Reinventing the House

Open building is a systematic method of efficient, adaptable design and construction; here's one builder's approach

BY ANDREW DEY

If you ask most builders whether the homes they build are above average in quality, they are likely to answer "of course." But the reality is that most homes today are built through a process that is inefficient and unpredictable. In an environment where building high-quality homes is difficult and expensive, low-quality homes tend to be the norm.

In the 2006 issue of *Fine Homebuilding*'s *Houses* (pp. 8-16), timber-framing pioneer Tedd Benson provided a sobering assessment of the "dismal standard" of many homes being built today. The problems Benson identified include increasing shortages of skilled labor; poor coordination between subcontractors; inefficiencies and quality concerns due to job-site conditions; lack of organization between and within the various systems in a home; and poor quality control. These issues all contribute to unpredictability in schedule, cost, and quality: the elements of any project about which the builder, the client, and the designer care most.

With recent predictions of a housing market slowdown clouding the horizon and the National Association of Home Builders (NAHB) reporting builder confidence to be at a 14-year low, the existing problems within the industry are likely to be magnified in coming years. We need innovative methods for designing and building homes to serve homeowners better and to ensure the long-term health of the industry.

During the past several decades, many architects, building theorists, and researchers have contributed to the principles of a strategy called *open building* (sidebar, p. 60). While companies in Europe and Japan have been creating construction systems based on these concepts, open building has been slow to take root in the United States. Our company, Bensonwood, and its founder, Tedd Benson, are working to spread the word.

Keep everything separate and flexible

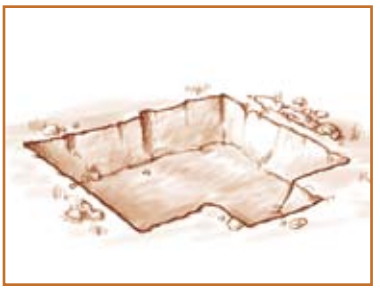
Open building views a house as a collection of layers or levels. These layers are characterized by their expected (or desired) life span and by their anticipated need for modification (drawings below).

In open building, these layers are kept as distinct as possible to optimize their performance and flexibility. This disentanglement between the layers of structure and skin works elegantly in a timber-frame wrapped with insulating wall and roof panels. The skin protects the structure, and the structure does not compromise the skin's insulation. In contrast, conventionally framed exterior walls tend to be highly entangled: framing creates thermal breaks in the insulating skin; wires, electrical boxes,

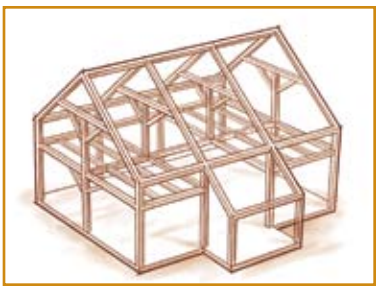
Thinking in layers

A building can be seen as composed of layers, each of which has a distinct function and a theoretical life-span that dictates its need for alteration or replacement. The more often a layer needs to be replaced, the more accessible it ought to be.

