Future-Proofing Principle #10:

Local Traditional Materials

For

Architecture 537 – Traditional Building Materials

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Introduction

It is, perhaps, not so well known that local and regionally based building methods and materials can result in enduring and stunning architecture. It is also less understood that these traditional building techniques have been used for centuries in a manner which resists the challenges, both human and environmental, that they have been subjected to for decades and centuries.

Traditional building methods, materials, parts and labor are future-proof techniques of creating a built environment and are the basis of one of the Principles of Future-Proofing.

The Principles of Future-Proofing provide a framework for the consideration of the design of the built environment which is not only resilient, but promotes responsible stewardship of our environment and more sustainable and enduring structures that will serve us far into the future.

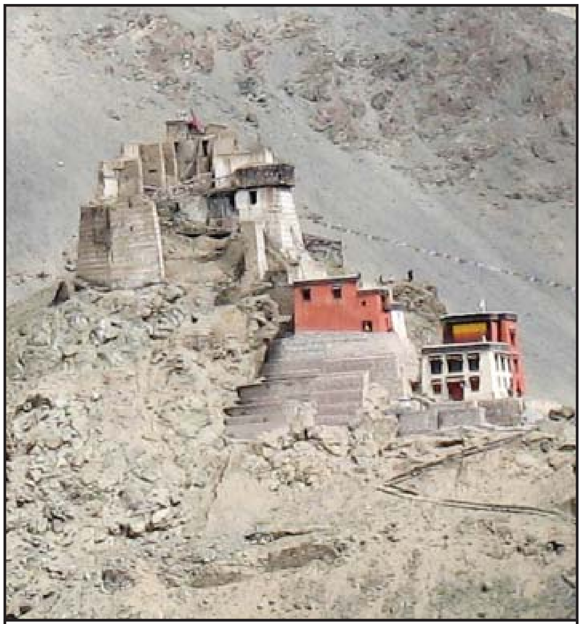

Figure 1 (previous page): Leh Palace & Fort, India, built in the 17th century. It was abandoned in the 19th century. Credit: http://upload.wikimedia.org/wikipedia/commons/5/57/Leh_Palace;

Figure 2 (above): The deteriorating Namgyal Tsemo Monastery in Leh, India. Credit: http://www.ghumakkar.com/ladakh-odyssey-part-2-of-4/;

The Principles of Future-Proofing

There are several industries using the term "future-proofing" today outside of the Architecture, Engineering, and Construction (AEC) industry. This term is commonly found in the electronics, data storage, and communications systems. It is also found in Industrial Design, computers, software, health care/medical, and product design. Generally speaking, in these industries, the term refers to the ability of something to continue to be of value into the distant future; that the item does not become obsolete.

The concept of future-proofing is the process of anticipating the future and developing methods of minimizing the effects of shocks and stresses of future events. In considering architectural projects, the underlying principle of future-proofing is that no harm is done to the structure in the course of the intervention which would damage the structure or make it unavailable to future generations.

Based on analysis of the industries mentioned above, the principles of future-proofing can be derived and codified to assist in the application of the concept to new projects. Through prior research, the Principles of Future-Proofing have been developed. They are:

1. **Not promote deterioration – do no harm.** It is natural for all building materials to deteriorate. Interventions in historic structures should not accelerate the deterioration of the existing building fabric.

2. **Allow understanding of the structure.** The design of, and interventions in, building structures should allow the students of history in our future to understand and appreciate the original building as well as the interventions which have kept it viable.

3. **Stimulate flexibility and adaptability.** The interventions in an historic structure should not just allow flexibility and adaptability, but also stimulate it. Adaptability to the environment, uses, occupant needs, and future technologies is critical to the long service life of a historic building.

4. **Extend service life.** Interventions in historic buildings should help to make the building useable for the long term future – not shorten the service life.

5. **Fortify against extreme weather and shortages of materials and energy.** Interventions should prepare the building for the impacts of climate change by reducing energy consumption, reducing consumption of materials through durable material selections, and be able to be fortified against extreme natural events such as hurricanes and tornadoes. Ideally buildings would be designed appropriately for seismic zones and sea level change.

6. **Increase durability and redundancy.** Interventions in historic buildings should use equally durable building materials. Materials that deteriorate more quickly than the original building fabric require further interventions and shorten the service life of the building. Materials selected should meet the other Principles by being appropriate for the region and the use on the structure.

7. **Reduce the likelihood of obsolescence.** The building should be able to continue to be used for centuries into the future. Take an active approach: regularly evaluate and review current status in terms of future service capacity. Scan the trends to provide a fresh perspective and determine how your historic building will respond to these trends.

8. **Consider long term life-cycle benefits.** The embodied energy in existing structures should be incorporated in environmental, economic, social, and cultural costs for any project.

9. **Incorporate local methods, materials, parts and labor.** The parts and materials used in historic building interventions should be available locally and installed by local labor. This means that the materials and manufacturing capabilities will be readily available in the future for efficient repairs.

The Principle of "incorporating local materials, parts and labor" will be the focus of this research paper. Use of local indigenous materials is inherently future-proof from the point of view of the last principle. In reality, the use of traditional building materials and methods can also meet the intent of other principles as well. Certainly traditional materials and methods of construction such as rammed earth, mud bricks, and bamboo construction contribute much less to the carbon footprint of the built environment. These building materials also generally allow for a very intelligible building structure which can be readily understood. Some of these materials are not easily adaptable, but are relatively durable and provide for a long service life, given appropriate design takes the potential modes of deterioration into account. Traditional building materials and methods seem neutral with respect to obsolescence compared to manufactured materials, but have clear long term life cycle benefits.


