國 立 交 通 大 學 建 築 研 究 所

碩 士 論 文

共享元件 - 多系統設計的解決方案

Sharing Components - Multiple Systems, Uni-Solution

研究學生：洪子捷

指導教授：曾成德

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Sharing Components

Multiple Systems Solution

Advisor Prof. C. David Tseng
Author Tzu-Chieh Hong

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Abstract

Architecture is composed of numerous systems, and each system is related to one another. In some cases, one system may even contain several minor systems, hence the structure and the behavior are extremely complex. Before the computer age, the complexity is the major obstacle to analyzing the building system. With the advent of powerful calculation ability, the complexity analysis has become feasible. My thesis therefore focuses on building a uni-solution to address multiple systems in the architecture field.

中文摘要

建築由各種不同的的系統所組成，每一個系統都與其他系統有所連結並互相影響。在某些情況當中，系統之中還包含著子系統，因此整個建築架構與行為將便成極度地複雜。在電腦問市之前，建築設計師難以處理複雜度太高之系統分析，但所幸現今強大的運算能力足以讓多系統甚至複雜系統的分析得以實現，透過系統的分析，建築設計師能夠更準確地做出決策，並且能夠進一步產出更有效率的「共用元件」，讓建築設計能夠更進一步最佳化，而且也讓建築設計有一套邏輯客觀的理論作為依據，必免設計者浪費資源或是造成負面的系統影響。

I

Chapter 1 Introduction

In this thesis, 6 architecture design projects are introduced, each of which has different conditions and contexts. To make the illustrations clearer, these projects are described with diagrams and drawings instead of pictures. Moreover, with the aim to analyze the behaviors of systems and to find out the methodology to achieve a uni-solution, some mathematical representations are used to explain the projects. I believe that there would be a theoretical module similar to a mathematical form in terms of architecture. Hence, the purpose of this thesis is to help designers define the architecture systems and find out a uni-solution which is simple but multi-functional.

When it comes to uni-solutions, PE (Polyethylene) sealing films used for the cups of Taiwanese tea-based drinks is a typical example, as shown in Fig. 01. Traditionally, it is a plastic lid used to cover beverages, as shown in Fig. 02. However, plastic lids are not cost-efficient because their volumes are not easy for storage and transportation, nor eco-friendly because they are not reusable. In addition, the use of plastic lids has a beverage leak issue that annoys people on the go. Plus, beverage with a plastic lid is not able to be put in the handbag because any slant position may spill out the beverage and destroy the handbag. Not even mention to put more than one cup of beverage in the bag. Furthermore, when manufacturing plastic lids, it needs an additional process to drill a straw slot for each lid.

To address the problems of plastic lids, sealing films that adopt PE membrane then came into use. Using sealing films has many advantages. First, the membrane is 100% leak-free, thus can prevent the beverage from spilling over, and more than that, keep it fresh. Second, using membrane means no need to pre-drill a straw slot during manufacturing because the material is easy to be punched in by a sharp straw. The sharp shape of straws can also increase the suck-on volume, therefore make beverages easier to drink. Third, it lets people to conveniently as well as elegantly bring beverages on the go. Forth, one roll of sealing film can be used for a large number of beverage cups, which means the storage space and transportation cost are significantly reduced. This case reveals the benefits of using uni-solution (sealing films) which comes from a multi-system concept. Fig. 03 depicts the relationships among the existing systems, wherein the overlap parts are the possibilities that uni-solution may exist.

As shown in Fig. 04, more than one possible solutions can be found to respond to those diverse systems. To build a uni-solution, the most prominent strategy is to collect all information and adjust the design to fit every single condition.

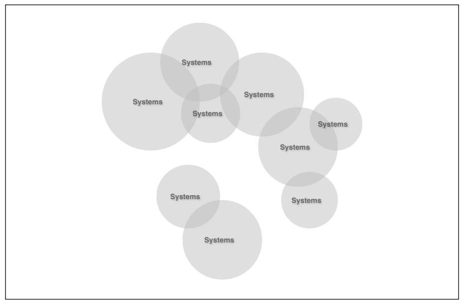


Fig. 03 Multiple Systems

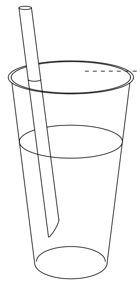


Fig. 01 PE Caps

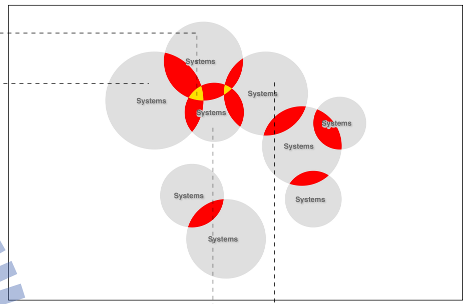


Fig. 04 Solutions of Multiple Systems

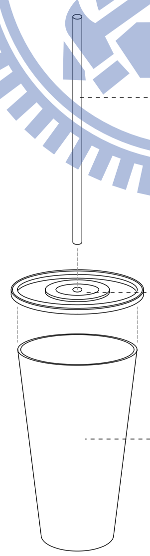


Fig. 02 Old Cap

II

Chapter 2 Complexity

Christopher Alexander has written a prominent article to describe the structure of a city. In his perspective, the structure contains numerous systems overlapping one another. Consequently, the whole structure is more like a mesh structure, in which the connections among the components result in enormous complexity. Each component can influence the others and vice versa, thus the analysis of the behavior can hardly be done because of the intricate networks.

A city actually is in a delicate balanced situation, one subtle change may cause a devastation that would never be expected. Christopher pointed out one fact. The mistakes appear when urban planners simplify the urban structure to a simple tree structure. Therefore, the semi-lattice structure was introduced in Christopher' s paper, and he mentioned that all the systems should be regarded.

An unprecedented communication methodology named LDPC (Low Density Parity Check) proposed in 1960s' could be an appropriate instance to explain how significant the information collecting is. The operation diagram of LDPC is demonstrated in Fig. 05. LDPC adopts a brilliant concept to correct errors within the communication systems. Furthermore, it is proved that LDPC is the only one method which can approach the Shannon Boundary [1] most, thereby being implemented recently. The concept of LDPC is to collect the information as much as possible. After the large amount of collection, all information is processed to obtain a precise outcome. This progress is similar to the natural evolution. The functions and the appearances of natural creatures are determined by the factors received from the contexts.

An ideal design method therefore should be able to perceive all slight variations and take them into the progress. In other words, all the information should be shared with all the systems. The information exchanging among diverse systems are shown in Fig. 06 to Fig. 10. Each system can receive and transmit the information. One system can form a simple feedback loop where the system can change itself. The complexity will rise dramatically by increasing the number of the feedback loops. The structure of a building is far more convoluted, as a result, the analysis of mesh structures virtually cannot be done. Unless the mathematical form of the structure is determined, computers are unlikely used to overcome this obstacle. In the next section, a project is introduced to test the complexity of the information sharing system.

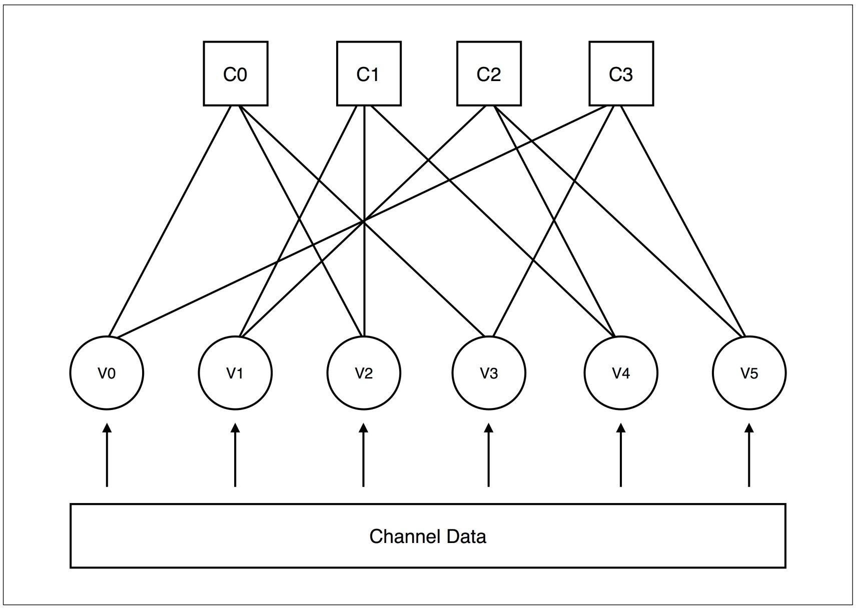


Fig. 05 Structure of LDPC

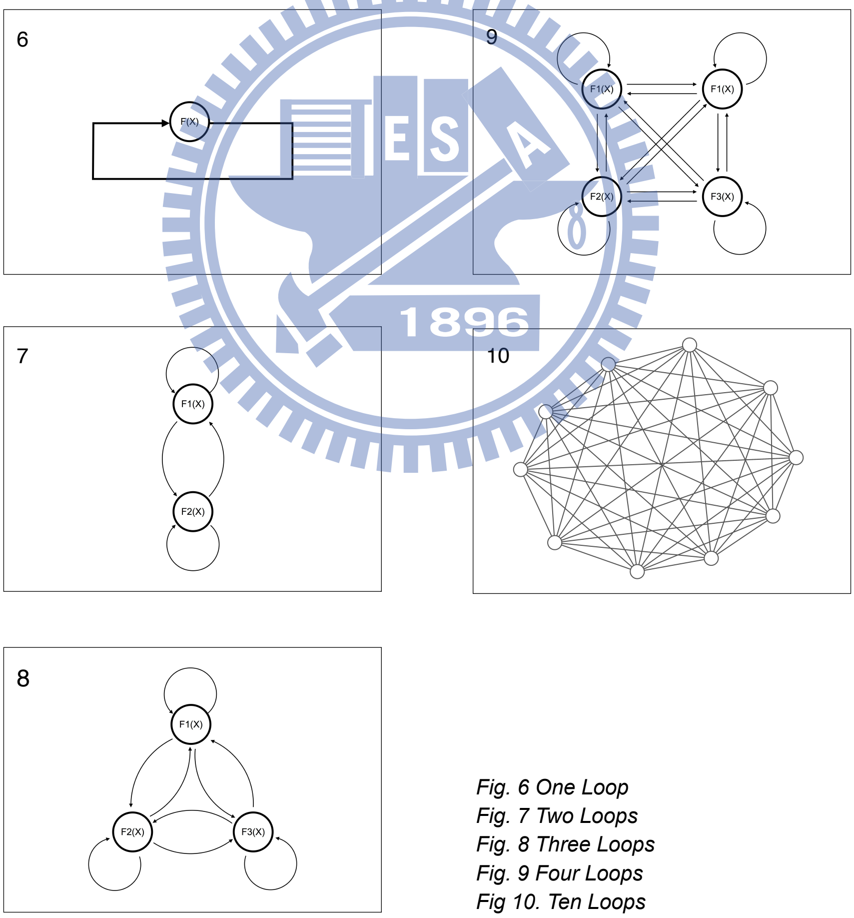


Fig. 6 One Loop
Fig. 7 Two Loops
Fig. 8 Three Loops
Fig. 9 Four Loops
Fig 10. Ten Loops

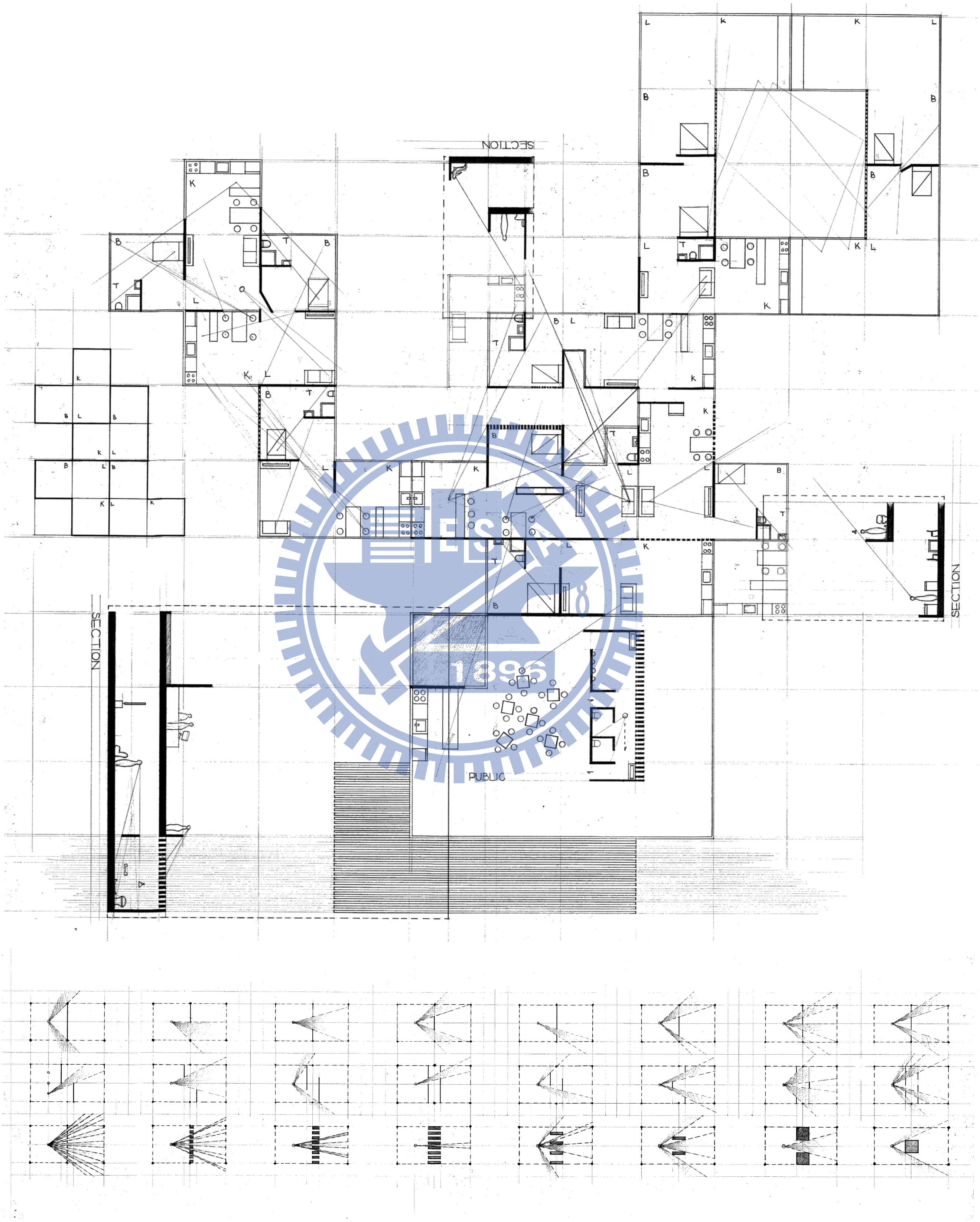
Project: Collective Housing

This project is an experiment about complexity, called Collective Housing. In this project, each room in the plan is related to its neighbors. In the first place, the initial room is located in the middle of the plan, and the second room is placed beside it by giving some constraints. The process is repeated in this way. After several iterations, the increase of complexity occurs at an exponential rate, and the whole plan runs out of control. This phenomenon is similar to the multiple feedback loops where a change cause more new changes. All the systems are interrelated with one another and become complex. This also means the systems change all the time.

After the experiment, the plan is reorganized within the module. To integrate the structure and the space, adopting a standard module is an efficient method. All the columns are within a grid system; therefore every unit can fit in the system. Without a module system, all the variables are difficult to be controlled. Each unit influence other units and receive the feedback information from other units. Consequently, the final design can scarcely be confirmed because of the uncertainty. Hence, some factors needed to be fixed first, so that the design process can continue.

The same strategy can be applied to the section to determine the relationship between any two adjacent units. As a result, the relationship occurs in both plan and section, and the entire building is constructed according to this relationship weaved by these two dimensions; in other words, this design is fitting to two dimensions with the same concept. Multiple dimensions can also be found in Le Corbusier’s well-known work, Villa Stein. The transparency that Collin Rowe mentioned in the case can be regarded as the harmony between plans and sections. Therefore, the identical relationship within different systems is actually similar to the concept of uni-solution.

Fig. 11 The Experiment of Complexity



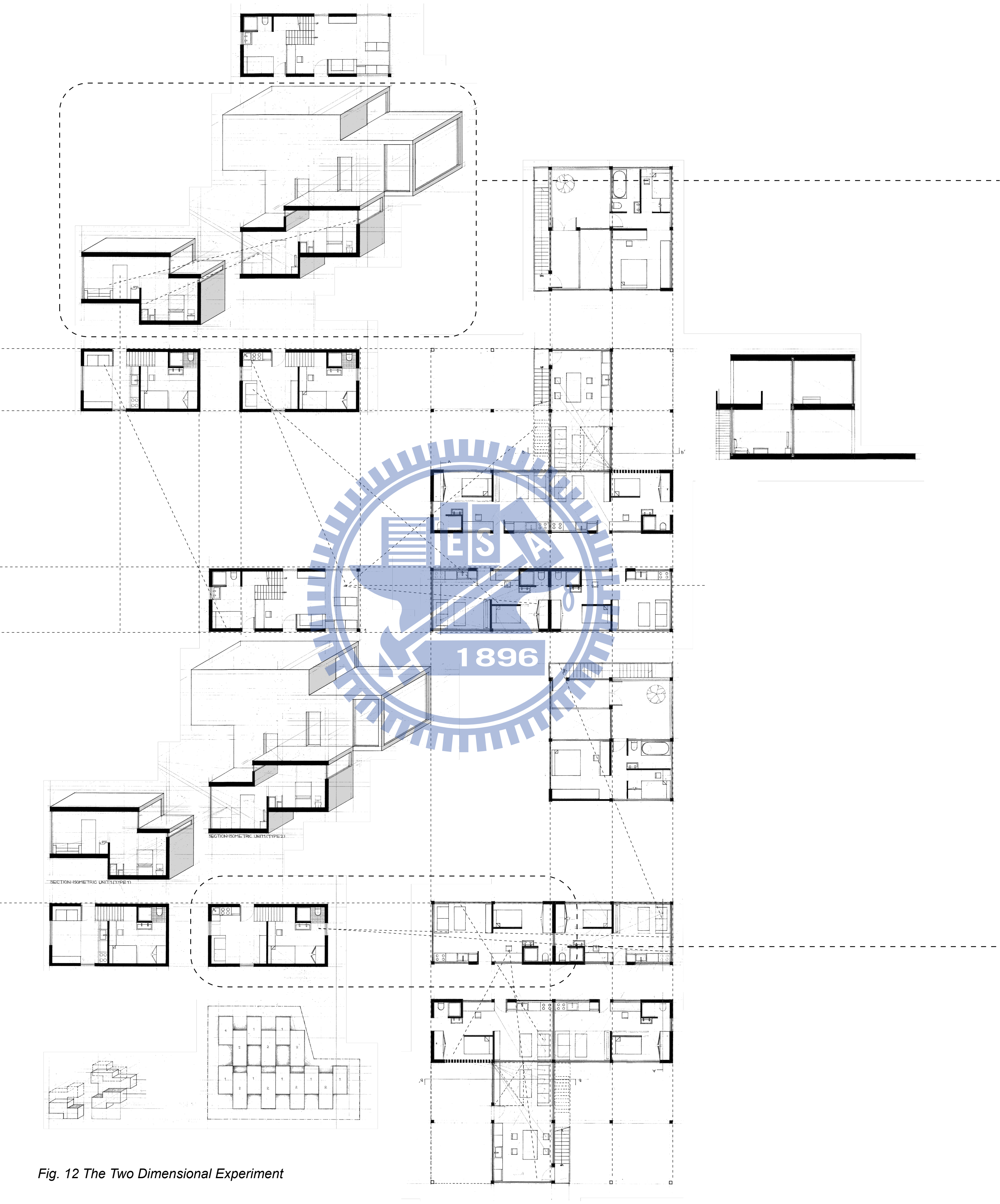


Fig. 12 The Two Dimensional Experiment

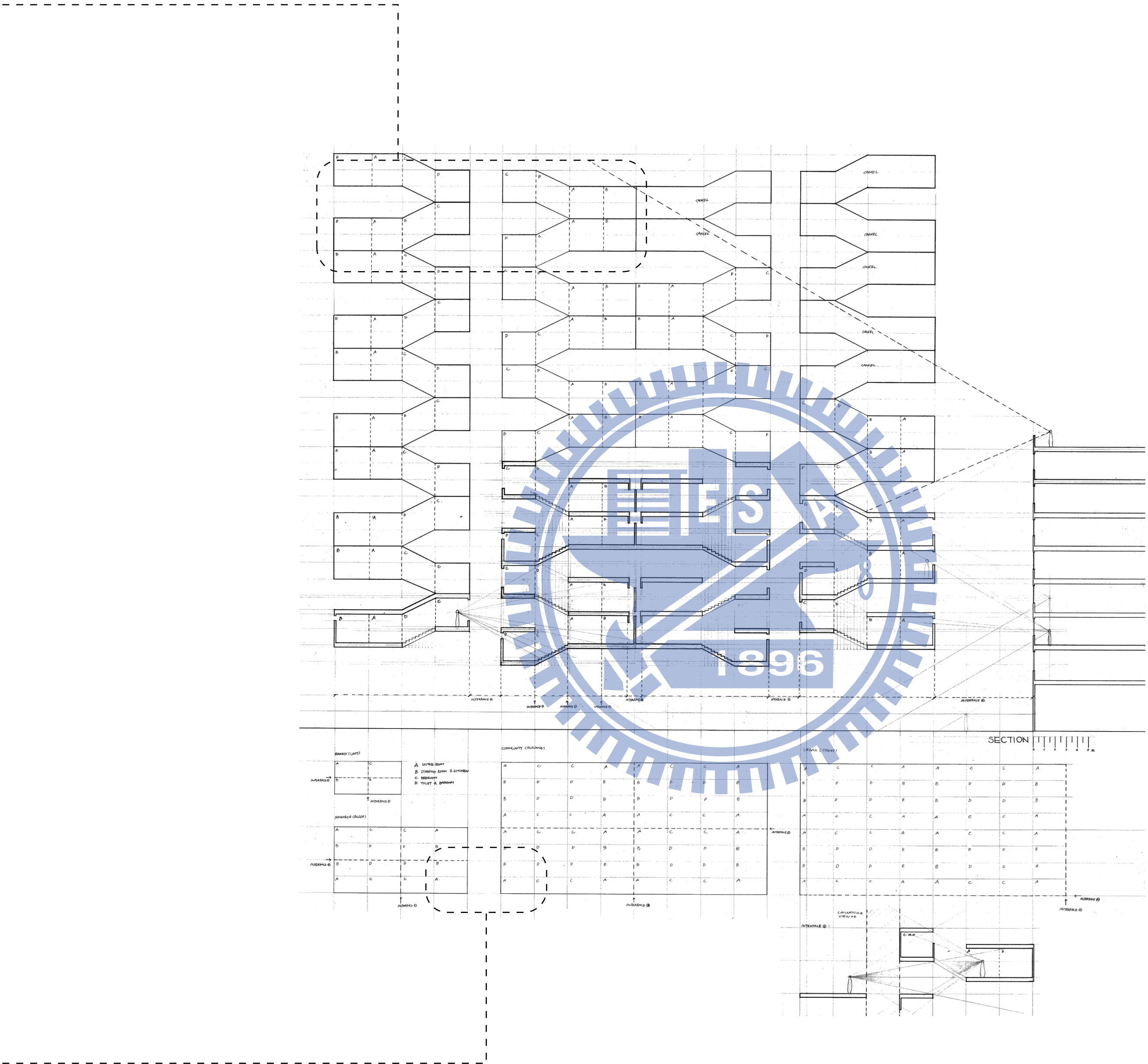


Fig. 13 The Two Dimensional Complexity

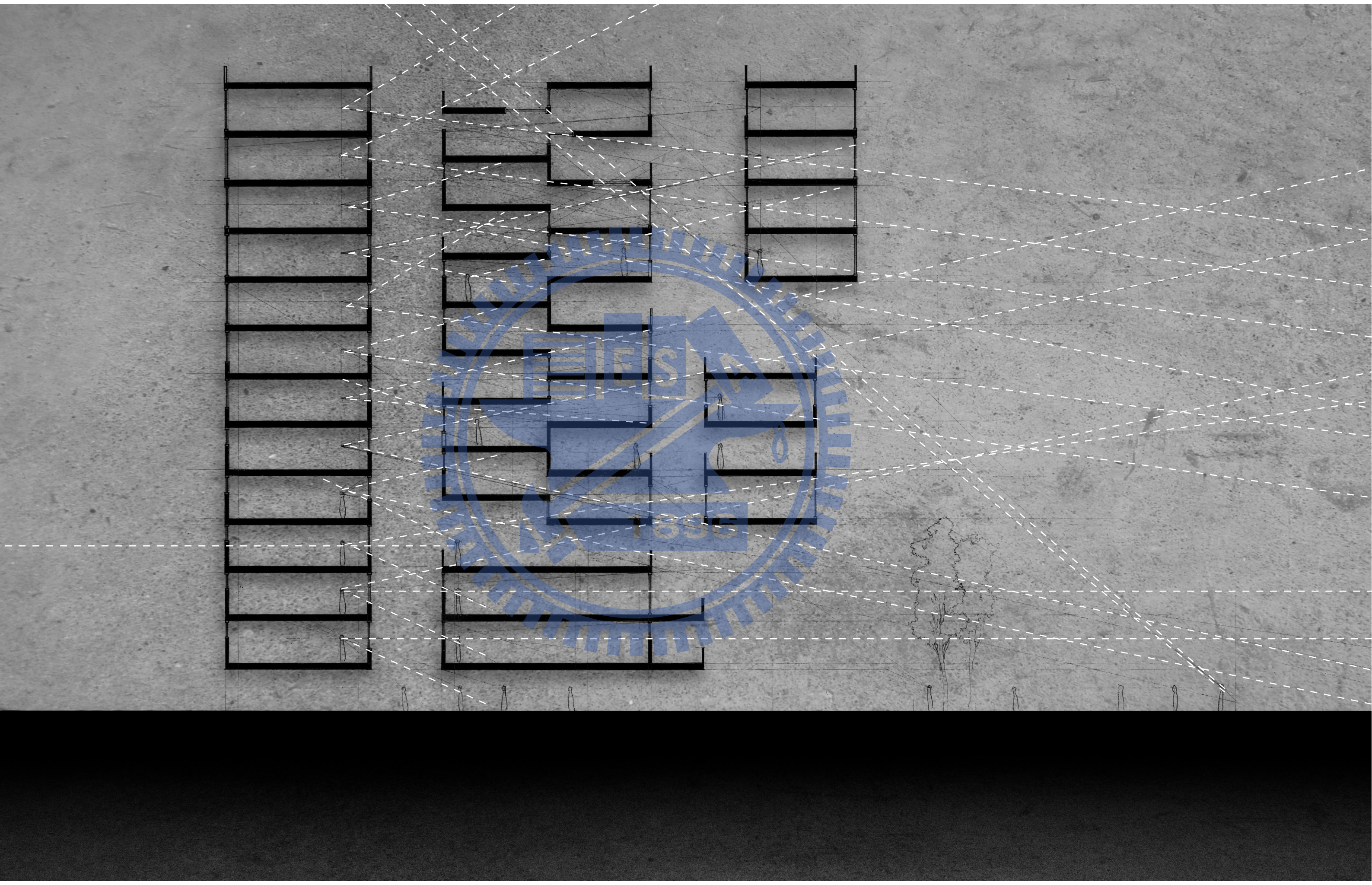


Fig. 14 Section Under 2 Dimensional Visual Conditions

Project: Slime Mold

A study of slime mold is presented in this section to explain collective behaviors. Slime mold is a collective creature consisting of numerous single cells. However, one slime mold cell has only few simple functions.

