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PUBLIC SPACE AND PRIVATE SPACE CONFIGURATION IN INTEGRATED MULTIFUNCTIONAL RESERVOIR: CASE OF MARINA BARRAGE, SINGAPORE

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ABSTRACT

A proper space planning influences efficient design and planning of public and private spaces. This paper analyses public and private space configuration in the Marina Barrage, Singapore. The aim of this study is to identify the level of permeability and wayfinding in the case study. The study applies space syntax analysis illustrated in graphs on the degree of permeability and wayfinding with reference to the numbering system of a Likert scale. The analysis classifies the measurement into five levels of permeability of the Likert scale. This study concludes that the degree of permeability and wayfinding in Marina Barrage has a moderately clear distinction between public and private spaces. This positive circulation provides satisfactory accessibility level to the users leading to a deeper understanding of public space and private space configurations of the Marina Barrage.

1. INTRODUCTION

In the planning of successful spatial development, public space and private space configuration must be designed accordingly. This study will focus on public space and private space configuration in Integrated Multifunctional Reservoir. Public spaces and private spaces differ in several ways. Georgiou (2006) identified that space and its elements should be able to improve or reduce privacy according to the customised need of its occupants. Spaces should be categorised not only depending on their degree of privacy but must take consideration of their capacity to regulate privacy. Studies by Hilier (1993) found that spatial configuration affects spatial behaviour and human navigability patterns.

As an introduction to the case study, Marina Barrage is a unique 3 in 1 project in Singapore. Various key features in Marina Barrage as stated in figure 1. The barrage is designed for flood control

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and providing needs for water supply and recreational activities for Singapore. Marina Barrage comprises four separate buildings. This study focuses on wayfinding in a complex public building. This study is carried out by doing the graphs of level permeability and wayfinding using the numbering system. In aiding to examine the level of permeability and wayfinding, space syntax theory is applied. For analysis, the layout of the case study is analysed using the degree of permeability and wayfinding. This paper may contribute to providing an approach for the distribution of private space and public space configuration in the Marina Barrage according to their level of privacy and the level of public space configuration.

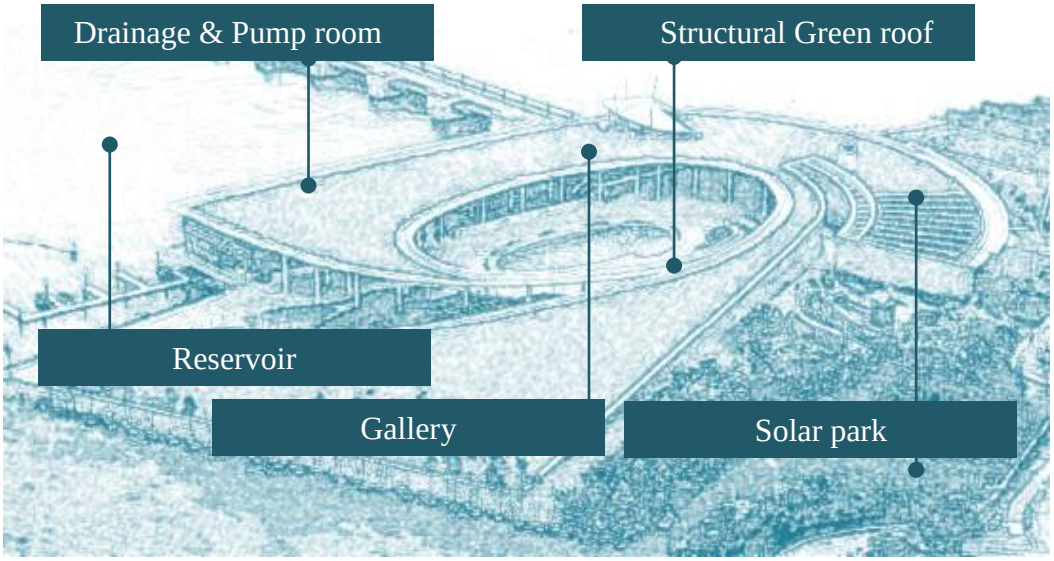

Figure 1: Key features of Marina Barrage.

2. LITERATURE REVIEW

2.1 BUILDING TYPOLOGY

A study is conducted at Marina Barrage, Singapore to identify the public space and private space configuration. In a research by Wung (2009), Marina Barrage is a unique 3-in-1 project which will provide Singapore with three benefits, namely flood control, water supply and lifestyle attraction as shown in Figure 2.

Figure 2: (Left) Aerial view of Marina Barrage.
(Right): Aerial view of Marina Barrage taken from the green roof area.
(Source: https://www.pub.gov.sg/marinabarrage/aboutmarinabarrage)

2.2 DEFINITION OF SPACE SYNTAX

According to Hillier (2001), space syntax method provides some tools that allow to penetrate the

mechanics of architectural spaces and view these spaces as social formations presented in architectural formation. The author concluded that space syntax models the spatial configuration of spaces by using connectivity graph representation. Analysis of the spatial characteristics using space syntax methods provided a finding that's spatial configuration and level of permeability and wayfinding are all related to one another.

