Learning Sustainable Design from the Recent Past:
Mid-Twentieth Century Southern California Houses

PABLO LA ROCHE[1], LEINA NAVERSEN[2] MARGARET JAMISON[2]

[1]Cal Poly Pomona University & HMC Architects, California USA
[2]Cal Poly Pomona University, California, USA

ABSTRACT: The connection of mid-century Los Angeles architecture with nature has been frequently discussed and mentioned. This paper provides additional insight into how several of these houses performed. To achieve this we did interviews with the occupants and one living architect, energy and daylight modelling, recorded data with data loggers in the houses over the summer and winter of 2012 and 2013, studied original documents, and even utility bills. We studied four mid twentieth century California houses: The Garden House at the VDL Research House (1939-40) by Richard Neutra, the Kallis House (1946) by R.M. Schindler, the Schrage House (1952) by Raphael Soriano, and the Kappe House (1966-68) by Ray Kappe. Emphasis is on the role of the house as an environmental mediator and the role of the occupant in this process. Time is important in day to day operation, and modifications on the house over the course of the years. This study demonstrates that a smart occupant can maintain thermal comfort in a mild climate with minimum energy use. Due to space limitations this paper will only discuss energy and solar control issues while daylight will be discussed in another paper.

Keywords: sustainable mid-century California homes, learning from the past, Kappe, Schindler, Neutra, Schrage

INTRODUCTION
The connection of mid-century Los Angeles architecture with nature has been frequently discussed and mentioned. This paper studies some of these houses with more rigor, emphasizing the connection between the occupant and the environment using the house as the mediator. Four houses have been studied over a period of more than a year. We interviewed owners and one of the Architects, performed daylight analyses and measured daylight levels on site, studied utility bills over many years, installed data loggers to record temperature and relative humidity, and performed carbon footprint calculations. Due to space limitations this paper will only discuss energy and solar control issues. Daylight and carbon footprint will be discussed in another paper.

ENVIRONMENT: CLIMATE OF LOS ANGELES
At a latitude of 34 degrees north, Los Angeles has a mild Mediterranean climate with summer temperatures between 29° C and 18° C and winter values between 19° and 9° C. According to ASHRAE [1] Los Angeles has 1495 Average Annual Heating Degree Days, base 65, and 4306 Annual Average Cooling Degree Hours, base 74; and from 8 AM to 4 PM there are 1849 hours a year with temperatures between 55 and 69° F, with only 145 hours below 55° F for this same hour period. Cool ocean breezes are common during the whole year and only for several days a year conditions are reversed when warm air blows from the desert. Most of the rainfall is during the winter months of January and February.

However, even though the buildings are located relatively close to each other, there are many differences due to micro-climates created by the topography and the effect of the Pacific Ocean. The Schrage House in experiences a 26º C average annual temperature differential, while the Kappe House in Pacific Palisades only experiences an 11º C temperature differential and is cooler in the summer and warmer in the winter. Both houses are located in hilly terrain, but the Kappe house is located a mile from the coast while the Schrage House is 15 miles from the coast and less subject to the ocean's effect.

RESPONSE TO SITE: LAYOUT AND MASSING
All of these houses are intricately connected with the natural environment around them so much so that the design of the garden becomes as important as that of the living room. This is an attribute perceived very favourably by the occupants.

Schrage House
The layout of these houses was not typical, and as Miriam and Steve Dodge said of the Schrage house where they have lived for many years *"In terms of the way the house is sited… it turns its back on the street and faces all of Griffith Park so you get a good view, and who wants to look at a street with all the cars going by?"*[3]. This topography also affected the breezes *"Every afternoon the breeze comes straight down."*[3]. Integration with the natural environment was an

important design idea and is understood and perceived by the occupants *"It's the siting and the way he has opened up the whole yard with the wall of glass. You feel you're entirely part of the whole site, not just cloistered inside and have to go outdoors."* [3].

Kallis House

The house steps down the hilly site in three layers (Fig 1). At the highest level, the driveway goes through the garage which follows the curve of the street. Below, in the space between the garage and the habitable portions of the house is the main entry room. The living spaces and terrace form the last layer, arranged in a bent L following the contours of the hill, and overlooking the valley below. [8].