The fundamental functions of one cell include:

1. Roll toward one place where a signal is detected.

2. Transmit the received signal to its neighbors.

The mechanism of slime mold as shown in Fig. 15 to Fig. 21 demonstrates the signal transmitting and rolling behavior. The analysis of slime mold displays a potential design. Such a simple yet remarkable concept has slime mold adopted that higher leveled intelligent design is feasible. By tapping into the mechanism of slime mold, the concept of information sharing may be implemented in the architecture design. All messages from circumstances are combined together as a confluence, establishing the major principles of a design, for instance, DNA of the beings. Consequently, an objective and transparent design methodology can be approached.

Information sharing is also the model of globalization, especially after the internet has been epidemic. People today share information without any barrier. An individual is also likely to be affected by the information received. As a result, the internet connects everyone from everywhere, and all messages exchanged in this worldwide net influence one another, just like a mesh structure. The LDPC shows the potential of information sharing leading to an evolution. Additionally, the simplest creature, slime mold, demonstrates the possibility that information sharing might produce a higher intelligence. More details about feedback loops and information sharing systems are described in references. The specified mathematical analysis and computation will not be explained in this thesis.

Fig. 15 Slime Mold

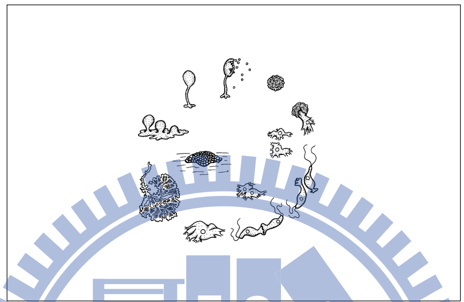


Fig. 16 Life Cycle of Slime Mold

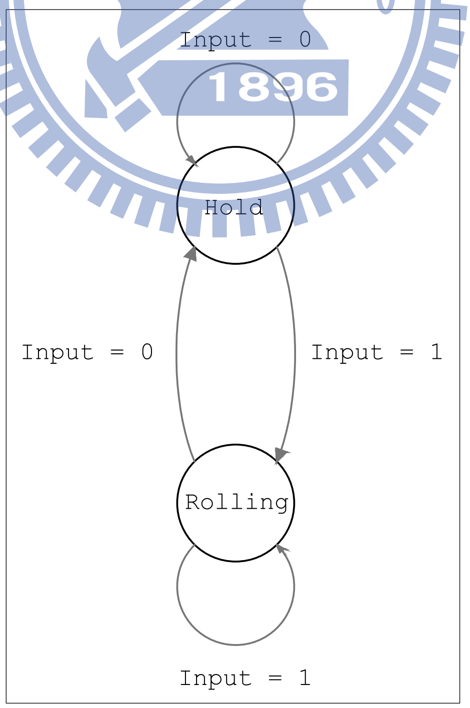


Fig. 17 Behavior of Slime mold cell

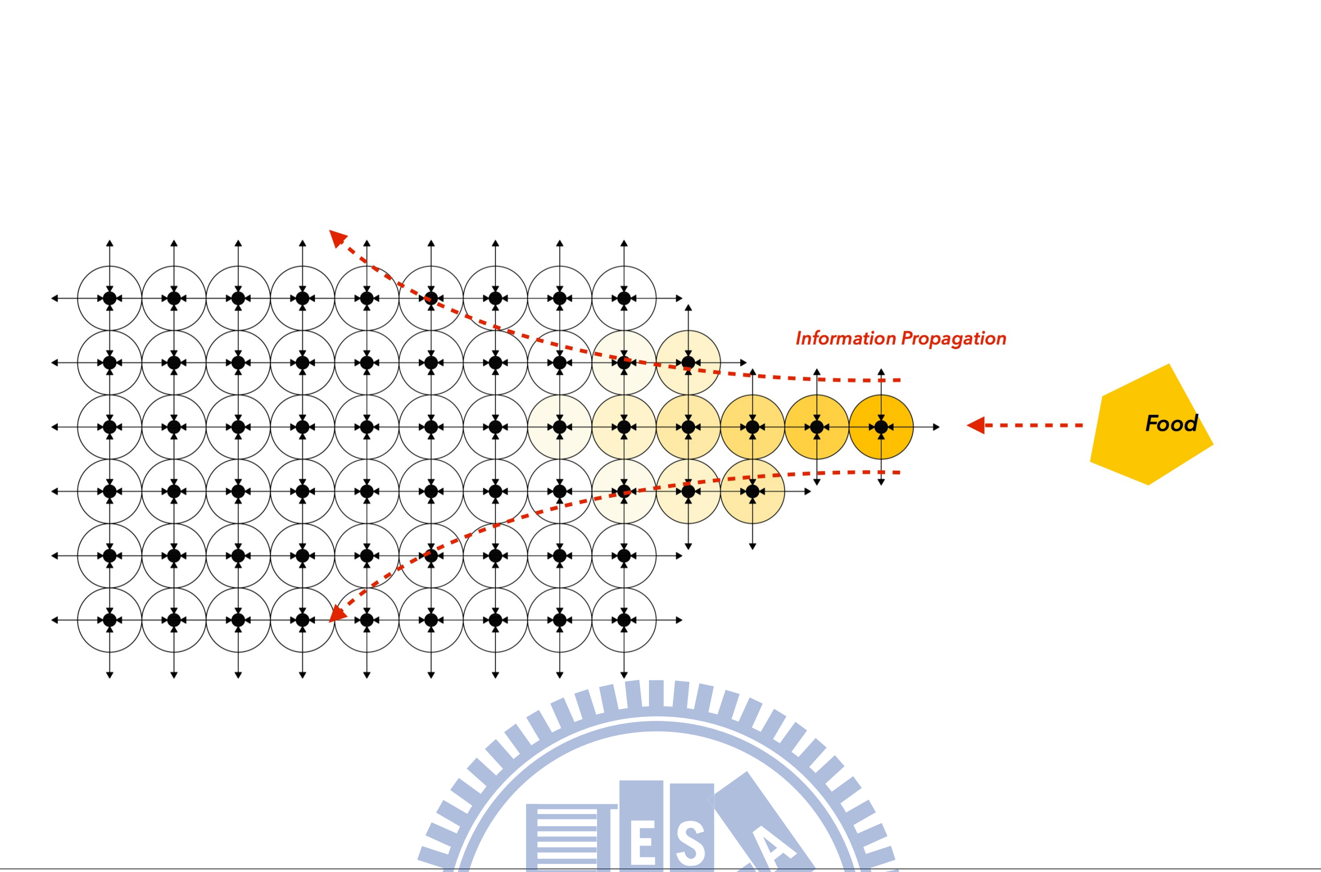


Fig. 18 Group Model of Slime Mold

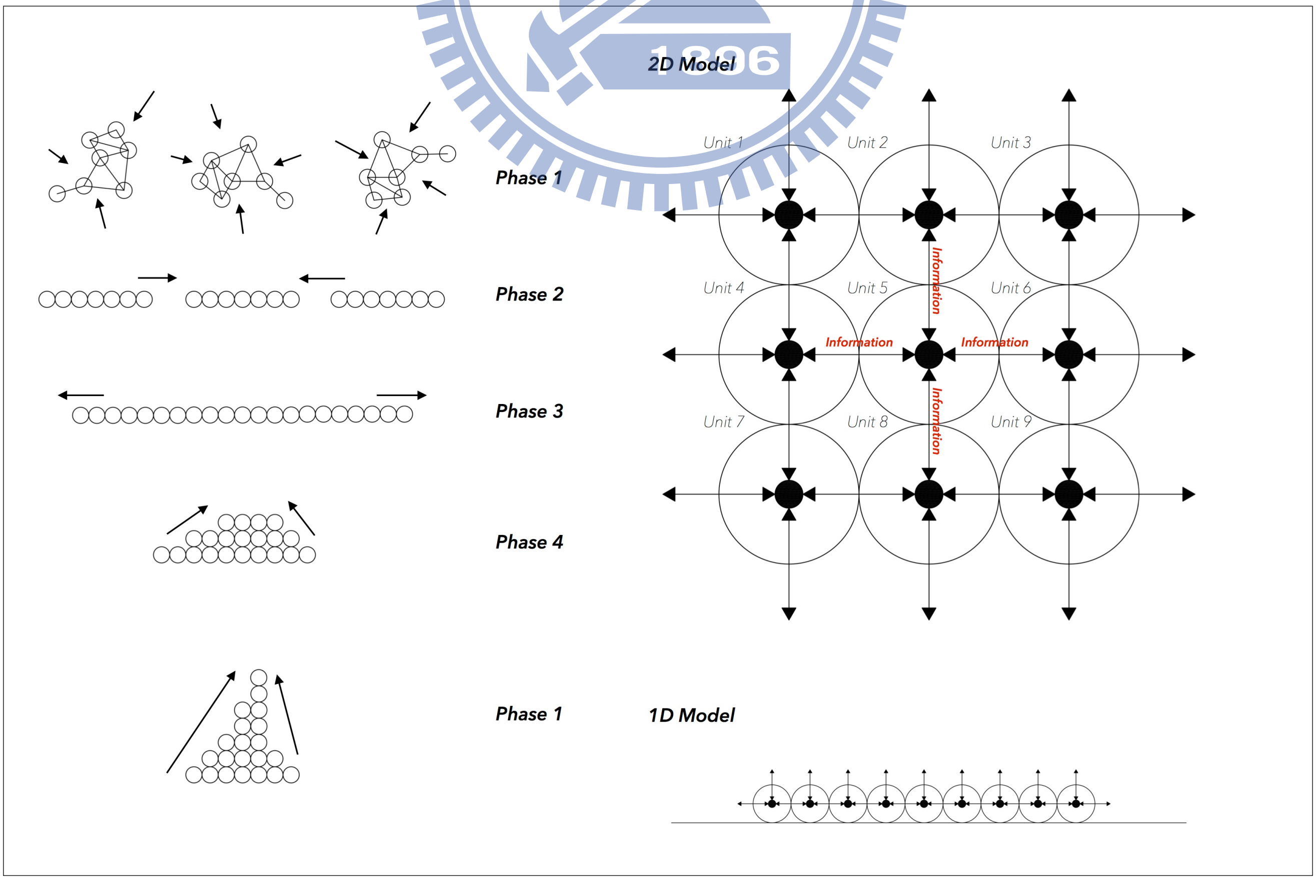


Fig. 19 Behavior Model of Slime Mold

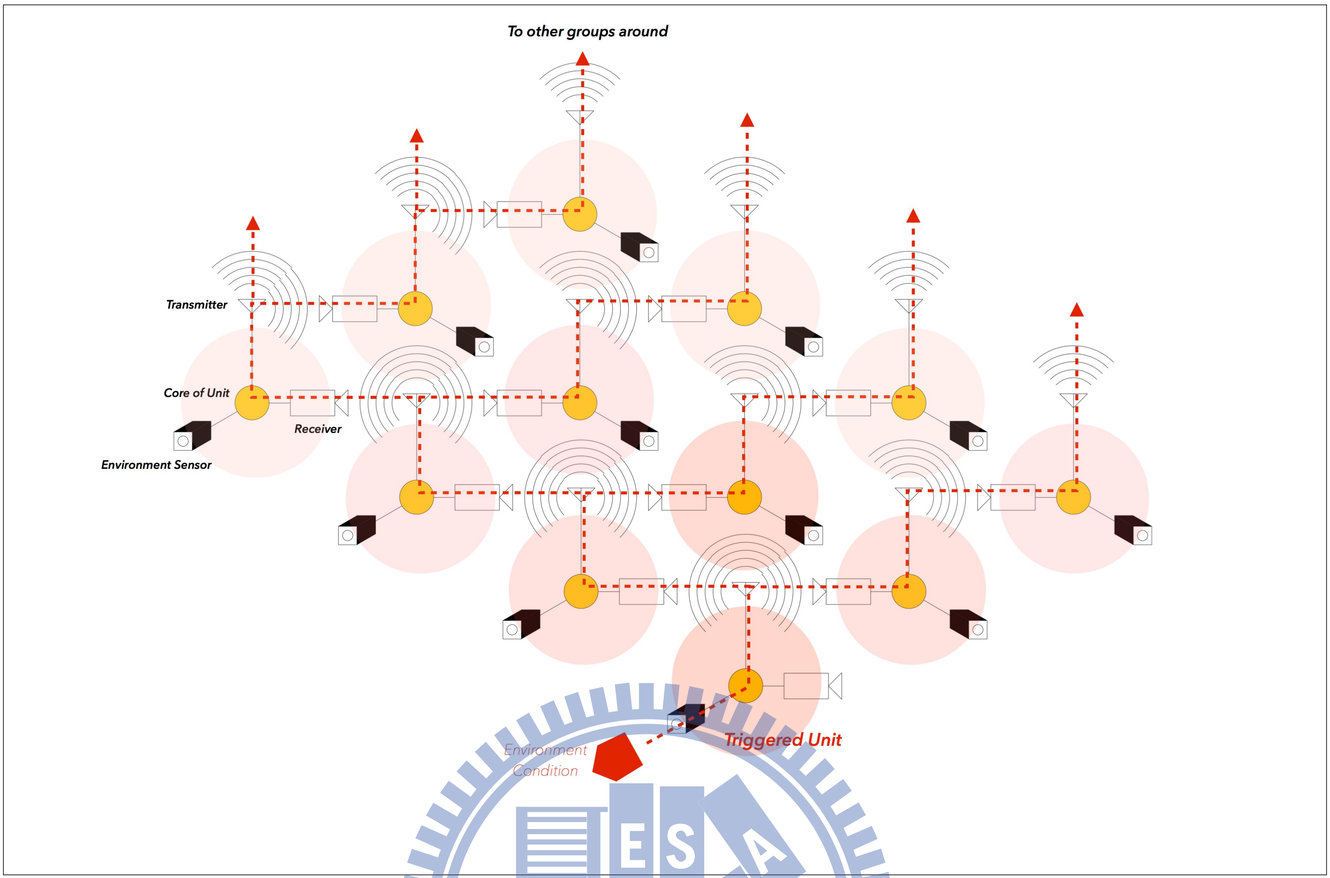


Fig. 20 Signal Propagation in Slime Mold

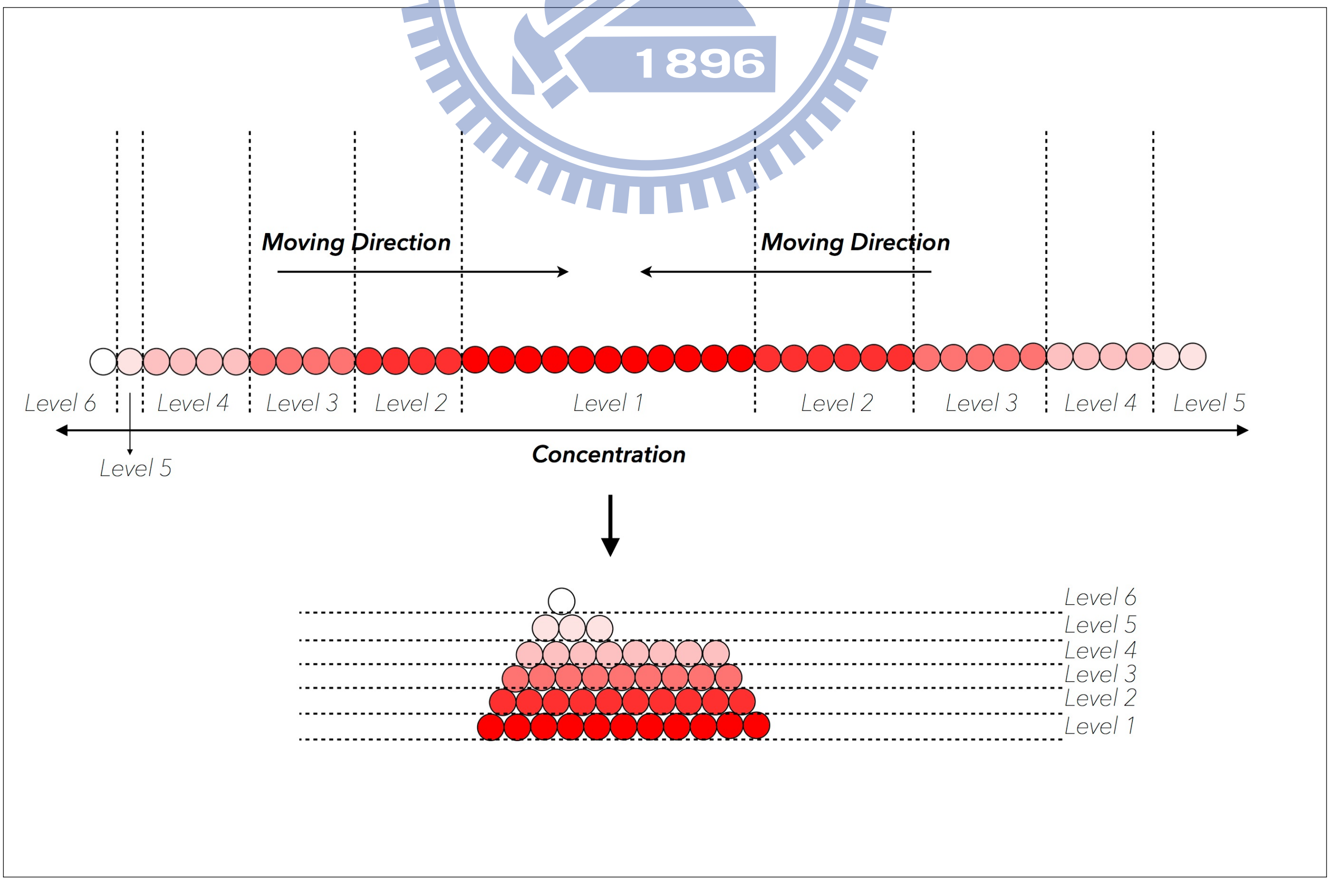


Fig. 21 Hierarchy of Behavior

To implement information sharing, each unit should be equipped with the ability to act according to the information received and transmit the information to other units. In the study of slime mold, each slime mold cell can roll in one direction. Each cell is covered by thousands of yellow threads which provide enough friction between cell surface and the ground for moving, as shown in Fig. 22. Furthermore, the power driving the cell is generated in the cell itself. In each cell, there is a chemical solution which can be transformed into gel in the front part of the cell as shown in Fig. 23. Because the gel is structural and thick, the volume of the front part is larger than the tail part, and the hairy surface can extend forward and grab the ground, thereby moving forward. On the other hand, the gel will be decomposed to the solution in the tail part, so the volume becomes smaller, and therefore the surface can be drawn back, as shown in Fig. 24.

With microscope, a tunnel structure is found in the cell and the solution can be channeled from the tail part to the front part within this tunnel. When the solution is pushed to the front, the solution will be mixed with a chemical material which is like glues helping the solution transform to the gel, the structural form. This process is critical to the unit design because each unit should be able to respond according to the changes of the circumstances. In the previous section, the algorithm in an individual cell is simple, but the group of the simple cells can act as a creature with advanced intelligence. This collective behavior can also be found in the urban environment and used as the model to simulate the behavior of a city.

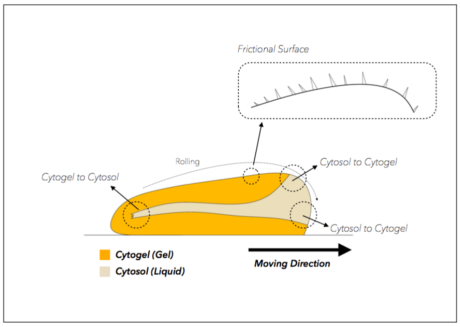


Fig. 22 Moving Mechanism of Slim Mold Cell

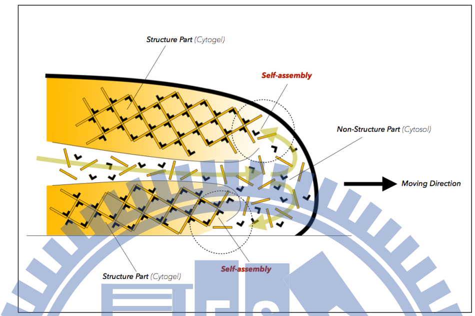


Fig. 23 Inner Power of Slim Mold Cell

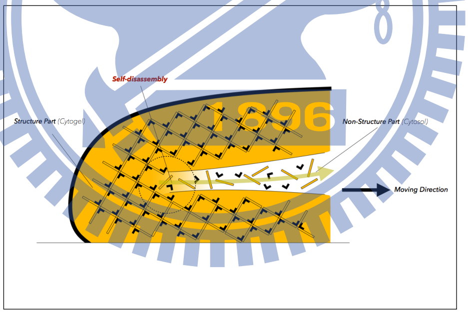


Fig. 24 Inner Power of Slim Mold Cell

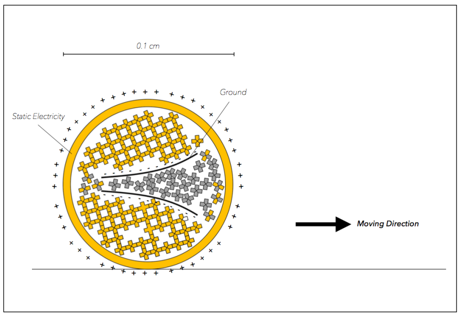


Fig. 25 Implementation of Inner Power

To realize the power of each unit, one of the implementations is to adopt the environmental variations as the power to driver the unit, such as the temperature variations, voltage variations, current variations, magnetic variations and so on. In this project, I tried to adopt voltage and temperature variations as the power to drive the units. However, the voltage variations is hard to be found in the natural circumstances. Even if the static electricity on the surfaces of objects is found, the power is still too weak to use. Therefore, the temperature variations seem to be more feasible; moreover, Taiwan locates in a tropic area, so the temperature discrepancy between day and night is obvious.

The phase-change-material such as wax and ice is another method to use the differentiation of temperature. The temperature required for forming ice is too low, thus water is not appropriate to be used in this design. However, the wax needs lower temperature to melt and higher temperature to solidify, so the wax seems to be a more viable material.

As shown in Fig. 26, the metal used to conduct heat is not horizontal, and thus the wax will be solidified into a slant form. Because of the slant form, the gravity will force the wax to keep horizontal; therefore the wax will rotate back to stay in the horizontal state, thereby providing the force to the axis. Additionally, the slant design may be applied to the roof design for constantly generating the power.

However, to provide a stable power, electricity is the most feasible option. Environmental differentiation or other natural power such as wind power and solar power are either too weak to use or too unstable to control. As shown in Fig. 27, a tiny wind mill is installed in the component; however, the direction of the air current is practically random on this scale. Moreover, the wind mill is too small to drive the device. If the wind mill is expanded to provide sufficient momentum, the loading of the wind mill itself turns out to be too heavy. In the end, the wind power will be waived and a steady power is adopted, electricity. The electricity may come from clean energy such as solar energy or thermal energy. Eventually the electricity can drive almost all the devices and the amplitude of the power can easily be adjusted. The power issue is not the major subject that I try to research; instead, the issues such as geometry and bias are what I mainly focus on in this project.

