Ordering the Structure of Light Wood Framed Row Houses to Sustainably Accommodate Change: San Francisco's Sunset District as a Cautionary Tale

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ABSTRACT

As the last neighborhood developed in San Francisco, the center of the Sunset District stands today as one of the least altered built environments in that city. Through the detailed survey of 12 blocks, original construction documents and field research, this paper argues that the Sunset District tunnel houses have limited opportunities for change due primarily to their design and how they were constructed. By considering construction as the assembly of elements with varying degrees of permanence and using Open Building hierarchies, conventional construction techniques, such as light wood platform framing, can be used to structure the built environment to better accommodate change without the need for specialized systems or materials.

KEYWORDS:

ordered structure, row housing, light wood framing, San Francisco, Sunset District

INTRODUCTION

Light wood frame construction accounts for over 90% of all new buildings in North America (Thallon 2008), and this building method is still used for the bulk of new residential construction, both singlefamily and low-rise multifamily, in the United States. As the only commonly used building system consisting of a low carbon, low embodied energy, and renewable resource, light wood framing will continue to be an attractive alternative for housing construction in the foreseeable future. Consequently, the longevity of housing using conventional light wood framing and how it accommodates change must be examined.

While "Open Building" research into light wood framing in the United States to date has focused on single-family detached houses, the suburban sprawl associated with this building type has fallen increasingly out of favor over the past two decades as progressive planners, developers, and architects have promoted denser, more compact and connected models of development as more walkable, livable, and healthy (Larco 2009). As 18 percent of all CO2 emissions in the United States were a result of gasoline consumption for personal vehicle use (U.S. Department of Energy 2009), reducing automobile use not only reduces congestion but also reduces one of the major sources of greenhouse gas emissions. Increasing the density of housing and associated development reduces the need for automobiles by creating the minimum levels of density needed to

support a public transit network and allow residents to walk for shopping trips (Smart Growth Network, 2010). Urban form, specifically increasing both the density of housing to exceed 13 residents per acre and employment to exceed 75 employees per acre, is associated with a reduction in single occupancy vehicle travel (Frank and Pivo, 1995).

Light wood framed row houses offer a more sustainable and viable alternative to the current development of single-family detached houses. By removing the underutilized five-foot side "yards" between the typical contemporary detached houses, row houses can increase density to levels necessary to reduce single occupancy vehicle travel. Sharing or abutting walls with neighboring houses, row houses reduce the amount of energy required for heating and cooling. At the same time, row houses still provide many of the amenities American homeowners seek in a single family detached house. These include ownership of both the property and building, attached garages, backyards, adequate privacy, and multiple stories. In contrast to multilevel, multifamily housing, row housing offers a wider array of options for transformations as space is more readily available for extensions outside the original building envelop both horizontally and vertically.

This paper documents the transformations of conventional light wood framed row housing in San Francisco's Sunset District over 60 years at multiple scales. While not designed or built with longevity and future adaptations in mind, these row houses highlight the importance of using Open Building principles of support and in-fill to create a hierarchy that orders light wood framed systems. It is critical to examine not only how a single row house can be transformed but also how the subsequent interventions of individual homeowners impact adjacent properties and the neighborhood as a whole. As an increasing number of houses are being demolished and replaced, the Sunset District serves as a cautionary example for architects and developers of light wood framed row housing today.

OPEN BUILDING AND CONVENTIONAL CONSTRUCTION

The origins of the Open Building movement are most often associated with the publication of N. John Habraken's *Supports* in 1961 where the concept of "support structures" that are in filled to create housing is introduced. What is less commented on is that Habraken promoted the use of "modern production techniques" and "assembling prefabricated elements" for both support and infill systems (Habraken 1972). While there are many benefits to prefabricated construction systems, including reducing construction waste and onsite construction time, conventional light wood frame construction has dominated residential construction over the past 50 years. This is in spite of many attempts in the past decades to promote prefabrication, including HUD's Operation Breakthrough in the 1970s and Dwell magazine's Dwell Home competitions in the 2000s.

In built multifamily examples of support and infill or "base building" and "fit out", such as NEXT 21 in Osaka, Japan, there is a clear material difference between the concrete structure for the support and the aluminum panels, as well as other materials, for the infill (Kendal 1999). This reinforces the hierarchy of what is permanent and what can be transformed over time. In conventional light wood frame construction, no clear material hierarchy between support and infill exists as the same wall system is used for load bearing and non-load bearing walls. This does not mean that a hierarchy or support and infill system cannot exist in this type of construction. Ari Friedman (2002), in his book The Adaptable *House*, reinforced the notion that "limited adaptability is possible" in platform wood frame structures with the exception of interior walls where long-span, engineered floor systems are used. Consequently, Friedman focused primarily on strategies for interior transformations in his study of adaptability in wood framed housing.

