



# Space Syntax Analysis of Iowa State University Student Innovation Center

Louis Ting Kwang Liou<sup>1</sup>, Yasser Arab<sup>2\*</sup>, Ahmad Sanusi Hassan<sup>1</sup>, Boonsap Witchayangkoon<sup>3</sup>

<sup>1</sup>School of Housing, Building & Planning, Universiti Sains Malaysia, 11800 USM, MALAYSIA.

<sup>2</sup>Department of Architectural Engineering, College of Engineering, Dhofar University, OMAN

<sup>3</sup>Department of Civil Engineering, Thammasat School of Engineering, Thammasat University, THAILAND.

\*Corresponding Author (Tel: +968 99872907, Email: [yarab@du.edu.om](mailto:yarab@du.edu.om)).

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## Abstract

The research examines the building space planning for the Iowa State University Student Innovation Center based on permeability and wayfinding for various sorts of users. The study used space syntax analysis, depicted in graphs on the degree of permeability and navigation using a Likert scale numbering method. The study divides the measurement into five degrees of Likert scale permeability. According to this study's findings, the degree of permeability and navigation in the Iowa State University Student Innovation Center has a relatively apparent separation between public and private spaces. This positive circulation offers users a reasonable level of accessibility, allowing them to grasp better Iowa State University Student Innovation Center's public and private space layouts.

**Discipline:** Architectural Engineering.

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## 1 Introduction

In the architectural industry, space syntax theory and practices are widely used. It is used to investigate spatial cognitive elements of a location, such as navigating and learning new places (Beck and Turkienicz, 2009). As a result, their spatial arrangement influences how people use buildings (Hassan, 2004). These are the interactions between space and individuals.

The purpose of the research is to understand better the innovation centre's space layout and the connection across spaces. This research is also necessary to determine the efficiency and functioning of regions that may impact the human experience within the structure. Furthermore, this research aims to determine the depth of the spaces depending on the user of the facility. The

study's goals may be met by analysing architectural space planning based on the degree of permeability and wayfinding for various types of users. It is predicted that different users would have varying degrees of permeability and navigational experience in the building.

The case study chosen for this paper is an education facility which is Iowa State University Student Innovation Center. It is located in Iowa in the United States of America. This building has two primary programs: an innovation centre and an education centre. The innovation centre provides space for students, faculty and staff to share ideas, experiment and create new products.

## **2 Literature Review**

### **2.1 Space Syntax**

According to Hillier and Hanson (1984), Space syntax is a mathematically generated theory that helps people comprehend a building's spatial arrangement via the lens of social interactions among its occupants. Convex space, axial line, and visibility graph analyses are the three traditional methods of space syntax study. These three techniques turn urban and architectural designs into a collection of specified areas, lines of sight, and visual places, respectively. Once this has happened, the relationships between these pieces may be quantitatively analysed. Space syntax seeks to describe human behaviours and social activities from a spatial perspective by providing a configurative description of urban structure and architectural space. The majority of space syntactic research focuses on urban patterns, although the technique is equally applicable to urban and architectural design studies on a larger scale. Space syntax can generate a type of knowledge that might help architects figure out how well their plans might work, what properties they have, and so on. In practice, by studying the morphological structure of the design plan using space syntax, urban planners and designers can estimate pedestrian movement flows before the actual production of natural urban systems and buildings.

### **2.2 Level of Permeability and Wayfinding**

Wayfinding is an architectural design that provides individuals with directions based on their physical surroundings, allowing them to comprehend better and enjoy the area (Mohd Yasin, Hassan, Al-Ashwal, 2017). It's also a challenge of addressing spatial space. When you are in a building or an area, it will tell you where your desired place is and how to get there from your current location (Natapov et al., 2015; Montello, 2001). According to Emo, Holscher, Wiener, and Conroy-Dalton (2012), the surroundings impacted wayfinding behaviour. Visual access, layout plan arrangement, architectural distinction, and signage are four environmental elements that have been identified as having an impact on wayfinding behaviour.

On the other hand, wayfinding is the users' perceptions of the environment (Abrams and Brandom, 2010). Essential principles for successful human navigation performance concerning the visual-spatial characteristics of the surroundings. It exemplifies simplicity, superb shape, and visual access with the appropriate architectural qualities (Carratin, 2011).

According to Ephes (2006), the level of permeability is the movement of spaces from one to another. Permeability is also defined as people's contentment with places dependent on the qualities of the surrounding environment (Yavus et al., 2012). Permeability is defined as the degree to which a place is accessible in this study. The higher the amount of permeability, the easier the place is to access.

## **2.3 Iowa State University Student Innovation Center**

The case study chosen is Iowa State University Student Innovation Center (Figure 1). The Student Innovation Center at Iowa State University strives to encourage students to create via experimentation and cooperation. It allows students, teachers, staff, and the general public to meet with and learn from industry experts in the fields of innovation and entrepreneurship.

### **2.3.1 Background**

The building, located in the heart of Iowa State University, has four levels and a basement level, providing students with a range of different areas for collaborative learning and creation. Students will get the opportunity to work on projects from beginning to end, including planning, design, production, testing, marketing, and distribution. The complex has specific areas for Iowa State's six undergraduate colleges.

It all began when two institutions came up with the concept of constructing a centre that would stimulate creativity in their respective disciplines. The Student Innovation Center, open in August 2020, is unlike any other in terms of scale, breadth, and participation. The five-story, 140,000-square-foot complex serves the whole university community by providing outstanding facilities, workspaces, and activities that stimulate creativity across all elements of Iowa State's land-grant mission.

With more than 60% of the facility dedicated to shared, collaborative space for all students, the Student Innovation Center is the place to be. Students, instructors, and staff can work together to develop breakthrough products and bring new ideas to market. It creates a welcoming atmosphere where all university stakeholders may discover resources, thanks to the generosity of donors and funding from the State of Iowa.

### **2.3.2 Building Typology**

The selected case study compromised the components mainly on education and research area. Hence, the building typology is under the educational building. Buildings that house educational institutions such as schools or colleges connected with and recognised by a relevant board, university, or other affiliation authority. The structure facilitates the gathering of instructional, pedagogical, and recreational activities for educational objectives.