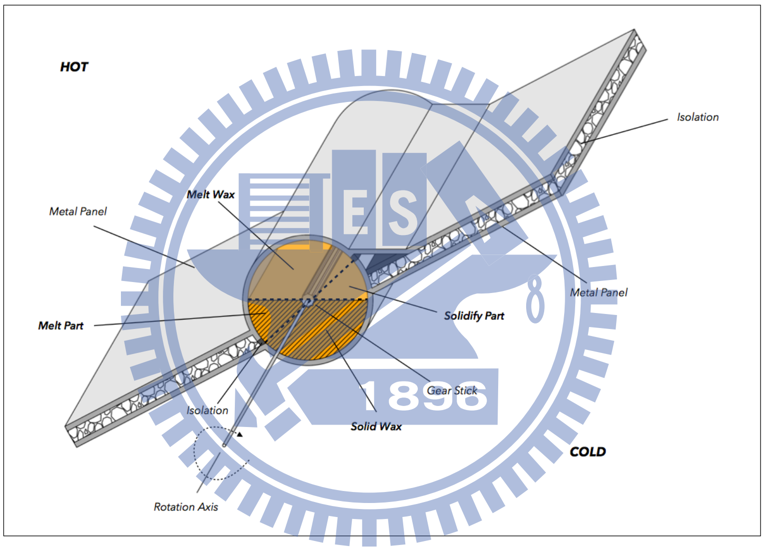
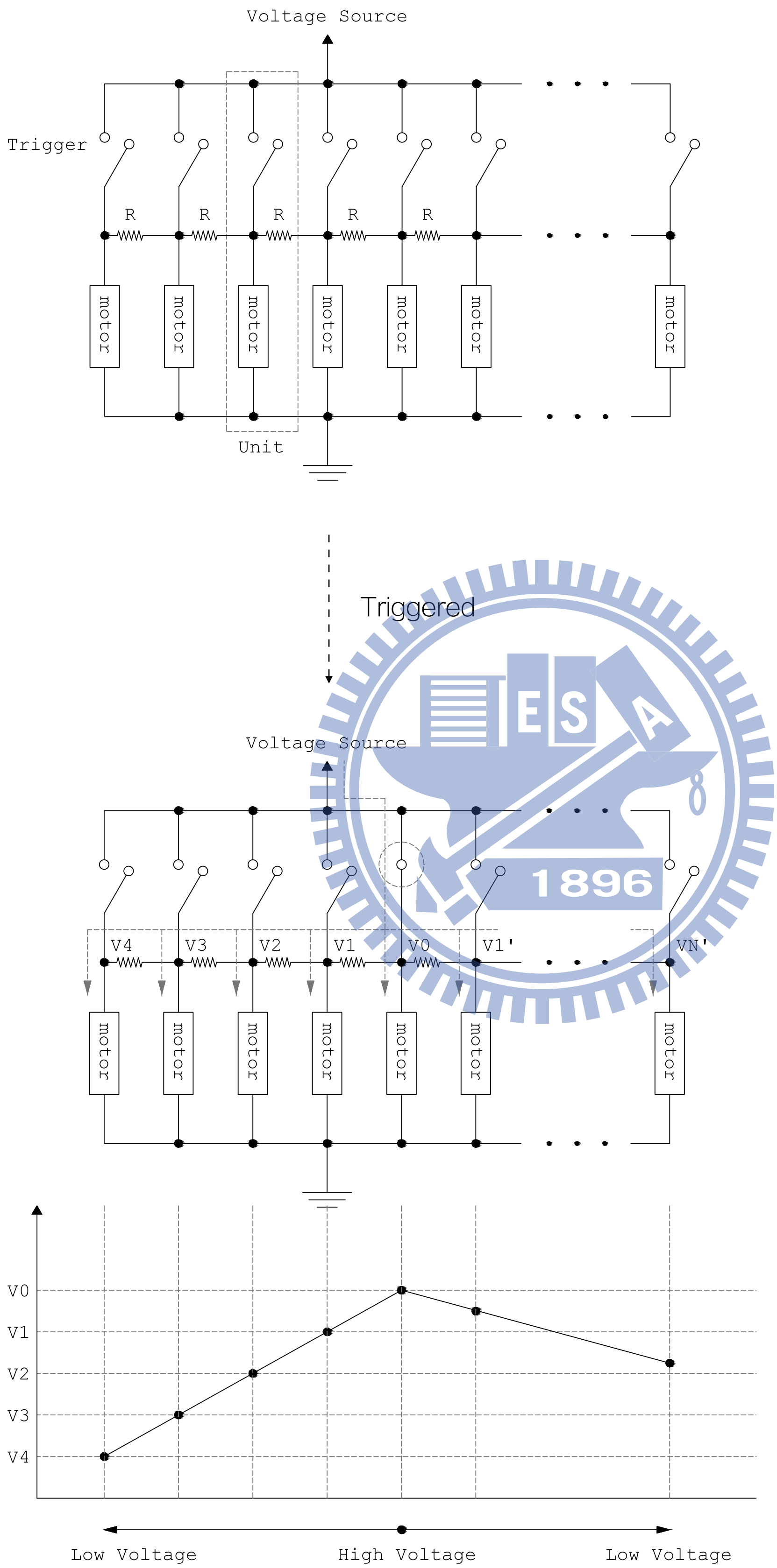
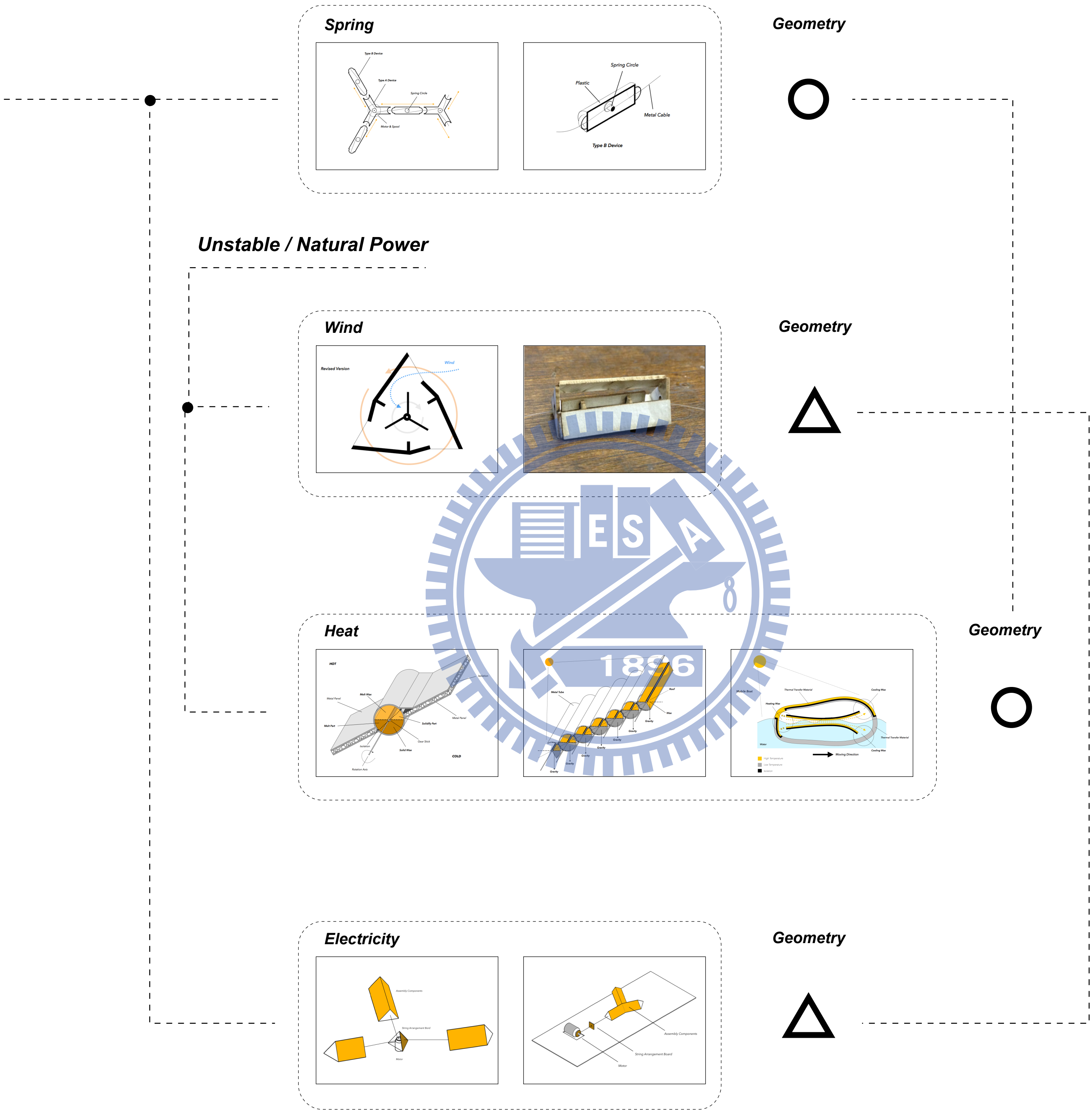


Fig. 26 Power Generating Method by using Wax



Stable / Artificial Power

Fig. 27 The experiment of Implementation



7 Bias

In addition to the power, another requirement for the unit design is bias. Since the unit can connect with other units, the way of the connection is important. How they combine together can decide the functions or forms. Without the bias, the combination will be chaotic and orderless. And, only the combination with orders can offer useful functions because random composition can hardly be controlled and may generate unpredictable results. Therefore, the bias need to be implemented on each component, this way, all the components can form with order when they connect together.

As shown in Fig. 28, this is a kind of bias design; however, this bias design can only provide 180 degree positioning, which means that there are two possible results for each connection. In other words, it cannot promise 100% positioning. Thus, another method is adopted to achieve precise alignment as shown in Fig. 29. In this design, three strings are used as the elements to precisely align two connected components. Likewise, the strings also offer the power when they are pulled. Once the strings are pulled, those components will be put together and align one another in the given order. Fig. 30 shows the details of the components. In order to reduce the obstacles of fabrication, there are three slots connected to the holes in which the strings are placed. The slots can make the fabrication process easier and save a lot of time; moreover, if the string goes through the wrong hole, it can easily be corrected by using the slot.

After the overall form is confirmed, all the components are generated by Grasshopper. All components can be 3D printed and the structure is strong enough to be against the pulling force from the strings. Therefore, the entire fabrication is calculated by the computer and the angles can be changed as needed. All the components are adjusted simultaneously. The algorithm concludes the needs of the limits of the 3D printer and the materials.

8 Geometry

The basic unit is a polyhedron which has twenty pentagon surfaces and thirty sides. Each side is designed as a bar with three holes for aligning. Between any two bars is a joint which plays an important role to connect bars. The angle between any two bars is put on the joint; hence the whole structure can be separated into two types of components: bars and joints. The length of the bar determine the size of the unit while the angle of the joint determine the shape of the unit.

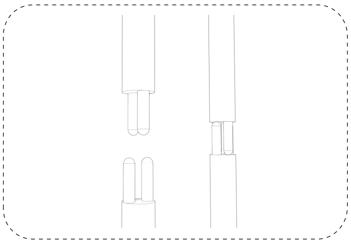


Fig. 28 Two Dimensional Bias

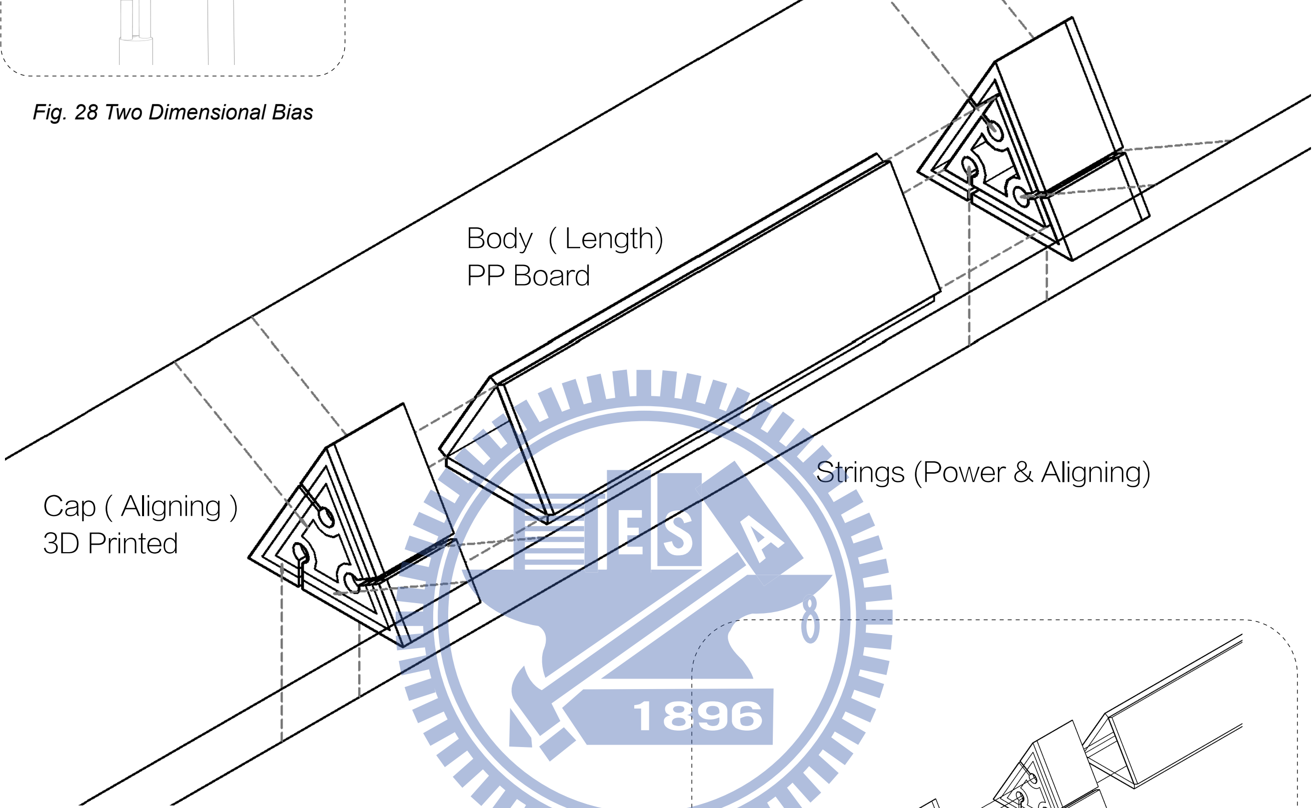


Fig. 30 Detail of Implementation

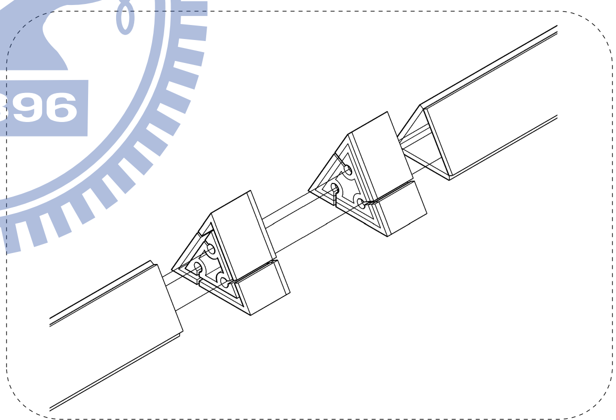
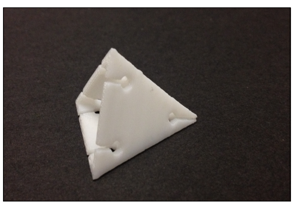
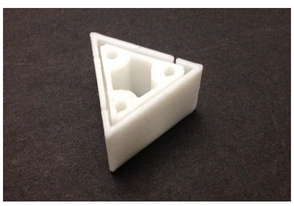
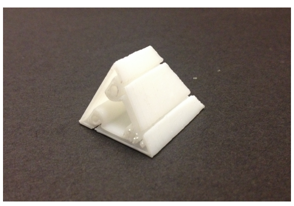
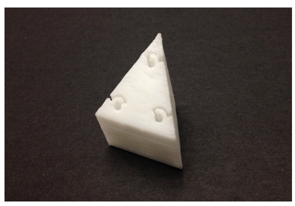
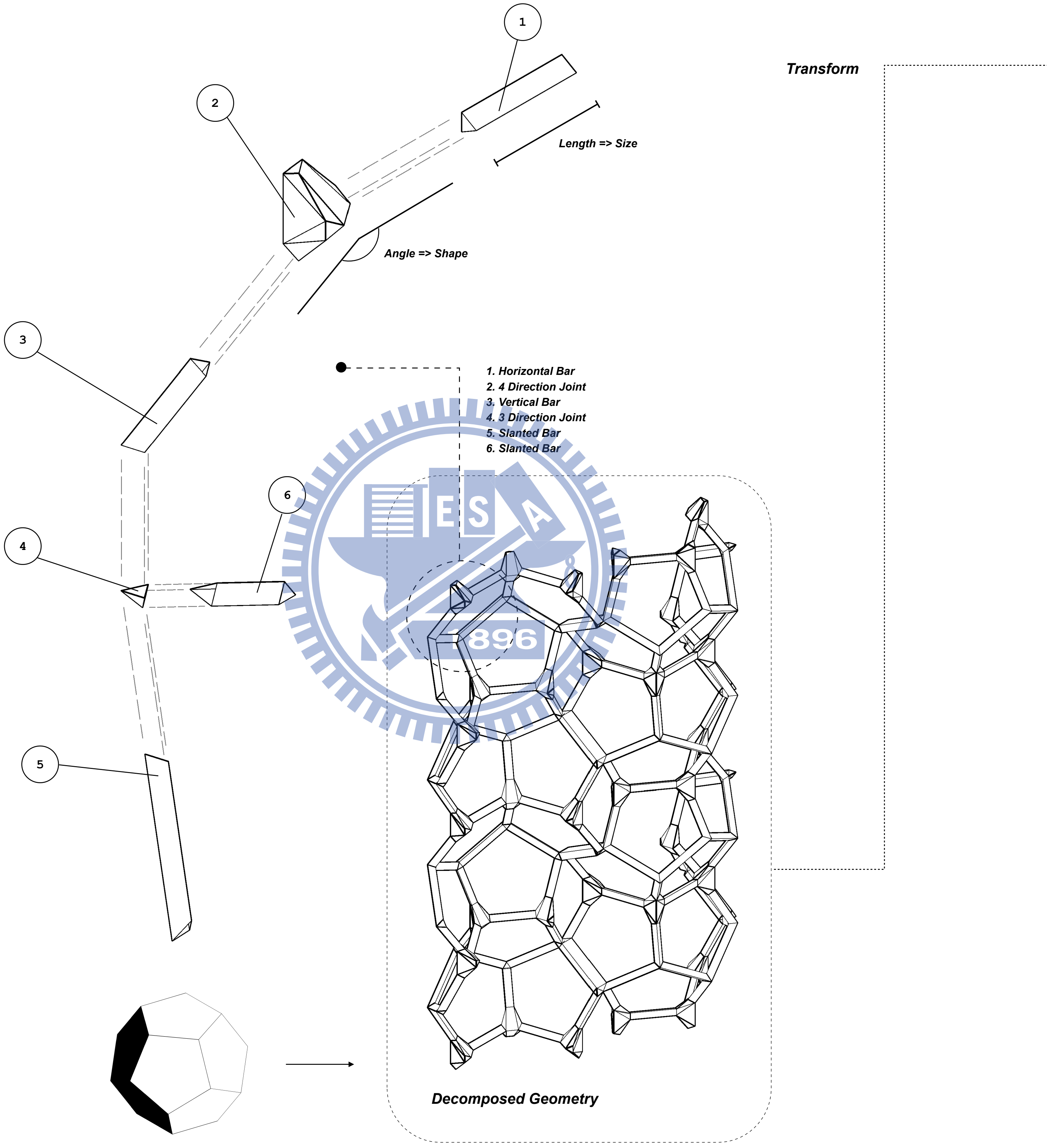


Fig. 29 The Implementation of Bias


1
2
3
4
5
6
Length => Size
Angle => Shape
Transform
1. Horizontal Bar
2. 4 Direction Joint
3. Vertical Bar
4. 3 Direction Joint
5. Slanted Bar
6. Slanted Bar
Decomposed Geometry

Prototype

Fig. 31 The development of Geometry

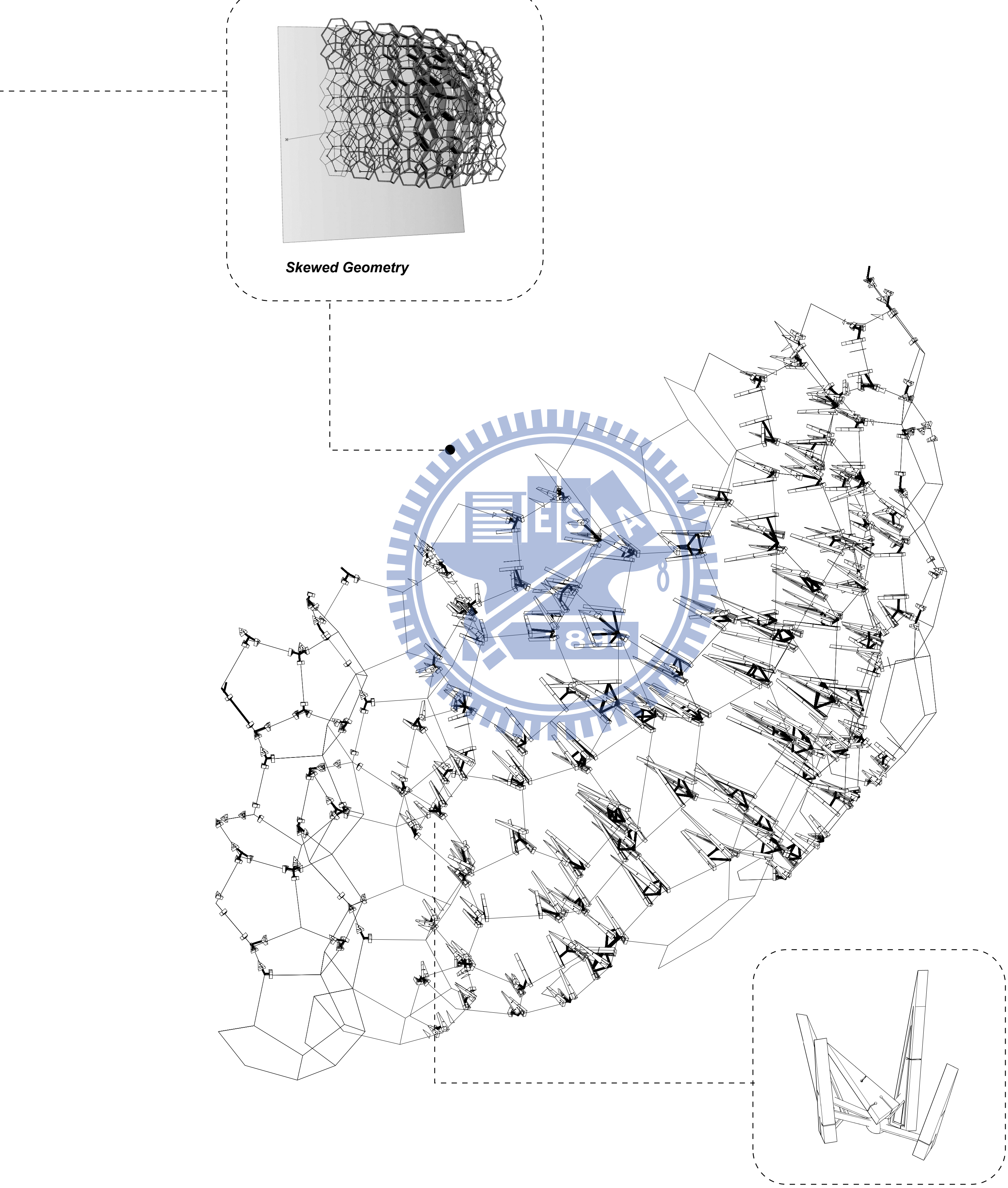
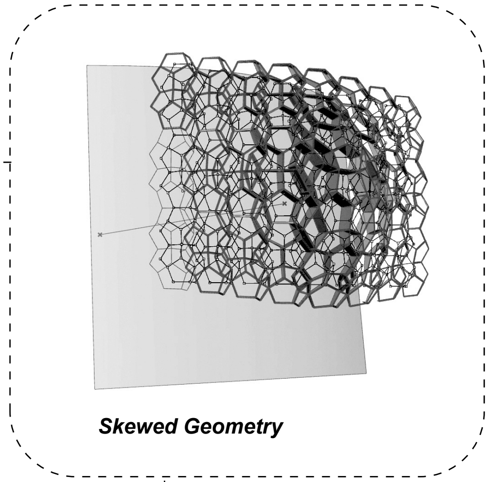
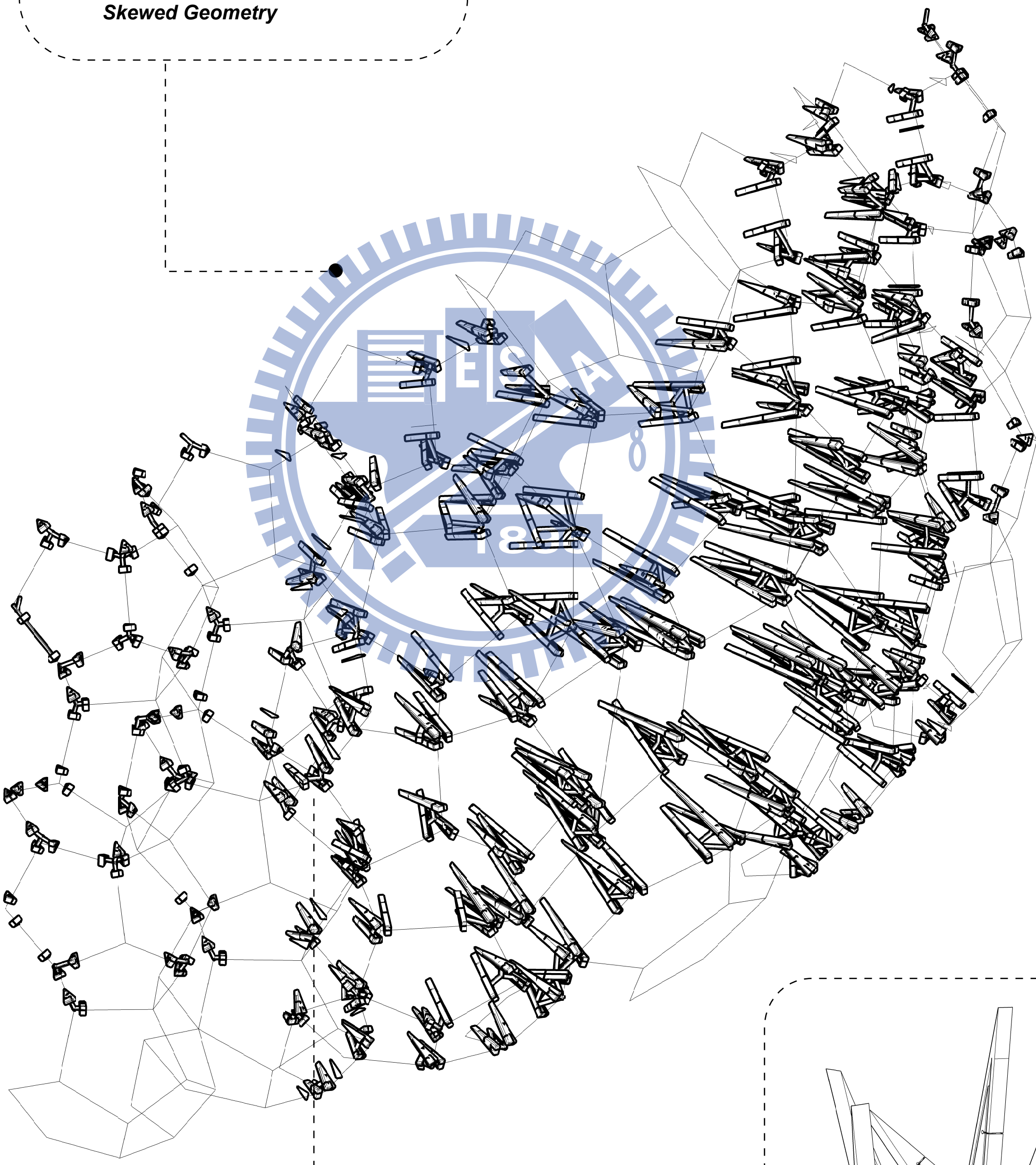


Fig. 31 The development of Geometry





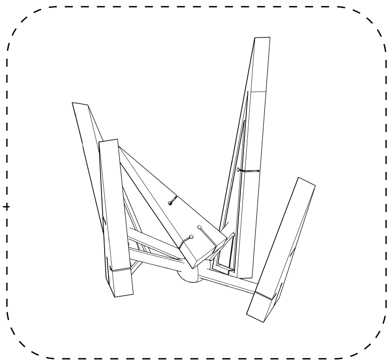


Fig. 32 The Final Model

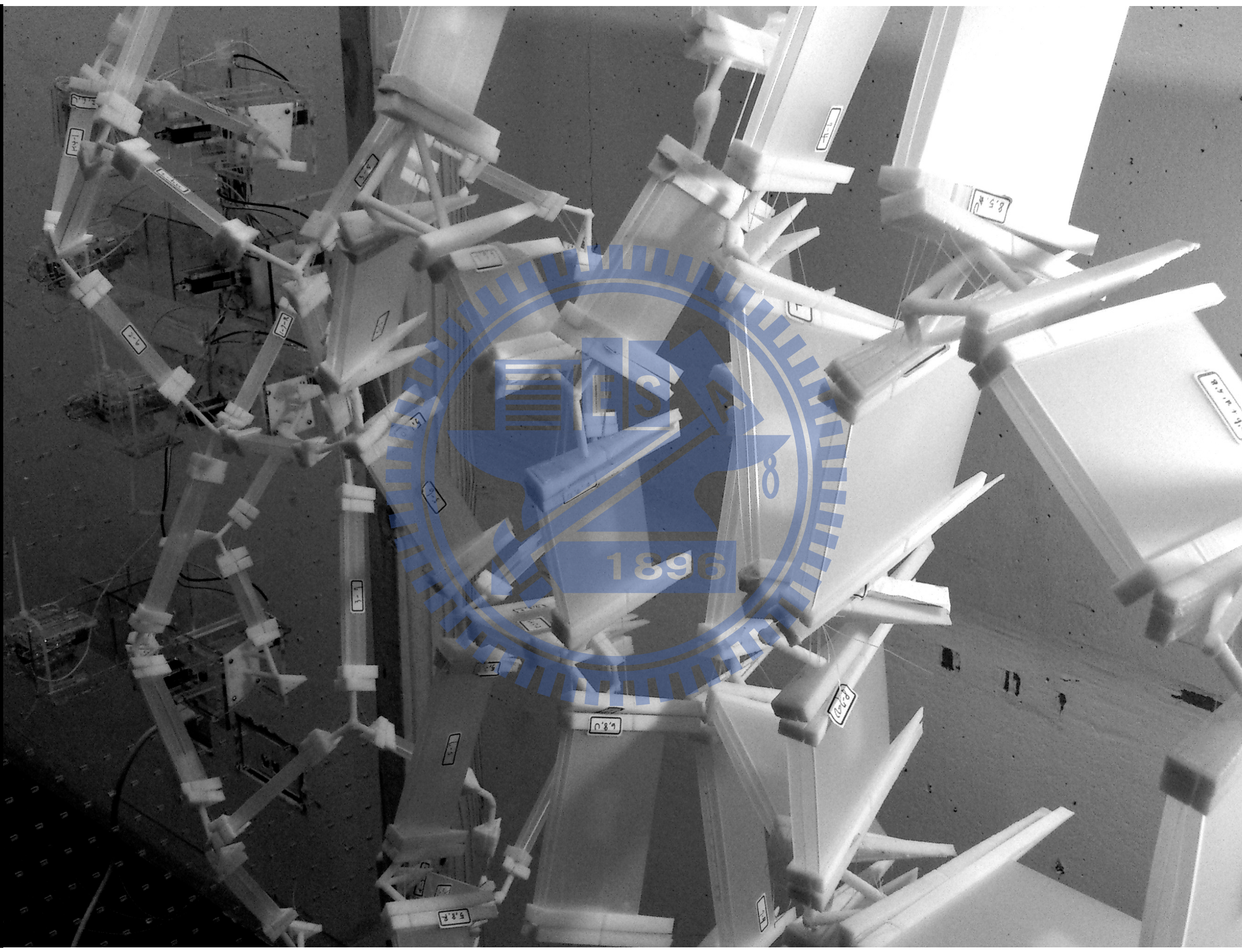


Fig. 33 The Final Model

III

Chapter 3 Systems

In this chapter, the following question is going to be discussed: How does the information propagate among different systems? Before probing into this issue, the definition of a system should be deliberated. If a hypothesis is made that a system operates as a "mathematical function", the model can be described as the diagram in Fig. 34.

