Approaches to Affordable Housing Design Using VAE and Space Syntax: Case Studies from Los Angeles

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ABSTRACT: The purpose of this study is to explore the opportunities and challenges in the use of the Visual Access and Exposure (VAE) and the Space Syntax approach in design for the future of affordable housing development in Los Angeles. Historically, affordable housing developments have been related to a lack of attention to society's housing needs in architectural design. Architectural design is a crucial element to achieving good quality affordable housing, yet this element has played a minor role in deliberations concerning various aspects of the lives of low-income residents such as their social and cultural values. In this respect, the Space-Syntax-based approach to understanding the relationship between socio-spatial practices and residential environments has been strongly connected to the efficacy of the result in the urban and architectural design processes (Hanson 1998; Hanson and Hiller, 1998). This study focuses on designing the affordable housing model provided by the Skid Row Housing Trust, currently on the market in Los Angeles, California. This study points out that the socio-spatial practices related to housing use and experiences are not fully considered in the spatial forms of affordable housing. Therefore, this study addresses the need for affordable housing suitable for low-income households and proposes a sufficient housing plan using the Space Syntax methods within the design process. In the design process using the Space Syntax method, spatial configuration and behavior of residents are analyzed through spatial connectivity, integration, and depth.

KEYWORDS: Affordable Housing Design, VAE and Space Syntax in Design Process

INTRODUCTION

Design innovation is needed to shift public perceptions about affordable housing, which has traditionally been associated with public housing for low-income families. Los Angeles, in particular, is experiencing a serious housing issue as a result of a lack of available homes, limited housing supply, land use regulations, and high rent prices. However, architects and various non-profit groups in Los Angeles have recently begun to seriously investigate innovative affordable housing design despite a severe housing shortage and high economic demands. In the development of affordable housing in Los Angeles, non-profit affordable housing development companies, including Community Housing Corporation, are working with architects to develop and preserve affordable rental housing in a variety of ways and changing the lives of families living there. The purpose of this study is to determine whether affordable housing developments applying Space Syntax and VAE improve the quality of housing and highlight innovative affordable housing design as an important solution for the housing crisis. In this study, the analysis of affordable housing in Los Angeles could be a good example of architectural innovation that could better serve the needs of its residents and could reveal the spatial characteristics of public housing or low-income housing through physical and visual analysis. This study also contributes to supporting new possibilities in the architectural design process of affordable housing development using Space Syntax and VAE by evaluating the cases of recently built affordable housing in Los Angeles.

1.0 BACKGROUND

1.1 Affordable Housing in Los Angeles

The City of Los Angeles has produced more residential units since 2010 compared to nearly every other city in California for its population growth. Less than 7,300 units were built in the City of Los Angeles in the last five years, and 6,200 affordable homes were built in The County of Los Angeles during the same period. LA County is also significantly increasing funding through its Affordable Housing Trust Fund, Measure H, and No Place Like Home programs (McKinsey Global Institute, 2019). Despite this housing construction boom and the production of affordable housing increasing every year, the shortage of housing for the low and middle class is still serious. The low level of affordable housing construction is particularly problematic, as Los Angeles has the highest number of chronically homeless people in the nation (13,000), according to the U.S. Department of Housing and Urban Development (2016).

Although more public money is urgently needed, the reality is that Los Angeles must mobilize private capital to meet the scale of this problem. Good and innovative design is an important factor in improving the quality of affordable housing, but it generally plays a minor role compared with cost and value deliberations (Wright, 2014). It's time to turn this local housing crisis into an opportunity to reimagine Los Angeles. At the beginning of the design process, if a new

approach to space design based on the analysis of the living patterns of residents is applied, it can be a part of the solution to these problems in a cost-effective, efficient and creative way in designing affordable housing. Interest in a specific design method in the design process can reduce the cost of construction and provide practical benefits to the vulnerable, such as low-income individuals, thus signaling the need for investment in affordable housing.

1.2. VAE and Space Syntax in Design Process

Space Syntax provides a theoretical framework for spatial analysis because it objectively and quantitatively shows the social characteristics inherent in space. By using Space Syntax, it is possible to provide a framework for an objective approach necessary to understand the relationship and composition of each space and to explain the movement of people who connect the spaces and the social exchanges that can occur within the building.
Therefore, although the built environment is formed by the social environment, it is not easy to understand the design logic and structure inside it.

