Article

A Study on the Spatial Layout of Newly Built Townhouses in Kaohsiung City

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Abstract: Due to their independent structure, piping, and access, townhouses offer great flexibility in floor plan changes and high spatial autonomy, making them the mainstream housing type in Taiwan. This study focuses on row houses and examines 2022 completion cases in Kaohsiung City. It collects floor plans from 14 newly constructed buildings, totaling 227 units, and analyzes spatial dimensions including the facade width, depth, habitable room, staircases, bathrooms, and total floor area for each case. The objective of this study is to examine the spatial layout of row houses in Kaohsiung City, with the aim of providing a reference for the future planning and design of such structures. The study results showed that 81.8% of the row houses analyzed have a total floor area per unit ranging from 136 to 192 m^2, a facade width between 4.1 and 6.38 m, and a building depth from 7.67 to 12.68 m. In addition, they showed a low negative correlation between the facade width and total floor area, a high positive correlation between the building depth and total floor area, and a moderate negative correlation between the facade width and building depth. The spatial distribution within these houses includes 78% allocated to habitable room, 13.1% to staircases, and 8.7% to bathrooms. The total area of habitable rooms and bathrooms increases with the total floor area of the building. However, the total area of staircases remains almost constant as the area of habitable rooms increases. Furthermore, the most common location for staircase planning is the rear-right (RB) position, while the least common is the rear-left (LB) position. Among various staircase types, the C-shaped staircase has the largest average area per floor and the highest average proportion. Conversely, the I-shaped staircase has the smallest average area and the lowest average proportion. The U-shaped staircase is the most frequently planned, whereas the C-shaped staircase is the least frequently used. This means that planning of staircase location and type significantly affects the size and layout of habitable rooms and bathrooms in townhouses.

Keywords: townhouses; principal spaces; spatial layout; relevance

1. Introduction

In Taiwan, statistics show that nearly 50% of buildings are townhouses. For example, in Kaohsiung City, about 85% of building-use permits are townhouses. The space in a townhouse primarily consists of habitable rooms, staircases, and bathrooms. The habitable room serves as the actual living and activity space. Townhouse are characterized by narrow and elongated facades. Developers control the total building area to meet budget constraints, resulting in limited floor area per level. The elongated space, further constrained by considerations for staircases and bathrooms, presents significant spatial limitations. The size of these elements directly impacts the functional living space within the residence.

Housing is a primary need for human daily activities, and a good living environment contributes significantly to comfort and quality of life. Housing quality is a critical indicator of overall living standards [1–3]. In Europe, the development of townhouses or rowhouses has a history of over 1000 years. These structures, prevalent in both rural and urban

areas, evolved from the land measurement system "acre" and represent a sustainable architectural prototype. They reflect differences between rural and urban environments and societal, cultural, and economic influences, and they enhance community awareness and privacy [4]. In Egypt, townhouses are designed in rows with small gardens. Historically, these structures became the choice of nobility and the wealthy, evolving into luxurious and popular housing units due to design, political, and cultural factors [5]. In Japan, townhouses originated in the medieval period as narrow, street-front shops. These buildings, known as machiya, have a standard width of 5.4 m and extend backward, creating narrow and deep shop houses typical in traditional urban settings [6]. In Thailand, townhouses typically have a lot area of 64–100 square meters and a total floor area of 83–162 square meters, including 2–4 bedrooms, 2 bathrooms, and a parking space. They are particularly favored by middle- and low-income families [7].

Taiwan's residential types have been influenced by both Chinese and Japanese models. During the agricultural period, the concept of separate and live apart led to the development of street houses, which were incrementally divided along roads. This evolved into the townhouse format after 1951. Urban design and planning have since shifted towards increasing density [8]. From 1968 to 1979, townhouses were extensively developed, becoming typical rural housing in Taiwan and predominantly used by the middle class. However, due to population growth and advancements in construction technology, the scale of buildings has gradually expanded. The design type of residential buildings is similar, and it is built in several buildings, rows, and quantities (multi-family). The land and building ownership are usually consolidated under a single entity, with complete ownership extending from the ground floor to the top, commonly referred to as "townhouses" or "townhouse residences".

In Taiwan, townhouses typically consist of three to four stories. The evolution of their design is influenced by factors such as family, community structure, construction technology, architectural types, building regulations, and culture. During the planning phase, developers often focus on maximizing land use efficiency, resulting in townhouse designs that are narrow in width and deep in length. Site planning usually involves designs for single units, paired units, row houses, or community-style layouts. Townhouse are characterized by their frontage facing the road, with partition walls (common walls) on the sides. These structures have clearly defined land boundaries and are connected to neighboring units. Townhouses can be classified into commercial and residential types. The commercial type typically includes a first floor designated for commercial use, with an arcade as required by regulations, and residential use on the upper floors. The residential-type townhouse is used solely for residential purposes and is usually priced higher, primarily serving high-income families.

