Natural building: The viability of straw bale as a sustainable construction material for the future

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ABSTRACT: The research paper highlights the importance of the (interconnected) *systems theory* model as one of the most relevant and pertinent approaches toward addressing sustainable construction material-technology for the future. By taking a values-based approach that integrates social and ecological good with health, resource efficiency, and durability, the paper advocates the urgency for future material-technology research to re-examine natural and sustainable building techniques vis-à-vis systems thinking and therefore, a more holistic approach towards design and the building process. In doing so, the paper examines the viability of *straw bale* as a sustainable material-technology for our future construction needs. As evidenced by numerous precedents, straw bale buildings results in energy efficient, durable, and non-toxic structures. Straw bale walls incorporate remarkable thermal, acoustic, fire, and insect resistance properties. In addition, they are characterized by relatively low maintenance, high longevity, improved indoor air quality, and embody intangible aesthetic qualities. Most importantly, they are environmentally responsible and contribute to sustainable development of the built environment. Related to straw bale wall systems, the research paper explores essential concepts related with its building science including, straw stalk, structural system, stud framing, pony wall, wall cavity, and base plaster. In terms of building performance, (of the myriad qualities associated with straw bale) three of its most critical (and perhaps most misunderstood) characteristics are examined - thermal capacity, moisture performance, and fire resistance. Material presented herein, has been largely gleaned from first-hand experience while working with experts on a straw bale structure at Yestermorrow Design/Build School in Vermont.

KEYWORDS: Sustainability, Natural Building, Straw Bale

INTRODUCTION

The four traditional components – cost, function, aesthetics, and time, typically associated with the architectural design process are now complimented with an essential new concern – *sustainability*. According to the International Institute for Sustainable Development, it should be our aim to meet the needs of the present without compromising the ability of future generations to meet their own needs. The American Institute of Architects defines sustainability as the ability of society to continue functioning into the future without being forced into decline through exhaustion or overloading of the key resources on which the sustainable systems depend. Broadly defined, sustainability vis-à-vis the building industry is therefore not merely an environmental concept, but also a social and economic one – an idea that seeks to judiciously address the effects of buildings on the environment and define limits for consumption of resources, while simultaneously considering the needs of the future. In this regard, rather than encumber the traditional components, sustainable design has provided remarkable environmental benefits while contributing positively to the traditional design process. Arguably, sustainability has fostered and forged *systems thinking* among various participants in the building industry. With systems thinking at its epicenter, one may now expect a more embodied, meaningful, inclusive, and integrative approach related with myriad components of sustainable design including: economic decisions (evidenced in life-cycle and matrix costing); functionality (reflected via the buildings energy use and efficiency); architectural scheduling (observed through the integrated design approach); and design aesthetics-appeal (expressed via the judicious use of related material-technology). This new paradigm of sustainable design implies not only a growing consensus in favor of environment-friendly design, but also a greater holistic approach to building – an all-encompassing model of architecture that centers the designer and its users to an *ecologically sensitive* world-view.

Economic researcher and futurist, Chris Martenson's (2011) analysis of the critical relationship between our economy, energy, and environment clearly demonstrates the pressing need for a more sustainable world-view vis-à-vis the systems theory. Martenson ingeniously makes the thesis that our economy must grow to support a debt-ridden money system that in turn requires compounded growth, but is challenged by an energy system that is limited, and where, both economy and energy are linked to a natural resource world that is rapidly being depleted. A sustainable equilibrium between our economy-energy-environment therefore remains critical to our very survival as a species. In this regard, the sustainable mode of being remains not an option, but rather a dire necessity. Within the context of future building materials and research thereof, the sustainable model therefore, becomes our highest priority – specifically as it relates to our efforts and decisions in addressing the energy-environment duo.

