

Exploring a Health-Based Model for Sustainability

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Please consider the following facts:

- “Among nearly 80,000 chemicals in commerce, EPA has required toxicity testing of only 200 in nearly 25 years. These test results led EPA to ban or phase out only five chemicals. The overwhelming majority of chemicals in buildings remain untested.” (Wargo)
- Several recent surveys estimate that US children now, on average, spend 90-97% of their time indoors (EPA, Wargo)
- Indoor air quality has been estimated to be an average of 5-10 times more unhealthy than outside air (EPA, WHO)

The vogue strategy in the US green building industry of airtight shells and increasingly chemically-based construction materials, driven by an unchecked zeal to pursue increasingly incremental energy efficiency savings, is broadly accepted throughout the industry. However, we feel this strategy and the value structure that supports it should be earnestly re-examined. We feel there is a better way.

Is it possible to build without chemicals and toxins and still achieve cost and efficiency parity with the existing model? We believe so, and advocate for an industry-wide exploration of “Health-Based Building” and as an emerging trend in sustainable design and construction..

How We Came to Discover This Path

Push Design was founded to address a unique set of circumstances. Founding Partner, Anthony Brenner, discovered that his 9 year old developmentally disabled daughter suffered from an acute case of MCS, Multiple Chemical Sensitivity Syndrome. Through one father’s passionate quest to build a safe and healthy environment for his daughter we discovered a promising new path for sustainable design and construction.

Bailey’s tolerance for the common chemicals that surround each of us every day in our modern lives is extremely low. If she is exposed for any extended period of time, she erupts into violent seizures. Since her development was truncated by her condition, her parents had to learn to carefully assess the level of toxicity in every material she comes in contact with.

This led us to an exploration of a new standard, employing the strictest standards in regards to toxins and other potential health hazards in the built environment, while still achieving high performance and incorporating the myriad of other goals associated with sustainable design and construction. From this simple beginning, we have developed a formative model for what we feel is the next frontier of sustainable design and construction – “Health-Based Building.”

We have been successful in achieving many of our goals in recent projects, and have been able to prevent negative reactions not only with Bailey (she has not had a seizure in three years) but with other MCS clients we have worked with since.

Energy Efficient – But At What Cost?

It is clear that in the established hierarchy of values of the industry, energy efficiency is the primary measure. While energy efficiency is without question an important *component* of sustainability, it

is but a single component, and establishing it as the defining parameter and sole measure is a misappropriation. A more comprehensive perspective is called for.

It is understandable how this has happened – energy efficiency is the most visible, attainable and quantifiable measure of success. However, we feel we are at a crossroads where a reassessment of this value structure is within the industry is called for. Is an energy efficient home that does not sincerely account for the environmental impact or long-term health effects of its residents truly sustainable?

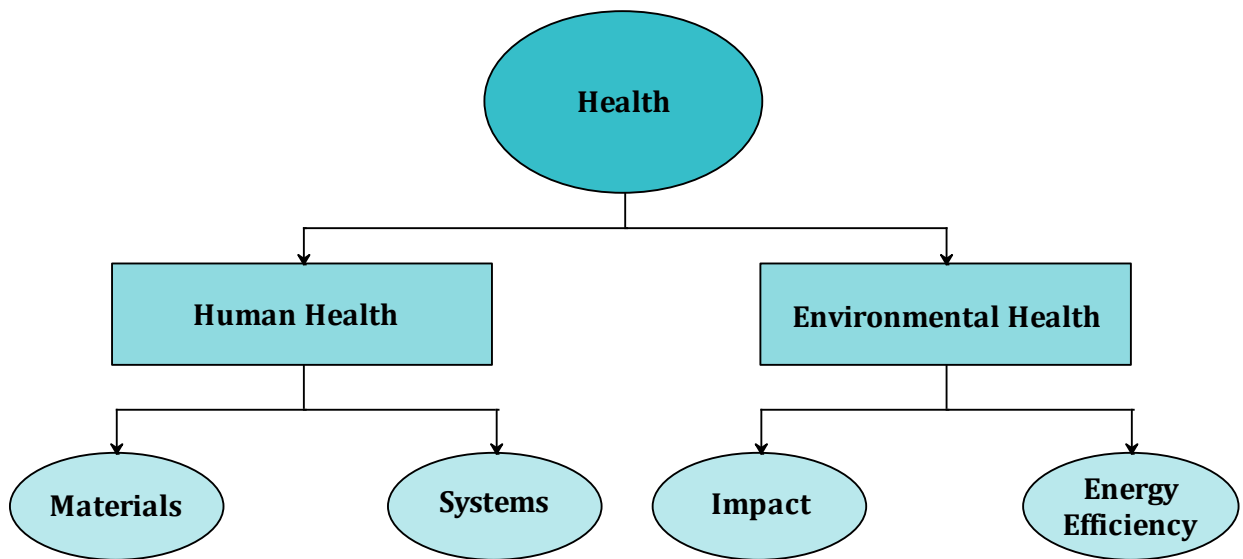
We applaud the progress that has made over the last decade and in no way intend to diminish the efforts of all those who have helped to advance the US green building industry. We do hope to spark an open discourse on these issues and ideas and expand the range of tools available to builders, architects and others who see the value in seeking balance between health, environmental impact and energy efficiency.