According to statistics from Taiwan's Ministry of the Interior for the year 2018, the total residential type in each city accounts for approximately 49.20%, except for the Taipei metropolitan area types. The average total floor area of these houses is 170.04 m^2, with about 91.15% featuring four to five bedrooms. Typically, the staircase is located centrally in long-depth houses and is adjacent to the bathroom facilities. Additionally, 40% of families living in townhouses consist of four members. Row-type townhouses are favored due to advantages such as property ownership, structural independence, separate utilities, and flexible space adjustments.

Architectural designers often utilize fundamental principles of geometry to plan the basic shapes of architectural designs. The design process must include the type, form, geometry, and dimensions of the design subject. In the design of row-type townhouses, functional characteristics determine the use of each space. Topology dictates spatial relationships, and form characteristics influence the layout and forms of floor plans [9]. The planning of townhouses must first confirm the building layout and involves interactive adjustments with the building's floor plan. Factors affecting the lot size of townhouses' residential site include planning concept, site depth, topography, road conditions, regulations and neighbor relations, and relative influence on the relationship between the residential width and depth. In addition, the size of the lot is a primary factor in determining the

permissible total floor area. Furthermore, the total building area influences the construction costs of townhouses. Based on this, the layout of the lot is the most critical factor affecting the design of townhouses.

Wu (2011) studied the types of building lot layouts and classified them into six categories: I-shaped, L-shaped, Goose type, Parallel type, C-shaped, and Mixed type, as shown in Figure 1. The l-shaped configuration accounts for 86% [10]. Figure 1 illustrates that regardless of the unit type, townhouses predominantly feature middle units, except for the end and corner units. These middle units have a common wall on both sides, with natural light coming only from the front and rear. Furthermore, the layout of these units is significantly influenced by the parking space, entrance orientation, and stair placement, resulting in a unique layout pattern for the townhouse spatial area.
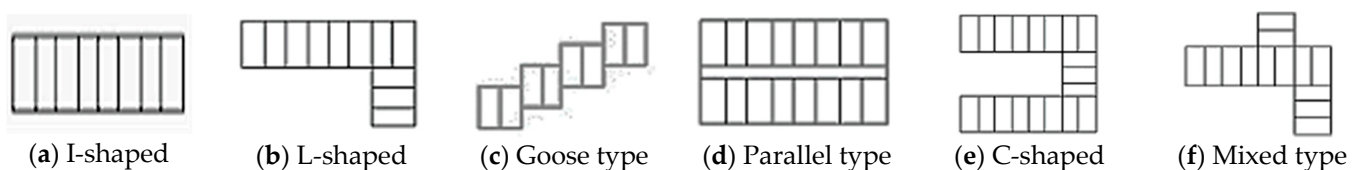
| (**a**) I-shaped | (**b**) L-shaped | (**c**) Goose type | (**d**) Parallel type | (**e**) C-shaped | (**f**) Mixed type |

Figure 1. Townhouse building lot layout types [10].

In narrow and elongated townhouse residences, the spatial progression is directed along the depth of the building, with the spatial sequence being entrance → living room → dining room → kitchen. In row houses, the "principal spaces" consist of habitable rooms, stairs, and bathroom facilities. Habitable rooms are designated for residential, work, assembly, recreational, and cooking functions. Stairs provide vertical circulation between floors, while bathrooms serve for sanitation and bathing purposes. Due to the limited base area of each floor, the spatial arrangement is constrained, and considerations for the placement of stairs and bathrooms affect the layout and functionality of the spaces.

In addition, stairs serve as the vertical circulation path for residents moving between floors. The configuration of stair types including spiral, straight, and U-shaped stairs. Each type of stair has distinct dimensions for handrails, stair platforms, tread depth, and riser height. Movement on stairs is primarily constrained by the depth of each tread and the height of each riser [11–13], which affect the overall stair area. Common stair configurations in townhouses include I-shaped, L-shaped, U-shaped, and C-shaped designs. Bathroom spaces, being the second most critical area in a home, possess characteristics that are not easily modified. The design of bathroom spaces should consider the needs of all household members [14]. The type and size of stairs, as well as the dimensions of bathroom spaces, significantly impact the overall habitable room area and spatial utilization.

