Bioclimatic Design in Vernacular Architecture

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Introduction

The thesis of this short text is that the way we understand the world is reflected in and influenced by the technologies we use to imagine and build it. By “world” I mean not just the earth, but the cosmos—the totality of what is out there. And by “technology” I mean not just computers and hammers, but also the knowledge it takes to make tools as well as the practices in which we engage when designing and building. If this seems very abstract, let me provide an example that will also narrow the discussion.

Many historians have recognized that architects are a rank of people who, in the 15th century when linear perspective found its way to Italy from the Arabian Peninsula, distinguished themselves from their fellow stone masons by finding use for this mathematical game. The use to which perspective drawing was put by Brunelleschi and others was the planning of major projects made possible by the accumulation of large amounts of capital by an emergent merchant class. Rather than allow building projects to be conceived and realized piecemeal by successive generations of a community, the proto-architects of the Quattrocento were able to represent, and thus fix, the alternative futures which could be imagined by their patrons.

Linear perspective was, then, a technology particularly well suited to the interests and world view of wealthy merchants, the aristocracy, and the Church. Through architecture the powerful were able to interpret what they understood to be the fixed order of the Christian cosmos. What is so remarkable is that linear perspective has endured for over five hundred years as the principal method used to envision the future even though the cosmological assumptions held by most of us have radically changed.

To be clear, I do not want to leave the impression of having said that linear perspective is somehow wrong, or inaccurate. My point is that linear perspective is a way of representing only one aspect of the world—the visual relationship between objects in space. And it was these relationships that were most valued by those who commissioned and used this technology. In continuing to use it in successive eras we architects have unconsciously
affirmed a 15th century perspective of the cosmos.

From a more contemporary position, the problem with seeing the world, and planning its future only through the technology of linear perspective is that such lenses are static and the world is not. Stuff moves. Put less bluntly, my argument is that if we expect to design a sustainable world we should now attempt to understand it, and the problems of our future, not only as cosmological constructs but as dynamic and interactive flows—flows of the sun, wind, water, energy, species, traffic, information, capital and so forth.

The historian, Tom Peters, has observed that by the early 19th century, four-hundred years after architects embraced the representation of objects as their discipline, European and American societies articulated a need for yet another new class of individuals—those who could plan the material process of building ever-larger and more complex projects. So, where architects became more and more skilled at representing things, engineers became devoted to planning material processes like the mixing of concrete or the making of iron, steel, and glass. To do so, engineers developed a new type of mathematics based on empirical observation.

To be clear once more, my argument is not that engineers, because they design dynamic processes, are superior to architects who design objects. Sadly, engineers too have masked the complexity of living systems by representing the world only in mathematical terms. Where architects have represented reality by limiting it to phenomena that we can count. Both disciplines, then, have historically depended upon reductive representations of the world to plan our future. As Peters argues, the continued specialization of knowledge, as in the alienation of engineering from architecture, can be considered successful only if you accept reality as it is filtered through one set of values or another. To gain a more holistic view it will be helpful to go back to basics.

The laws of physics in place

Back to basics

To consider the integration of all the flows I mentioned above it would take a text far longer than this one and would necessarily include the concerns of planners, sociologists, and economists. But if we limit the current discussion to the alienation of engineering from architecture, it is reasonable to propose that there are a few basic rules of flow that should influence the design decisions of architects and engineers alike. And to make these abstract principles concrete, I’ll use examples from vernacular architecture. My reasoning here follows that of Kenneth Frampton who, in his proposals for an architecture of Critical Regionalism, argued that premodern builders enjoyed “a direct dialectical relation with nature,” which was not only visual, but also showed a dynamic understanding of local conditions. To characterize this relationship he coined the term, “place-form” to emphasize the way that vernacular builders employed architectural forms to engage local flows in a manner that enhanced human dwelling in that place. In other words, vernacular architecture represents cosmological order and participates in local flows. Frampton’s point was not that we should mimic vernacular builders, but that we can “mediate the impact of universal civilization with elements derived indirectly from the peculiarities of a particular place.”