In assessing the viability of a building material for future development, we would be remiss in the first instance, not to examine its ecological underpinnings. Two typologies of analysis (or boundaries) remain pertinent to the ecological impact of a building material (primarily through its energy use and environmental impact). These are: 1) Cradle-to-Gate; and 2) Cradle-to-Grave. The cradle-to-gate analysis more commonly known as *embodied energy* is simply a calculation of the amount of energy consumed to produce a material from raw feedstock extraction through production and manufacturing. By comparison, the cradle-to-grave analysis is a comprehensive measure of all energy used in resource extraction, manufacturing, production, transportation to site, inclusion within a building, and its ultimate disposal (Hammond and Jones 2011). The cradle-to-grave method is obviously much more relevant and pertinent to sustainability in comparison to the cradle-to-gate method. Within the context of sustainability therefore, sourcing of building materials (in terms of local availability and transportation to site) remain critical in the material selection process.

On a yearly basis, the building industry is responsible for contributing 35% of greenhouse gases emitted in North America (Biello 2008). As architects, our decisions regarding selection of building materials have a direct impact to contribution of greenhouse gases. Since, carbon dioxide is the most common heavily produced anthropogenic gas related with the production of building materials, its study related to sustainability warrants attention. It follows that choosing materials with a low carbon footprint has immense potential in reducing the buildup of greenhouse gases in the atmosphere. Production of building materials typically accounts for 13% to 18% of the overall energy consumption of a building – operating the building in terms of heating and cooling during its life span encompasses the remaining (Racusin and McArleton 2012). Life-cycle analysis of building materials in relation to their performance therefore, has the most significant bearing on the ecological impact related with the analysis of carbon footprint of a building. According to International Standard ISO 14040, life-cycle analysis is broadly defined as a compilation and evaluation of the inputs, outputs, and the potential environmental impacts of a product system throughout its life cycle. Further, critical factors considered in the life-cycle include: fossil fuel and non-renewable resource depletion, water use and contamination, global warming potential, and toxic release to air, water, and land. In this regard, minimizing waste (end of life impact) also has substantial ecological implications – particularly in terms of a materials reuse and recycling potential.

Toxins associated with the production, usage and ultimate disposal (or even reuse/recycling) of building materials remains a critical concern to the ecological realm. Similar to cradle-to-grave energy and carbon footprint analysis, the cradle-to-grave toxic footprint remains an important area of inquiry. In this regard, toxicity associated with some building materials has been well established – asbestos, lead, mercury, arsenic, creosote, and ozone depleting CFC's among others. In some cases and to some extent, remediation related with toxicity may be accomplished through judicious reuse and/or recycling of materials. In other cases, and to the general detriment of the environment, post construction use and disposal issues has lead to the wide-spread acceptance of generic building materials that has fostered an out-of-sight, out-of-mind legacy within the building industry. The relentless harnessing and over consumption of energy resources related to high carbon footprint building materials (including life-cycle operation of buildings built with such materials) have lead to negative contributions in terms of our local and greater ecological system. Such anthropogenic consequences related with ecological disturbances are clearly evidenced in oil drilling and mining operations among other resource extraction processes. As a sustainable building material for the future, straw bale clearly remains formidable in terms of its minimal impact to ecological concerns.

1.0. BUILDING SCIENCE

1.1. Straw stalk

Straw refers to the stems of various grasses belonging to the *Poaceae* family, particularly cereal grains such as wheat, rye, rice, barley, etc. Straw remains distinct from hay, in that straw is the woody hollow stalk of the cereal grain plant, while hay is the top of the plant where most of the primary nutrition (grain) is located. While hay is most often used as feed (secondary nutrition) for livestock, straw is generally treated as a waste by-product. Rarely is straw used as livestock feed, on account of its low nutritional value. However, as a component in the sustainable building process, straw remains a highly viable option, particularly on account of its 'waste by-product' nature. Further, straw is readily available in large quantities during the year (specifically during the harvest season) due to its high 'regenerative' ability related to farming. Lastly, straw has diverse uses as a material in wall systems including straw bale, adobe block, and cob among others.