The essential problem in understanding a building is to show how to recognize basic building functions and components, how those functional elements create a space structurally, and how to analyze the hidden building system. In this respect, Space Syntax plays an important role in the building design evaluation. Because the spatial topology method is effective in understanding these spatial relationships, it provides an effective tool for architects to show their ideas through buildings and how their designs actually work. In other words, Space Syntax, which approaches topology by quantifying it, can be a powerful means to evaluate building design by finding the formal and functional regularity of buildings in real systems.

In addition, spatial analysis with VAE is based on two variables: visibility and accessibility, which are the most important factors for human behavior in space. Visibility is the variable that determines how far you can see, and accessibility is the variable that determines how easily you can get to each space. Given sensitive issues such as privacy in a home, tools such as Space Syntax and VAE can be prioritized for objective assessment and can be used at an early stage in space organization. For example, in the design process, VAE analysis is used to determine in advance how visual interaction can occur in the space used by actual residents, and adjust the level of privacy protection, plan to install surveillance cameras in crime-prone spaces, separate the flow of movement between residents and visitors, etc. When making such a plan, you can understand the relationship between each space. These case studies of affordable housing show how Space Syntax and VAE can contribute to the design process in a practical way.

2.0 METHODS

In this study, Space Syntax analysis is largely divided into physical spatial analysis and visual analysis. The physical spatial analysis focuses on the connection between one space and another and adjusts the characteristics of spatial configuration. Visual analysis is based on visual perception referred to as the methodologies which focus on human perception and behavior. Techniques usually include Isovist, Visual Access and Exposure model (VAE) model, and Visibility Graph Analysis (VGA) techniques (Benedikt, 1979; Archea, 1985). This study focuses on the VAE model and the integration and connectivity in Space Syntax.

First, the VAE model is based on theory and methods developed by Benedikt and Archea, which quantifies the visual characteristics of space and behavior. This model indicates how the selection of one's location and orientation within an architecturally bounded setting could affect both the information about surrounding activities and the ability of others to observe one's behavior. Benedikt (1979) and Archea (1985) suggest that visual characteristics of a space can be largely divided into Visual Access (VA), which refers to the degree to which information can be obtained from a point through unobstructed visual surveillance, and Visual Exposure (VE), which represents the degree to which an individual can be seen from other arbitrary locations. In other words, it is to grasp the visual interaction that works in space as the ability of ‘seeing’ and ‘being seen.’ The VAE value is the sum of all the grids that enter the field of view when space is decomposed into a grid, in which the view is limited to an angle of 30 degrees. The characteristic of vision is very closely related to human behavioral characteristics. Since the more one is exposed in space, the more constrained one behaves, and on the contrary, the more able to grasp a surrounding space, the less restriction to one's behavior. Thus, one is most likely to be proactive without considering the surroundings if the degree of self-exposure in space is small and the degree of seeing is large.

Second, the boundary of the living space is set for the analysis and the entire space is decomposed into spaces for each function, the connection relationship between these spaces is established, and finally, a quantitative analysis index for the connection relationship between each space is calculated. There are two methods for setting the unit space: a convex space and an axial line. The convex space method is a method of expressing a unit space as a kind of closed polygon, and the axis line method is a method of connecting the unit spaces by expressing a route as a single line through a visual analysis method. Based on this method, each unit space can be set as a node, and the connection relationship between each unit space can be expressed as a graph. In Space Syntax, quantitative analysis is performed based on numerical values and graphs analyzed in the spatial structure expressed in this way.

The degree of integration refers to an index indicating the relative depth and connectivity from one space to another. The higher the degree of integration, the easier it is to access other spaces. In other words, the degree of integration is an index indicating the hierarchical centrality of the spatial structure. Here, depth means ‘distance’ in graph theory,

which is different from the general concept of physical distance. That is, the depth means the minimum number of spaces passed when moving from one space to another unit space. The core of the degree of integration is to find the depth of the shortest path to another node for each node on the graph based on this depth concept. The connection diagram refers to an index indicating the possibility of going from one space to an immediately adjacent space, and the connection diagram for a specific space indicates the number of other unit spaces directly connected to the space.

