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OCEAN CONSERVATION AND WASTE PREVENTION CENTRE: THE STUDY OF SPACE SYNTAX IN RECYCLING FACILITY

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ABSTRACT

Space Syntax is an approach of relating a correspondence between spatial configurations of a building and site planning. This paper concentrates on the study of Space Syntax on the Recycling Facility. The objective of this study attempts the scientific approach to define how the spatial layout of the selected building typology gives influences on how people use and utilise the building spaces. The building typology is a Recycling Facility, which is under the category of a factory building's typology. To study the space syntax of the building spaces, this work uses the inventory of the layout plan. While use graphs to analyse the way-finding and the permeability level inside the buildings. The result shows that the building has proper spatial planning of orientation and circulation. Thus, the spaces are well-defined as the way-findings of each space are distinguishable. This study shows that space syntax is important and influencing spatial configurations on the building that measures the characteristics of the building typology.

Disciplinary: Architectural Sciences.

1. INTRODUCTION

This study analyses space syntax for the Recycling Facility, in which the typology is a factory type of building. Space syntax is a combination theory of space, analytical set that has descriptive and quantitative methods to analyse the various forms of spatial formations such as; interior spaces, buildings, landscapes, cities, etc.(Hillier, 1997). Thus, the spatial layout of buildings influences the way people use them (Hassan, 2004).

Space Syntax is a technique for describing and studying the connection between spaces of buildings. The spaces are comprehended as voids such as rooms, squares, streets and fields, between walls, fences and other things that limit movement of people or the visual field (Ching, 2014). The

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purposes are to assume that most people, most likely, will take the easiest and uncomplicated direction to their stopping place. That path tends to include little changes of direction. The more changes in direction, the more complex the space syntax system, and consequently the more ineffective or inefficient the spatial arrangement design becomes (Sadalla & Magel, 1980).

The idea initiated 20 years ago in the United Kingdom was not efficient by Julienne Hanson and Bill Hillier while they describe and analyse how the housing layouts interacted with space accessible (Dursun, 2007).

The study is to identify and analyse the layouts of the case study building. It is to make a relationship between the spatial layout and the function of the building and is to discover the best layout plan to be used as guidelines for designing this building typology in the future. The focus of this study is on a typology of factory type. The chosen building is from international which is located in Naples, Italy which is Waste-to-Energy Plant, Termoutilizzatore.

2. LITERATURE REVIEW

2.1 DEFINITION OF SPACE SYNTAX: LEVEL OF PERMEABILITY AND WAY-FINDING

Space syntax is a technique analyse the relationship between spaces of urban areas and buildings. It evaluates the performances of integration and connectivity of spaces within a building and represents it in a formalised graph-based version of spatial layout configuration into the architectural analysis (Li et al., 2009).

The concept of space syntax analyse based on the deep analysis of permeability and way-finding level. Permeability can be defined as to allow or limit of movement of people or vehicles in a direction or within the spaces inside a building. For instance, the level of permeability contains public, semi-public, semi-private and private spaces. Way-finding is defined as a design process that leads people through the physical environment and deepens their experience and understanding of the space. Consequently, circulation and ease of way-finding of that building can be proven through the space syntax analysis (Natapov et al., 2015).

2.2 DEFINITION OF BUILDING TYPOLOGY

An industrial building typically comprises of regular buildings and machinery, with a variety of building types. Whereas workers create goods and operate the machines process one into another. It begins with the introduction of machinery during the Industrial Revolution when the capital and space requirements became substantial for cottage industry or workshops. Many past and new factories have large warehouses that accommodate heavy equipment utilised for fabrication and production lines. That includes numerous types of transportation, some have rail, highway and water loading and unloading facilities.

A materials recycling facility is a plant that collects, segregate and prepares recyclable materials for marketing to end-user manufacturers. It is a factory for processing used or abandoned materials. Recycling transforms waste materials into new materials and products. It is another better way to "conventional" waste disposal that can conserve material and help lower the effects of environmental degrading. Recycling can avert the waste of the possibility of useful materials and decrease the consumption of fresh raw materials, thereby lowering energy usage, environmental pollution.

2.3 CASE STUDY: WASTE-TO-ENERGY PLANT, TERMOUTILIZZATORE, NAPLES, ITALY

The Waste-to-Energy Plant is a processing centre locate in Termoutilizzatore, Naples City, Italy, see Figure 1. This recycling facility building was built in 2011. That curbside metal, glass, and plastic recycling are undertaken by its local council. While it is design influenced by its programmatic use as a recycling center that inspired reuse throughout.