Site: Geological, timeless



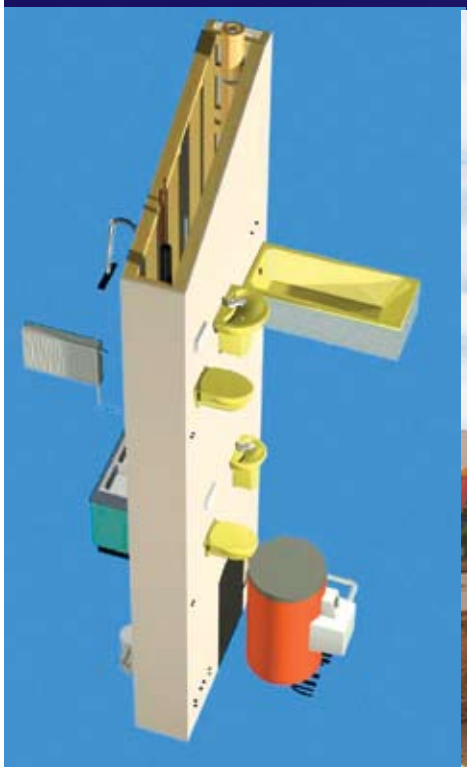
Structure: Lasts 100 to 300 years



Skin: 40- to 100-year life span

Open building separates the house into layers based on their life spans

The one-piece service layer reduces chaos



One of open building's main concepts is to build modular components off site in an environment where efficiency, cost, and climate can be controlled. A good example is the mechanical core wall, essentially a self-contained electrical, plumbing, and HVAC chase all in one. Assembled in the shop, the core is craned into place on site. Services already contained in adjacent components can be connected with a minimum of effort.

and various pipes run through both the insulation and the structure.

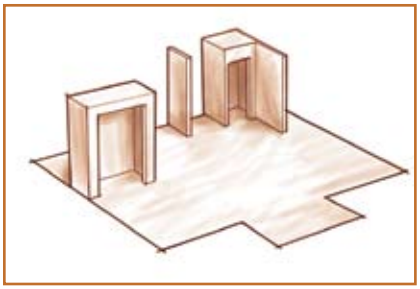
Regardless of the type of construction, open building argues that services such as electrical, plumbing, and HVAC systems should have dedicated zones (or chases) in which to run that are distinct from the skin and the structure. Such zones help to reduce the chaos typical of mechanical systems, and they allow for parallel, rather than sequential, installation of these systems.

Disentangling layers and systems in a house allows one layer or system to be modified without affecting the others. This flexibility makes a house adaptable to the needs of its occupants, to the environment, and to new technologies. Adaptable houses tend to remain useful and relevant for generations.

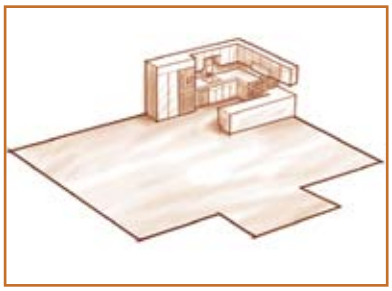
In a house that is truly adaptable, the various layers not only are disentangled but also are accessible. Providing long-term access to the services layer is particularly important because modifications to electrical, plumbing, and HVAC systems generally are driven by advances in technology and changes in lifestyle. If a home's wiring is run in a chase that is accessible, then adding an outlet, a data port, or speaker wiring can be relatively straightforward. Various systems currently on the market provide accessible wiring chases. Many of them were developed first for commercial construction, where forms of open building have long been practiced. Bensonwood's wire-chase system consists of a removable baseboard that installs over a bottom chase in the wall panels. In the second-floor system, access to the mechanical chase is through removable wood ceiling panels (photos p. 62).

While we generally tout the long-term benefits of accessibility, the builders and homeowners with whom we work have appreciated this accessibility during construction. There was the electrician who had to add two wall sconces to a nearly completed home when the client decided there would not be enough light in the dining room. After popping the cover off the recently installed Bensonwood-style baseboard, the electrician was easily able to snake the necessary wires through the wall to the sconce locations. A homeowner experienced the benefits of our second-floor system when, just before she was to move into her new home, the tub drain began to leak through the kitchen ceiling. The fix involved popping out a ceiling panel, tightening the plug in the drain trap,

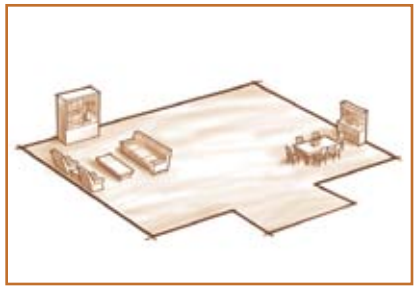
Space plan: Lasts 10 to 30 years



Services: Replaced every 1 to 10 years



Stuff: Can change monthly



Disentangled layers allow access to

and touching up the paint on the ceiling panel before re-installing it. No messy drywall surgery, no waiting for three coats of joint compound to dry, and no dust.

