ISSN 2228-9860 eISSN 1906-9642 CODEN: ITJEA8

International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies

http://TuEngr.com

Space Syntax Analysis of Users' Accessibility in Shunchang Museum

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Paper ID: 16A3B

Volume 16 Issue 3

Received 04 March 2025
Received in revised form 24 April 2025
Accepted 26 May 2025
Available online 09 June 2025

Keywords:
Museum typology; Culture exhibition; Spatial study; Exhibition space; Floor plan; Justified graph; Visibility Graph Analysis (VGA); Semi-public space; Permeability level; Wayfinding.

Abstract

This study measures the spatial configuration of the Shunchang Museum's design, employing space syntax analysis to unravel the impact of layout plan design on the users' perception of their movement patterns. The selected case study is the Shunchang Museum in Nanping, China, with a gross floor area of 10,138 square meters. Renowned for its cultural wealth and scenic allure, this area is a centre for local heritage and artistic displays within Nanping. This study unveils the museum's spatial configurations through a quantitative survey in the space syntax, utilising justified graphs and Visibility Graph Analysis (VGA). The findings show that this building has 60% semi-public space, emphasising high and medium VGA integration for the permeability level. Wayfinding also has easy accessibility, with 48% and 50.5% interconnecting spaces.

Discipline: Architecture.

Cite This Article:

Rosidi, A. A., Hassan, A. S., Witchayangkoon, B., Abdul Nasir, M. H., and Arab, Y. (2025). Space Syntax Analysis of Users' Accessibility in Shunchang Museum. *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 13*(3), 13A3B, 1-15. http://TUENGR.COM/V13/13A3B.pdf DOI: 10.14456/ITJEMAST.2025.16

1 Introduction

Shunchang Museum's building has a space function beyond typical museum designs. Blending local culture with a modern approach creates a place that is not just for exhibition but also for visitors to have a unique way to experience the cultural space. Museum typology consists of public, semi-public, semi-private, and private. Hence, the space arrangement will significantly impact the overall productivity and the quality of work (Ab Majid et al., 2021). The choice of the Shunchang Museum as a case study stems from its innovative approach beyond traditional museum

architecture. The design connects land, sea, mountains, and community, blending built and natural elements seamlessly. This innovative approach presents this museum as an ideal subject to explore the impact of design on user experiences within its cultural spaces. When designing a highly efficient security building, it is crucial to investigate and comprehend how the spatial layout impacts the level of privacy and the extent to which it is determined (Mustafa et al., 2010). However, in the case of this study, the museum typology prevails, with most museums being public or semi-public spaces aimed at welcoming people to explore the historical and cultural aspects of the location

This study investigates spatial arrangements, specifically delving into the analysis of floor plan design and spatial organisation. The primary goal is to evaluate how well the building allows movement and depth within its layout. The research will investigate wayfinding and accessibility within the building's functional areas, examining the balance between preserving historical aspects and integrating fresh, modern concepts to establish a rich architectural setting.

2 Literature Review

The Space Syntax serves as both a quantitative and qualitative measure, allowing for the identification of relationships between human activities and the built environment (Bafna, 2003). Permeability is defined as the flow of spaces and is associated with the accessibility of space (Hiller & Iida, 2005). Space syntax analysis delves into the progression of human movement from one space to another and illustrates the permeability level within the design of the building (Tan et al., 2020). A space becomes more permeable with increased accessibility. Integrating physical building appearances with visual aids like information boards, signs, floor maps, and landmarks works most effectively to improve wayfinding (Nordin et al., 2020).

Consequently, space syntax can be characterised as examining accessibility levels, employing connectivity graph representation to derive wayfinding results (Yusoff et al., 2019). Space syntax measures the ease of facilitating users' navigation from one space to another. According to Lynch (1960), the analysis concludes that spatial configuration, wayfinding levels, and permeability are interrelated.

3 Background of the Case Study: The Shunchang Museum

The Shunchang Museum, nestled in Nanping, China, serves as a cultural stronghold, seamlessly melding regional heritage with avant-garde architectural brilliance. Conceived by the Architectural Design and Research Institute of Zhejiang University (UAD), a trailblazing institution renowned for its innovative architectural endeavours, this museum is a testament to modernity, capturing the cultural legacy of Shunchang County. The design philosophy intricately weaves local traditions, natural aesthetics, and contemporary elegance, creating a space that transcends traditional exhibition norms, immersing visitors in a captivating spatial odyssey. In alignment with Whitehead's perspective (2009), the research concept within museums varies across regional, national, and international contexts.

The architectural marvel features a double-volume lobby, visually connecting the two floors and exuding grandeur and warmth, as noted (Wong & Aziz, 2020). The ground floor level functions as exhibition spaces and areas for model displays, following a well-thought-out "street" layout along a central spine and minor spines, artfully guiding visitors through diverse sections (Alif Munir, 2015). The minor spine incorporates storage, a staff room, and service functions, while the loop circulation layout provides users with multiple routes to explore, in line with (Natapov et al., 2015).