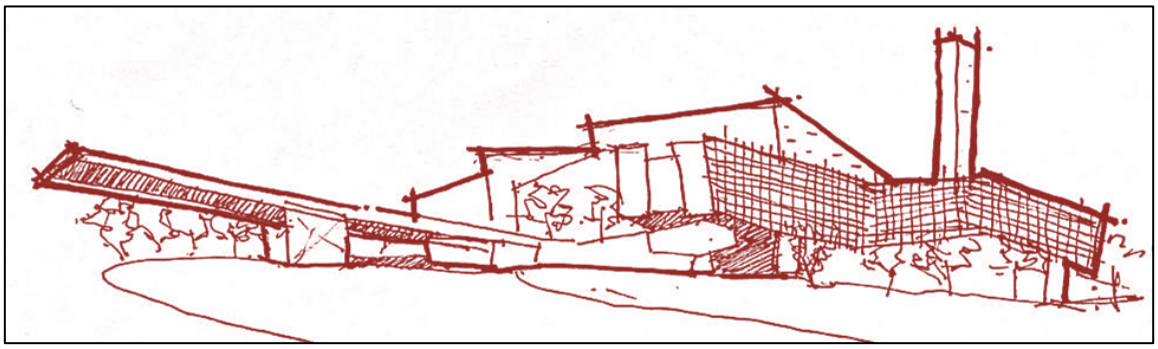

Figure 1: An exterior perspective of the Termoutilizzatore Waste-to-Energy Plant.

The project was developed in a competition for the construction and management of a waste-to-energy plant. The plant is composed of three major manufacturer lines, with a steady nominal thermal power of 84.33 MW for each line. Which means an equivalent of a mass 450.000-750.000 tons/year of waste that can be used in order to create this amount of thermal power (CREW, 2015). The plant covers a lot of 44515.4 sqm situated in the city of Ponticelli (NA). The complex is made of various buildings: boiler and ashes treatment/flue gas filtering, a discharging hall; a waste bunker; a turbine building, some subsidiary buildings, garages, offices, a control room, visitor center along with the reception. From an architectural point of view, the buildings are designed with the focus to minimise the visual impact with the surrounding environment. The primary purpose is, in the meanwhile, the development of a new landmark for the contemporary urban landscape.

3. RESEARCH METHOD

The initial approach in this research was to understand the definition of space syntax theory by doing studies of previous literature reviews on related topics which are mostly gained from books, journals, articles and references were collected. The research about the background and history of the selected case study were collected. This research uses a qualitative method to explore the spatial arrangements in Recycling Facility and realize the context of the space with qualitative layout observation and collection of data, to get a clear synthesis about the way-finding and the permeability of the building. A method of the numbering system is used to study the space syntax of the building within the inventory of the plan layout and graph of the building as a method to analyse the way-finding and the permeability of the buildings.

The conducted study divided into two phases. The first content review from published journals, books and seminars. In addition to that, a layout of the three case study buildings is mapped out with a layout image source by software such as Autocad and Photoshop to conduct the survey. While the second phase is a fieldwork study that conducts in Waste-to-Energy Plant, Termoutilizzatore, Naples, Italy to observe the quality of spatial arrangements by collecting the layout plan online. That explains

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the visibility of the spatial arrangements the numbering methods and space syntax graph analysis. That could record the existing layout and space functions to understand the context of the building entirely. The scale of measurement on the graphs is indicated using the Likert Scale to show the level of permeability and wayfinding of users of the building. The Likert Scale is defined in Table 1:

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

Likert Scale Numbering	Level of Permeability	Level of Wayfinding
0	-	-
1 - 3	Public	Easy
4 - 6	Semi-Public	
7 - 9	Semi-Private	Hard
10 - 12	Private	

4. ANALYSIS

This research chooses the spatial aspects of the building based on the building typology.

4.1 AN INSPECTION ON SITE PLAN

Figures 3 and 4 respectively show the re-drawn Site Plan and the Measurable Scale of the Site Plan of Termoutilizzatore Waste-to-Energy Plant.