In Kaohsiung, the widespread design of townhouses began around 1980. About 85% of the new buildings in 2018 are designed as townhouses. Among these, about 48.18% have a lot size between 61 and 87 m^2. The floor width of most building bases is 4.0 M, with a building coverage ratio of 50%, and the building depth ranges between 7.6 and 10.88 m. This indicates that townhouses characterized by narrow widths, extended depths, and limited single-floor areas. Unlike high-rise apartments, townhouses are influenced by external factors such as the street width and neighborhood characteristics as well as internal factors like the building lot width, floor area size, and floor plan, which significantly affect property value. This study focuses on the spatial layout of townhouses in Kaohsiung, examining the relationship between the floor plan shape, principal space area, and total floor area to identify designs that meet basic residents' living needs.

2. Materials and Methods

2.1. Research Cases

This study collected completion drawings of townhouses in Kaohsiung City from 2022 as case studies. A total of 14 architectural cases were gathered, encompassing 237 units,

which represents approximately 14% of the total building cases in 2020. The floor types and unit quantities are depicted in Figure 2.
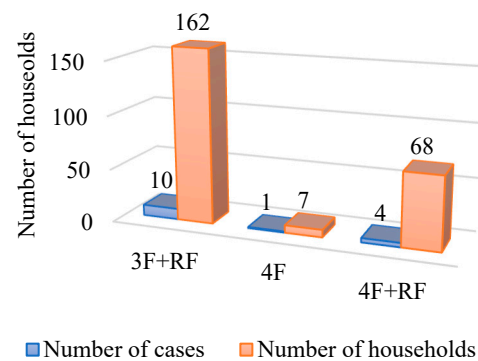

Figure 2. Floor configurations and number of units.

In Taiwan, common row townhouses are generally designed with three to four floors, and their floor plans typically exhibit a rectangular shape with a narrow width and long depth. A three-story building is represented as 3F, and a four-story building is represented as 4F. If an additional floor is added above the three-story (3F) or four-story (4F) structure, it is labeled as a 'staircase space' and designated as the roof floor (RF); these townhouses are primarily used for residential purposes. This study has categorized the floor types into three configurations: 3F+RF, 4F, and 4F+RF. Among these, there are 10 architectural cases of 3F+RF with a total of 162 units, 1 architectural case of 4F with 7 units, and 4 architectural cases of 4F+RF with 68 units. In total, there are 14 projects with 15 different floor plans and 237 units. The 3F+RF configuration accounts for 68% of the cases, followed by the 4F+RF configuration at 29% and the 4F configuration at 3%.

2.2. Data Analysis

This study used relevant values such as width, depth, and total floor area (xi). Since the number of units varies across different building cases, each value was weighted by the number of units (wi) to calculate the respective weighted averages ($\overline{x}$). The calculation formula is shown in Equation (1) [15–21]:

$$\overline{x} = \frac{\sum_{i=1}^{n} wi.xi}{\sum_{i=1}^{n} wi},$$

(1)

$\overline{x}$: the respective weighted averages;
wi: the number of units;
xi: values of width, depth, and total floor area.

3. Results
3.1. Characteristics of Shape and Total Floor Area
3.1.1. Mean and Standard Deviation

In the study case, the mean ($\overline{x}$) and standard deviation (σ) of the width, depth, and total floor area are calculated based on weighted counts of units. As shown in Table 1, the mean values for the width, depth, and total floor area are 4.86 m, 9.34 m, and 154.81 m^2, respectively. The corresponding standard deviations are 0.76, 1.67, and 18.79.

Table 1. The mean and standard deviation of the architectural width, depth, and total floor area.

Item	Width	Depth	Total Floor Area
Average ($\overline{x}$)	4.86 m	9.34 m	154.81 m^2
Standard deviation (σ)	0.76	1.67	18.79

3.1.2. Limit Values and Normal Distribution

The minimum and maximum values for the building width, depth, and total floor area were shown in Figure 3. The minimum width is 4.0 m, and the maximum width is 6.3 m; the minimum depth is 7.3 m, and the maximum depth is 11.4 m; and the minimum total floor area is 142.94 m^2, and the maximum total floor area is 217.96 m^2. Consequently, the width of terraced townhouses ranges between 4.0 and 6.3 m, the depth ranges from 7.3 to 11.4 m, and the total floor area varies between 142.94 and 217.96 m^2.
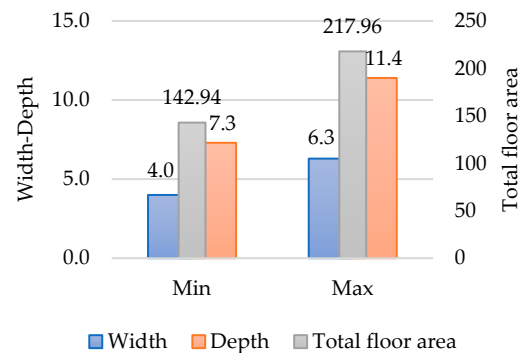

Figure 3. Minimum and maximum values of building width, depth, and total floor area.

