Re-materializing Construction
22 Propositions

Edited by Sarah Nichols
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**22 Propositions**

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Building depends on materials – a lot of them. The construction sector uses two-fifths of all gravel and sand as well as a quarter of the virgin wood consumed in the world. It is also responsible for 40% of energy and 20% of water used globally. If tomorrow’s cities are built like today’s cities, business-as-usual material protocols will have serious and possibly irreparable costs for the environment. Using less a little bit better cannot offset the increases projected for expanding cities. Yet within this potentially troubling scenario there is also possibility: since construction uses significant amounts of material – and will likely soon use even more – rethinking materials and material use also has tremendous potential to lower greenhouse gas emissions and reduce dependence on resource extraction.

The following 22 propositions draw from three Roundtables held from 2014-2018 in preparation for the 2019 LafargeHolcim Forum for Sustainable Construction. The Roundtables brought together researchers and practitioners from different fields – architects, engineers, historians, material scientists, policy makers, sociologists, and the material industry – to envision a more sustainable future for construction. The goal of the Roundtables was to develop strategies for both the material supply chain and material use in buildings.

The propositions aim to “re-materialize” construction by rethinking the building material cycle from extraction to processing, design, transport, installation, maintenance, and removal. It is hoped that changes such as those proposed in this booklet would lead to a construction industry with a smaller ecological footprint and a shift away from the unsustainable assumption that raw materials are infinitely available. Thinking farther, what if there were no trade-offs between costs and benefits – could we make materials that are only beneficial?

While alternate futures can and should be imagined, from the perspective of the world we all inhabit today providing good materials in the quantities that will be required is a major challenge. Supplying the comforts that materials can provide – shelter from the elements, privacy, a place in the world – while at the same time reducing harm requires careful consideration of the political, economic, social, and energy frameworks in which the
building trade is situated. As such, many of the material shifts proposed here also presuppose immaterial changes to the business of material supply, construction, and real estate. Put simply, though the focus here is on materials, the material and immaterial are inseparably related.

Over 40 propositions were discussed. The propositions that follow are not universally endorsed by all Roundtable participants and are, in some cases, openly contradictory. This reflects the lack of consensus among different stakeholders and the fact that a diverse planet will require diverse solutions – that the right solution in one situation may be harmful in another. The first proposition, for example, was hotly debated but is ultimately included as a familiar starting point for thinking about materials. The propositions range from pragmatic to utopian in acknowledgment of the fact that perhaps tactics that can be applied today and long-term strategies for systemic change are both needed.

Sarah Nichols

R. Buckminster Fuller posed this question, used as the title of a recent documentary, as Norman Foster showed him designs for the ultra-lightweight Sainsbury Gallery at the University of East Anglia. The question implies that lighter is better – and that reducing the amount of material in a project also reduces the embodied energy of a given structure. This principle is useful to apply in an apples-to-apples scenario: a building with less steel will probably have less embodied energy that a building with more steel.

However, in an apples-to-oranges scenario, this principle can be misleading. A lightweight steel-and-glass structure does not necessarily have less embodied energy than heavy masonry. Some lightweight materials require high energy expenditure for their production, others do not. Timber may be both lightweight and low energy while aluminum is lightweight and recyclable but energy-intensive. It may be useful to think of material use in terms of performance: what is the minimum of any given material needed to perform a certain function, and, how would another material's performance compare?


2 Know your materials

What materials are in this building? Where did they come from?

These simple questions are not always easy for designers, clients, consultants, and contractors to answer. Yet, rethinking material use in buildings is predicated on being able to answer such questions. To re-materialize construction, we have to know our materials. And knowing our materials isn’t a very simple matter at all.

How was the material produced? Who made it and under what conditions? What byproducts were incidentally made along with it? What happened to those byproducts? How did the material arrive to the site? How long will it last? Will it behave as predicted or as promised? What can be done with it afterwards? … Could I eat it?

Knowing materials means asking more questions. This is the first step to understanding business-as-usual, finding alternatives within the present system, and inventing future alternatives.

The shipping company Maersk is developing material passports for its vessels that index the materials in new ships and provide a reference for how they can be disassembled and reused. Maersk argues that doing so will both improve the recycling rate and increase the costs recovered.

Image source: Maersk, redrawn by Something Fantastic.
3 Do not forget CO₂

The construction sector is directly or indirectly responsible for approximately half of all global CO₂ emissions. CO₂ is produced at every stage of a structure’s use cycle.