3.0 CASE STUDIES

3.1. New Carver Apartments

Skid Row Housing Trust's New Carver Apartments were developed to provide permanent housing for older and disabled residents who were previously homeless. On the ground floor, there are many support services for the residents, as well as common facilities such as a kitchen, a common room, and an area where medical professionals and social workers can meet with the residents, as well as a large courtyard. The courtyard is open to all residents and visitors and functions as a space for social interactions. Entering the lobby through the building entrance leads to the center of the building, which then leads to a wide staircase in the central courtyard. The apartment's six-story spiral-shaped building defines a courtyard in its center, providing each unit with natural light and views in all directions. This project contributes to the formation of a community network where residents interact with each other and furthermore, are connected to the neighborhoods around the building.

Figure 1: New Carver Apartments and Courtyard (Photo courtesy of Michael Maltzan Architecture, source: https://www.mmaltzan.com/projects/new-carver-apartments/)

3.1.1. Visual Access (VA)

The highest VA value on the first floor is the parking lot because the parking lot is an open and visible space. On the other hand, interior spaces of the building seem to have a low VA value because there are offices, meeting rooms, recycling rooms, the kitchen – all spaces where private activities take place. Thus, VA values are low. The highest access point is also the central courtyard and the public space. The corridor of each floor is visible from the courtyard, which makes this space the most visibly active. Since the study only analyzed the boundaries of the rooftop garden, VA value is seen as low. However, if the analysis boundaries are expanded the rooftop garden should have a high VA value. Thus, the highest VA value of the interior would be the central courtyard, and the highest VA value of the exterior (within building boundaries) would be the rooftop garden. In addition, public spaces (including the community space) and the corridors have also high VA values in the apartment building. The round shape of the corridor makes the spaces open but at the same time, the louver partitions make the space semi-closed.

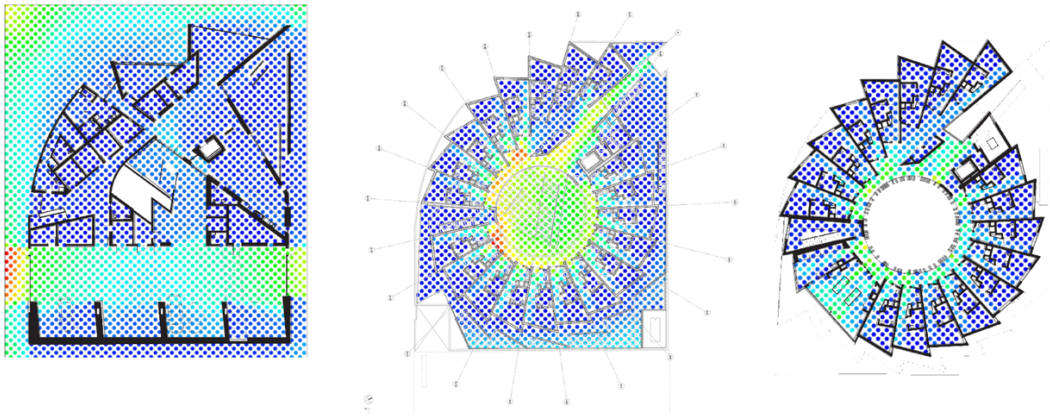

Figure 2: Visual Access of Floor Plan (1st, 2nd, and 3rd Floor)

3.1.2. Visual Exposure (VE)

The most exposed space on the first floor is the parking lot. However, with the exception of the parking lot, the entry and lobby space has the second-highest VE value within the boundaries of the building. This means that this space is easily seen from other spaces. Transitory space such as the entrance, lobby, and corridor seems to have a high VE value. The most exposed space within the second floor is the central courtyard and the public space. This space is composed of a large staircase and a community space. This space is easily seen and is highly visible from its surrounding especially the staircase where most activities of the residents take place. This space works as the most core space that links the first floor to the second floor. The highest VE points are the public space/corridor because the circle-shaped courtyard is open and the corridor is designed according to the shape of the courtyard. However, this space can be seen as a semi-closed space since longitudinal louvers have been installed on the railings (from the ground to top on the void spaces) making the space semi-closed. The purpose of the louvers is to give the residents some privacy when entering their units. Thus, the corridor space is seen to be the most active and exposed space, but, due to the louvers, this space becomes not completely open but semi-open. The community space on the ground level also has a higher VE value than the units. This is because the space is composed of glass walls. The community facility is easily viewed room the corridor where people can see people's activities that are going on within the space.

