTABILITY

Economic pitfalls

There may be higher initial soft costs and hard costs associated with design for adaptability. For example, structural systems often need to be more robust. Additionally, some future uses may require additional ceiling height—either to serve a programmatic function or to facilitate future systems that have greater requirements (such as for HVAC, electrical, data/IT, and fire protection). Anticipating the need for additional below-floor or overhead space (whether closed ceiling or open ceiling) is one way to provide for a wider range of potential future uses. In any case, this may require owner buy-in plus a higher level of engagement with the structural engineer and the use of more and higher-quality materials.

Environmental pitfalls

Because more materials may be required, the initial embodied impacts—the environmental costs of creating the materials—can also be higher. This is an important consideration since avoiding later embodied impacts is a major goal of design for adaptability, and there are no guarantees. Although design for adaptability makes it more likely that a building will be reused, no one can predict whether that will really happen.

Process pitfalls

Finally, an integrative design and construction process is desirable to help ensure that design for adaptability is prioritized and implemented. The process first requires early buy-in from owners, who likely have multiple competing priorities, including budget constraints; long-term adaptability is seldom at the top of their wish list. Communication requirements are higher in such a process, and the architect has the opportunity to lead the way, navigating through the needs and desires of the owner and each member of the project team. If the team doesn't start thinking about it early enough, or if conflicting priorities arise, design for adaptability might not make it into the final project.

APPROACHES AND STRATEGIES

Fortunately, the principles of design for adaptability are fairly straightforward, and strategies should be relatively easy to implement if owners express interest early. (If it doesn't come up on the owner's side, architects have the opportunity to introduce the idea and describe the benefits.) That's because many of the prevailing approaches dovetail with other common architectural and environmental goals.

Figure 2: 2015 COTE Top Ten Recipient Hugh Warehouse by Overland Partners showcases clear spans, regularly spaced structural elements, and mechanical fasteners. Image: Dror Baldinger, AIA and Scott Adams, AIA

- **Clear spans** are a hallmark of design for adaptability (Figure 2). They create wide open spaces full of possibility, allowing for multiple alternate uses of the interior in the future without costly structural alterations. Clear spans have additional advantages, such as supporting open-office design.
- **Generous floor-to-floor heights** are a good way to plan ahead; they can allow switching between commercial and residential uses, for example. They are also helpful for daylighting, natural ventilation, and adding or upgrading building services.
- **Flat floors** with few transitions from one floor height to another are preferable. This allows for more flexibility when renovating or changing uses. It also contributes to universal design.
- **Interior non-load-bearing partitions** instead of load-bearing walls help ensure that programs can be adapted without threatening the structural integrity of the building (Figure 3). The ability to disassemble and move the partitions also contributes to flexibility and adaptability.
- **Regularly spaced structural elements** (Figure 2) where clear spans are not feasible allow for simpler, more flexible planning when adaptation takes place later in the building's life. A reasonable column grid incrementally larger than a conventional grid can facilitate change.

Figure 3: Non-load bearing partitions can be adapted without threatening the structural integrity of the building. 2016 COTE Top Ten Recipient Dixon Water Foundation Josey Pavilion by Lake|Flato Architects. Photo Credit: Casey Dunn

- **A stronger structural system** designed with flexibility in mind can make a building easier to reuse. For example, giving load-bearing supports extra strength can allow interior openings to be readily moved around within the space. A stronger foundation can later permit vertical additions (adding extra stories to the building). More structural flexibility can also facilitate the addition of future beneficial systems such as photovoltaics and green roofs.
- **Early engineer engagement** is essential. Due to the integral structural goals, the structural engineer should be on board quite early in the process to help facilitate design for adaptability. It's best to start the conversation about structural systems early because the type of framing system chosen will impose design constraints and introduce different opportunities.
- **Separation of systems** from one another and from the envelope of the building helps ensure that the building's mechanical, electrical, plumbing, IT, and other services can be maintained, replaced, or upgraded without damage to the building or to other services (Figure 4). Consider making a building solar-ready or electric-vehicle-charging-ready by providing electrical chases or pre-wiring. This will make future upgrades less expensive and reduce impacts to existing walls and finishes. It's also important to think about future upgrades and repairs to cladding. Having a cladding system that is easily removable and replaceable can save a building from destruction.

Figure 4: from one another and from the envelope of the building helps ensure that the building's mechanical, electrical, plumbing, IT, and other services can be maintained, replaced, or upgraded without damage to the building or to other services. Image credit: Brad Guy, AIA

Use of durable materials and minimal use of extra finishes (especially finishes that are glued rather than mechanically fastened) can go a long way toward ensuring a longer life for the building; durable materials don't need to be torn out and replaced. Durable materials can also potentially have another life if mechanically fastened (Figure 5). And they typically need less maintenance during the building's life, reducing operating costs. They also stand up to the forces of nature better, increasing resilience. When considering durability, be sure to take climate change into account; extreme heat and other extreme weather may change your view of what's "durable."

