A NEW SPACE TYPE FOR MULTI-STORY HOUSING:
A support design with sectional variations

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ABSTRACT

The focus of this study is the variety of space height in a
dwelling unit of multi-story housing. This thesis introduces a
new space type, named as 'stepped-level' type. The idea of
stepped-level type came from the fact that a dwelling is
normally composed of two bays. The multi-story housing of the
stepped-level type can have spaces of different heights in a
unit of the dwellings. The floor heights of the stepped-level
type can be chosen by the designers without any design
constraints. I propose a method to design with this type and
give some support designs as an example.

The role & place of this 'space type' in architectural design
process is discussed in Chapter 3. The charateristics of this
type are revealed by comparing two relative groups of space
types in Chapter 4. The way of making the stepped-level type
and its tools are described in Chapter 5. Support designs of
stepped-level are illustrated in Chapter 6.

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I want to thank my God and all the people who helped me make this thesis.

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I - 1 MOTIVATIONS AND OBJECTIVES

In the process of modernization, the living environment has experienced dynamic changes of built form. This process is directly related to the point in time in which economic development produced modernization. Some countries, called developed countries, already started to go through this change a century ago; developing countries are in the midst of the experience in this century.

One of the most common distinguishable features of this transformation in built form is the introduction of many multi-story housing developments in urban areas in order to accommodate a rapidly increasing number of people who moved from rural areas. The economic way of sharing the modern facilities and the development of building technology make this phenomenon the inevitable process of modernization.

Nowadays, there are several strong negative issues related to multi-story urban housing, especially serious questions regarding the desirability of multi-story housing and the control of the neutral land which seems to be owned by everybody but belongs to nobody. However, it is apparent that there is no intention of returning back to the single-family house type which exclusively occupies a piece of land and does not share the site with other dwellers. It seems to me that this is an unrealizable dream because of the soaring cost of scarce land in urban areas in general. Multi-story & multi-family housing already has become the norm as urban housing in several areas of the world and this trend will, I believe,
continue in the next century.

However, most people prefer a single-family detached house to a unit of multi-story & multi-family housing. The reason is quite simply that multi-story & multi-family housing do not provide what the counterpart does.

At this point, I want to introduce my experience of living in two flats. I happened to stay in Scotland for a year and I was lucky enough to rent a well-maintained Georgian style flat in Glasgow. That building was built more than a hundred years ago and the height of a room is much higher than that of the modern flat. Even though I knew that fact before moving to the flat, the space height was my most dominant impression. In a living room and a dining room & kitchen, the higher space height gave me a feeling of spaciousness that the minimum space height of the modern one did not. However, in a bed room and a bath, the space was too high to give me a cozy feeling. When I lived in a modern flat in Korea, the reverse feeling was sensed. The living space was too cramped because the minimum space height of a modernized flat was mainly decided in relation to the 'special purpose space'.

What I want to point out here is that the uniform space height in a unit is one of the crucial problems inherent in multi-story housing. The space height does not have to become a fixed design variable within a unit of multi-story housing. Now we need a method to eliminate the negative meaning of the terminology 'flat', the form of the same space height, in
multi-story housing.

The other reason why I tried to pursue this typological study of a building type is that I realized that the SAR methodology and the concept of support structure provide me with good conceptual tools to do this kind of study. The concept of the type essentially evolves and can be successfully represented around a support structure.

The objective of my thesis is to introduce a new space type which can have vertical variety of space in a unit of multi-story housing and to illustrate support designs developed from this space type in order to prove its possibility as a new architectural type.

This suggestion starts from the belief that all spaces of a housing unit must not have the same spatial height because some spaces require certain characteristics which others do not. Another reason to provide this variety is that the support designs with sectional variations, I believe, could give us a way of increasing the qualitative aspects of space in multi-story housing. Nowadays the technological development in computer engineering invites us to have another 'General Purpose Space' as the work place inside of our dwelling units. The introduction of a commonly agreeable 'General Purpose Space', in addition to a living space, in our dwelling seems to me to promise that this space type will be a favorite architectural type for the future multi-story housing.

Nowadays, multi-story & multi-family housing has become a norm in
urban housing. It is no more chosen only for the low income sector of the population. There have been many demands, on the part of the dwellers for variety among the various unit types of multi-story housing. However, the vertical variety of space in a unit has not been studied deeply compared with others in multi-story & multi-family housing.
1 - 2. PRESUPPOSITIONS

This thesis is based on the particular methodology called SAR. It is highly recommended that the readers of this thesis have some understanding of this methodology beforehand. This is not only because the technical terms of SAR methodology appear frequently in this thesis without explanation, but also because the space type which I am proposing here is highlighted within the concept of support. The principles of SAR methodology are not explained in this thesis, and readers may turn to the reference materials shown in the bibliography if they have no experience with this methodology.