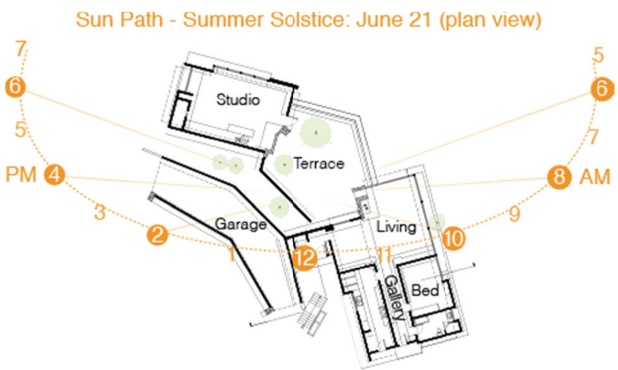

Figure 1: Layout of Schindler's Kallis House

VDL Garden House

Neutra built his VDL house to promote "biorealism" – a concept he defined as people being in harmony with nature and themselves. The VDL House was Neutra's living laboratory to provide lessons about human scale and interaction with the natural environment that could be applied to work for larger public projects. He strove to "achieve a privacy and spacious living despite the constraints and density of the urban neighbourhood," stating this was possible through discovery of the "profound assets rooted in this site and buried in it like a treasurable wonder." He considered the landscape and architecture equally in design, paying careful consideration to views, sources of wind, and the changing positions of the sun [9].

The Garden House was a guest house added to the primary residence in 1939, seven years after the earlier construction. Neutra closed off the back garden into a courtyard with the building of the new T-shape structure, adding an asymmetrical volume to the pure geometry of his International Style home [5]. This is one of the houses that we have analyzed in the next sections.

Kappe House

Ray Kappe's house was completely driven by site conditions, the slope and the springs, which determined the method of constructing the house by touching down as little as possible. As he explained, *"I couldn't drive piling beyond where I'm sitting. I came to the conclusion to use these 6 tower units that would carry the house and I would bridge between them and cantilever as much as possible."* (Fig 2). *"The site comes 45 degrees to the house because I wanted the house to be parallel to the street, and that creates the step-up from the low point to the high point. Those were strong determinants in the process."* [4]

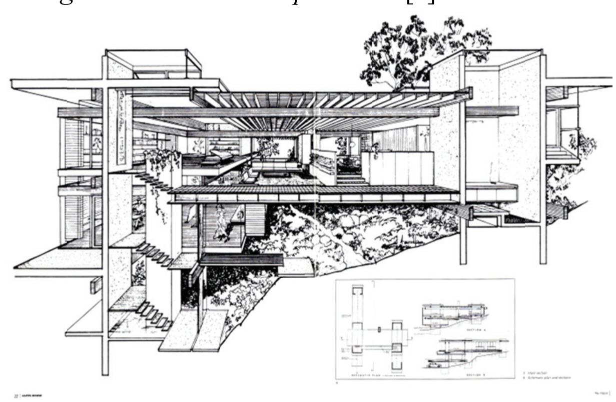

Figure 2: Ray Kappe's house on the site (image courtesy Ray Kappe)

ENVELOPE

The building envelope regulates outdoor conditions to maintain thermal and luminous comfort. These houses were not well insulated, and usually had extensive glass surfaces. However, because the climate is relatively mild and the buildings are shaded with numerous operable windows and sliding doors, they respond quite adequately to outdoor conditions and usually better in the summer than in the winter. The act of connecting the outdoor with the indoor responded to a new attitude towards nature. This connection could not be achieved simply by increasing the size of the conventional window openings; a more drastic change was needed and thus floor to ceiling windows appeared.