Based on another study by Liu et al. (2018), defined that space syntax is a method to study the relationship between space, spatial structures, and human behaviour. To determine the access and visibility to a particular space, space syntax would provide the result to determine the social patterns of users by the description of spatial configuration (Bafna,2013

Wayfinding measured by how users experience and the ease of facilitating getting from spaces to spaces based on the research by Kevin Lynch (1960), where he defined wayfinding as "an organisation of definite sensory cues from the external environment. Wayfinding is not just signage; it comprises many factors combined which together form an environment for us to navigate through. According to Gerald (1981), he found that plan configuration was the most influential factor for wayfinding strategy, followed by spatial landmark, spatial differentiation and finally signage and room number. Wayfinding can be summarised into 5 points:

- Orientation
- Locating information
- Determining your path
- Keeping the path
- Accessor denial

However, permeability is defined as how the people inside the building to permit movement. According to Kohl (2012), permeability also is described as the peoples' opinion in satisfaction of the spaces based on the properties of the environment. In this study, permeability is defined as the level of accessibility of the space. The level of permeability is categorised to five which is a public area, semi-public area, private area and extremely private. Integration is the index for space centrality. It is also sometimes regarded as the index of accessibility. If its value is high, space is located at the centre of the system. If the mean value system is high, it means that the system is firmly connected and integrated. Thus, the system accessibility is high. This research uses the most common integration value defined by Hilier and Hanson (1984).

2.3 CASE STUDY

2.3.1 MARINA BARRAGE, SINGAPORE

Marina Barrage is located in the southern part of Singapore. The overall cost of the project is SGD$250 million. The architect for the project is Architect Team 3 Pte. Ltd. Marina Barrage is an ideal venue for various outdoor activities such as boating, windsurfing and water skiing. Nowadays, Marina Barrage becomes a distinctive landmark for Singapore and providing an iconic infrastructure for all visitors. To showcase if Singapore's achievements towards, environmentally sustainable development, Marina Barrage will presenting Singapore's focal points.