The normal distribution of building cases for the width, depth, and total floor area is illustrated in Figure 4. It shows that the majority of values for the width, depth, and total floor area fall within the range of the mean ($\bar{x}$) plus or minus one standard deviation ($\pm\sigma$) and up to two standard deviations ($+2\sigma$), i.e., ($\bar{x} \pm \sigma$) and ($\bar{x} + 2\sigma$). It is evident that the values for the width, depth, and total floor area do not appear within the range of the mean minus two standard deviations ($\bar{x} - 2\sigma$). Most of the observed values are located to the right of the mean, and the distribution exhibits left skewness, indicating a negative skewness.
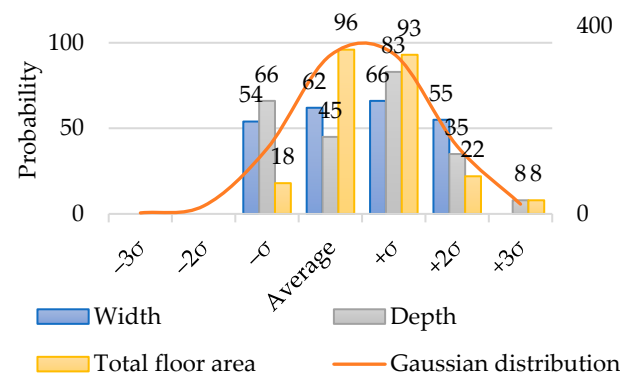

Figure 4. Normal distribution of building width, depth, and total floor area.

Based on calculations using the mean $\pm$ one standard deviation and the mean + two standard deviations, specifically ($\bar{x} \pm \sigma$) and ($\bar{x} + 2\sigma$), the range of the facade width, depth, and total floor area of the attached townhouses, as shown in Table 2, indicates that there is an 81.8% probability that the facade width will fall between 4.1 and 6.38 m, the depth between 7.67 and 12.68 m, and the total floor area between 136.02 and 192.39 m^2.

Table 2. Building floor area, facade width, and depth range.

Item	$-\sigma$	$\bar{x}$	$+2\sigma$
Width	4.1 m	4.86 m	6.38 m
Depth	7.67 m	9.34 m	12.68 m
Total floor area	136.02 m^2	154.81 m^2	192.39 m^2

3.2. Correlation Analysis

3.2.1. Correlation Coefficient

The correlation coefficients (*r*) for factors such as the facade width, depth, total staircase area, total bathroom area, habitable room area, and total floor area of building cases in this study were shown in Table 3. They indicated that the correlation between the facade width and depth is relatively high, with a coefficient of -0.5, which is considered moderately correlated. The correlation between the facade width and total floor area is low, with a coefficient of -0.04, which is considered weak and is the lowest overall correlation.

Table 3. Correlation coefficients.

r	Width	Depth	The Total Area of the Staircase	Total Area of Baths and Toilets	Habitable Total Area of the Habitable Room	Total Floor Area
Width	1.0	-	-	-	-	-
Depth	-0.51	1.0	-	-	-	-
The total area of the staircase	0.43	-0.26	1.0	-	-	-
Total area of baths and toilets	0.13	0.16	0.09	1.0	-	-
The total area of the habitable room	-0.14	0.75	-0.43	0.14	1.0	-
Total floor area	-0.04	0.75	-0.26	0.39	0.96	1.0

The depth of the interior space has a higher correlation with both the total habitable room area and total floor area, with coefficients of 0.75, indicating a high correlation. The correlation between the depth and total bathroom area is low, with a coefficient of 0.16, indicating a weak correlation. The total staircase area has a higher correlation with the total habitable room area, with a coefficient of -0.43, which is moderately correlated. The correlation between the total staircase area and total bathroom area is low, with a coefficient of 0.09, indicating a weak correlation. The correlation between the total bathroom area and total floor area is 0.39, which is the highest correlation but still considered moderate. The correlation between the total bathroom area and total living area is low, with a coefficient of 0.14, indicating a weak correlation.