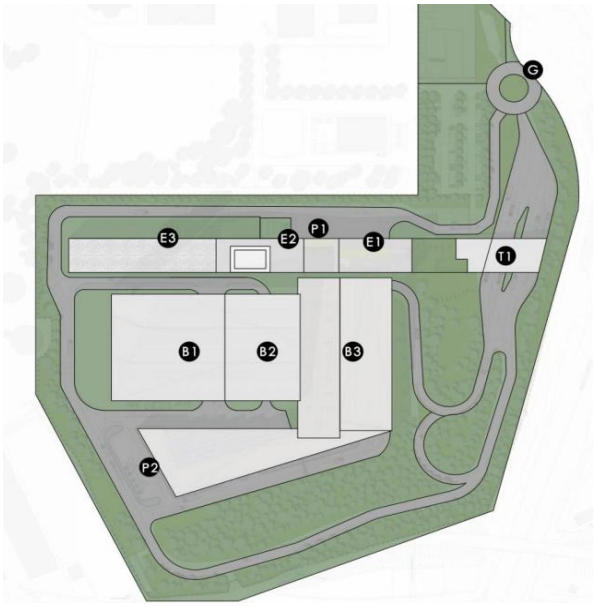

Figure 2: Re-drawn site plan (Source: CREW - Cremonesi Workshop (2015)).

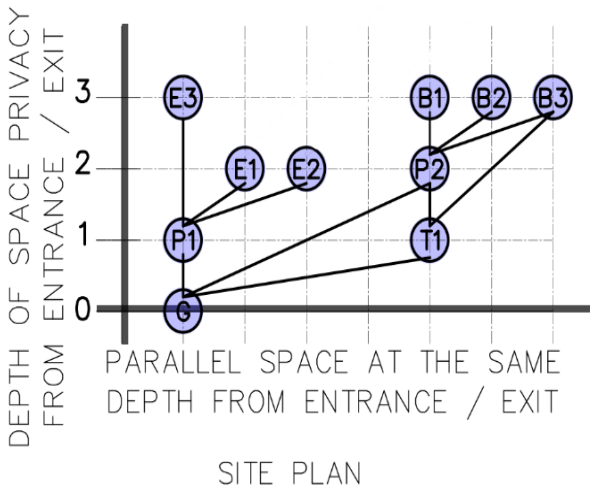

Figure 3: Measurable Scale of the Site Plan.

Likert scale for space syntax explains the relation between public and private area as shown in Table 2. Table 2 shows the Likert Scale for Space Syntax Analysis of each measurable scale graph for the site plan of the Termoutilizzatore Waste-to-Energy Plant.

Table 2: Likert Scale for Space Syntax Analysis: Measurable scale graph for the site plan.

Area	Depth of Space form Entrance / Exit	Level of Permeability	Level of Wayfinding
G	0	Public	Easy
P1, T1	1	Semi-Public	Easy
E1, E2, P2	2	Semi-Public	Easy
E3, B1, B2, B3	3	Private	Medium

In Figure 3, the level of permeability for users in context to the site plan is mostly considered the public area. Both visitors and staffs are allowed to use these spaces, and the wayfinding is easier since

it is visible and noticeable. However, when entering the site plan at G, both are required to go to each direction of their purposes such as private or public. Public visitors are required to enter P1, while for staff or truck drivers they are required to enter through T1. Figures 4 and 5 show the re-drawn Ground Floor Plan and the Measurable Scale of the Ground Floor Plan. Table 3 shows the Likert Scale for Space Syntax Analysis of each measurable scale graph for the ground floor plan of Termoutilizzatore Waste-to-Energy Plant.

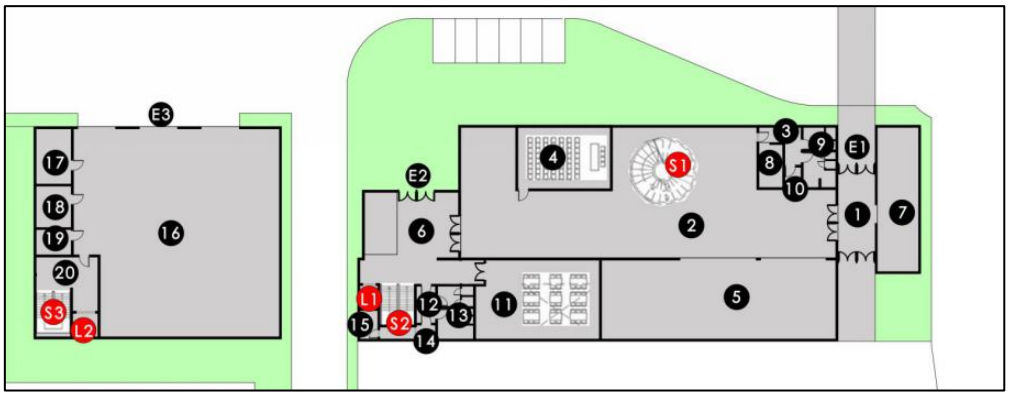

Figure 4: Re-drawn ground floor plan (Source: CREW - Cremonesi Workshop (2015)).