It never rains on this job site. On the floor of Bensonwood's large workshop, a section of an attic floor is being assembled, complete with the home's HVAC unit. Lots of light, space, and cranes overhead make it easier to build a better product more efficiently.

Make design efficient with a universal system

As we have developed building components based on layers, disentanglement, and flexibility, we increasingly have seen the need for an organizing system that defines the relationships between the components of a home. For custom builders, each new project tends to be a journey into the unknown. Foundation plans often seem dimensioned without regard to standard form sizes. Floor-to-floor distances rarely are driven by the height of a comfortable stair riser. Walls and windows can be located in ways that complicate load paths or result in the inefficient use of materials. Tasks such as venting the kitchen sink, achieving the necessary pitch on a toilet drain, or running an HVAC duct from the first floor to the second can be frustrating and time-consuming.

A commonly shared organizing system does not exist in residential construction, although most carpenters could point to the beginnings of such a system. The dimensions of building materials (2x lumber, 4x8 sheet goods, etc.) are a good start, as are standards such as 8-ft.-tall foundation forms, 36-in.-high kitchen counters, and 3-ft.-wide exterior doors. Layout conventions, such as 16 in. on center, relate to standard material dimensions and provide some predictability to the assembly of parts. The guidelines of advanced framing (see Joseph Lstiburek's article in *FHB* #174, pp. 50-55) are part of the answer. However, these conventions fall short of a universal design system. At Bensonwood, our designs are organized by a virtual three-dimensional grid that's expressed in a computer-based catalog of standardized components.

This grid system underlies the floor plans of the houses we design. For example, by fixing the standard floor-to-floor heights in our homes as multiples of 7½-in. risers, we have significantly increased the chances of the stairs being functional and to code. Our designers generally don't design a new kitchen layout for the 12x16 quadrants common to our homes because they can choose from among the hundreds of 12x16 kitchens they have created in our electronic design catalog. The same is true for the bathroom sizes—4x6 and 6x8—typical for the homes we build. As we continue to increase the number of plan blocks in our electronic catalog, the possibilities for creating custom floor plans using standard components based on an organizing grid become limitless.

Rather than being constrained, our designers have found that such an organizing grid frees them to focus on larger design issues. A system based on predesigned and pre-engineered components—be they stairwells, floor-plan blocks, or dormers—allows for a tremendous variety of aesthetic expression. The same 8-ft.-wide gable dormer ends up in varying numbers and at different locations on many of the homes we build, but each of these homes is a unique design. The design system allows us to achieve a form of mass customization in which we provide high-quality work without the investment of time and money usually required for custom design.

The designs created for our virtual 3-D catalog also contain the information necessary to build the components in our shop. These virtual components reflect input not just from our design team, which is focused on the function and aesthetics of a component, but also from our engineers, who want the component to be structurally sound,

The history of open building

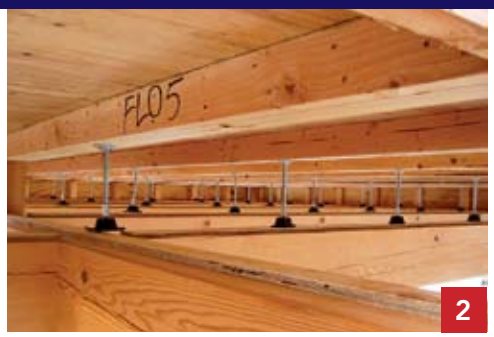
by Tedd Benson

Somebody once pointed out that "To steal ideas from one person is plagiarism; to steal from many is research." But for that, my whole professional life would be on shaky ground. As it is, my company associates and I are avid researchers, constantly on the lookout for good ideas we can pluck from wherever they might be on the never-ending quest to do things better.