Overall, the correlation between the total habitable room area and total floor area is 0.96, the highest overall correlation, approaching 1, indicating a nearly perfect positive correlation, which means that as the total floor area of a multi-story residential building increases, the habitable room area also increases. The correlation between the facade width and total floor area is -0.04, the lowest overall correlation, indicating almost no correlation, showing that the size of the total floor area of a multi-story residential building is unrelated to its facade width.

3.2.2. Width, Depth, and Total Floor Area Ratio Correlation

In Figure 5, the coefficient of determination (R^2) between the building width and total floor area is 0.0018; it indicates that there is no significant linear relationship between the building width and total floor area. Furthermore, the correlation coefficient (*r*) between the building width and total floor area, as shown in Table 3, is -0.04, reflecting a low negative correlation with no significant association. The primary reason for this weak correlation is that the design of townhouses typically starts with the building lot layout. The building width is mainly influenced by factors such as the economic conditions of the

era, regional land prices, and building lot conditions, resulting in a low correlation with the total floor area.
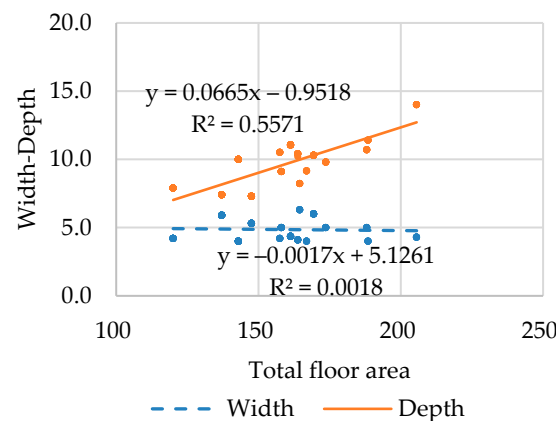

Figure 5. Correlation between building width, depth, and total floor area.

Figure 5 demonstrates that the coefficient of R^2 for the correlation between the depth and total floor area is 0.5571, indicating a strong linear relationship. Additionally, Table 3 shows that the correlation coefficient (*r*) between the depth and total floor area is 0.75, representing a high positive correlation. This implies that the total floor area of townhouses increases with the depth. This phenomenon may be attributed to the depth of townhouses is influenced by the width, plot area, and building coverage ratio. With a minimum acceptable width of 4.0 for townhouses, further reduction is not feasible. Consequently, in cases where the depth of the plot is extensive and nearing saturation to optimize the coverage ratio, the increased plot depth results in a larger ground floor area, which subsequently increases the total floor area. Furthermore, the preference of Taiwanese residents for townhouses with a greater depth further strengthens the positive correlation between the depth and total floor area in such buildings.

The relationship between the building width and depth, as shown in Figure 6, has a coefficient of R^2 of 0.2604, which is less than 0.5, indicating a weak linear relationship. Table 3 displays the correlation coefficient (*r*) between the width and depth as −0.51, suggesting a moderate negative correlation. This implies that the depth of a townhouse decreases as the width increases. The reason for this trend is that townhouses, typically three to four floors in Taiwan, have their width and depth determined by factors such as layout plans, site conditions, and construction costs. Each floor has a specific range of area, so when the width increases, the depth is usually reduced to keep the total floor area within a controlled range.
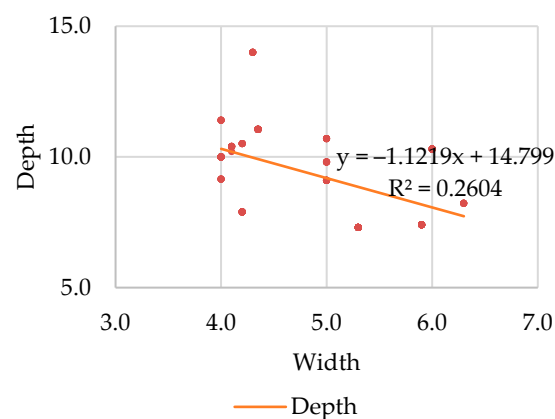

Figure 6. Correlation between building width and depth.