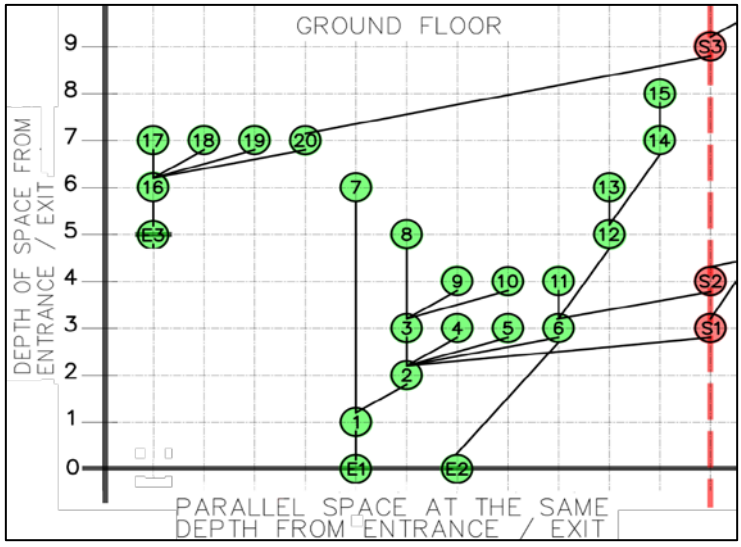

Figure 5: Measurable Scale of the Ground Plan.

Table 3: Likert Scale for Space Syntax Analysis - measurable scale graph for ground floor plan

Area	Depth of Space form Entrance / Exit	Level of Permeability	Level of Wayfinding
E1, E2	0	Public	Easy
1	1	Public	Easy
2	2	Public	Easy
3, 4, 5, 6	3	Semi-Public	Easy
9, 10, 11	4	Semi-Public	Medium
E3,8, 12	5	Private	Medium
7, 13, 16	6	Private	Medium
14,17,18,19,20	7	Private	Medium
15	8	Private	Hard

The level of permeability for users in ground floor plan is still considered a public area since the spaces landed on scale 1 to 4. These mean that these spaces are designed for the use of visitors and

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staffs. The wayfinding between spaces is easy to access as of how it is shown through the lines connecting between each space in Figure 5. Figures 6 and 7 show both re-drawn the plan of the first floor and it is a measurement scale. Table 4 shows the Likert Scale of Space Syntax Analysis for each measurable scale graph of the first-floor plan of the Termoutilizzatore Waste-to-Energy Plant.

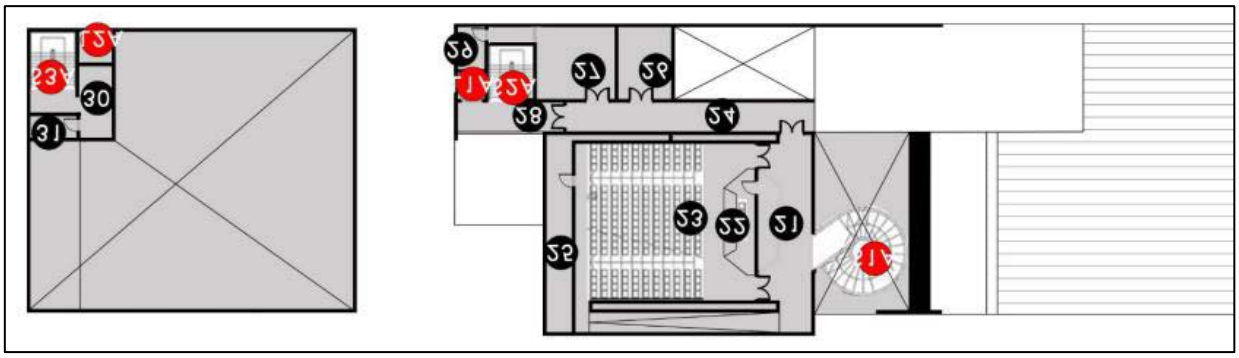

Figure 6: Re-drawn first floor plan (Source: CREW - Cremonesi Workshop (2015)).