Figure 3: Stone floor at the chapel at Columbia University in 2013. The stone material is failing for obscure reasons, but was not a future-proof selection for this location. Credit: Brian Rich, 2013.

However, if used inappropriately, local traditional materials can also result in structures that may not be considered future-proof. Traditional materials and methods may not be suitable for a particular use and may not be readily transferrable to different regions. Some traditional materials are not available in certain regions of the world, and it is contrary to the nature of this principle to import the materials. In addition, in some environments, materials may not be appropriate due to potential deterioration, code requirements, or economics of the project.

The future-proofing principle of incorporating local traditional methods, materials, parts and labor is focused on the ability of the structure to be maintained and have its service life extended. It supports several of the other Principles, but is also worthy of being called out as a separate Principle.

Does this Principle prevent the use of locally manufactured building materials in industrialized societies? How local do the materials have to be to be considered future-proof? The raw materials? Refined materials? The final processed and fabricated materials? These questions and others will be discussed later in this paper. First, an overview of some firms using traditional building methods, materials, and labor will clarify what is meant by "traditional building materials and methods" as discussed by this paper.

3 Firms: Martin Rauch, Vo Trong Nghia Architects, and MASS Design Group

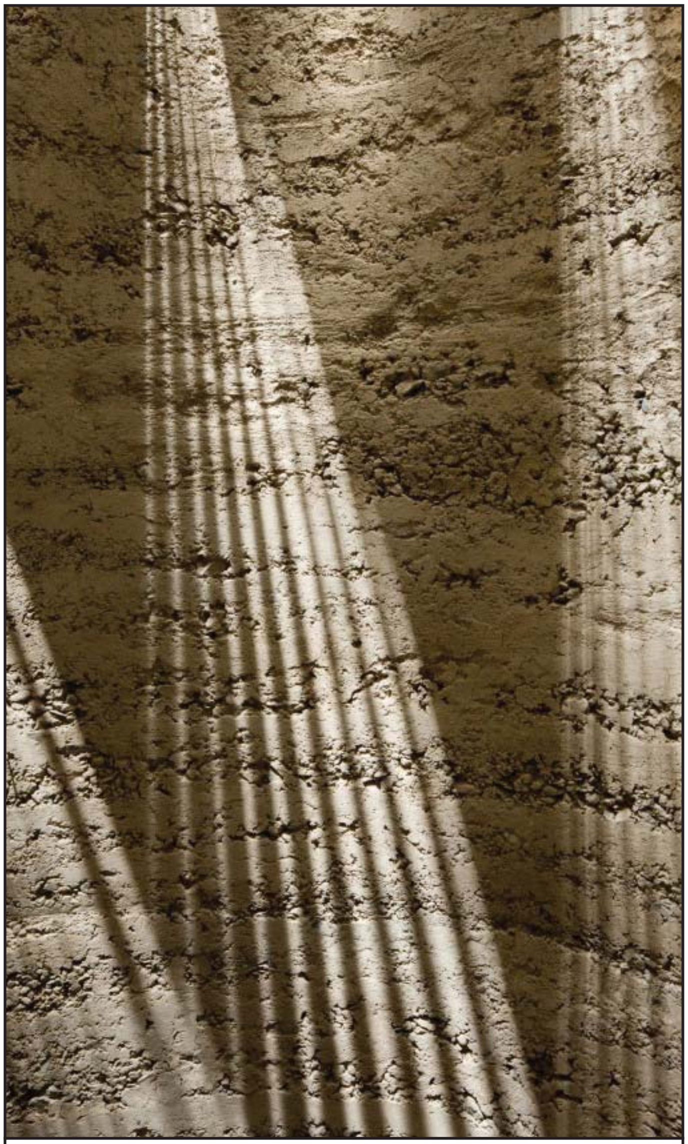

Figure 4: Rammed Earth House Martin Rauch by Boltshauser Architekten 004. Credit: http://ideasgn.com/architecture/rammed-earth-house-rauch-boltshauser-architekten/attachment/rammed-earth-house-martin-rauch-by-boltshauser-architekten-004/

Martin Rauch is a design build firm that practices out of Schlins, Austria. The team consists of several architects and several in-house contractors who work in a collaborative design process. Often the architects themselves help to build the projects as well and occasionally external contractors are also used. Originally a ceramicist, Rauch discovered a passion for exploring rammed earth construction in response to the "extremely complex, ecologically far worse, difficult to repair, and non-recyclable" building methods of the industrialized world and his volunteer work in Africa, where he was exposed to "building in simple cycles and with the optimal use of resources." (Rauch 2014)

Their projects range from residential buildings and sacred spaces to public and commercial structures and include research as well. Projects range in size from bus shelters to 30,000 to 40,000 SF buildings and 180 meter long rammed earth walls. Materials include primarily rammed earth, though this is often combined in hybrid construction with other industrialized materials such as steel, glass, extruded aluminum, wood, etc., to achieve a thoroughly modern aesthetic while still taking advantage of the benefits of the traditional rammed earth material. (Rauch 2014)

Vo Trong Nghia Architects is an architecture firm based in Ho Chi Minh City and Hanoi Vietnam founded in 2006. The firm consists of about 40 architects, engineers, and staff between the two cities. VTN's projects range from residential projects to cultural and commercial projects worldwide. The firm's philosophy is described on their website as