In the equation of f(x) = Y, x represents the input while y the output, between which there is a relationship. Whatever is given to this function, there must be a result corresponding to the input. In other words, a function is a description of the relationship between inputs and outputs.

Now assume that there is a room in which a chair, a book and a lamp are placed, as shown in Fig. 35. These elements exist in this room can establish one or more systems.

At the beginning, the definition of each object should be clearly clarified: The chair only serves as a seat, the book is to be read and the lamp is for illuminating this room. Each object can only provide a single function. Thus, a person entering this room can sit on the chair or read the book in a bright environment.

There are 8 possible combinations with these components, as described in Fig. 36:

{ } ; Emptiness ;

{C} ; (Chair only)
{B} ; (Book only)
{L} ; (Lamp only)

{C,B } ; (Chair and Book)
{B,L} ; (Book and Lamp)
{C,L} ; (Chair and Lamp)
{C,B,L} ; (Chair and Book and Lamp)

Not every combination is capable of forming a system. To construct a system, each combination should be able to provide at least one output in response to the input. In this case, the input is a person and the output is a specific function. The eight possible outputs are shown in Fig. 37.

{ } ; (Emptiness) => Nothing

{C} ; (Chair only) => Sitting
{B} ; (Book only) => Nothing
{L} ; (Lamp only) => Nothing

{C,B } ; (Chair and Book) => Sitting
{B,L} ; (Book and Lamp) => Reading
{C,L} ; (Chair and Lamp) => Sitting
{C,B,L} ; (Chair and Book and Lamp) => Sitting & Reading

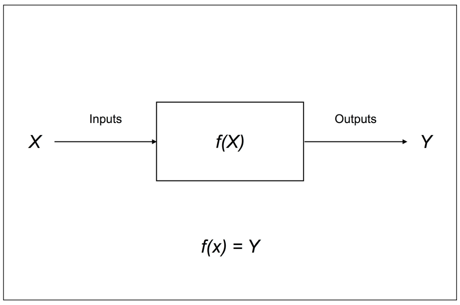


Fig. 34 System Definition

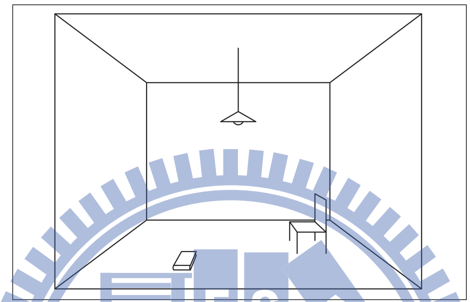


Fig. 35 Room

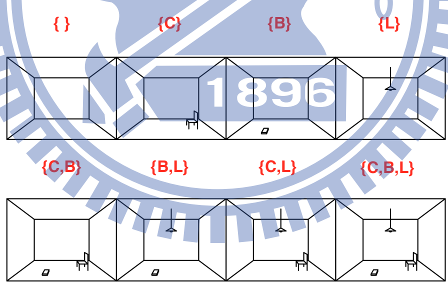


Fig. 36 Possible combinations of the Room

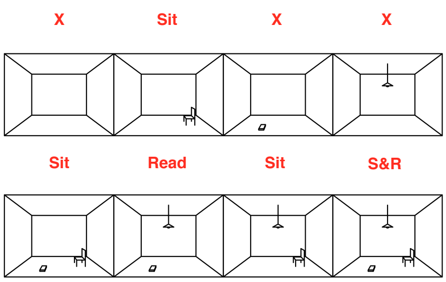


Fig. 37 Possible Outputs of the Room

Three different actions can be done with these eight possible combinations: Sit, Read, Sit and Read. According to the definition, only four combinations, however, can be defined as a system. Therefore, the structure of this room can be explicitly drawn as Fig. 38, and further written as a logical form as shown in Fig. 41.

{Room} = {{}, {C}, {B}, {L}, {C, B}, {B, L}, {C, L}, {C, B, L}} ;

If the useless subsets are removed, this universal set can be revised as Fig. 39.

{Room} = {{C}, {C, B}, {B, L}, {C, L}, {C, B, L}} ;

Only five combinations have the ability to respond to the input and hence, the redundant combinations are deleted to obtain a more precise form. To achieve a concise structure of the system, the combination with a function that is equivalent to others but is of higher complexity will be excluded first. The ultimate structure is presented in Fig. 40.

{Room} = {{C}, {B, L}, {C, B, L}} ;

{Room(x)} = {{C(x)}, {B(x), L(x)}, {C(x), B(x), L(x)}} ;

{Room(x)} = {C(x), BL(x), CBL(x)} ;

{Y} = {Sitting, Reading, Sitting & Reading} ;

As a result, this room can be represented as a universal combination consisting of three minor combinations, and each minor combination has a respective output. The corresponding logical structure is described in the diagram of Fig. 42.

Theoretically, every space or building may be represented as a systematic form, and the behaviors of the space or building can be elucidated.

According to the above definition, neither "book" nor "lamp" can be regarded as a system alone; therefore, book and lamp need to work together to form a system, {B,L}.

There is a common condition when it comes to the book, the lamp and the light. The lamp is the source of illumination, and one person needs the light to read a book. A supply-demand relationship therefore links the book and lamp to establish a simple system. This relationship is based on the common element existing both in the lamp and the book. The connection among different devices of a system will be discussed in detail in the later sections.

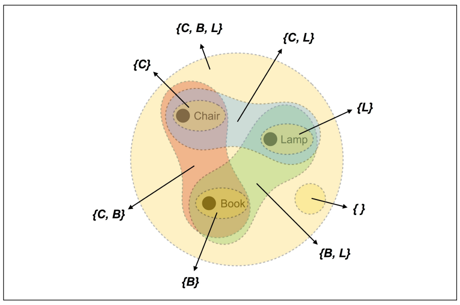


Fig. 38 System Structure of the Room

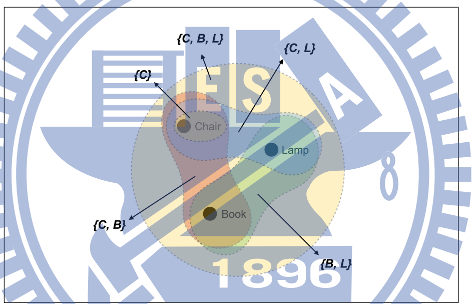


Fig. 39 Revised System Structure

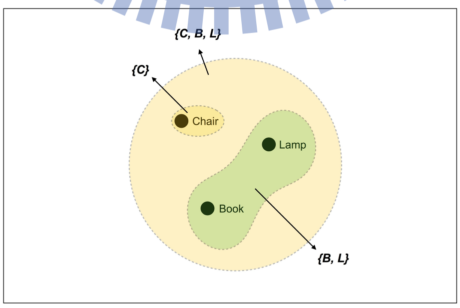


Fig. 40 Optimized System Structure

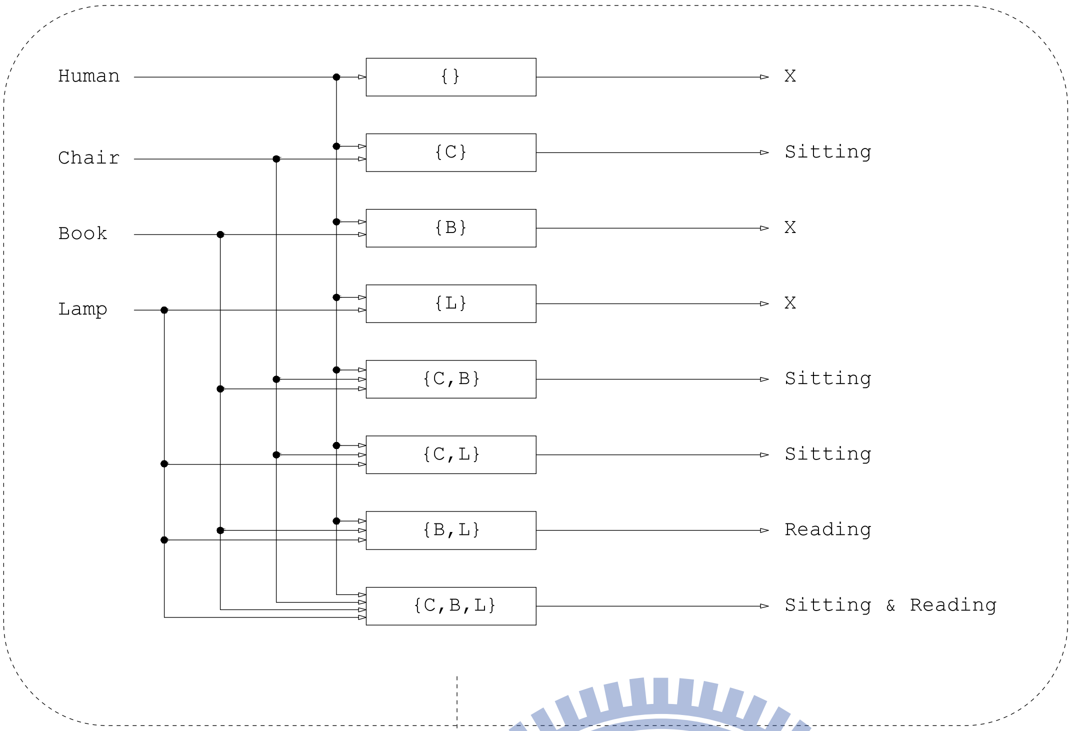
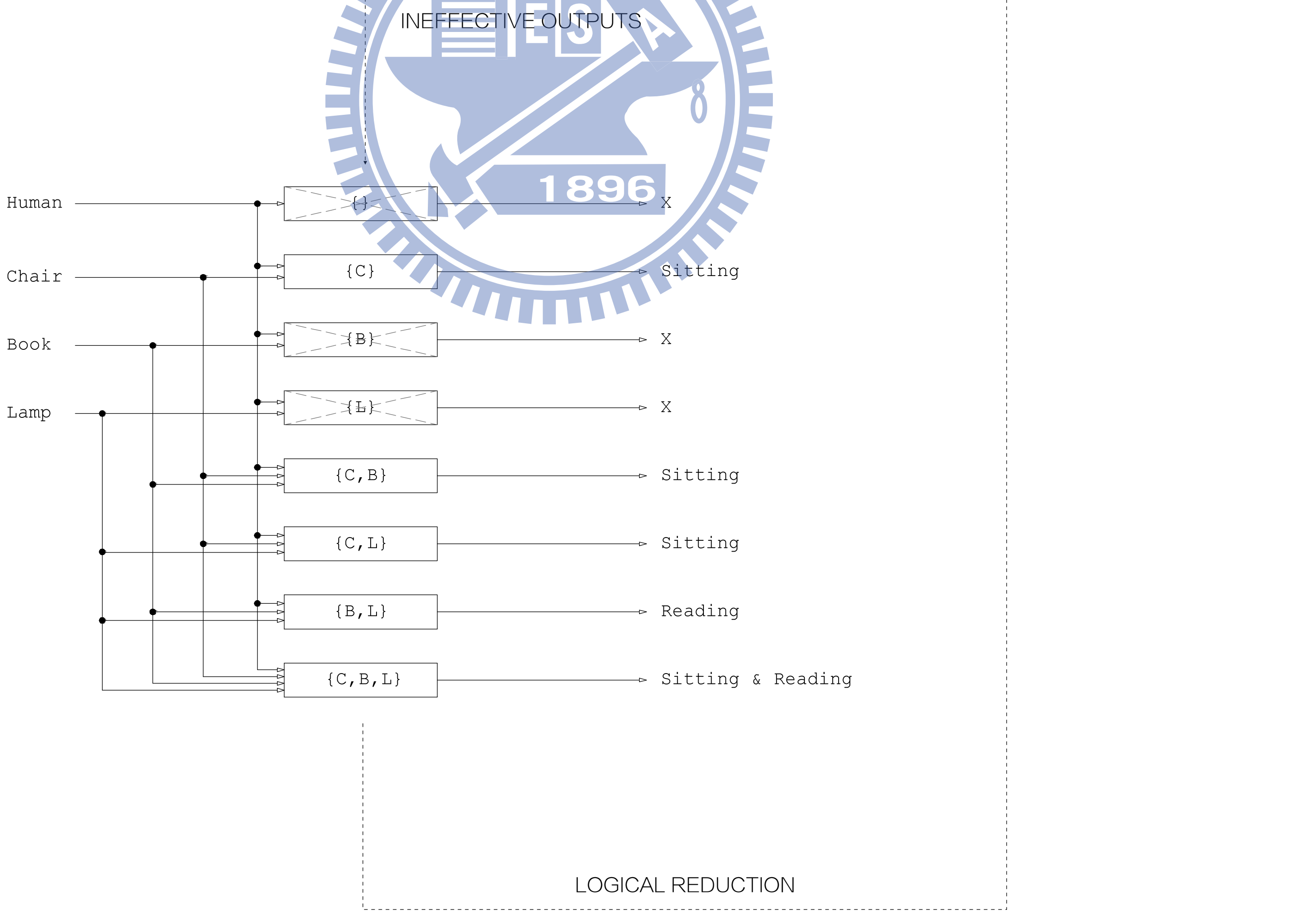


Fig. 41 Original Logical Structure



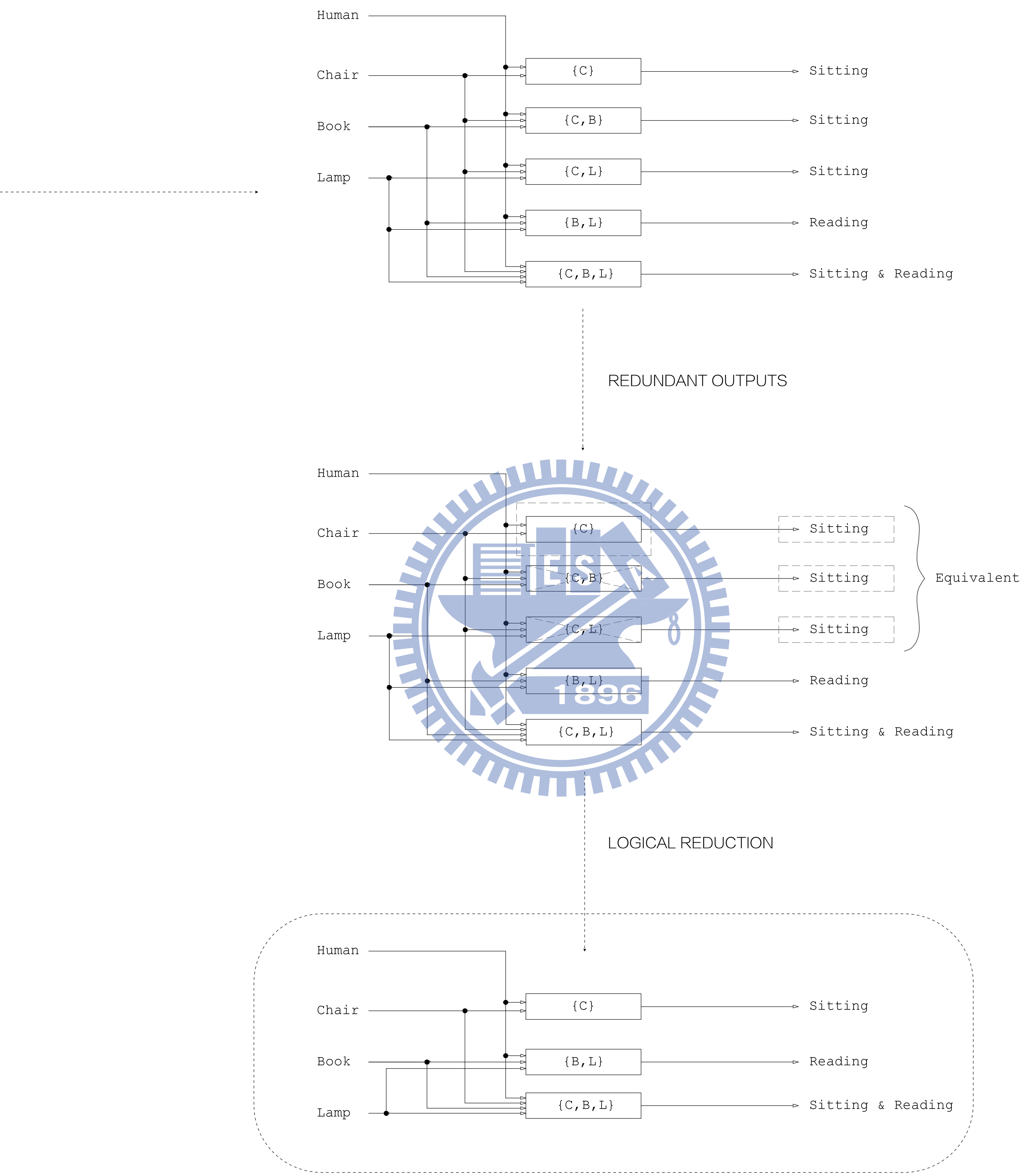


Fig. 42 Optimized Logical Structure

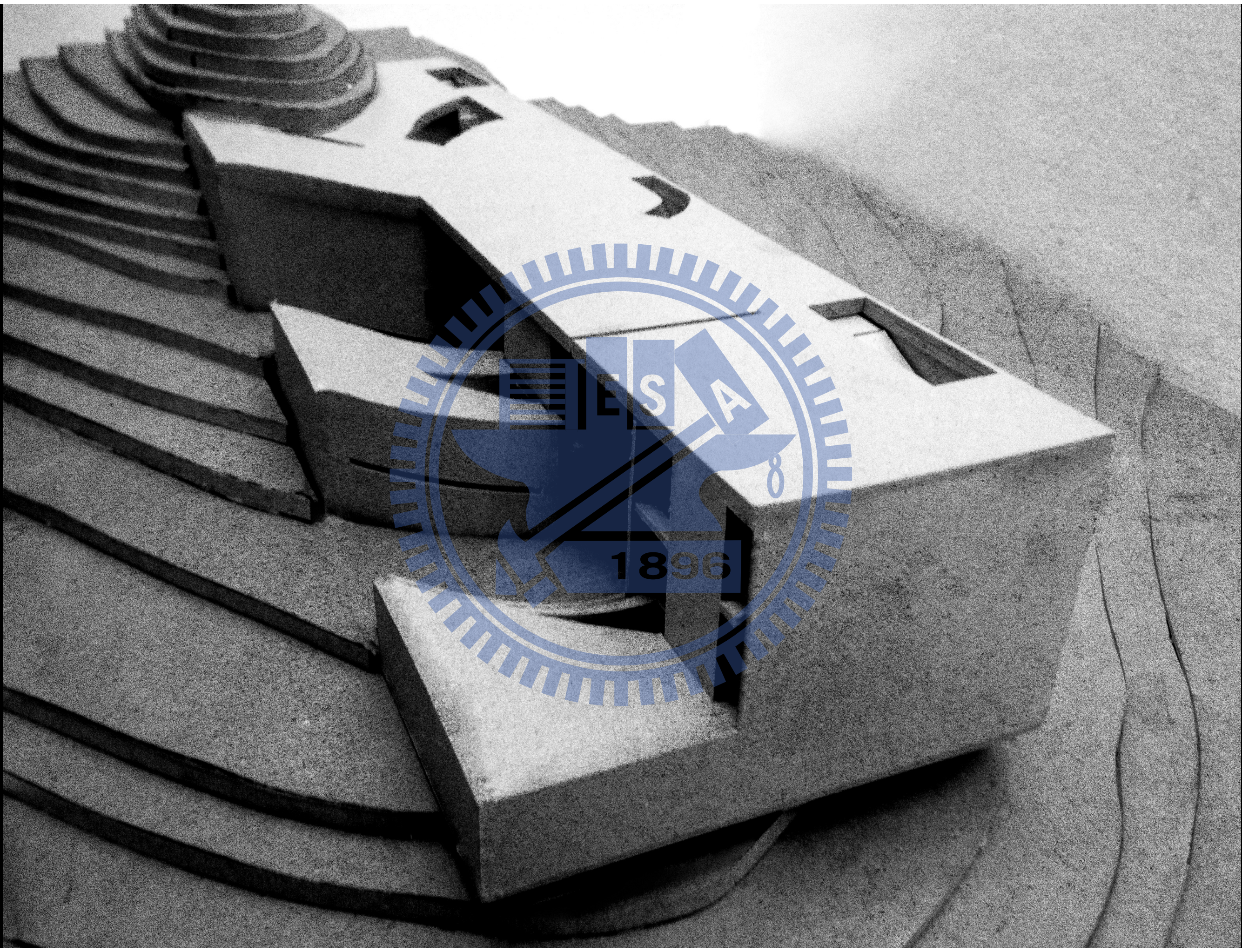


Fig. 43 The Multiple Complexity Design

Project: Island

10 Figure / Ground

The classic issue of architecture, Figure-Ground, can be re-defined in different perspectives. Fig. 44 shows the typical relationship between figure and ground. By increasing the number or area proportion of the objects, the figure-ground relationship becomes more ambiguous. However, the figure-ground ratio is too simple to illustrate the real relationship between architecture and environment. The connection between figure and ground should be defined as the harmony between the architecture (figure) and the environment (ground). The architecture should be well connected to the systems of the circumstances. Nonetheless, the whole environment is always too complicated to analyze. In this project, it is aimed to find out a strategy achieving the harmony between the site and the architecture. On the other hand, the design is required to fit several dimensions.

The site is a reservoir in Hsinchu County, Taiwan. Several characteristics such as the drain-supply axis, north-south axis, contour lines, figure-ground elevations, water table and structure are chosen as the conditions of the site. Therefore, they are defined as the dimensions that should be fitted. This strategy is adopted to re-define the new figure/ground relationship instead of simple volume or area ratio. Here uses the table in Fig. 44 as the example to describe the new f/g relationship. In this table, the unknown blank can be determined with the information from the adjacent numbers. Precisely, the unknown number must contain the relative information from others. Thus it can fit to the environment; furthermore, even though the numbers in the table seem to be random, theoretically, there must be a relationship among them. In consequence, this design contains the information from the site, and the information is transformed into the spatial form which can be perceived. In other words, the invisible information from the land is transformed into the space experience.