1.2. Structural system

When building with straw bale, three general types of structural systems may be used – load bearing, non-load bearing, and hybrid (combination of load bearing and non-load bearing). The non-load bearing category most commonly includes the post-and-beam system with straw bale infill, stud wall framing with straw bale infill, or a combination thereof. Within the context of sustainability, and in keeping with the theme of viability of straw bale as a material for the future, this paper explores important facets of the *non-load bearing stud wall framing with straw bale infill*. Primarily because, wood framing provides the structure for the building, which serves to support the roof, thereby allowing the roof to be erected prior to, and provide waterproof protection to the installation of straw bales. This strategy makes straw bale construction viable not only in dry/arid and moderate climates, but also in the extreme cold wet climates of the northeastern United States.

1.3. Stud framing

Lumber used in the construction of stud walls should be locally harvested. Where local sourcing is not possible, the use of green lumber harvested via silvicultural practices and milled by regional sawmills is preferred (Racusin and McArleton 2012). Stud framing (stick framing) in the first instance, is highly predictable in its pattern of layout and also universally accepted by builders on account of its simplicity, repetitive nature and feasibility in terms of time and ease of construction – it is the preferred method of construction due to its affordability and efficiency of production in the field. Regarding sustainable concerns related to wood resource consumption, *value-engineered framing system* (advanced framing technique or optimum value engineering) may be utilized. These techniques involve strategic design decisions to reduce wood usage in framing systems. Further, these sustainable framing strategies are code-compliant, thoroughly detailed and vetted (by National Association of Home Builders and United States Department of Energy) for structural performance, including cost and resource savings in documented field testing.

1.4. Pony wall

In most circumstances, and depending on soil conditions, a slab-on-grade may be used in conjunction with the straw bale wall system. The level difference provided by the slab in relation to grade offers the first level of ‘lift’ (protection against moisture damage). An additional lift of 12 inches above the slab in the form of a ‘pony wall’ provides adequate and much needed moisture protection to the base of the wall. Various options pertaining to the materiality of the pony wall are available, including insulated concrete forms, concrete blocks, durisol blocks, faswal blocks, etc. Accroding to Racusin and McArleton (2012), a double-stud pony wall (box framing) blown with cellulose (for insulation) has multiple advantages: it offers the opportunity for various types of interior and exterior wall base finishes (siding, shingles, veneer stone, cement board, stucco, tile, drywall, plaster, wood-board finish, etc.); it offers the opportunity to inset shelving or storage into the pony wall (although R-value of the wall decreases with this feature); it provides ease of installation in terms of electrical cable runs and boxes; and it functions on the interior as a study base for installing a ‘toe kick’ (base board) which in turn provides protection to the base of the wall, especially when plastered.

Figure 1: Squaring of bales (prior to installation) and beveling of window wall edges with chain saw.

1.5. Wall cavity

Upon successful completion of building design and execution of on-site building components including foundation, framing, and roofing, constructing straw bale walls typically involves three processes: 1) bale preparation; 2) bale installation; and 3) plastering and finishes. Beyond the contextual purview of the paper, but of critical consequence to the actual design of straw bale buildings is a thorough understanding of the actual anatomy of bale units, individually and collectively, within the wall section. Knowing the full thickness of the wall (thickness of straw bales plus thickness of plaster), prior to designing the foundation and overall footprint of the plan is critical. It is essential to understand that the bales are laid either *on-flat* or *on-edge* and further, notched to accommodate the studs within the wall framing of the building (Fig. 1). An individual straw bale module typically measures 14-inch x 18-inch x 36-inch. These measures remain approximate, as minor deviations in dimensions of the straw bale modules are to be expected. Bales laid along the 14-inch direction are termed *on-edge*, while bales laid along the 18-inch direction are referred to as *on-flat*. Regardless, bales within the wall system typically follow a running bond (staggered seams) pattern for increased wall integrity and will result in a wall thickness (excluding plaster and finishes) of either 14 inches or 18 inches. The specific layout of bale modules (on-edge or on-flat), including the resultant wall thickness are important considerations in the design process – designing to an iteration of the bale module in terms of window heights and other enclosure elements increases construction feasibility.

