Demountable and Interchangeable Construction System: R. M. Schindler's Panel Post Construction

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Abstract
Architects as well as manufacturers have proposed numerous researches and experimentation of demountable and interchangeable construction system for the development of sustainable housing. Many alternatives have been proposed with the capability of being adjusted to the change of circumstances and technologies. The components are designed for being erected, disassembled, shipped, re-erected, and reused without special tools and waste. This approach definitely encourages the move towards an environmentally just and sustainable future. Among other projects, Rudolph M. Schindler's Schindler Shelters, his designs for low-cost, mass-producible housing, stands out the most within the above subject. This project illustrates Schindler's long-time interest in flexible design strategies and integrated construction systems which underpin his Space Architecture. In the Shelter project, systematic design strategies were used to achieve flexible layouts for mass-produced dwellings. The Panel-Post construction system was developed as a means of achieving this goal; this system uses unit components and allows for interchangeable assembly of its parts. This article reconstructs the archival material related to the project by analyzing housing layout variations to reveal the underlying logic of Schindler's scheme, and by fabricating scaled models to simulate the construction process.

Keywords: Schindler Shelters, Panel Post Construction, Flexibility, Interchangeability, Demountability

Introduction

During the early twentieth century in the U.S., research on prefabricated housing construction and design made considerable headway in the development and growth of prefabricated housing.[1] Development of innovative housing solutions continues to generate interest in design investigations along with the use of technology to produce diversity and spatial flexibility in designs.[2] Despite heightened awareness of prefabricated housing, the variety and quality of designs have been lacking.[3] This may be due to the narrow focus on cost efficiency and standardization in manufacturing. As a result, the predominant perception is that prefabricated housing offers only repetitive housing of poor design quality. Although prefabrication has been seen as a means of promoting a more diverse housing typology, the gap between design and production still remains large. According to Burns, "The sense of richness and complexity that should characterize the industrialization of housing production is lacking."[4] In Ahrentzen's view, for democratic choices to be possible among diverse people, housing diversity is a necessity.[5]

Beginning in 1933, Schindler undertook the design for his Schindler Shelters under his own initiative, in response to a program for the Subsistence Homesteads division of the Department of Interior which focused on low-cost housing projects.[6] Mass prefabrication of housing was under significant consideration in the U.S. due to the economic depression and growth population in urban areas. The Roosevelt administration became aware of a wide range of housing-related issues including severe housing shortages, the deterioration of existing housing conditions, the growth of slums, and homelessness.

The concern for low-cost public housing was reflected in the approach of contemporary architects in developing construction systems and unique housing designs. Theodore Larson compiled examples of contemporary housing in his article, "New Housing Designs and Construction Systems" in *The Architectural Record* (January 1934). These examples included Buckminster Fuller's Dymaxion Houses, George Fred Keck's House of Tomorrow, and Richard Neutra's One-plus-two Diatom House.[7] More research on prefabrication continued in the 1960's and 1970's, particularly by Lucien Kroll, Ezra Ehrenkrantz, and N John Habraken.[8] However, there was little mention of Schindler Shelters.

For Schindler, efforts to develop a new construction system for housing needed to address not only reduced construction costs, but also, improvements in building efficiency, speed of fabrication, interchangeability of parts, reduction of labor, durability, better design, and finally, personalized housing designs. He wrote, "The system shall permit individualization of house and garden. Unless a personal relation can be established between a house and occupant, both will become meaningless cogs in a social machine without cultural possibilities." Not wanting prefabricated housing to lose the "charming" quality of the freestanding individual house, Schindler was adamant that there be "No rabbit hutch housing."[9]

In the Schindler Shelters, Schindler advocated a low-cost housing system that involved systematic design strategies and integrated construction systems. Throughout his career, Schindler maintained that design strategies were universal vehicles to organize space and space forms.[10] The construction system was a technical strategy to realize the space form, "an integral part of the conception of a building."[11] Schindler was technically innovative, pushing systems of construction beyond conventional wisdom, however his theory of 'Space Architecture,' was at the heart of innovative experiments using new materials and techniques.[12] The development of new construction systems was essential for Schindler because conventional or standard construction systems were not always suitable for the execution of his vision of Space Architecture.

Compositional Strategy

Schindler designed the Schindler Shelters beginning in 1933. He devised a basic scheme with a center hall which allowed much flexibility of arrangement, and demonstrated this with a number of different layouts. The basic spatial scheme of the unit plan placed a hall in the center of the unit with a clerestory above for ventilation and lighting. Clerestory windows for the bath, living room, and kitchen were also provided. On one drawing Schindler noted that the "kitchen, utility, bath and hall [were] standard arrangements."[13] These spaces were consolidated as a core unit to concentrate the plumbing systems into a single wall. These units could be fully fabricated at the time of manufacture, shipped to the site, and assembled in place. All other rooms varied in size and arrangement, and were positioned in a pinwheel pattern around the central hall. The closet partitions opened alternately into one room or another and could be easily removed for spatial flexibility, optimizing the use of interior space to accommodate different needs. Finally, the garage was a separate unit which could be added to any side of the house.

Utilizing the basic unit, Schindler applied its potential to the design of a number of variations on a street.[14] (Figure 1.) The shelters line both sides of the street and the garages are added in different locations. Shrubs border each lot property, defining private yards for each unit. Schindler also illustrated other unit variations, including three-bedroom and two-story designs.