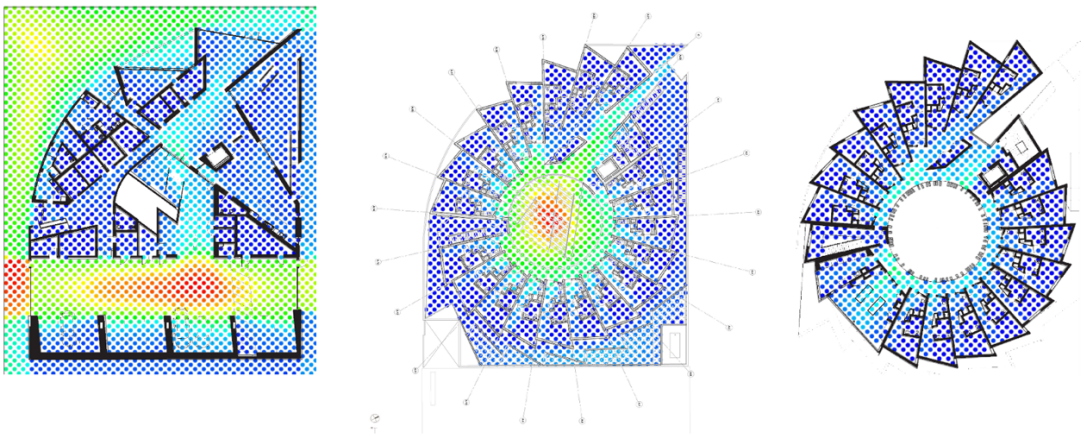

Figure 3: Visual Exposure of Floor Plan (1st, 2nd, and 3rd Floor)

3.1.3. Integration and Connectivity

The most integrated space is the service core (stairs and elevators) and the corridor. The service core that connects the third and fourth floors seems to be the most integrated space along with the corridor at the top of the third and fourth floors. This is because it acts as a connector that links the ground to the third floor and the fourth floor to the rooftop. This space shows the centrality of the entire building. Thus, the ground floor and the rooftop are the least integrated space within the unit. Additionally, as the core on the other floors is composed of spaces moving up and down, the ground floor and the roof floor are composed of core spaces moving one way. The corridor at the center is drawn as four bisecting lines due to the round shape of the building. However, it can be seen as one single space. As the corridor connects all the units this space has the highest integration value. The transitory space that is placed next to the service core has the second most integrated value. This can be interpreted as the second most active space within the floor and building. When the space is to be defined as 'active,' it means that it is easily accessed and most transitions occur within the space. As the space is active, the space is defined to be open (public space). The corridor and the parking lot are seen as the most connected space within the building. This is because of the characteristic of what a corridor is – a connection space and a transitory space. The parking lot has a high connectivity value due to the number of spaces connected to it such as the store, the corridor, the mechanical room, etc. In addition, the outdoor space on the ground floor and second floor also has a high value. This is because this space connects both internal and external spaces. Overall, the corridor and the service core have the highest integrated value which means they can be defined as the most public space within the building. The dwelling units are the least integrated space which is

defined as the least active spaces and private spaces. In addition, most activity occurs on the lower floors (ground and first floor).