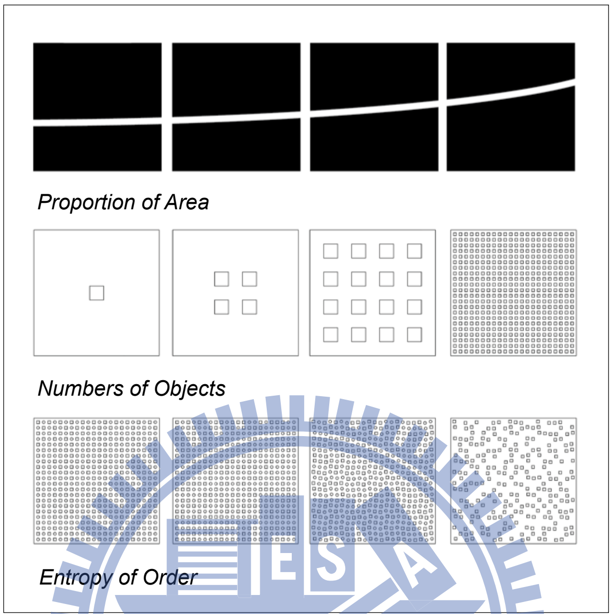


Fig. 44 Traditional Figure/Ground Transition

1	2	3	4	5	6	7	8	9	10
3	4	7	12	19	28	39	52	67	84
5	6	11	20	33	50	71	96	125	158
7	8	15	28	47	72	103	140	183	232
9	10	19	36	61	94	135	184	241	306
11	12	23	44	75	116	167	x	299	380
13	14	27	52	89	138	199	272	357	454
15	16	31	60	103	160	231	316	415	528
17	18	35	68	117	182	263	360	473	602
19	20	39	76	131	204	295	404	531	676

Fig. 44 Multiple Systems Table

Site : *Bao-shan Reservoir*

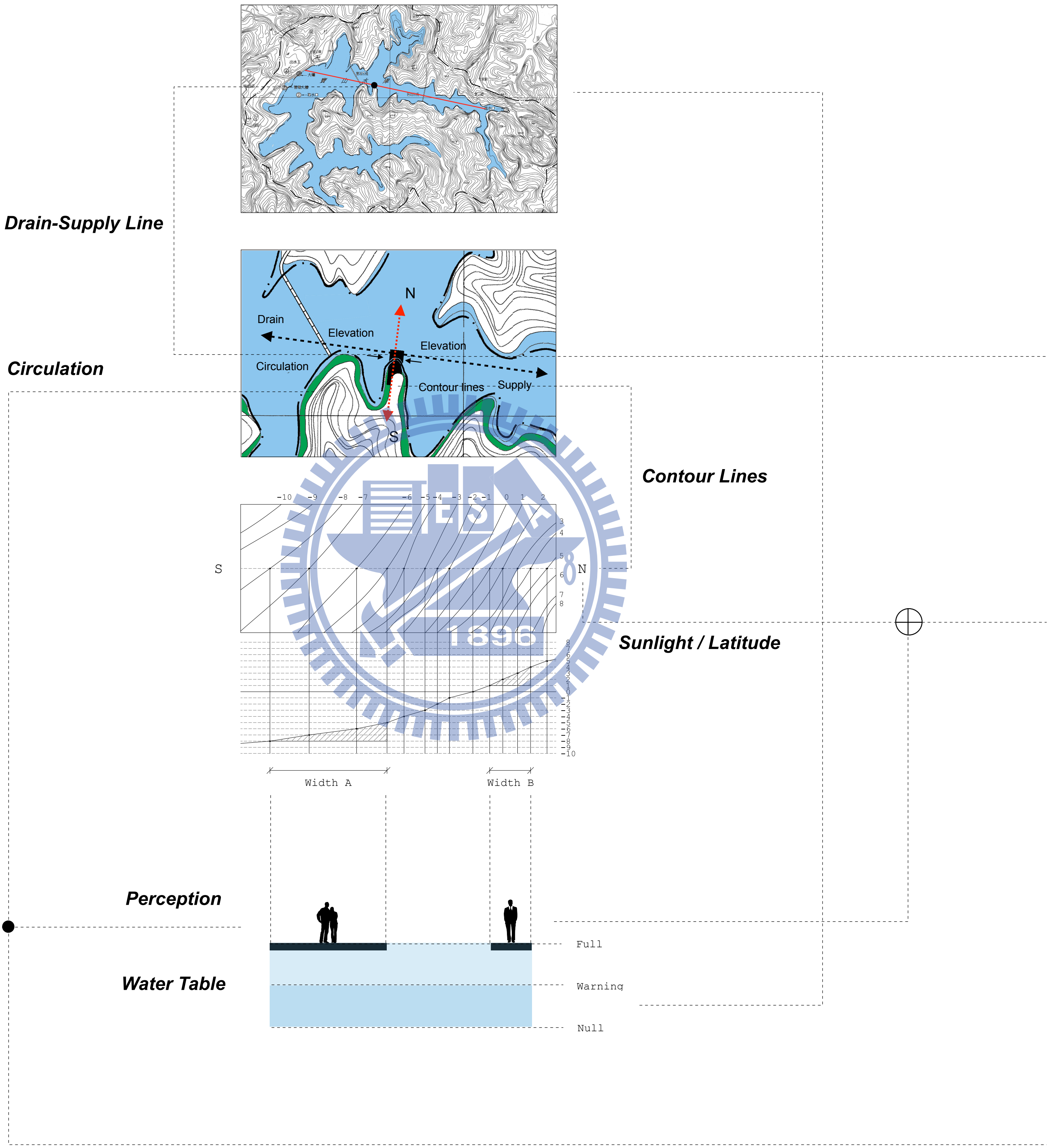
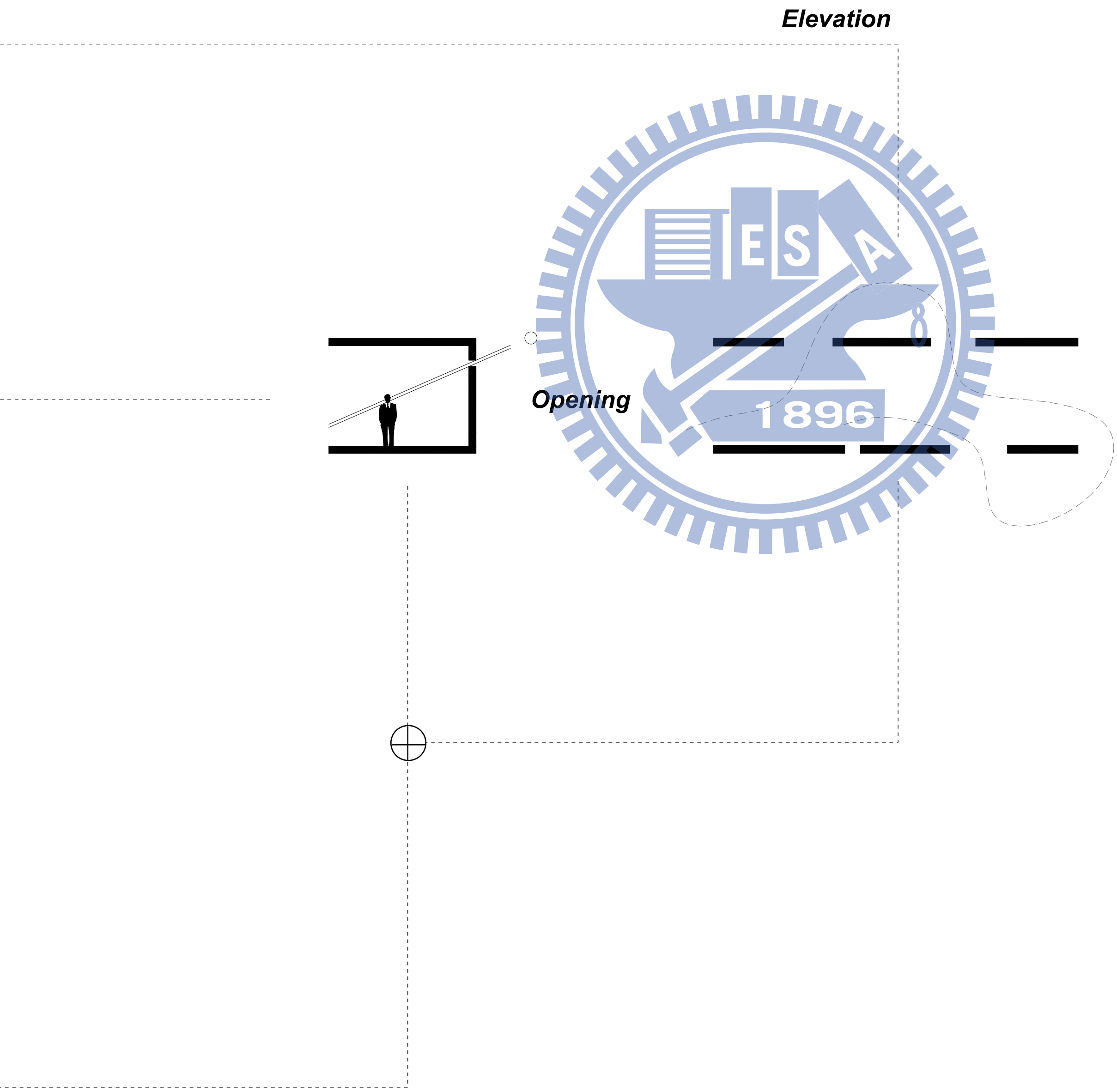


Fig. 45 The Connection of Site Conditions



The site conditions chosen form the multiple dimensions of this design. Fig. 45 shows the connections among the different conditions. Since every condition could influence one another, the harmony among all dimensions is complex. Fig. 46 shows the diagrams of those conditions that are responded in the design. While people are walking in the path of the building, the spacial experience which is from the information of the site can be perceived, as shown in Fig. 46, the series of sections. The successive sections establish a spacial scenario in which people can perceive the information from the site. All the abstract messages from the environment are transformed into the spacial experience and organized within a visiting path. For example, one of the dimensions is the contour lines. By definition, the contour line is the line that is connected by all points at the same altitude. Thus, the slope of the terrain can be transformed into the width, and the width of the path is one of the spacial perceptions. People can barely perceive the slope but can easily feel the width while walking on the path. So, the invisible contour lines are recorded as the width of the paths.

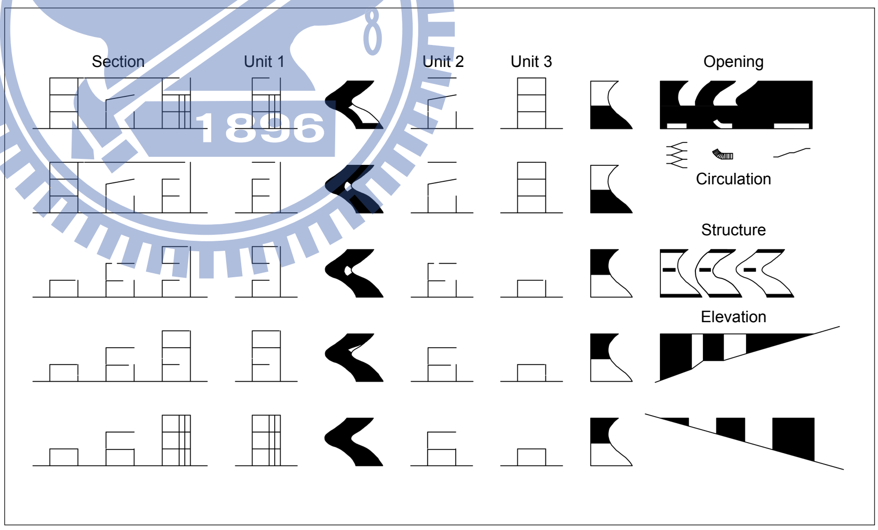


Fig. 45 The Connection of Site Conditions

Fig. 46 The Series of Sections

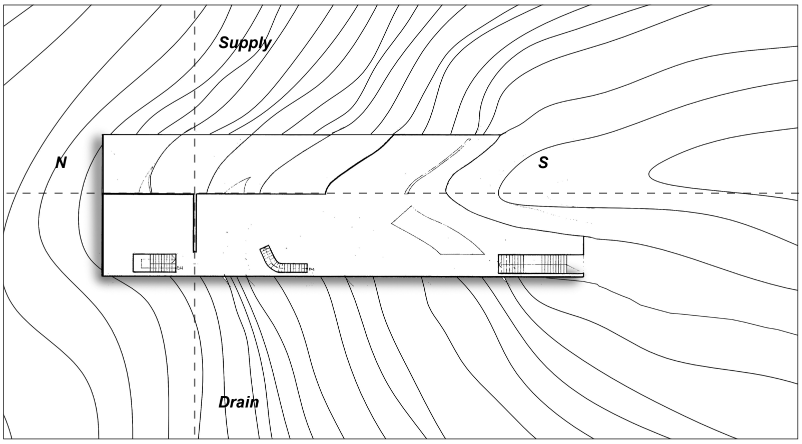


Fig. 47 Roof Plan

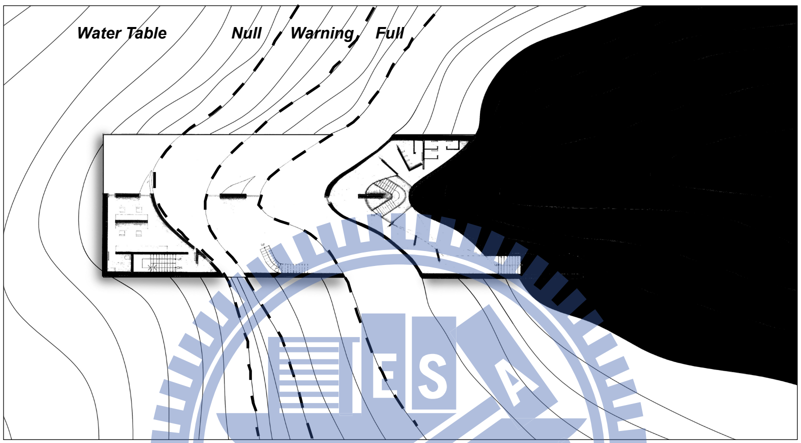


Fig. 48 B1 Plan

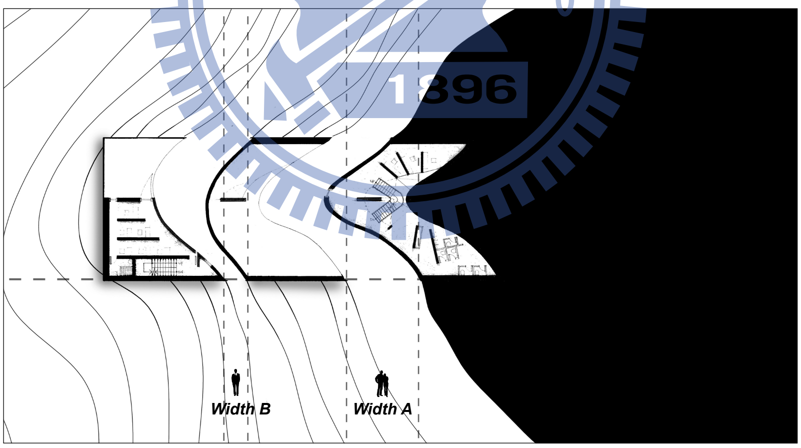


Fig. 49 B2 Plan

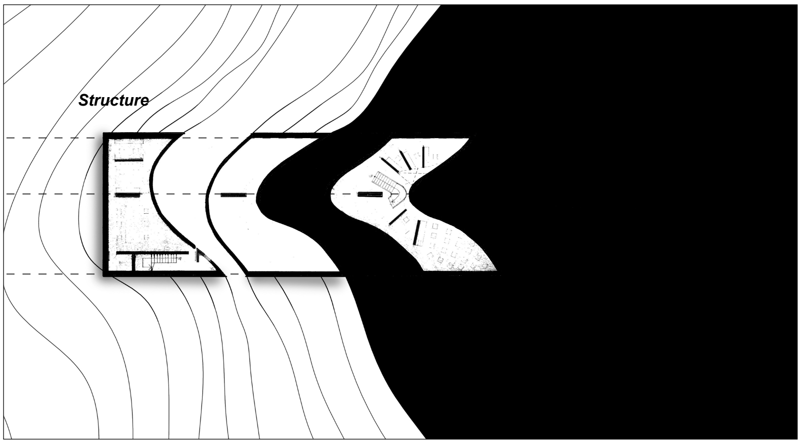


Fig. 50 B3 Plan

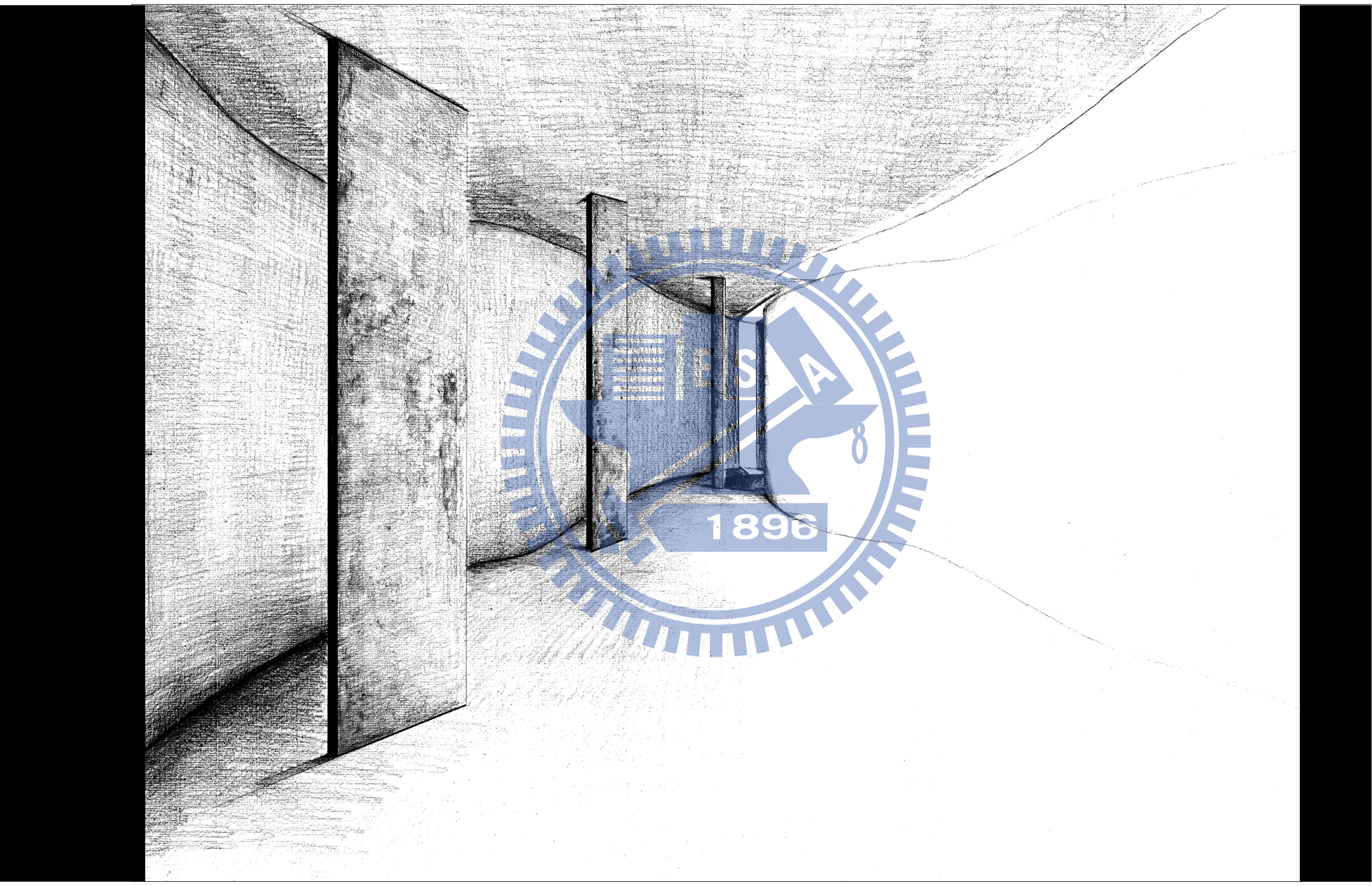


Fig. 51 The Perspective in B1 Level

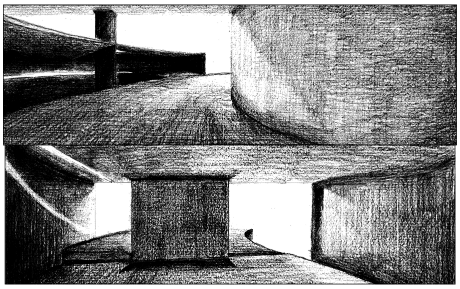


Fig. 52 The Perspective in the Path

IIII

Chapter 4 Set Theory

A classic publication, The Architecture of the City[3], written by Aldo Rossi, puts forward an imagination of the prototype theory. In his book, prototypes are described as the fundamental components of a city, and hence the research of prototypes and typology is undoubtedly a prominent subject when it comes to urbanism. Typology can be defined as a study on a group with the identical properties that resemble a mathematical theory, known as Set theory. In my perspective, Set theory is considered a structure of typology. The essential concept of Set theory can be described as Fig. 53. In fact, any space, for instance a restroom, as shown in Fig. 54, can be described as a set comprising the elements from other sets.

There are three sets (Set C, Set B and Set L) in Fig. 53, each has virtually countless elements with similar properties. For instance, Set C stands for the set of "chairs", which includes all chairs in the world. Although chairs have a huge diversity in appearances, materials, or functionalities, they are all called "chair" and belong to the same set. Meanwhile, Set B is for the set of "books" and Sec L is for the set of "lamps".

Referring to the room in the previous section, that room contains one chair, one book and one lamp. That room can thereby be defined as another set, Set R, having three elements that come from three other sets.

Set C = {C0, C1, C2, … };
Set B = {B0, B1, B2, … };
Set L = {L0, L1, L2, … };
Set R = {Cn, Bn, Ln};

Set C, B and L serve as the prototype sets because these sets collect all elements that have the same properties while Set R as a normal set that contains several elements with different properties. Nonetheless, those elements with different properties may be able to construct a system. There is likely some special relationships among different elements that can connect them to form a system.

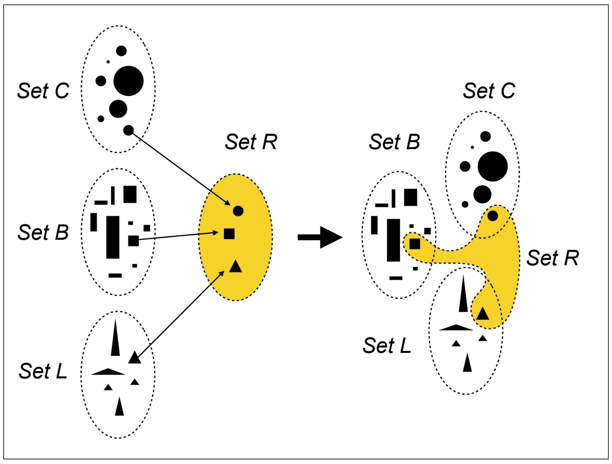


Fig. 53 Set Theory

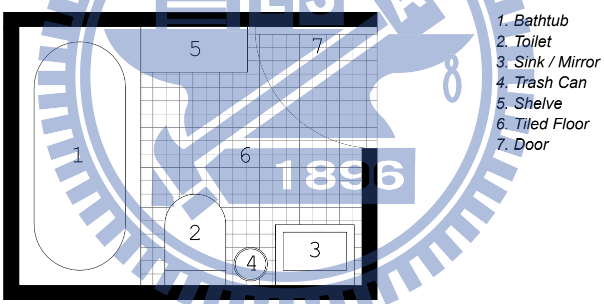


Fig. 54 Set from Other Sets

13 Projection

Now a concept of Set theory called projection, needs to be introduced to further explain the relationship. According to Set theory, one set might be the projection from another, as shown in Fig. 55.

Here is an example to describe the projection. Assume that Set B is a set of "churches", which is the projection of Set A. And assume that Set A is the set of the demands of churches. In the beginning, the church is simply a place for christians to worship God, but as people' s demands are increasing, now the church may function related to wedding, tourism, historical research or filming themes. The set of demands thus projects the set of churches. If the demands vanish, the churches will no longer exist. In other words, this relationship can be regarded as a demand-supply.

The concepts above conform to the rules and principles of Set theory. According to Set theory, it is assumed that there is a "basis" in each set which is the fundament to constitute the set. All elements in the set are generated by its basis. Moreover, the basis represents the main feature of a set. Fig. 56 shows a simplified diagram of Set theory.

Based on Set theory, there are two approaches to derive the basis from a set:

1. Get a spanning set for the vector space, then reduce this set to a basis.

2. Build a maximal linearly independent set, adding one vector at a time.

These two approaches are used in mathematics; here, the same concept is adopted to find out the basis of a set. Eventually, the basis may be derived from both the projection set and the original set. Otherwise, another approach named "induction" can also be used to find out the basis. The technical details will not be discussed in this thesis; however, they will be briefly explained in Appendix A. Fig. 57 shows the complete structure of Set theory, and Fig. 58 shows the concept of a basis.

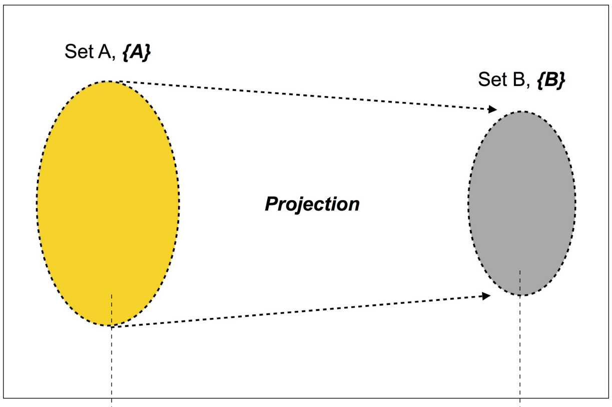


Fig. 55 Projection

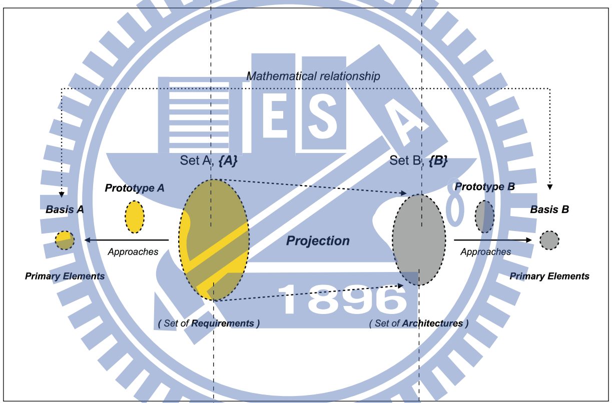


Fig. 56 Prototypes of Sets

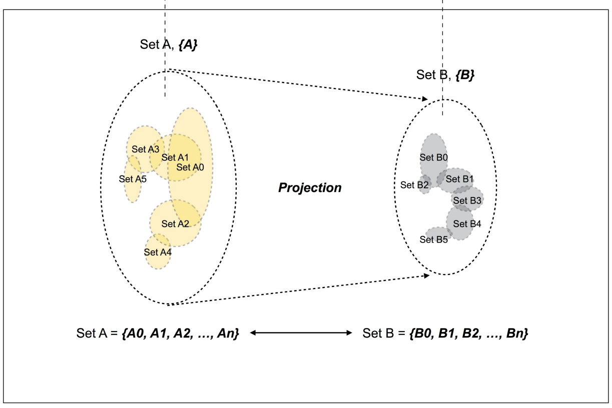


Fig. 57 Requirement Set & Architecture Set

As time changes, a set will not constantly be the same because variations in a set frequently occur. Factors such as the shift of cultures, human behaviors, environments, and even the climate can trigger changes of a set. Besides, the elements in a set may disappear or be replaced with a new one. For instance, the programs within a building may be erased and reprogrammed. Referring to the theory, once changes are made in a set, the according changes may be found in its projection set. In other words, if the demand set changes, the supply set changes, too. However, changes on the basis are more critical than those on the normal components because the basis is the essential element, and the variations on the basis will lead to drastic reshaping of a set. Fig. 59 and Fig. 60 show the transformation of a set and its projection set. In Fig. 59, Set B varies along with time, which later causes its demand set to change as well.

Furthermore, one set can be described as “tag cloud” when an element of which may simultaneously belong to two or more sets. On the other hand, this kind of elements can be tagged with various properties. For instance, in Fig. 61, an element is pasted with a “chair set” tag and a “room set” tag.