This is to say that the numbing abstractness of scientific knowledge can only be made useful through attention to the cultural and natural history of places (without falling into representational kitsch).

Rule of Flow 1

All flows are induced by solar energy.

This is to say that, except for solar radiation, the earth is a closed system. Without the sun, there would be no movement—as in pictures constructed by linear perspective. The movement of heat, air, and water derives from unequal exposure to the sun as the earth orbits and is further mediated by local conditions on the ground—including mountains, oceans, and architecture. The following four rules derive from the first.

Rule of Flow 2

Hot air rises (because it is lighter) and cold air falls (because it is heavier).

Consider Figure 4: in this image a large cistern below the barrel vaults holds water collected from a series of sloping tunnels, or gnots, that radiate out into the desert. The water retains the temperature of the soil approximately 20 feet below the surface, which is determined by the average annual temperature for this locale. Here it is less than 70° Fahrenheit, due to the large diurnal swings of the high desert climate. The relative coldness of the water chills the base of the tower in the background, which then cools the air inside, causing it to fall and create a negative or down-draft pressure. The resulting cool breeze at the base is then directed to cool the inhabitants of adjacent rooms.

This place-form is, of course, an early version of air conditioning achieved in a manner that connects inhabitants to the flows of air and water around them. Frampton’s argument is not that we should replicate the bod-gir, but rather that we can appropriate the physical principles behind the system and employ them in an architecture of our own time and place.
Rule of Flow 3

A vacuum cannot exist in nature, so fluids move to fill volumes of reduced pressure.

The example used here is a Maine crib-stone bridge, built in an area with tides that reach 7 to 8 feet. Ocean tides reverse their direction of flow every 11 hours in syncopation with the waxing and waning of the moon. The weight of the granite blocks is enough to resist being dislodged by water flows without any mechanical fasteners, which would erode quickly in the salt water. The cribbed stacking of the granite blocks allows water to flow through, but at a higher speed than the tidal flow itself, thus avoiding a vacuum.

The same principle can, of course, be applied to any other fluid, like air. The classical Texas “dog-trot” cabin is another example of what physicists refer to as the Venturi effect. The same general rule of flow is illustrated by the design of an airplane wing using the Bernoulli effect. Air travels more slowly along the wing’s bottom surface and more quickly along the top, thus creating buoyancy.

The traditional barns of Texel Island, which protects The Netherlands from strong North Atlantic winds, takes the third rule of flow to another level. In addition to consistently turning a sloped back to the wind, and thus avoiding direct impact, these barns create a calm eddy-effect on the lee-side where farmers can work in relative calm.

Rule of Flow 4

Heat radiates from warm to colder bodies.

Anyone who has entered one of Texas’ 18th century Spanish Missions, as pictured in Figure 9, has empirically experienced this rule of flow. It is not that the thick stone walls radiate cold, but the reverse, that they absorb the latent heat of human bodies. Radiant cooling is most effective in regions with large diurnal temperature fluctuations like high deserts, but they can still be very effective in relatively humid places like South Texas.

Radiant heating is the same process in reverse and is most comforting in temperate and cold climates. Radiant thermal transfer is significantly more efficient than air convection because materials with higher mass can hold far more energy than low mass elements like air. And for most uses, it is also more effective because radiation takes place noiselessly, unlike air moved with mechanical fans. The single limitation of radiant cooling and heating is that energy flows require unobstructed lines of sight, so furniture can cause problems. The relatively recent use of hydronic chilled ceilings tends to avoid this problem.

Rule of Flow 5

Material phase changes absorb or emit heat.

When water is changed from a liquid to a gas (steam), heat is absorbed from the burner on your stove. Likewise, when water is changed from a liquid to a solid (ice) in your refrigerator, heat is rejected into the kitchen. In architectural and landscape terms, the atomization of water from a courtyard fountain has provided the simplest and perhaps most elegant expression of this rule of flow for centuries.