Building material production is a significant source of CO₂ emissions. Cement production releases 5-7% of all anthropogenic CO₂ emissions. Steel for construction may represent another 5% of CO₂ emissions. These represent significant areas for improvement though reducing CO₂ output needs to be balanced with improving resource efficiency – two aims that are sometimes in conflict with one another.

Building operations are also a significant source of CO₂. Heating buildings emits about 20% of all anthropogenic CO₂ and most of these emissions are produced in the northern hemisphere. Though this is in large part a question of which sources are used to supply energy, it is also a material question (at least until a total shift is made to renewable, non-harmful energy sources!).

Putting thermal mass to use, insulating, or even reflecting upon thermal comforts standards (wearing a sweater is easier than renovating a facade) may all be pathways to reducing the CO₂ output from heating through buildings. Cooling buildings currently produces comparatively less CO₂ than heating but is expected to increase. In general, low income regions use less energy because of the prohibitive cost of energy. In Brazil, for example, only 2% of CO₂ emissions are associated with building use – and this is mostly for cooking.

For steel supply in the UK, waste is produced at almost every stage of production and use but is often reincorporated back into the production cycle.

4 Produce leaner

What if all the matter extracted for building materials was used somewhere in the supply chain? To mine resources, much more mass is extracted from the earth – typically two to three times more than the amount used. For some resources, as a deposit is quarried, this ratio continues to increase, requiring more and more extraction for the same output.

Reuse of byproducts is already part of the material supply chain. Timber production, for example, incorporates several forms of reuse. Shavings are used to produce particleboard and sawdust can be used to fire kilns used in the lumber drying process.

Improving the production chain of building materials could greatly reduce the amount of raw materials consumed by urbanization, increasing material efficiency. Or, perhaps the question should be stated more radically: Could materials be produced without any raw material extraction at all?

Higher material efficiency could have advantages for all actors. Reduced material costs could be an incentive for manufacturers to improve product supply chains – savings that should be passed on to users.

5 Supply better

What if all the materials on a construction site were used? The last step from manufacturer to building offers significant possibilities for reducing material use. How materials are handled on site and how they reach the site could both be improved.

Most construction materials are relatively inexpensive compared to the cost of transportation. Contractors in many different places use large overage estimates to ensure that the basic materials needed are readily available on site. When extra material is not used, it often becomes waste. Improper storage, damage during transportation, cutting down to size, and mixing materials like plaster on site all also contribute to construction site waste, which is often estimated to be around 10%. For some projects, this figure is perhaps far higher: recent studies of Brazilian construction sites show that median wastage rates for cement and aggregates can be as high as 45%. More accurate estimating practices and training to improve on-site handling of materials could both significantly reduce the amount of waste created by delivery and construction. Reclaiming and reusing offcuts and excess would further improve material use on-site.

6 What is the labor cost?

Making materials and assembling them requires labor. In evaluating material choice, the working conditions for producing a material should be part of the equation, from raw material extraction, to the factory, and construction site.

Even materials that look and perform identically may have been produced under wildly different conditions. Workers have the right to a safe, equitable, and healthy work environment and workers should be employed with a living wage, health care, and fair contracts; materials produced without these conditions are not sustainable. In the construction industry, however, these conditions are often not met – most construction work worldwide is carried out as day labor or under temporary or informal contracts.1

Where work for a construction site comes from should also be considered. If construction creates employment within the community, projects have an immediate local benefit through the influx of wages and the potential introduction of new skills. If work is done remotely or workers have been transported to the site, under what conditions has it been conducted and on what grounds?


7 Is the price right?

What if producers and consumers were responsible for the full impact of a material? Currently, material prices don’t take costs to the environment, labor, and finite resource stocks into full account. In the book *A History of the World in Seven Cheap Things*, Raj Patel and Jason W. Moore argue that many undervalued elements – from lives to nature – lead to commodity prices below their full impact.¹

Human and environmental costs are generated by a material during extraction, production, and installation but also during de-montage, removal, and recycling. If lifecycle accounting were reflected in material pricing, the actual impact of material use would be more evident to consumers. Prices that reflect the full environmental cost of production, use, and disposal could help make material use more sustainable.²

A recycling tax modeled on electronic waste recycling fees could provide one possibility. In places like Switzerland, the European Union, and California, consumers pay a nominal surcharge for future electronics recycling at the moment of purchase and California also uses a similar model for mattresses, for instance. Could something similar work for building components? What price should we set for the value of coming generations to have access to the same environmental quality and resources?