We applaud the Cascadia Green Building Council's Living Building Challenge™ (www.ilbi.org) as an example of this type of comprehensive and balanced model, and indicative of the restructuring of goals and methods for which we advocate.

A Reassessment of Values and Priorities

Although there is no question that efficiency improvements to the current and future building stock is without a worthwhile goal, we question the proportion of its influence over the current industry and the potential environmental and health risks that are being incurred under this imbalanced structure.

We put forth the premise that the overriding principle should be Health. Health can then be divided into two major categories – Human Health and Environmental Health. Energy Efficiency is but a component of the latter sub-category, and should be reassigned to this position.



A Basic Restructuring of Values – Health-Based Building

If the priorities and goals of green building and sustainable development are restructured in this fashion, one must seriously reexamine many of the standards of practice now being broadly employed. We submit that the risk and impact to both human and environmental health being incurred using the

tight, chemically-based shell strategy is unnecessary and based on a false assumption that there is no effective method or material where *all* these goals can be simultaneously achieved.

Estimates now peg the US MCS population at 4m and growing, with significantly more suffering from lower grade forms of environmental and chemical sensitivities, including increased rates of childhood asthma and other ailments. (EPA, Wargo) According the American Medical Association, 94% of all respiratory ailments are caused by polluted air, accounting for 1/3 of the total cost of health care in the United States.

As we work regularly with hyper-sensitive clients, we have developed strategies and implemented materials that prove that a significantly higher standard of health can be implemented without sacrificing performance or incurring significant additional costs.

If cost and performance parity can be achieved with no risk of adverse health effects, why take the risk or incur the environmental impact associated with the current methods?

Basic Design Strategies

In an attempt to develop a protocol for healthy, high-performance design and construction, we have established some basic design principles.

Passive Solutions are Preferable to Active Solutions Where Possible and Appropriate

We advocate designing as much performance into the shell as possible. One of the major failings in modern building practice is an over-reliance on mechanical solutions and the lack of sincere exploration of the potential impact of passive strategies. This failing is at the core of many, if not all, of the trends that have led us to this point where such massive strides need to be made to bring the US housing stock and construction industry even to a respectable level of performance and efficiency.

Employ scaled down active systems as a *secondary* strategy as opposed to relying primarily or solely on mechanical solutions. Maximize the benefit of the passive strategies (thermal mass, breathable wall systems) first, and only then supplement these with minimized active systems (ERV/HRV, renewable energy). Maximizing the capacity of the passive elements allows us to effectively reduce the initial cost *and* ongoing energy consumption associated with the active systems, therefore offsetting some of the upfront investment associated with the passive elements.

Exercising the Precautionary Principle in Lieu of Sufficient Industry or Governmental Testing

“The Precautionary Principle states that if an action or policy might cause severe or irreversible harm to the public, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action.” —Wikipedia

“While the majority of corporations, industries and governments currently take the opposite approach, we have adopted the Precautionary Principle because it puts the onus of proof on the makers of new technologies, products, materials, chemicals and systems to prove that they are safe, rather than the public having to prove that they are not after potential harm has been done. Where doubt exists the Precautionary Principle prevails.” (Living Building Challenge™)

We completely agree with Dr. Wargo that “(t)he burden of proof of safety should rest with chemical and building product manufacturers”, but it is clear that this is not the case in the current system, a system that has produced some high profile catastrophic failures in terms of public health protections over the last 100 years (DDT, lead paint, asbestos, et al).