The building is categorised under the museum typology. It encompasses various spaces such as exhibition areas, creative galleries, halls, conference rooms, research offices, and an auditorium, embodying museums' intricate complexities and multifunctional nature (Sirefman, 1999). The museum's spatial configuration is designed for public use, significantly influencing user movement and behaviour. The placement of exhibits, ease of navigation, and the amalgamation of historical and modern elements all shape how visitors interact with and respond to the museum's offerings, forming a dynamic and enriching cultural experience.

3.1 Location of The Shunchang Museum

The Shunchang Museum stands within Shunchang County, a part of the Nanping prefecture in Fujian Province, China. Positioned precisely within Shunchang County, the museum invites both residents and tourists to discover its exhibitions and impressive architecture amidst the breathtaking landscape of Fujian Province. Among the areas within the jurisdiction of Nanping, Shunchang County is renowned as "the hometown of cedar wood in China." At the same time, Wuyishan City is one of China's only four "World Natural and Cultural Heritage Sites" (Zhao, 2021).

3.2 The Shunchang Museum Building Style

Shunchang Museum has a parametric architectural style with contemporary and innovative design, featuring a unique spindle-shaped structure. It represents connections between nature and community, the fusion of traditional heritage with modern concepts. Parametric design is a concept bolstered by the growing accessibility of computer-aided techniques and advancements in manufacturing processes, enabling the realisation of intricate and complex forms (Al-Azzawi et al., 2021). This design serves as an exhibition space and a symbol of connecting the past with modern innovation, merging local heritage with new architectural concepts.

4 Method

The first phase of this research involves choosing a building as a precedent study. The selected building is the Shunchang Museum, categorised under museum typology. The paper presents an analytical study employing qualitative and quantitative space syntax analysis methods. Sourcing information about this structure from journals and online articles will be sufficient for the study. The data, including floor plan drawings, is then replicated using AutoCAD to create an original version by the author. The findings are then translated into maps, where spaces are defined

and labelled using an alphabetical and numerical system, each associated with distinct colours (Yusoff et al., 2019).

Subsequently, the map is transformed into a graphical diagram with nodes and lines symbolising the spaces and connections between them. It is organised across multiple levels, commencing from 0, which serves as the root space (Elizondo, 2022). Visual connectivity and integration of spaces are scrutinised through a computational approach utilising the simulation of Visibility Graph Analysis (VGA) generated from the depthmapX-0.8.0 software. The level of connectivity is depicted in the graph through a colour spectrum ranging from red to dark blue, as outlined in the work by Chau et al. (2018).

4.1 Likert Scale

In surveys and research, the Likert scale is widely utilised as a psychometric tool for assessing attitudes, opinions, perceptions, or behaviours. Respondents can use this scale to indicate their degree of preference with a sequence of statements (Joshi et al., 2015).

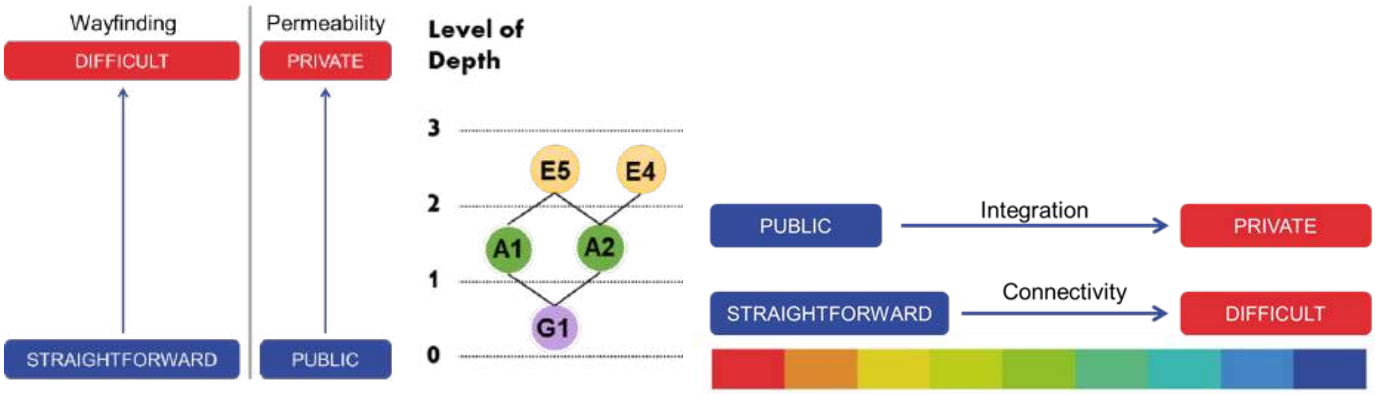


Figure 1: Example of Level of Depth (left), Justified Graph (middle), and Visibility Graph scale (right)

The configuration of the Justified Graph undergoes alterations when the graphs are produced from distinct root spaces. Two types of spatial systems exist: (A) Symmetric spatial system and (B) Asymmetric spatial system (Hiller & Hanson, 1984). This paper has utilised the (B) asymmetric spatial system type of justified graphs.

In a symmetrical spatial system, spaces are directly linked to the root space and necessitate minimal depth. Conversely, spaces are arranged linearly within an asymmetrical spatial system, resulting in maximum depth (Mustafa & Hassan, 2013).