The concept of support came from the belief that large numbers of inactive and unresponsible dwellers are incompatible with a truly healthy, robust and live environment that can grow and improve over time. ¹) From this ideological belief support is distinguished from detachable unit in mass housing. Whether an element belongs to support or to a detachable unit is decided by the main body who makes decisions about the element. If the dweller as an individual can make decisions, the element is a detachable unit. On the other hand the support is the product about which a group of individual dwellers can make decisions. ²) So, the question regarding which element belongs to support, in fact, depends on the agreements between the people who are involved in the project.

The initial intention of introducing the concept of support is to provide dwellers with more variety of decision making about their own physical
environments to the dwellers in mass housing, that was previously not allowed to have. In my project, the floors and the skeleton frame of the physical structure including the public access system of the building are considered as the support. The room partitioning and the facade system remains in the category of the detachable units.

This concept is supported by the careful observation of the successive transformation of the built environments. I know that it is not possible for the reader to have a certain notion of the concept of support from the above two paragraphs. However, I hope this introduction will lead him into the materials about the concept of support and the SAR methodology.
Chapter 1

1 - 3. SCOPE AND FRAMEWORK

In this thesis I want to introduce the new space type with which architects do their designs in multi-story & multi-family housing. The major tasks are on the spatial forms of the dwelling units in multi-story housing and the support structure of them. However, this necessarily contains the capacity study with lower level elements. (ref. Fig 1-1) The variations in support designs in chapter 6 show this study.

Figure 1-1: THE SCOPE OF TASKS

This research emphasizes the spatial aspects of the dwelling units in multi-story & multi-family housing. Even though basic structural and technical problems of physical systems were considered in support
designs, architects must do their designs in accordance with their own decisions regarding the major physical systems, such as the materials and details of support structures and partitions, mechanical and electrical systems, etc.

In the framework of this thesis, I will start with specific examples which I developed with the new space type. This is mainly because I think that most of the readers of my thesis must have a certain degree of experience in designing multi-story housing and can recognize the new space type without difficulty.

In the third chapter, I want to make clear the role of my proposal in the design process. What I am proposing here is not a specific design as a model which, in the architectural design field, results in mere copying, but an architectural type on which architects can build their own formal values through design development.

Because I believe that a type cannot exist without its name, I further classified the space types of multi-story housing according to the spatial properties of sectional morphology in dwelling units and made some names for the types including my discovery. In Chapter 4, the merits and demerits of the space types are discussed in a method of comparing the two distinguished groups of types.

In the fifth chapter, the principles for generating the new space type and their implications & constraints in the implementation of the type are
explained with diagrams. The examples of support designs developed from the new space type are illustrated in Chapter 6.
2. INTRODUCING EXAMPLES

"prototype principle: The most specific event can serve as a general example of a class of events." --- Q.1

In this chapter, I am inviting you to have a look at the dwelling units developed from the space type which I am proposing in this thesis. The major purpose of this process is to help you to form a picture of the space type applied in the units of multi-story housing, in your mind.

There are two reasons why I do this before I discuss the generation of the new type, which is the major subject of this thesis.

Firstly, I believe that showing examples is one of the best ways of explaining about the type. When the observer has certain experiences of designing multi-story & multi-family housing, I am sure he can easily recognize the new type in my examples. I think this is general for my readers. This example will help them go through this thesis with their own interests in their mind.

The second reason comes from the actual design procedure through which I got to the space type that I am proposing here. To discover the new space type did not come only from mental speculation on design problems. It came by doing. In the beginning I had the objective, 'the elimination of continuous space height', but I did not know what kinds of space form can achieve this objective. I made sectional sketches searching for alternatives and thinking about the capacities of these
schemes in consideration of my objective. The exploration with sketches and physical models opened a new area of speculation which was not familiar to me. So, by placing this chapter before the description of the space type, I intend to inform you that the process of searching for this space type was preceded by doing.

I introduce three design proposals for multi-story housing. They are one set of dwelling units which has three kinds of units with different spatial configurations.