3.2.3. Relationship between Interior Space Area and Total Floor Area in Buildings

Figure 7 shows the average floor area if each floor were divided into the first floor as 48.70 M^2, the second floor as 46.10 M^2, the third floor as 45.36 M^2, the fourth floor as 41.63 M^2, and the roof floor 21.63 M^2. Floor area gradually decreases as floors increase. The overall average proportions of space in the building are as follows: bathrooms account for 8.7%, stairs for 13.1%, and habitable rooms for only 78.2%. The average proportion of bathroom space is highest on the third floor at 13.5% and lowest on the first floor at 6.4%. The average proportion of stair space is highest on the fourth floor at 14.4% and lowest on the first floor at 8.2%. The average proportion of habitable room space is highest on the first floor at 85.3% and lowest on the fourth floor at 72.7%.
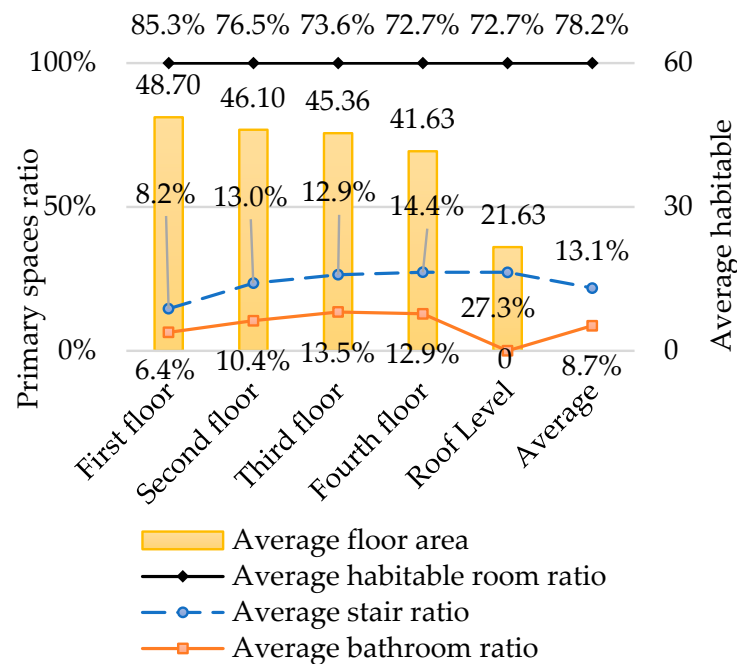

Figure 7. Proportion of main space and average floor area.

Figure 7 also shows that the average proportion of bathroom space on the first floor is 6.4%, and the average proportion of stair space is 8.2%, both of which are the lowest among all floors. Consequently, the first floor has the highest proportion of habitable room space at 85.3%. This is because the first floor of a terraced house typically serves as the starting point for the stairs, resulting in a smaller stair area. This floor is often designed for vehicle parking with limited living space, and the bathrooms usually have no shower facilities, which contributes to a larger habitable room area. The fourth floor has the highest proportions of stair and bathroom space at 14.4% and 13.5%, respectively. Therefore, the average proportion of habitable room space on this floor is only 72.7%, the lowest among all floors. This is primarily because the total floor area of the fourth floor is reduced rather than an increase in the stair and bathroom areas.

As shown in Figure 8, the coefficient of determination (R^2) between the total stair area and the total floor area is 0.0666, which is greater than 0.5, indicating a weak linear relationship. Additionally, Table 3 shows a correlation coefficient (*r*) of −0.26 between the total stair area and the total floor area, demonstrating a low negative correlation. This implies that as the total floor area of the building increases, the stair area does not increase correspondingly but tends to decrease. The area of the stairs is determined by the number of steps, tread depth, stair width, and landing area. The number of steps is decided by the floor height. In typical townhouses, the floor height of the living and dining room level is generally higher than that of other floors, ranging from 3.4 to 3.6 m, while other floors are around 3.0 to 3.2 m. Consequently, the number of steps varies between 15 and 23 steps. The

tread depth and stair width are regulated by building codes, with little variation beyond the minimum requirements. The landing area is crucial in determining the type and size of the stairs. Therefore, the stair area does not increase with the total floor area but is determined by the stair design. When the building's total floor area increases due to wider or deeper plots, ample space may allow for staircases without intermediate landings or changes in stair design, directly connecting different floors and reducing the proportion of the stair area. Hence, as the total floor area increases, the proportion of the stair area decreases.

Figure 8. The coefficient of determination between the main space and the floor of the main building.

As shown in Figure 8, the coefficient of determination (R^2) between the total habitable room area and the total floor area is 0.9162, which is greater than 0.5. Additionally, Table 3 shows a correlation coefficient (*r*) of 0.96 between the total habitable room area and the total floor area, indicating a strong positive linear relationship between the two variables. This means that the total habitable room area increases with the total floor area. The reason for this is that in the real estate market, when projects with a high total floor area (such as luxury houses) are introduced, the bathroom area also increases. However, the primary selling point is the increase in the total habitable room area, which provides more space for daily activities and living comfort.