Figure 5: Dixon Water Foundation Josey Pavilion is constructed using durable materials. Photo Credit: Casey Dunn

Use of mechanical fasteners and minimal use of adhesives make it easier to adapt the building later because assemblies can be taken apart without damage and even, in some cases, be reassembled in another part of the building (Figure 6). See more about deconstruction below.

Figure 6: Use of mechanical fasteners and minimal use of adhesives make it easier to adapt the building later because assemblies can be taken apart without damage and even, in some cases, be reassembled in another part of the building. Dixon Water Foundation Josey Pavilion. Photo Credit: Casey Dunn

- **Clear and effective documentation** of adaptability features helps ensure that future owners and designers understand their options for flexibility and adaptability. Such documentation should be incorporated into computer models, Owner's Project Requirements, and Basis of Design.
- **Beauty and quality design**, while not essential to a building's physical capacity to be adapted over time, definitely contribute to its fate (Figure 7). If a building has not captured the hearts of those who live in it and work in it, that building will not be maintained (increasing the cost to adapt it), and few will fight for its adaptation and reuse. Demolition is typically the easiest path to follow, and passion is often needed to tip the scales toward extending a building's life.

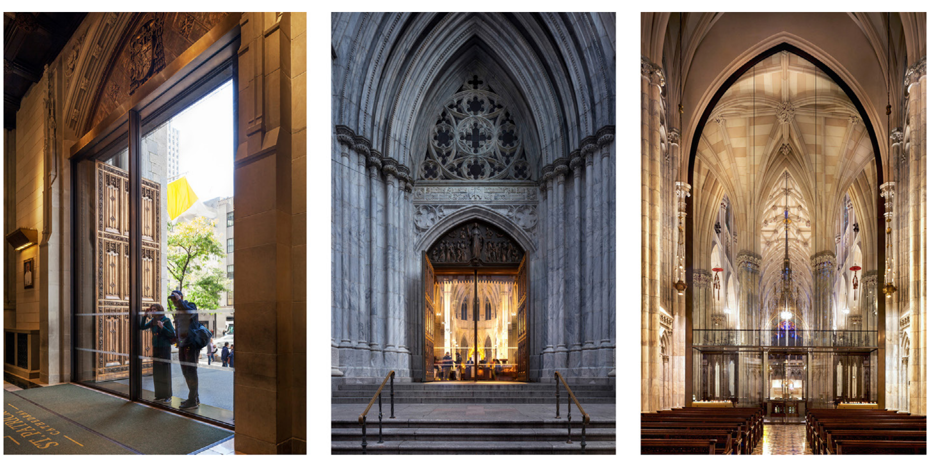


Figure 7: 2019 COTE Top Ten Recipient, St. Patrick's Cathedral renovated by Murphy Burnham & Buttrick Architects, is a centuries old example of beauty and quality design. Image: Elizabeth Felicella

CASE STUDY: PERRY HALL AT CHAMPLAIN COLLEGE

BUILDING TYPE: Higher education

LOCATION: Burlington, Vermont

AREA: 18,000 sq. ft.

OWNER TYPE: Academic institution

ARCHITECT: Murphy Burnham & Buttrick Architects

"Long life, loose fit"—one way designers talk about design for adaptability—was the watchword during design of Perry Hall at Champlain College in Burlington, Vermont. "It was part of the design intent from the get-go," explained Jean Carroon, FAIA, principal at the design firm Goody Clancy. "It's an academic building with open office space, and how it was going to be used and by whom was fluctuating even as we were doing the design." The need for long-term flexibility is common for higher-education projects. "They are constantly reworking buildings, constantly changing program space," Carroon said. "The more they can do that without massive costs, the better.

Completed in 2010, the project consists of a two-wing addition to a historic 1860s house acquired by the college in 2004. Why two wings? A big part of that decision had to do with the adaptability goals: Because of other design constraints, this was the best way to ensure that the project had clear spans to allow for wide, open spaces that invite flexibility for future uses (Figure 8). The narrow footprint of each wing also contributed to other important goals, such as widespread access to daylight and views.

Figure 8: Perry Hall's two wings allow for access to plenty of daylight and views while ensuring flexible wide, open spaces for future uses.

The team engaged with the structural engineer early in the process to compare different structural systems and because of the need to align the new addition with the existing floor plate of the historic house. “We really wanted to do a wood building,” Carroon recalled, “but we couldn’t get the spans we needed; we would have had to compromise on ‘long life, loose fit.’” So the project went with a steel structure instead.