> "…experimenting with light, wind and water, and by using natural and local materials, Vo Trong Nghia Architects employ a contemporary design vocabulary to explore new ways to create green architecture for the 21st century, whilst maintaining the essence of Asian architectural expression." (VTN 2014)


Figure 5: Bamboo Wing In Vinhphuc, Vietnam, 2009 by VTN Architects. Credit: http://vo-trongnghia.com/

VTN's project range in size from multi-million dollar hotels and resorts to single family residences. Though the firm is perhaps best known for its compelling use of bamboo for building structure and finishes, it is equally conversant in the use of concrete, steel, stone, and other modern industrialized materials. VTN Architects often combines traditional methods and materials into hybrid designs. (VTN 2014)

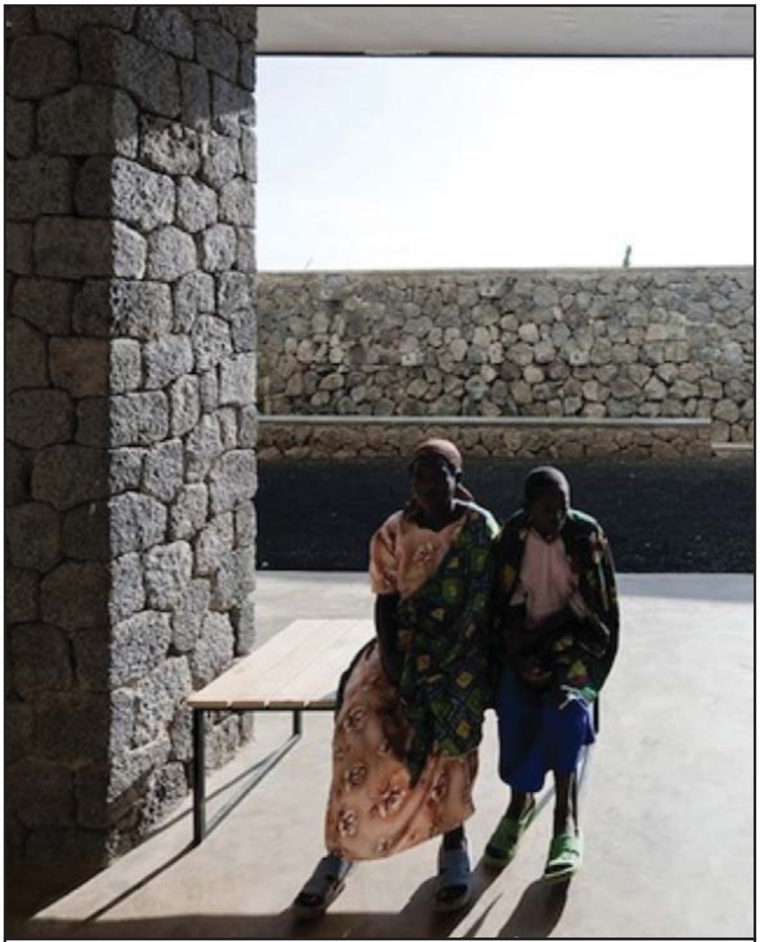
Figure 6: Butaro District Hospital, Rwanda, 2009 by MASS Design Group. Credit: http://massdesigngroup.org/portfolio/butarohospital/

MASS Design Group is a firm of 36 people started in 2008 by two students while still in school as they responded to the design for the Butaro District Hospital in Rwanda. Their "BIG IDEA" is to "design, build and advocate for better buildings, and empower the people that build them." The firm's work is focused on more than just architecture and engineering. They are forming a social movement that engages economic, social, cultural, and political dynamics to create buildings that "provide dignity to the users." (Scovel

2014) Projects are completed in third world countries around the world, including Africa and Haiti, as well as the United States. Funding often comes from NGOs focused on health initiatives in Haiti and Africa. In Africa, MASS Design found that architecture was a part of the problem by creating conditions where disease spread. MASS Design sought to insert themselves as a translator who implemented the visions of the NGOs not just as part of a moral imperative but also as smart business. (Contract August 22, 2013) MASS Design Group's interest in local investment is focused on capacity building, job creation, economic development, and education. (Murphy August 30, 2011)

Mass Design group's projects are largely comprised of medical, educational, and other public buildings ranging in size from small doctor's housing to hospital buildings over 100,000 SF. Their projects in Haiti and Africa use significant quantities of local materials such as stone, compressed stabilized earth blocks, but also uses modern materials such as concrete, aluminum window systems, metal roofing, and some steel structure. (MASS 2014) The use of local materials, often in a non-traditional manner, grows out of the social goals of the local investment noted above.

Overview of Traditional Methods and Materials

Rammed earth is a building method involving moistened soil compacted within forms and is usually found in arid environments. Several rammed earth buildings have been known to last for centuries. Its main advantages are the natural, readily available, highly sustainable material, low cost, high humidity buffering, and its distinct appearance. The major drawbacks are low thermal resistance, longer than average construction durations, and expensive formwork. (GreenSpec 2014b) In the alpine region of Grenoble, France, there are over 300,000 rammed earth structures, many of which are well over 150 years old. A 20 year study involving over 100 rammed earth specimens demonstrated the high durability of unclad rammed earth walls. The study shows an average of 2mm for a 5% cement stabilized wall and 6.4mm for an unstabilized wall. (Bui) Rammed earth walls are sometimes stabilized with cement, compromising the environmental benefits of using earth as a building material. Lime is an alternative to cement which

Figure 7: Rammed Earth house in Vietnam. Credit: http://en.wikipedia.org/wiki/Rammed_earth

does not compromise the hygro-thermal performance of rammed earth walls. Lime stabilization "improves the strength, stiffness, plasticity/workability and water absorption of the raw soil." (Cianco)