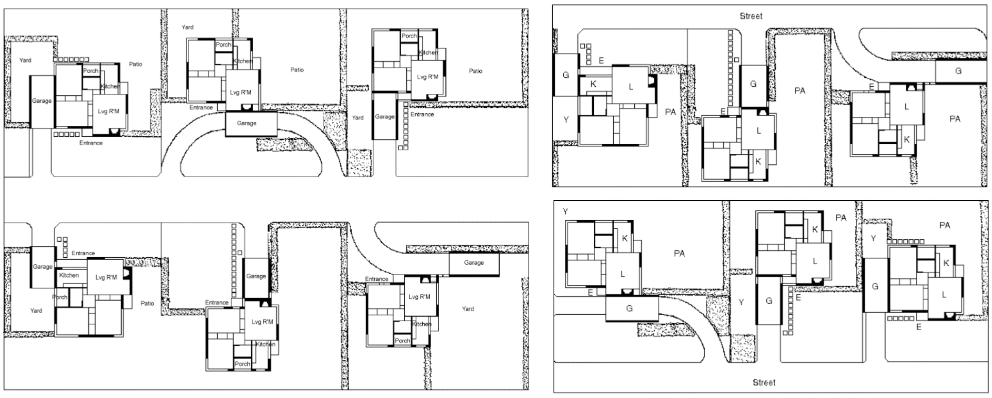


Figure 1. Six housing layout of the Schindler Shelters redrawn by the author

These original schemes initially utilized Neal Garrett's patented shell construction system, which used concrete hollow double-wall construction for the walls, partitions, floors, and roof. [15] As a result, the entire house became a monolithic shell resembling a building made of one material without any joints. All plumbing is contained in one wall and interior closet partitions were constructed with plywood as factory units.

The Garrett construction system was based, uncharacteristically for Schindler, on a 5-foot unit module. According to Schindler, the unit of dimension was the choice of the architect. He wrote, "[The space architect] needs a unit dimension which is large enough to give his building scale, rhythm and cohesion." Schindler had developed his own proportional system which he called a space reference frame.[16] In this system, Schindler recommended 48 inches (4-foot) as the basic unit, to be used with 1/2, 1/3, and 1/4 subdivisions. He chose these dimensions for two reasons. First, he thought the unit must be related to the human figure (6-foot) to satisfy all the necessary sizes for rooms, doors, and ceiling heights. For example, the standard door height was 6 feet 8 inches (1 2/3 units), and the standard room height was 8 feet (2 units), or 9 feet 4 inches (2 1/3 units) with the clerestory. Second, for practical reasons, the 48-inch module fit the standard dimensions of common construction materials available in California at that time. Schindler used the unit system as early as 1920.[17] Since then, the unit was consistently employed with very few exceptions.

Schindler's system offered various advantages in rational planning and construction and was grounded in two principles. First, all locations and sizes of the parts with respect to the whole were precisely identified during the construction process. Thus, no obscure or arbitrarily unrelated measurements were involved in the unit system. Second, the unit system offered the means to visualize space forms in three dimensions. He emphasized that "[the] last, but most important [part of the unit system] for the 'space architect,' must be a unit which [the architect] can carry palpably in his mind in order to be able to deal with space forms easily but accurately in his imagination." This led him to search for a basic unit of length for the building, where the dimensions were integer multiples or subdivisions of the basic length. In his system, there needed to be coordination between the architects of the buildings and the manufacturers of the components.

As early as 1935 Schindler replaced the Garrett system with one that he designed himself that was more cost efficient and flexible, the Panel-Post construction system, which used wood posts and plywood, and was based on his standard 4-foot module.[18] The modules of the unit plan were clearly marked with numbers and letters on the drawing. (Figure 2.) While the vertical module was usually identified with an elevation grade on Schindler's drawings, no grade mark was presented in the Panel-Post construction system because the heights of wall panels were predetermined as a set of modules.

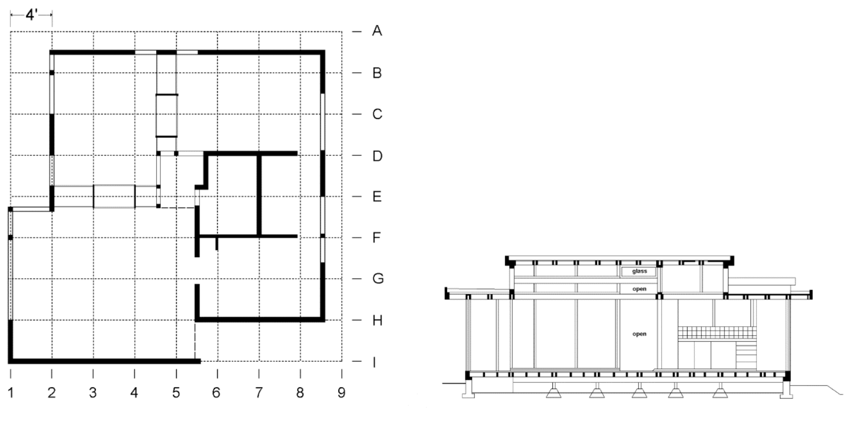
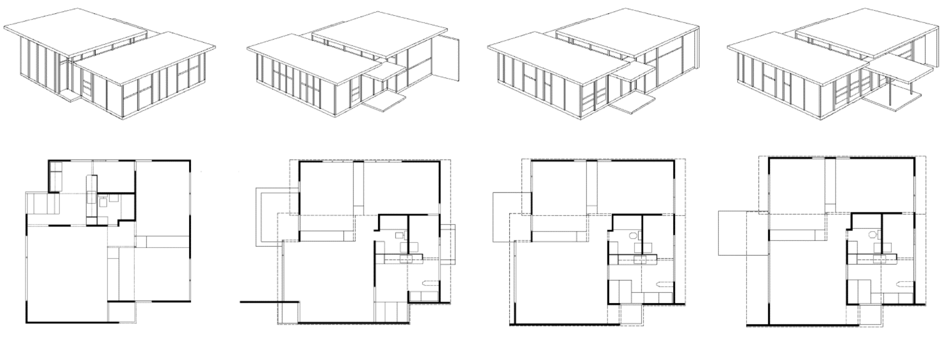