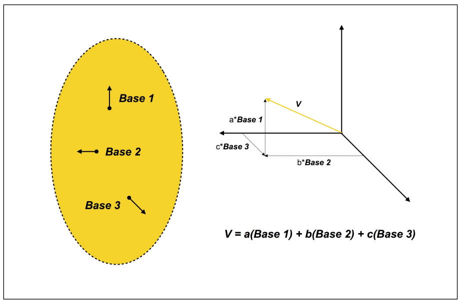


Fig. 58 Basis of Sets

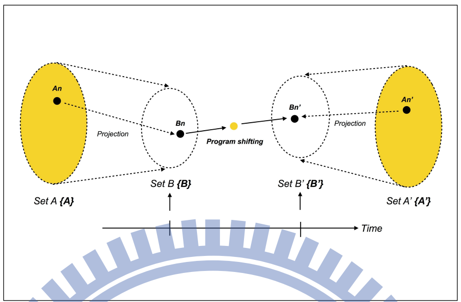


Fig. 59 Shifting of Sets

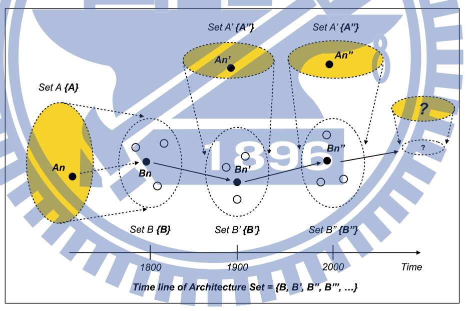
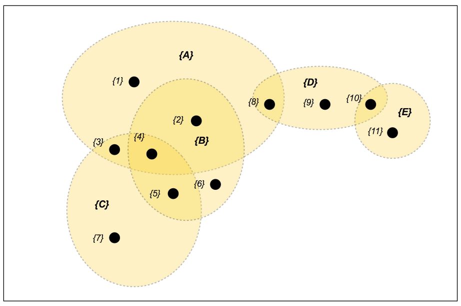


Fig. 60 Time line of Sets



{1} => {A} ;
{2} => {A}, {B} ;
{3} => {A}, {C} ;
{4} => {A}, {B}, {C} ;
{5} => {B}, {C} ;
{6} => {B} ;
{7} => {C} ;
{8} => {A}, {D} ;
{9} => {D} ;
{10} => {D}, {E} ;
{11} => {E} ;

Fig. 61 Tag Cloud Representation

Project: Light of the City

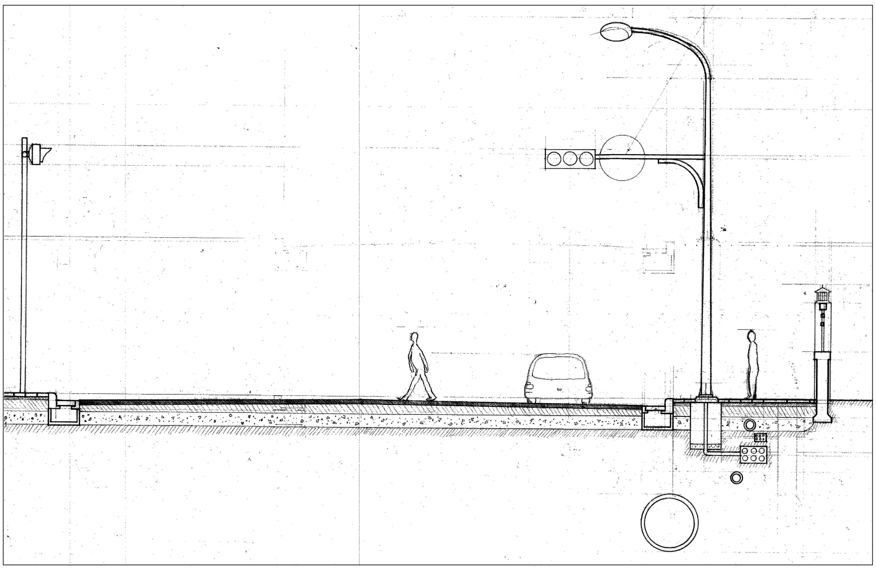
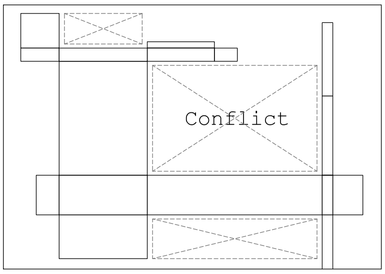


Fig. 62 City objects

The conflict between old systems and current systems can be easily found in Taipei city. As colonized by Portugal, Spain, Japan and the KMT government at different periods, Taiwan has a complicated history. As as result, a variety of systems coexist in Taiwan. This disparity appears not only in the physical aspect but also in the cultural and mental aspects. Hence, there are a lot of gaps such as the invalid space in this site, and those gaps are the best evidence that supports the multi-cultural life in Taiwan. This design is aimed to display the differentiation between the old Japanese system and modern system. Conflicts could exist between any two systems without well-arrangement, and thus cause a lot of wastes. To demonstrate the conflicts among different systems, an algorithm is introduced as depicted in the below figure:



1. One rectangle should be placed one time.
2. The rectangle placed should be next to the existing rectangles with 2mm width gap.
3. The length of rectangles' sides should be equal to the adjacent one.

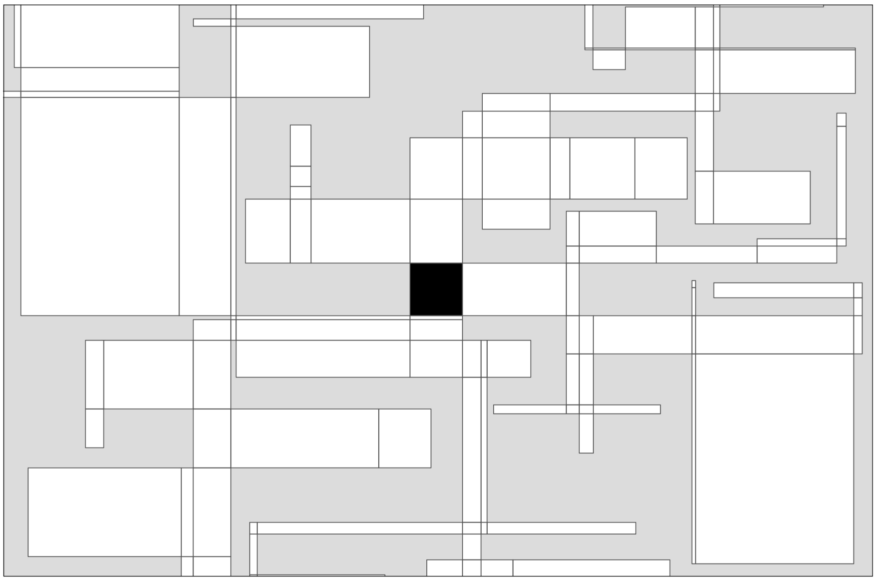


Fig. 63 Conflicts Generating Algorithm

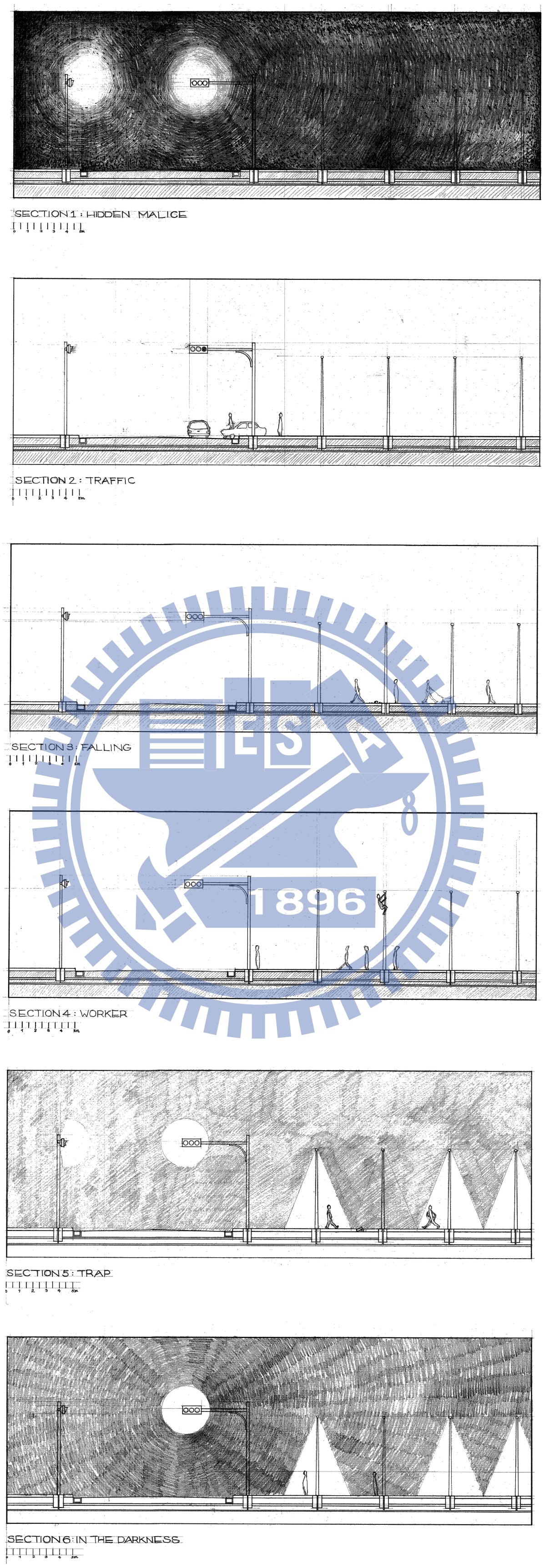
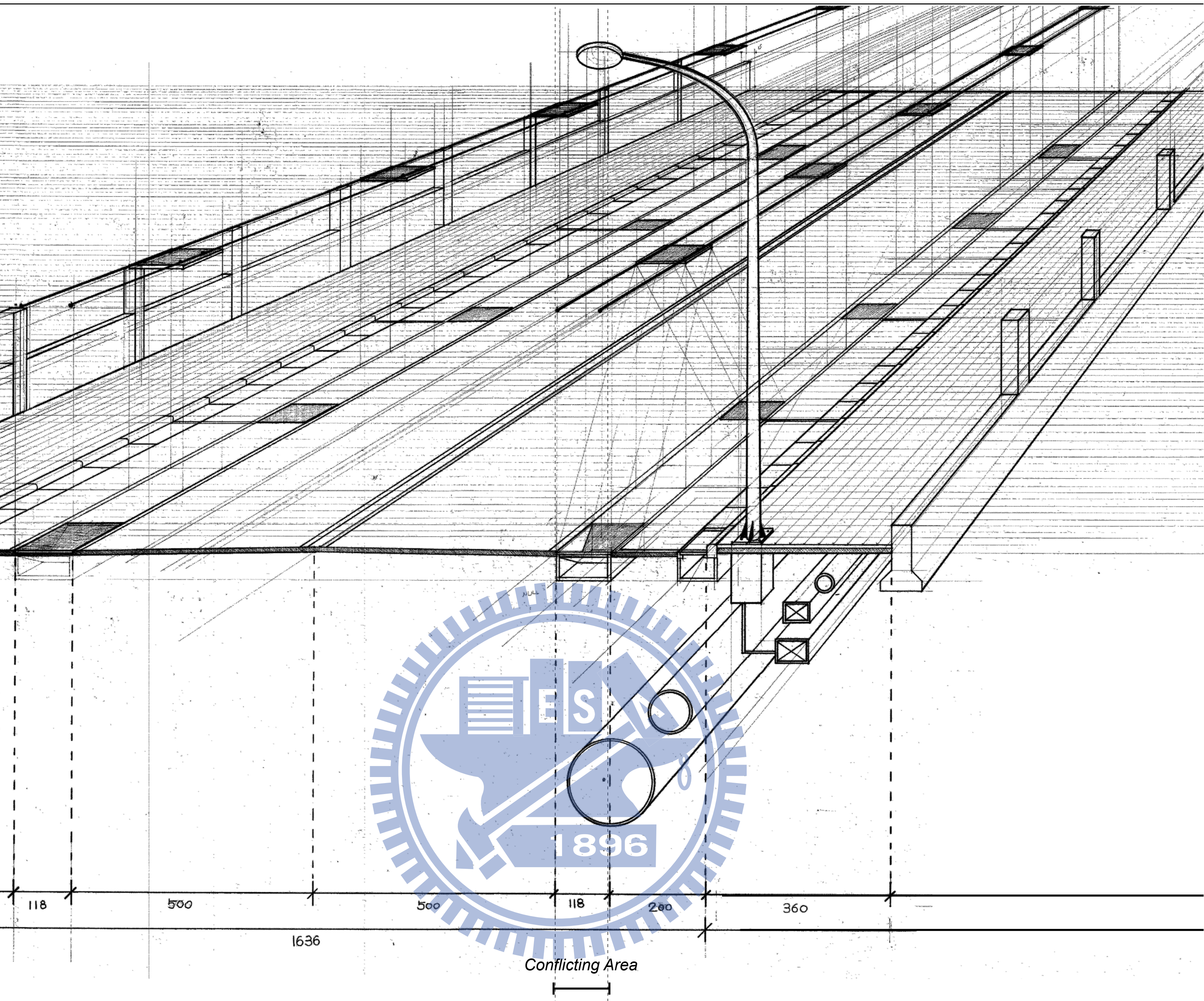
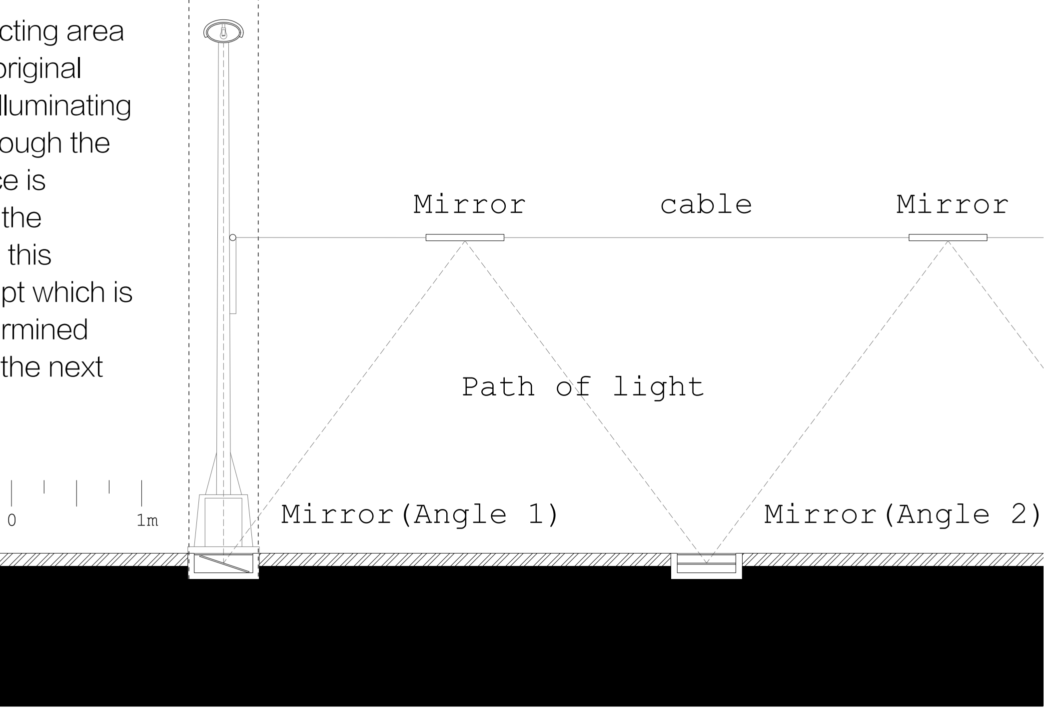


Fig. 64 City Objects Conflicts



The mirrors are installed in the conflicting area reflecting the light which is from the original street lamps instead of adding new illuminating systems. The light can only pass through the empty space, so the conflicting space is highlighted by this way. Additionally, the original street lamps are shared with this design. Hence, a consequent concept which is named "sharing component" determined from this design will be discussed in the next section.



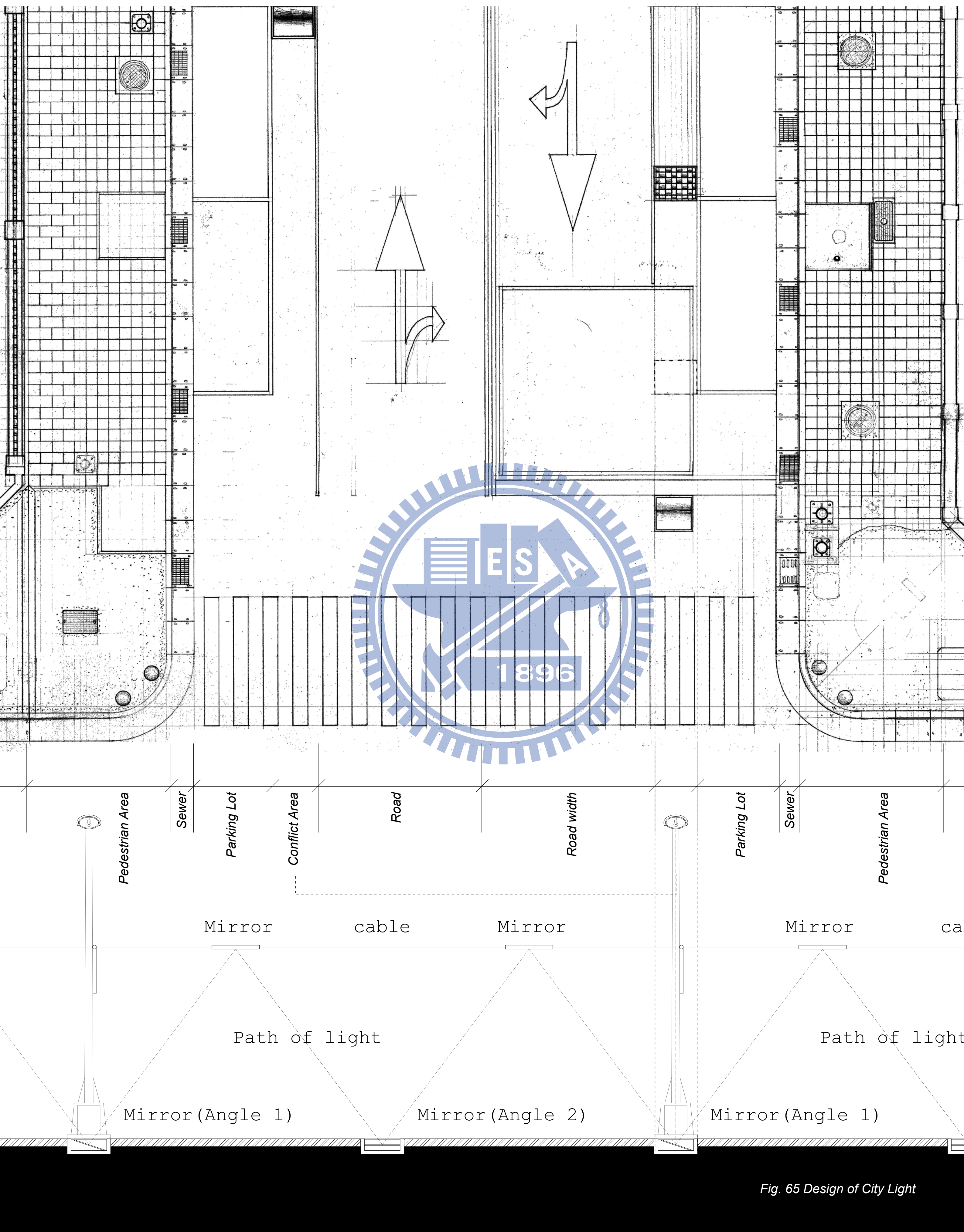


Fig. 65 Design of City Light

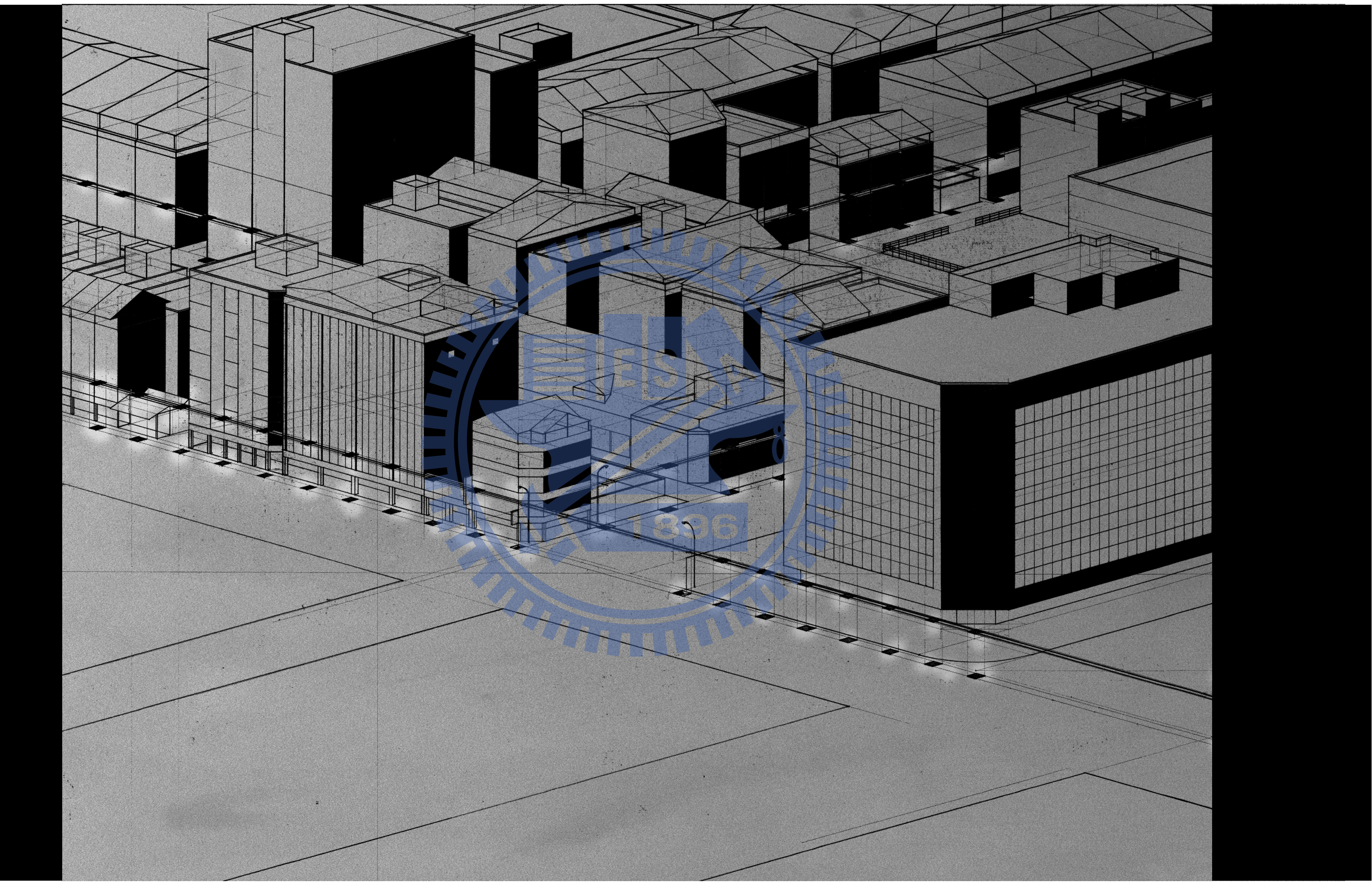


Fig. 66 Light of City

Project: Wall(s)

The program of this project is to design a wall around a historical building which was built during the period of Japanese colonial rule. By definition, a wall is to define a space. With the purpose of establishing an area for citizens to hold activities, the area should be soundproofing but accessible. Therefore, the whole area is separated into several zones, and each zone is defined by placing objects on its four sides. For example, zone 4 is defined by the 4 different objects as shown in Fig. 67. The zone defined can offer the citizens a place to hold concert without bothering neighborhoods. According to the requirements, each placed object should be capable of reducing the sound. Moreover, the way to place objects is determined by the simulation of the sound paths as shown in Fig. 69. Instead of adding a new object, the street objects are “shared” to form a wall; meanwhile, these objects are used for different functions or programs. To be brief, there is not a new wall but those street objects are shared to achieve the function of a wall. The objects shared are described in Fig. 68.

In order to achieve the soundproofing function, the surface is designed to be able to absorb the sound. The membrane with numerous small holes can prevent the sound from reflecting. Once the sound get into the holes, they can hardly escape from the membrane; therefore the wall can reduce the intension of sound reflection.

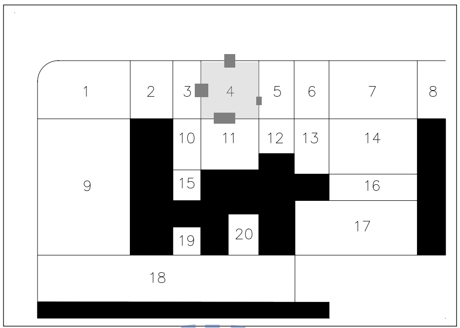
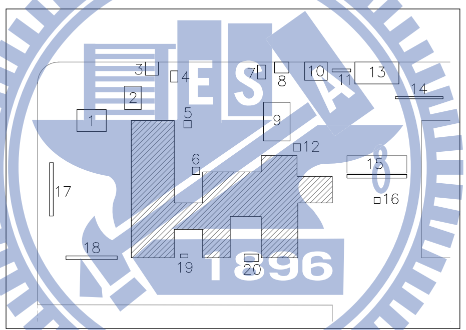


Fig. 67 Zone Defined by Objects



1. Projector Room
2. Ware House
3. Security Guard
4. ATM
5. Light
6. Trash Can / Ash Tray
7. Information / Ticket
8. Pay Phone
9. Cafe'
10. Toilet
11. Bus Stop
12. Light
13. Bus Station
14. Sign Board / Map
15. Stage
16. Projector
17. Screen
18. Screen
19. Ash Tray
20. Trash Collector