8 Build local material industries

Using locally sourced materials – whether high- or low-tech – holds a number of social and economic benefits. It may also reduce the energy costs of transportation. In some places where not all materials are available, this may mean prioritizing materials according to local availability and encouraging the development of local material industries. Developing countries still rely heavily on building material imports. In Ethiopia, for example, more than 80% of construction material is imported.¹

While local material use reduces emissions and the expenditure of fossil fuels for transportation, this may be offset by less clean manufacturing – the embodied energy of concrete produced in Switzerland is lower than that of concrete produced in Brazil, for example. Thus, local material use will not always immediately result in a savings of embodied energy. Investing in local industry can, though, eventually give material supply chains the economic basis to become cleaner, making a long-term positive change to a community’s material flow.


Image source: genderandinnovation.org

A micro-concrete roofing enterprise in rural India.
9 Mine the city

What if we mined cities? The city is a rich material resource. There is, for example, more copper in buildings than is left in the earth’s crust. In Switzerland, the total copper stock in buildings is 65 kg per capita.\(^1\) By reusing the materials already deposited in our settlements rather than extracting new raw materials, the rate of material accumulation would slow down and the amount of building materials removed and redeposited as waste would be reduced.

Formally or informally, we already mine the city. In parts of the United States, copper extraction from abandoned and inhabited buildings is so lucrative that police task forces have been formed to combat metal theft. But the institutions needed to effectively mine the city are presently missing. The labor needed to sort and select materials for reuse needs an economic apparatus. Presently, although the labor of erecting new buildings is a crucial part of the economy, demolishing them is often done haphazardly and with a minimum of time and labor.

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10 Maintain or renew, reuse or recycle?

When does it make sense to stick with an existing building and when to renew it? When does it make sense to use a new material versus re-using or recycling an existing one? For buildings, the energy costs of existing construction can be weighed against potential savings with renovations or new construction.

Similarly, the benefits of reusing and recycling materials can be weighed against other factors like potential reductions in material performance. Recycled aggregates in concrete, for example, have lower performance than natural ones which can lead to additional cement in the concrete mix, thereby increasing the resource efficiency of the aggregate but also increasing the CO₂ output of the concrete as a whole.¹ Jonathan Cullen frames it as follows: “Two guiding questions to ask when assessing end-of-life options for waste materials or products are: How much energy is required to restore the recovered material back to the desired material or product, and, How does this quantity compare with obtaining the desired material or product from virgin or primary sources?”²


Image source: Gary Anderson.
Designing for non-toxicity: “Could I eat your furniture, IKEA?”

What if materials were not just non-toxic but also regenerative – could a building clean the air? Titanium dioxide facade coatings are being studied for pollution capture and a range of studies are underway on carbon sequestration in common materials.

Designing for non-toxicity is a first step toward regeneration that can be taken today. Materials that contain chemicals hazardous to human or environmental health are not recyclable, create enduring waste, may harm the workers producing them, and may emit hazardous chemicals – especially if they catch fire.

Some of the most common building materials are made from hazardous materials. PVC, used for pipes, polyurethane (insulation), resin (flooring), formaldehyde (plywood), flame retardants, petrochemical-based products, heavy metal additives (used in many products like sealants), and persistent bio-accumulative toxics (PBTs) like chlorine are all harmful. Chemicals in hazardous materials travel down and upstream, and some, like PBTs, only break down after long periods of time.

1 Vivian Loftness, 2nd LafargeHolcim Roundtable, 2015.

Image source: Something Fantastic.
12 Simplify material labels

Revealing the impacts that our material needs have is an important first step toward allowing design professionals, companies, and global citizens to make informed choices. What if the lifecycle costs and embodied energy of materials were clearly communicated to make the impact of different options comparable?

Currently, there are many competing material labels that offer complex metrics unintelligible to many consumers. The standard nutrition labels on food packaging may provide an alternative model to consider; something similar has been proposed with the “Declare” material label. Certainly, material performance under different site and programmatic conditions is more difficult to calculate and convey than caloric values. Still, labels may provide a rough but useful measuring stick. The aim of unified labeling should be simplicity, transparency, and legibility for all consumers. What if labels were so clear that the informal sector could also be well-informed about their material choices?

Image source, left: Food and Drug Administration (public domain).
Image source, right: © living-future.org
What if building materials became nutrients for biological or technical cycles? Cradle-to-Cradle thinking proposes re-designing building materials so they can be reused or repurposed after they are reclaimed from buildings, creating value and products out of used material. Materials could be biodegradable or endlessly recyclable – resources that are used and reused rather than discarded and then extracted or produced anew.¹

Instead of just the cyclical logic of recycling, materials could flow back into other cycles of production, exchanging between biological and technical loops. Building materials that break down into agricultural and industrial nutrients would help eliminate waste. Textiles or fiber panels can be designed to biodegrade so that they can be reused as nutrients. Other materials like glass and aluminum can be designed to be recycled multiple times, though the energy intensity of the recycling process needs to be taken into account. Cycling can work in both directions: just as construction components could be transformed into agricultural nutrients, packaging, industrial, or agricultural byproducts could become building materials.