### 2.3.3 Building Style

Design by Kieran Timberlake & substance architecture. A one-of-a-kind, bespoke pleated curtain wall system is included in the project. Each unit has two clear view lines on one side and a full-height shadow box, allowing natural light in while decreasing energy transmission—the pleats accordion from flat to angled across elevations, employing 17 distinct angles throughout the pattern. The façade is similarly made out of perforated and solid metal panels.

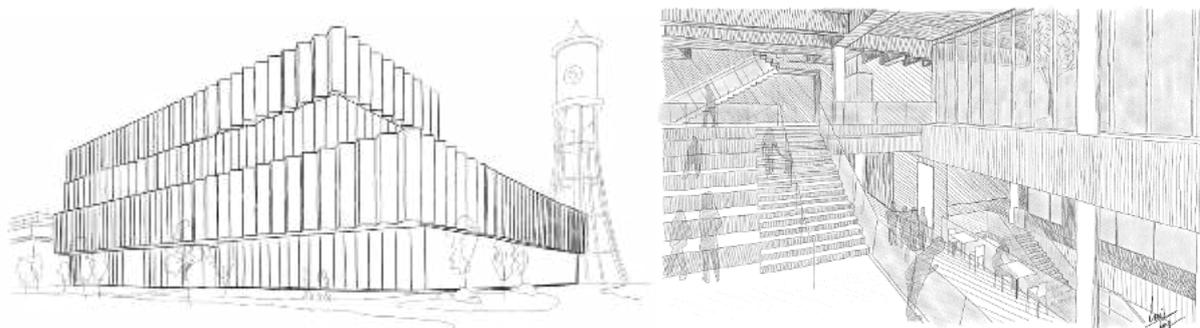


Figure 1: Sketch of exterior and interior perspectives for Iowa State University Student Innovation Center.

## 3 Method

According to the linearity of the space, space syntax may be classed as indoor or outdoor analysis, and the researcher is interested in the indoor one. As a result, there are three alternative visual representations of space syntax (e.g. axial, convex, and Isovist). The essential notion of syntactic space analysis is based on depth analysis. In a spatial layout, the total depth is the sum of all shortest distances between nodes. A node is deep if it is separated from the others by many steps. On the other hand, a node is shallow if it is only a few steps away from others.

The distribution of depth in the spatial configuration, also known as integration, may be estimated using this information to quantify the configuration attributes of spatial or formal complexes. The degree to which a node is integrated or detached from the rest of the system is indicated by its integration value (Hillier 1999).

The degree of permeability will be assessed using a four-category scale: (1) public; (2) semi-public; (3) semi-private; and (4) private. The y-axis of the Justified Graph (Figure 2), which is the depth level of space, will be the level of permeability. The difficulty of wayfinding will be assessed on a three-category scale using the Likert Scale: (1) easy, (2) medium and (3) hard.

Table 1: Likert Scale for Space Syntax Analysis of each measurable scale graph.

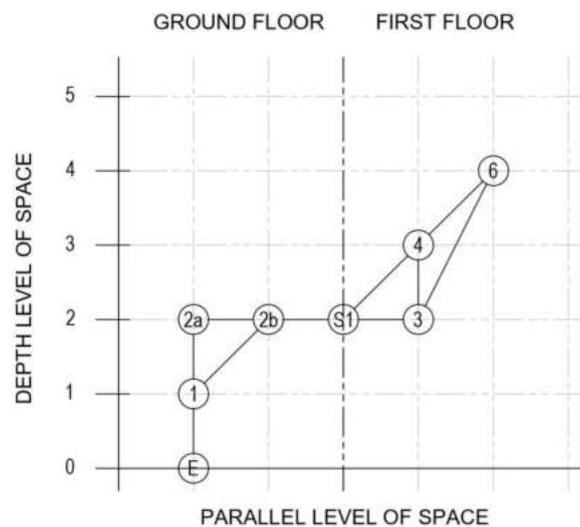
| Likert Scale Numbering | Level of Permeability | Level of Wayfinding |
|------------------------|-----------------------|---------------------|
| 0                      | -                     | -                   |
| 1-2                    | public                | easy                |
| 3-4                    | semi-public           |                     |
| 5-7                    | semi-private          | medium              |
| 8-9                    | private               | hard                |

For the space syntactic approach, there are two sorts of methods used. First, alphabets and numerals are used to denote both case studies of floor designs. The letter E represents the most common method of entry into the building in the alphanumeric (E1, E2, E3, etc.). The letter B is used for services compartments such as fire, water, and electricity (B1, B2, B3, etc.) in the building services section, whereas the letter D is used for storage or storerooms (D1, D2, D3, etc.). Toilets (T1, T2, T3, etc. ), corridors (C1, C2, C3, etc. ), stairs (ST1, ST2, ST3, etc. ), and elevators (L1, L2, L3, etc.). Meanwhile, the primary useable spaces are indicated by numerical labelling (1, 2, 3, etc.).

Depth from 0 to 3 = Public

Depth from 4 to 9 = Semi-Public or Semi-Private

Depth from >9 = Private



**Figure 2: Justified Graph and Graph Model**

According to Ephes (2006), permeability is the passage of space from one place to another. Permeability is also defined as people's contentment with places dependent on the qualities of the surrounding environment (Yavus et al., 2012). Permeability is defined as the degree to which a place is accessible in this study. The higher the amount of permeability, the easier the place is to access. On the other hand, wayfinding is the users' perceptions of the environment (Abrams and Brandom, 2010). Significant principles for successful human navigation performance in relation to the visual-spatial characteristics of the surroundings. It exemplifies simplicity, superb shape, and visual access with the appropriate architectural qualities (Carratin, 2011).

## 4 Results

This study looked at the level of permeability and navigation for each floor plan, from the basement to the 4th-floor design. Iowa State University Student Innovation Center is a highly connected location with several links to neighbouring areas. Five entrances have been connected to various regions on the site design. The sorts of usage of this building define the amount of permeability and wayfinding research. The following criteria were used to determine the kind of user:

- Visitor

- Staff

## 4.1 Spatial Configuration

Figures 3-7 show the layout plan for each floor of the Iowa State University Student Innovation Center. Legends for each space are given.