Fig. 68 Street Objects

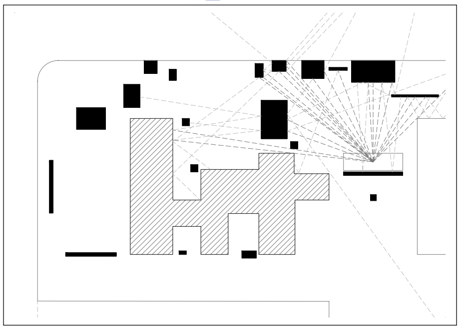


Fig. 69 Soundproofing Wall

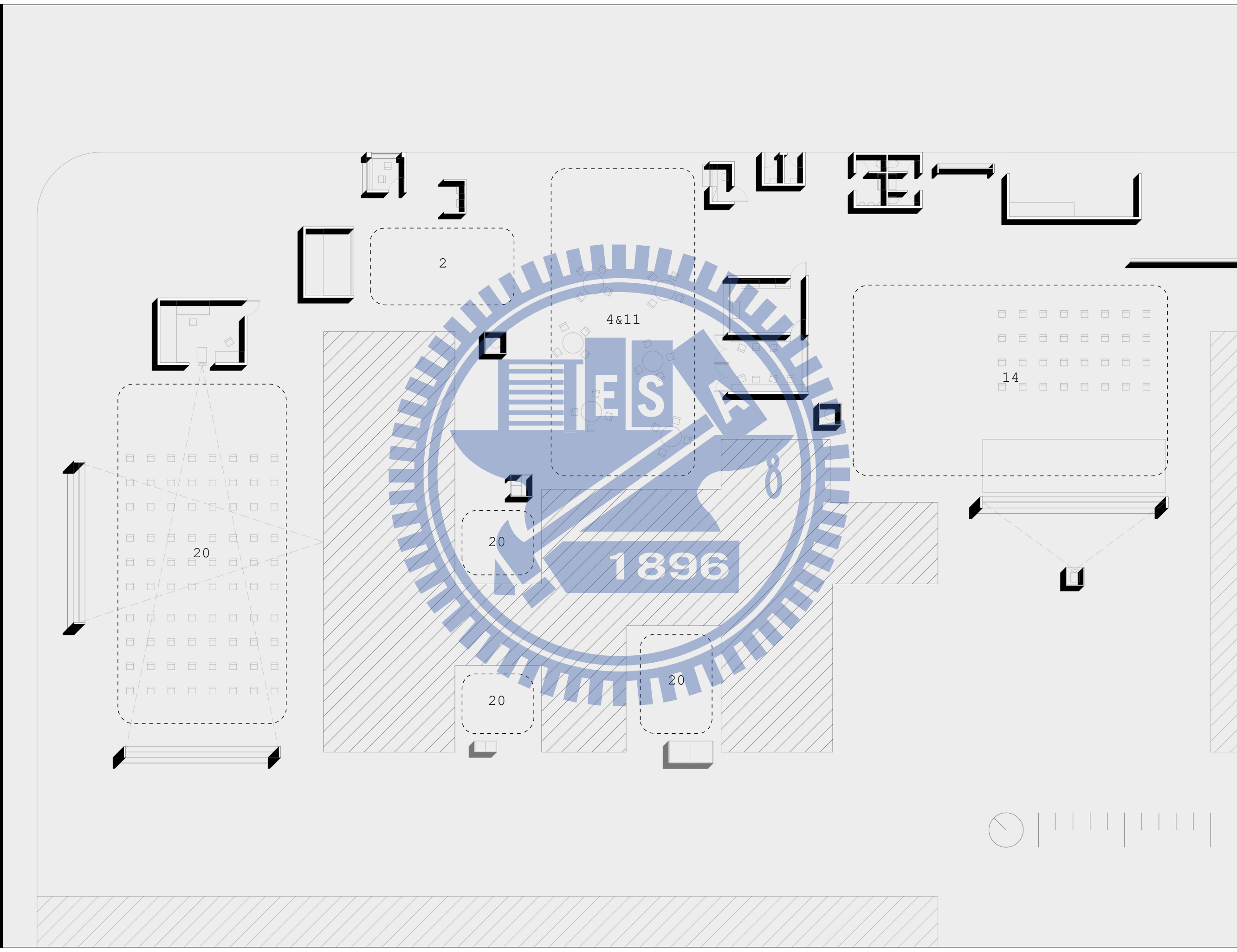


Fig. 70 The Wall of Objects

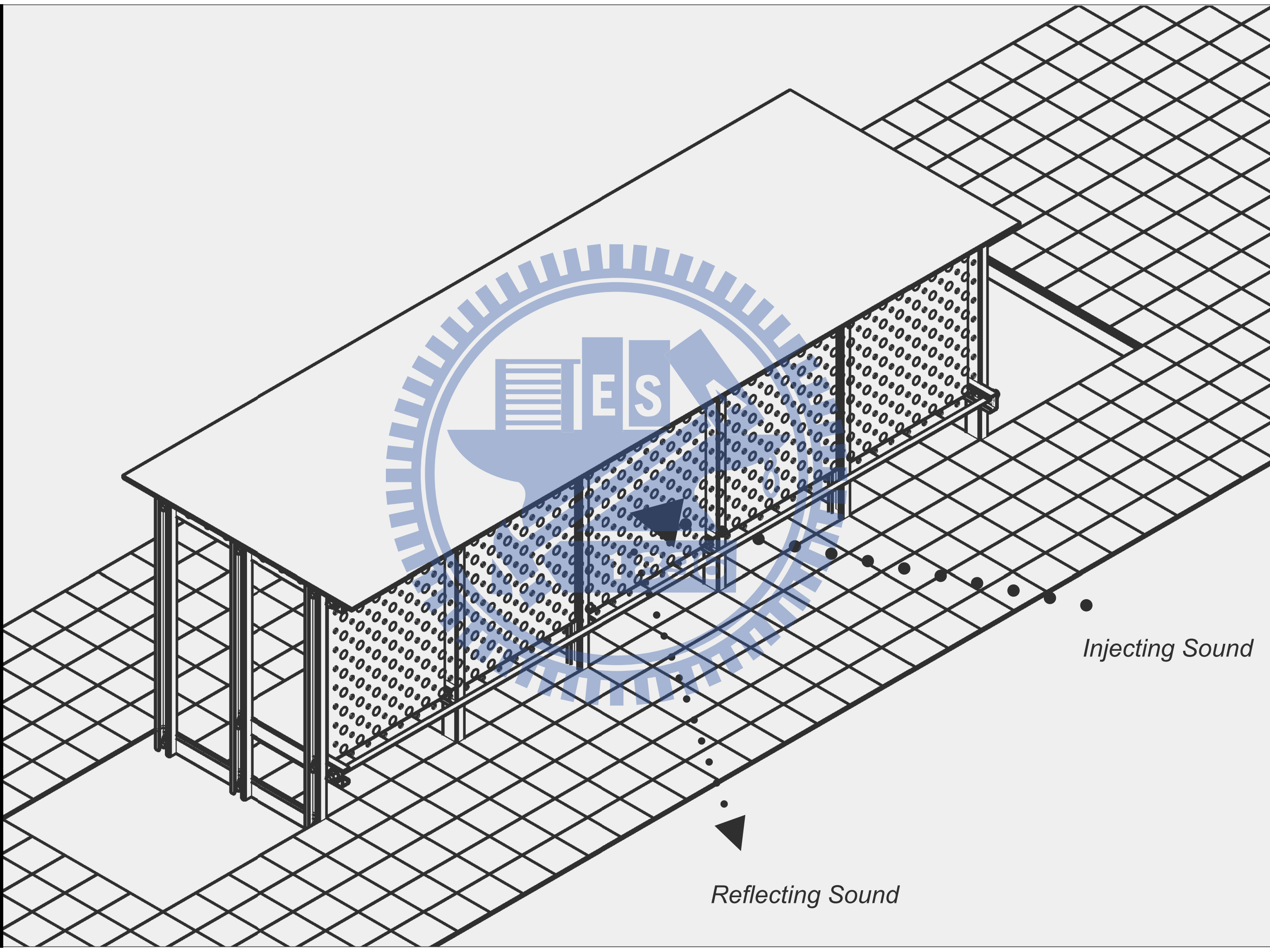


Fig. 71 The Bus Station

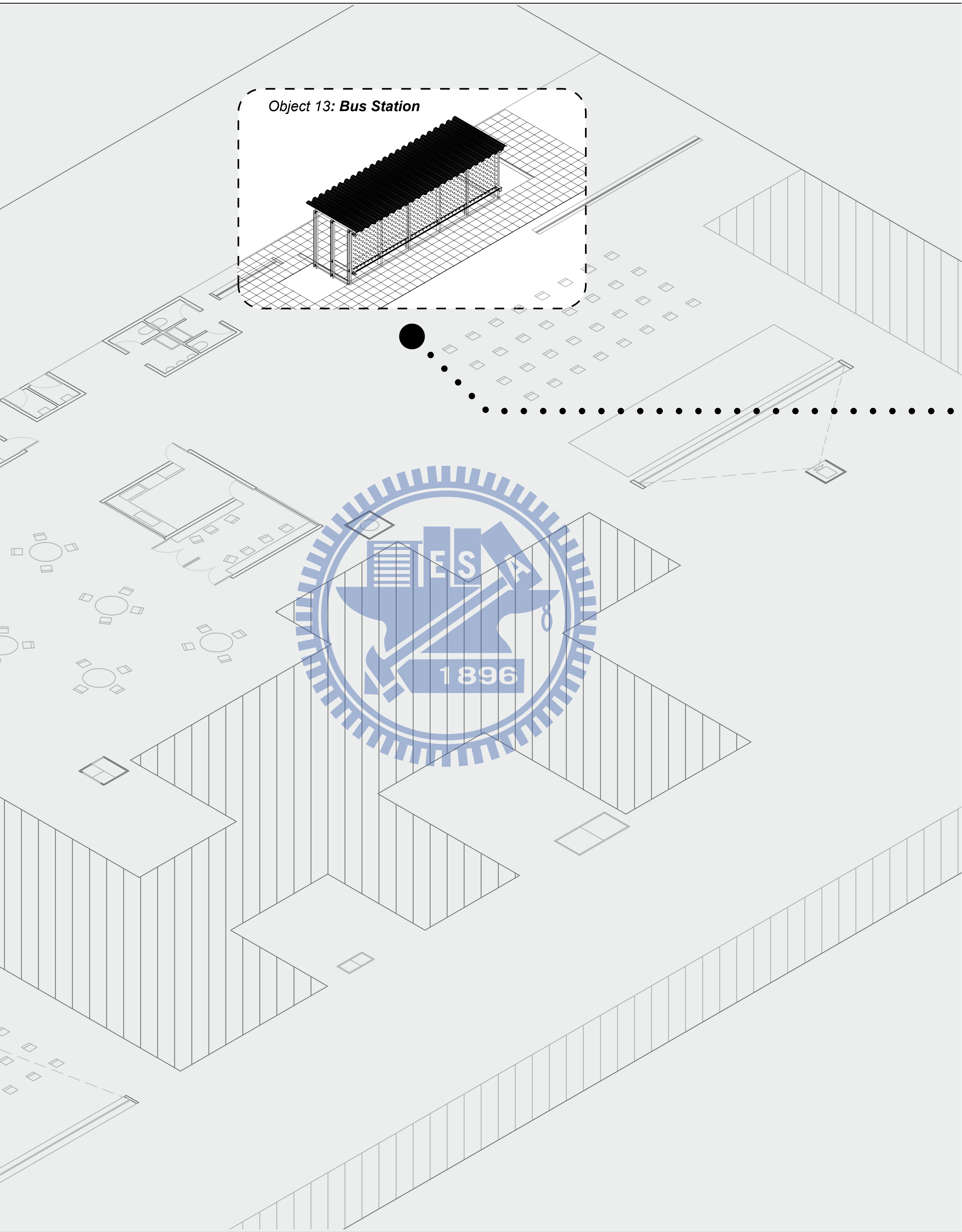
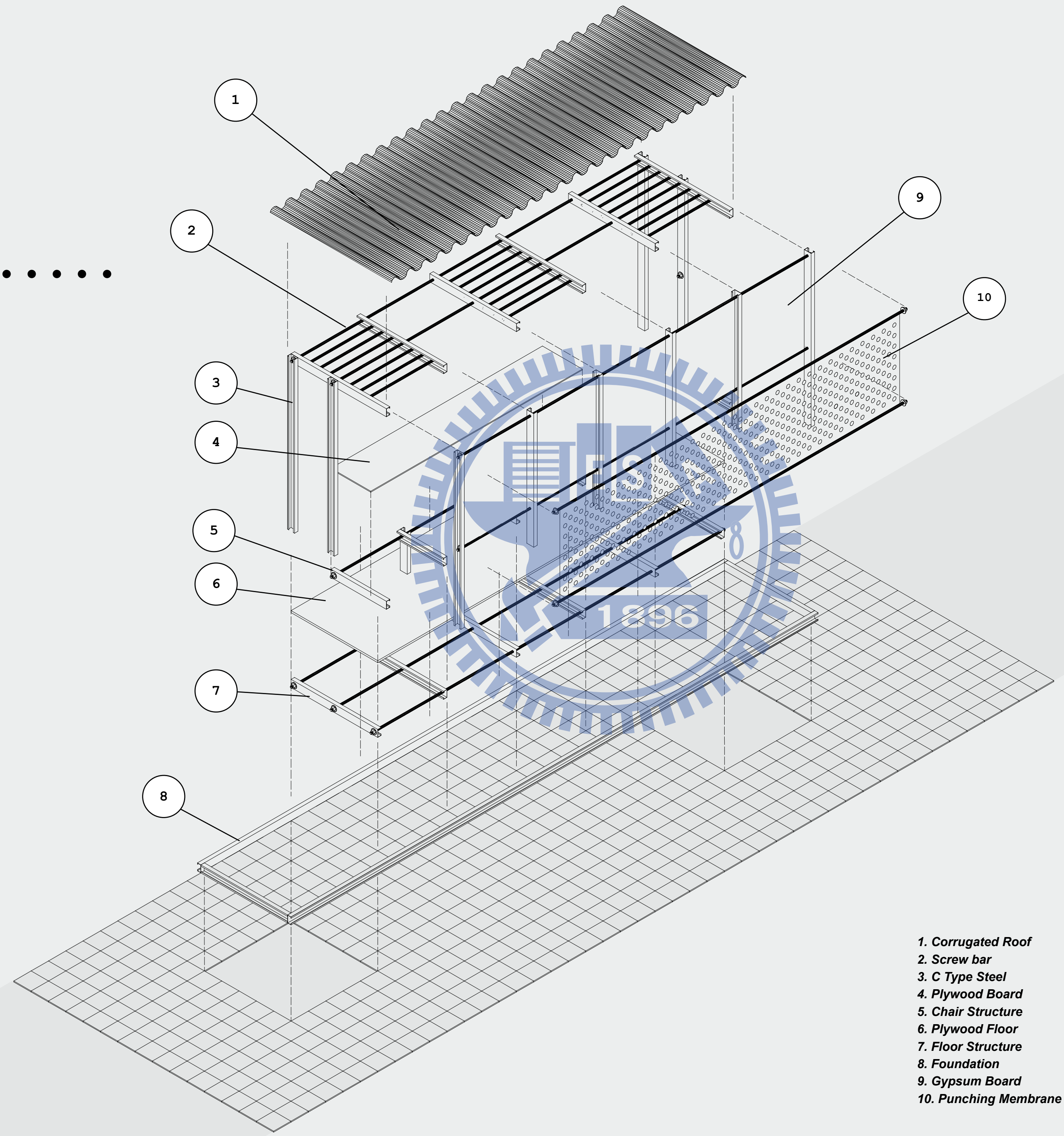

Object 13: **Bus Station**

Fig. 72 The detail of Bus Station



1. Corrugated Roof
2. Screw bar
3. C Type Steel
4. Plywood Board
5. Chair Structure
6. Plywood Floor
7. Floor Structure
8. Foundation
9. Gypsum Board
10. Punching Membrane

Project: City Gallery

1. Sport Field A
2. Auditorium
3. Sport Field B
4. Entry Square
5. Historical Building
6. Media Square
7. Garden (Forum)
8. Gallery A
9. Cafe
10. Garden (Cafe)
11. Gallery B
12. Citizen Square
13. Tree Garden
14. Gallery C / Office
15. Toilet
16. Toilet
17. Bus Stop

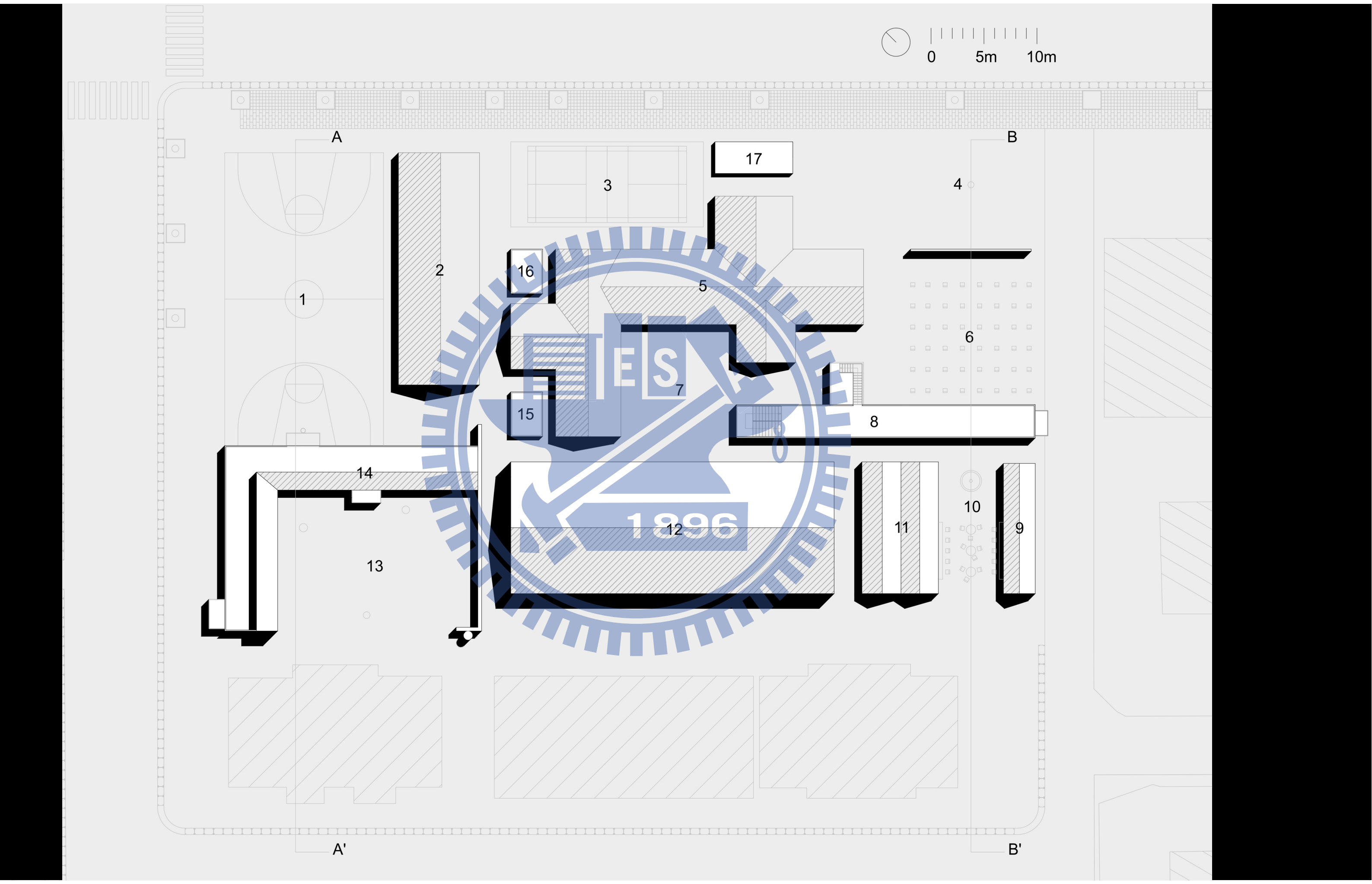
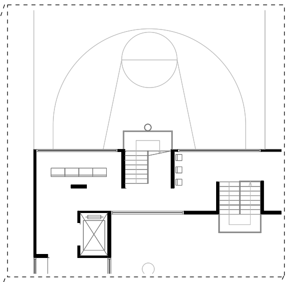


Fig. 73 Roof Plan



The handrail of the stairs is also the basketball board. It means that the handrail can be the sharing component between basketball field and the stairs.