Also paramount to design for adaptability was the choice to use durable, low-maintenance materials like brick, slate, and polished concrete. This is important because a durable, easily maintained building is more likely to be treasured and cared for by occupants and therefore remain standing.

Although the team did not fully quantify the effects, Carroon said the choice to build two wings instead of one larger addition likely increased the cost of the project because it added “roughly a third more exterior envelope.” However, she added, “‘Long life, loose’ fit was not one of the issues they were willing to compromise on,” so the added cost didn’t come up as a concern. It’s likely that at least some of the first cost will be offset by the ease of renovation later on.

“‘Long life, loose fit’ should and easily can be a value embraced from the very beginning of design that adds value for clients,” Carroon said, noting that it’s not just academic clients that can benefit. “Even for a developer, the flexibility of a building would make it easier to flip or sell,” she said. “Designers have the opportunity to bring that to the forefront for their clients from the very first meeting.”

ADAPTIVE REUSE: THE ARCHITECT’S ROLE

Design for adaptability happens at the beginning of the building’s lifespan; it means intentionally designing the building so that adapting it for future uses is not impossible or cost-prohibitive. Adaptive reuse is what happens when an existing building is already in place and ready to be altered to accommodate a new use. Adaptive reuse is a vital strategy because of the major impacts—especially the embodied carbon impacts—of new construction. As awareness of climate change grows in the profession, it’s increasingly important to cultivate the architectural skill set needed to support adaptive reuse.

The architect’s role may seem unusual in scope for an adaptive reuse project since there’s already a building in place. But don’t let that fool you: There’s still plenty to accomplish, and adaptive reuse leverages an architect’s vision and creativity.

The first role of the architect in an adaptive reuse project is to encourage the owner to consider reuse in the first place. Many clients get excited about a new building without thinking about how an existing building might serve their needs and even offer architectural features that only an older building can provide. Raising awareness of the impacts associated with demolition and new construction—and challenging preconceived notions that only new buildings can be energy efficient—may help convince some owners to be open to adaptive reuse. Owners may also find that an existing building offers amenities such as a central location in the city that wouldn’t be feasible with new construction or the cultural value of a historic building. Starting with an existing structure can also save time—and money—by avoiding extensive site and structural work.

Some localities offer financial or other incentives for reusing existing buildings. These can range from tax breaks to reduced parking requirements to increased allowable floor-area-ratio density bonuses (to add vertically). Also, since most green building programs have a block of credits for building reuse—and, in turn, local governments may have requirements for use of green building certification—seeking adaptive reuse opportunities is a good way for owners to meet environmental goals.

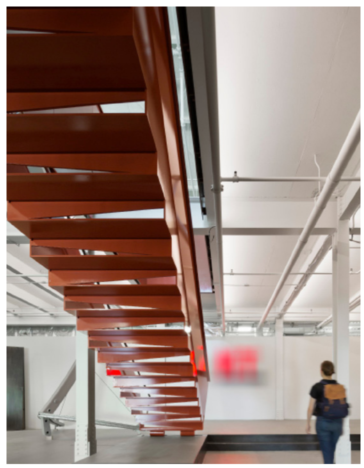
It’s important to manage expectations on adaptive reuse projects. For example, in some cases adaptive reuse can cost just as much as building new. And surveys may turn up surprise issues that need to be resolved, such as the abatement of hidden toxic materials.

Once adaptive reuse is confirmed as a possibility, architects can help identify buildings that might be a good fit for the intended program. It's especially important to look at features that can't readily change, such as location, structural systems, ceiling heights, etc.

Specialists in structural and envelope analysis of existing buildings will survey the building to better understand its limitations and any repairs that will be needed. The architect should be closely involved with this process to ensure that the project remains feasible and to understand which features can best be leveraged to support and enhance the new use.

Instead of starting a model from scratch, the team will model the existing building and work from there. Make sure it's clear what can and can't be altered—such as the structural system, ceiling height, etc.

CASE STUDY: ORTLIEB'S BOTTLING HOUSE



BUILDING TYPE: Commercial office

LOCATION: Philadelphia

AREA: 60,000 sq. ft.