Furthermore, the current system has effectively given the public a false assurance that a stricter protection standard has been established, either by the government or the certifying authority, where actually “the average LEED-certified building achieves only 6 percent of its total points for ‘indoor environmental quality,’ the category most closely tied to health, although some of these credits are often given for lighting and thermal comfort rather than assurance of reduced exposure to dangerous substances.” (Wargo)

The unfortunate truth is that the onus for material safety testing standards falls primarily to the manufacturers, a clear inherent conflict of interest and a system that has again and again led to health-related disasters. We practice the Precautionary Principle and concur with Dr. Wargo’s assessment that all standards and certifications need to begin a serious discourse on the appropriate valuation of health-related issues.

Until that time, we continue to only use materials that are proven safe by the strictest measure.

Systems-based Solutions are Critical to Health and Innovation

We often face the offhand objection that our approach must be significantly more expensive as we employ materials that are at a premium price. However, our recent projects have come it at market cost or less when the final tally was calculated - and with a unique palate of benefits not found in most projects (carbon negativity, nearly toxin-free, mold-resistance, pest resistant, others).

Our current system of choice is Tradical® Hemcrete® as an exterior shell and Purepanel™ as the interior wall system. Both products are expensive if only examined in a cursory material to material fashion. However, one needs to look a little deeper to truly make a valid value comparison.

Hemp delivers several advantages and attributes. We significantly reduce the size of the HVAC system. The thermal mass significantly lowers the heating and cooling load, which generates an ongoing energy and cost savings. It is breathable, and due to its hygroscopic qualities it is able to modulate indoor humidity levels (assuming the finish surfaces are adequately breathable). “This hygroscopic performance has beneficial aspects to prevent condensation and control internal relative humidity, with consequential health benefits to its occupants.” (Bevan & Woodley)

The homeowner was able to secure a 60% reduction in homeowners insurance due the high level of fire resistance. The walls are estimated to last over 500 years (durability is an important measure for us) and not only does the hemp plant sequester an enormous amount of carbon while growing, but the lime binder continues to sequester carbon post-construction.

Purepanel™ is another breathable wall system, comprised of a 100% post consumer recycled paper core skinned with Magnesium Oxide (mgo), creating a highly structural panel. Beyond the obvious benefit of the recycled content and non-toxicity, it is installed and finished with shocking speed. We currently have two unskilled laborers installing 5-6 panels per hour (typically 4 linear feet per panel). At that point, fiberglass mesh tape is applied to the seam, one pass of mud is applied and sanded, and the wall is ready for paint (no primer needed).

Material to material, these materials are more expensive than their traditional alternatives. With Purepanel™, the labor and project time savings significantly offset this premium, even in very small projects (in a commercial setting, in many instances the Purepanel™ system is now actually less expensive installed than steel stud and sheetrock partitions). However, the benefits are unlike any traditional system currently in the marketplace. For designers and clients who are serious about the health, environmental and sustainability goals of their project, they warrant serious consideration,

By taking a systems-based approach and keeping an open mind to new materials and solutions, a standard for indoor environmental quality and health is able to be attained that is simply not comparable to the traditional methods and materials currently employed.

IAQ and Material Specification

“A lot of home-contamination cases aren’t even identified as such, and we don’t understand the scope of the problem. You can’t adequately address this problem until you raise awareness, and we’re not even there yet.” - Linda Rosenstock, Director, National Institute for Occupational Safety and Health

The term “Indoor Air Quality”, commonly used for matters related to resident health, is indicative of the de-prioritization of health as a measure and is, in our opinion, too limited. One measure that is commonly lacking throughout the industry is the systemic risk that many of the basic principles of construction employed invoke. We feel we must develop strategies that *preclude* future indoor health risks and account for common installation errors and failures.

The seemingly universal solution of installing an ERV/HRV has not been proven effective as a *singular* strategy towards offsetting the “the paradoxical effect of more effectively trapping the gases emitted by the unprecedented number of chemicals used in today’s building materials and furnishings.” (Wargo)

In our opinion, there are several materials currently almost universally employed that are highly suspect. Having the “advantage” of working with hyper-sensitive clients who immediately recognize and negatively react when these materials are introduced into their environment, we have moved beyond their use. The assurances of governments and manufacturers mean little in the face of a severe respiratory reaction to these chemicals. These clients act as “canaries in the mine” in a way, clearly more sensitive than most users, but it does not logically follow that clients who do not severely and immediately react in this way are not also negatively affected by these environments over time. The Precautionary Principle leads us to explore other alternatives, and solutions that the most sensitive users respond to positively ought to be the standard for *all* users.