This set has the public circulation system called 'gallery access'. Each unit is composed of two sectors with different widths, the narrow one is 3.0 m wide and the wider one is 4.2 m wide. It consists of five zones: gamma, alpha, beta, alpha, and delta zones. The total depth of the unit including the width of the public corridor is 15.7 m. The service duct runs vertically in the beta zone on two sides of the unit. (ref Fig. 2-1, 2, 3)

The first unit has two high spaces of different shapes. One has a depressed floor and is 4.2 m wide, but the other has elevated roof and is 3.0 m wide. However, both of these spaces are placed in an alpha zone. One constraint on exploring the variations of layout plans is that the position of the entrance to the unit is confined to one side of the unit because of the level difference between gallery and depressed floor. Two examples of layout plans for this unit and some perspective views are shown in Fig. 2-1 and in Page 15,16.
The second unit also has two different high spaces. Both have elevated roofs. However, one is placed in an alpha zone and is 4.2m wide, but the other is placed in the beta zones and is 3.0m wide. There is one area of normal space height which merits special attention. This space adjoins two high spaces and has an elevated floor. This unit limits the possible positions of the entrance as the first unit does. Two examples of layout plans for this unit and some perspective views are shown in Fig 2-2 and in Page 17, 18.

Even though the third unit also has two different high spaces like the other two, this unit does not have one floor level which can be considered as the standard. The unit is divided into two areas of different level floors. The area with the higher floor has the same normal space height and the other area with the lower floor has two high spaces. One high space is placed in an alpha zone and is 3.0m wide, but the other is placed in the beta zone and has 4.2m wide. In the area with the lower floor, there is also a space of normal height which requires your special attention. This space is adjoining two high spaces and has a low roof. Since this unit does not constrain the position of the entrance, it can be accessed from either side of the unit. A layout plan variation for this unit and some perspective views are shown in Fig. 2-3 and in Page 19,20.

Probably, you have already noticed that there is a rule on the vertical arrangement of the units. The first unit must be positioned on top of the third one or beneath the second one. The second unit must be positioned on top of the first one or beneath the third one. The third unit must be
positioned on top of the second one or beneath the first one. This is the rule of 'vertical concatenation' in the stepped-level type.
FIGURE 1-1.
SUPPORT OF THE
UPPER DWELLING UNIT

FIGURE 1-2.
SUPPORT OF THE
MIDDLE DWELLING UNIT

FIGURE 1-3.
SUPPORT OF THE
LOWER DWELLING UNIT
TWO LAYOUT PLANS FOR THE UPPER
UPPER DWELLING UNIT

SECTION PERSPECTIVE FROM SECTION-1

SECTION PERSPECTIVE FROM SECTION-2
AXONOMETRIC FOR THE TWO LAYOUT PLANS OF THE UPPER DWELLING UNIT

SECTION PERSPECTIVE FOR PLAN-1

SECTION PERSPECTIVE FOR PLAN-2
TWO LAYOUT PLANS FOR THE MIDDLE DWELLING UNIT

SECTION PERSPECTIVE FROM SECTION-1

SECTION PERSPECTIVE FROM SECTION-2
AXONOMETRIC FOR THE TWO LAYOUT PLANS OF THE MIDDLE DWELLING UNIT

SECTION PERSPECTIVE FOR PLAN-1

SECTION PERSPECTIVE FOR PLAN-2
TWO LAYOUT PLANS FOR THE LOWER DWELLING UNIT

SECTION PERSPECTIVE FROM SECTION-1

SECTION PERSPECTIVE FROM SECTION-2
PERSPECTIVE OF LAYOUT PLAN-1 FOR THE LOWER UNIT

PERSPECTIVE OF LAYOUT PLAN-2 FOR THE LOWER UNIT


3. SPACE TYPE & DESIGN PROCESS

The major purpose of this chapter is to define the role & place of the ‘space type’ I propose in the architectural design process. Even though this chapter seems to be somewhat remote from the major task of this thesis, I feel that it is indispensible to include my understanding of the term, 'type' somewhere in this thesis. The reason for viewing a type from the point of view of the design process comes primarily from my expectation for the implementation of this new type. I do not want designers just to recognize the new type, but I do hope that some designers will use it in their own design processes. Another reason comes from my personal belief that understanding the conceptual setting of our working process can give us confidence in doing the job. I believe that a discussion of the design process will help us understand our behavior in designing and thereby improve our design ability.

I will review the history of the design process model and elaborate it further for my own purpose. After that I add some discussion and introduce the term 'space type', retrospective to the story of my discovery.
3 - 1. THE MODEL OF THE DESIGN PROCESS

In the early 1960's, a new approach to design methodology was introduced by the realization of 'design' as a process. This assumes that better design solutions will be arrived at by more informed design decision making. It suggests that a key to informed design decision making is the externalization of the design process. One way of externalizing the design process is to chart a route through the process from beginning to end, that is, to make a model of the design process.