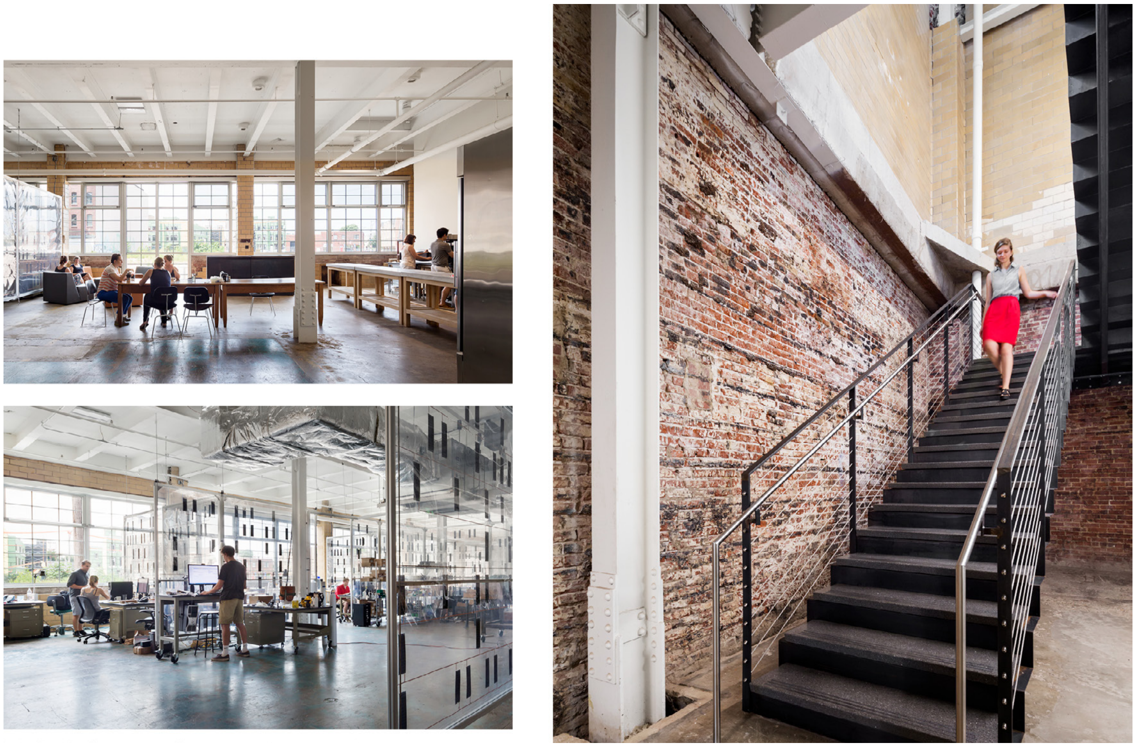
OWNER TYPE: Private

ARCHITECT: Kieran Timberlake

Ortlieb's Bottling House is a 1948 factory building now repurposed as a commercial office space for the architecture firm KieranTimberlake in Philadelphia. Completed in 2014, the building houses the firm's studio as well as a fabrication shop. KieranTimberlake is both the owner and the architect of the project.

Adapting an existing structure rather than building new had many advantages, according to Stephen Kieran, FAIA, a firm partner. "We wanted to stay in the city: That was a requirement," he said, and the former beer-bottling plant was perfectly located to allow that, with nearby opportunities to walk, bike, and take mass transit.

Purchasing an older structure at the tail end of a recession also meant getting great value for their investment. "The only thing we might have been able to get for the same money is a one-story metal pre-engineered building," he said, and that wouldn't have the same charm and inherent sustainability features as the historic plant.



Ortlieb's Bottling House case study: The historic warehouse maintains some of its charm while finding new life as a flexible, daylit office space. Image credit: Michael Moran/OTTO

Adaptive reuse was also simply the right thing to do, Kieran adds. "We have an ethical responsibility to take care of what already exists." It also helped keep the neighborhood fabric intact at a time when other historic buildings were being torn down to make way for new condos.

The choice has paid off. Employees love working in the space, which is filled with natural light even when it's overcast thanks to two roof monitors that run the length of the building (Figure 9). And because the space was designed before air conditioning was common, it can be naturally ventilated for part of the year. The large volume of the studio also enhances the quality of the workplace, says Kieran. "Being able to see not just out but up has huge appeal aesthetically," he said. "People feel better, more motivated, energetic, and creative in high spaces."

Figure 9: Employees love working in the space, which is filled with natural light even when it's overcast thanks to two roof monitors that run the length of the building. Ortlieb's Bottling House. Image credit: Michael Moran/OTTO

Interior adaptations were relatively light because there are no private offices in the entire building. Major renovations focused on restoring the roof monitor, replacing windows to be double-glazed, and replacing the roof to improve insulation.

The process was not always smooth, however. One design challenge was figuring out how to integrate new systems into the historic structure. “We made a decision to invest in a raised floor throughout the whole studio space,” Kieran said, explaining that all the studio furniture is on wheels, and desks get moved around frequently. “This gives us a lot of flexibility in terms of configuration and movement” while also addressing the challenges of incorporating modern mechanical systems.