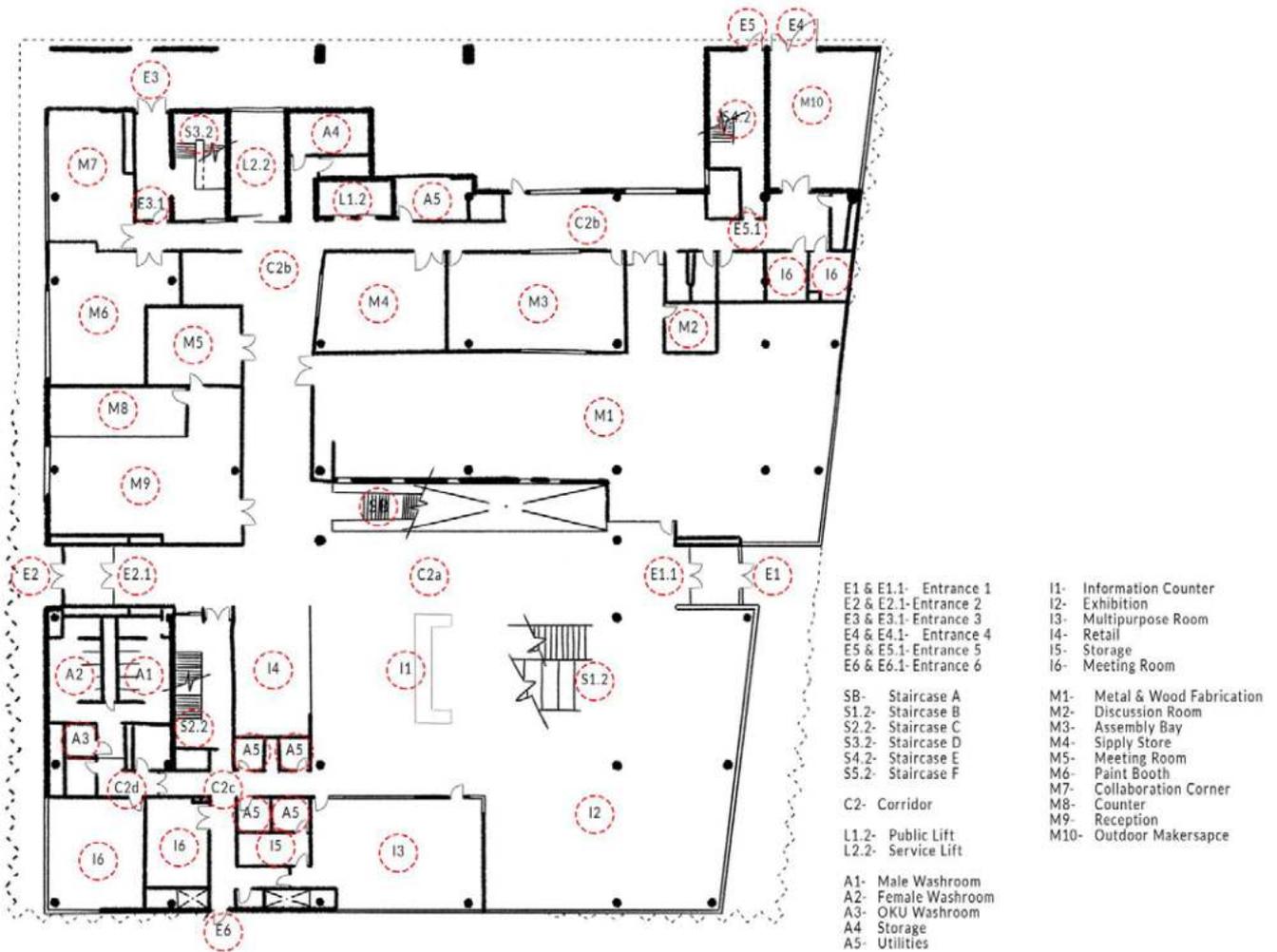
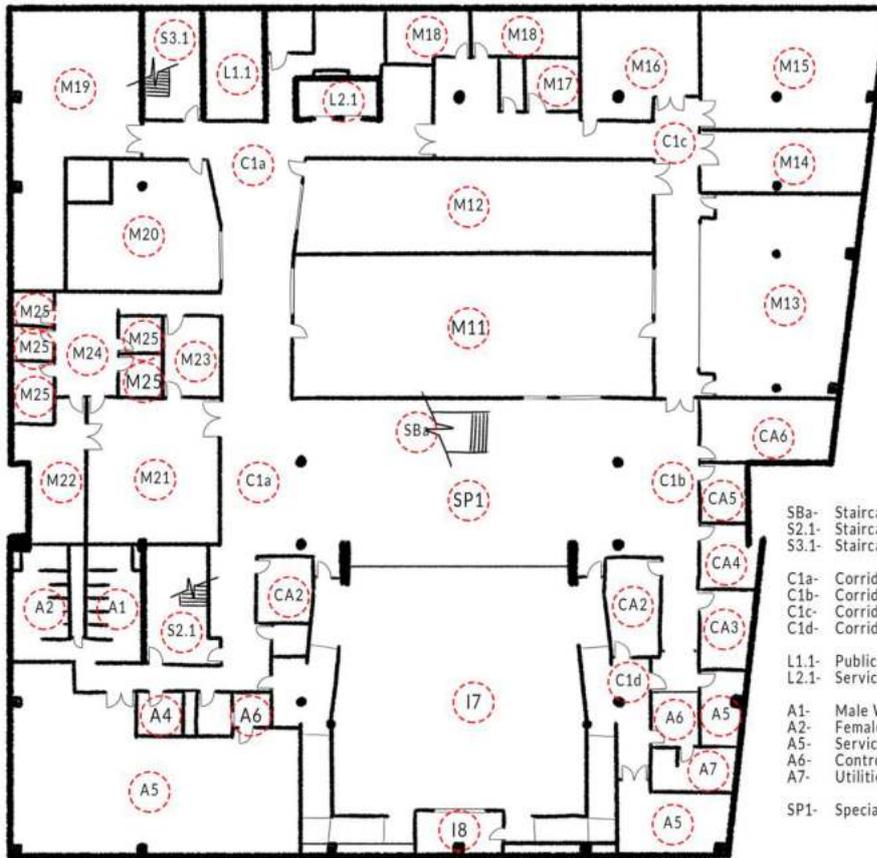
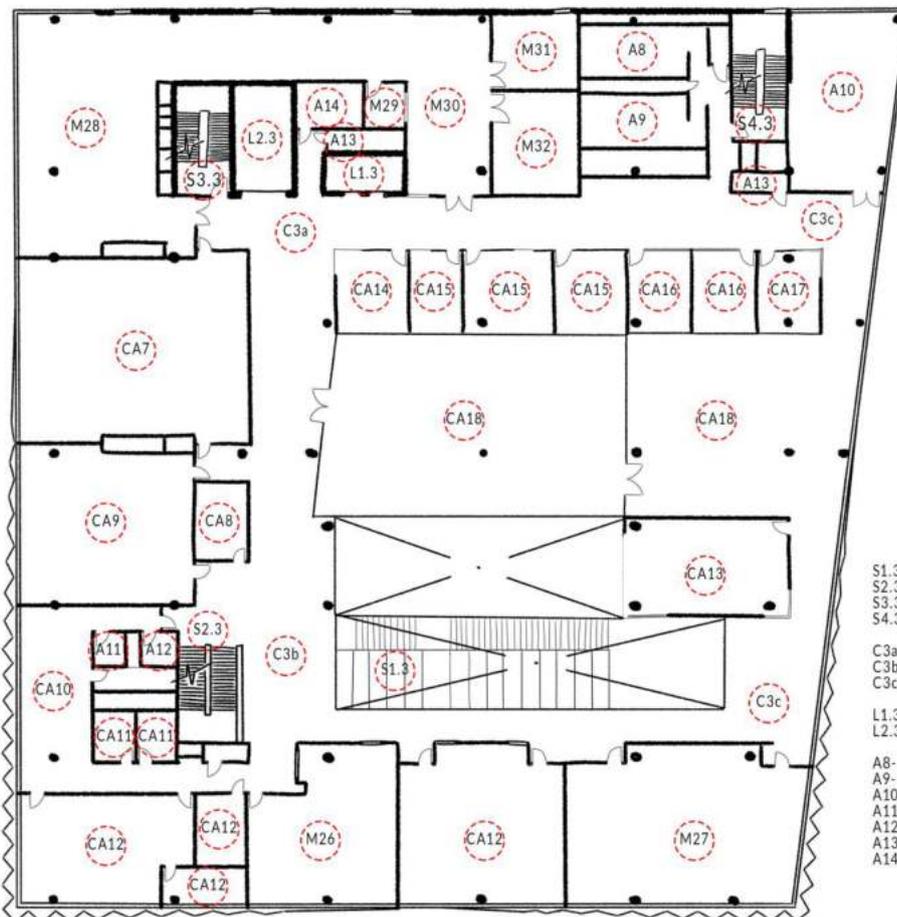