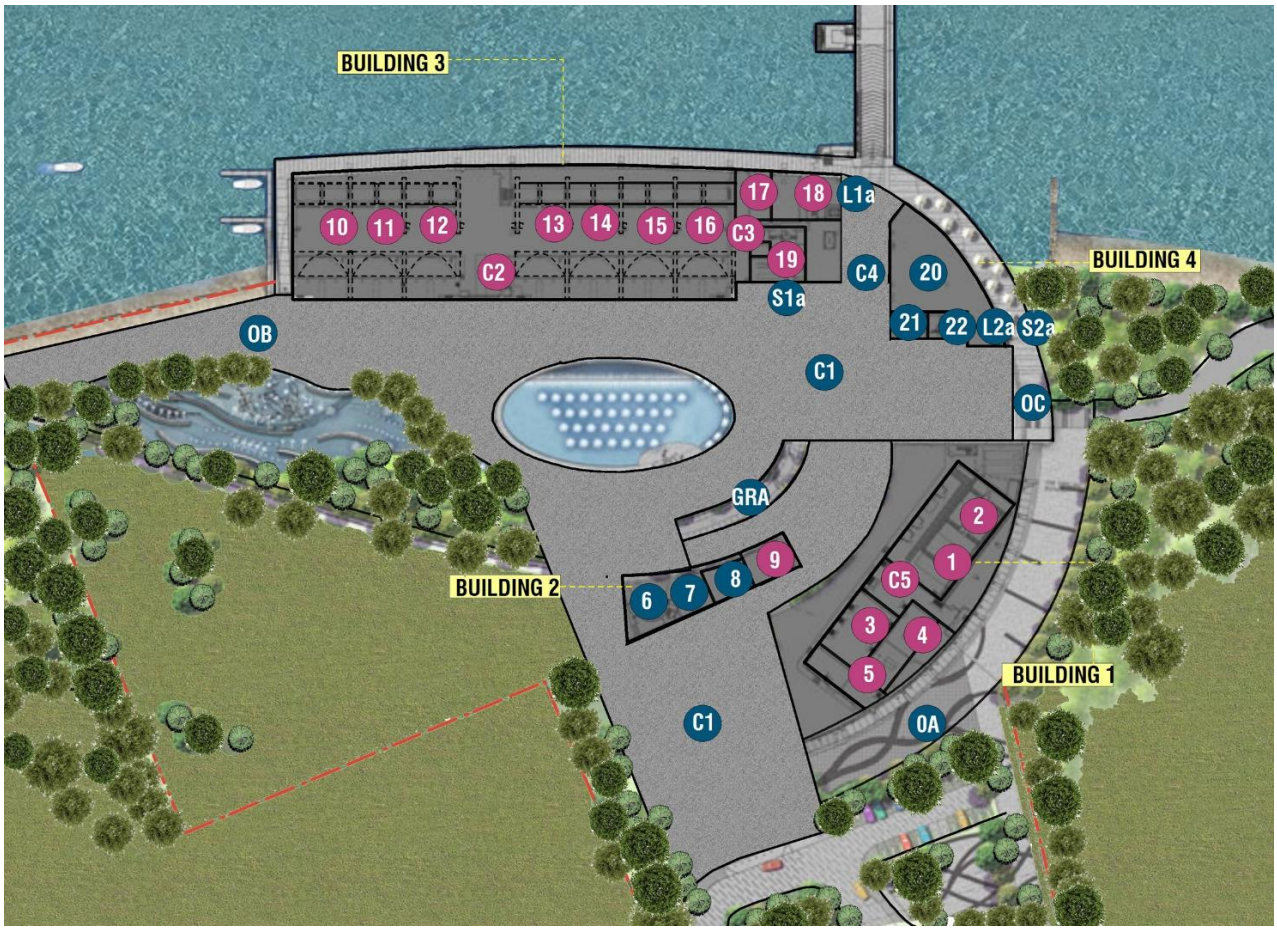

Figure 3: Site plan of Marina Barrage, Singapore.
(Source: Redrawn from https://www.pub.gov.sg/marinabarrage/aboutmarinabarrage)

Table 2: Schedule of accommodation for the site plan and ground floor

CODE	SITE PLAN: SPACE OF ACCOMMODATION	CODE	GROUND FLOOR: SPACE OF ACCOMMODATION
OA	Entrance A	10	Vertical shaft 1
OB	Entrance B	11	Vertical shaft 2
OC	Entrance C	12	Vertical shaft 3
C1	Corridor 1	13	Vertical shaft 4
C2	Corridor 2	14	Vertical shaft 5
C3	Corridor 3	15	Vertical shaft 6
C4	Corridor 4	16	Vertical shaft 7
C5	Corridor 5	17	Pump room 1
GRA	Green roof ramp	18	Pump room 2
CODE	GROUND FLOOR: SPACE OF ACCOMMODATION	CODE	GROUND FLOOR: SPACE OF ACCOMMODATION
1	Maintenance room 1	19	Security control room
2	Maintenance room 2	20	Public lounge
3	Control room 1	21	Information centre
4	Control room 2	22	Ticket counter
5	Utility	S1A	Staircase 1
6	Gift shop 1	L2A	Lift 2
7	Gift shop 2	S2A	Staircase 2
8	Public toilet		
9	Administration 1		

In Marina Barrage, it has four different buildings which are a courtyard and solar operation room (building 1), public and retail (building 2), visitor centre and gallery (building 3) and drainage and pumps room (building 4) as shown in Figure 3. There are three entrances into the building which is

entrance A (0A), entrance B (0B) and entrance C (0C) (Table 1). Building 1 and 4 is only permeable by staff while building 2 and three is accessible by the public — corridor 1 act as transition space. In research done by Kray (2010) states that transitional spaces are a space that generally located between indoor and outdoor spaces. They might share specific properties of both indoor and outdoor spaces, or exhibit distinct characteristics.

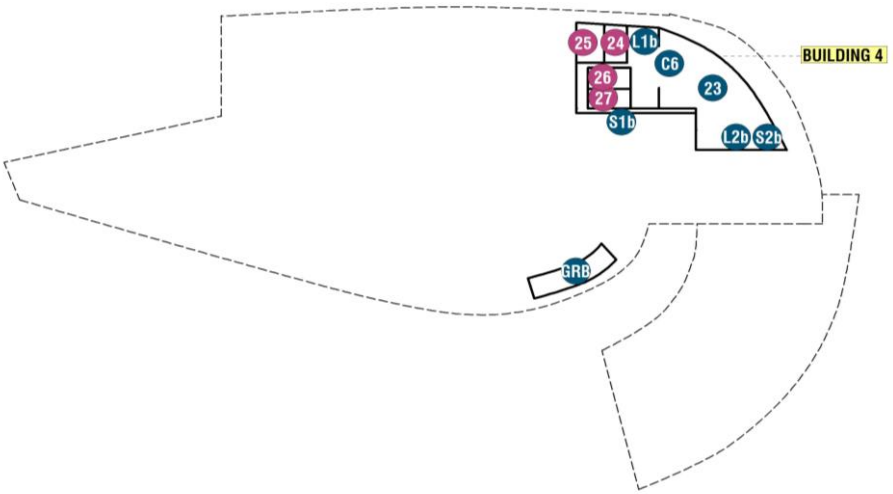

Figure 4: Ground-floor plan of Marina Barrage, Singapore.

Table 3: Schedule of accommodation for the first-floor plan.