1. Gallery
2. Lounge Room / Audience Seats
3. Gallery
4. Gallery
5. Projector

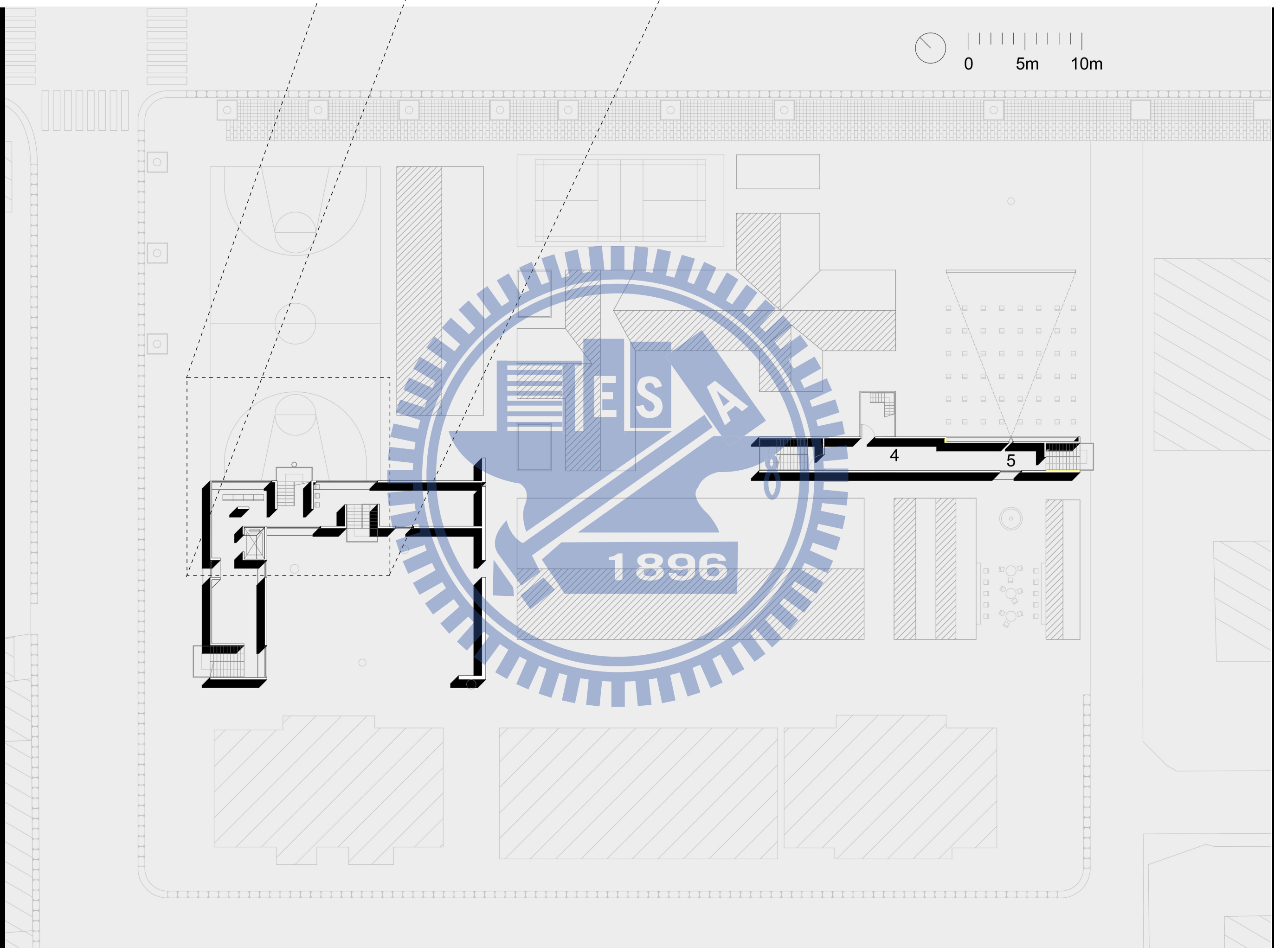


Fig. 74 3rd Level Plan

1. Gallery
2. Lounge Room / Audience Seats
3. Reception / Audience Seats
4. Office

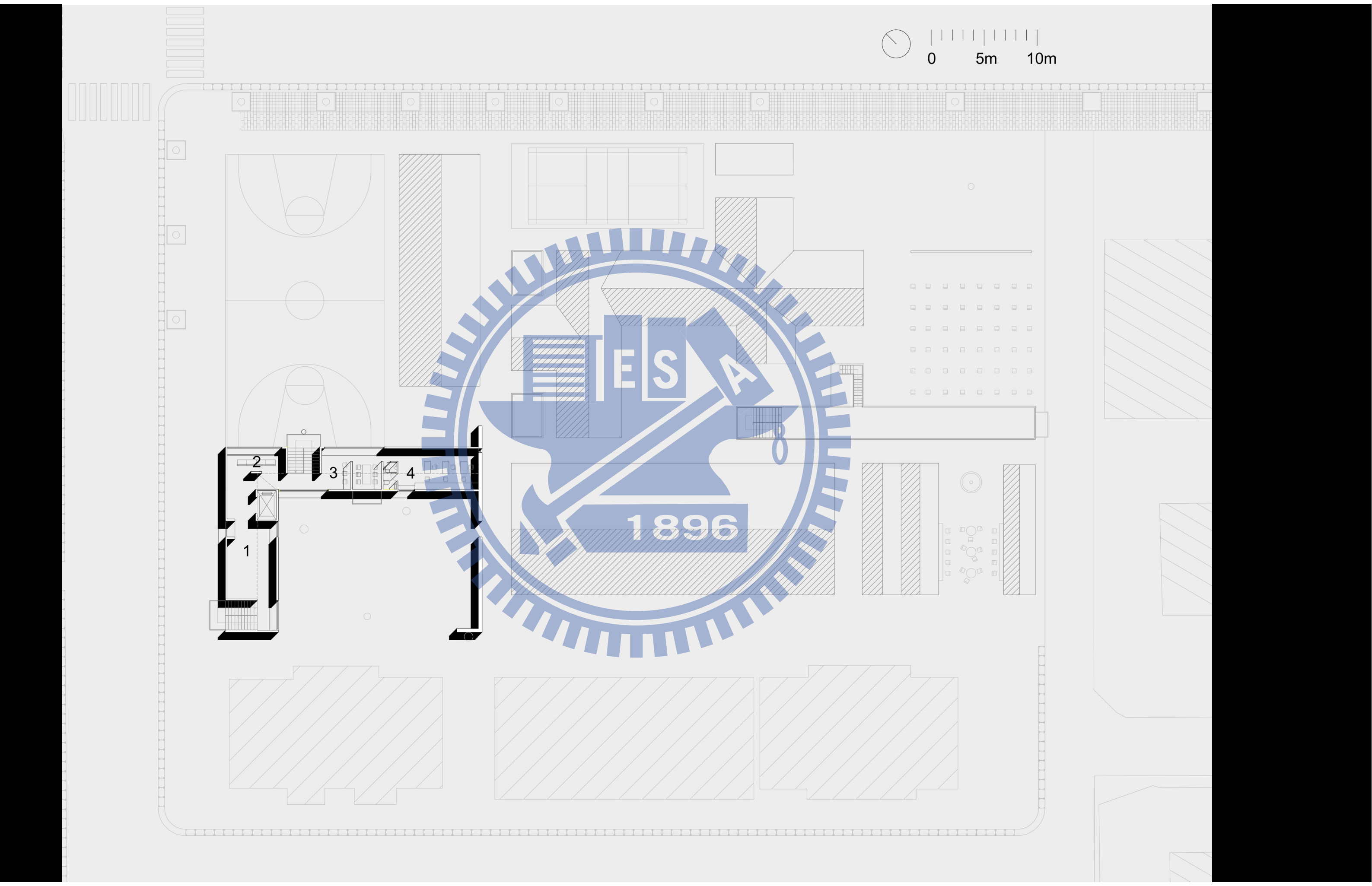


Fig. 75 2nd Level Plan

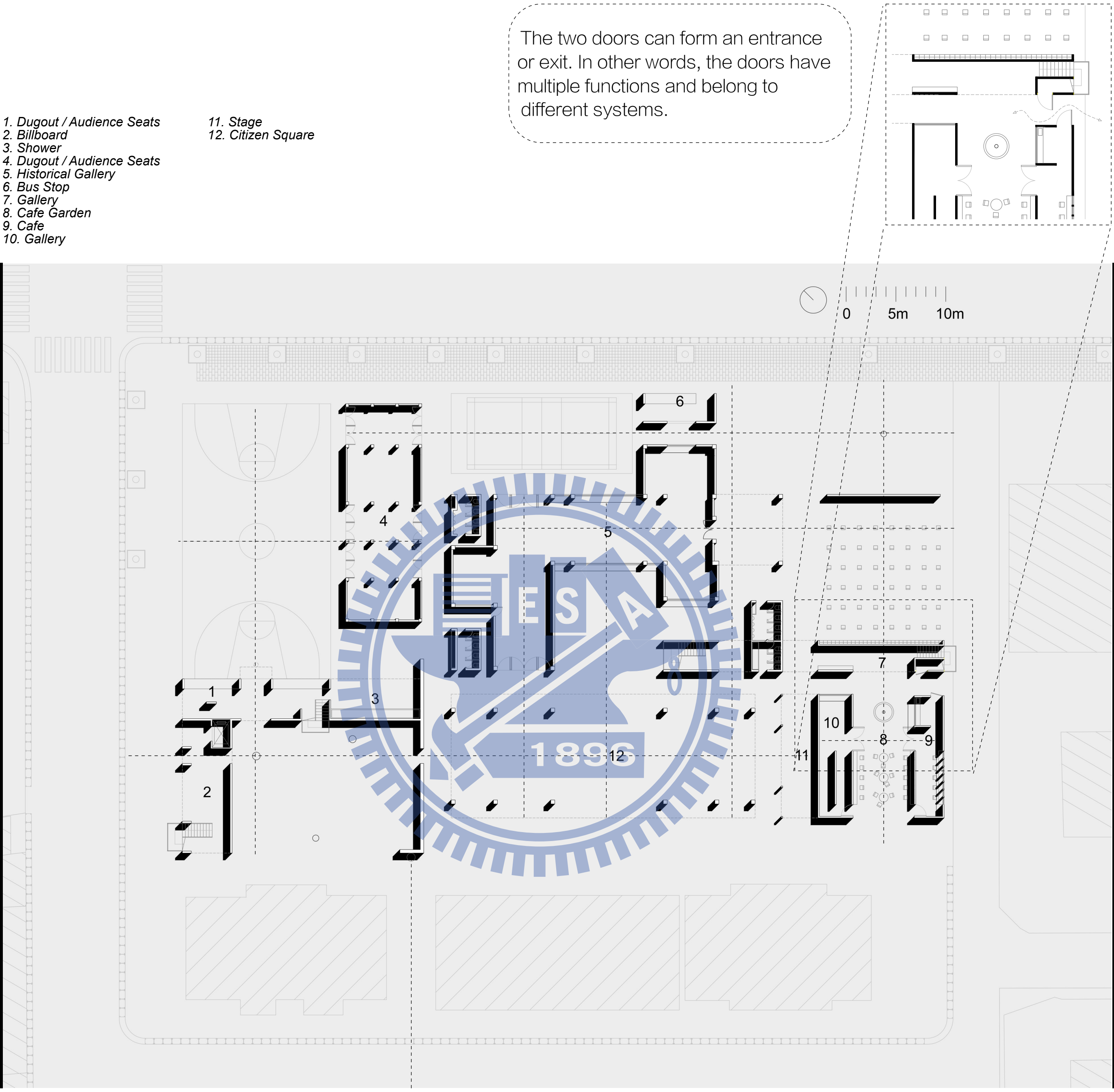
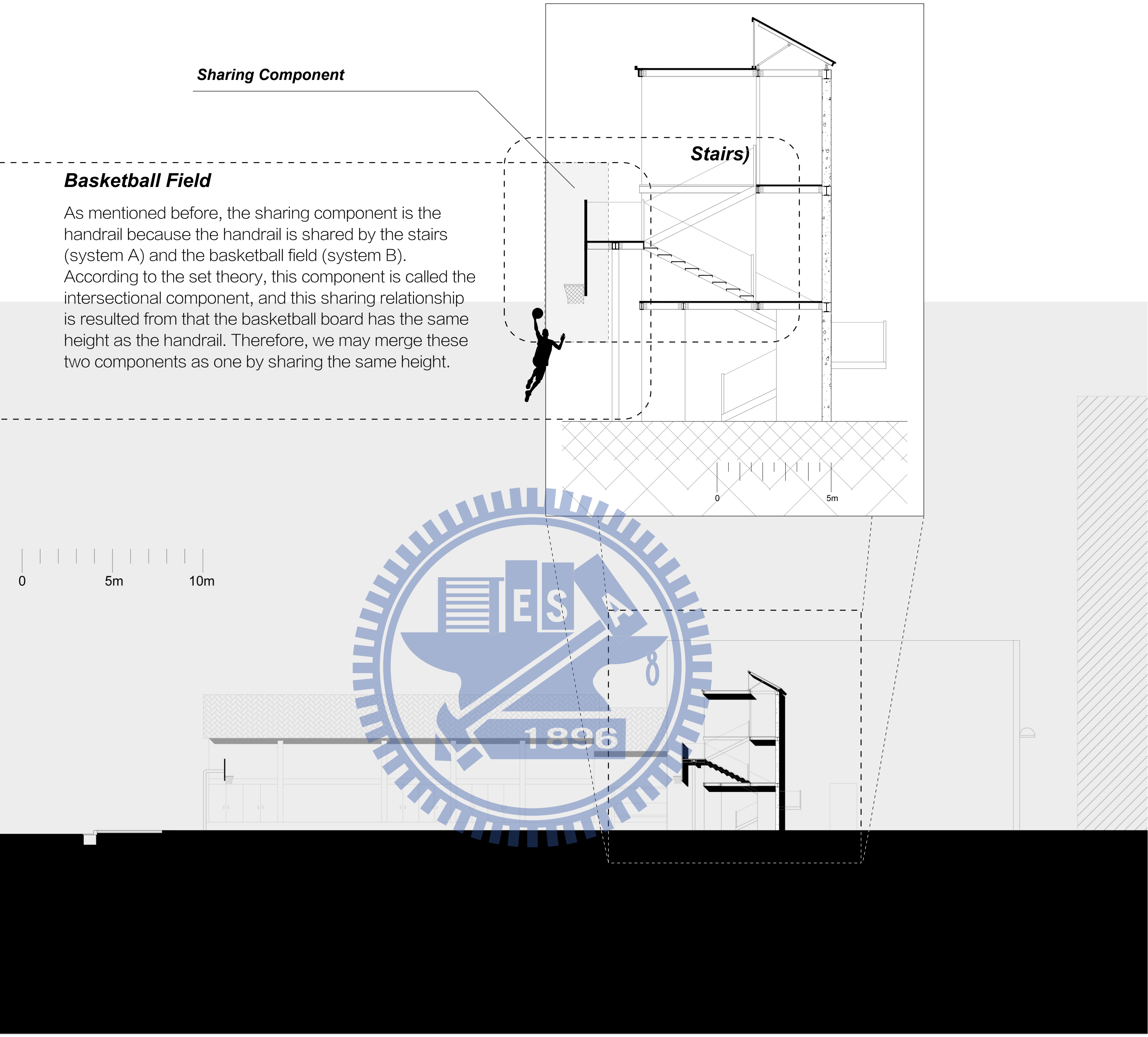


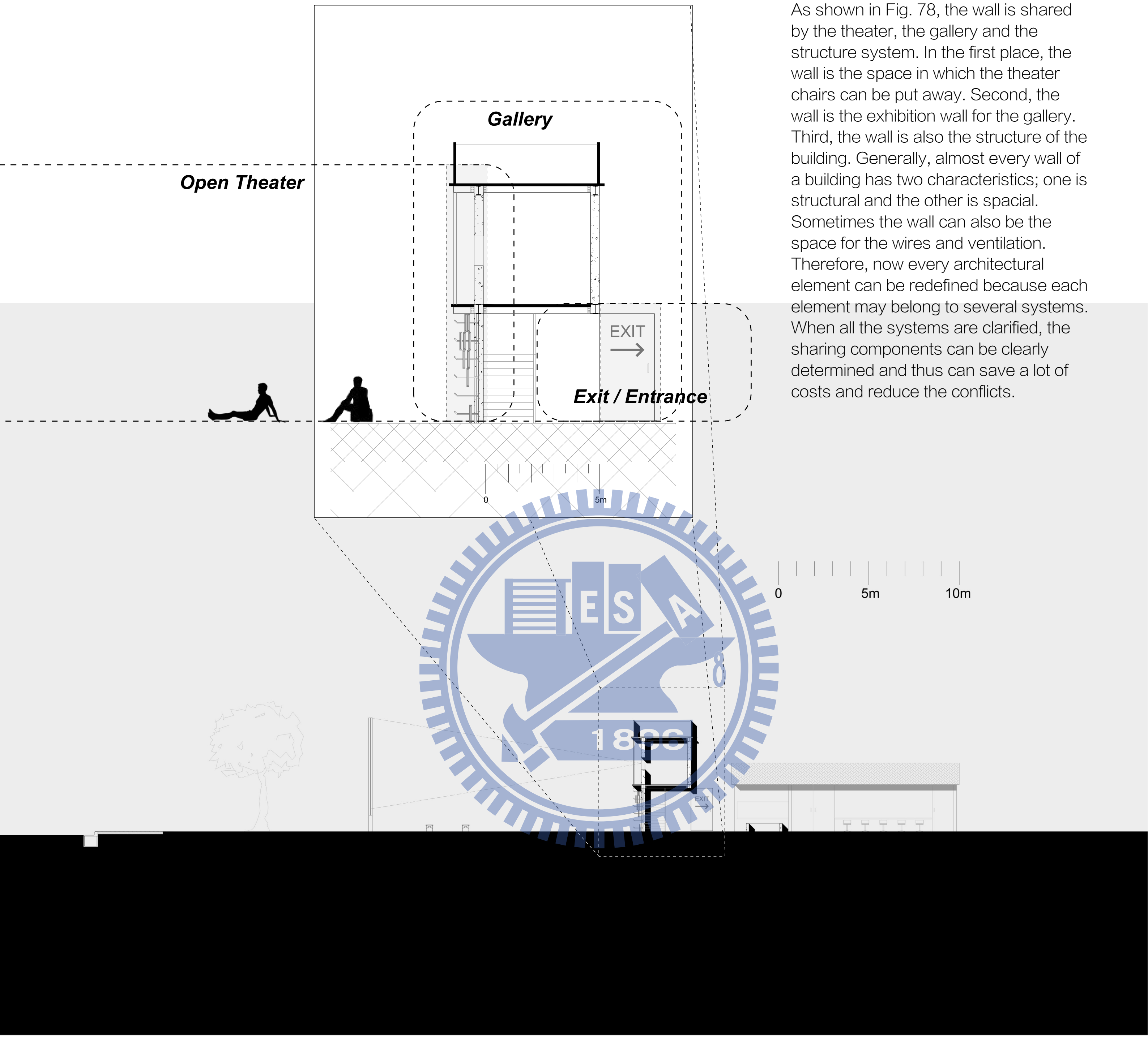
Fig. 76 Ground Level Plan



Basketball Field

As mentioned before, the sharing component is the handrail because the handrail is shared by the stairs (system A) and the basketball field (system B). According to the set theory, this component is called the intersectional component, and this sharing relationship is resulted from that the basketball board has the same height as the handrail. Therefore, we may merge these two components as one by sharing the same height.

Fig. 77 AA' Section



As shown in Fig. 78, the wall is shared by the theater, the gallery and the structure system. In the first place, the wall is the space in which the theater chairs can be put away. Second, the wall is the exhibition wall for the gallery. Third, the wall is also the structure of the building. Generally, almost every wall of a building has two characteristics; one is structural and the other is spacial. Sometimes the wall can also be the space for the wires and ventilation. Therefore, now every architectural element can be redefined because each element may belong to several systems. When all the systems are clarified, the sharing components can be clearly determined and thus can save a lot of costs and reduce the conflicts.

Fig. 78 BB' Section

IIIII

Chapter 5 Conclusion

The link between systems and Set theory may be the "demands" as mentioned in the previous section. In the room example, the book and the lamp form a system because they have the same property from the same demand — light.

Therefore, we can extract the common properties from devices belonging to the same system. The common properties reflect the same demand set, and, moreover, the elements of this demand set can be used to explain the formation of the system. On the other hand, we may use the elements of the demand set to analyze the system structure. Fig. 79 illustrates the architecture by using Set theory and the system analysis.

In this thesis, I intend to make an induction of a mathematical, objective and analyzable structure for architecture designs. The design theory must be constructed on a solid ground in a visible, touchable and feasible manner. In the nineteenth century, there was a similar situation in calculus. Before Cantor had proposed the infinity theory, the calculus was in a fragile condition. Even though the concept of calculus was intrinsically correct, no one could affirm that the calculus was safe to use. The whole science was established on an unproved hypothesis until Cantor originated the infinity theory. Considering that, a concrete theory must be built for architecture designs as soon as possible, otherwise we may get lost in the future.

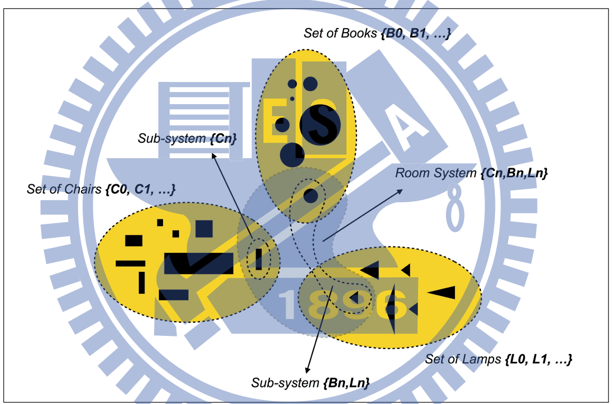
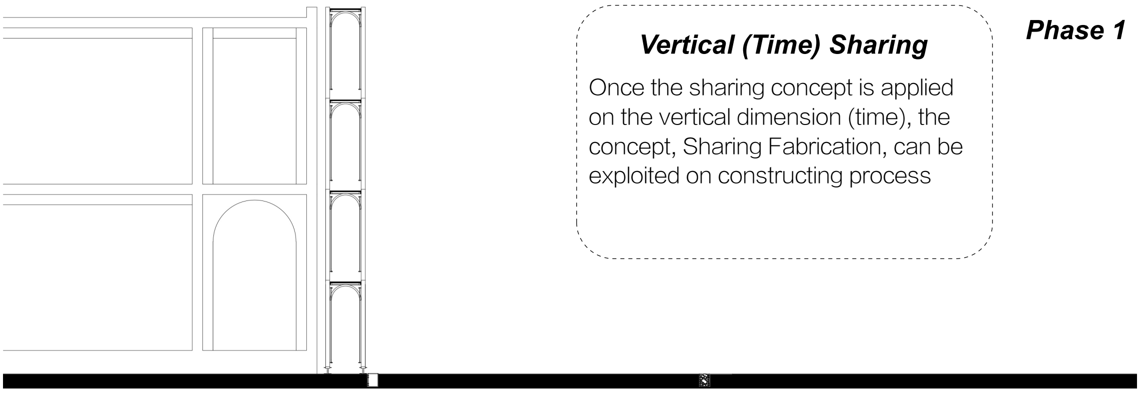


Fig. 79 System and Set Structure

Phase 1

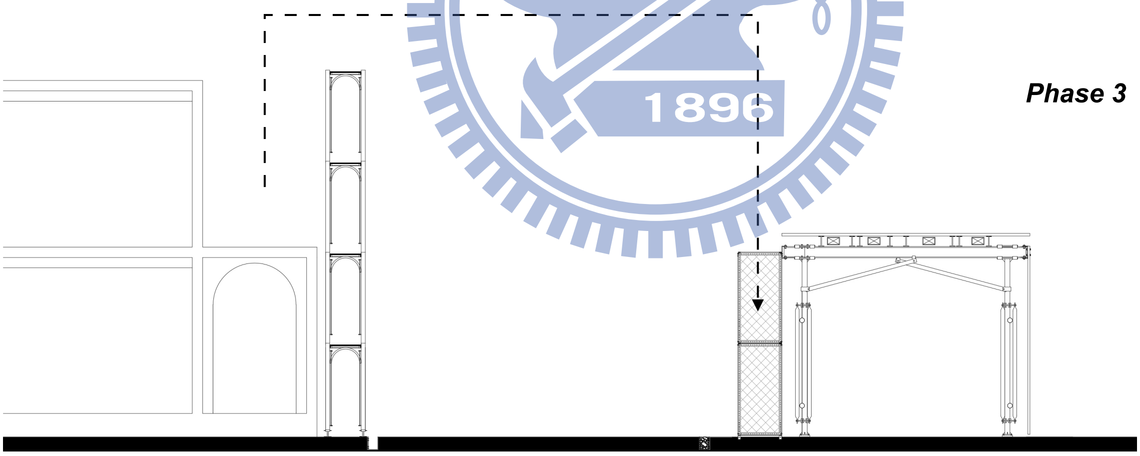
Vertical (Time) Sharing

Once the sharing concept is applied on the vertical dimension (time), the concept, Sharing Fabrication, can be exploited on constructing process

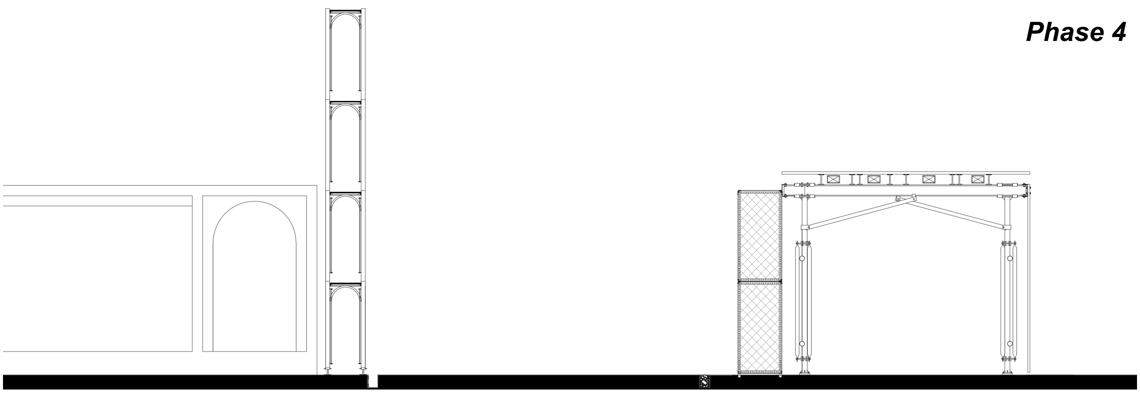


Phase 2

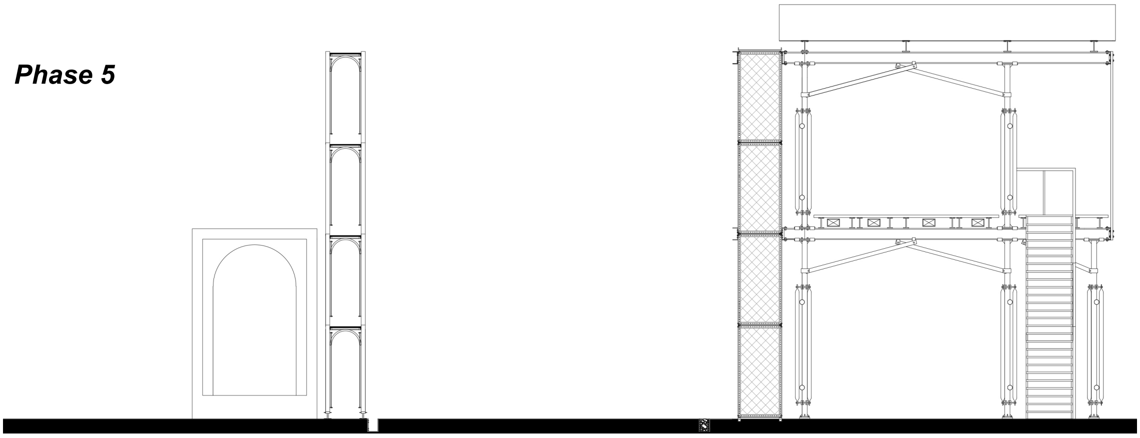
Phase 3



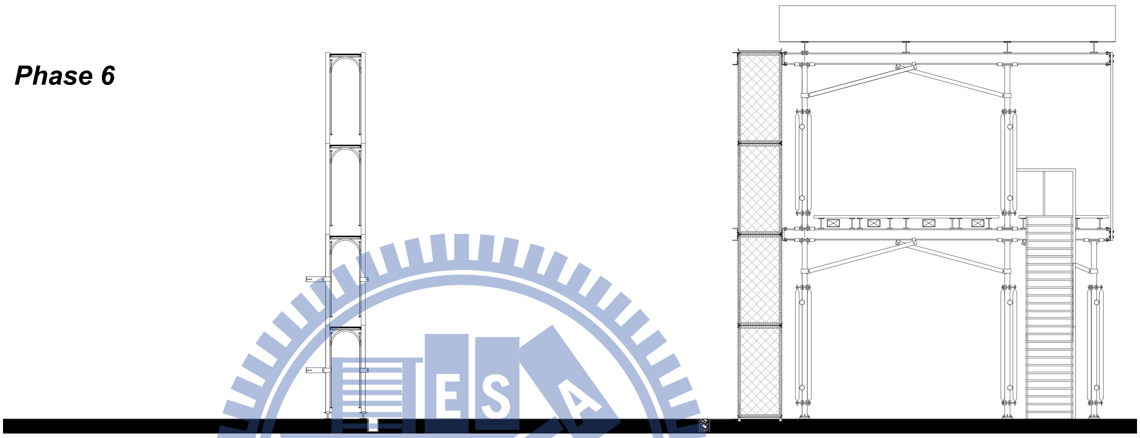
Phase 4



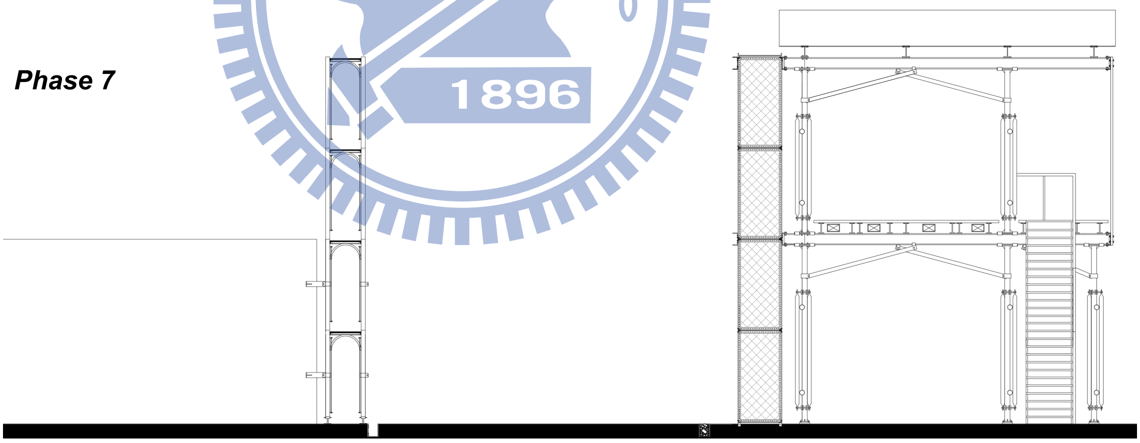
Phase 5



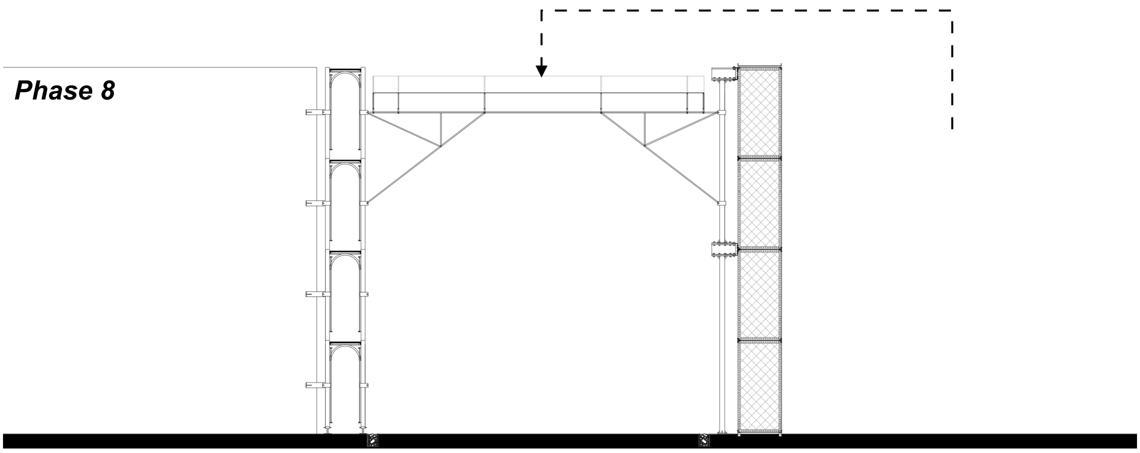
Phase 6



Phase 7



Phase 8



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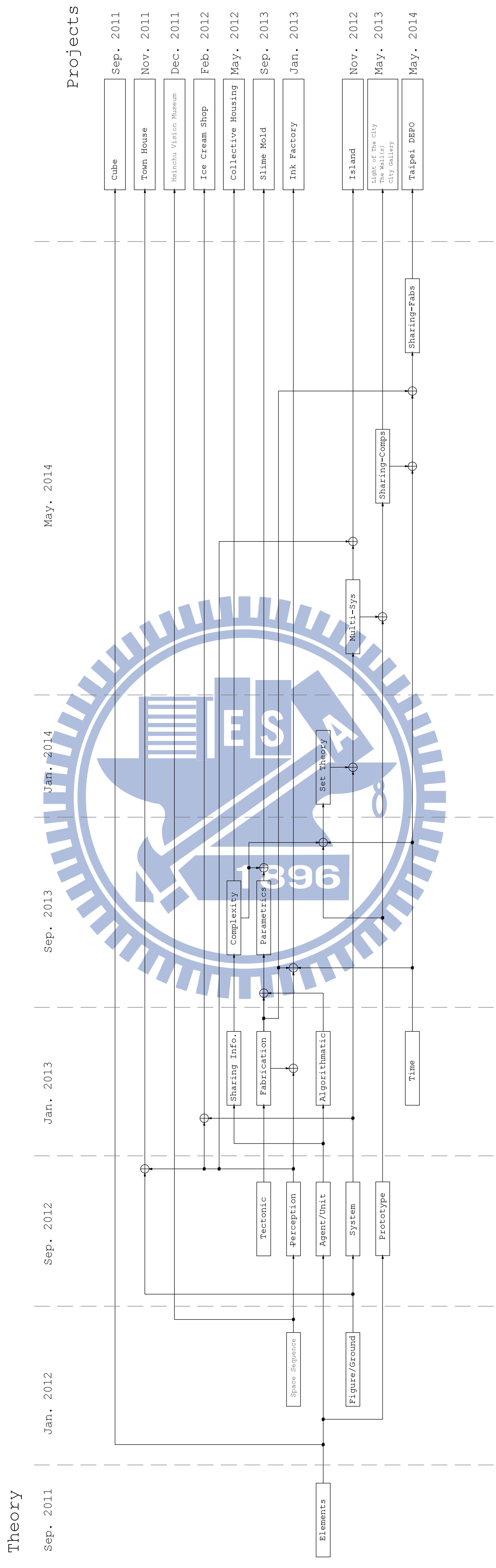
Projects
Sep. 2011
Cube
Nov. 2011
Town House
Dec. 2011
Hsinchu Vision Museum
Feb. 2012
Ice Cream Shop
May. 2012
Collective Housing
Sep. 2013
Slime Mold
Jan. 2013
Ink Factory
Nov. 2012
Island
May. 2013
Light of The City
The Wall(s)
City Gallery
May. 2014
Taipei DEPO
Theory
Sep. 2011
Jan. 2012
Sep. 2012
Jan. 2013
Sep. 2013
Jan. 2014
May. 2014
Elements
Space Sequence
Figure/Ground
Tectonic
Perception
Agent/Unit
System
Prototype
Sharing Info.
Fabrication
Algorithmatic
Time
Complexity
Parametrics
Set Theory
Multi-Sys
Sharing-Comps
Sharing-Fabs