Kallis House

Schindler wrote of his ideas on comfort through natural means in 1926, "Useful as our heating systems may be … their basic principle is faulty. … Anyone who has experienced the stimulating effects of a cool pure breeze on a sunny mountaintop … will realize that the old campfire uses a more wholesome method of heating than all of our complicated modern plants. The house of the future will provide cool, clean, constantly changing air, but will keep us warm by means of direct heat rays emanating uniformly from the walls and the ceiling." [6] The occupants of the Kallis house are aware of the lack of insulation, mentioning in their interview, "*There is no insulation here…. That certainly makes you aware of living in the climate that you're in.*" [7]

Schrage House

The Schrage House was designed with a broad overhang to the south that protects the sun in the summertime and allows it in in the wintertime. When these homes were built, insulation was not required or common, and over time some of them have had to improve the quality of their envelope. As Steve and Marion Dodge mentioned, "*We have added lots of insulation in our restoration and that is as good as we could improve the design. The roof insulation has a lot of fiberglass batts, better sealed."… Infiltration is an important element of that (that affected performance). Soriano had insulation in the south wall – insulation was a brand new thing and he was into everything that was brand new.*" [3]

Kappe House

These architects were aware of the importance of insulation and good glazing, however they were also aware of the moderate climate. As Ray Kappe said, "*Probably today you have to* [use dual pane glass] *to get by Title 24. That always bothered me in California. Our climate is not so severe that you have to do all that. We didn't think like that at all. Look back in the days when Schindler was doing his stuff and you were supposed to sleep outside and shoji panels let all the cold air through. It was a different time. We didn't even used to insulate hardly. I didn't insulate the walls at all because I had so much glass everywhere, what's the use in insulating a few pieces of wall. The roof was half inch Solitex, or one inch if you were extravagant. Today it's 4 inches. It's just a whole different way of thinking.*" [4]

THE OCCUPANT, OPERATION AND THERMAL COMFORT

There are several variables that affect thermal comfort, usually defined as thermal environmental factors (dry bulb temperature, relative humidity, air movement, solar radiation) and personal factors (activity level, clothing).

In these houses the occupant is a key figure to achieve thermal comfort. The architects provided the solution and the occupants operated the solution which was the house. These occupants were engaged with the buildings and knew what to do to achieve and maintain thermal comfort. They knew when to open and close a window or when to open and close blinds. They even knew how to add elements to improve the performance. An example are the large drapes in the Schrage house that the Dodge's added to reduce heat losses in cool nights and were also sometimes used to block solar gains when the overhang was not sufficient in the summer afternoon. These simple but beautiful buildings provided simple methods for engaged occupants to control the natural forces around them to maintain indoor comfort.

Schrage House

The Dodge's relationship with the Schrage house is a good example of the how the occupants operate it on a daily and seasonal basis while also modifying it over the longer term and restore the heating system to the original radiant floor method designed by Schrage. In their interview they mentioned that, "*The first thing we did was restore the radiant heating in the floor. The forced air* [system] *was completely inadequate. There was just one small register in this huge living room and one small register in the dining room. By having the radiant heating it's just even heats throughout the house and it does work just like he said it would.*"[3]

They also replaced the glass on the north side, adding a better sealed glass and explained that, *"we can open windows and get ventilation. There are a few days each summer that are pretty rough, but we keep the house closed and try to open it up to get the night cooling air. I think we have been able to manage and use the windows and curtains to manage* [the indoor temperatures]*."* [3]

In regards to operable windows and shading, they also state that they *"open it wide in the winter and close it down sometimes all the way in the summer. We let it vent a little bit in the summer but block the western sun. It's changeable depending on the season and how hot the day is. We can also close the curtains to block the west sun from directly coming in. In the winter the sun is almost getting too low."* [3]

It is also interesting to see how they find different ways to understand the house. *The cats find the warm spots most of the time, so we'll open it as wide as we can every winter day for them and close it at night because it will rain. Having moveable stuff like curtains and the shade does help select what you need to do for that day, it gives you flexibility."* [3]

Kappe House

Ray Kappe starts using the radiant floor heating system around November and stops using it around March. According to Kappe, the trees and the sloped site shelter the house from cold winds in the winter. Deciduous trees in the front yard lose their leaves in the fall and allow solar heat gain through the SE glass doors off of the living room in the mornings. Direct solar gains through the southeast glass doors off of the living area warm the space by solar radiation.