Figure 3: 1st Floor Layout Plan



- |       |                       |      |                         |
|-------|-----------------------|------|-------------------------|
| SBa-  | Staircase A           | I7-  | Auditorium              |
| S2.1- | Staircase C           | I8-  | Control Room            |
| S3.1- | Staircase D           | M11- | Assembly Bay            |
| C1a-  | Corridor              | M12- | Misc/Shared Fabrication |
| C1b-  | Corridor              | M13- | Engineering Capstone    |
| C1c-  | Corridor              | M14- | Project Suite           |
| C1d-  | Corridor              | M15- | Mechanical Room         |
| L1.1- | Public Lift           | M16- | Machine Room            |
| L2.1- | Service Lift          | M17- | Dyno Testing            |
| A1-   | Male Washroom         | M18- | Storage                 |
| A2-   | Female Washroom       | M19- | Composites              |
| A5-   | Services              | M20- | Composites              |
| A6-   | Control Room          | M21- | Media Production Suite  |
| A7-   | Utilities             | M22- | Dark Room               |
| SP1-  | Special Project Space | CA2- | Meeting Room            |
|       |                       | CA3- | Student Org Office      |
|       |                       | CA4- | Student Org Office      |
|       |                       | CA5- | Student Org Office      |
|       |                       | CA6- | Gaming Room             |

Figure 4: Basement Layout Plan



- |       |                 |       |                        |
|-------|-----------------|-------|------------------------|
| S1.3- | Staircase B     | CA7-  | Learning Space         |
| S2.3- | Staircase C     | CA8-  | A/V Control Room       |
| S3.3- | Staircase D     | CA9-  | Team Base Learning     |
| S4.3- | Staircase E     | CA10- | Open Co Working Area   |
| C3a-  | Corridor        | CA11- | Meeting Room           |
| C3b-  | Corridor        | CA12- | SIC Admin              |
| C3c-  | Corridor        | CA13- | Digital Modeling Space |
| L1.3- | Public Lift     | CA14- | Meeting Room           |
| L2.3- | Service Lift    | CA15- | Discussion Room        |
| A8-   | Male Washroom   | CA16- | Student Office         |
| A9-   | Female Washroom | CA17- | Student Office         |
| A10-  | Services        | CA18- | Design Studio          |
| A11-  | Male Washroom   | M28-  | Electronic             |
| A12-  | Female Washroom | M29-  | Office                 |
| A13-  | Storage         | M30-  | Digital Fab            |
| A14-  | Utility         | M31-  | Secure Assembly        |
|       |                 | M32-  | Assembly Bay           |