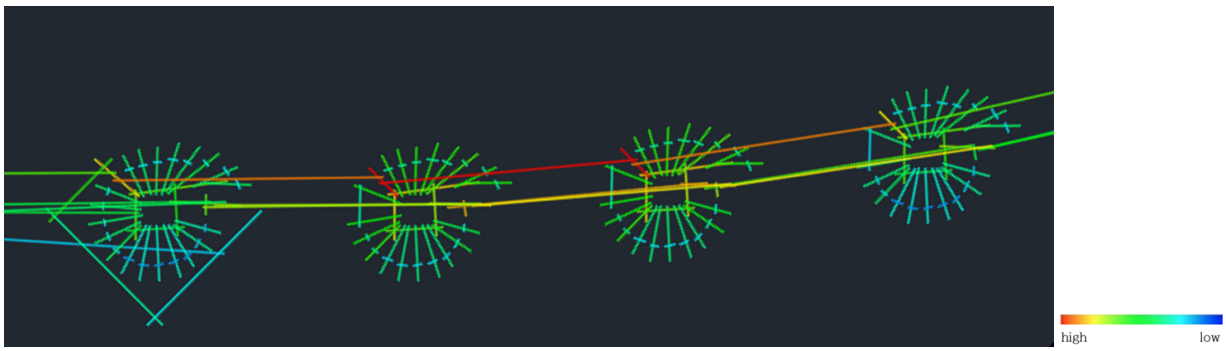

Figure 4: Integration and Connectivity of Each Floor

3.2. The Six

Developing in the Skid Row Housing Trust and designed by local firm Brooks + Scarpa, the five-story apartment complex provides a range of supportive services along with 52 permanent, affordable housing units for formerly homeless veterans. The first floor contains offices, support space for veterans, and bicycle storage and parking. The second floor contains a large public courtyard for apartment residents. The second-floor community room adjacent to the courtyard provides an outdoor gathering space with plenty of light and the rooftop re-illuminates the protected outdoor space. The top floor features a green roof, a large public patio, and a communal garden with panoramic views of the area. All public amenities in this building have been tailored to enhance the building's sense of community. The architects have designed the courtyard, a public space, to encourage residents to meet each other and engage in various activities together in one space rather than being confined to their own spaces. In addition, the architect tried to connect the two-story courtyard surrounded by four-story dwelling units spatially and visually with the inner space of the building as well as the surrounding streets. This allows residents to interact with other residents and visitors in the community space and enjoy more open space.

Figure 5: The Six and Courtyard (Photo courtesy of Brooks+Scarpa, source: https://brooksscarpa.com/the-six)

3.2.1. Visual Access (VA)

The space located inside the first floor has a very low VA, so it seems difficult to observe the user's behavior.
In general, these spaces exhibit the characteristics of spaces that have no choice but to passively accommodate residents or visitors. Since this space is being used as a conference room, it can be said that it is placed in an appropriate location visually and functionally. Since the VA is high in the south parking entrance and the west exterior space on the first floor, people can identify the parking space at a glance when they enter the building. It can be seen that the VA on the second floor appears high in the space in front of the north stairway and in the south hallway. This means that the residents interact a lot with the courtyard and are also visually open to the exterior of the building. The VA value of the 3rd to 5th floors with dwelling units was highest in the corridor leading to each household. This means that the area that can be seen from the hallway is the widest, except for private spaces where both VA and VE values are low. On the other hand, unlike the stairwells and elevator cores in the south, the stairwells in the north have low visual interaction. Both VA and VE are low, so it can be said that the probability of crime in this space is the highest. The rooftop garden, like the courtyard on the second floor, generally shows a high VA, suggesting that it is a space suitable for residents to interact.

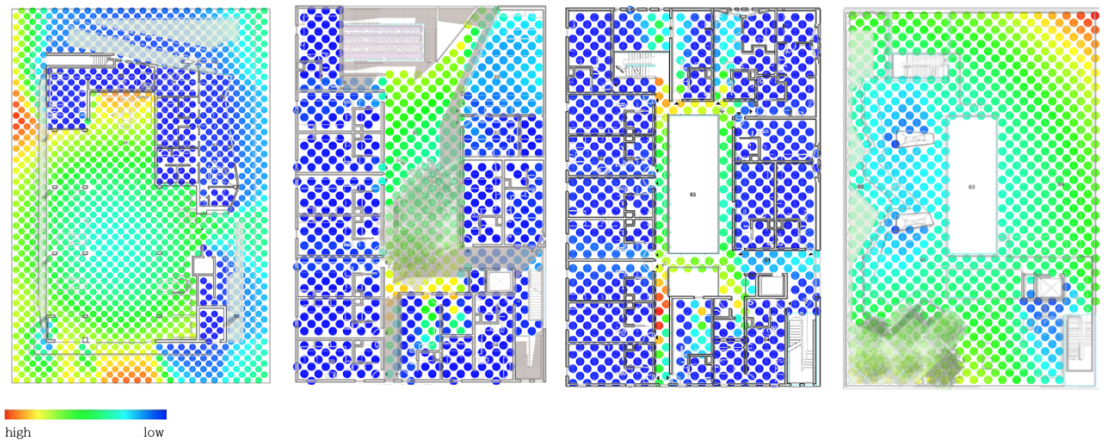

Figure 6: Visual Exposure of Floor Plan (First, Second, Fifth Floor and Roof garden)