In the winter Kappe usually wakes up around 7 am and sets the thermostat to 70º F. In the morning and early afternoon the southeast facing doors on the living room are cracked opened to allow for natural ventilation. Louvered windows in the bedrooms, upper living room, and studio are also cracked open for cross ventilation. When Kappe is not working he likes to sit in the living room and enjoy the view, watching the sun change and see the night coming in. Heating is necessary when it gets down to the 40's, 50's at night and the thermostat is set to 64º F which usually happens only between October and March in the very early morning. Figure 4 shows temperatures one winter week in the house. The effect of the radiant heating system is evident. The temperature in the living room is also higher than in the study room which is in the ground floor.

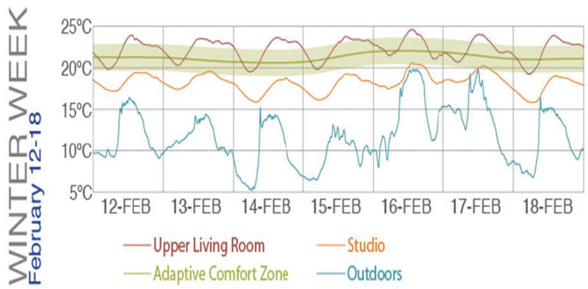

Fig 4. Winter week temperatures Kappe house

Pacific Palisades has a very mild summer and outdoor temperatures are rarely above 70º F or even above the indoor temperatures (Fig 5). The natural spring runs under the house and keeps the lower parts of the house cool with evaporative cooling. The thermal mass of the concrete towers moderates temperatures even more and keeps the house cool. Trellises and leafy trees shade the house during the sunny parts of the day. The balcony doors and louvered windows in the studio and bedrooms are also opened to allow for cross ventilation. Kappe says that during the summertime he does not have to do anything with the thermostat, the house is completely passive, free running and comfortable most of the time.

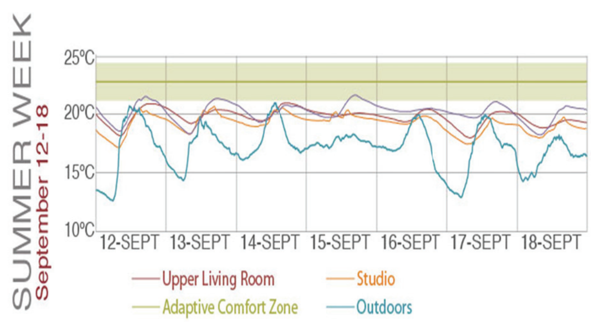

Fig 5: Summer week temperatures Kappe house

Kappe also states that, *"Because I have a lot of glass and I don't have any protection on the glass (blinds, or drapes) you're going to get a little more heat loss than you would normally because there's no potential to keep the heat in. I'd rather have a view. ... You don't need air conditioning in this climate. I have clients that have houses down at the beach who want air conditioning. I tell them they're crazy. ... The hottest we get here is 88 to 90. We've had those days, in fact we've had two major affairs here. We had 200 people in here on the hottest day of the year. We opened the doors and everybody was very comfortable even with all that added body heat BTU's. If you have one hot day, who is going to put on air conditioning for that?"* [4] In other words he can tolerate a couple of uncomfortable days in the summer instead of dealing with additional electrical energy use and sealing the house for air conditioning.

VDL Garden House

Overhangs block out direct rays in summer while winter rays are able to penetrate deeper into the space from lower angles. The Garden House is shaded by the main house from the warm afternoon sun, and the courtyard environment between the two structures is pleasantly cooled by shading plants and a reflecting pond (Fig 6).

Fig 6: VDL Garden House. Photo Courtesy Kenneth Naversen

Data loggers recorded environmental conditions at the VDL Garden House over a week in the winter, showing how the garden modulates the extremes of the outdoors without use of insulation or mechanical heating. However, it was usually cool inside the house and its current occupants complained of the cold (Fig 7).