1.6. Base plaster

Upon successful installation of bales within the framing system, a base coat of plaster is applied to the exposed surface of straw on both sides of the wall. For optimum results pertaining to thermal performance, quality control must be exercised – the plaster coat must be continuous with no breaks or gaps in its plane of application. In this regard, air fins are an important component of the straw bale wall system as they ensure continuity in the plaster coat. Cracks developed (due to the non-rigid substrate nature of straw bale or due to potential shrinking and expansion of framing or other wall components when exposed to liquid or moisture vapor) in the plane of the plaster coat may compromise thermal and moisture performance. Therefore, attention to consistency and proportions of plaster components (water, clay, fiber aggregate, etc.) is essential. The base coat must be flexible such that it inhibits cracking. In this regard, a clay-based plaster (typically one inch thick) is preferred. In terms of performance attributes, a clay-based plaster base offers the greatest advantage in terms of the 'drying' component as defined by John Straube (1999). Clay possesses excellent vapor permeability and hydrophilic properties. Clay's greatest strength (its ability to attract and hold substantially large amounts of water without deformation) also counteracts straw's greatest weakness (its susceptibility to rot in prolonged presence of elevated moisture levels). Due to the vulnerability of clay to erosive action from precipitation, the application of a hardy but vapor-permeable finish of lime-sand plaster over the coat of clay-based plaster is highly desirable – the finish offers tremendous durability to the wall.

The base coat of plaster for a straw bale wall system is mainly composed of three constituents: aggregate (sand, gravel, fine sand, and stone powder); binder (lime, clay, gypsum, stucco), and fiber (chopped straw, animal hair, cellulose, and plant material such as cattail, hemp). An additional component in the form of additives is also added occasionally based on subtle characteristics desired for the coat. Aggregates make up the bulk (in terms of volume) of the mix, while binders provide the gluing action in the mix. While aggregate and binder form the basic structural base of the plaster, fiber provides tensile strength and functions within the mix to reduce or eliminate cracking. According to Weismann and Bryce (2008), the plaster mix must be composed approximately of 85% aggregate. Racusin and McArleton (2012), based on substantial experience in the field related with straw bale buildings, advice on approximately 30% of fiber (or lower), and 2% to 15% of additives (if used) within the mix. Further, they suggest a binder-to-aggregate ratio (range) of 1:2 to 1:4. For optimum results, field tests must be conducted to gauge the consistency of the plaster mix primarily in terms of its workability, strength, cracking potential, and texture.

2.0. BUILDING PERFORMANCE

2.1. Thermal capability

Given that the largest amount of embodied carbon comes from energy consumption related with the thermal performance and operation of the building during its life span, the primary goal of wall systems is that of minimizing heat loss or gain. As has been thoroughly documented in field testing, the two primary avenues of heat loss or gain are convective air infiltration and conduction through the building envelope. Related to sustainable design and therefore energy performance, the main criteria in the selection of a wall system, therefore remain its insulative qualities (R-value) to counter heat loss or gain, and efficient detailing of the wall system to counter air infiltration. The fundamental component of thermal performance strategy of a building therefore is the integrity of the thermal envelope of the building, in that the following two elements are typically desired: 1) a thicker plane of insulation (that reduces conductive losses); and 2) a continuous thin plane of air barrier (that reduces convective losses).

Thermal and moisture performance of straw bale wall systems are intimately related. In the first instance, straw bale as a wall system relies on vapor permeability for its thermal performance – the wall assembly is designed to allow drying toward the interior and exterior of the building. Vapor barriers are therefore functionally redundant in a straw bale wall system. Rather, materials that allow vapor to permeate, diffuse, and evaporate through the wall membrane are preferred. In the straw bale wall system, the base plaster (on both sides of the wall) functions as the essential vapor permeable air barrier. In this regard, and as has been evidenced in field testing at Oak Ridge National Laboratory in 2004, the integration of vapor permeable air barriers on both sides of the wall assembly maximizes thermal performance while enhancing moisture mitigation. Results from the study demonstrated a very high net of R-33 for a three-string bale on the flat. Complimenting its high net insulative qualities, a straw bale wall system inherently eliminates heat loss or gain that would otherwise have occurred through the phenomenon of thermal bridging in a conventional 2 x 6 stud wall framed 16” on center with typical fiberglass batts. In this regard, the straw bale wall system essentially decouples the framing from running through the entire thickness of the wall, thereby eliminating conductive heat loss or gain enabled via the phenomenon of thermal bridging.