4.2 Coding System

A justified graph is a visualisation that outlines spatial arrangement, presenting all areas positioned from a particular space at varying reference levels (Klarqvist, 2015). The permeability survey evaluates the pathway openness within the case study location. It is accomplished through a justified graph depicting the building's entrance, halls, corridors, rooms, stairways, and Lifts. Each space is labelled with unique codes and colours for easy identification. The vertical axis in the

visualisation signifies spatial depth from the starting point, reflecting the degree of permeability. Lower depths suggest decreased privacy, while higher levels indicate increased privacy in each area. The lines linking these points illustrate the connections among the pathways. The examination of spatial configurations encompasses the interrelated concepts of permeability and wayfinding, as discussed by Abdul Nasir et al. (2022).

The floor plan will undergo a detailed analysis to demonstrate the building's permeability study. Each node will be identified, named, and evaluated for accessibility and depth using various colours. The numbering system will indicate positive or negative aspects of wayfinding and permeability. Detailed data from the justified graph will be organised into a table, comprehensively representing permeability and wayfinding levels and revealing the building's hierarchy and narrative. All areas in the building are organised using this system. For example, numeric labels (1, 2, 3, etc.) designate key functional spaces, while alphanumeric labels (E1 & E2) indicate entrances, building access, and exit points. Vertical access points, like staircases and escalators, are denoted by S1 and S2, and lifts are identified as L1 and L2. Corridors are labelled sequentially as C1, C2, C3, etc. The main entrance on the site plan is marked as G1, and parking areas are specified as CP1 & CP2 (refer to Table 1).

Table 1: Categorisation of Alphanumeric and Colour Based on Building Function.

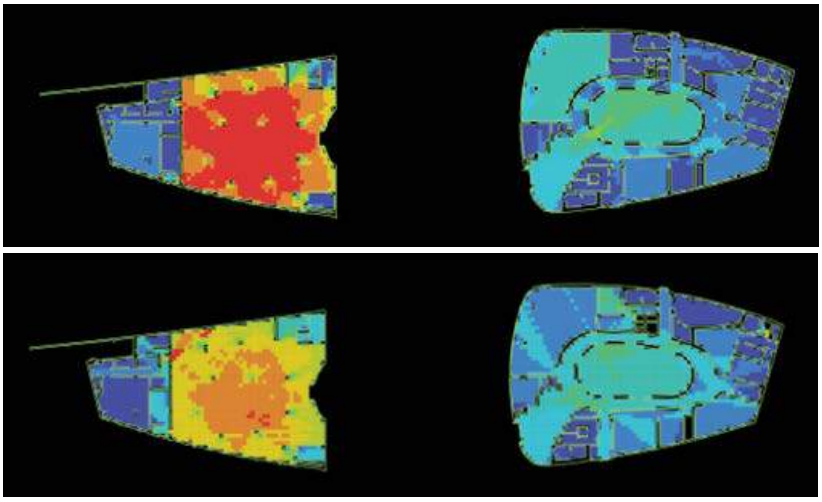
Function	Alphanumeric	Colour
Site Access	G1 & G2	Purple
Parking Access	G3	Purple
Car Parking	CP1	Orange
Bus Parking	CP2	Orange
Building Access	E (E1, E2, E3, etc.)	Yellow
Public Green Area	A1, A2 & A3	Green
Public Space for Visitors	(1, 2, 3, etc.)	Green
Staff and Semi-Private	(4, 7, 11, etc.)	Red
Corridor	C (C1, C2, C3, etc.)	Grey
Lift/ Bomba Lift/ Loading & unloading Lift	L (L1, L2, L3, etc)	Blue
Staircase/Firestaircase	S (S1, S2, S3, etc,)	Blue

5 The Analysis

The extent of permeability within the Justified Graph (Figure 1) is established by assessing the depth level of cells. This depth level refers to the count of cells traversed to reach a specific cell based on the root space. In this research, spaces categorised from Level 0 to Level 2 are deemed public or semi-public. Conversely, spaces from Level 3 and beyond are regarded as semi-private or private areas requiring authorised access, some exclusive to specific user groups. To reinforce these conclusions, examining the Visibility Graph Analysis can provide further validation. Public or semi-public spaces, characterised and integrated, are depicted in red, whereas semi-private and private spaces are denoted in blue.

5.1 Level of Permeability and Level of Wayfinding

The degree of permeability within the Justified graph's space is established by examining the cell's depth level, denoting the number of cells traversed to reach the desired cell from the root space. This investigation categorises spaces designated from Level 0 to Level 3 as public or semi-public. Conversely, spaces from Level 4 onwards are identified as semi-private or private, with restricted access, and some areas are exclusively accessible to specific user groups. Examining the Visibility Graph Analysis can enhance these findings' validity. Spaces classified as public or semi-public, boasting high visual connectivity and integration, are depicted in red, while semi-private and private spaces are represented in blue.



(a)

(b)

Figure 2: Example of VGA Connectivity Graph (a) and VGA Integration Graph (b)

Examining the building's spatial system can gauge the extent of wayfinding proficiency. When alternative routes are present, an asymmetrical spatial system emerges. This diversification of relations results in a reduction in depth, signifying straightforward wayfinding. Conversely, a symmetrical spatial system with a high depth level suggests increased complexity and difficulty accessing spaces.