CODE	FIRST FLOOR: SPACE OFACCOMODATION
23	Gallery
24	Archive 1
25	Archive 2
26	Utility 1
27	Admin 2
L1B	Lift 1B
S1B	Staircase 1B
L2B	Lift 2B
S2B	Staircase 2B

The first floor of the Marina Barrage consists of the gallery for visitors (Figure 4). As illustrated in Table 3, the first floor is typically for visitors. There is also located two spaces for archives (space 24& 25) who is restricted only for staff. There is also other space for staff which is utility 1 (27). Staircase1 (S1A), staircase 2 (S2A) and lift 2 (L2A) act as a linkage to the first floor (Figure 4). The gallery (23) on the first floor will allow visitors to learn more about how to create a liveable and sustainable Singapore. To access the gallery on the first floor, the visitor has to get the tickets from the ticket counter (22) located at level ground floor.

Figure 5 and Table 4, public spaces at the roof floor plan are commonly for the visitor to do the recreational activities. The roof level is connected by two vertical connectivity which is lifted 1C (L1C) and green roof ramp A (GRA). A large number of people is carrying out recreational activities on the Marina Barrage green roof area. Also, Marina Barrage enables the visitor to navigate the green roof area by cycling and walking. The solar park (28) featured the most extensive collection of solar panels in Singapore. The solar park(28) provides daytime electricity for gallery and offices in the Marina Barrage.

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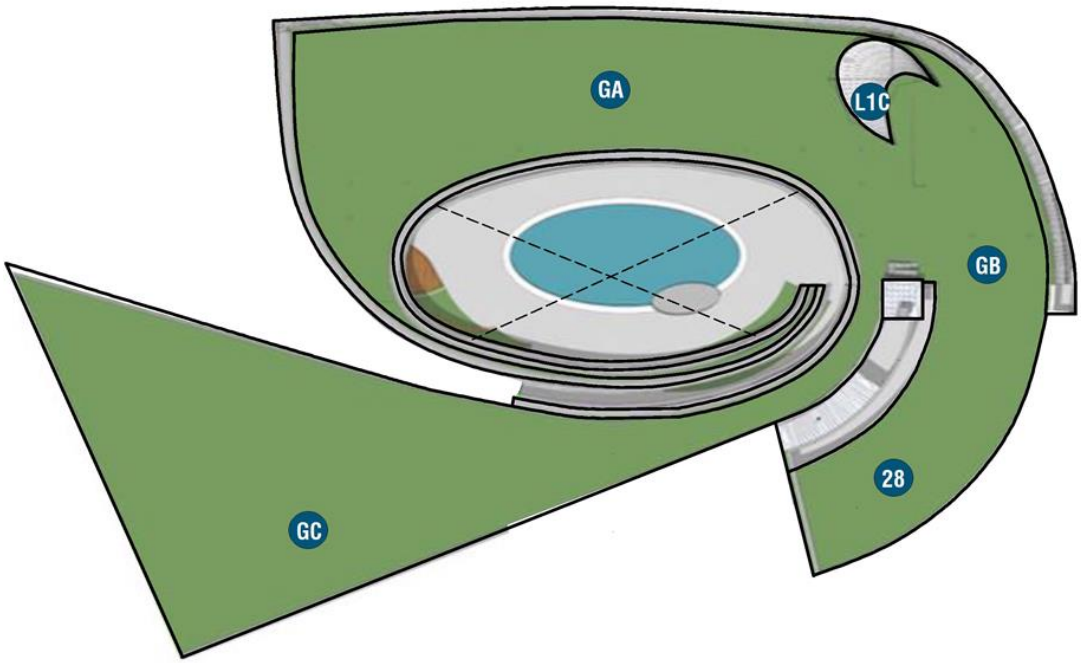

Figure 5: Second-floor plan of Marina Barrage, Singapore.
(Source: Redrawn from http://www.landdesign-one.com.sg/public)

Table 4: Schedule of accommodation for second-floor plan

CODE	FIRST FLOOR: SPACE OF ACCOMMODATION
28	Solar park
GA	Green roof A
GB	Green roof B
GC	Green roof C
L1C	Lift landing 1C

3. METHODOLOGY

The ideal way to achieve this wayfinding task is to incorporate spatial hierarchies through levelling in the numbering graph (Brandon.J, 2010). Hence, numbering graph has illustrated the level by levelling system. The method used for analysis is by labelling the floor plans for the case study. The spaces on the floor plans are labelled in numbers and alphabets with numbers and associated with different colours. Measurable scale graph analysis using a numbering system is used to perform an architectural analysis of Marina Barrage spatial configuration.

Determining the level of permeability and level of wayfinding according to the user which is divided into staff and visitor will aid in the navigability. With the aid of the floor plan by levels will help to analyse the level of permeability and wayfinding of Marina Barrage. The measurable scale graph is measured based on five-category scale: (1) public; (2) semi-public; (3) semi-private; (4) private; (5) extremely private.From the result of the level of movement graph, level of permeability and wayfinding will be rated by using Likert-scale to classify the result based on the quality of spatial networking. Direct observation and behaviour is a more direct way of measuring wayfinding performance.