Figure 2. Basic *parti* of unit variations without a garage and cross section between the living room and the kitchen. Drawings are redrawn by the author.

Based on the unit *parti*, four variations of the standard two-bedroom unit were suggested by Schindler. The variations were based on slight modifications of room size with additional architectural elements. (Figure 3.) By rotating and mirroring the basic unit and adding a garage, Schindler could achieve a multitude of unit plans and their variations. (Figure 3a and b.) Additional elements include pergolas, a cantilevered entrance or deck, and a built-in flower box, which could also be attached to each unit as options to increase visual protection, varied exteriors, and privacy. Thus, the number of housing unit possibilities that could be developed was immense; Schindler provided only a few examples.



a b c d

Figure 3. Rudolph M. Schindler, Panel Post Construction, Four variations of a standard two-bedroom unit with their axonometric. Drawings are redrawn by the author.

Schindler provided four different housing prototypes using the Panel-Post construction system for different households. (Figure 4.) The variations derived from the basic unit plan, yet differed in sizes. These schemes were not fully developed, but they were sketched. Although the garage was attached to the kitchen in four schemes, it could also be attached or detached to any side of the unit.

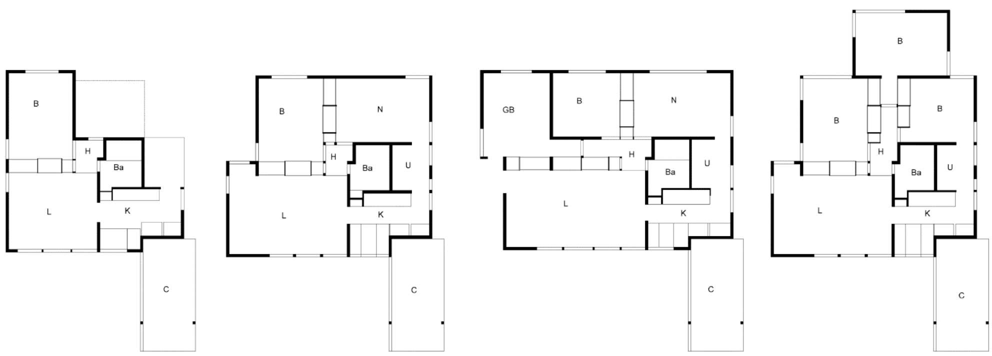


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Figure 4. The Schindler Shelter schemes with the Panel Post Construction, dated in 15 August 1942. a. One bedroom house, 480 sq/ft. b. Standard two bedroom house, 730 sq/ft. c. Three bedroom House, 890 sq/ft. d. Three bedroom house, 904 sq/ft. Drawings are redrawn by the author.

The stylistic appearance of the Panel Post Construction schemes resembled projects that Schindler experimented with earlier in Park Moderne (1929-1938) designed in Calabasas. (Figure 5.) Cabin #1 and a typical cabin (dated 1929 on the drawing) closely resembled the Schindler Shelter unit plan in their spatial configuration. Interestingly, one of Schindler's detail drawings demonstrated that the Panel Post Construction system was tested in one of the Park Moderne designs.[19]

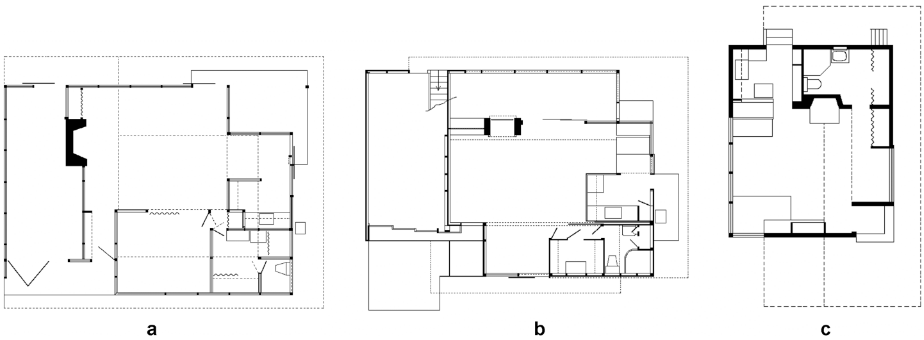

Figure 5. R. M. Schindler. Park Moderne (1929-1938), Calabasas: a. Cabin #1. b. Typical Cabin. c. Cabin #3