To qualify for a tax credit that would make the project affordable, the team had the building listed on the National Register of Historic Places. This took time and effort but ultimately succeeded. At the same time, the historic designation placed extra limitations on the project because window profiles and the open interior space had to be preserved. These limitations didn’t have a major impact, especially since the team had already been planning to keep the interior space wide open.

One unanticipated problem did come up: Several steel lintels supporting the exterior walls had rusted out, and they had to rebuild a parapet wall that ran the length of the building. “There are inherently more unknowns in adaptive reuse projects,” Kieran warned, adding that owners should “have enough money in terms of contingencies retained to address those things as they come up along the way.”

Even after occupancy, issues can continue to creep up on you. At first, the building was not equipped with air conditioning because it was designed for natural ventilation. But that wasn’t enough on the hottest days, and a cooling tower was added after the first difficult summer. Fortunately, the team had planned ahead and equipped the raised-floor system to prepare for that eventuality.

Kieran said one reason the project worked so well was the compatibility between the existing building and the desired program. “The first important thing is getting a match between the proposed reuse and what the existing building offers, and to be realistic about that,” he cautioned. “If you have to change a lot of the fabric of the existing building, you could easily get into situation where you’re spending more and getting less.”

And in keeping with that principle, “listen to the building,” Kieran concluded. “Let it tell you what fits and works and what systems are the least invasive.”

> DESIGN FOR DECONSTRUCTION

All good things must come to an end—even buildings. And when they do, what happens next? Typically buildings are demolished, with all the materials destroyed and mingled together, and most of it going to landfills.

But that's not the only way to take down a building. Building materials are valuable items, and when removed intact through a process called "deconstruction" or "disassembly," they can be reused in other buildings. During this process, workers sort materials, separating those that can be reused in other buildings. Those that can't be reused can often be more readily upcycled, recycled, or, if need be, downcycled when they've been carefully separated.

Design for deconstruction is the intentional design of buildings to make it feasible to deconstruct them and reuse the intact materials in other projects.

BENEFITS OF DESIGN FOR DECONSTRUCTION

Environmental benefits

As with design for adaptability, design for deconstruction avoids the impacts from demolition and landfilling of existing materials, and from sourcing of new building materials—and preserves the natural resources withdrawn to produce and install the materials in the first place.

Extending the life of materials and buildings conserves resources and avoids environmental pollution associated with new manufacturing and construction, including global warming potential.

Economic benefits

Design for deconstruction helps keep a much higher percentage of still-valuable materials out of landfills at the end of the building's lifespan, protecting economic and cultural assets. It also increases the availability of lower-impact reusable materials in the marketplace. Markets for reused materials tend to be localized, so design for deconstruction can also support local economies and the creation of green jobs.

Design for deconstruction can also add at least a small amount of financial value to a building, since many materials can be sold or donated for a tax benefit at the end of the building's service life. It also avoids the tipping fees associated with landfilling materials.

These economic benefits could increase as reuse markets develop and economies of scale help make used materials available for larger projects and across local boundaries. As methods of deconstruction, storage, and transport of used materials start to match those of newly harvested materials, the trend towards reuse could start to make even more economic sense.

Flexibility benefits

There are shorter-term advantages to design for deconstruction, such as greater adaptability and reuse during the building's service life. And many owners may be keen to think about whether valuable materials are likely to eventually end up in landfills.

Finally, design for deconstruction may even have benefits during initial construction: If elements are more easily removed, design errors and construction change orders or mistakes can be more rapidly or economically reversed and corrected.

Health benefits

Buildings may have better air quality and lower VOC emissions due to the use of fewer adhesives, sealants, coatings, and binders. Additionally, compared with demolition, deconstruction of buildings is a more careful process that increases the team's ability to control exposures to hazardous materials and dust—for both jobsite workers and surrounding communities.

SOME POTENTIAL PITFALLS OF DESIGN FOR DECONSTRUCTION

Economic pitfalls

Design for deconstruction may increase soft costs, especially if the project team isn't already familiar with design for deconstruction techniques. That's because it may take extra care to design assemblies that can be deconstructed. Greater engagement with the structural engineer may also be necessary, possibly increasing costs.

Exposed systems such as spiral duct or architectural connections for wood systems may cost more in materials and labor as isolated components. However, their use as exposed systems would eliminate the need for drywall coverings, suspended ceilings, etc.

Communication pitfalls

Communicating early with the construction team about design for deconstruction is vital to success. It's commonplace for subcontractors to work independently and to use adhesives and other materials that make assemblies difficult to deconstruct; preventing this takes time, effort, and clear communication across the team. Consider codifying in Division One of the specification and conducting an all-subcontractor meeting at construction kickoff to review project goals, expectations, and strategies.