Some materials, salts in particular, are very good at absorbing moisture and physicists classify such materials as desiccants. Even some liquids, like sodium bromide, are effective desiccants. Combined with solar radiation to “bake” out the moisture, desiccant technologies are becoming more and more common.

In sum, each of the examples that I have used to illustrate these five rules of flow are both general and very particular at the same time. By this I mean that they illustrate general rules of physics, but in a way that is unique to the
culture and ecology from which they come. They are, as Frampton argues, place-forms that mediate the abstract universal flows of capital, commodities and information.

Conclusion

Analog and/or digital futures?

My purpose in illustrating universal flows with vernacular buildings is that these structures tend to be transparent—meaning that the visual characteristics of the forms can be read and understood by untrained casual observers. One advantage of transparent origins is that they also allow us to read physics with our own senses through experience. In other words, place-forms are pedagogical—when we interpret them they teach us how they work, and thus how to live thoughtfully and successfully in a place.

By logical extension, the digital technologies of today may be every bit as efficient as the best premodern place-forms, but they remain opaque to most of us. We have a far harder time interpreting how the mother-board of our computer works on our behalf than we do a courtyard fountain, yet both are technologies. This is not to argue that digital technologies are bad, only that they are less accessible to interpretation.

If we return to the problems I have associated above with the technology of linear perspective we should now be able to recognize that all technologies and modes of representation tend to reveal certain aspects of reality and conceal others. A T-square is not inherently better than a computer, nor is a Form-Z reveal how they perform work on behalf of inhabitants.

1. Technologies show up, not by magic, but by choice. As Langdon Winner argues, choosing a technology is not choosing a thing, it is choosing a way of life in a particular place. This is the responsibility of architects.

2. Good architecture is pedagogical: it instructs people about how to live well in the places they choose.

3. Finally, sustainable design is not a matter of simple energy efficiency. A place that merely increases output and reduces input may be a terrible place to live, work, or play.

Glossary

Vernacular Architecture: building practices flexibly determined by cultural traditions that are in turn influenced by ecological conditions such as climate and available materials.

Place Forms: A term coined by historian Kenneth Frampton in reference to architectural forms that engage local flows in a manner that enhances human dwelling in that place.

Transparent architectural forms: Those that reveal how they perform work on behalf of inhabitants.

Opaque architectural forms: Those that conceal how they perform work on behalf of inhabitants.

Notes


Figures

Figure 1: http://media-2.web.britannica.com/eb-media/31/20131-004-9177BDE6.jpg

Figure 2: The Enlightened observer, from, Athanasius Kircher, Ars Magna Lucis et Umbrae (1671). Courtesy of the Harry Ransom Humanities Research Center, The University of Texas at Austin.

Figure 3: Steel making. Courtesy Google Images.

Figure 4: Persian Wind-tower, or bod-gir; Kerman, Iran. Author’s photo, 1968.

Figures 5-6: Bailey Island, Maine; Crib-stone Bridge. Author’s photo, 2006.

Figure 7: Texas Dog-trot cabin at the Joyful Horse Equestrian Center. Courtesy of Rachel Steen.

Figure 8: Traditional barn at Texel Island, The Netherlands. Author’s photo, 2008.

Figure 9: Mission San Juan de Capistrano; San Antonio, Texas. Courtesy of the Library of Congress.

Figure 10: Courtyard Fountain, Barcelona. Author’s photo, 2008.

Further Reading


Biography

Steven Moore (b. 1945) received his Bachelor of Arts in Architecture at Syracuse University, his PhD at Texas A&M, and is a Loeb Fellow of the Harvard Graduate School of Design. At the University of Texas he is the Barlett Cocke Regents Professor of Architecture and Planning, director of the Graduate Program in Sustainable Design, and a Faculty Fellow of The Center for Sustainable Development. Moore began his career as a practicing architect in Maine in the 1970s and describes his built work of that period as “regionalist.” As a scholar he is the author of five books and many articles related to the social development of sustainable architecture.