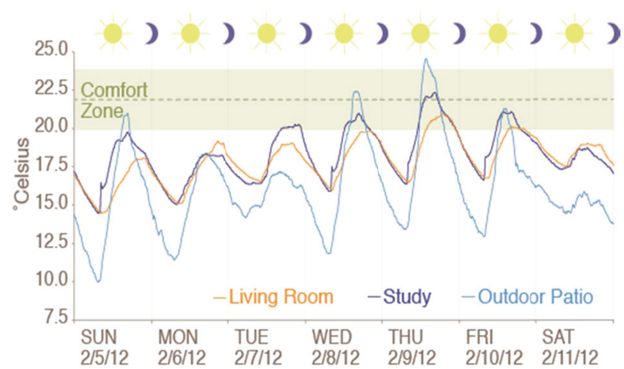

Fig 7: Temperatures for winter week in VDL Garden House

The VDL garden house is not insulated, and residents don't use the old gas heating system. Indoor temperatures stayed below the comfort zone for much of the testing, but daily fluctuations were only 5 to 10° F indoors, compared to outdoor swings of up to 20° F and from a low of 50° F to a high 76° F. Overnight temperatures were similar for the living room and the study throughout the week, usually about 6-8° warmer than the outdoors. The study was often warmer than the living room. Although it receives no direct radiation, perhaps less overall glass coverage towards the exterior prevents some of the heat loss in the winter time. On a warm winter day such as Thursday February 9, the outdoor temperature exceeded the comfort zone, while inside the study it remained comfortable. Shaded by the main house, the garden house can still remain cool in higher temperatures.

SOLAR CONTROL

Solar control was usually achieved with overhangs and vegetation and the architect understood its importance to keep the building from overheating in the summer.

VDL Garden House

Though interested in modern technological advancement, Neutra relied upon the sun for warming and illuminating the space before mechanical and electrical means. However, the VDL garden house uses single paned windows, no insulation, and is leaky. Using large plates of glass on east and west walls, abundant sunlight enters the house both morning and afternoon. In the main living room, his design was effective in allowing direct radiation to warm the space in the winter, while permitting long periods of natural daylight in interior spaces year-round. The west facing study does not perform as well because it allows direct radiation for three hours on the summer solstice (when shadows from the main house are not long enough to shade the windows), but none on the winter solstice (when shadows from the main house are long). In the winter, the study receives about two hours less daylight overall. The guest room, though one of the only south-facing spaces, is deeply shaded by the main house. With the fewest windows, it permits the least amount of natural light year round. However, its orientation does allow one hour of insolation to the interior environment on the winter solstice, while preventing any solar intrusion during the summer.

Figure 8 shows the hours of ambient daylighting (at least 10 footcandles covering half of the space) and direct solar radiation for the three rooms on the winter and summer solstice. The spaces received adequate daylight the whole year, were mostly shaded in the summer with some unnecessary radiation and good insolation overall in the winter.

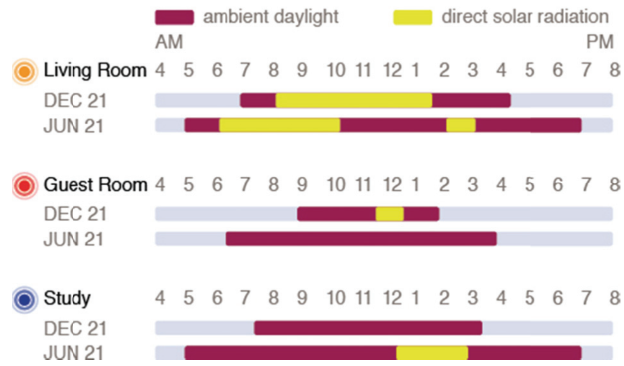

Fig 8: Daylight and Solar Radiation inside the VDL garden house

NATURAL VENTILATION

Natural ventilation was an important strategy in these houses and a very simple one to implement.

