

The Charnley-Norwood House: A Turning Point in the History of American Environmental Design

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ABSTRACT: The Charnley-Norwood House, situated along the Mississippi Gulf Coast, is a lesser-known vacation bungalow drawn by Frank Lloyd Wright as an experiment while working under his “Lieber Meister”, Louis Sullivan. Built in the latter part of the 19th century, it exemplifies a turning point in American architecture as the groundwork for Wright’s signature Prairie Style was taking root. Embedded within this structure are fundamentals about an organic approach to architecture, clearly demonstrated by the assimilation of the building into the interworkings of both site and climate. Sullivan and Wright scholars both agree that this house, undocumented to-date, serves as a significant milestone in the history of American environmental design.

What is unknown about the house is how the dictates of the coastal gulf climate influenced its spatial disposition and how this composition grew out of well-established traditions of environmental design. The T-shaped bungalow encompasses many distinctive features including its overall horizontality, an overarching parasol roof plane, a permeable building exterior and intermediary space types along its perimeter. The open plan organization follows its predecessors in its thinness with rooms dispersed along each axis, creating multiple exposures that alter the orientation of interior spaces to year-round climatic effects. Operating in concert, these attributes serve to admit prevailing breezes, extend views to the surrounding landscape, and shade inhabitable areas; hallmarks that would alter the course of 20th century residential architecture in America.

Using computational simulation tools, this paper discloses how the bungalow advances strategies of passive design utilized by early 19th century predecessors and paves the way toward an environmentally integrated 20th century period of residential construction. Additionally, this paper offers insight into a formative moment in architectural history when two American masters were in direct collaboration.

KEYWORDS: computational simulation, organic architecture, thermal zoning, Louis Sullivan, Frank Lloyd Wright

INTRODUCTION

Architect Louis Sullivan with his emerging assistant Frank Lloyd Wright designed the Charnley-Norwood House, originally constructed in 1890. Commissioned by James Charnley as a vacation retreat for his family during harsh Chicago winters, the house sits along the Mississippi Gulf Coastline, in Ocean Springs. In 1895, the house was sold to another Chicago merchant, Frederick Norwood. Following restoration in 1980 and severe damage due to Hurricane Katrina in 2005, the house was built to its current state with restoration efforts concluding in 2013. The house is managed by the Gulf Coast National Heritage Area Program under the Mississippi Department of Marine Resources and is currently open for public tours (Hoglund and Quinan, 2017). The T-shaped three-thousand-square foot bungalow is positioned along the southern edge of the estate, neighboring the waterfront, with expansive panoramic views of the Davis Bayou on the Gulf of Mexico to the south. The main axis of the house runs in the north-south direction while a secondary axis crosses perpendicular in the east-west direction. The distribution of programmatic spaces adheres to its formal composition where the private bedrooms are situated at the ends of the east-west axis while the public entry hall, octagonal dining room and service areas including the kitchen and the butler pantry run from south to north along the main axis. From the entry point at the southern end of the house, distinct programmatic zones flow freely from one to another, separated only by narrow passages defined by enclosed utility spaces. Each programmatic zone opens directly to the exterior with generous windows and doors to the outside that operate for ease of cross ventilation. Public spaces such as the entry hall and the octagonal dining space open directly to the exterior where intermediary porches further soften the transition from outside to inside. A large parasol roof plane unifies the composition, protecting all inhabitable spaces from the harsh summer sun and rain while its ventilated cavity helps exhaust hot air accumulating within the structure (FIG. 1).

While the house is unarguably distinctive within its late-nineteenth century Victorian context, its attribution is shrouded in mystery. Louis Sullivan and Frank Lloyd Wright scholars alike ascribe authorship to their respective subjects since both Sullivan and Wright take credit for the design on separate occasions.