Figure 8: Bamboo wing In Vinhphuc, Vietnam, 2009 by VTN Architects.
Credit: http://votrongnghia.com/projects/bamboo-wing/

Bamboo is a common building material found in "tropical regions of Asia, Latin America and Africa." (van der Lugt, van den Dobbelsteen, and Janssen 2006) It is often used as bundled structural elements, roof thatching, and woven mats for floors and walls. Certain species can grow very rapidly and thus it is a rapidly renewable material. Bamboo is as strong as mild steel and has compression strength similar to concrete. Studies have shown that termites refuse to eat untreated bamboo, though it is more common in some regions to soak the bamboo in mud to make it more resistant to other insects. Because of the flexibility of bamboo structures, they often survive earthquakes better than other building materials such as light wood famed construction. Bamboo structures in Japan have been known to survive for up to 200 years. (Bamboo_Living)

Bamboo has several advantages as a building material, but also has some drawbacks. Problems with bamboo as a material include it's "shape (round, hollow, and tapering), the irregularity of the material, and the lack of knowledge and building codes" for its use. (van der Lugt, van den Dobbelsteen, and Janssen 2006) It is eminently suited for use in the regions where bamboo regularly grows, but is not as competitive in Europe, North America and other temperate regions due to transportation costs which can account for up to 90% of the material cost and create a significantly higher carbon footprint. Bamboo is comparable in cost to wood materials, but life cycle analysis shows that steel is by far the best alternative due to its long life span.

Mud bricks are often referred to as unfired clay bricks and include cob blocks, adobe, and mudbricks. Mud bricks help to buffer indoor temperature, provide passive humidity control, and generally decrease the amount of energy needed to operate a building.(Heath 2014) Mud bricks also have health advantages similar to rammed earth in that they can absorb harmful chemicals in the atmosphere. In a 1983 study in India, it was found that nearly half of the population lives in buildings with mud or unburnt brick walls (49.34%) with natural material roofs such as grass, leaves, reed, thatch, wood, mud, unburnt bricks, and bamboo (Bui). (Ansari and Goel 1983) Mud and mud brick are traditional materials found often in the Asian subcontinent and have become traditional building materials for this region. One reason is the higher thermal efficiency when compared to concrete, fired brick, and steel. In addition, mud is a very inexpensive material that is readily available in these regions.

Figure 9: A man makes construction bricks from mud at one of several refugee settlements in Dadaab. Credit: http://blogs.ft.com/photo-diary/tag/mud/

Straw bale construction, first developed in the United States, has been spreading to other regions of the world and is proving to be a valuable building method. The high insulating value of straw combined with its inherent fire and rot resistance when bailed tightly and protected from inclement weather have made it a viable building material even in the wet climate of the Pacific Northwest.

Benefits of Traditional Building Methods and Materials

There are numerous benefits to local traditional building materials that go well beyond the needs of future-proofing. Traditional building materials are readily and locally available and are usually very inexpensive because they are readily available in large quantities. They become traditional materials because the community found them in the region and figured out how to use them to provide shelter and beauty. Traditional building materials and methods are also well understood amongst developing countries precisely because they have been used for such a long time. New materials are treated with skepticism. “There is, in fact, increasing evidence to indicate that the poor will not buy new building materials unless they are first tried and tested by those more able to take the risk.” (Wells 1994) Traditional building materials and methods are

Figure 10: A truth windowin the wall of a straw and adobe house. Credit: http://www.wabash.edu/photo_album/home.cfm?photo_id=18004&photo_album_id=2504

Figure 11: Making mud bricks in Africa. Credit: http://www.lavoutenubienne.org/sites/default/files/stock/photos/technique/bricks.jpg

also culturally and regionally appropriate. Often, the traditional building methods are sacred to a community.

Traditional building materials are also sustainable, rapidly renewable, and contribute little to no contamination to the environment. Consider the bamboo structures of VTN Architects. Ideally traditional materials also do not release contaminants into the environment when they eventually deteriorate either. Traditional building materials often have a low embodied energy and carbon footprint. This makes the materials highly valued in an ecological and environmental sense. Most local and traditional building techniques are able to be designed to accommodate most regional weather patterns. Long roof overhangs and openings can be used to combat rain. Mass wall systems can be used to even out temperatures.

Traditional building methods also frequently have a low level of construction difficulty which is well suited to an unskilled labor force. The skills learned on one project are often expanded and built upon in the next project, increasing the future-proof nature of the whole community. Labor is often readily available, especially in undeveloped regions, and the community is often willing to help when they see that a project is for the benefit of them all. The benefits of community building as demonstrated at the Butaro District Hospital are enormous and can change the economy and stability of a region.

The economics of construction with local building materials and methods combined with a large local work force are an excellent example of Okun's leaky bucket economy. (Okun 1975) In the process of building a project, funding for the project is spread across the entire community to the benefit of them all. Local labor adds revenue into region which is then used to spur the economy of the region significantly. Use of local traditional building materials also encourages development of transferrable skills. Once an unskilled laborer learns a method of construction, they can take this knowledge and extend it to other projects and other communities. Last, use of traditional building materials creates a market for the technologies that can be repeated and expanded upon. The people of the region may see the success of a project and desire more.