3.3. Staircase Planning

3.3.1. Staircase Locations on Each Floor

The planning of the staircase location and type significantly affects the size and layout of habitable rooms and bathrooms in townhouses. The schematic diagram of the ground floor layout for a townhouse, as shown in Figure 9, divides the building's width (x-direction) into left and right sides and its depth (y-direction) into front, middle, and rear sections when facing the road from inside the house. Consequently, the single-story floor plan is divided into six zones: left front (LF), right front (RF), left middle (LM), right middle (RM), left rear (LB), and right rear (RB). The location of the staircase on each floor is calculated accordingly, and if there is an intermediate landing, its position is counted twice.

Figure 9. Schematic diagram of staircase location zoning.

The positions of each floor in the case studies are shown in Figure 10. Regardless of the floor level, the highest proportion of staircase planning occurs at the rear-right (RB) position. This is especially evident on the first floor, where the number of cases with staircases planned at the rear-right (RB) position is the highest. This phenomenon can be attributed to Taiwanese customs, where the main entrance is traditionally placed on the left side (the "dragon side"), resulting in the main circulation path being on the left. Thus, positioning the staircase on the right side optimizes space. It is common for townhouses to have parking spaces on the first floor, requiring a deeper layout to accommodate vehicles, which pushes the staircase position to the rear.
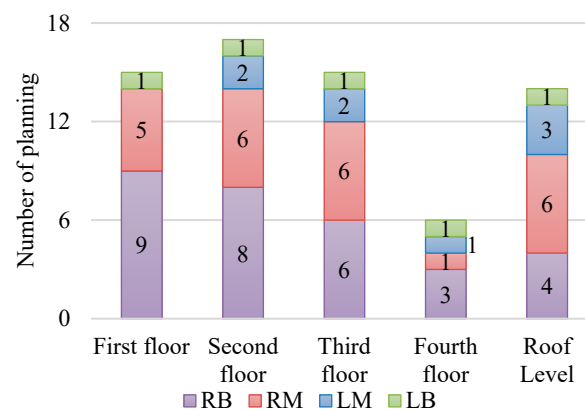

Figure 10. Statistical analysis of staircase locations on each floor.

On the second floor, most spaces are used as living rooms, dining areas, and kitchens. If the layout is open and has good visibility, it creates a spacious-feeling interior, which enhances sale opportunities. This layout results in the highest number of staircases at the rear-right (RB) position. The second most common position for staircases is the rear-middle (RM) on the second and third floors. This is primarily due to the fact that townhouses, except for the first and last units and corner units, are mostly middle units. Middle units have a common wall on both the left and right sides, with lighting available only at the front and rear. Positioning the staircase in the middle allows for windows in the front and rear sections, which can be used as bedrooms [22], thus fulfilling the spatial needs of townhouses.

3.3.2. The Area and Proportion of Each Ladder Type

The frequency of the planning, area, and proportion of each staircase shape are shown in Figure 11. The average area and average proportion of the various shapes of staircases, ranked from lowest to highest, are as follows: I-shape staircases with 3.78 m^2 and 9.2%,

L-shape staircases with 4.13 m² and 10.4%, U-shape staircases with 5.20 m² and 11.4%, and C-shape staircases with 5.51 m² and 12.9%. The frequency of planning, from highest to lowest, is as follows: U-shape staircases 48 times, I-shape staircases 8 times, L-shape staircases 7 times, and C-shape staircases 4 times. This indicates that I-shape staircases have the smallest average area and proportion, while C-shape staircases have the largest average area and proportion. U-shape staircases are the most frequently planned, with 48 instances, indicating that U-shape is the most commonly used.

Figure 11. The planning frequency, area, and proportion of each type of staircase.