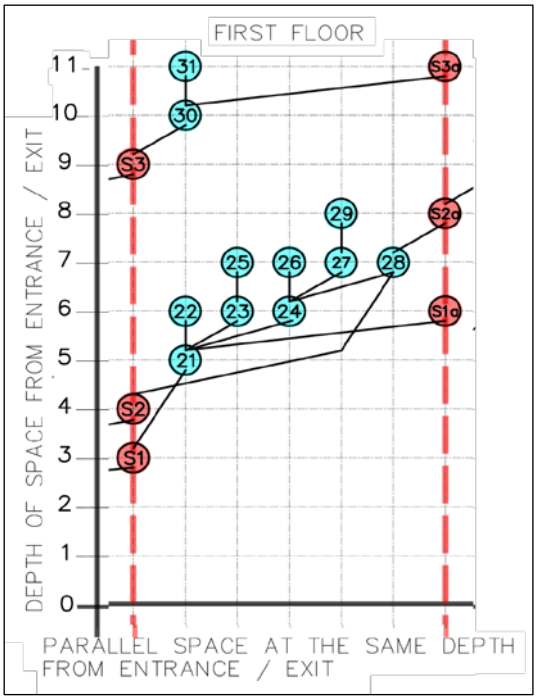

Figure 7: The plan of the measurable scale of the first floor.

Table 4: First floor: Likert scale of space syntax and measurable scale graph

Area	Depth of Space form Entrance/Exit	Level of Permeability	Level of Wayfinding
21	5	Semi-Public	Easy
22,23,24	6	Semi-Public	Easy
25,26,27,28	7	Private	Medium
29	8	Private	Medium
30	10	Private	Medium
31	11	Private	Medium

The level of permeability for users in first-floor plan has become more private as it is intended to make it less accessible by visitors. The wayfinding between spaces is harder to find without the aid of signage like how it is shown through the lines connecting between each space in Figure 7. Figures 8 and 9 show the re-drawn Second Floor Plan and the Measurable Scale of the Second Floor Plan of

Waste to Energy Plant, Termoutilizzatore. As shown in Figure 10, private in the second-floor plan is more than the first floor plan. Thus, the wayfinding is harder to find since the spaces are mostly designed for authorised personnel and very private areas for staff. Table 5 shows the Likert Scale for Space Syntax Analysis of each measurable scale graph for the second-floor plan.

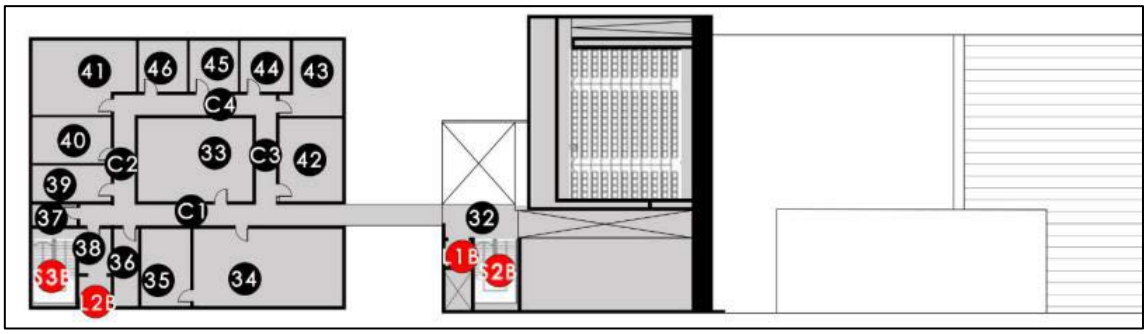

Figure 8: Re-drawn second-floor plan (Source: CREW - Cremonesi Workshop (2015)).