5.2 Levels of Permeability and Wayfinding Analysis

The results obtained from the Justified Graph can pinpoint the degree of permeability and the effectiveness of wayfinding within the layout. A substantial proportion of space revealed at a shallow depth level signifies increased permeability and accessibility, classifying it as a public area. Conversely, many spaces at a deeper depth level are identified as private spaces with lower permeability. Analysing the percentage of diversity and depth within the spatial system allows for determining the level of wayfinding. A more diverse relationship between spaces corresponds to a shallower spatial system, indicating a higher level of wayfinding.

6 Results

6.1 User Category

The building's spatial structure analysis involves identifying two user categories: 1) Staff and 2) Visitors. In the Justified Graph, distinct colours differentiate the spaces accessible to each group.

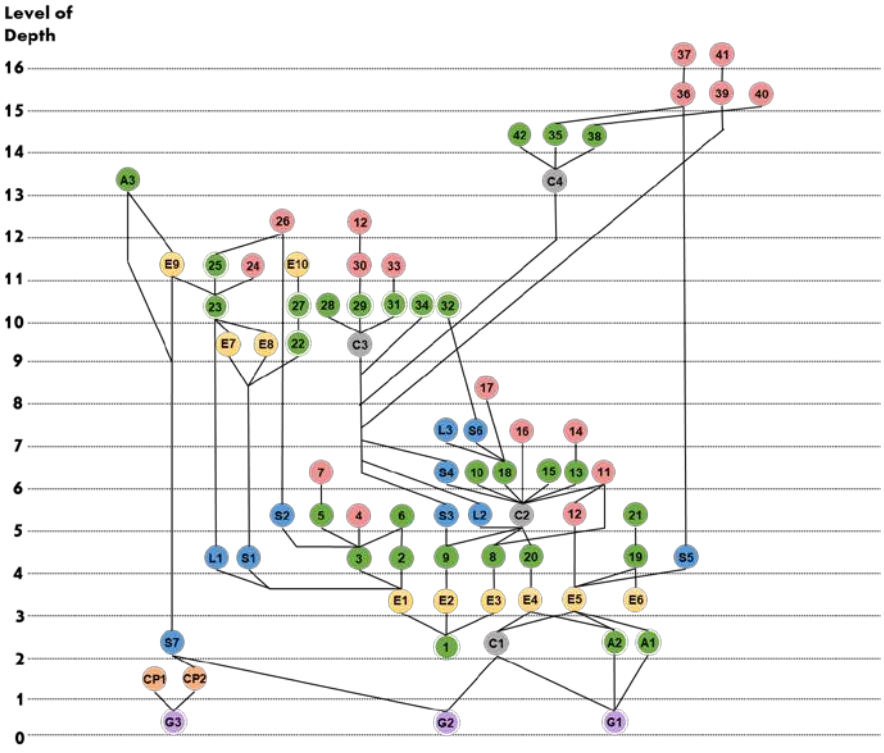
Spaces accessible by visitors are marked with green circles, while red circles denote those restricted to staff. Vertical connections between floors are represented by blue circles, corridors by grey circles, and access points to the building by yellow circles.

6.2 Site Plan

The justified graph comprises four depth levels, from level 0 to level 16 (Figure 3).

(a)

No.	Space
G1,G2	Public Ingress to Site
G3	Car access to parking
CP1	On-site Parking
CP2	Bus Parking
A1,A2	Public Plaza
A3	Roof Top Garden
E4,E5	Building Entrance
S7	Outdoor Staircase



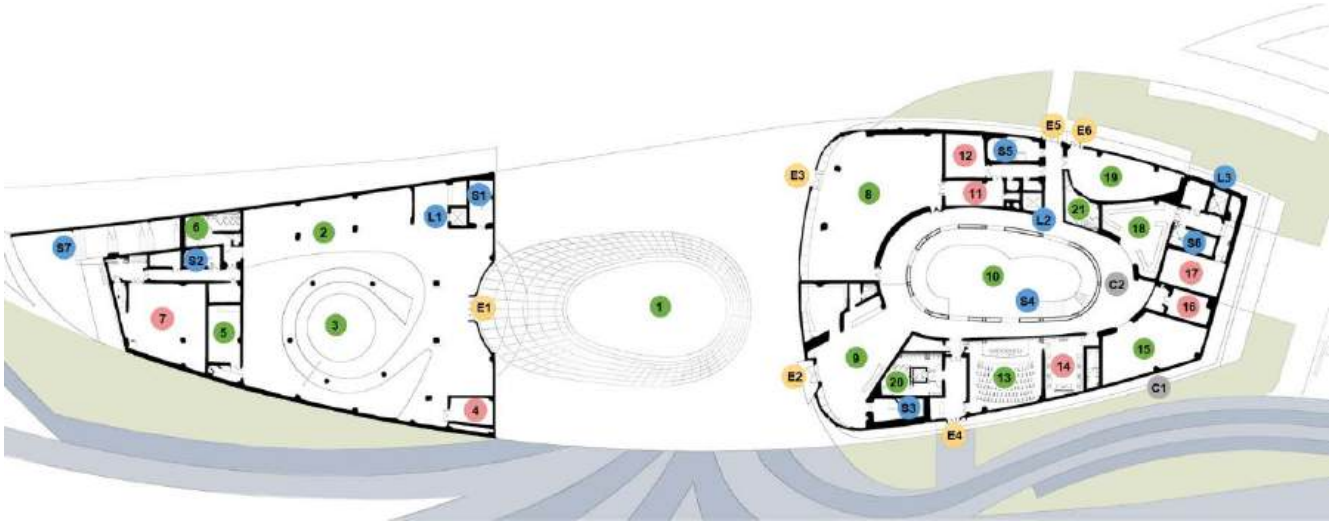
(b)

Figure 3: Site Plan (a) and Overall Justified Graph of Shunchang Museum (b).