Clearly, the trend towards airtight homes built of increasingly chemically-based materials is a perfect storm of health risks, with each factor multiplying the danger of the other. With our most sensitive clients, we actually individually expose them to each material during the design and specification process. We read the MSDS for *every material that goes into each project*. We examine every system, from wall systems to caulks and sealants. We assume materials have not been adequately tested and, when in doubt, if it is not a natural material, we exercise extreme caution or seek another solution.

Material selection and specification is a complex task, involving assessment as a component of larger systems, cost, beneficial qualities and myriad of other factors. All materials ought to be examined for their embodied energy, including production and delivery, and examined for durability and performance. Many of these factors are alluded to and accounted for in existing systems and certifications, but one area where improvements can be made is in terms of the environmental impact of associated with the production of materials and by developing a comprehensive system to test materials and chemicals for long-term health effects.

We believe that *all users* would benefit from this standard and environment. Certainly, it would cause no harm, especially considering the environmental benefits associated with a shift away from petroleum and chemically intensive materials to natural materials. If this higher standard of health and IAQ is able to be attained with no loss of performance, and if all would benefit from its implementation, we again have to question why serious explorations of the means to this end are not currently underway.

Mold and Breathable Wall Systems

It is our responsibility to prevent contamination of the indoor environment, and delivering a system that is susceptible to massive failure does not meet this standard. While vapor barrier-based impervious wall systems may perform in a laboratory setting, it is well established they are highly susceptible, over the life of the structure, to water intrusion and consequently – mold.

A Harvard study of 10,000 US and Canadian homes showed that over 50% had some level of mold growth, and the residents of those infested homes suffered a significantly higher rate of respiratory-related health issues.

Systems that utilize sealed, vapor barrier-based methods are, by nature, at risk of mold. The risk of mold infestation through water intrusion over the lifetime of the wall system (via caulk failure, vapor barrier tear, faulty installation, pipe break, roof leakage, flood, etc) is just too great of a risk not to be responsibly considered. *Preventing* mold contamination is a core design requirement and should be at the heart of wall system design.

We feel much of the stigma against natural and breathable wall systems is due to a misunderstanding of the vocabulary, science and concepts. Although a thorough scientific explanation of the science behind breathable walls is far too cumbersome for this article (we recommend George Swanson & Oram Miller's *Breathing Walls* for a thorough primer on the science and concepts), it can be simplified to the definition of breathable walls and materials are able to absorb and desorb moisture on a capillary level, known generally as *hygroscopicity*. The movement of air also occurs through these systems, but one must differentiate between "infiltration" (such as air moving through adjacent studs or around outlets) and "diffusion", where the air travels through the wall so slowly that, especially in a heavy mass system, that it does not hinder thermal performance. In fact, the effective combination of mass and breathability not only can deliver significant benefits in terms of health and comfort, but absolutely can be designed to achieve high performance in terms of energy efficiency.

The capacity to modulate indoor humidity is another major benefit of breathable wall systems. As building scientist Carstem Rhode of the Technical University of Denmark stated, "if indoor humidity is the main reason for setting the requirements for (mechanical) ventilation, the peak ventilation requirement may be reduced because of the humidity interaction with the materials." This aligns perfectly with our strategy of designing systems as opposed to individual components. We have time and again been able to find efficiencies and savings by accounting for the atypical benefits associated with many of these strategies.

In our exploration of breathable materials we have attempted to limit our use Portland cement where possible. Although in some forms and applications, Portland-based materials are worthy of consideration, there are a number of negatives associated with this material that need to be considered prior to its specification.

Portland cement was a key component in the Industrial Revolution and the development boom that followed, and its widespread use allowed for much of the world's modern infrastructure and construction to be built. It is easy to use and cheap. However, it is ironic that in most modern concrete structures, the amount of structural required is largely to support its own dead load. It is a good thermal mass, and we do use a few materials that are Portland-based. We also have seriously explored alternative cement products and believe that Portland cement use should be limited and judicious.

Our initial reservation is that it is not, in most formats, as breathable as we would like and would typically lower the performance of our walls systems in terms of breathability. There are healthier materials that can deliver the mass benefit associated with Portland cement (hemp is at once massive and insulative, a rare combination). Studies in Europe and elsewhere are in increasing numbers beginning to associate PC with fatigue, “concrete sickness” and other health issues. The embodied energy, carbon and environmental impacts associated with production is also a negative to consider.