Image source: www.ethz.ch
What if building components were sold and resold and resold again? To reuse building materials, they need to be recovered, inspected, stored, and resold. Institutions that make this exchange, verification, and re-valuing possible could be exciting new actors in the material supply chain.

Building component exchange companies survey buildings that are to be demolished or renovated and assess the feasibility of reclaiming components; act as experts in carefully extracting and transporting the materials; sort, clean, and store the components; and build a client pool of contractors and designers to whom they can resell. Their role as guarantors for the resold components is equally important. Without a legal entity that can be held liable in the event of failure, building components – especially structural assemblies that need to be retested – often cannot be reused.

Specifications also play an important role in facilitating or hindering reuse. They could be assessed and potentially rewritten to enable the use of reclaimed materials wherever possible by, for example, allowing for irregular lengths.¹

¹ Maarten Gielen, lecture at ETH Zurich, April 1, 2015.

Image source: Rotor Deconstruction, rotordb.org

Material storage warehouse operated by Rotor Deconstruction outside Brussels; the company recovers and resells architectural elements from buildings slated for demolition or renovation.

14 Create building component exchanges
Imagine a world without waste

What if waste did not exist? This sounds like a utopian idea in today’s economy, but waste as we know it is a relatively new concept. Waste is tied to the idea of consumption: commodities are purchased, used, and then discarded. A world of consumers has exploded the amount of waste produced, and produced types of waste that would be unfamiliar to previous generations. Understanding that business-as-usual is not the natural order of things helps generate alternatives. Perhaps, even just redefining the words we use to talk about material flows can also help redefine the infrastructures that produce and move materials.

Eliminating the idea of waste suggests producing leaner, supplying better, mining the city, crossing loops, and exchanging building components. In short, it summarizes the idea of employing all strategies at once – nose-to-tail production (no waste in the production stream), reuse (circular within one sector), and cradle-to-cradle (looping between sectors, up-cycling and down-cycling) – while also providing a larger vision for all of them.

Image source, left: Werner Sobek Group.
Image source, right: © Zooey Braun.

R128 project designed by Werner Sobek is fully dismountable and recyclable, significantly reducing waste when the building has reached its end-of-use cycle.
16 Match use-span

What if we made materials do more by using them longer? In *Making the Modern World*, Vaclav Smil proposed that “design for durability is perhaps the most obvious option.”\(^1\) Durability, however, would require a reformulation of the building economy, which currently makes buildings obsolescent far before buildings and infrastructures reach the end of their use cycles.

It may be useful to think about matching the durability of materials to the projected use-span of a building. Will a building be in use for 200 years, 40 years, 20 years, or two months?

Do the amount of materials used and their expected service life make sense? A building’s projected use-span should affect the materials it uses and how they are assembled. In some cases, projects can and should be designed for longevity and use durable materials that also ensure the maintenance needed to keep them operational can be carried out.

It is also important to understand how user needs will change over time and whether these needs will generate new or different demands. For some functions, adaptability can be built-in, allowing a structure to perform beyond the lifespan of its given use. For others, a project can be built with the intention of growth so that additional space and material is only used if and when it is called for and when the inhabitants are able to pay for the expansion.


Image source: Böle Tannery.
17 Design for disassembly

What if we eliminated the idea of demolition? Until the beginning of the 20th century, it was commonplace for buildings to be un-built and their parts to be sorted, reclaimed, and reused. This provides a powerful example of how to think of buildings as a stockpile of materials instead of as future waste.

Composite materials are particularly difficult to reuse because their individual components cannot be recovered. Similarly, using insoluble adhesives make building products difficult to reuse.

If materials can be easily recovered, they are more likely to be reused. Whenever possible, materials should be combined in ways where they can be re-separated or reused as an assembly, using screws or nails or even magnets and hooks. Temporary structures could be built entirely as components. Like a circus tent, Olympic venues or exhibition halls could be moveable pop-ups instead of fixed buildings, appearing when and where they are needed.

Image source: https://www.wilkinsoneyre.com/projects/olympic-basketball-arena
“It's a matter of never demolishing, subtracting or replacing things, but always adding, transforming and utilizing them.”