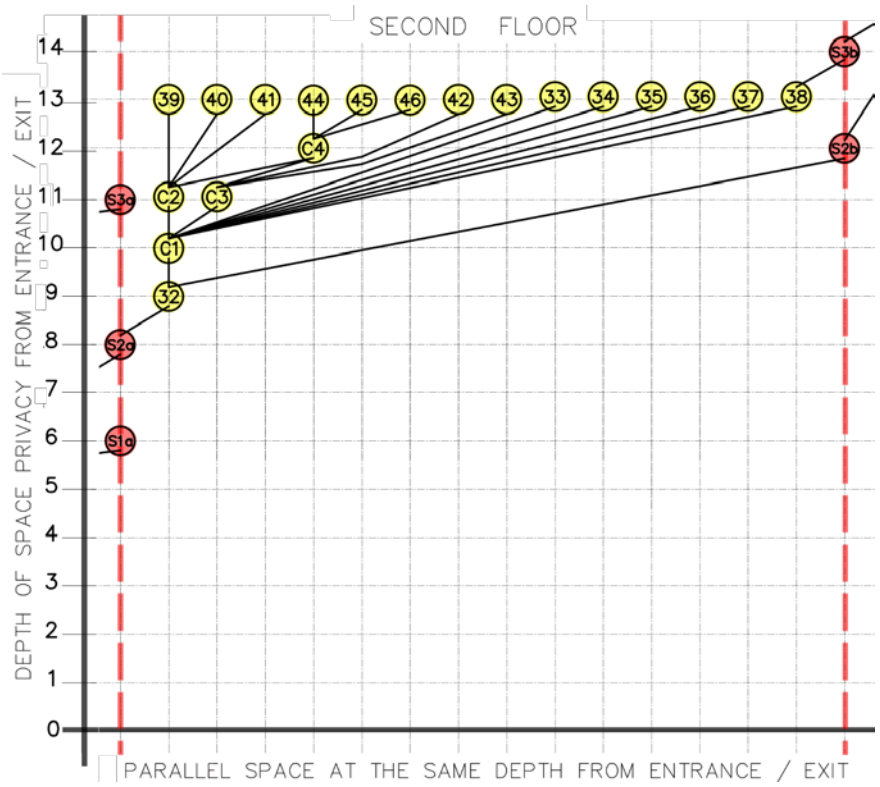

Figure 9: The plan of the measurable scale of the second floor

Table 5: Likert Scale for Space Syntax Analysis - measurable scale for Second Floor Plan

Area	Depth of Space form Entrance/Exit	Level of Permeability	Level of Wayfinding
32	9	Private	Easy
C1	10	Private	Easy
C2,C3	11	Private	Medium
C4	12	Private	Medium
33,34,35,36,37,38, 39,40,41,42,43,44, 45,46	13	Private	Medium

Figures 10 and 11 show the re-drawn Third Floor Plan and the Measurable Scale of the Third Floor Plan of the Termoutilizzatore Waste-to-Energy Plant.

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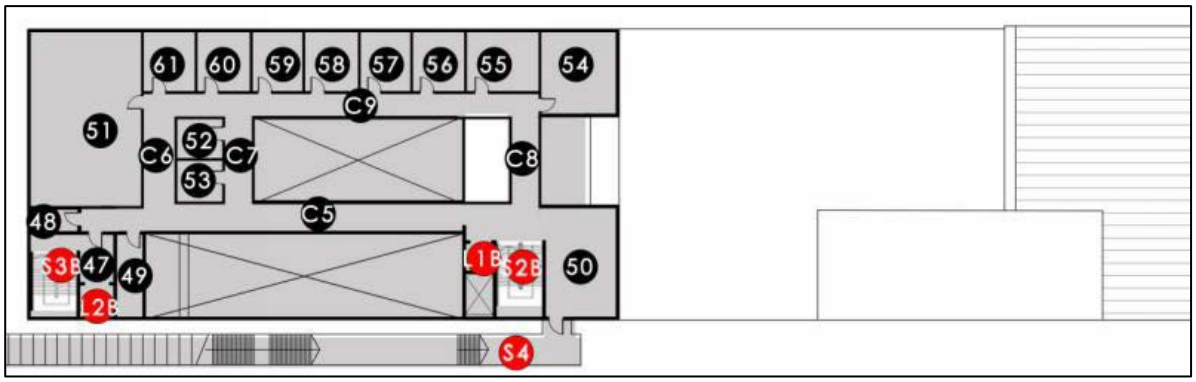

Figure 10: Re-drawn third floor plan (Source: CREW - Cremonesi Workshop (2015)).