Figure 5: 2nd Floor Layout Plan

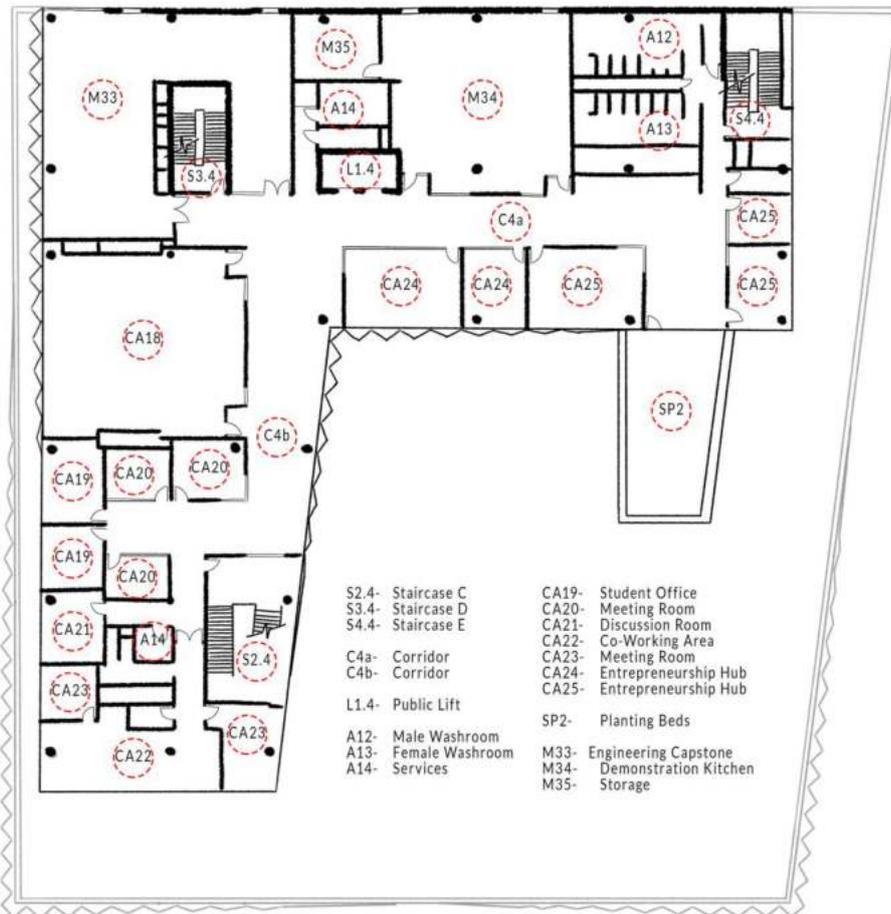


Figure 6: 3rd Floor Layout Plan

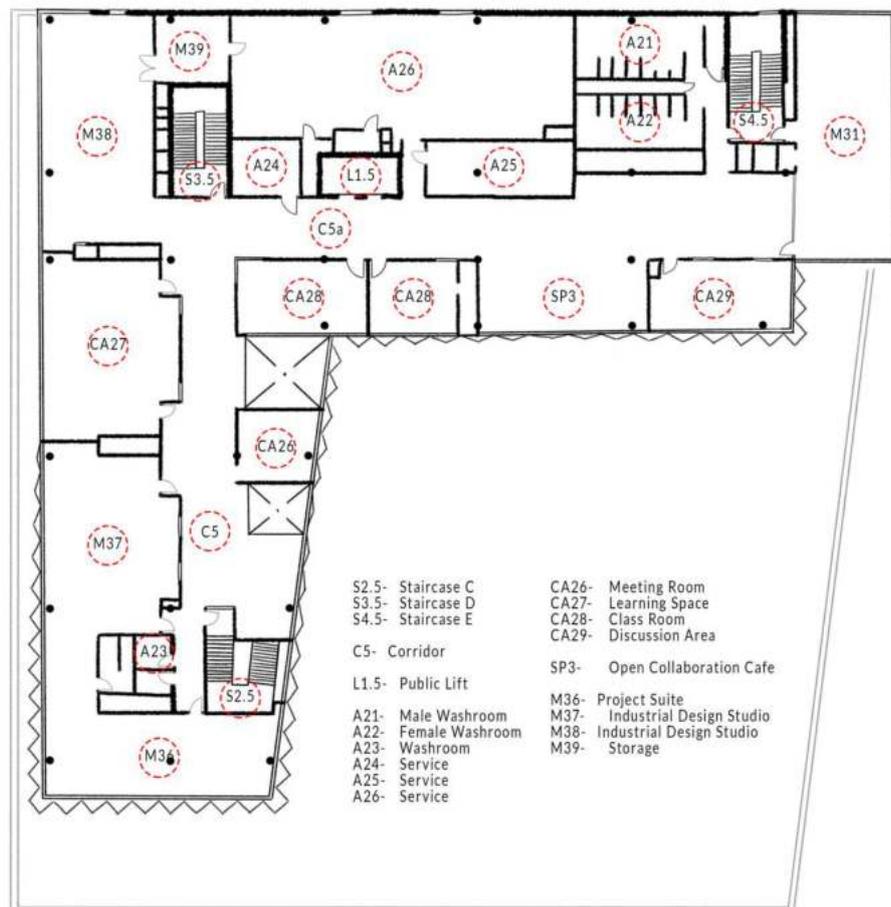
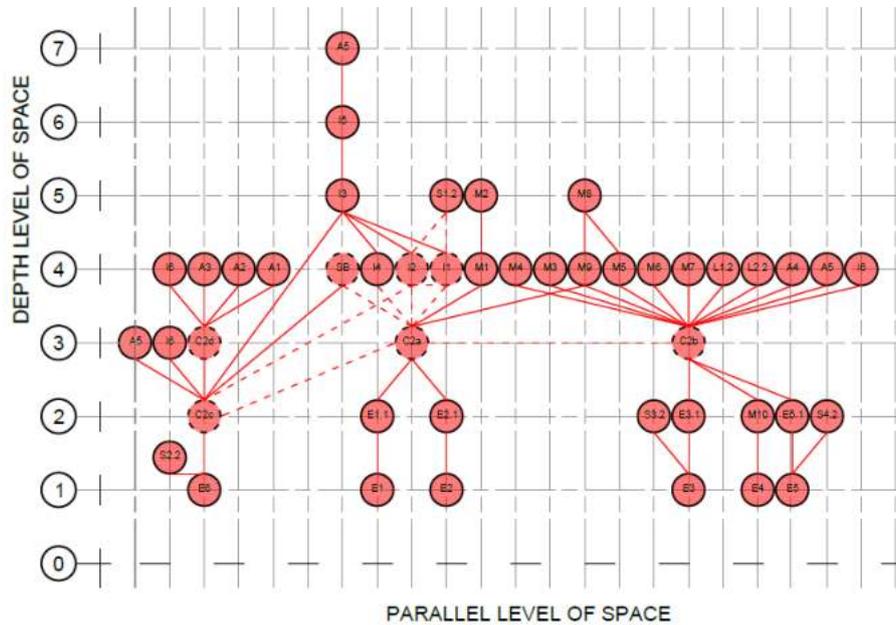