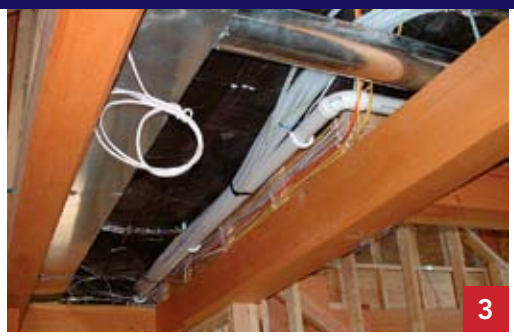
So it was in the early 1990s that I bumped into a marvelous little book by the Dutch architect John Habraken titled *Supports* (Urban Press, 1999). Originally written in 1961, it was a response to the European mass-housing experiments of the post-WWII period. He argued passionately that the process of making housing must preserve the "natural relationship" that humans need to have with the place where they live. He also believed that the building's shell can be constructed without specific concern for the occupant, but fixing the interior without consideration of particular people and their constantly changing requirements does a disservice to the very concept of home. This book was

wiring and plumbing where it's needed most


1



2


3

and from our project managers, who review the component for cost-effectiveness and "buildability." As we have moved toward integrating wiring, plumbing, and HVAC elements into our components, we have sought input from the appropriate subtrades. When the relationships between these components are determined by an overarching system that embodies good design, sound engineering, and construction savvy, then we can be confident that these components will fit together well.

The site should be more for assembly and less for building

In our version of open building, we see a job site as the appropriate place to join together large prefinished components, rather than a place to turn raw materials into a house. Quality can be increased, waste minimized, and construction time on site dramatically reduced if more of the assembly and finishing is done off site (and under roof). These realities have motivated our efforts to increase the level of finish on the assemblies that we deliver to the site and have inspired us to seek out like-minded subcontractors and suppliers.

When was the last time you milled door jambs, routed (or chiseled) them for hinges, and hung a door? Prehung doors have not always been the norm, nor cabinets that are delivered fully assembled to the site. Clearly, the trend in the building industry is away from low-margin commodities and toward value-added products. In many Bensonwood homes, the stairs are delivered assembled

In conventional building, installing or modifying electrical or plumbing services can be difficult and expensive. Think of the labor involved in running new wires in an old house or fixing a leaky pipe that's buried in a wall. Instead, Bensonwood created a floor system (1, 2) that creates its own chases (3). Removable panels in the ceiling allow electricians or plumbers easy access to wiring or plumbing (4).


4

---

the birth of the open-building concept, which is ultimately about infusing the concept of building with the realities of life. In retrospect, it's amusing to see that I underlined most of the book.

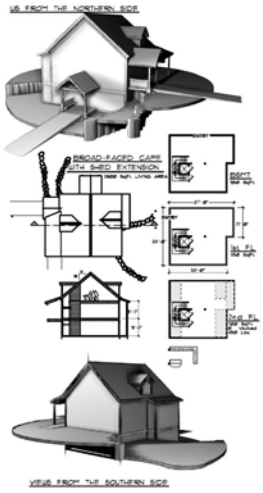
Subsequently, I tracked down other books by John Habraken and also learned that he was then the head of the architectural department at the Massachusetts Institute of Technology (MIT) and living in Cambridge, Mass. I sought him out there and had the good fortune of getting to know John over a period of time. He gave a seminar to our company and I later made several trips to Holland to learn more about how John and his colleagues were putting the ideas into practice.

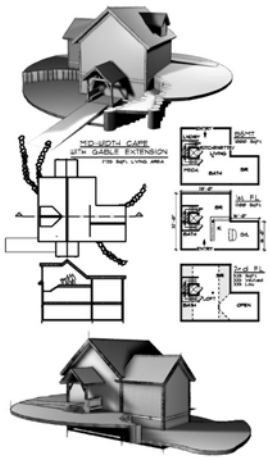
For our company, there was a natural acceptance of the open building ideas. We were determined to do everything necessary to ensure that our houses could last hundreds of years and, with that in mind, already thought of the building's shell and the interior layout as two different issues. We were searching for ways

continued on p. 62

Design should be based on a system of standardized components

A design system that we call the 3-D grid incorporates compatible, interchangeable house parts that include everything from dormers and stairs to kitchen and bathroom floor plans. A computer catalog (right) and design software (below) allow the designer and homeowner to try variations on a particular theme. Once chosen, the design is transmitted to the shop for production.





and finished. These stairs fit well in the spaces framed for them because the stairs and the stairwell framing are built from the same electronic model. The interior-trim kits that we supply to our homes also are highly finished. Whenever possible, we assemble interior-window casing in our millwork shop, securing joints with pocket screws and applying the final finish. An adjustable extension-jamb detail accommodates minor variations in wall thickness on site. The broad acceptance of such shop-assembled and -finished components will increase savings in time and money, and help to ensure quality.