Kappe House

The Kappe's continuously use natural ventilation. As Ray Kappe expressed in the interview, "*Normally the doors to the front deck are open. The other window down by my studio – that pretty much does this part of the house. On a hot warm day like today the house is cooler than the outdoors, so I open it up to let some warm air in. The concrete mass accepts the cold air so it takes a few hours for the house to warm up. You get the ocean air through the canyon – that does the job. Windows in bedrooms are open too. When it's cold we don't open it up as much. Shelley is particularly susceptible to breezes – we're really opposite – I like air and she doesn't – it affects her shoulders, so we don't open up as much when it's cool.*" [4]

VDL Garden House

Prevailing breezes arrive off of the Silverlake Reservoir across the street to the west of the house. Ventilation is able to pass through the house into the central courtyard between the main house and the Garden House. Shaded by the higher structure, and cooled by ventilation, foliage and evaporation from the reflecting pond, the garden house enjoys a cool micro-climate facing the courtyard. Over time, the front windows of the VDL House have been closed off due to street noise and pollution [2]. These changes have diminishing some of the potential benefits of natural ventilation through the house when cooling is needed, though many of the large windows are still operated by its occupants.

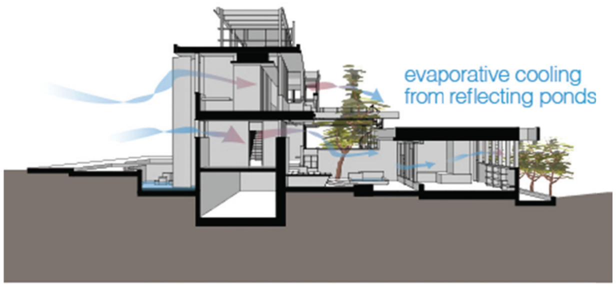

Fig 9: Natural ventilation, cooling breezes from silver lake reservoir

CONCLUSION

These homes were intimately connected with their sites. They understood the topography, surrounding vegetation, views and natural features of the terrain. The conventional house was typically conceived as a solid mass growing out of the ground. These houses were integrated with the environment, as a single unit in which everything was integrated: site, form and indoor space.

These architects believed in an enclosure that controlled the environment through air movement and solar gains. They achieved this by designing operable envelopes and large openings that created the now famous indoor-outdoor connections and that provided numerous opportunities for cross ventilation, daylight and solar control. These large glazed openings also increased heat losses in the winter when they were not associated with solar gains. Ray Kappe did numerous studies to demonstrate that in the cool but sunny southern California winters, more glazing in the right orientations was more beneficial than limited glazing None of these homes had an air conditioning system nor did the owners complain about the lack of cooling except for a few days in the summer. However, the Sharlins after living for many years in the Kallis House added air conditioning in 2002, because the husband was getting uncomfortable after returning home from an air conditioned work, and they believed this would increase the value of their home.

The architect also understood that thermal comfort was more than just providing an adequate temperature and implemented non-traditional systems such as radiant heating which affected radiant gains. Bad buildings have low Mean Radiant Temperatures MRT's in winter and high MRT's in summer; this contributes to large differences in the vertical air temperature; creates excessive drafts and increased radiant asymmetry. Radiant systems helped to reduce this asymmetry.

All of these homes have engaged occupants that love the homes in which they live, and have lived in them for many years. They know how they work and they operate them appropriately, demonstrating that an active user is an important piece in the process to achieve and maintain thermal comfort with minimum energy use.

These buildings were not more expensive or complicated than other buildings of their time. They provided simple solutions for engaged occupants to control the natural forces around them and achieve thermal comfort. This interaction between the occupants and the houses is affected by daily and seasonal cycles. This study demonstrates that these houses, when operated by an educated occupant, can maintain thermal comfort and good lighting with minimum mechanical heating and cooling while reducing their carbon footprint, something that we seem to have trouble doing more than half a century later .Subsequent papers will discuss daylight issues in more detail.

ACKNOWLEDGEMENTS

This research was developed for the exhibit “Technology and Environment: The Postwar House in Southern California” co curated with Judith Sheine, Lauren Bricker, Philip Pregill, and Tim Sakamoto on display during the spring of 2013 at the Kellogg Gallery at Cal Poly Pomona University, partially supported by the Getty Foundation as part of the series Pacific Standard Time presents.

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