Panel-Post Construction System

Schindler was aware that differences in design stemmed from differences in basic approaches to construction systems in prefabricated houses. The concrete-based Garrett system proved too expensive and Schindler's alternative timber-based Panel-Post construction system reduced construction costs. Schindler believed: "[The] consequent increase of efficiency and the use of machinery reduces COSTS and furnishes a better product."[20] However, the Panel-Post construction system was not explained or published until 1943 in *California Arts and Architecture* under the title "Prefabrication Vocabulary."[21] In the article, Schindler detailed the construction features of the system, under 34 headings, illustrated with unit panel drawings, perspectives of the houses, and cross-sections.[22]

The Panel-Post construction system was a full-fledged prefabrication process for mass-production. All prefabrication of building components was made in an off-site factory, and later assembled on site. To increase mobility, an attempt was made to cut the weight and bulk of the components. According to Schindler, the prefabrication “permitted easy packing” and was light in weight. Heavy lifting equipment to handle the components was not necessary and the materials could be loaded into the space of a standard truck. All components and their details were greatly simplified. Assemblage of components on site was easy and simple, as was the altering or replacement of components. Thus, there was less need for a highly skilled work force or special heavy machinery.

Schindler classified the structural system by its major components: the floor panel, post, vent board, base, roof panel, floor panel, wall panel, sash panel, door panel, end-rafter, and fascia. In order to be efficient and practical, there were only nine components; Schindler favored a minimum number of pieces and a maximum size for each piece. (Figure 6.)

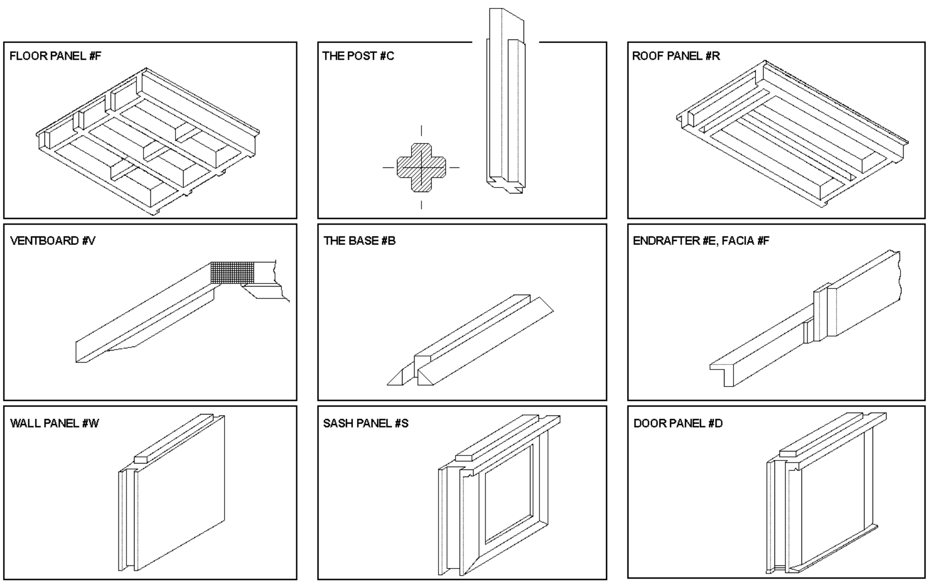

Figure 6. Unit components of the Panel-Post construction redrawn by the author (Garland no. 2582).

The posts carried vertical structural loads. They functioned as the structural skeleton that supported the roof and the wall, window and door panels. Joint details were extremely simple to produce and easy to erect in the field. (Figure 7.) The posts were shaped like crosses and erected at standard distances based on 4-foot module to allow the panels to be inserted into the grooves of the post. When set in place, the panels were interlocked with the four-way post. It was a true kit-of-parts solution to the affordable housing problem.

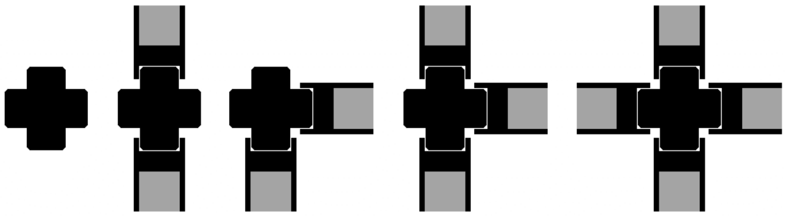

Figure 7. Panels and Post: Four ways of joining system

Partitions and panels could be made of cheap and easily altered materials, such as plywood, boards, etc. They formed a non-load bearing wall system. Wall panels were double sided, made with 1/2-inch stained plywood. Studs were set at 16" apart. Insulation materials were added between studs as in a typical sandwich panel.[23] Window and door sash panels, with headers and studs at each jamb, were designed as units to be inserted between vertical posts. Floor panels were finished with stain or covered with linoleum.

In many respects, the Panel-Post construction system seemed to foreshadow many other similar ones, including the General Panel System developed by Konrad Wachsmann and Walter Gropius in 1941.[24] In this system, the entire house was composed of interchangeable structural panels with a four way jointing system. The wedge-shaped joining elements were set in a pinwheel form.