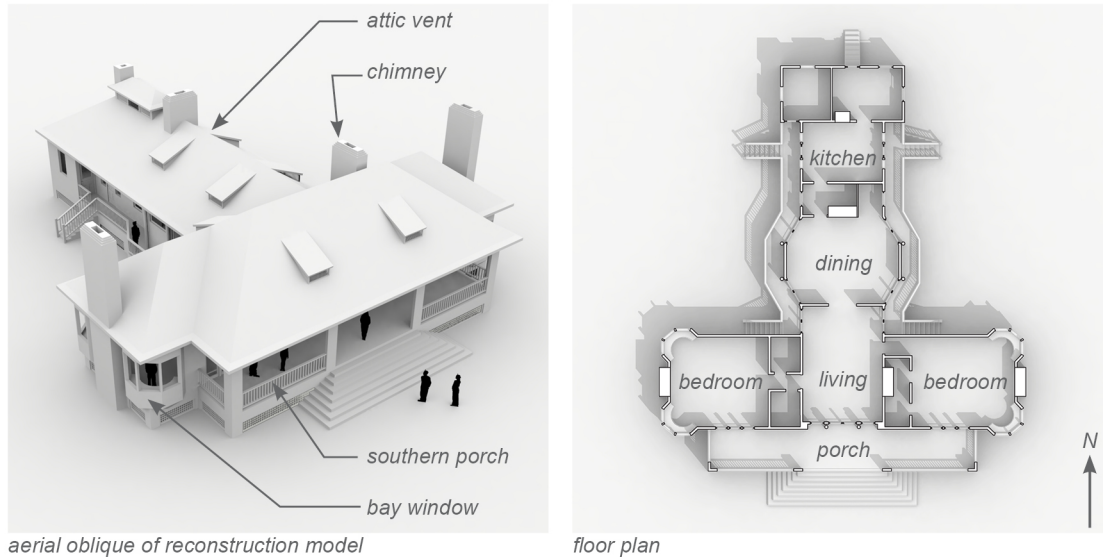


Figure 1: Digital reconstruction of the Charnley-Norwood House. Source: (Clark and Frank 2016)

Sullivan recalls giving a local carpenter drawings for the ‘shack’ to construct after designing the structure in hurried fashion (Sullivan, 1956 [1924]). The reconstruction of the house in 1897, following a fire, supports this point because it was built to the original specifications even though Wright was no longer working in Sullivan’s office. Wright, on the other hand, takes credit for the drawing of the ‘cottage’, the first modern house in America from his perspective, in reflecting upon experimentation during his early career with Sullivan (Wright, 1949). This account is also sustained by the office workflow during this period, where Sullivan, occupied with much larger commissions at the time, often bestowed smaller projects to draftsmen like Wright to develop. Regardless, signatures of both Sullivan and Wright permeate the structure including its flowing disposition of spaces and sweeping intermediary zones along the perimeter, representing a time in American architecture where two masters were in direct collaboration, forging a distinctive approach to environmental design. Rooted within this house are Wright’s early ideas about ‘organic’ architecture that extend Sullivan’s principle that ‘form ever follows function’ (Sullivan, 1979 [1896]). The belief that a building should sustain its most fundamental purpose of physical dwelling within the particularities of a place is the shared principle that connects them and carries them both into the early-twentieth century era of modernism in America.

1.0 BACKGROUND

For Wright, the concept of Organic Architecture was the modern ideal that a building is an integrated network of relationships comprised of elements both internal and external to the structure itself (Conrads and Bullock, 1970). This understanding of architecture coincides with studies in human ecology that also emerged at the beginning of the twentieth century that holistically examines the mediating factors that regulate natural and human ecosystems (Raffestin and Lawrence, 1990). While formalized as such in the early-twentieth century, this understanding of the built environment’s role in moderating relationships between people and their surroundings traces back to Hippocrates in the fifth-century BCE and was elaborated upon by Vitruvius in the first-century BCE, whose work Sullivan attributes as the core of his aforementioned adage (Sullivan, 1979 [1896]). According to Wright, the completeness of the structure, where the coherent whole is greater than the sum of its parts, should incorporate provisions for viewing, lighting, heating and cooling. Integrating these factors reinforces the symbiotic relationships that exist between the human inhabitant and the natural world instead of trying to merely replicate organic forms within the building itself, a prominent approach during the mid-to-late nineteenth century Victorian era (Wright, 1975 [1914]). In his outline for a new twentieth century modern architecture, Wright articulates the following architectural strategies that reinforce these organic relationships between people and place (Wright, 1960 [1957]). Decentralization is a model proposed by Wright for urban development and smaller tributary applications that extends inhabitable space along the ground plane to better connect to natural resources. Following suit, horizontality is a strategy employed by Wright to integrate building elements directly into the earth resulting in the planar stratification of space that softens the distinction between ground and the built environment. Permeability results from ingenuities in twentieth century material science that enables Wright to utilize larger structural spans and lighter building enclosure systems that result in direct connections between interior and exterior while offering freedom in planning. Moreover, open planning is a principle used by Wright to leverage new freedoms enabled by larger structural