Meeting the Goals of Future-Proofing: Local Traditional Building Materials and Methods

One of the major characteristics of a future-proof structure is that its service life can be easily extended. Thus, the methods, materials and technology that go into a building should not only be durable, but also continue to be available in the distant future. Hybrid building systems can make best use of the advantages of durable, local, traditional, and manufactured materials. Having the material without knowing what to do with it does not meet the intent a future-proof building. The technology required not only to create the materials and products but to install and then maintain them must also be available. Construction labor and building design are also factors in creating future-proof buildings.

Building Materials

Low durability materials such as straw and mud can have relatively short lives when exposed to inappropriate climates. For example, mud wall or mud brick buildings are not likely to last long in rainy climates unless protected by carefully designed roof systems. However, earth and straw and other similar traditional materials will continue to be available long into the future and are thus future-proof materials.

Building methods and materials that are less technologically dependent – and thus a repeatable or re-learnable process – are more likely to be future-proof. The issue here is whether the technology will continue to be available in the future. There is an argument that with all of the capability to store information available today that no technologies will ever be truly forgotten. They will be recorded and available to anyone in the future. The ability to restore and implement this technology anew does not mean that it will be simple and readily available to a project when the manufacturing plant has been demolished to make way for a lower density population. As one study notes, even rammed earth technology can be forgotten and must be relearned. (Delgado 2006)

A future-proof material and building method does not necessarily have to be low cost. In many third world countries, traditional building

Figure 12: Hybrid construction of Compressed Earth Block (CEB) and wood stud construction. Credit: http://www.udcinc.org/CEB2.html

methods are common because labor is cheap and readily available. This is in large part what makes it viable in third world environments. Note for example that the Butaro District Hospital in Rwanda used 12,000 people to build it, but cost significantly less than standard construction in developed countries. (Contract August 22, 2013) However, in industrialized countries where labor is significantly more expensive, traditional materials and methods lose their competitive economic advantage and become less viable.

Scarcity of Materials

While aiming for materials and building products that are less technologically dependent, and with the understanding that the most appropriate building material may not be the least expensive one, one must also account for material availability, or, rather, scarcity. Statistics indicate that the current world population is using the resources of the planet at a rate 1.5 times greater than the ability of the planet to replenish them. (Global_Footprint_Network 2013) "In 2008, the Earth's total biocapacity was 12.0 billion gha, or 1.8 gha per person, while humanity's Ecological Footprint was 18.2 billion gha, or 2.7 gha per person. This discrepancy means it would take 1.5 years for the Earth to fully regenerate the renewable resources that people used in one year." (WWF 2012) In a world of rapidly depleting material resources and over consumption, it is imperative that buildings consider material availability in our choices for creating the built environment as well as our stewardship of the built environment that is already existing.

Hybrid Building Systems

Hybrid building systems can leverage the advantages of traditional building materials while combining them with more durable and stronger modern materials to create highly sustainable future-proof structures. Hybrid structures that have significant health benefits as well as significantly extended service lives. For instance, the combination of rammed earth walls with a metal structure and large roof overhangs to protect the earth from erosion can make for a building with a significantly longer service life. In another example, straw bales clad in plaster wall systems, held up off the ground, and covered with durable roofing materials make for long lived energy efficient structures.


Figure 13: Soe Ker Tie House, Noh Bo, Tak, Thailand by TYIN Tegnestue Architects, 2009. Credit: Pasi Aalto

Construction Labor

It might be said that the ability to construct a building using local unskilled labor makes it future-proof. The ability to build with unskilled labor may be an indicator of the ability to readily repair and maintain a building. However, this argument is facetious because it is clear that building techniques can be learned and re-learned. Depending on the density of a region and the number of projects being executed, a sustainable industry in building materials, techniques and methods is possible. The key here is that there are a number of ongoing projects and an assured flow of future projects such that the techniques and materials continue to be used. This is a familiar story for housing in the Puget Sound Region. There is a sustainable regional economy based around light wood framed housing which is likely to continue into the distant future.

Building Design

Building design can also leverage the advantages of traditional building materials future-proof by allowing for adaptable and flexible design. While rammed earth or mud brick walls are not in themselves flexible, a steel truss roof structure supported by steel or wood columns can allow the earthen walls to be removed or built in different places to accommodate different room configurations in the future.

It is also clear that some design ideas and techniques from industrialized countries can improve traditional building methods. For instance, the addition of foundations under the Soe Ker Tie House by TYIN Tegentsue to raise the buildings off the ground prevents damage during the heavy rains is a building technique brought from first world developed countries to help improve these structures. (TYIN 2014) However, it did not change the use of bamboo and local wood that are available in the region. The medical understanding required to know that ventilation is required to prevent the spread of tuberculosis made the design of the Butaro District Hospital future-proof. The hospital will not be torn down because it is the site where more people catch than are cured of tuberculosis. (Contract August 22, 2013)

The intent of future-proofing is not to prevent use of manufactured materials and modern building techniques. Manufactured materials are often more future-proof than local traditional materials, depending the environment and installation. Traditional building materials, in and of themselves, can be characterized as highly future-proof in the sense of Principle 10, but must be closely examined in light of the other Principles. For instance, the materials themselves can be installed in construction systems that can last for centuries. However, in inappropriate applications, such as mud houses in Bangladesh which are subject to frequent flooding, are not future-proof because they cannot withstand the flood waters. Similarly, the life cycle costs of bamboo structures make great sense in tropical regions where bamboo is plentiful. However, bamboo is not a future-proof material in temperate regions where it would have to be imported due to the importing costs negate much of the benefits of the material.

Traditional Materials and Methods in Industrialized Regions

The question of whether the use of traditional building materials and methods is viable in industrialized countries must also be explored. Is it realistic to use traditional building materials and methods? Is it economically viable?