The frequency of stair-type planning for each floor is illustrated in Figure 12. Among the different floor types, U-shaped stairs are the most commonly planned. This preference is likely due to the linear floor plan configuration of townhouses with only front and rear illumination. When a U-shaped stair is positioned in the middle or rear section of the floor plan, it creates front and rear living spaces, thereby shortening circulation paths and optimizing space utilization. In contrast, I-shaped stairs are less common because their midsection lacks a landing, making them more difficult to navigate. However, due to their minimal area and proportion, I-shaped stairs are often found in spaces such as stair transition levels, rooftops, and first floors. L-shaped stairs, planned five times on the first floor, are chosen due to their relatively small area (slightly larger than I-shaped stairs) and the design's suitability for wall-side placement. They also provide additional space for vehicle parking and improve accessibility. The C-shaped stair, despite its largest area and proportion, is the least frequently planned type.
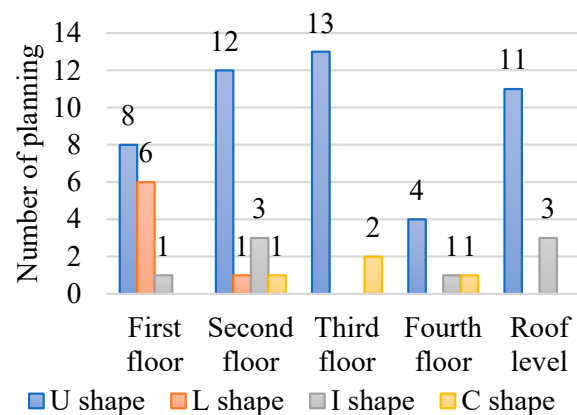

Figure 12. Statistics on the number of planning instances for each type of staircase on each floor.

4. Discussion

The planning of townhouse residences begins with the setting of the frontage width during the site layout phase. The determination of the frontage width is primarily influenced by factors such as the economic conditions of different eras, deformed land prices, site characteristics, and irregular land regulations. The studied result findings indicate that both the minimum and the normally distributed frontage widths did not fall below 4.0 m, suggesting that 4.0 m is the minimum acceptable frontage width for townhouse residents. After determining the frontage width, the depth of the building is considered based on the layout plan, site conditions, and construction costs, which subsequently determine the total floor area. The study showed that the total floor area has a low correlation with the frontage width but a higher positive correlation with the building depth. This may be related to the preference among Taiwanese residents for townhouses with a greater depth. However, as the frontage width increases, the depth is often reduced to control the total floor area and align with construction costs.

This results in the phenomenon where townhouses with larger frontage widths tend to have shorter depths. After the frontage width is determined, the building depth is considered based on the layout plan, site conditions, and construction costs, which subsequently influence the total floor area. The study results indicated that the total floor area shows a low correlation with the frontage width but a stronger positive correlation with the building depth. This trend may be associated with the common preference among Taiwanese residents for townhouses with a greater depth. However, as the frontage width increases, the depth is often reduced to manage the total floor area within acceptable construction cost limits, resulting in the observed pattern where townhouses with larger frontage widths tend to have shorter depths.

5. Conclusions

This study examines 14 cases of townhouses in Kaohsiung City, completed in 2022, with 15 different floor plans as research samples, totaling 237 unit plans. The research investigates the spatial configuration types of townhouses. The conclusions of the study are as follows:

(1)   For townhouses, the architectural planning of each unit shows an 81.8% probability that the width, depth, and total floor area will fall within the following ranges: the width between 4.1 and 6.38 m, depth between 7.67 and 12.68 m, and total floor area between 136.02 and 192.39 m^2.

(2)   The width of the building exhibits a low negative correlation with the total floor area; that is, while a larger width tends to be associated with a smaller total floor area, the correlation is not pronounced. In contrast, the depth of the building shows a high positive correlation with the total floor area, meaning that a greater depth is strongly associated with a larger total floor area. Additionally, the width and depth of the building are moderately negatively correlated, indicating that a larger width tends to be associated with a shorter depth.

(3)   The primary internal space allocations within a building are as follows: habitable room areas account for 78%, stairs constitute 13.1%, and bathrooms represent 8.7%. Both the total area of habitable room spaces and bathrooms increase with the expansion of the total floor area, while the total area of stairs remains constant.

(4)   The most frequently planned stair location is the rear-right (RB) position, followed by the middle-right (RM) position, with the least frequent being the rear-left (LB) position. The average area and proportion of each stair type, ordered from smallest to largest, are as follows: I-shaped stairs, L-shaped stairs, U-shaped stairs, and C-shaped stairs. The frequency of planning each stair type, from highest to lowest, is as follows: U-shaped stairs, I-shaped stairs, L-shaped stairs, and C-shaped stairs.

(5)   In the research cases, the highest proportion of staircases across various floors are planned for the rear-right (RB) position, followed by staircases on the middle-right (RM) position in the second and third floors. This trend is primarily due to the

prevalence of middle units in townhouses, with fewer units at the head, tail, and corners. Middle units are characterized by partition walls on the left and right sides, with natural lighting limited to the front and rear faces. By positioning the staircase in the central section, windows can be placed in the front and rear sections to provide lighting, optimizing the space for bedrooms and fulfilling the spatial needs of townhouses.

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