spans and increasingly slender supports that unify interior spaces, inviting more liberal planning and flexibility of use. This leads to the strategy of continuous space employed by Wright, opening interior spatial dispositions to the outside while enabling renewable natural resources to enter, diversifying the occupiable zones of a structure through the introduction of intermediary space types. While published at the end of Wright's career, evidence of these strategies pervade the Charnley-Norwood House, one of the earliest buildings in his oeuvre, demonstrating the lasting influence of his architectural roots from Sullivan's mentorship to the indigenous tactics used by their predecessors.

Scholars of both Sullivan and Wright agree that the Charnley-Norwood House, undocumented to-date, is a neglected milestone in the history of American environmental design (Twombly, 1986). While the environmental movement was scientifically explicated in forms of mid-twentieth century modern architecture, the Charnley Norwood House foreshadows the impact of structural and envelope advancements in the built environment. Moreover, correlations have been made between the house and southern vernacular building types including the bungalow and the dogtrot due to its characteristic central breezeway, multi-nuclear plan, parasol roof and sweeping verandas on the eastern, western and southern edges of the house (Storrer, 2017). These attributes are consistent with traditional buildings in the humid Southern United States that exhibit elevated floors to catch prevailing winds; parasol roofs to shelter from sub-tropical sun and rain; continuous porches to extend living areas outdoors; operable apertures to maximize cross ventilation; ventilated attic cavities to exhaust buoyant hot air; and shutters for ventilation and privacy (Banham, 1966; Fitch, 1961). By exhibiting many of these traits, the house provides ample evidence that the design was likely devised in response to the dictates of the southern climate. Furthermore, by echoing the strategies outlined in Wright's new architecture above, these indigenous characteristics appear to underpin his organic philosophy, a common theme of Wright's who often found inspiration in the work of pre-industrial societies (Fitch, 1990). However, the primary question posed in this paper is how the structure, identified as a milestone in the history of environmental design, advances passive technologies from vernacular to modern traditions, a question that requires further investigation with the use of state-of-the-art simulation and modeling tools.

In light of our ongoing climate crisis and the role buildings have in curtailing high grade energy usage, the survival of indigenous building strategies, especially those that moderate environmental forces using largely architectural means, is crucial and worthy of further investigation. Furthermore, a deeper understanding of environmental design principles is of great interest within today's socio-political climate which has tended to marginalize the significance of the natural environment and the impact human enterprises have on it. Understandably, if one is able to uncover and become aware of a wider array of climate-responsive techniques that underpin a building's compositional strategies, the preservation and promotion of these approaches becomes increasingly likely. With the emergence of building performance simulation (BPS) tools in recent decades, our ability to observe building boundary and environmental state interactions have increased exponentially. The simulation techniques presented below help measure the cause and effect of design decisions on the environment while making explicit connections between design, environment and quality of life within a shared domain. Through observation of simulation outcomes, we are able to tap into the vast body of knowledge that resides within case studies such as the Charnley-Norwood House to understand the progression of environmental design strategies over recent centuries for adoption in contemporary development.

2.0. METHODOLOGY

State-based BPS, within the full spectrum of computational simulation tools, involves the use of mathematical models to emulate the behavior of physical states such as light, heat and air. State-based BPS takes place within a defined digital domain comprised of geometric boundaries representing building elements, input states that approximate the prevailing climate conditions and output states that are measured against criteria for occupant well-being. Building data, obtained from reliable sources, serves as the basis for a digitally reconstructed model of the structure that is centrally located within the simulation domain. Climate data, recorded and logged from local weather stations is used to configure the input state profile and initiates the simulation analysis within the domain. Cultural data, taken from literary sources and adjusted in accordance with contemporary standards for comfort is used to evaluate output states to ascertain how the building provides occupant well-being with purely architectonic devices. Furthermore, the observation and measurement of state change, from input to output, within the modeling domain indicates the degree to which the building is able to modulate extensive climatic factors.