The growth of shop-assembled components has not been restricted to products like doors and cabinets. Many builders take frequent advantage of prefabricated roof trusses and are experienced at working with a crane to install them. Methods for prefabricating foundations have advanced rapidly in the past decade. We see exciting possibilities opening to builders and manufacturers alike if the use of cranes becomes the norm on job sites.

On a recent collaboration with the Massachusetts Institute of Technology called Open Prototype (www.open-prototype.com), we delivered wall panels with exterior and interior finishes installed, roof panels with an integral cold roof, and floor and wall systems with elements of the mechanical systems installed. A prefabricated mechanical core wall running vertically through the middle of the house contained the primary elements of the electrical, plumbing, and HVAC systems. We joined together the two sections of this core wall on site, then connected the pipes, ducts, and wires in this core wall to the branches that had been installed in the partition walls and floor systems.

New ways of building will include plug and play

As the construction industry develops new ways of building, opportunities are multiplying for manufacturers to develop innovative products and for builders to use them. For instance, building large, prefinished, well-insulated wall and roof panels is relatively straightforward with the proper facilities and equipment. The trick is to join these panels together efficiently on site. These days, we're relying on gaskets of EPDM and other materials rather than on more rigid materials such as sprayed polyurethane foam to seal the joints between assemblies.

The technology also exists to connect on-site plastic pipe or electrical wires quickly, easily, and securely; you only have to lift the hood of a late-model car to see good examples. Many of these plug-and-play connections already are approved for use in homes. We anticipate that these products and materials increasingly will find their way into the residential-building market.

In the Open Prototype, we used standard neoprene no-hub connectors to join the rigid-PVC drainpipes in adjacent sections of the plumbing core wall. We also used PEX tubing for the water lines because it's flexible and easy to join. From a distributor in Germany, we obtained the plug-and-play electrical connectors we used to join wires in adjacent wall and floor assemblies. In a future prototype home, we hope to eliminate the need for wire nuts (can you imagine finding wire nuts under the hood of your new car?). Alternatives exist in the form of junction boxes, outlets, and switches that use plug-in connections. By providing dedicated spaces for the wires to be run and by locating the switches, outlets, and fixtures on a design grid, the lengths of the wires connecting the various electrical elements could be determined in advance,

The history of open building *continued from p. 61*

of making our buildings more adaptable, and therefore more durable. We didn't need convincing; we needed to find or develop methods that would work with our design and building systems.

Coincidentally, in the same time period, I also had the opportunity to communicate with Stewart Brand as he was completing his book, *How Buildings Learn* (Penguin, 1994). The essential point of the book is that houses appear to be insentient, but are more like living organisms, no matter what the intentions of the designer and builder. After showing examples in many types and styles of buildings, Brand concluded that attempts to prevent adaptation and change are both futile and shortsighted. Life is not static; therefore buildings that house life should be mutable.

In the book, Brand built on a theory developed by British architect Frank Duffy that there are actually distinct layers in buildings that live in time differently. To make buildings more flexible and durable, these layers should not be entangled with each other. Duffy described four layers, but Brand amended the four to six, and he called them the six Ss: site, structure, skin,

and the end fittings necessary for these wires and devices to plug and play could be preinstalled. Cable would not be wasted, and installing the rough wiring in a home could be as simple as plugging in an extension cord.

Craftsmanship vs. production

Any article that compares the state of home building unfavorably to the auto industry is bound to elicit strong reactions. Are we suggesting that the ideal future is one in which skilled carpenters are reduced to workers on an assembly line or replaced by robots? Certainly not. Nor do we envision that in the future, success will be reserved only for builders with large prefabrication shops and all-terrain hydraulic cranes.