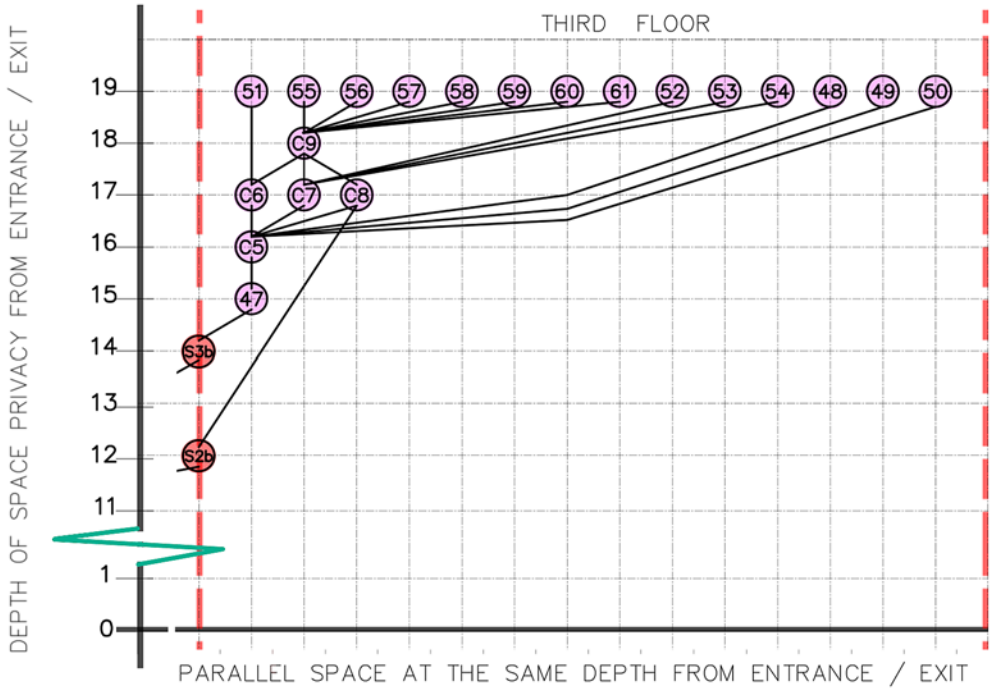

Figure 11: Measurable Scale of the Third Floor Plan.

Table 6 below shows the Likert Scale for Space Syntax Analysis of each measurable scale graph for the third-floor plan of Termoutilizzatore Waste-to-Energy Plant.

Table 6: Likert Scale for Space Syntax Analysis - measurable scale graph for Third Floor Plan

Area	Depth of Space form Entrance/Exit	Level of Permeability	Level of Wayfinding
47	15	Private	Medium
C5	16	Private	Medium
C6,C7,C8	17	Private	Hard
C9	18	Private	Hard
48,49,50,51,52,53, 54,55,56,57,58,59,60, 61	18	Private	Hard

Figure 11, the third-floor plan is the most private part compared to others. This area consists of a higher level of staff such as an employer. Thus, the wayfinding is harder to find since the spaces are mostly designed for authorised personnel and very private areas for staff. Figure 12 shows the space syntax of the whole building.