In the Panel-Post construction system, dimensions of all components were related to Schindler's space reference frame. Since dimensional coordination between all the components is essential in prefabrication, the application of a modular design is fundamental. Although variable, basic dimensions of all components in the Panel-Post construction system were multiples and subdivisions of the 4-foot unit. For example, a variety of wall panels were 1', 2', 3' and 4' in width. The heights of wall panels were based on 16" increments, which were 1/3 of the unit module. (Figure 8.)

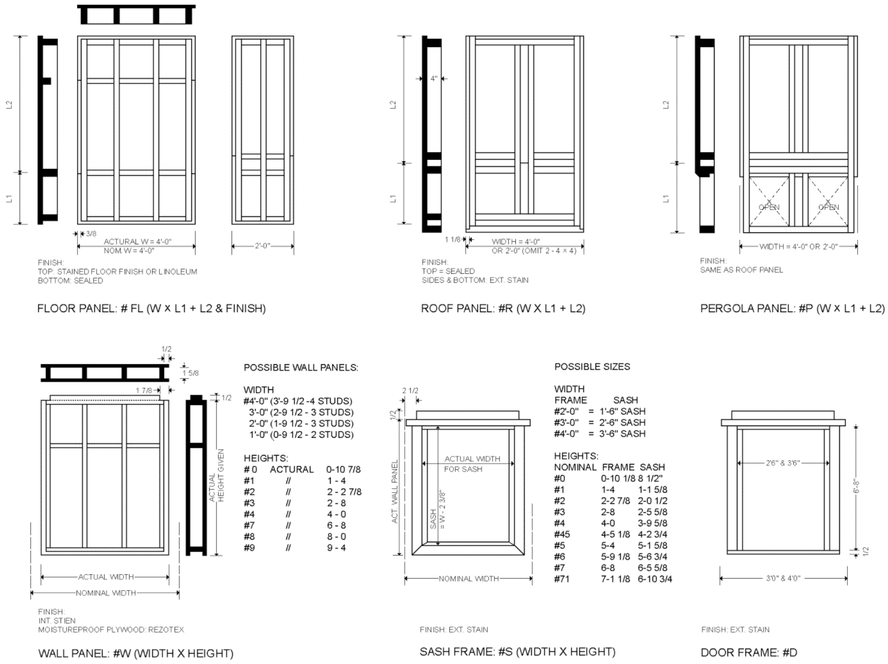

Figure 8. Details of the floor, roof, pergola and wall panels, sash and door frame redrawn by the author (Garland 2585).

Since these components would be positioned according to the 4-foot unit square grid, the actual size of building components ended up a little shorter than the four-foot unit module due to the thickness of the post. (Figure 9.) Because of this, Schindler used both the actual dimension and the nominal dimension to avoid dimensional confusion when the components were fabricated and assembled.[25]

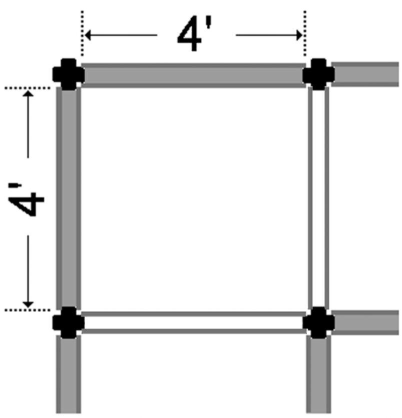

Figure 9. The way that components are positioned according to the 4-foot unit square grid

Most revealing in the Panel-Post construction system was the fact that all panel units were easy to detach, assemble, and exchange by caulking rather than nailing or stapling joints to make them weather tight. According to Schindler, the joints should be "inconspicuous but permanently accessible and renewable without marring the finish of the building."[26] His cross-section isometric presented an illustration of how the components came together. (Figure 10.) These components could be assembled with relative ease and little waste into various structures.[27] For Schindler, the panel-post unit could be used or reused for different buildings. He posited: "My system for prefabrication [uses] a skeleton of structural posts connected by exchangeable wall panels of various materials including glass. The system achieves permanent flexibility and allows changes in the ceiling heights of the various rooms, allowing better architectural articulation outside and inside."[28]

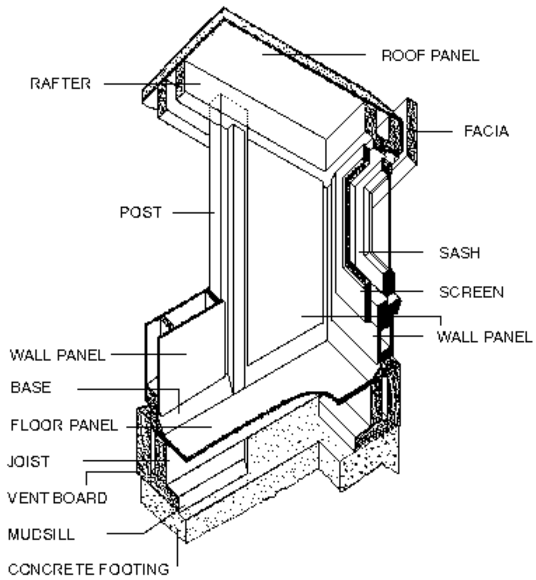

Figure 10. Cross-section of a typical panel and post connection redrawn by the author (Garland no. 2581)

Once the building was erected, infrastructure, including electrical, plumbing and heating systems, was installed. Mechanical systems and power connections were to be accessible from the exterior to accommodate easy "repairs, alterations, and modernizations." Plumbing and pipes of lightweight material could be laid out and preinstalled within the components. Thus, the efficiency of construction was increased and the amount of onsite labor was reduced accordingly.