To facilitate the wayfinding and permeability, the Likert scale is the most widely used approach to scaling responses in survey research which is on a five-category scale which is: (1) public; (2)

semi-public; (3) semi-private; (4) private; (5) extremely private. Analysing and interpreting data from the Likert scale will assist the wayfinding and permeability more efficiently.

When conducting this study, the Likert scale will measure the level of permeability and wayfinding according to the public spaces and private spaces in the Marina Barrage. The increasing of the number shows in the graph indicate the level of wayfinding and permeability of the space (Figure 7).

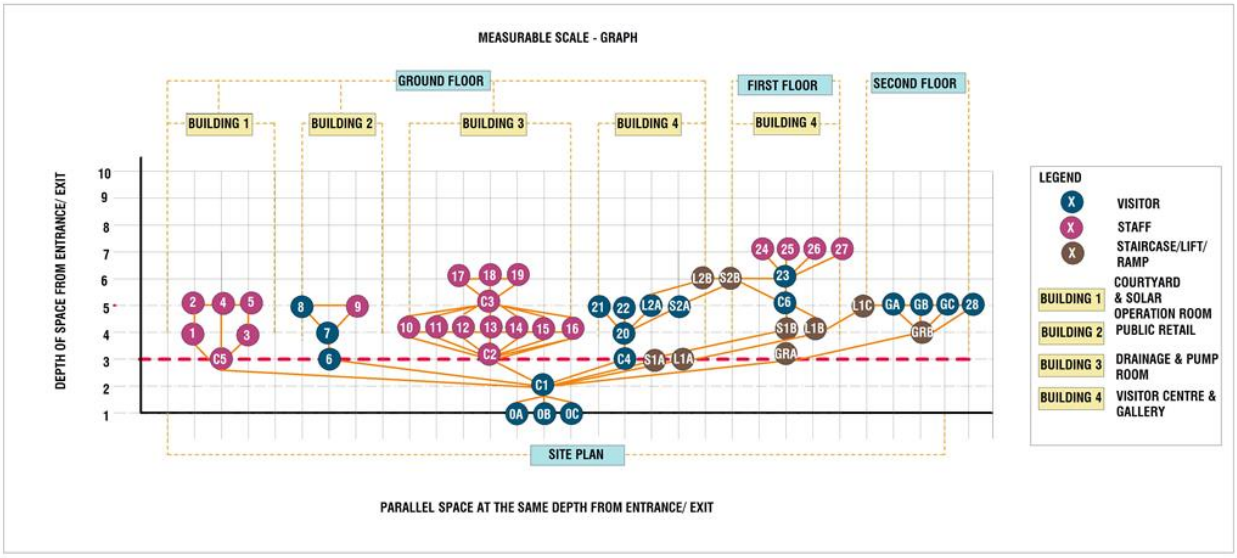

Figure 6: Measurable scale graph.

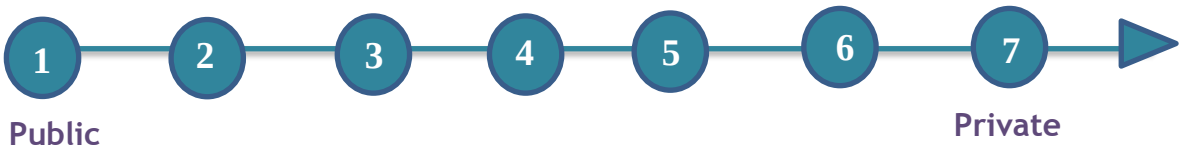

Figure 7: Levelling of the graph based on the wayfinding and permeability.

For this case study, there are three indicators to differentiate the type of user which is indicated by three different colours. Pink colour indicated space is restricted for staff, and brown colour indicates the vertical connectivity while blue colour indicates the space that is permeable by the visitor (Figure 6). This will aid in assessing the level of the permeability in the case study. Staircase and lift are indicated in brown colour. Staircase in the ground floor is indicated as S1A, S2A. As increasing by levels, the staircase at the first floor is labelled as staircase 2A (S2A) and staircase 2B(S2B). Entrances are classified as 0A, 0B and 0C which marks the first space to navigate. However, transition spaces like corridor are described as (C) to lead a better understanding of how people navigate in general to various spaces in the Marina Barrage.). The degree of the connectivity is measured by the levelling of the numbering graph (Figure 6). As the levelling is increased from 1 to 11, the level of the permeability and wayfinding can be concluded.

To find the findings, assessment of wayfinding and permeability is measured by the increasing levelling of the graph. Solid lines on the justified graph indicate a physical connection (Figure 6). The more the spaces are indicated at the highest level, the greater the tendency of permeability and

wayfinding of the space. Revealed that permeability and wayfinding are determined by assessing the. As the connectivity increases, there is a highly permeable network in the areas. The result is obtained by identifying the scale of level of permeability and wayfinding of the numbering graph. The numbering graph may result whether the wayfinding and permeability are positive or negative.