The initial stage in the analysis workflow involves the digital reconstruction of the case study using reliable sources. In the case of the Charnley-Norwood House, the fact that it is open to the public facilitated its on-site survey in addition to the restoration documents that are available to review during tour hours. From these on-site observations and orthographic datasets, a three-dimensional model of the house is constructed using

Rhinoceros™, a base interoperable modeling platform developed by Robert McNeel & Associates preferred for its navigable interface, interoperability and its facility in geometric alteration as it negotiates the formal language. As a non-uniform rational B-spline (NURBS) based platform, planar representations are imported into the domain, traced and translated to generate closed polysurfaces suitable for myriad forms of simulation analysis. At this stage, the ability to simplify complex building geometries for analysis abstraction is crucial to ensure the effective use of computational resources during periods of simulation. The interoperability between the base modeling platform and the simulation plug-in components in a shared interface eases the reiteration of testing sequences to give a more holistic understanding of a precedent's environmental design characteristics with state-based lighting, radiation and fluid dynamics analysis programs.

Once the building boundaries are digitally reconstructed within the NURBS-based platform, the workflow moves to the second stage, the systematic exposure of these geometric boundaries to input states that mathematically represent light, heat, and airflow patterns. This weather data, supplied by local instrumentation and maintained by the United States Department of Energy, supplies information on sunlight, temperature, moisture and wind on a continuous basis. The Mississippi Gulf Coast is classified in the Köppen system as temperate with hot and fully humid summer seasons. This climatic region resides 30 degrees north of the equator and 88 degrees west of the prime meridian. Significant seasonal variation is present with an average dry bulb temperature of 48° F in January and 82° C in July. The prevailing winds in the region generally come out of the north in the winter with average speeds around 10 mph while winds come off the Gulf from the south with speeds averaging 6 mph during hot summer months. Additionally, from the winter to the summer solstice, the sun's elevation angle along the coast shifts from 35–83° when measured at noon. The psychrometric chart indicates that only 5% of yearly hours reside in the comfort zone with shading, ventilation, cooling and dehumidification strategies providing a majority of the remaining comfort hours yearly in the region.

Changes in thermal, luminous and fluid states are observed in the context of the case study structure and evaluated against two cultural benchmarks. The first is comprised of qualitative performance outcomes desired by Wright, articulated in his late essay that underpins his organic philosophy while the second consists of quantitative norms for occupant comfort and wellbeing customary in the building practice today. In his 1957, "The New Architecture: Principles", Wright describes the multiplicity of views enabled by an organic architecture through spatial flows between outside to inside that cannot be controlled through singular points of view. Furthermore, the interpenetrating depths produced by permeable enclosure systems invites daylight from the outside to become an integral part of the built environment's interior disposition. An organic architecture also offsets the need for mechanical heating and air conditioning systems by integrating these functions into the building structure itself through elements with thermal mass including hearths. Cooling is prioritized in Wright's organic architecture through the operability of windows and doors that bring fresh air into the building while using an expansive roof plane to shade the interior during hot summer months (Wright, 1960 [1957]). In contemporary architectural practice, performance parameters are expressed in increasingly quantitative ways. These parameters include abundant access to uniform daylighting with a minimum of 250 lux over 90% of a floor plate, with maximum levels at 4000 lux to minimize discomfort glare and uniformity ratios of at least 0.4 when measuring the minimal daylight level over the weighted illuminance average to offset the need for electric lighting and to increase occupant wellbeing. The achievement of air quality occurs through the controlled distribution of fresh air to interior spaces with natural ventilation rates ranging from 0.2 - 1.5 m/s, providing evaporative cooling to inhabitants when temperatures elevate above the comfort zone. Finally, direct lines of sight to outdoor areas for 90% of regularly occupied floor areas are prioritized to maintain view sheds to outdoor areas to enhance the connection between occupants and their natural setting for the sake of well-being.

3.0. PRINCIPLES

The aforementioned organic strategies outlined by Wright in his essay, "The New Architecture: Principles" include decentralization, horizontality, permeability, open planning and intermediary space types. Together, these strategies underpin the basic disposition of the Charnley-Norwood House, carrying signatures of Sullivan's belief in a functional approach to building while reflecting earlier examples of vernacular traditions in the Southern United States.