Within every region of the country, regionally appropriate traditional building materials exist and remain available today. This is true of industrialized countries as well as developing countries. The challenge seems largely to be the standards to which people in industrialized countries have become accustomed and the lack of open minded acceptance of traditional materials.

Economics also plays a role here as well. The economics of the dense urban environments of industrialized regions often do not lend themselves to use of traditional building materials simply because a site might not be economically viable. When a site is limited to less dense development, it may not earn enough revenue for the project to be profitable, and thus is likely not to be proposed or executed.

In many instances, the character of a place would be completely changed, if not impossible, due to material limitations. Imagine Manhattan with only stone and brick buildings. There would be no buildings over 15 to 20 stories. The Pacific Northwest is a region well known for its timber industry. However, imagine if buildings were limited to the capabilities of timber. Likely there would be no buildings over 15 stories – and that still requires use of industrialized processes to create composite lumber materials such as CLT panels and glu-laminated beams. Mexico City (8.84 million people in 573 sq. mi., (Wikipedia 2014)) might be an excellent example of the density of urban cities using traditional building materials. Most structures would be limited to a few stories. [PICTURE] (ESWalls.com November 25, 2013)

Future-proofing encourages less dense development which is contrary to the recommendations and requirements of sustainable design. Certainly it would mean less natural environment would be saved to accommodate the world population. In sum, it suggests that a less dense urban environment would be developed with a higher number of small urban centers.

Are Locally Manufactured Materials Future-Proof?

Locally manufactured products could be considered future-proof under certain circumstances. One must examine the question of what is meant by “local.” While a specific distance from the site is not proposed here, the distances suggested by LEED rating systems are reasonable. However, the closer the raw and finished materials are to the site, the better. Often, straw for straw bale construction is available within a few miles of the building site. Similarly, with the right additives, soil from a building site can be used to create the rammed earth walls of a structure. (Rauch 2014)

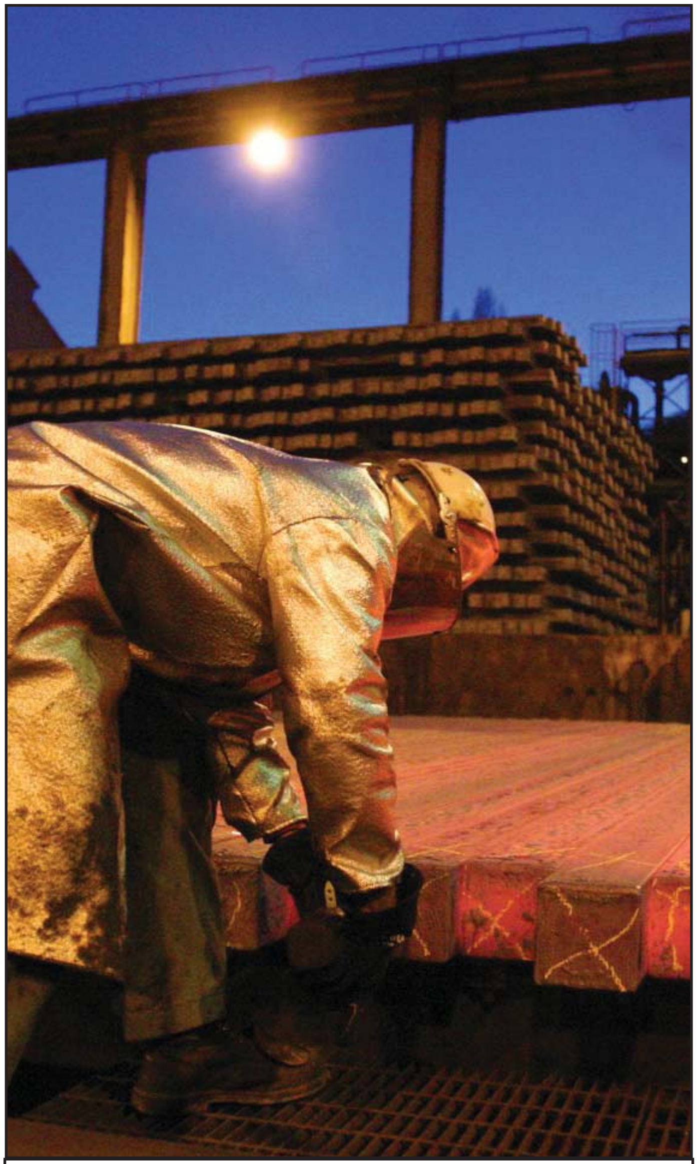

Figure 14: Quality control check on red hot steel ingots at the Nucor plant in Seattle. Credit: http://www.seattleindustry.org/images/SP_08_ExportSurge/SP08Nucor.jpg

First, the entire manufacturing process should be completed locally, from extraction of raw resources to fabrication and installation. Ideally a future-proof material should not be something that requires extensive transportation to process the raw materials into the manufactured product. For instance, there is a Nucor steel plant in Seattle, near the West Seattle Bridge. Even though the steel ingots this plant produces are local, the number of steel products this plant produces is limited to certain steel angles, bars, and rebar. Structural steel beams are rolled in a different plant. Similarly, it's not clear where the train loads of raw and recycled materials come from. Nucor sources materials from metal recyclers around the country and raw materials from around the globe. (Nucor March 25, 2011) Thus a vertically integrated business system, where one company owns and operates all steps along the supply chain, is most appropriate.