Figure 2: Application of air-fins, flashing, and metal lath at critical transitory locations along the wall plane.

Field testing related to thermal characteristics of seven straw bale homes in Northeast (Vermont and New York) by Building Performance Services LLP in 2011 demonstrated that in every case, the largest incidents of air infiltration occurred in the non-straw-bale components of the building, such as roof assemblies. Further, the study revealed that air fins (Fig. 2) functioned very effectively at controlling heat loss and preserving the integrity of the air barrier in transition from plaster to wood elements, both along the roof-to-wall and foundation-to-wall connections. What remains critical along these connections is quality control related to the air fins – proper sealing between two separate pieces of air fins, including proper sealing between the air fins and framing. In this context, the thermal performance of straw bale walls is largely derived due to its ‘mass’ characteristics. The phenomenon of thermal lag in relation to a straw bale wall has been field tested to be approximately twelve hours (King 2006). The heating/cooling cycle of a straw bale wall remains directly and therefore advantageously opposite the diurnal cycle. This ‘mass effect’ further improves thermal performance of straw bale walls by a factor of 1.5 to 3 times its original R-value rating and is described as ‘dynamic benefit for massive systems’ (Kosney 1999). This phenomenon, although largely pertinent to the southwestern United States (i.e., regions with a high diurnal temperature swing), is still relevant in cold climates as demonstrated in field tests conducted at Oak Ridge National Laboratory.

2.2. Moisture performance

Moisture control strategies for straw bale buildings begin prior to construction. In the first instance, bales sourced from suppliers must be dry. Further, the bales need to remain dry during transportation from source to site and then again, when stored on site, requiring considerable precaution in scheduling and logistical support (Racusin and McArleton 2012). It is for this reason that straw bale buildings favor construction and waterproofing of the roof assembly first, prior to installation of the wall system itself. Water penetration via capillary action at the base of the straw bale wall system (connection with concrete foundation/slab) remains an area that requires careful consideration. An efficient solution to this problem is to isolate the base of the straw bale wall system via toe-ups in conjunction with a capillary break (water proofing membrane). In this regard again, stick framing remains advantageous in conjunction with straw bale wall systems.

Precipitation in the form of rain and snow present the biggest challenge to straw bale wall systems in terms of water driven damage. In this regard, flashing and material connection details require considerable attention. Further, the erosive action of water on plastered surfaces, primarily through wind-driven rain and splash-back effect near the base of the wall system must be considered. Design features such as generous roof overhangs, roof gutters, water-dispensing ground cover, and bottom-of-wall protection features provide effective counter measures to moisture damage. According to Racusin and McArleton (2012) a minimum 2-feet overhang is required for a two-storey building, while a three-storey building requires a 3-feet minimum overhang. Similarly, incorporating an additional lift of 18 to 24 inches above grade (pony wall), provides adequate protection for the plaster at the base of the wall system. This raised box functions not only to protect against splash-back, but also provides the added opportunity for electrical, plumbing or other service runs. This feature also prevents moisture accumulation at the base of the wall system that would otherwise have occurred via capillary action through the concrete foundation/slab.

As evidenced in thermal performance, the moisture performance of the straw bale wall system in terms of vapor diffusion remains highly advantageous. In the straw bale wall system (i.e., vapor-permeable building system), moisture build-up in the form of vapor inside the building (generated via cooking, washing, respiration, etc.) is allowed to diffuse through the wall membrane to the outside depending on the direction of the vapor drive. According to Racusin and McArleton (2012), diffusion-borne moisture is in and of itself insufficient to cause moisture damage to wall systems – diffusion's potential as a drying mechanism outweighs its liability as a moisture vector. Within this context, note that conventional vapor barriers strive to reduce or halt vapor diffusion altogether. Of importance is the highly practical strategy and well-researched model of 'moisture balance' as outlined by John Straube (1999) in *Design of Straw Bale Buildings*. The model highlights an efficient moisture control strategy via optimum balance of the following three elements – wetting, drying, and safe storage of moisture within the building assembly. To elaborate, short-term moisture accumulation in a building will not lead to long-term problems, as long as the rate (length of time) of wetting does not exceed the rate of drying by more than the safe storage capacity of the building.