3.1. Principle 1: Decentralization

Decentralization is a planning principle that disperses spatial volumes horizontally along the ground plane while using a strong horizontal datum, like a parasol roof plane, to gather up the spatial grouping below. This multi-nuclear schema is evident in the Charnley-Norwood House through the distribution of four service cores that loosely define the bedroom, living, dining and kitchen spaces between. This principle is tested using CFD tools to examine how the plan is climatically adapted to catch prevailing winds from the south in the summer and to buffer northern winds during winter seasons. During the summer, continuous wide open spaces like the bedrooms, the living room and the dining room preserve ample access to southerly winds off the Gulf

through the T-shape plan and positioning of service cores to constrict the airflow, increasing air velocity between. On the other hand, the service cores buffer cold northerly winds in the winter and house internal heating elements like fireplaces to aid in warming interior spaces (FIG. 2). This principle is akin to the southern dogtrot housing typology with a central breezeway defined by a binuclear planning scheme used to intensify light winds and promote evaporative cooling for the occupants inside. Composing interior spaces in a manner that directly engages seasonal shifts encourages inhabitants to concentrate activities in zones of the home particularly well adapted to shifts in airflow and temperature, improving inhabitant well-being on the interior while reinforcing the collective identity of the occupant group.

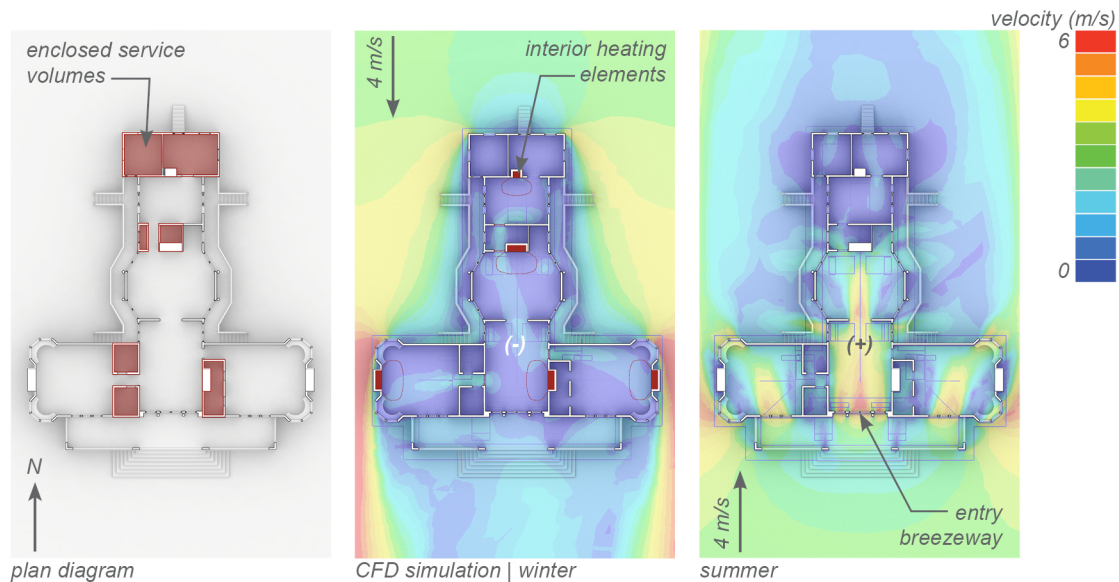


Figure 2: Decentralization analysis outcomes. Source: (Frank 2017)

3.2. Principle 2: Horizontality

Horizontality is a principle that uses architectural strategies like extensive roof planes or elevated floors as constructed systems to buffer interior spaces from climatic extremes. In the Charnley-Norwood House, the ventilated parasol roof plane provides overhead shade while collecting and exhausting buoyant hot air while the elevated floor places inhabitable spaces in closer proximity to prevailing breezes. This principle is tested using CFD and ray tracing tools to examine how the ventilated roof cavity promotes stack ventilation while shading interior spaces below. When winds prevail off the Gulf, large southern apertures draw air into the living and dining spaces that are vented into the roof cavity where they exit through apertures in the roof plane. The roof is expansive enough to provide adequate shading throughout the day with a high sun when measured at hourly intervals (FIG. 3). The parasol roof plane and the elevated floor plate are both common attributes of southern vernacular structures like the dogtrot and bungalow in response to heavy periods of rain and intense summer heat. Exaggerating the horizontal disposition of space through the combination of expansive floor and roof systems with low ceiling heights helps constrict airflow, increasing air velocities while providing ample shading to facilitate heat removal and evaporative cooling for occupants during hot summer seasons.