Three entrances grant access to the site: G1 and G2, accessible to public users from the main road, and G3, designed for car access, featuring parking areas CP1 and CP2. Public plazas A1 and A2 are accessible from G1. The rooftop garden A3 is solely accessible via stairs S7. E4 and E5 possess a permeability level 2, classifying them as semi-public spaces. Additionally, the rooftop garden is semi-private due to its permeability level 3. Access to G1, G2, and G3 is straightforward due to their proximity to the main road, facilitating easy wayfinding. E4 and E5 also offer a straightforward wayfinding as they are highly accessible and visible entrances. However, A3 presents a more complex and deeper route, making access more difficult.

6.3 Ground Floor Plan

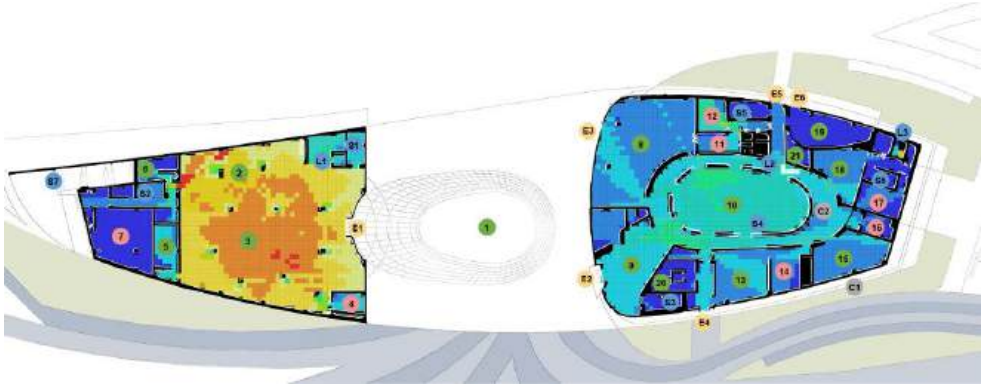
The depth level on the ground floor plan within the justified graph extends to level 8, originating from level 3. This ground floor connects to the first floor through nine vertical connections, comprising three lifts (L1, L2, and L3), six staircases (S1 - S6), public access points, and fire escape routes.



(a)

No.	Space
E1	Main Public Entrance
E2,E3	Main Exhibition Entrance
E4, E5	Fire Exit – Comprehensive Hall
E6	Rest Area Entrance
S1,S2,S3 and S5	Fire Staircase 2
S4	Spiral Staircase
S7	Outdoor Staircase
L1 and L2	Lift
L3	Loading-unloading Lift
C1 and C2	Corridor
1	Public Leisure
2	Cultural Display
3	Model Display

No.	Space
4	Staff Room 1
5	Classroom
6	Toilet
7	Main Storage
8	Exhibition Hall
9	Reception Foyer
10	Comprehensive Hall
11	Control Room
12	Storage 1
13	Auditorium
14	Co-working Space
15	Multifunction Hall
16	Staff Room 2
17	Storage 2
18	Exhibition Space
19	Cultural and Rest Area
20 and 21	Toilet



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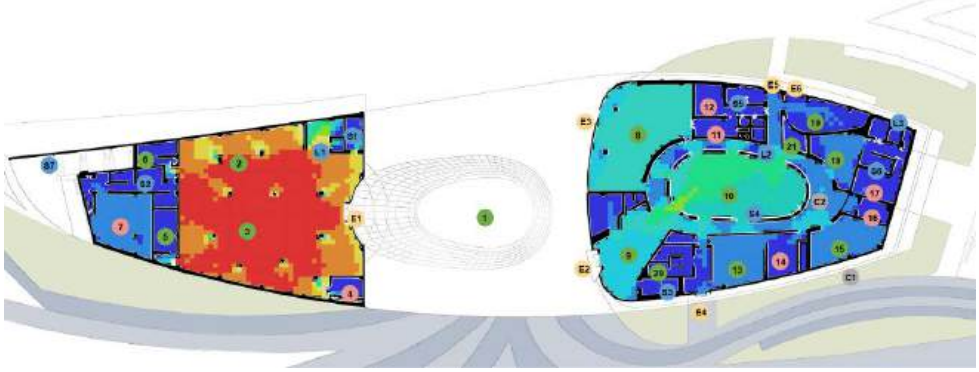


(c)

Figure 4: (a) Ground Floor Plan, (b)VGA Connectivity Graph, and (c) VGA Integration Graph.