Figure 3: Spraying clay slip (drywall texture gun and air compressor) and two-hand trowel plaster method.

Base plaster on both sides of the straw bale wall helps in the creation of climatically responsive and adaptive structures – being hygroscopic in nature, the base plaster helps moderate changes in indoor humidity, with the result being a more uniform and comfortable indoor environment. The relevance of a clay-based plaster base (Fig. 3) to straw bale wall systems cannot be understated – the clay seeks to actively draw moisture to itself, thus keeping it away from the straw. Superior functional attributes of clay as a base plaster material have been discovered in 500-plus year old cob wall in Europe, where straw inside the clay was perfectly preserved and mummified (Lacinski and Bergeron 2000). Owing to its high vapor permeability, clay allows the moisture to diffuse into the air. It is important to note that in relation to plaster-type, a cement-based plaster is in fact detrimental to straw bale wall systems – cement possesses a very low vapor-permeability coefficient which leads to trapping of water within the wall system, rather than enabling transpiration of moisture into the air. In this regard, to encourage diffusive drying to the exterior (encourage vapor drive from indoor towards the outdoor), the exterior base plaster should be made more permeable than the interior base plaster, which is simply achieved by adding additional coats of plaster to the interior. Through field testing, Racusin and McArleton (2012) have verified that moisture content threshold for rot and decay related to straw remains approximately 30% - comfortably higher when compared to the range of seasonal fluctuation and incidental wetting that occurs in northeastern United States. In addition, due to the large pore sizes of the tubular stalks, straw reduces capillarity, with the result that localized water exposure on the exterior face of the bales is less likely to wick the liquid into the wall cavity.

Moisture testing in straw bale wall systems conducted by Racusin and McArleton, repeatedly evidence that elevated moisture content percentages drop off rapidly moving from the exterior into the center of the wall system. Through field tests conducted over a ten year period using a Delmhorst hay probe moisture meter, Racusin and McArleton reported a seasonal moisture content range of 5% to 14% for straw bale buildings in the Northeast region. Field testing conducted by Building Performance Services LLP in 2011 showed moisture contents of 12% to 15% for one year old straw bale buildings, even when surface and pin scans and visual inspection of the plaster registered near-saturation levels. Further, the test corroborated that moisture content readings in the center and interior edge of the wall systems were still considerably lower, demonstrating that the vapor drive was directed towards the exterior and that moisture was not evenly dispersed throughout the entire thickness of the wall, but rather more localized towards the exterior. Based on the 'wetting' potential of its assembly, straw bale wall systems are therefore, intentionally designed to store substantial amounts of moisture for short periods of time. This approach acknowledges and embraces the pragmatic reality that constructing absolute water proof walls on site remains verifiably cumbersome, if not impossible. Straw bale wall systems are typically criticized by builders for problems related to rotting caused by moisture. However, such patterns of concern remain typically attributed to poor design, poor detailing, poor execution, and ultimately poor comprehension of how moisture works in buildings.

2.3. Fire resistance

Plastered straw bale wall systems possess superior fire resistance qualities in comparison to standard fiberglass-insulated stud walls. Unplastered straw bales within the wall assembly, when exposed to fire, begin to smolder in a low-oxygen state, once the exterior layer of straw has charred. This occurs due to dramatically low levels of oxygen reaching the inner cavity of the wall upon combustion of the outer layers. In this regard, unplastered straw bales possess fire-resistance capabilities similar to those of heavy timber. In 2007, Ecological Building Network commissioned formal American Society of Testing and Materials International fire-rating testing on two straw bale wall systems: a two-string flat-laid straw bale wall plastered with two ½-inch earth plaster coats; and a two-string edge-laid straw bale wall plastered with two ½-inch lime-cement coats. In both cases, the wall samples (10 feet x 10 feet) were subjected to a 1700°F blast furnace for a prescribed amount of time to test their fire resistance capabilities. Results of the test were as follows: the earth-plastered straw bale wall system successfully passed a 1-hour fire resistance test, while the lime-cement plastered wall successfully passed a 2-hour fire resistance test. In both cases, only 3-4 inches of the depth of the straw bale wall exposed to the furnace was observed to be charred. In the final analysis, both wall systems successfully passed code-recognized testing.