3.3. Principle 3: Permeability

Stemming from innovations in structural systems, permeability is a principle that opens interior space through the removal of large load-bearing interior walls. In the Charnley-Norwood House this results in large operable windows on the southern, eastern and western sides of the structure to source natural light, fresh air and views to transmit from inside out. CFD simulations are used to test the combination of open plans for cross ventilation and open sections for stack ventilation while raytracing tools reveal the amount of natural light transmitting into the interior spaces. While isovist analysis tools disclose the extensive view sheds enabled from even central areas of the plan the CFD and raytracing outcomes demonstrate increased air velocities due to constricted flows along with well-lit interior spaces attributed to the abundant use of glazing (FIG 4). Thin plans and aligned apertures are common features in southern vernacular housing yet the structural and glazing technologies that emerged in the 20th century exploit these characteristic traits. It is with this principle that the inhabitant's connection with their natural surroundings becomes clear through large expansive openings around the building perimeter and open planning that together blur the distinction between interior and exterior spaces.

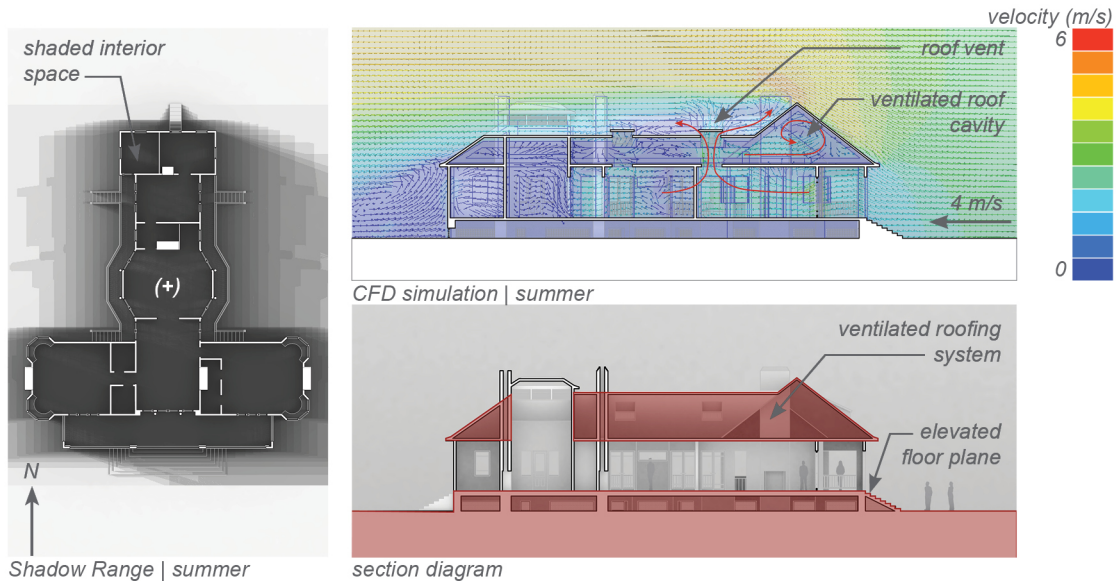


Figure 3: Horizontality analysis outcomes. Source: (Frank 2017)