Market pitfalls

Finally, local markets for salvaged materials are not always well-developed. Consequently, when it comes time for deconstruction, it may be hard in some areas of the country to predict when and where to locate potential homes for the materials. Some materials can also overwhelm a market; it may be important to understand and prioritize materials that are regarded as particularly valuable and in demand in the community, or evaluate opportunities to connect to adjacent communities.

In the event that salvaged materials require transportation to their new homes, the project team must factor in this transportation cost and logistics in the whole picture as it assesses viability.

Design pitfalls

Designing for disassembly may limit product and design choices. Designers cannot specify materials that are problematic for reuse, and may need to keep the sizes and designs within common parameters to make the parts widely reusable by an unknown next user.

APPROACHES AND STRATEGIES

Some of the strategies for design for deconstruction mesh well with strategies for design for adaptability, covered above; this is due to shared principles of making assemblies easy to understand and take apart. Others are unique to design for deconstruction.

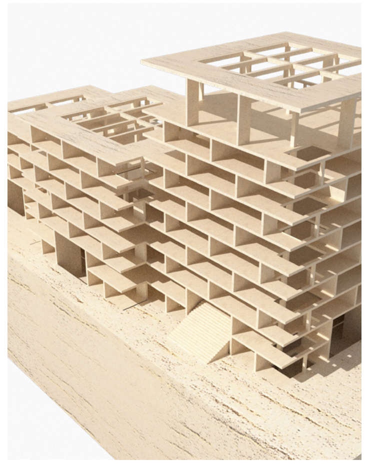
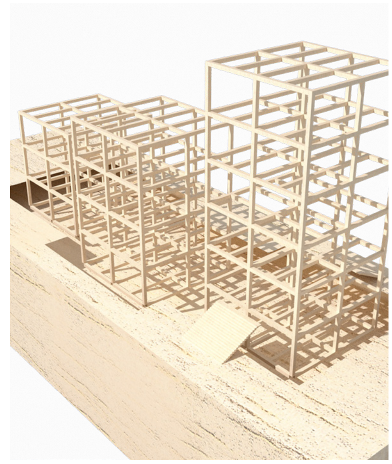
- **Separation of systems** from one another helps ensure that the building's mechanical, electrical, plumbing, IT, and other services can be removed or upgraded without damage to other systems and materials.
- **Durable high-quality materials** should be selected to help guarantee that materials are actually worth saving and have market value after deconstruction.
- **Viewing finishes as temporary** is appropriate when uses are intended to be short-term, or with businesses or clients that benefit from frequent stylistic changes in their facilities. In such a case, the material can be viewed as a service, used for a fee over a time, and then returned. This is already fairly common for office furnishings and equipment, and it is becoming a more common practice to lease carpeting.

- **Low-toxicity materials** are preferable to reduce the occupational hazards associated with deconstruction and to increase salvage yield.
- **Exposed connections** help future owners and workers see that disassembly is possible and aid in deconstruction and reuse (Figure 10). Wood and steel structures are good candidates for exposed connections and mechanical fasteners.

Figure 10: 2019 COTE Top Ten Recipient Tasjian Bee and Pollinator Discovery Center by MSR Design frames its exhibits with exposed connections. Image credit: Richard Brine

- **Mechanical fasteners** instead of adhesives ("screws, not glues") help ensure that systems can be readily taken apart down the road and reused. (Choose high-quality hardware when using this approach so screws don't strip during disassembly.) It's also important to remember that other materials, such as spray-foam insulation and concrete, adhere permanently.
- **Deconstruction planning** is important: Will workers be able to safely access and remove materials? How can the assembly be designed to ensure this? Creating a deconstruction manual will help future owners and workers complete the job safely and efficiently.
- **Simplicity of systems**—for example, making all the beams one standard size and avoiding complex composite systems combining more than one material type—can help with disassembly and marketability of materials.
- **Safeguard original construction drawings** as a guide to the building systems and materials which will be available even many decades into the future.
- **Early engineer engagement** is essential. In particular, the structural engineer should be on board quite early in the process to help facilitate design for deconstruction.

CASE STUDY: W.A. FRANKE COLLEGE OF FORESTRY AND CONSERVATION

BUILDING TYPE: Higher education

LOCATION: Missoula, Montana

AREA: 70,000 sq. ft.

OWNER TYPE: Academic institution

ARCHITECT: HDR

The new W.A. Franke College of Forestry and Conservation building at the University of Montana is being designed for deconstruction. This design imperative stems from the environmental mission of the college and centers around the use of a cross-laminated timber (CLT) structural system.

CLT is a type of mass timber made of layered boards (Figure 11); each layer's grain is stacked perpendicular to the next. The alternating grains give CLT special structural properties that unlaminated timber members can't match. The owner finds CLT attractive because it's a renewable material that can be used in place of concrete or steel. Also important: Wood sequesters carbon, and the longer it's in service, the longer that carbon remains sequestered. Design for deconstruction will ideally lengthen the service life of the wood, ensuring a longer period of time for sequestration. The building is targeting not only net-zero energy but also net-zero carbon.