CONCLUSION

The importance of sustainability vis-à-vis the *systems theory* model to address architectural research related with future material-technology cannot be understated. Within the context of systems thinking, architectural research related to future building materials must remain meaningfully relevant to sustainability and further, critically pertinent the economy-energy-environment model. In addition to merely addressing aesthetics concerns, researchers need to study future building materials vis-à-vis their local availability, affordability, ecological impact and social context, among a slew of other building science and performance concerns. In this regard, with its roots in ancient building techniques, modern natural building in the form of straw bale is currently experiencing its re-emergence as a valuable design-construction strategy (Fig. 4).

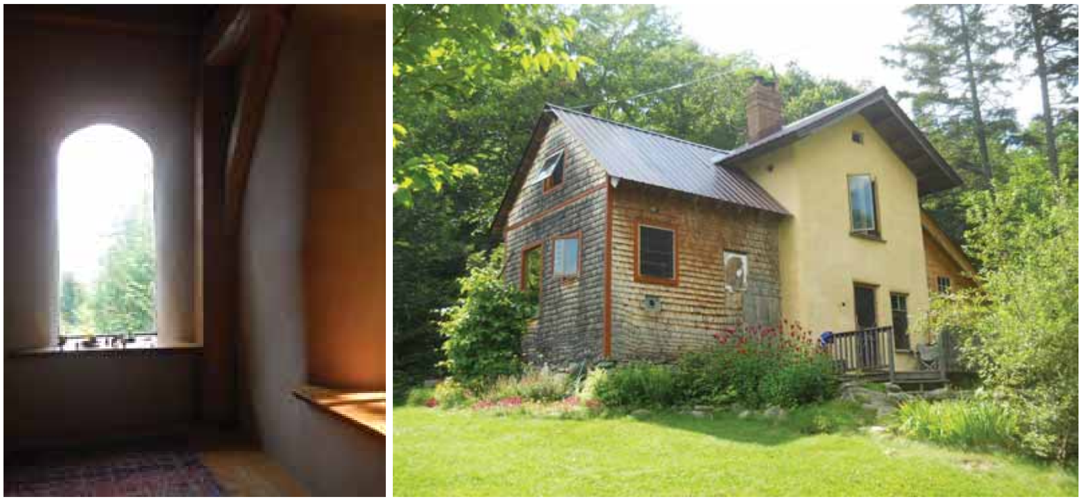

Figure 4: Straw bale building built in Waitsfield, Vermont.

Founded on a values-based approach (that integrates social and ecological good with health, resource efficiency, performance, and durability), straw bale buildings offer tremendous benefits. What remains critical to its success though, is quality control in construction and attention to detailing in design. Further research is required and may help dispel myths related to perceived drawbacks, specifically those related to its moisture performance and durability. Although largely unexplored as a construction material-technique, it arguably remains one of the most viable options for sustainable, ecologically sensitive, and aesthetically beautiful wall systems. When detailed meticulously, straw bale wall systems possess stellar performance characteristics in terms of R-value, durability, moisture and fire resistance, including interior air quality and comfort. Further, it successfully meets current stringent performance standards expected by the building industry. It is for this reason that straw bale construction merits a substantive and legitimate place in the lexicon of performance-oriented building materials, specifically in relation to the sustainable mode of being. In the final analysis, straw bale offers a connection to ancient ways of building, – one that is time-tested, timeless, and one that has the potential of exceeding expectations as a sustainable material-technology for the future.

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