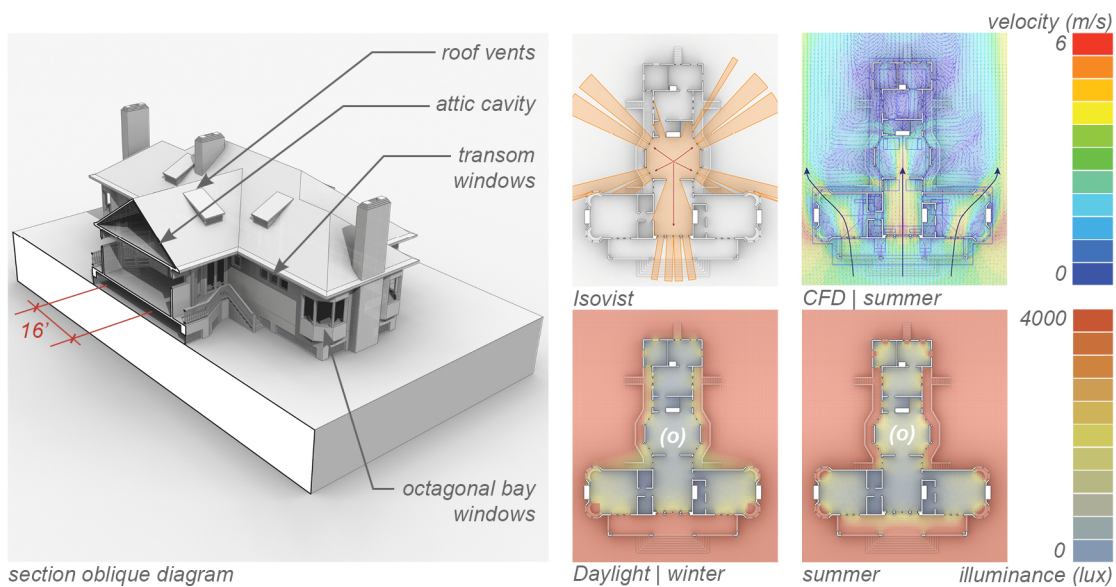


Figure 4: Permeability analysis outcomes. Source: (Frank 2017)

3.4. Principle 4: Open Planning

Also enabled by new structural technologies, the principle of open planning amalgamates interior spaces while offering flexibility in occupant use and interaction. With the Charney-Norwood House, this flexibility promotes the migration of activities whereby interior and intermediary rooms are zoned to accommodate events based upon the climate profile at that point in time. CFD and solar radiation studies examine this variety of zones, looking at the comfort levels provided by each during different climate conditions, namely during summer and winter seasons. Summer space types include bedrooms and living areas, tuned by operable apertures and narrow floor plates to channel constricted southerly airflow while shaded from the hot summer sun overhead. Winter space types include the southern porch and enclosed areas supported by internal heating elements that moderate the cold northerly wind through mass buffering while opening to direct solar radiation from the south (FIG 5). In the dogtrot southern housing typology, a bi-nuclear planning scheme separate functions with and without internal heating elements while it's orientation along cardinal directions makes use of east-west zoning for morning-evening migration. Heterogeneous thermal zoning accommodates various social patterns

ingrained in dwelling through migration from one area of the house another, giving the occupant choice in determining the ideal location for desired activities and broadening the comfort range of the home for users with different inclinations.

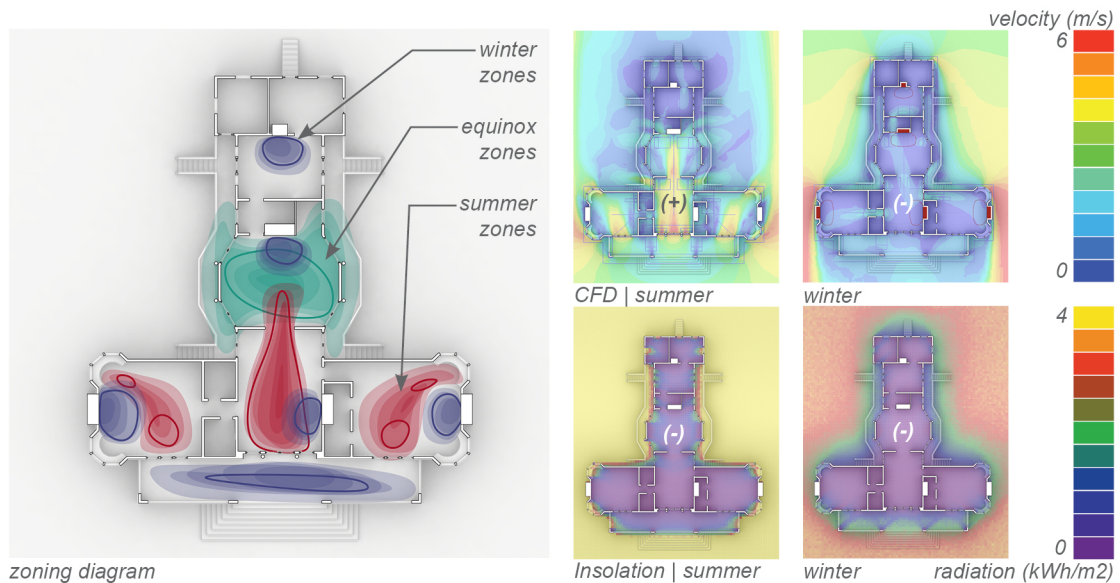


Figure 5: Open planning analysis outcomes. Source: (Frank 2017)