Figure 11 caption: Cross laminated timber (CLT). Image credit: Structurlam

The structural system is also unique in employing biomimicry principles. “I was talking to the dean about how, in a way, buildings are the exact opposite of a tree,” recalls Thomas Knittel, AIA, design principal at the architecture firm HDR. “They move people and nutrients and fluids on the interior, but in a tree it’s around the perimeter. Wouldn’t it be interesting to have the structural core in the center?” That’s how the system will work, he explained, “a honeycomb wrapped around an open frame,” blending slab-and-bearing-wall construction on the perimeter with a post-and-beam open floor plan at the core.

It’s typical for CLT projects to include concrete toppings on every floor to efficiently add compressive strength, but, crucially, the Franke building will not include these concrete elements. “Once you do that, you then bind the wood assembly to the concrete, making it hard to reuse again someday,” Knittel explained. The mass timber structural elements will all be mechanically connected, making their assembly reversible, and the firm is looking into the possibility of using dowel-laminated timber to provide even further deconstructability. This means the layers of wood are attached together with dowels instead of with glue or nails, making them easier to work with later and avoiding any health concerns associated with adhesives.

Knittel said it’s also easier to reuse CLT than it is to reuse steel or concrete structural systems. “The other thing that’s interesting about CLT is that most is shaped through CNC [computer numerical control] machinery down to millimeter tolerances,” he said. “It’s fairly easy to take raw CLT back into the CNC machine and reshape it for your needs with minimal waste.” He added that the reversible mechanical connections could also be beneficial even during the life of the building if parts need to be replaced over time due to building leaks or other unexpected occurrences.

BUILDINGS AS MATERIAL BANKS

What if instead of viewing materials as used up once they’re integrated into a building, we saw them as being temporarily in storage? That’s the concept behind “material banking,” an offshoot of the principles of circular economy. A circular economy model encourages materials that are perpetually reusable or recyclable rather than on a one-way track to the landfill.

In order to treat a building as a material bank, with materials retaining all their value while temporarily in use, it needs to be deconstructable. Ideally, how to disassemble all the parts and put them back together for reuse in a different building would also be clear.

Project BAMB (Buildings As Material Banks)[2] is a network of 15 partners from seven European countries working together to realize the goal of a circular economy for buildings. The group is developing the idea of “materials passports”—data about products and materials that can be used to track their attributes and instruct future users on how to deconstruct and reinstall them (Figure 12). This data could be incorporated into a building information model or encoded directly on the product.

Ideas like these could someday help create more mature markets for reused materials, making it more likely that buildings will be commonly designed for deconstruction—and will actually be deconstructed rather than demolished.

2 Project BAMB, bamb2020.eu/about-bamb

REUSING MATERIALS: THE ARCHITECT’S ROLE

Design for deconstruction is only one side of the coin; the other side is the use of reclaimed materials in projects. How can architects help create markets for these materials?

The first role for the architect in designing around reused materials is to raise awareness with clients about the embodied impacts of new materials and introduce the possibility of reusing materials salvaged from other projects. Oftentimes reused materials are an attractive option because they have aesthetic charms associated with their vintage—but newer items are commonly reusable as well.

Opportunities to reuse materials are most obvious when another building is being taken down on the same jobsite, obviating the need for a local search for reclaimable items while also retaining the cultural or historical value of the previous use. If that's the case, the architect helps determine which items to reuse and how to make best use of them in the new building.

But reusing materials presents challenges. Finding materials in sufficient quantities for the project may be difficult. It's important to have a backup plan in case you do run out of a material you were planning on. It may also be difficult to work around size constraints: The materials are what they are. Some can be modified, but this can come with its own difficulties (for example, finding a mill to work with salvaged wood might prove difficult). And if you plan to reuse structural materials, they may need to be re-graded by an engineer; some engineers may be reluctant to do this, so don't count on it getting a simple rubber stamp.

Despite the challenges, designing for material reuse can be a rewarding process for both environmental and aesthetic reasons—not to mention for potential cost savings.

INCENTIVIZING DESIGN FOR ADAPTABILITY, DECONSTRUCTION, AND REUSE

Many sustainable design features, such as energy efficiency, entail monetary or other rewards for owners. But that's not always the case for design for adaptability, deconstruction, and reuse: These require commitment and follow-through (and sometimes added upfront costs) without short- or mid-term payback. Getting the market to reward this aspect of sustainable design is a long-term project.