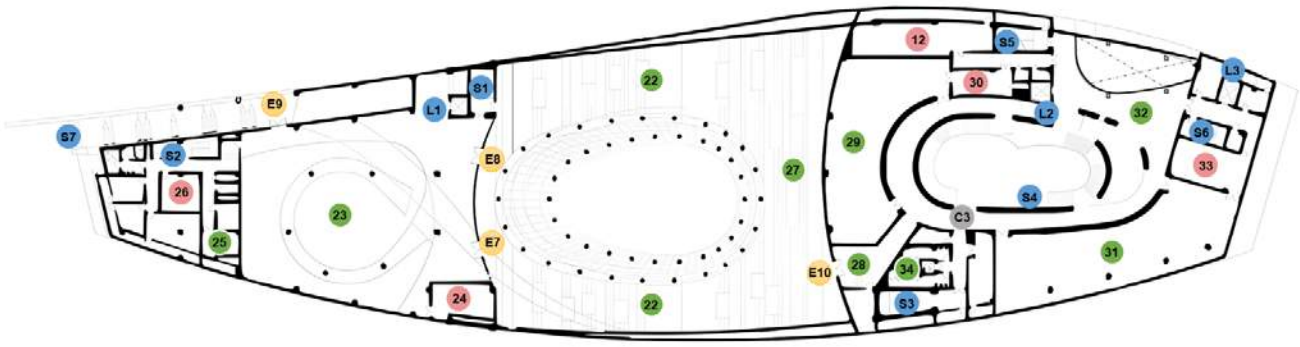
Six entrances are available to access the building. E1, E2, and E3 are designated for public use and can only be accessed from 1, where parking CP1 is provided. The permeability levels of E1, E2, and E3 are set at level 3, categorising them as semi-public entrances.

E4, E5, and E6 share a common hierarchy at depth three but are not easily discernible. They can be reached from A1 and A2 at the transition point between G1, which is situated at the 0 permeability level. Consequently, these spaces are classified as semi-private access points. The wayfinding for E1, E2, and E3 is straightforward, given their high accessibility and visibility.

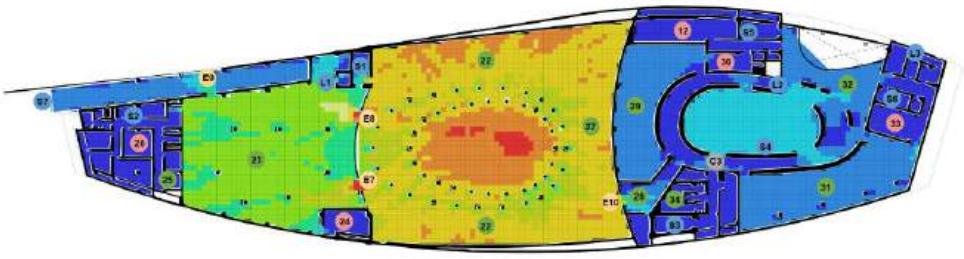
6.4 Middle Floor Plan

Access to the first floor is primarily through lifts L1 and L2, where public exhibition and gallery spaces are located. Figure 5 indicates that storage and staff rooms on the first floor, extending to level 12, are designated private areas. The organisation follows the exhibition's function and storyline.

For spaces related to the history and culture exhibition (22) and modelling display (27) on Level 10, the depth level suggests semi-public accessibility, confirmed by the connectivity graph in Figure 7A. Corridor C3 with stairs S4 connects to the ground-floor comprehensive hall (10), serving as the main route to spaces like 27, 28, 29, and 31, with a depth level of 9.



(a)



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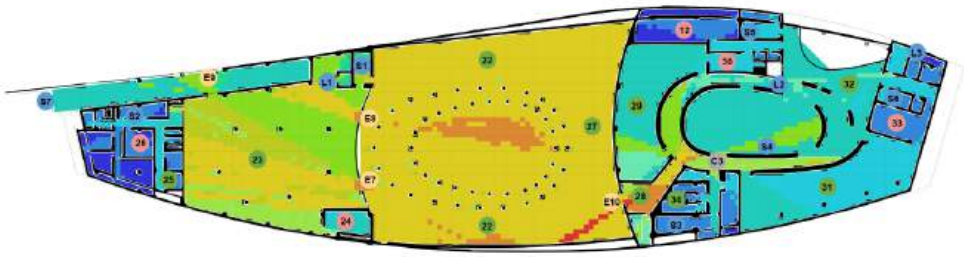


(c)