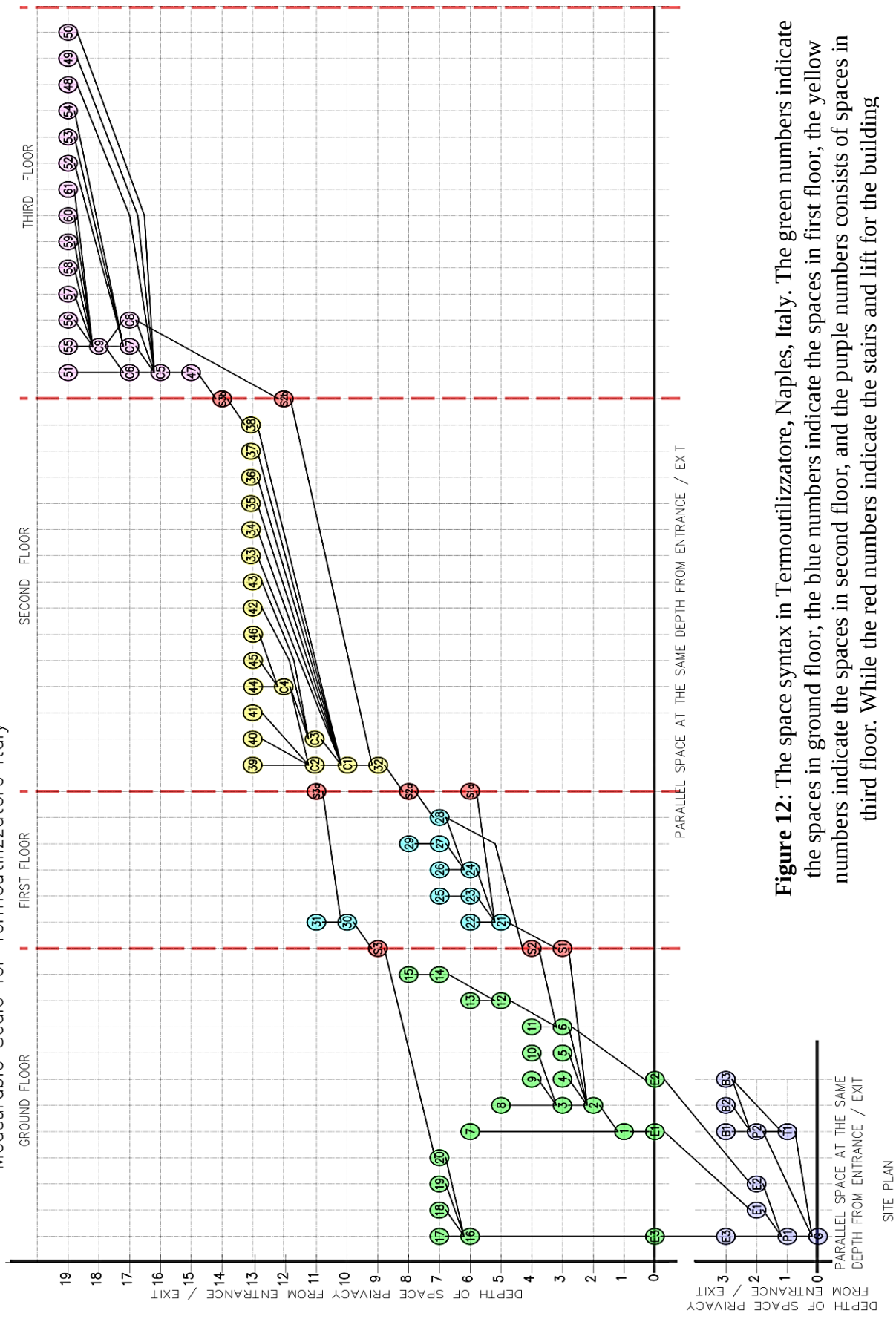

Figure 12: The space syntax in Termoutilizzatore, Naples, Italy. The green numbers indicate the spaces in ground floor, the blue numbers indicate the spaces in first floor, the yellow numbers indicate the spaces in second floor, and the purple numbers consists of spaces in third floor. While the red numbers indicate the stairs and lift for the building

5. DISCUSSION

According to the site plan graph which is the yellow numbering, there is only one entrance, and it is considered as public access. The facility is accessible by both public and privately for staff and workers. After the entrance, only P1 can be directly accessed by the public while T1 is only accessible by the workers. This shows that the site plan is almost can be accessed by the public through their way-finding although strictly cannot be accessible. The only building that is public is the building which is the educational centre and administrating building. Thus, the next spatial study can only be done in this building. Focusing on the building that is on the ground level, the numbering is labelled as green, is show that the graph defined the way-finding and the permeability as the main administrating building, making the spaces more private as people walk into the level. Furthermore, the first level gives the users space for educational purposes. The students or visitors are welcomed as they enter the ground level and directly to the stairs or lift to the first level which is the educational area. After that, they can also go to the above level that is the second level to access the walkway to the other buildings. Its purposes are to let the students see the showcasing of production building next door without disturbing the private working area. The last floor plan which is the third-floor plan would be the most private part and the least permeability in the building as space contains an area for staff and private personnel only. Which means it is strictly inaccessible by the public.

6. CONCLUSION

The analysis of the graph of space syntax, the Likert scale and the spatial arrangement of the case study showed that it could be divided into three parts. The first is the educational building that consists of classrooms and auditorium. While the second part is the spatial arrangement which administrate the building that related to staffs and meeting room. Moreover, the last part is the warehouse building that is focusing on factory and manufacturing building. As the recycling facility that is the Termoutilizzatore Waste-to-Energy Plant, which design base on it is a function of segregate the spaces. The educational building has good wayfinding and permeability in its floor plan and with important layout space in the forming of the functional building, development to arrangement spatial in terms of privacy, permeability, and wayfinding.

So, in the planning and designing of the Termoutilizzatore Waste-to-Energy Plant, has accurate thought with a basic layout that easy to understand its spatial arrangement. While the readability of the Plant produces quality spaces through the elements of space syntax with good style.

7. AVAILABILITY OF DATA AND MATERIAL

Data can be made available by contacting the corresponding authors

8. ACKNOWLEDGEMENT

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