Government regulations can help somewhat. Massachusetts, Vermont, West Virginia, Washington, D.C., and many local jurisdictions ban construction and demolition materials from landfills.[3] This can help incentivize deconstruction, reuse, and recycling of building materials. The D.C. Green Construction Code has requirements and electives that include building reuse, materials reuse, and design for deconstruction. Various other cities have deconstruction requirements for removal of buildings of a certain age.

Tax credits for restoring historic buildings have been exceptionally effective in enabling building reuse but address a very small part of our building stock. The economic payback is well-documented, however, and could be extended to non-historic buildings.

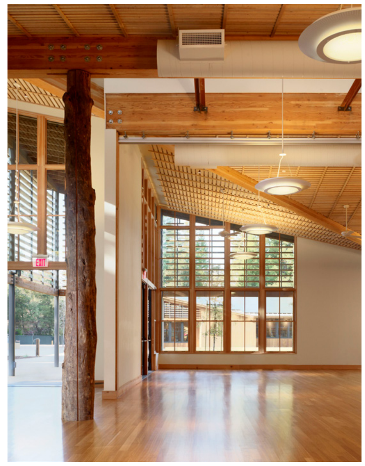
The AIA Committee on the Environment (COTE) Top 10 Awards[4] have a Design for Change criterion, requiring applicants to submit a narrative as to how the project incorporates design for adaptability (or how it repurposes an existing building).

The LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), and Green Globes rating systems encourage reuse of whole buildings as well as of building materials through optional credits. BREEAM and Green Globes offer credits for design for deconstruction, and LEED offers a credit called Design for Flexibility for healthcare projects as well as a flexibility option for commercial interiors under the Interiors Life-Cycle Impact Reduction credit.

3 Earth911, "What's Banned in Landfills: A State-by-State Guide," earth911.com/business-policy/landfill-bans/, 2017

4 American Institute of Architects, "COTE Top Ten Awards," aia.org/awards/7301-cote-top-ten-awards

CASE STUDY: PORTOLA VALLEY TOWN CENTER

BUILDING TYPE: Civic

LOCATION: Portola Valley, California

AREA: 20,000 sq. ft.

OWNER TYPE: Public

Portola Valley Town Center[5] is a civic center in the town of Portola Valley, California. Completed in 2008, the project integrates reused materials from a prior civic center that was deconstructed on the same property. The center consists of three buildings and houses town offices as well as a library and community hall (Figure 14).

It was the townspeople's sentimental attachment to the beloved old town center—which was seismically unsound—that first led to the idea of using reclaimed materials to preserve some of the look and feel of the existing structures. But it didn't stop there. About 90 percent of the existing structures were reused, but that was only half of the total amount of reclaimed materials integrated into the new town center, according to Larry Strain, FAIA, of Siegel & Strain Architects. The most visible reused materials were finishes re-milled out of wood decking from the older buildings.

Figure 14): New structures made use of old town center materials. Photo Credit: © Cesar Rubio, courtesy of Siegel & Strain Architects

At first Strain thought that the wood structural members would be reused as finishes—but that was before they brought a deconstruction specialist onto the team. "I made all kinds of assumptions that were wrong," Strain admitted. "We wrote a spec, and then the actual deconstruction specialist got

5 Public Architecture, Design for Reuse Primer, issuu.com/publicarchitecture/docs/design_for_reuse_primer_issuu, 2011

onboard and we rewrote the spec." The structural beams were not suitable for re-milling, Strain said, because they had too many knots. Instead, they ended up intact, used on the exterior to support shading devices.

The expertise of that deconstruction specialist as well as a reuse specialist was vital to the project. "Bring in someone who really knows how these things work, what the market is, how easy it is to get certain materials out of the building, and then re-mill them," Strain advised. "They understand more than most architects would. There are now deconstruction people all around the country willing to be hired as consultants in that process." (The Building Materials Reuse Association offers a Designated Deconstructor Certification and a member directory.)

Finding reclaimed materials from beyond the site was even more challenging at times, and after a long search they were ultimately sourced from a long distance away. Also, notes Strain, it's important to keep in mind that reclaimed lumber can be more expensive than buying new, and the results can be unpredictable. "The client has to be willing to accept the blemishes, the nail holes, etc., in reclaimed materials," said Strain. It may also be difficult to order in the quantities needed. "On small projects it's not that hard to do. But on bigger projects, you're not going to get that kind of consistency as easily with reclaimed materials or products. It changes your thinking as a designer."

And don't forget that some ordinary lower-value materials can be reused as well. "All the concrete blocks got ground up onsite and got used for base rock. It was equally important but wasn't very visible," Strain emphasized. Because of this choice, the project didn't have to truck in gravel or truck out the concrete, he said. "We saved tons and tons of carbon from doing that."

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