How much of a building needs to change along with uses and desires? Most modern buildings last between 12 and 50 years. During that time, renovations often also lead to additional material turnover. What if buildings took adaptation into account from the beginning?

Simple architectural strategies could extend the usable lifespan of buildings. Buildings can be designed to be as neutral as possible, with dimensions, partitions, and circulation that can host different activities without much change. Buildings can also be designed as frames that facilitate changes to the interior or the facade. Any change removes and adds some material, but changing a part is less effort than unbuilding a whole building and rebuilding anew.


Image source: photograph by Philippe Ruault.
Industrialized countries, despite being perceived as ‘developed’ and therefore already decreasing their material consumption needs, use the most construction materials per capita.

19 Rightsize

Much of the world still needs better housing. As their needs are met, it may be useful to reflect on the standards of the developed world. Is bigger always better? As living standards increase, the average area per inhabitant for living space, working space, and infrastructure also grows.¹ The most notable changes have been in housing, as area has grown while household size has shrunk. The average area of a new American home increased from 154 square meters in 1973 to 234 square meters in 2007.²

An increase in building volume typically requires more structural materials, creates larger surfaces for finishes, and needs more energy for heating, cooling, lighting, and appliances. These increases may be mitigated through efficient structural design, sustainable materials, and renewable energy sources. Larger living spaces can also create a barrier to using higher performance or more sustainable materials because the cost of upgrading gets multiplied by the additional area. Smaller spaces can thus be a direct way to reduce material intensity and lower the barrier for using quality materials.


20 Embed know-how

Construction can create social and micro-economic value. Using local building techniques or teaching new ones to a community can introduce or help maintain craftsmanship within a community - and maintain the notion of community itself. When know-how remains local and the necessary tools are available, communities can maintain, re-build, adjust, or expand according to their needs. If local or vernacular construction also addresses climate regulation passively, long-term savings on energy expenditure may also be a benefit.

Techniques that require periodic maintenance like rammed earth, stone masonry, or thatched roof construction keep know-how alive through regular cycles of repair. Each maintenance cycle can be used to train new laborers and is income for local workers. As long as know-how remains, what is treasuring can be maintained for generations and new projects can also employ the same techniques.

By using local techniques, there is less dependence on external materials and expertise, promoting self-sufficiency. If a project uses unfamiliar techniques, strategies for passing on and maintaining knowledge and standards will also be important parts of the design. Transmitting new techniques may also require unconventional, non-technical forms of representation or communication.

Image source: © Jenny Ji.
21 Make it desirable

Desire is a powerful mobilizer – sometimes stronger than duty or responsibility. If products and buildings that reduce the material cost of building are desirable, they are more likely to catch on with a wider public. Adding beauty, convenience, or novelty to a project can help transform sustainability from something that subtracts to something that adds.

The food industry provides a reference for how to tap into the force of desire. People are willing to pay a higher price for a sustainable, organic, pesticide-free tomato not only because it is more sustainable but because it tastes better. Science and technology may develop new, very efficient, low-carbon footprint materials but unless they are cheaper, faster, or easier to use than conventional ones, they are not going to be preferred. In order to promote sustainable materials with the strong force of immediate gratification, we should find a way to make the joy of them more tangible.

Image source: LafargeHolcim Foundation.

Foregrounding the value of water in Medellín, architects Mario Camargo and Luis Tombé from Colectivo 720 and winners of the Global LafargeHolcim Awards 2015 combine technical and social infrastructure by creating public spaces in a low-income neighborhood.
Construction can contribute to and help shape society. But is new construction always the best solution to the supposed problem? Sometimes, as client or designer, it may be necessary to question this assumption. Facing the enormous additions expected to cities worldwide, questioning a project’s initial objectives – among a palette of options like using less material, reusing material, and repurposing material – is a powerful option and is sometimes the best solution.

A project by French architects Lacaton & Vassal illustrates the value of doing everything with nothing, albeit certainly in a different way than Fuller originally imagined. Asked as part of a brief to embellish an existing square in Bordeaux, they studied how it already functions and determined that change was unnecessary. “Embellishment has no place here. Quality, charm, life exist. The square is already beautiful. As a project, we have proposed doing mostly nothing, besides some simple and quick maintenance work – replacing the gravel, cleaning the square more often, treating the lime trees, slightly modifying the traffic – to improve the square’s use and satisfy the community’s needs.”

1 Attributed to Rem Koolhaas, circa 2005
2 lacatonvassal.com

Image source: lacatonvassal.com
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