In "The Control of Complexity," Habraken (1987) distinguished between two types of hierarchies. The first is the "part-whole hierarchy, a hierarchy of assembly" that breaks down the physical components of a building, such as studs make up walls and walls make up a house. The second is the "control hierarchy" or "dependency hierarchy" that designates levels of intervention in which infill is dependent on the support system and can be manipulated independently over time. The major distinction between the two is that the lower level, the infill, in a control hierarchy can be changed without altering the higher level, the support. A control hierarchy can have multiple levels that range in scale from the city to the placement of furniture and could be used to break down a given system, such as light wood framing, into multiple levels of control.

Based on the amount of time a given level might change, Stewart Brand (1994) developed a six-step hierarchy, based on the work of Frank Duffy, that disentangles building components with different rates of change and includes site, structure, skin, services, space plan and stuff. With founding partners Bensonwood Homes and the MIT House_n Research Consortium, the OPEN Prototype Initiative was responsible for the design and construction of two prototype houses that primarily use conventional building materials and adhere to Brand's hierarchy. Unlike conventional light wood framing, both prototypes used timber frames for load-bearing structural elements and then used prefabricated walls made from light wood framing in order to separate structure and skin. Services such as water and electricity that typically run inside walls and floors in conventional light wood construction were routed through raised floors and accessible chases in walls. While there are significant strengths to these strategies, there are is one major concern with Brand's model. Space planning occurs within the structure, skin and services, making transformations outside of the original envelope more difficult. As was the case with Friedman's Grow Home, change is primarily accommodated through interior renovations.

ORDERING STRUCTURE

While specialized open building construction systems for residential supports and infill may one day be as accessible and comparable in cost. conventional wood frame construction can be improved to support building longevity and better accommodate change. As noted earlier, light wood framing is the construction and structural system overwhelmingly used to build most housing in the United States. While arguably malleable, conventional light wood framing integrates many building systems (structure, insulation, plumbing, electrical) into one, which Open Building advocates argue is not able to accommodate change over a long period of time. Yet, a number of houses using light wood platform framing, including San Francisco's Victorian houses, have been transformed and adapted to new technologies for over 100 years. Light wood framing itself is not an impediment to change, but how it is deployed could be.

By considering construction as the assembly of elements with varying degrees of permanence, conventional construction techniques, such as light wood platform framing, can be used to structure the built environment to better accommodate incremental change. How a house is built influences how it can be changed. Seemingly simple decisions during construction, such as which direction to run joists in a given space, can assign some walls to be more permanent, either through structure or services, and less likely to be altered than other walls. The larger organization of permanent and less permanent elements, supports and infill, influences how a house can be transformed. Consequently, a hierarchy based on how a building can be changed is necessarv.

Using light wood frame platform construction, an order of permanence can be developed and used to structure incremental change. In a two-story house, the foundation, vertical load-bearing walls and floor joists are the least likely to be changed and are considered primary assembly elements. The floor joists are considered primary because the direction they span determines which walls below are loadbearing. The second floor load-bearing walls and ceiling joists or trusses are dependent on the walls and floor joists below but can be altered without having to alter any primary assembly decisions. These elements are considered secondary. Finally, the tertiary elements refer to all non-load-bearing walls on either the first or second story as they can be altered without disruption to primary and secondary elements. In places with extreme lateral loading, such as seismic zones, walls not carrying vertical loads, tertiary in the order of permanence, may be needed to carry lateral loads. This does not mean they cannot be altered, but after any transformation, the capacity of the altered structure to resist lateral loading must be reassessed. Any lateral support removed must be compensated for with another transformation.

While not used in contemporary housing, light wood balloon framing has a different order of permanence and offers a useful comparison to how permanence is ordered in platform framing. The foundation and load-bearing walls are primary. In balloon framing, the stud walls run the entire height of the house, so the order of permanence is not tied to a vertical hierarchy. Secondary elements includes all floor and ceiling joists which could be raised, lowered or completely removed without altering the loadbearing walls. Finally, all non-load bearing walls, including single height interior partitions and the double height non-load bearing exterior walls, are all tertiary elements. While both balloon and platform framing have non-load bearing tertiary walls that can be treated as infill, each story of this wall in the platform framed house can be alter without disturbing the other. This is not the case with balloon framing as the lower and upper floor walls are a single structural element using continuous studs. Without ordering the permanence of each system, these subtle yet important differences could be missed in the design and construction of new housing.

It is not enough to offer legible opportunities to alter tertiary elements and, by doing so, accommodate incremental change. There must be a shared understanding of how additions and alterations could be realized. Structuring incremental change across lot lines ensures that each house can be transformed in the same way without sacrificing the quality of existing spaces, those of the house being altered or those of a neighboring house, or impeding any transformations a neighboring house might undergo.