4. RESULT AND ANALYSIS

4.1 LEVEL OF PERMEABILITY & WAYFINDING

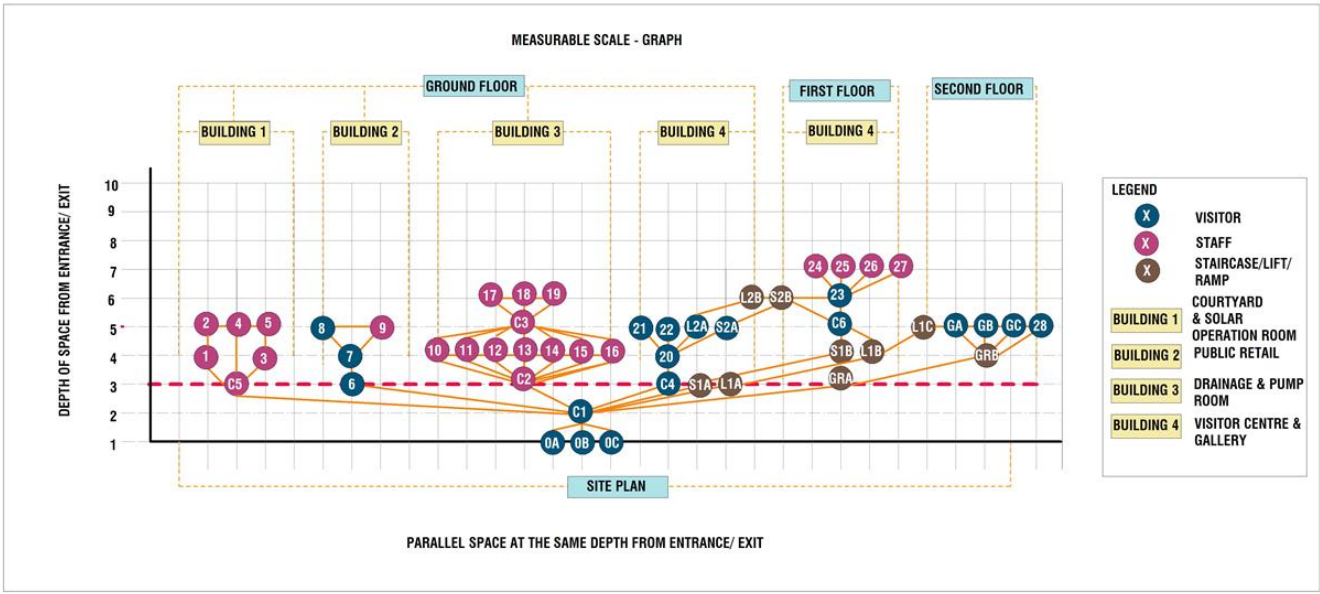

Figure 8: Overall measurable scale graph.

From this analysis, this research studied the level of permeability and wayfinding divided to respective floor plans which is site plan ground floor plan, first-floor plan, and second-floor plan. Marina Barrage is a space with extensive connectivity and has many connections to other areas. In the site plan, there are three entrances have been connected to various areas. The study of the level of permeability and wayfinding are defined by the types of use of this building. The kind of users based on the following:

- Visitors
- Staff

The overall floor plan is illustrated in the overall measurable graph (Figure 8). The Corridor 1(C1) merges with the building and connect and many spaces. Therefore, people can move through corridors and courtyards. Each building or open spaces relate to the courtyard (Figure 10). This type has high connectivity and a large selectively of routes. Each open space and connects to the water courtyards and people can choose various routes for moving. Thus, the path selectively is very high.

Multiple entries are directed into the building including entrance A (0A), entrance B (0B) and entrance (0C). Entrance A (0A) is accessible by the visitor who commutes by car because space is linked to the visitor car park (Figure 8). However, entrance B (OB) & entrance C (OC) is permeably accessible by a pedestrian. Corridor 2 (C2) is solely for staff access and determined as a private area. The ground floor of the Marina Barrage accommodates drainage and pump room which is allocated for respective staff. Spaces 10,11,12,13,14,15,16,17,18 and 19 are permeable by the respective staff

which is mechanical room for drainage pumps. Corridor 2 (C2) and corridor 3 (C3) are acting as transition space in the drainage and pump room.

Green roof ramp A (GRA) provides accessibility for the public to access the green roof area(GA, GB & GC). The ground floor level is connected to the first-floor level by two vertical connectivity which is staircase 1A (S1A) (Figure 12) and lifts 1A (L1A) is located at the centre and has high connectivity. The ground floor level is connected to the first-floor level by two vertical connectivity which are stair 1 (S1), stair 2 (S2) and lifts (L1) which are semi-public This will ease the user to navigate the space. The particular configuration in this space at this ground floor level allows the occupants to browse the areas easily. Based on the graph in Figure 9, the highest level of permeability for site plan at level 2, which is very low. Hence, it determines the accessibility and wayfinding extremely easy.