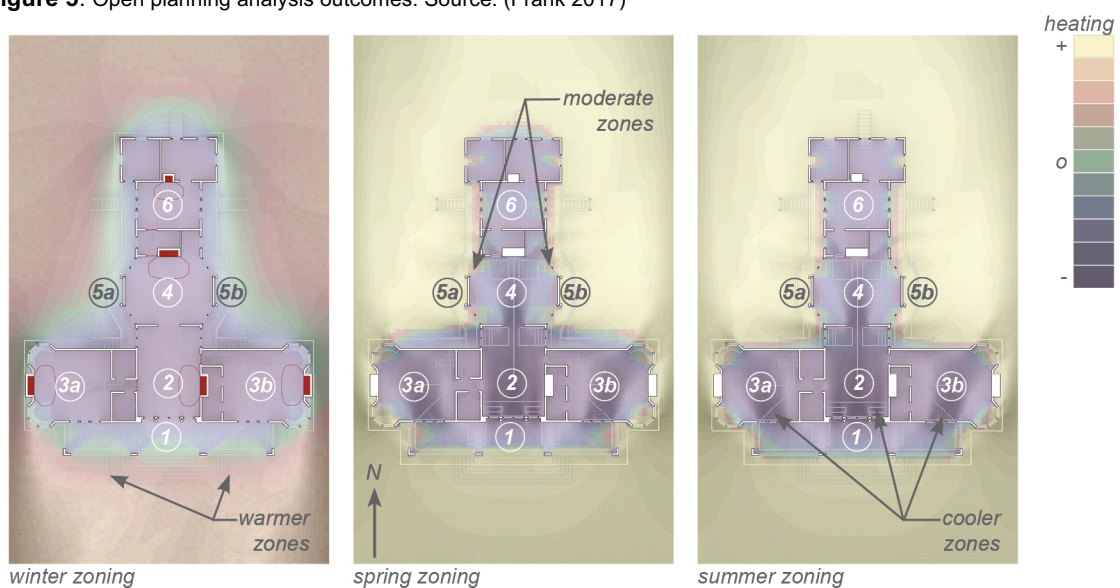


Figure 6: Intermediary space making analysis outcomes. Source: (Frank 2017)

3.5. Principle 5: Intermediary Space Making

Extending space beyond the conventional boundaries defined by a building is the basis of intermediary space making. This involves provisions for semi-enclosed outdoor rooms at the Charnley-Norwood House including sweeping east-west porches in addition to a long and deep southern porch overlooking the Gulf. Each of these intermediary space types are examined under the prevailing solar and wind conditions at three points annually; the winter solstice, the spring equinox and the summer solstice. Results from the analysis indicate that the southern side of the house, including the southern porch are the warmest areas due to solar exposure and protection from cold northerly winds. The middle of the house including the sweeping east and west porches are moderately exposed to both wind and sun depending upon the time of day while the southern zones of the house are both sun protected and exposed to constricted high-velocity southerly winds (FIG. 6). Intermediary space types like the southern porch are a common feature used in southern vernacular houses

due to the oblique relations between the changing sun angle and the shifting wind direction from winter to summer seasons. Providing intermediary spaces, intended to be used year round, extends seasons for outdoor comfort, locating inhabitants along building edges to directly engage the site and the neighboring community.

CONCLUSION

Taken together, the principles embedded within the Charnley-Norwood House offers a high standard for American environmental design, one that softens the architectural boundary to embrace the continuity of space resulting in a rich inventory of passively conditioned zones that enhance occupant well-being. While contemporary society has been criticized for producing subpar architectural outcomes when compared to their predecessors, the Charnley-Norwood House offers ample evidence of how vernacular strategies can be advanced using technological innovations of the day. While this paper offers insight into a formative moment in architectural history when two early modern masters were in direct collaboration, it also concretizes their impact on environmental design and the important lessons it offers for contemporary adaptation in light of our ongoing climate crisis. This watershed moment in environmental design should underscore the urgency of continued advancement in the field that is needed using developing technologies at hand to offset the use of high-grade energy sources while maintaining the delicate relationships that exist between people and their surroundings.

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