CASE STUDIES IN SAN FRANCISCO

The geography and topography of the San Francisco peninsula influenced the density and type of housing constructed there. Steep hills and limited land encouraged the development of housing unlike that found in other large cities of the western United States, such as Los Angeles and Portland, Oregon. While not technically row housing, as party walls are not shared and some cases there are small side yard setbacks of about three feet, the Victorian houses and Sunset District tunnel houses in San Francisco offer contrasting examples of higher density single-family housing using light wood framing.



Figure 1: The average age of housing in San Francisco by neighborhood with light gray being the oldest, Victorian houses that remained after the 1906 earthquake, and black denoting the newest, the heart of the Sunset District.

Victorian Houses

In her book Built for Change, Anne Vernez Moudon (1986) focuses on the adaptability of the Victorian houses that have accommodated a significant amount of change without undergoing significant physical alterations. She credits this to the generous dimension, regular shapes, and the variety of possible connections between rooms as well as the organization and structure that permit every room access to daylight and ventilation. Furthermore, she appreciates "the malleable construction system of the wooden houses" as it has allowed the Victorian row houses to accommodate change through flexible alterations such as adding rooms to the rear or raising the entire house a full story for a garage. Renee Chow (2002) documented in detail plans how the Victorian houses currently accommodate a wide range of occupants and their lifestyles and in particular the role that access, claim, dimension and assemblage all play in accommodating change. In particular, the density of the Victorian houses has increased by easily converting each story into a separate flat due to the organization of the access and assembly.

The structural order for a San Francisco Victorian house is straightforward as it is balloon framed with the load baring walls running perpendicular to the street. The foundation and shared party walls are primary. The floor and ceiling joists are secondary, and all remaining non-load bearing walls are tertiary. Consequently, transformation to the front and rear of the Victorian houses are straightforward and relatively uncomplicated. It is obvious from Chow's documentation of how these houses have changed over time, that the primary and secondary elements have remained constant while the tertiary elements have been significantly transformed on the interior to break up houses in multiple units and on the exterior to create storefronts and add new spaces in the rear.

Sunset District Tunnel Houses

As the last neighborhood developed in San Francisco, the center of the Sunset District stands today as one of the least altered built environments in the city. Produced in the late 1930s and early 1940s by a relatively limited number of developers using similar plans across numerous blocks, the single-family row houses served as "starter homes" offering suburban amenities, such as attached garages and back yards, with easy access to downtown. Despite 70 years of use and shifting demographics over that time period, relatively few of the houses show any sign of alteration. This suggests that either the houses asbuilt have fulfilled the changing requirements of San Francisco's population or, more likely, people move when the Sunset house can no longer meet their needs. It is clear that the design and assembly of these houses seriously impedes incremental change.

Despite the small range of floor plans, all of the houses in the Sunset District share some basic design attributes. The Sunset District consists of long narrow blocks, all platted 25-foot wide and 125-foot deep lots, and the houses are typically set back ten to fifteen feet from the sidewalk and span the entire width of the lot. As designed, all of the living space is on the upper floor, and due to this, each two-story house has an exterior stair to the entry. Collective spaces, such as the living and dining room, open onto the street while individual spaces, namely bedrooms, open onto the backyard with service spaces, like the kitchen and bathrooms, in between. Primarily used as a garage, the entire ground floor is labeled as a "basement" in the original plans and is accordingly unfinished with studs and floor joists exposed with only an eight foot height between the rough concrete slab and the bottom of the floor joists. The houses are typically more than two rooms deeps and require lightwells and skylights to ensure each room has adequate ventilation and daylight (Figure 2). As over three quarters of the row houses in a twelve-block study of the Sunset district are tunnel houses, named after the tunnel-like entry, this paper will focus on this typology.

The assembly of the tunnel house is complex and severely limits incremental change. The Sunset houses primarily use light wood platform framing, and consequently, the party walls are actually just two stud walls built on either side of the lot line and not a shared wall. This allows for one house to be transformed or altogether demolished without disturbing neighboring units. Most joists run between three load-bearing walls, one along each of the lot lines and the third dividing the width of the house into a 14-foot and 10-foot wide dimension. In the basement, a series of posts and beams are used for all interior supports, and the floor joists at the front and back of the house are turned parallel to the first set of load-bearing walls, in order to create three-foot cantilevers, which require both the front and rear façade to be load bearing as well.

These cantilevers are a result of the Federal Housing Authority (FHA) design guidelines for insuring mortgages that limited the size of the ground floor. In order to initially create slightly more living space, the ability to easily transform the front and back facades was compromised.