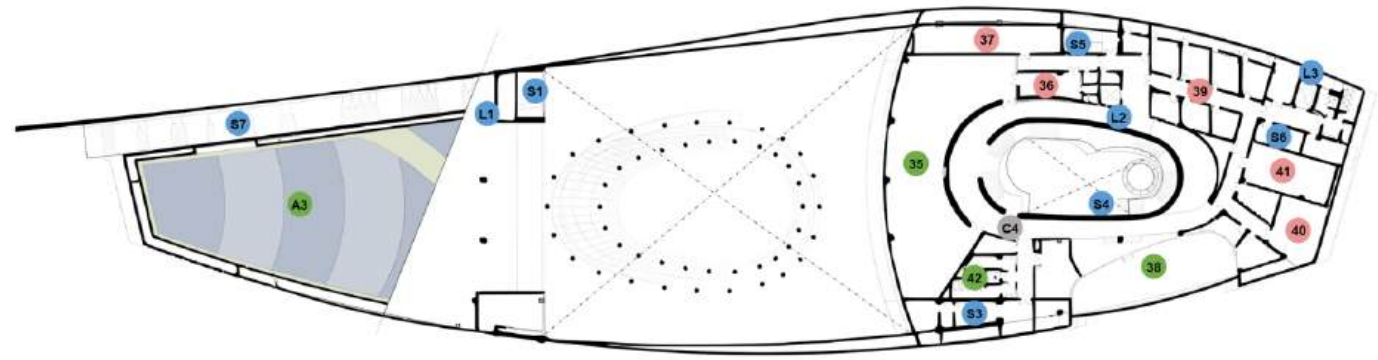
No.	Space
E7,E8	Public Entrance
E9	Access to the Roof Top Garden
E10	Fire Exit – Comprehensive Hall
S1,S2,S3 and S5	Fire Staircase 2
S4	Spiral Staircase
S7	Outdoor Staircase
L1& L2	Lift
L3	Loading-unloading Lift
C3	Corridor
22	History and Culture Exhibition
23	Model Display
24	Staff Room
25	Rest Room
26	Conference Room
27	Creative Gallery
28	Foyer
29	History Exhibition Hall
30	Control Room
12	Storage 1
31	Culture Exhibition
32	Sitting Area
33	Staff Room
34	Toilet

Figure 5: (a) Middle Floor Plan, (b) VGA Connectivity Graph and (c) VGA Integration Graph.

The first-floor spatial structure mirrors the ground-floor plan, displaying complexity and low wayfinding levels for most spaces, as shown in Figure 4. This result aligns with the conclusions from the justified graph. However, for staff familiar with the layout, wayfinding is straightforward, especially in the exhibition area, which has an open layout that facilitates easy navigation and item showcase.

6.5 Top Floor Plan

The justified graph for the second-floor plan reaches a depth level of 16, commencing from level 16. Like the first floor, this level is accessible through the vertical connections L2 and S4, serving as the main access points.



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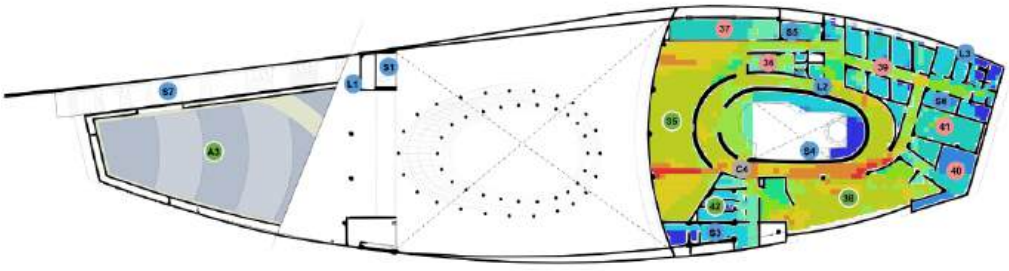

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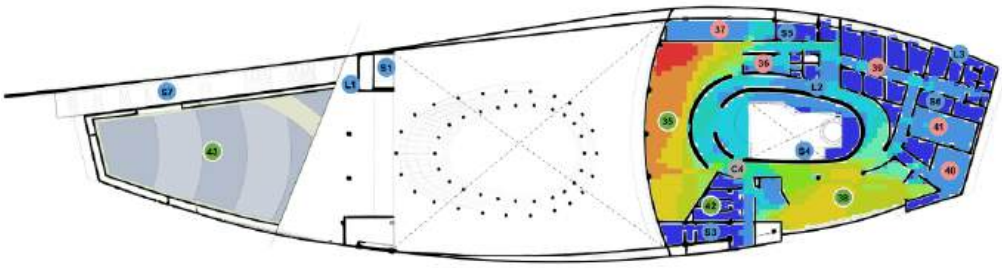

(c)

No.	Space
S1,S2,S3 and S5	Fire Staircase 2
S4	Spiral Staircase
S7	Outdoor Staircase
L1 and L2	Lift
L3	Loading-unloading Lift
C3	Corridor
35	Exhibition Hall
36	Control Room
37	Storage
38	Roof Garden
39	Research Office
40	Conference Room 1
41	Conference Room 2
42	Toilet
43	Roof Top Garden

Figure 6: (a) Top Floor Plan, (b) VGA Connectivity Graph, and (c) VGA Integration Graph.

Referring to Figure 6's justified graph, depth levels 13 to 14 are semi-private, level 15 is private, and level 16 is highly private. Staff access points (E4, E5, E6) offer direct entry to the workplace, avoiding semi-public spaces. The right-wing houses research offices, a conference room, and an exhibition hall, while the left-wing features a rooftop garden via the S7 staircase. Corridors C4 connect semi-public and private areas, with research offices strategically located near L3.

L2 and L3 are primary lifts for private areas, with L2 exhibiting the lowest connectivity value. Spaces linked to these corridors include semi-private areas, with private workspaces at level 15

accessed through separate corridors from C4, emphasising privacy. Wayfinding ranges from easy to very difficult on the top floor, characterised by a symmetric spatial system. Depth level 13 spaces pose moderate wayfinding challenges.