Regardless of the source of the raw materials noted in the example above, steel structure could still be considered to be future-proof in the sense that it meets the Principles of high durability, decreased obsolescence, and long term life cycle benefits. Steel is a highly durable material and can be designed to withstand the most extreme earthquakes and other natural disasters. Steel structures are often sought because of their highly flexible and adaptable nature. The independence of the structure from any interior or exterior walls allows for them to be changed and readily adapted to different uses and configurations in the future.

Second, local expertise in the installation, maintenance, and repair of these systems should be available at the time of installation and into the future. The key to this is that it is not a burden to maintain and continue the service life of a building. If maintaining or repairing the building is difficult or impossible, its features fall into disrepair and deteriorate faster until they are no longer viable. Demolition by deferred maintenance may seem to make economic sense when the owner of the building doesn't have the finances to renew and restore a building for ongoing use. However, it does not make for a future-proof building. In addition to the decreased service life due to excessive deterioration, the building may also become more vulnerable to the shocks and stresses in the future that we are trying to avoid. For example, the

Calf Creek Barn in Benge, Washington nearly collapsed because the roof developed leaks that were not maintained and the structure beneath deteriorated. (Larsen February 24, 2011)

Figure 15: The Calf Creek Barn, before rehabilitation, 2009. Credit: Chris Moore, Washington Trust for Historic Preservation.

Figure 16: The Calf Creek Barn after rehabilitation, 2010. Credit: Chris Moore, Washington Trust for Historic Preservation.

Third, the durability of industrialized materials becomes an important criterion in the Future-Proofing Principle of considering the long term life cycle benefits of the material. Industrially produced modern materials often are designed for very short life spans. By contrast, modern production of traditional building materials has been shown to produce materials consistent with historic materials which are highly durable. (Bell and Böke 2010) This close match of modern traditionally produced materials is important in meeting the principled of future-proofing. The modern produced materials will not promote deterioration, reduce the likelihood of obsolescence because a product is no longer made, has significant life-cycle benefits, and is a readily repairable and replaceable. Modern testing methods enable the adjustment of the modern production of traditional building materials "so as to create interventions more compatible with historic fabric and appropriate to [the building's] conservation." (Bell and Böke)

Fourth, embodied energy is an important consideration in the life-cycle benefits of a future-proofing a building. The intent of this Principle is to invest the energy of creating a building wisely to reduce environmental impacts. The embodied energy in the creation of mud brick or straw bale is significantly less than that of steel or concrete. (GreenSpec 2014a) Thus steel and reinforced concrete installations should be designed for extremely long life-spans to compensate for the higher embodied energy in their creation. Too often in current design in industrialized regions, structural steel may be used for a building intended to last for less than 50 years. The following table compares several common building materials and is ranked from the lowest embodied energy to the highest. It serves to illustrate that traditional building materials have significantly less embodied energy than industrially produced modern materials.

INVENTORY OF CARBON & ENERGY SUMMARY

(Hammond and Jones)

Materials	Embodied Energy & Carbon Coefficients			Comments
	EE (MJ/kg)	EC (kgCO2/kg)	EC (kgCO2e/kg)	EE = Embodied Energy, EC = Embodied Carbon
Straw	0.24	0.01	-	Refs. 63, 201, 202 & 281.
Rammed Earth (General)	0.45	0.023	0.024	
Rammed Earth (Cement stabilized @ 5%)	0.68	0.060	0.061	Assumed 5% cement content.
Concrete (General)	0.75	0.100	0.107	Assumed cement content 12% by mass.
Concrete Reinforcement (Rebar)	1.04	0.072	0.077	Add for each 100 kg steel rebar per m3 concrete.
Stone (General)	1.26	0.073	0.079	ICE database average (statistic), uncertain. See material profile.
Gypsum Plaster (General)	1.80	0.12	0.13	
Clay (General - Simple Baked Products)	3.00	0.23	0.24	General simple baked clay products (inc. terracotta and bricks)
Sawn Softwood	7.40	$0.19_{fos}+0.39_{bio}$	$0.20_{fos}+0.39_{bio}$	Includes 4.2 MJ bio-energy.
Timber (General)	10.00	$0.30_{fos}+0.41_{bio}$	$0.31_{fos}+0.41_{bio}$	Includes 4.3 MJ bio-energy. All values do not include the CV of timber product and exclude carbon storage.
Sawn Hardwood	10.40	$0.23_{fos}+0.63_{bio}$	$0.24_{fos}+0.63_{bio}$	Includes 6.3 MJ bio-energy.
Glue Laminated Timber	12.00	$0.39_{fos}+0.45_{bio}$	$0.42_{fos}+0.45_{bio}$	Includes 4.9 MJ bio-energy.
Glass (Primary)	15.00	0.86	0.91	Includes process CO2 emissions from primary glass manufacture.
Steel (General - UK (EU) Average)	20.10	1.37	1.46	EU 3-average recycled content of 59%.
Aluminum (General)	155	8.24	9.16	Worldwide average recycled content of 33%.