The balance between craft and production at our shop has been a recurrent theme. Most members of the Bensonwood team were drawn to the company because of its emphasis on quality. To many of us, timber-framing represents one pinnacle of quality home building.

In the early days, timber-framers in our shop argued about whether a saw or a chisel could more accurately cut the shoulder of a tenon. The debate shifted in the late 1980s when we began considering investing in an automated tenon-cutting machine. For the past eight years, we have kept a very large CNC machine busy cutting those tenons in one corner of our shop.

We embrace technology only after convincing ourselves that it will help us to maintain the quality of our products, improve working conditions for our associates, and reduce the costs for our clients. You don't have to cut hundreds of mortises with a drill and chisel before that "craft" begins to feel like drudgery. At its best, the technology used in our timber-frame shop frees our timber-framers to focus on those elements of the craft that require a wealth of experience, sharp thinking, and a practiced eye. For instance, a timber-framer designates and orients each timber before it goes into the milling machine. When it exits the four-sided planer at the end of the machine, the timber is checked by a framer because wood is not perfectly uniform and machines are not infallible. Our framers still chisel housings square, apply decorative embellishments to timbers, and do carvings. Because our CNC timber-milling machine does not cut compound joinery on timbers, our veteran timber-framers are teaching these skills to newer members of our team. And veteran framers have grown their skills in new directions because much of the joinery that used to be laid out on timbers is now done on a computer.

You don't have to look hard for analogies in the world of conventional home building. Is the craft of stick-framing a home found in tasks like cutting a lift of 2x6 studs to length and nailing off a subfloor? Or does it reside more squarely in the knowledge and skills required to manage complex processes? Lining a long wall, sealing the intersection of a wall and a roof, and coordinating subcontractors to use available space efficiently are all tasks that require considerable thought and care. If builders were able to spend less time struggling in adverse site conditions to complete repetitive, backache-inducing tasks, perhaps they would have more time for those details that make a project unique, beautiful, and durable.

Great homes are being built today, but generally only by the most skilled and experienced builders, and at tremendous cost and effort. The principles of open building hold the potential for new and better ways of building. Because it is more a perspective than a prescription, open building can inform all types of home building. Using the principles of open building, we have created processes and components that work well in our homes. We are optimistic that these same strategies and solutions can be developed to bring greater efficiency, ease, and fulfillment to all homebuilders, and better quality at lower cost for the homeowners they serve. □

Andrew Dey is project steward at Bensonwood. Eli Gould and Tedd Benson contributed to this article.

Plug and play

In the service layer, modifications or replacements are made easier by plug-and-play components: crimpable plumbing unions, PEX plumbing lines, and quick-connect electrical unions.

Quick-connect manifolds, valves, and unions by Sea Tech (www.seatech.com) don't require specialized crimping tools or adhesives.

Popular in Europe, terminal-based electrical unions like these by Wieland (www.wielandinc.com) are fast, are code-approved, and are used instead of wire nuts and junction boxes.

Copper plumbing unions that are crimped instead of soldered make plumbing between component walls an efficient process.

services, space plan, and stuff. From our experience with timber-frame buildings, the idea of separating structure and skin from services and space plan sounded exactly right and provided us with a clear and memorable objective that could improve our homes.

Inspired and educated by Habraken and Brand, we have further developed their ideas, added our own and continued our research. From our own experience, we know that quality, efficiency and consistency can come out of a workshop setting in the form of parts and pre-constructed elements. From the Europeans, we have seen that is possible to build standard homes with firmer structure and better energy efficiency. From the Japanese, we have seen that it is possible for every home, even by the tens of thousands, to be customized for the owners. From the auto and computer industry, we have seen the systems and technology that should be available in the average home. More than anything else, we can see that the world is changing and home building should not drag behind. We should lead.

—Tedd Benson is the founder of Bensonwood, a design/build company in Hanover, N.H.

Photos this page: Krysta S. Doerfler