Although "closets, cupboards and cabinets [were to] be prefabricated units" as built-in or freestanding furniture, they were not necessarily prefabricated units within the Panel Post Construction system. Instead, Schindler felt it would be better to leave homeowners free to choose their built-in closets and kitchen cabinets as add-ons, satisfying their family needs. This increased each homeowner's freedom of choice. [29]

Schindler's idea was an integrated system of construction with interchangeability at its heart. This construction strategy was designed to attract the government or builders of large tracts of houses. However, despite its construction and economic efficiency, prefabrication was not extensively used in the 1930 and 40s.[30] Perhaps, Schindler's Panel-Post construction system was ahead of its time.[31]

To clarify Schindler's construction system, this author has attempted to construct a partial model of the system at half scale, after a careful reading of various drawings, in particular, cross section and plan drawings obtained from the Schindler archive.[32] The system's components were constructed with basswood, and then assembled piece by piece to demonstrate a construction sequence in which tectonic and demountable qualities could be observed.

The reconstruction not only reenacts the construction process of the system but also illustrates a complete design, indicating locations of panels and connection details. (Figure 11.) First of all, once the concrete foundation is poured and has dried, bentboards with mudsill plates are bolted to the foundation. After floor panels are lowered into place, bases, posts, wall panels, sash and door panels are positioned according to the design. On top, roof and pergola panels are set in place, and endrafters and fascias are anchored to the roof panels. Finally, roofing materials with insulation underneath, cover the plywood roof sheathing. All panels are glued to structural members. No nails are used to connect the components but all voids are sealed. This process echoes Schindler's words: "No attempt shall be made to conceal the joints … All attempts of the 'knock-down' systems to simulate monolithic construction will end in failure. Articulated joints will facilitate alterations and repairs." The procedural logic of the construction process is so clear that it speaks without ambiguity.

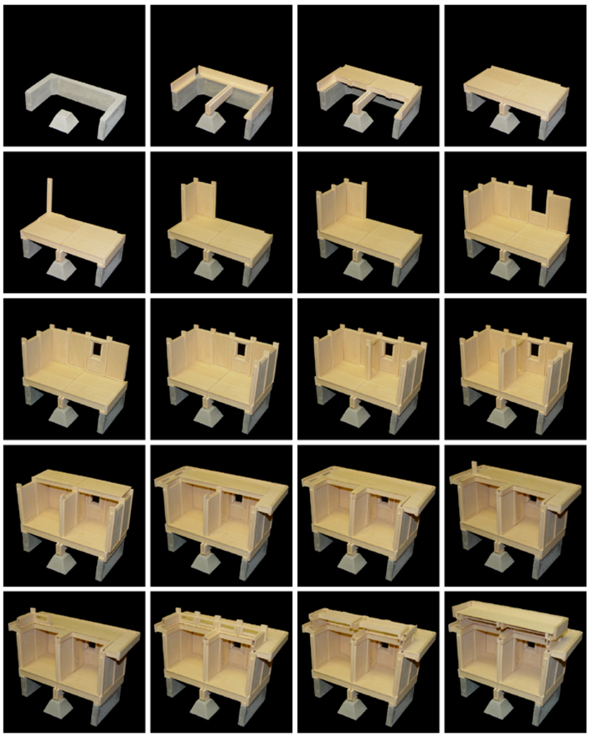

Figure 11. Panel Post Construction system: ½ inch scale model reconstruction of components with their step-by-step assembly (Model is constructed by Jacob Kwon).

Advances in computer technology make it possible to verify the whole construction process in which a standard unit is assembled with precise measurements, and to illustrate the spatial flexibility, diversity, and interchangeability of the housing design in a short time frame. Once an inventory of building components is fabricated in the computer, a multitude of unit variations can be easily constructed. (Figure 12.)

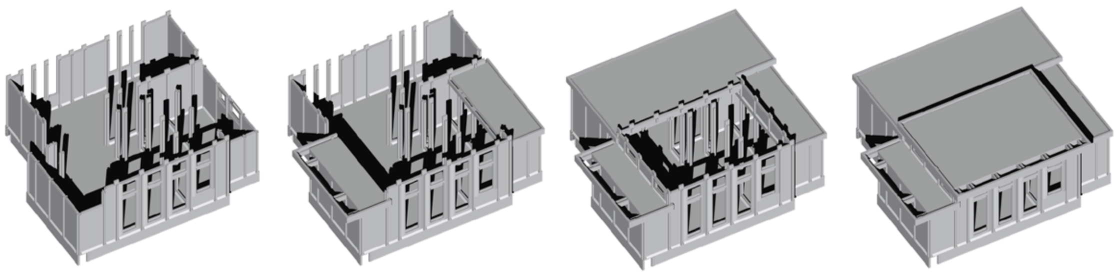

Figure 12. Computer generated unit model with the Panel Post Construction system

Conclusion

This study proposes that Schindler's Panel-Post construction system was, and could still be, an excellent solution to the contemporary low-cost housing problem in design and construction. One of the merits of the Panel-Post construction system is the systematic use of design strategies and the extraordinary variety of flexible space layouts. The kit-of-parts prefabrication is a solution to efficient and accurate construction and economy of costs. When Schindler's space reference frame, which is a proportional system, is incorporated with his principles of spatial organization, it can help to guide diverse spatial layouts of the components in housing design and planning. The interplay of Schindler's construction systems and design strategies demonstrates its potential for continued application in the development of a housing of quality and diversity.