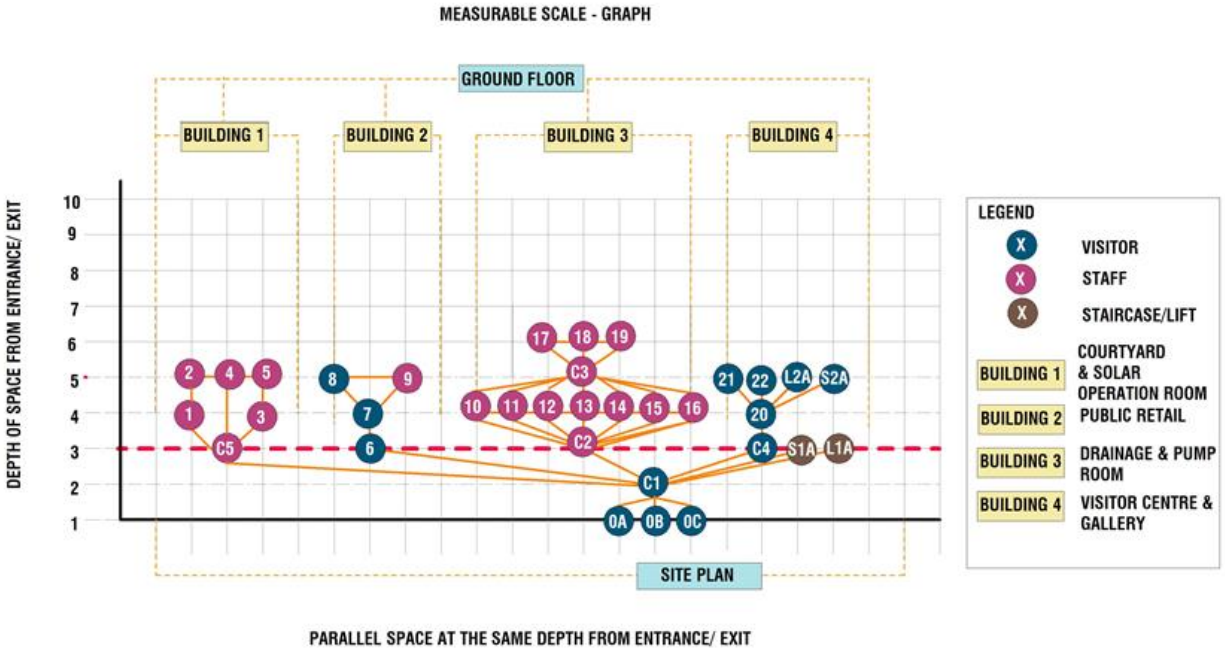

Figure 9: Measurable scale graph of site plan/ground floor plan.

At the upper level, there are only building four located on the first floor. Vertical access through the building is connected by a staircase and elevators. There are a total of two elevators which are elevator 1 (L1) and an elevator (L2). The first floor is accessible by two vertical connectivity which is lifted 1B (L1B), staircase 1B(S1B), lift 2B(L2B) and staircase 2B (S2B). The staircase 1B (S1B) and elevators (L1B) leads to the corridor (C6) and gallery (23). Staircase 2B(S2B) and elevator 2B (L2B) leads to corridor C6 and gallery area (23). Gallery (23) is connected by a corridor (C6) that act as transition space at the first-floor level.

Gallery (23) located at the upper level is only accessible by the visitor who purchased the entrance ticket from the ground floor. While space for respective staff which is archive 1 (24), archive 2 (25), utility(26) and admin 2 (27) is restricted for staff, this will limit the connectivity to the visitor(Figure10). Corridor (C6) acts as a transition space for the first-floor level. The graph in Figure 10 (left) showed the level of permeability that first floor is mostly semi-public where authorised people allow entering which are the visitor with the ticket.