Private areas exhibit low visual integration (blue to dark blue) in Figure 8A, while semi-public spaces show higher integration (red to light blue). Corridor C4 enhances wayfinding, though direct access varies. Overall, wayfinding is moderate for staff but challenging for unfamiliar visitors due to the complex spatial structure.

7 Discussion

The justified graph illustrates a complex symmetrical tree-like structure, with the most profound spaces reaching level 16. Most spaces fall within the depth levels ranging from level 2 to level 13, displaying high to moderate integration and connectivity values. This result suggests that the museum functions as a public-to-semi-public building. Serving as a prominent destination for the history and culture of Sunchang, it is imperative to maintain a high level of integration and connectivity for daily operations, facilitating public access to engage with the exhibitions.

7.1 Level of Permeability

The building incorporates many semi-public and public spaces, aligning with the museum typology. Specifically, 60% of the spaces are semi-public, and 6.7% are designated as public. Semi-private areas constitute 17.3%, while private spaces each account for 16% of this architectural design.

Table 2: Number and Percentages of Spaces based on Level of Permeability

Hierarchical Order	Level of Permeability	Visual Connectivity	Depth of space	Number Of Space	Percentage (%)
Primary Level	Public	High	Level 0-1	5	6.7
Secondary Level	Semi-Public	Medium	Level 2-9	45	60
Tertiary Level	Semi-Private	Low	Level 10-11	13	17.3
Quaternary Level	Private	Very Low	Level 12-16	12	16

7.2 Levels of Wayfinding

Regarding wayfinding, the distribution of spaces is as follows: 6.7% of the areas are categorised as very easy for wayfinding, followed by 48% designated as easy, 12% at an intermediate level, 17.3% considered difficult, and 16% categorised as very difficult for wayfinding.

Table 3: Number and Percentages of Spaces based on Level of Wayfinding

Hierarchical Order	Level of Wayfinding	Visual Integration	Depth of space	Number of Space	Percentage (%)
Primary Level	Very easy/straightforward	Very High Integration	Level 0-1	5	6.7
Secondary Level	Easy/straightforward	High Integration	Level 2-6	36	48
Tertiary Level	Intermediate	Medium	Level 7-9	9	12
Quaternary Level	Difficult	Segregated	Level 10-11	13	17.3
Quinary	Very difficult	Most Segregated	Level 12-16	12	16

7.3 Other Aspects

The distribution of spaces is as follows: 29.3% are end rooms, 33.3% for single connecting spaces, 5.3% for double connecting spaces, 16% for triple connecting spaces and above, 4% each for lift and site entrances, and 2.7% for car parking.

Table 4: Number and Percentages of Spaces based on other aspects.

Level of Wayfinding	Space	Number	Percentage (%)
End room	4, 6, 7, 10, 11, 12a, 14, 15, 16, 17, 21, 24, 26, 32, 33, 34, 37, 40, 41, 42, A3, and E10	22	29.3
Single (1) connecting space	A1, 2, 5, 12, 13, 19, 20, 22, 25, 27, 28, 29, 30, 31, 35, 36, 38, 39, E2, E3, E4, E6, E7, E8 and E9	25	33.3
Double (2) connecting space	A2, C1, 8 and 9	4	5.3
Triple (3) connecting space	1, C3, C4, E1, E5, 18, and 23.	7	9.3
Quadruple (4) connecting space	3	1	1.3
Septuple (7) connecting space	C2	1	1.3
Staircase	S1, S2, S3, S4, S5, S6, and S7.	7	9.3
Lift	L1, L2 and L3	3	4
Site Entrance	G1,G2 and G3	3	4
Car parking	CP1 and CP2	2	2.7

8 Conclusion

In conclusion, the analysis of the justified graph and spatial configurations of the museum reveals a comprehensive understanding of its layout, emphasising the integration of various access points, symmetrical spatial systems, and depth levels that establish distinct public, semi-public, and private spaces. The intentional design features in public spaces enhance permeability, facilitating easy access for the general public, while restricted areas employ deliberate design choices to establish controlled access and confidentiality.

The wayfinding experience is straightforward in public spaces, creating an intuitive path for visitors. In contrast, restricted areas have intentionally challenging wayfinding to ensure privacy and controlled access for staff familiar with the layout. The overall planning strategically segregates different user groups with clear limitations on access, contributing to a structured environment. However, challenges include confusion in open exhibition spaces, hindering navigation, and potentially leading to user frustration.

A notable constraint is the absence of a personal visit, relying solely on online sources for information and research papers for analysis. Additionally, the DepthmapX 0.8.0 software may face limitations in capturing intricate spatial arrangements, potentially impacting its efficacy in providing detailed insights into specific complexities and dynamic user behaviours within the museum environment.

9 Acknowledgement

This research is under financial support from ITJEMAST publisher for a joint research study with Universiti Sains Malaysia from the industrial grant No 304 /PPBGN /6501356 /I158 titled ‘A Study on Social Contexts of Building Space Syntax’.

10 Availability of Data and Materials

All information is included in this article.

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