Table 1: Data is “Cradle to Gate,” meaning from the source of the raw materials to the gate of the manufacturing plant. It does not include embodied energy of transportation, assembly and installation, or “end of life stages, which may include the burdens of disposal and benefits of recycling or reuse.” (Hammond and Jones 2011)

Fifth, Future-proof materials should still regionally appropriate. Adobe and mud bricks are not appropriate to the rainy cold climate of the northern tier states in the US because of the potential for deterioration due to the weather and due to the lack of insulating properties of earthen walls. Wood structures are not appropriate in southern US climates unless the heat and humidity is acknowledged and accepted without attempts to deny its effects such as air conditioning. Use of materials which require excessive use of energy to compensate for their performance are not future-proof due to the risk of the effects of increased energy availability and cost. In tropical regions, methods and materials which take advantage of passive solar design and prevention of heat retention would be a better choice. An excellent example of regional response to traditional building materials and regional climate are the vernacular housing types of eastern China. The influences of the Siberian anticyclone winter and the Pacific Ocean Monsoons combine to create great variation in seasonal weather patterns. As a result, the siheyuan, or "'four wings' buildings around a courtyard" have at least a 2000 year history. (Bouillot) In Vietnam, vernacular housing has creatively adapted to the "local natural conditions and uses various climate responsive strategies." (Nguyen et al.)

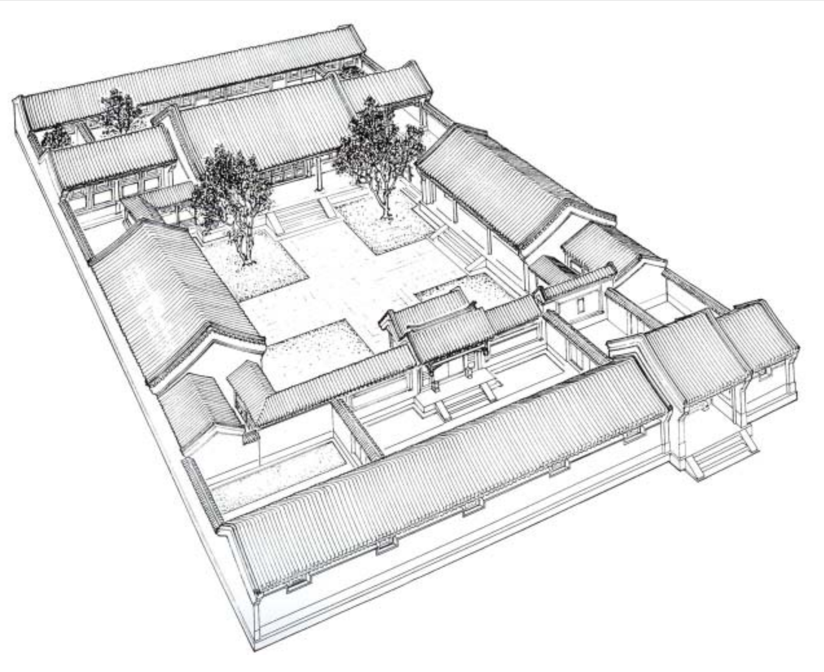

Figure 17: A Chinese courtyard house known as a siheyuan. Credit: http://appleeden.wordpress.com/2010/10/21/siheyuanquadranglesfour-side-enclosed-courtyardreprinted/;

Recycled and repurposed industrial byproducts may also be considered future-proof. They are the byproduct of industrial processes which may consume vast quantities of energy (and, thus, have a high embodied energy). It is difficult to know if these byproducts will be replicable, repairable, or easily maintained in the future. Distribution of the energy consumed over not only the primary product, but also the byproducts, reduces the apparent embodied energy required to create them. For instance, "blended cements using industrial wastes such as blast furnace slags, fly ashes, by-product gypsum, lime sludges etc." are available and sometimes used in developing countries since they are available at low costs. (CBRI 1994)

Highly technological products and materials do not meet the test of future-proofing: it is not known whether they will be able to readily repaired and maintained in the future. Expert level skills in the systems are required to repair them. As technologies advance, materials, technologies, and building methods become more complex and difficult to achieve. Further, if the technology or manufacturing plant were to disappear, would we not continue to be able to develop our built environment using these methods.

Building codes are also a significant factor in the viability of traditional building materials and methods. Similar to the US and most developed countries, in Nairobi, Kenya, some building materials are explicitly not allowed if they have not been tested and meet pre-determined standards. However, there are areas of the city and country where lower standards are permissible. This allows for use of untested traditional building methods and materials to be used more freely. (Ansari and Goel 1983)

In the US and other countries, building codes and standards are being developed for implementation of traditional building materials and methods in areas where they are not indigenous. For instance, rammed earth codes are being developed in Europe. The International Building Code used in the United States allows for the use of building materials not called out in the code if they can be demonstrated to meet performance requirements in the code. However, while these codes are being developed, the understanding of their execution by contractors and building officials is lacking. In addition, traditional building methods are, in some cases, inconsistent in the quality of production and may not be able to consistently meet the standards and code requirements.

Conclusions

The Principles of Future-Proofing seem to be urging a less technologically sophisticated world which is less consumptive of materials, energy, and other resources of the planet. While hybrid projects such as the Butaro District Hospital or the Soe Ker Tie House take advantage of the local traditional building materials and methods of their regions to make highly durable, efficient buildings that are low cost and typically very easy to build. They also incorporate some modern materials which make the projects much more durable and less likely to become obsolete, and thus more future-proof). Traditional building materials are also most future-proof when they are used in the regions where they originate and in a design which accounts for the potential modes of deterioration. Clearly there are minor improvements in traditional building methods in developing countries which can make significant improvements in their future-proof capacity. Future-proof local materials become subject to the specific conditions of the project type, location, funding, community, and several other factors. There is no one-size-fits-all answer to making a building future-proof.

Ultimately, there are still many questions to be considered in the development of traditional building methods to understand just how future-proof they can be. Use of local traditional building materials and methods also appears to suggest a return to pre-industrial materials and building techniques? Can we put that genie back in the bottle? Do we want to? What happens if we do not?

Word Count: 6,118.

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