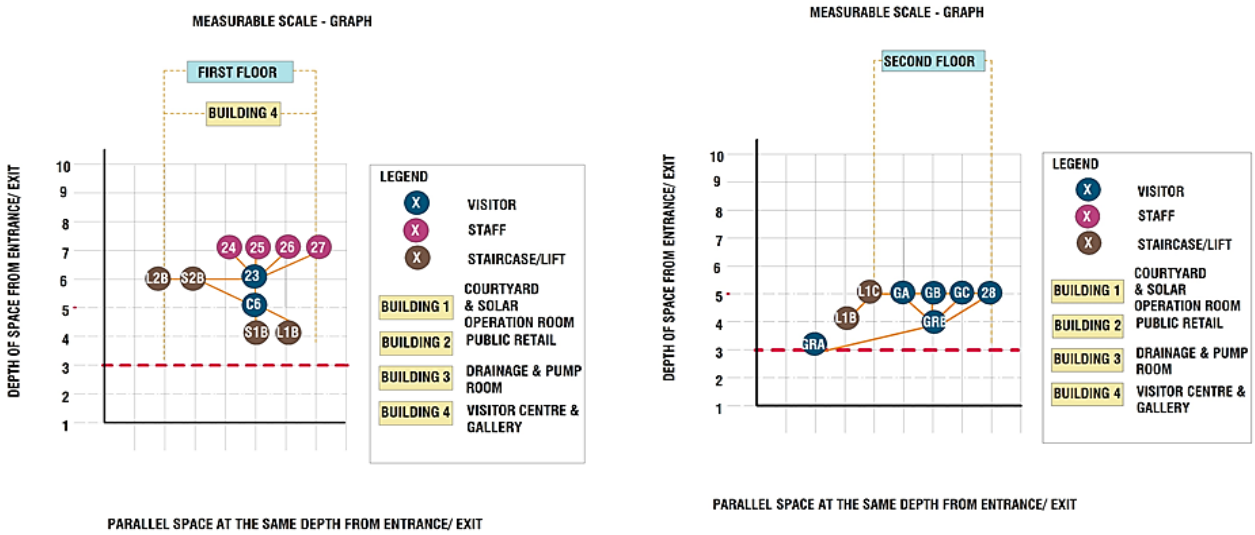

Figure 10: (Left): Measurable scale graph of the first-floor plan.
(Right): Measurable scale graph of the second-floor plan.

The graph illustrates the connectivity of the space on the roof level (Figure 10, right). There are three spaces for green roof area which is labelled as space GA, GB and GC and solar park which is mainly designed for the use of the recreational place for the public. The green roof and solar park at the rooftop area permeably access by the public. Space GA, GB & GC (green roof area) and 26 (solar park) are accessible by space GRB which is green roof helix ramp. A green roof is easy to navigate and easy to identify by the visitors and being connected by universal accessway which is helix ramp (GRA) Figure 11.

(a)

(b)

(c)

(d)

Figure 11: (a): Water courtyard at ground floor act as connecting spaces to various spaces.
(b): Drainage and water pump at ground floor is restricted for staff.
(c) Helix ramp providing access with the green roof area from the ground floor.
(d): Green roof area act as public meeting spaces and permeable to the visitor.
(Source: https://www.pub.gov.sg/marinabarrage/aboutmarinabarrage)

Figure 12: (Left) Sustainable galleries located on the first floor.
(Right): Staircase (S1A) connected the ground floor to the first floor. (Source: Darren Soh)

5. DISCUSSION

From the analysis, it is proven that the accessibility and visibility properties of space layout are shaping the patterns of wayfinding behaviour. The basis of this analysis is space connectivity and the permeability of space. The wayfinding pattern of the Marina Barrage was evaluated by analysing its user accessibility. This study is focused on human wayfinding in a complex public building in Marina Barrage. Not all the spaces inside the building can be accessed. Certain spaces can only be accessed with the authorisation of the facility and the private spaces in the building.

At the site plans, the highest depth of spaces is at level 2 showing that the depth of the accessibility for the visitor is very low. Based on the graph, it justified, the degree of permeability and wayfinding at the site plan area is mostly public space and easily accessible. There are also several private spaces for service and maintenance purpose specifically at the building drainage and pump room (building 3) and solar and courtyard operation room (building 1).

While at the first-floor level, the highest depth of spaces is at level 7 indicating that the depth of the accessibility for the visitor is quite high. This will conclude that the area on the first floor is semi-public and moderately access by the specific visitor. The semi-private spaces like an archive (24&25) are located in the first- floor level which are strictly available for workers. (Figure 10, left).

At the roof level, the level of permeability and wayfinding is reached at level 5 which is determined the respective wayfinding, and permeability level is easily accessible (Figure 10, right). Users are allowed to access the green roof area by accessing the green roof ramp (GRA). Elevator (L1C) also available on the roof floor to gain access from the first floor. Thus, this green roof area is highly permeable by public visitors — Marina Barrage fulfilling the recreational needs by providing public space at the roof level.

6. CONCLUSION

Marina Barrage is a public building that brings an attractive lifestyle for all to enjoy. From the analysis, it can be concluded that the level of permeability and wayfinding of Marina Barrage is carefully though as the level of wayfinding is readable by people. Successful wayfinding systems in Marina Barrage layout plan provide the user with adequate wayfinding information. The floor layouts are designed in the way where the user can access all the public space. Hence, the wayfinding in Marina Barrage is more direct and straightforward for user navigation. This creates engagement

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between the public and private space in Marina Barrage. There is a dynamic relationship between space and the environment to allow people to determine and facilitate the large-scale building like Marina Barrage. These findings contributed to my design thesis and led to a deeper understanding of public space and private space configurations that will be beneficial to others.

7. DATA AVAILABILITY STATEMENT

The used or generated data and the result are presented in this study.

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