Figure 7: 4th Floor Layout Plan

## 4.2 Space Syntax

### 4.2.1 1<sup>st</sup> Floor



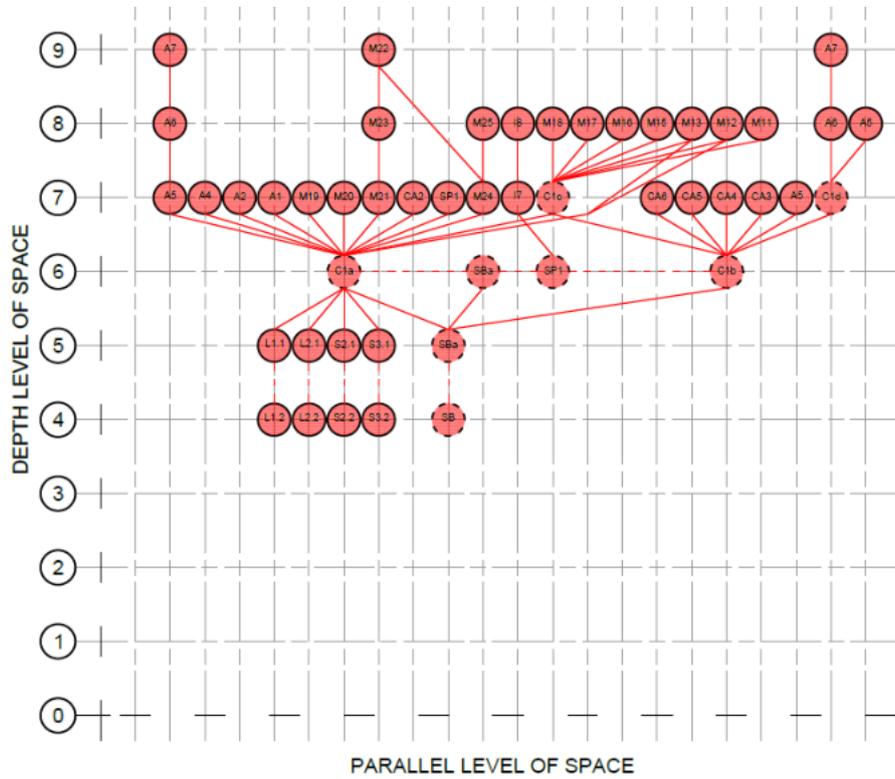
**Figure 8: Justified Graph of 1<sup>st</sup> Floor**

According to the ground floor plan (Figure 4) and justified graph (Figure 8), there is a total of 7 depth levels. The building has five entrances (E1, E2, E3, E4 and E5). The depth level of the permeability for the 1st floor is considered semi-public because most of the space in the 1st is located at the depth level of 4, which is semi-public according to the Likert Scale used in the justified graph. The most obvious public area is the exhibition area (I2), which is directly connected by two main entrances (E1 and E2).

The level of wayfinding is easy. This is because the space arrangement is in a linear layout with the corridor (C2a, C2b, C2c and C3d) linking to all spaces. For the vertical circulation, the main staircase (S1.2) located near to information counter (I1) and exhibition area (I2) has become the main access to the 2nd floor. Apart from this, the staircase (SB) is the main access that guides the user down to the basement floor. The rest of the vertical circulation also includes several fire staircases (S2.2, S3.2, and S4.2), an elevator (L1.2) and a service/goods elevator (L2.2).

### 4.2.2 Basement

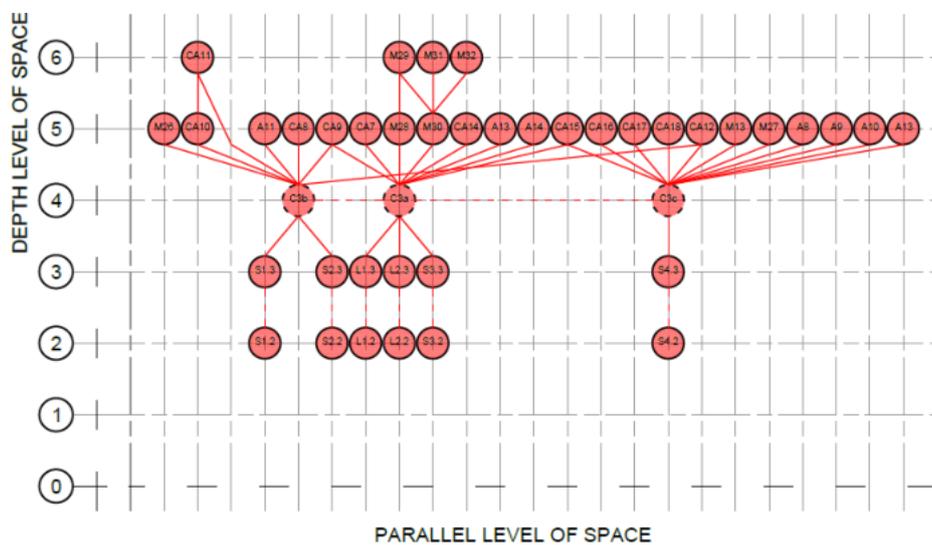
The total depth level of the basement is five according to the justified graph, as shown in Figure 9. Access from the 1st floor leads the users to special project spaces (I7) and corridors (C1a and C1b) that direct to different spaces. The depth level increases as the corridor connecting to the private corridor (C1c) and further leads to several spaces with higher privacy. The depth level of the basement is considered semi-private because most of the space is designed or caters to a specific individual.



**Figure 9: Justified Graph of Basement**

The wayfinding in the basement is medium. This is because the access is relatively straightforward. Two clear access from the open special project space direct to the auditorium(I7). Besides that, the assembly bay(M11) and misc/shared fabrication(M12) can be accessed from the public corridor(C1a) and private corridor(C1c), which makes it a buffer zone between public and private spaces. Spaces for respective staff or students, which include engineering capstone(M13), project suite(M14), mechanical room(M15) and machine room(M16), will limit the connectivity to visitors. The designer uses an effective approach to separate private and public areas. Even though having two different access, the auditorium(I7) is only accessible by the visitor who purchased the entrance ticket.