3.2.2. Visual Exposure (VE)

The first floor was designed with piloti and support facilities were arranged along with the parking lot to create a space with the highest VE and the first recognition of residents and visitors. However, the northern office space was designed with glass, so it was expected that it would communicate with the outside and give a sense of openness, but the VE value was not high. In particular, considering the low VE of the movement line approaching the stairs inside the building, it can be said that the privacy of the residents is guaranteed because it is not easy to access the upper floors when people visit from the outside. A high VE in a parking lot means a lower risk of crime because the space is more likely to be monitored by others. The high VE of the second-floor courtyard means that this space is very visually exposed. It is a space that many people, including residents and visitors, pass through, so it can be judged that a lot of exchange can take place here. Also, since the community space in the northeast shows the second highest VE value after the courtyard, it can be inferred that this space, including the courtyard, is an appropriate space for people to meet. The corridor space connecting the dwelling units connected from the 3rd floor is not blocked by walls or glass and is designed with a handrail, so you can see the courtyard of the 2nd floor or face the opposite hallway, which allows for a visual exchange between the residents. It has a high VE value. The 5th floor has a corridor that overlooks the courtyard of the 2nd floor and a bridge connecting the dwelling units on the opposite side, so this space shows a high VE value. The roof garden has the highest VE as most of it is an open space except for the formative elements that protrude like some walls.

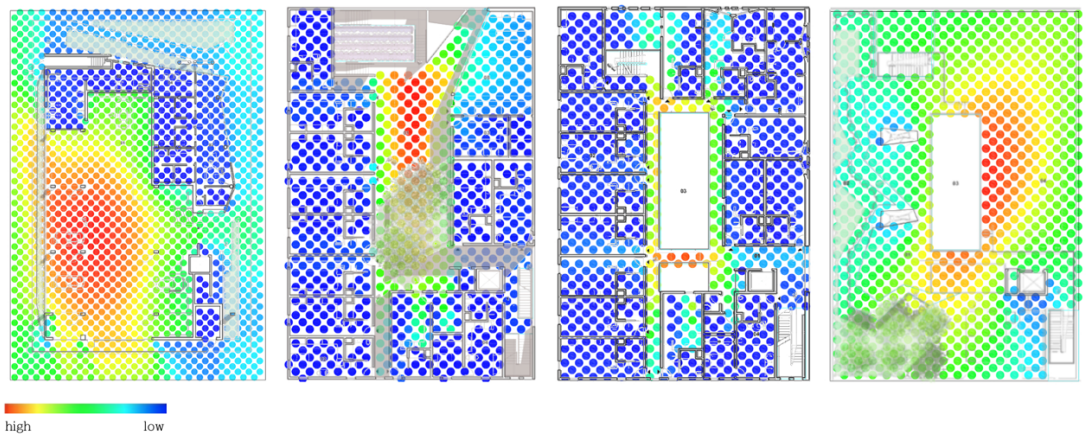

Figure 7: Visual Exposure of Floor Plan (First, Second, Fifth Floor and Roof garden)

3.2.3. Integration and Connectivity

As a result of analyzing the degree of integration, it can be seen that the highest spatial hierarchy in this building is the north stairway connecting the 3rd and 5th floors. The vertical movement of the building can be understood as movement through the stairwells on the north and south sides and the elevator core on the south side. Among these circulation axes, the spatial phase was highest in the vertical movement line of the middle floor connecting the 3rd and 5th floors. It can be seen that the living space of the remaining floors except the first floor shows a moderate degree of integration and connectivity. The degree of integration is lowest in each dwelling unit where privacy is protected. In particular, the corridor space connected to the vertical circulation shows the highest degree of integration, and since most of the

residential spaces on each floor are connected to the vertical circulation and the corridor space, the utilization of the corridor is expected.