We often look to history for clues, examining the methods and materials of earlier pre-industrial systems for effective and regionally appropriate methods. All ancient builders understood innately that buildings needed to breathe. Historically, both magnesium and lime have been broadly used around the globe as cements or binders. Both are significantly less impactful and more breathable than Portland. Understanding the benefits of these materials and when to appropriately to apply them has really broadened the range of tools at our disposal.

We realize the Breathable Wall strategy is hotly debated in some circles and in direct opposition to the “impervious shell” standard, but, when combined with other strategies such as thermal mass, we believe the results warrant a deeper exploration.

Thermal Mass

Another commonly misunderstood and underutilized strategy is thermal mass. When used properly, it provides a number of advantages and is a key to unlocking many of the above strategies and goals. It fulfills the dictum of using passive strategies to reduce the reliance on mechanical solutions, and augments natural and breathable materials in terms of energy performance.

The US National Bureau of Standards defines the effect of thermal mass as “the phenomenon in which the heat transfer through the wall...is delayed by the high heat (retention) capacity of the wall mass, also referred to as ‘thermal capacitance’.”

The effect of mass on diurnal temperature cycles is well documented. As stated by George Swanson, “(a) ‘flywheel effect’ is created by the combination of temperature modulation and thermal lag in thick wall construction.” If properly sized, this can significantly reduce the mechanical heating and cooling loads, thereby reducing the size and cost of the mechanical systems and offsetting the additional cost of the preferred passive systems.

Additionally, the common sense clues we always look for that a series of correct decisions has been made are there, most notably the quality and comfort of the indoor environment. Anyone who has experienced the uncomfortable, rapid hot/cold cycles of forced air heat in a light frame structure, and then experienced a radiant delivery environment, will innately understand the preference for the latter. Both Swanson and Edward Mazria discuss in some detail the physical and psychological foundations of heating the human body through radiant means, and it has been established that this mechanism of heat delivery will provide an equal level of comfort at lower air temperatures than conductive or convective systems, again effectively reducing heating loads through means other than energy consumptive mechanical methods.

“Thermal mass influences comfort by radiant exchanges with the skin. In fact radiant exchange with mass surfaces is singularly the most efficient way of maintaining comfort...as the body is more than twice as sensitive to radiant losses and gains than all other pathways combined (conduction, convection, respiration, evaporation) and more than four times as sensitive than any other single pathway.” (Baggs)

Oak Ridge National Laboratory has produced some poignant research on the use of thermal mass and has established “mass multipliers” to equate the steady state R-value of light frame systems to

the effective, “mass-enhanced” R-value for massive wall systems. Understanding of the difference between the steady state R-value, effective R-value and the myriad of factors that influence the actual performance of a system (including thermal bridging, installation shortcomings, etc) is critical in establishing the baseline of knowledge that will allow for the effective implementation of mass.

We feel strongly that both breathability and thermal mass are tools that need to be broadly added to the modern design and construction lexicon . By nature, they are able to reduce the reliance on mechanical systems (and therefore energy) and “are much more forgiving of defects, incorrect building practices, exposure to elements over time, and natural and man-made...events,” (Swanson/Miller) In this uncertain world, surrounded by simultaneous escalations in both natural and man-made disasters, the value of systems that are less grid-dependent to maintain health and comfort should be seriously considered.

Conclusions

“Many of the chemical ingredients in these building materials are well known to be hazardous to human health. Some are respiratory stressors, neurotoxins, hormone mimics, carcinogens, reproductive hazards, or developmental toxins. Thousands of synthetic and natural chemicals make up modern buildings.” (Wargo)

Although we applaud the advance of the sustainability industry in the US over the last 10 years, we have not yet achieved our goals. We are confident that the use of dangerous and impactful industrial chemicals is not the solution and that this strategy *does not* reflect the core principles of sustainability or ecological design. We should attain to a higher standard. In fact, we must.

We will devote our resources towards developing a complete toolkit of materials and methods that will produce truly sustainable structures that will stand the test of time and proudly perform by any measure, and welcome any and all that will join us in this vision.

We have admittedly only touched on the subjects we feel have been undervalued and where the most work has to be done. We hope to be a catalyst that begins to turn the vast creative resources of the industry towards a serious industry-wide discourse on the merits of health-based materials and methods.

References

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Resources

- International Living Building Challenge™, www.ilbi.org
- US Environmental Protection Agency, www.epa.gov
- World Health Organization, www.who.int
- Push Design (Authorized Distributor -Purepanel™, Authorized Associate –Tradical® Hemcrete®), www.pushahead.com