This study can also play a significant pedagogical role in promoting an ongoing discourse concerning the development of housing options. These lessons could be applied as canonical solutions and pedagogical references to the wider understanding of the structure of complex housing problems as well as to the development of new housing typologies, which can then be adapted for contemporary housing developments.

Endnotes

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[1] See Albert Bemis and John Burchard, *The Evolving House: Vol. III. Rational Design* (Cambridge: The Technology Press, 1936) and Brian Finnimore, *Houses from the Factory: System Building and the Welfare State 1942-74* (London: Rivers Oran Press, 1989).

[2] See, for examples, James Tice, "Theme and Variations: A Typological Approach to Housing Design, Teaching, and Research," *JAE* 46/3 (1993): 162-175. Ezra D. Ehrenkrantz, *Architectural Systems: A Needs, Resources, and Design Approach* (New York: McGraw-Hill Publishing Company, 1989). Manuel Gausa, *Housing: New Alternatives, New System* (Basel, Boston, and Berlin: Birkhaüser Publishers, 1998).

[3] Avi Friedman, *The Grow Home* (Montreal & Kingston: McGill-Queen's University Press, 2001).

[4] Carol J. Burns, "A Manufactured Housing Studio: Home/On the Highway, *JAE* 55/1 (2001): 51-57.

[5] Sherry B. Ahrentzen, "Choice in Housing: Promoting Diversity," *Harvard Design Magazine*, (Summer, 1999): 62-67.

[6] The program was undertaken under the National Industrial Recovery Act of 1933 initiated by the Franklin D. Roosevelt Administration. The Subsistence Homesteads was undertaken to develop experimental housing projects to decentralize the heavy industrial population resulting from the severe and prolonged depression of the 1930s. In fact, Schindler sent his plans to the Subsistence Homesteads division of the Department of Interior for their review. On January 10, 1934, L. Brandt returned the following comment to Schindler: "We would however call to your attention the fact that your designs show rather small kitchens. We believe it very important that the kitchens in subsistence homesteads should be the largest room in the house, as this becomes the workshop for the entire family." Schindler disagreed in his January 18, 1934 letter: "I realize the smallness of the kitchen and intended to increase its size for subsistence farm purposes. However I do not agree with the usual plan which makes the kitchen the mainroom of the house. Only the quick meals should be consumed in the kitchen. The evening meal which is of social importance. Should not be taken in an atmosphere of greasy pots and dirty dishes. This is why I made the partition between kitchen and livingroom removable." Correspondence between Schindler and Brandt is in the Architecture and Design Collection (ADC), University of California, Santa Barbara (UCSB). See Jin-Ho Park, *The Architecture of Rudolph Michael Schindler: The formal analysis of unbuilt work* (Ph.D. diss., University of California, Los Angeles, 1999) and Judith Sheine, *R. M. Schindler* (New York: Phaidon, 2001), pp. 94-95.

[7] Schindler in his 'Space Architecture' commented on Fuller's Dymaxion house "entirely from the viewpoint of facile manufacture." Schindler opined that Fuller was "putting the cart before the horse." See Rudolph M. Schindler, "Space Architecture," *Dune Forum*, (February, 1934): 44-46, and *California Arts and Architecture*, 47 (January, 1935): 18-19.

[8] See Lucien Kroll, *The Architecture of Complexity*, Peter Blundell Jones, trans (London: B.T. Batsford Ltd, 1986). Ehrenkrantz, *Architectural Systems: A Needs, Resources, and Design Approach*. N John Habraken, *Supports: An Alternative to Mass Housing* (New York and Washington: Praeger Publishers, 1972), and N John Habraken, et al, *Variations: The Systematic Design of Supports* (Cambridge: The Laboratory of Architecture and Planning at MIT, 1981)

[9] Rudolph M. Schindler, "Prefabrication Vocabulary," *California Arts and Architecture* 60 (June, 1943): 32-33.

[10] Lionel March and Judith Sheine, eds., *R M Schindler: Composition and Construction* (London: Academy Editions, 1993).

[11] Rudolph M. Schindler, "The Schindler Frame," *Architectural Record*, 101 (May, 1947): 143-6.

[12] See Schindler, "Space Architecture," pp. 44-46 and pp. 18-19. Also, Rudolph M. Schindler, "Answer to questionnaire from the school of Architecture, University of Southern California," (1949) R.M. Schindler Papers, ADC, UCSB.

[13] Garland Architectural Archives, *The Architectural Drawings of R.M. Schindler: the Architectural Drawing Collection, University Art Museum, University of California, Santa Barbar*a, ed., by David Gebhard, (New York: Garland Publication, 1993): Drawing no. 3179.