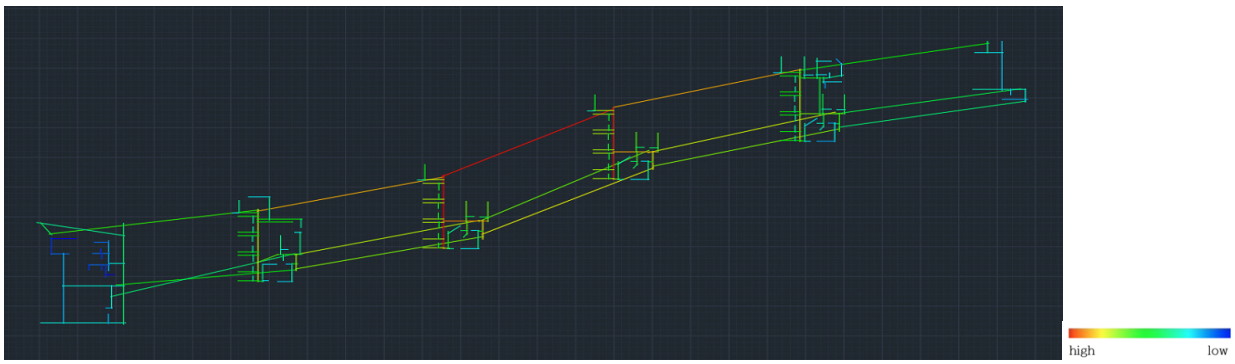

Figure 8: Integration and Connectivity of Each Floor

4.0 DISCUSSION

This study analyzed the spaces of two affordable housing developments in Los Angeles using VAE and Space Syntax. First, VA (Visual access) and VE (Visual exposure) of the space were accessed. In Space Syntax, the space was analyzed using integration and connectivity indicators. What the New Carver Apartments and The Six have in common is that the courtyard and hallway have the highest VA and VE values, which means that most of the activities take place in this space. The courtyard is located at the center of the building and the corridors are arranged so that the courtyard can be seen. Being visually open, the courtyard plays the most important role in this building as the most appropriate space for residents to communicate and exchange with each other. Therefore, as can be seen from these two cases, it can be considered that not only residents but also visitors can safely live in the building. Although VAE cannot simultaneously show the visual analysis that occurs between each floor, it reveals the importance of the courtyard and the atrium in both buildings by inferring the visual exposure and observability of the void space. Through this VAE analysis, it is possible to identify the crime-prone space and the well-monitored space, and it can be an opportunity to quantitatively check which design elements in this building allow visual interaction.

The VAE analysis has a feature where only analysis of a single floor is possible. Through this analysis, the space with high VA and VE can be easily recognized in various places in the building as a whole, and the activities of people in the space can be observed well. In addition, a high degree of visual openness and visual exchange in various places are sufficiently generated, so a high activation of the space can be expected. An individual in a space with high VA and low VE can look around well. but an individual located in that space is less likely to be visually exposed, so it is a space with a relatively high probability of crime compared to other spaces. On the other hand, a space with a low VA and a high VE becomes a space that can be observed from all spaces, such as a courtyard in a building, and it is not easy to observe other spaces in that space, so it has characteristics suitable for public space. In addition, a space with low VA and VE is a space with very high privacy and a space with high physical closure due to low visual exposure from the outside. In general, it can be seen that dwelling units have lower VA and VE in residential buildings to offer more privacy for the residents.

The integration of Space Syntax can explain the importance of each space inside a building, and the higher the spatial integration, the easier it is to access the space. The form of space is important because accessibility is greatly affected by the number of direction changes rather than the physical distance. Therefore, in the design process, the designer can quantitatively check the hierarchy of each space by creating an axial diagram that shows the relationship between spaces in the spatial positioning stage. Through this work, the architect can design the location and shape of a space suitable for the purpose of each space and the program characteristics of each space from a macroscopic point of view. Therefore, it is possible to proceed with the efficient space design process while checking the centrality of the space through the integration analysis and analyzing the connectivity to examine how connected each space is.

CONCLUSION

Many affordable housing projects that have been built with a large number of dwellings over a set period of time and on a tight budget have shown a lack of design considerations. As a result, the stereotype that affordable housing is low-income housing has been established. So what do architects need to consider for affordable housing? Which part of the residential design and development process should be prioritized? This study suggests that introducing the two methods of Space Syntax and VAE at the beginning of the design process can shed light on the possibility to promote the design and development of affordable housing to improve the quality of life for residents. Of course, these two methods can be applied to the design and development of not only affordable housing but also other buildings in general. However, a new paradigm that aims to give new value to affordable housing, which has historically been faithful only to functions, and to improve the quality of life of residents and promote their various activities within the building, should be considered. Therefore, in the initial stage of the design process, many residents should be able to

feel happy the units were “house-like”, and safety and peace-of-mind should be maintained through various social activities and exchanges of residents. All these factors should be taken into account in the design of affordable housing developments, and all of these considerations should result in homes that are a significant source of well-being for residents when planning the future of affordable housing in Los Angeles.

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ENDNOTES

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