As the entire perimeter of the tunnel house is load bearing, extensions, alterations and additions to both the front and back are difficult. The location of the existing living spaces on the upper floor as well as the cantilevers further complicated any extensions or additions. Services and the walls that contain plumbing are perpendicular to the load-bearing walls. blocking any attempt to significantly transform the interior spaces. The height and design of the basement makes any alterations to this space difficult. Transforming any part of the ground floor into a habitable area would be limited to the space adjacent to the rear wall as it provides the only windows on this level. The post and beam system used on the ground floor also drops the ceiling another foot imposing a boundary on any attempt to renovate the basement. Furthermore, the proximity of the house to the sidewalk and lack of sectional change between the sidewalk and ground floor would make any transformation of the front part of the basement awkward.

Consequently, the order of permanence for the Sunset tunnel house is complex, despite being platform framed, and impedes incremental change. The primary elements include the foundation, ground floor load-bearing walls, which include all perimeter walls due to the cantilevered joists at the front and back of the house, and upper floor joists. Instead of load-bearing walls, the interior vertical supports are a post and beam system and are also considered primary. On the upper floor, the three parallel loadbearing walls, the rear facade, ceiling joists and service walls, which run perpendicular to the loadbearing walls, are all secondary. Only the interior non-load-bearing partitions are tertiary in the tunnel house, and there are very few of those (Figure 3). Consequently, a secondary or primary element must be altered in order to make an addition or extension. This is the primary argument for why the Sunset District has changed so little. Finishing the rear portion of the basement and enclosing the tunnel are the only easy transformations, as they do not require altering any existing part of the tunnel house. These moves simply add more tertiary elements.



Figure 2: Four Sunset District tunnel houses as built (left) and showing the limited range of transformations (right).



Figure 3: The structure of the Sunset District tunnel house ordered in terms of permanence. Primary and secondary elements (supports) are shown in black while the limited tertiary elements (infill) are shown in grey.



Figure 4: Sections through two blocks of the Sunset District Tunnel houses showing the houses as built (top) and renovated (bottom) with renovations highlighted in black.

Access is equally problematic for incremental change in the tunnel house. First and foremost, there is no way to access outdoor spaces directly from the living spaces. A narrow, unfinished back stair leads into the basement, so one must always pass through the ground floor to access one of the most treasured amenities in the Sunset, the back yard. While a handful of houses have added decks and stairs to the rear of the house, people must still pass through bedrooms, typically individual and private spaces. There is also no way to access the backyard from the street without passing through the house. The consequence of this restricted access is that the back yards in the Sunset District are grossly underutilized on just a day-to-day basis and to accommodate change. In a likely effort to minimize the amount of space used exclusive for circulation, the entry tunnel delivers inhabitants to the center of the house and the front door opens onto the narrow corridor linking the living and sleeping spaces.

As a result of all these limitations, only onequarter of the houses in the 12-block survey of the Sunset District show any sign of incremental change. Furthermore, any alterations made are limited to finishing the basement or enclosing the tunnel on the ground floor, adding entire rooms to the rear of the house on the upper floor, or adding a third story. With each of these transformations, the quality of the original spaces is compromised, particularly in terms of daylighting and view. As there is no way to structure the incremental change that is actually taking place in the Sunset District, one individual can make it virtually impossible for his neighbor to construct a similar transformation as well as reduce the quality of his neighbor's spaces, for example, by blocking lightwells and skylights from receiving any direct sunlight with a third story or rear addition (Figures 4 and 5).

CONCLUSIONS

In the fifty years after the publication of Habraken's *Supports*, there has been slow but growing interest in Open Building principles. During this time older neighborhoods in San Francisco have accommodated a significant amount of change, including the transformation of the Victorian row houses and the adaptive reuse of warehouses in the South of Market. Though densities have increased and uses radically altered, these neighborhoods in San Francisco still have a strong sense of place. While this is the case for many urban areas built around or before the early twentieth century, most housing built over the past fifty years resembles the unalterable Sunset District tunnel houses more than the malleable Victorian houses. In fact, the tunnel house was a model for thousands of houses constructed after WWII in the new suburbs south of San Francisco. The result of several decades of districts like the Sunset is an increasingly placeless built environment with a transient population.

Both the Victorian and Sunset District tunnel houses used conventional light wood framing of their respective eras, but how the structure was deployed in each case is critical to accommodating significant and meaningful change in the future. More importantly, the initial construction of the tunnel houses did not allow for a shared understanding how additions or alterations could be realized. The resulting free-for-all negatively affects the existing spaces of the house altered and the larger fabric of the Sunset District. Instead of writing off conventional construction methods in favor of prefabrication that has yet to gain traction in the United States, ordering the permanence of light wood framing and structuring legible opportunities for transformations can accommodate incremental change in the vast majority of new construction today.

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Figure 5: Several blocks of the Sunset District as built in 1940 (top left) and as renovated in 2010 (top right). Each shade of gray denotes the type and floor level of the alteration.

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