[14] Schindler noted on the drawing (Garland no. 3153) in the upper case: "PLAN SHOWS SOME VARIATIONS OF LAYOUT & STREET FRONT DESIGN DUE TO CHANGE OF LOCATION OF GARAGE ONLY. FURTHER VARIATIONS POSSIBLE: 1) USE OF SEVERAL BASIC TYPES, 2) REVERSAL OF EXPOSURES (MIRROR PICTURE), 3) ADDITION OF PERGOLAS, ETC., 4) COMBINING OF HOUSES INTO GROUPS, 5) COLOR OF BLDG, 6) PLANTING." The spatial variations of the Schindler Shelters can be analyzed and described with regard to symmetry. Among variations, one of the units was a reflection and rotation of another unit with some adjustment of elements. The overarching advantage of these variations is that an enormous variety of units could be obtained with simple planar symmetry transformations including reflection, translation, rotation, and glide reflection. Furthermore, the symmetry strategy could be expanded for numerous possibilities of laying out shelters on a city block to maximize a variety of streetscapes. See Jin-Ho Park, "Symmetry and Subsymmetry as Characteristics of Form-Making: The Schindler Shelter Project of 1933-42," *Journal Architectural and Planning Research*, 21/1 (2004): 24-37.

[15] Using light metal forms, wire mesh, and cement plaster, two one-inch thick slabs are used to form double wall panels. These two panels were connected and braced by a steel truss-like system spaced 16 inches apart. Thus, it formed panels16 inches wide by 6 feet long weighing 12 pounds each. Although light and thin, these double walls were strong enough so that they work as structural supports. The detailed construction technique and process of the Garrett system were well explained by Lewis Goss in an article, "The Garrett plastered House – A Frameless, Reinforced Unit" in *Progressive Contractor*, in July 1933. Schindler was not the only architect who adopted the Garrett construction system. Raymond M. Kennedy used the system in his design, although it looks very

different from the Schindler Shelter. See *the Los Angeles Times Sunday Magazine* (May 7, 1933).

[16] Rudolph M. Schindler, "Reference Frames in Space," *Architect and Engineer* 165 (1946): 10, 40, 44-45. The first draft of the article was written and sent to Frederick Heath, Jr., who was the chairman of the subcommittee on Modular Products with a letter dated August 17, 1944. Schindler wrote, "Your [F. Heath, Jr.] KIND LETTER OF JULY 20TH SPURRED ME TO ORGANIZE MY IDEA OF THE UNIT PLAN AND I AM ENCLOSING THE RESULT." Schindler types in uppercase. Heath Jr. responded to Schindler's article as "the excellent presentation."

[17] Schindler's 1920 Free Public Library competition project attests to one of the first application of this system. See Jin-Ho Park, "Schindler, Symmetry and the Free Public Library, 1920." *Architectural Research Quarterly* 2/2 (1996): 72-83.

[18] The Panel-Post construction system was copyrighted in 1936 (Schindler applied for the copyright in 1935). In a letter to the Bureau of Patents in 1938 (June, 20), Schindler inquired about whether he could patent the system and referred to the copyright there, Class 1, No. 13836, April 1936, ADC, UCSB. In it, Schindler said that he developed the scheme in 1935.

[19] Garland 2537.

[20] Schindler, "Prefabrication Vocabulary," pp. 32-33.

[21] Ibid

[22] The 34 headings include: Building, Prefabrication, Purpose, Individualization, Production, Standardization, Transportation, Field Work, Simplicity, Speed of Erection, Regulations, Climatic Conditions, Soil Conditions, Building Plan, Modules, Flexibility, Salvage Value, Construction Joints, Weather-Proofing, Vermin-Proof, Mechanical Equipment, The Units, Materials, The Post, The Base, The Wall Unit, The Openings, Trim, The Roof, Built-Ins, Finish, Space Forms, Clerestory, Panel-Post Construction.

[23] Garland no. 2585.

[24] See Konrad Wachsmann, *The Turning Point of Building* (New York: Reinhold Publishing Corporation, 1961).

[25] Habraken gives a further discussion of the concept of the nominal dimension. N John Habraken, et al, 1981, pp.95-103.

[26] Schindler, "Prefabrication Vocabulary," pp. 32-33.

[27] Nevertheless, since the system has never been technically proven in practical use, the components and their assemblage must be subjected to a variety of physical and

structural tests and evaluations, including weather tightness, fire resistance, wind resistance, acoustical resistance, adequate racking strength, and heat transmission, when applied to actual housing construction.

[28] Schindler, "Answer to questionnaire from the school of Architecture, University of Southern California," (1949) R.M. Schindler Papers, ADC, UCSB.

[29] According to O'Brien (1999), "The extensive use of manufactured products in no way limits the space for making architecture." For O'Brien, architects should take the role of coordinators or consumers to select and accommodate manufactured products between manufacturers and clients in a given project. James P. O'Brien, "Consuming Sweets: The Work of Architecture in the Age of Selection Among Manufacturers' Manufactured Differences," *JAE* 5/1 (1999): 25-34.

[30] *The Architectural Forum* (December, 1934): 400-407.

[31] Schindler continued to apply the Panel-Post construction system in his consecutive residential projects. For example, the system was tested presumably on one of the Park Moderne projects in 1935-1938 (See Garland no. 2537) and the residence for J. Sollin in 1938 (See Garland no. 3272).

[32] Garland no. 2583 and 2584.