### 4.2.3 2<sup>nd</sup> Floor



**Figure 10: Justified Graph of 2<sup>nd</sup> Floor**

Going up to the 2nd floor, there is the total of four depth levels according to the justified graph shown in Figure 10. The most significant depth level of this floor's permeability is level 5, which is considered semi-private. Most of the spaces are connected to a single corridor (C3a, C3b and C3c) at depth level 4, which is still considered semi-public to allow the public to access this area. This corridor connects to all vertical circulations, making it the first space and path when users arrive on this floor and access different spaces.

The wayfinding on the 2nd floor is considered easy. This is because the access is relatively straightforward. The circulation is circular (most of the space is connected to a significant corridor, and the corridor is a linear loop arrangement. Hence, the user easy to finds their way into the building.

#### 4.2.4 3<sup>rd</sup> Floor & 4<sup>th</sup> Floor

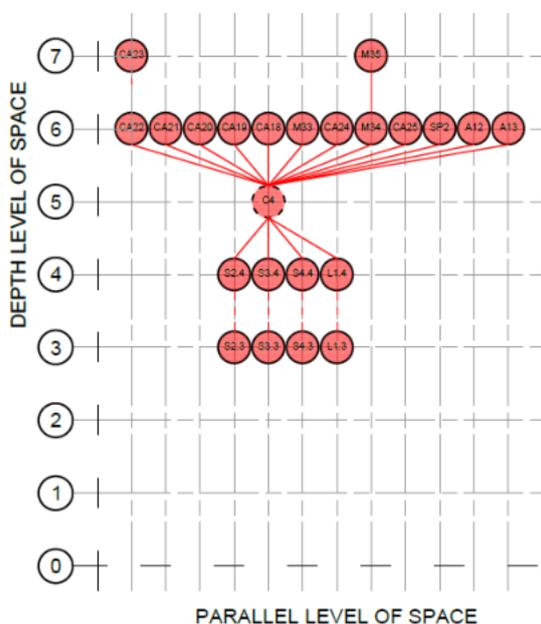


Figure 11: Justified Graph of 3<sup>rd</sup> Floor

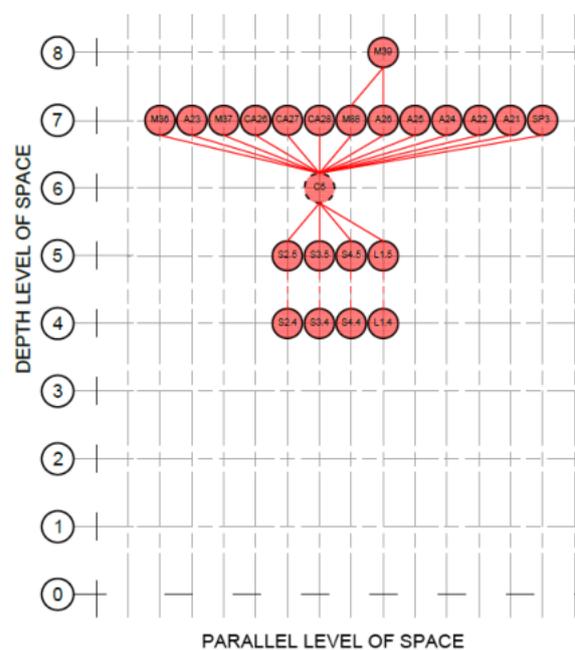


Figure 12: Justified Graph of 4<sup>th</sup> Floor

The level of permeability for users has become more private as the floor goes higher. The permeability for both the 3rd floor and 4th floor are considered semi-private to private, which reach up to 7 and 8 respectively, according to Likert Scale. This is because of the higher level from the 1st floor and the security purpose. These two floors are dedicated to authorised staff and students. It has become suitable to be more private classrooms and office areas. Vertical transplantation to these two floors has provided security doors to ensure no public visitors can easily access these floors. The total depth level of the 3rd floor and 4th floor are both 4, as shown in figure 11 & figure 12. The common area for circulation is still designed to be connected to several spaces with a more comprehensive and relaxing space.

The wayfinding for the 3rd floor and 4th floors is considered easy as the corridors are relatively short and straightforward leading to dedicated spaces. Access from the corridor to spaces is a branch-like shape. Hence the users easily find their way into the building.

## 5 Discussion

### 5.1 The Shape of Justified Graph

The overall justified graph of the case study is a shallow tree shaped into a pattern with a separate block with its functionality. Because of its simple accessibility and basic design, the case study's spatial structure satisfies the requirements of an education centre.

### 5.2 Level of Permeability

According to table 2, the primary level for the level of permeability is semi-private in the depth of levels 5 to 7, taking up to 55.4% consisting of a total of 92 spaces from a total of 166 spaces. This is because the Student Innovation Center is mainly for educational purposes. Private support facilities, including classrooms, workshops, laboratories, etc are all considered private areas. But at the same time, the building is designed to allow partial interaction between students and the public, making some of the spaces become transition areas to allow public access during event time. Hence, the level of permeability is more towards a semi-private setting.

**Table 2:** Levels of Permeability of Overall Floor Plan.

| Depth Level of Space | Level of Permeability | Number of Space | Percentages (%) |
|----------------------|-----------------------|-----------------|-----------------|
| 1                    | public                | 15              | 9.0             |
| 2                    |                       |                 |                 |
| 3                    | semi-public           | 42              | 25.3            |
| 4                    |                       |                 |                 |
| 5                    | semi-private          | 92              | 55.4            |
| 6                    |                       |                 |                 |
| 7                    |                       |                 |                 |
| 8                    | private               | 17              | 10.2            |
| 9                    |                       |                 |                 |
| Total                |                       | 166             | 100             |

### 5.3 Level of Wayfinding

The overall wayfinding for Iowa State University Student Innovation Center is easy. According to Table 3, even though it consists of 92(55.4%) spaces out of a total of 166 spaces are having a depth level from 5 to 7 which consider medium according to Likert Scale. But the interior circulation is very clear and straightforward, allowing users to get to their desired destination. A higher percentage of medium wayfinding also due to some of the spaces being required to be more private for education and research purpose.

**Table 3:** Levels of Wayfinding of Overall Floor Plan.

| Depth Level of Space | Level of Wayfinding | Number of Space | Percentages (%) |
|----------------------|---------------------|-----------------|-----------------|
| 1                    | easy                | 57              | 34.3            |
| 2                    |                     |                 |                 |
| 3                    |                     |                 |                 |
| 4                    |                     |                 |                 |
| 5                    | medium              | 92              | 55.4            |
| 6                    |                     |                 |                 |
| 7                    |                     |                 |                 |
| 8                    | hard                | 17              | 10.2            |
| 9                    |                     |                 |                 |
| Total                |                     | 166             | 100             |

The difficult wayfinding only consists of 10.2% out of 166 total spaces. This is because only a minimum number of spaces require complete privacy to ensure no public or unauthorised people access certain spaces such as research areas or machine rooms. Another reason is also due to the 3rd floor and 4th floor having individual access doors to prevent the public arrive at these two floors.

## 5.4 Others

According to table 4, with a total of 38% Single Connecting Space is the most prominent space in the building. This is due to a large number of separate classrooms and offices in the building. Aside from that, controlling accessibility at a single connecting place is easy. It will only have one door that can be opened, making it easy to monitor and regulate the privacy settings.

Double Connecting Space and End Room have similar percentages which are 25.9% and 22.9% respectively. This is because the building is more of a semi-private building, so most of the private space is located at the End Room and allows the Double Connecting Room to act as a transition space between private and public spaces.

Triple Connecting Space only took up to 1.8% of the total space. There are usually used as common spaces and as access to other spaces.

The corridors on the floors are included in Multiple Connecting Spaces as they are the main access to allow users reach to their desired rooms.

Vertical transportation areas including six staircases, one lift and one service life are relatively higher compared to the typical building which consists of a total of 5.4%. One of the reasons believe that is to provide sufficient and shortest fire escape for the users due to the occupant of the education building being high.

**Table 4: Percentages of Space.**

| Area                      | Spaces   | Number of Spaces | Percentages (%) |
|---------------------------|--|------------------|-----------------|
| End Room                  | I5, I6, M2, M3, M4, M8, A6, A7, I8, M13, M14, M15, M16, M17, M18, M22, M25, CA11, M29, M31, M32, CA23  | 38               | 22.9            |
| Single Connecting Space   | A1, A2, A3, A4, A5, I4, M6, M7, M19, M20, CA3, CA4, CA5, CA6, CA7, CA8, CA9, CA12, CA13, CA14, CA15, CA16, CA17, M28, CA19, CA20, CA21, CA24, CA25, SP2, M33, A24, A25, CA26, CA27, CA28, CA29 | 63               | 38              |
| Double Connecting Space   | E1.1, E2.1, E3.1, E5.1, I3, M5, M9, M10, M11, M12, M21, M23, CA2, CA10, CA18, M34, A26, M36, M37, M38, M39   | 43               | 25.9            |
| Triple Connecting Space   | M1, M30, CA22  | 3                | 1.8             |
| Multiple Connecting Space | C1, C2, C3, C4, C5 II, I2, SP1, SP3, I7, M24   | 11               | 6.6             |
| Staircase                 | SB, S1, S2, S3, S4, S5   | 6                | 3.6             |
| Lift                      | L1   | 1                | 0.6             |
| Service Lift              | L2   | 1                | 0.6             |
|                           | Total  | 166              | 100             |

## 6 Conclusion

The overall space syntactic performance of the building typology leans toward a semi-public setting suited for an innovation centre. This is done in order to improve public-researcher engagement. The public-to-semi-private permeability level is perfect for this type, and the building's navigation should be simple and uncomplicated. This guarantees that visitors do not become disoriented in the building and that users can converse more readily with one another. As a result, while constructing an innovation centre, the level of permeability should be semi-public, and the navigation should be obvious and straightforward. At the same time, specific locations must be kept private, and visitor connectivity must be limited to maintain privacy and security.

The schedule of accommodation of the selected case study is exciting because it does not just consist of basic facilities and support for education purposes. It also included facilities for the research centre and publicly accessible facilities.

The space syntactic analysis only depends on the Spatial Pattern Analysis, which is a restriction in conducting the research study. To improve the accuracy of the data, Convex Space Analysis and Graph Theoretical Measurements should be employed. Another constraint is that due to the COVID epidemic, the researcher is unable to do a site visit to the case study to better understand the circulatory flow.

## 7 Availability of Data And Material

Data can be made available by contacting the corresponding author.

## 8 Acknowledgement

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**Louis Ting Kwang Liou** is a master's student at Universiti Sains Malaysia. He received his Bachelor of Science (Housing, Building and Planning) (Hons) Architecture (LAM Part 1) from the University of Technology Sarawak in 2019. He worked as Assistant Architect at MinWee Architect, Kuching. He is now pursuing his Master of Architecture at Universiti Sains Malaysia.



**Dr Yasser Arab** is an assistant professor at the Department of Architectural Engineering, Dhofar University, Salalah, Sultanate of Oman. He is a researcher in Architecture. He obtained his Bachelor of Architecture from Ittihad Private University, Aleppo, Syria. He obtained a PhD. in Sustainable Architecture from Universiti Sains Malaysia (USM), Penang, Malaysia, his research focused on the Environment Performance of Residential High-Rise Buildings' Façade in Malaysia. He is a Registered Architect in the Syrian Engineers Union.



**Professor Dr.Ahmad Sanusi Hassan** is a Professor in the Architecture Programme at the School of Housing, Building and Planning, Universiti Sains Malaysia (USM), Penang, Malaysia. He obtained a Bachelor's and Master of Architecture degrees from the University of Houston, Texas, USA, and a Doctor of Philosophy (PhD) degree focusing on Sustainable Architecture and Urban Design Development for Southeast Asia from the University of Nottingham, United Kingdom. At the university, he is lecturing in courses related to urban design, studio architecture, history and theory of architecture and Computer Aided Design (CAD).



**Dr.Boonsap Witchayangkoon** is an Associate Professor of the Department of Civil Engineering at Thammasat University. He received his B.Eng. from King Mongkut's University of Technology Thonburi with Honors. He continued his PhD study at the University of Maine, USA, where he obtained his PhD in Spatial Information Science & Engineering. His current interests involve Applications of Emerging Technologies to Engineering.

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