The model is the conceptual description of the design process. However, it is difficult, if not impossible, to describe the full design process in a concrete way mainly because our thought process when designing is never fully reflected in the design acts taken. The mental process of designing still remains unknown and poses a formidable psychological problem. Even though I agree with the impossibility of formulating the design process comprehensively into a conceptual mapping diagram, I believe that the attempt to make such a diagram is a rewarding activity. It is worth noting that the purpose of a model of the design process is not to make a procedural instruction, but to provide us with a reasonable base for understanding our design behaviour.

As research and thinking on design methods proceeded, the study of the design process moved from an ANALYSIS-SYNTHESIS model to a CONJECTURE-TEST model.
The former model depends basically on a Cartesian principle. Many variants of this model exist. Most of them essentially say that design problems should be approached by first analyzing what the relevant factors are, which relations exist between these factors and what the boundary conditions of these factors are. Only then the designer could, by clustering the related factors, arrive at a form. The underlying idea of this principle is that the synthesis should not be attempted until a thorough analysis is completed. It was assumed that such a synthesis of various factors would, by its own, result in form. Thus a large slice of the design process could be replaced by a computer. That would be a less biased process and give better solutions.

However, architectural design problems, both large and small, are difficult or impossible to split up in this way without prejudice to performance, cost, appearance or other objectives that require many trade-offs between components. In real design situations, it is not possible to know what problems are relevant and what information will be useful until a solution is attempted. No meaningful division can be made between analysis and synthesis. We learn simultaneously about the nature of the problem and about the possible solution. 4)

The weakness of the analysis-synthesis-appraisal model of the design process is that this does not explain how the synthesis should be brought about. In designing, relevant problems can seldom be comprehensively formulated in advance nor can a solution be logically derived from such problems. Most design questions are simply too complex for the designer
to consider all the factors and variables at the same time. It is on this point that the later research focussed. The primary question now was how the design process actually proceeds in design practice.

As research and thinking on design methods proceeded there was growing doubt as to whether the analysis-synthesis model and its elaboration could still provide a satisfactory conceptual framework for describing the design process. In practice, the process of design only partly follows explicitly argued design propositions that subsequently are compared with the program of requirements to judge their feasibility. The degree of feasibility often depends on the quality of the alternatives considered and also depends on the time available for the development of other alternatives.

Hillier et al offer, in the place of the old analysis-synthesis model, a conjecture-test model for the next generation design method based on Popper's conjecture-refutation model. They pointed out very practical reasons why conjectures of approximate solutions should come early on. This is that a vast variety of design decisions cannot be taken, particularly those which involve other contributors, before the solution in principle is known. In fact, we cannot escape from the fact that designers must prestructure their design problems in order to solve them. Only by prestructuring any design problems either explicitly or implicitly, can we make them tractable to rational analysis or empirical investigation.

Based on this new model, the idea of PRIMARY GENERATOR was
introduced to be a useful way of conceptualizing a particular stage of design: a stage that precedes a design conjecture. Close observation of the real design process reveals that very early in the architectural design process, the architect imposes or identifies a particular generating concept or a limited set of objectives, and these objectives form a starting point for the architect to get into the problem. He does not list all the constraints first before making a first design proposal. We believe that most architects have a certain concept in mind, when they are explaining their designs to us. It is clear that this concept is usually arrived at before the requirements have been worked out in detail, and necessarily so, since many requirements can only become known in the context of a particular solution.

However, the actual form of a primary idea varies. It can be a vague symbolic image and the designer himself does not know how it will become tangible, or a pattern which implies a certain system as Alexander proposed, or a type which is composed out of a number of systems. It is worth noting that a primary generator must be general enough not to predetermine too much the final result.

The notion of a primary generator as introduced above is generally used to represent three possible forms of design ideas. It seems to me that even though an architect can start from any one of the three he must sooner or later visualize a type to proceed. In other words, when either an image or a pattern is the form of the primary idea, it must be developed to a type.
Therefore, I plan to divide further the stage of a primary generator into two stages, and elaborate the model further. The preceding part is named PRIMARY IDEA and the following stage is called GENERATOR. The primary idea refers to fragmented primitive concepts such as a symbolic image or a pattern, and the generator refers to a type. A generator must represent a combination of systems. For instance, within a building type one can distinguish a space system, a structural system, a facade system and so on. So the elaborated second model is: primary idea-generator-conjecture-test.

An architect often directly arrives at the known building type, without spending much time struggling with his vague symbolic images. In other words, GENERATOR can be reached by jumping over the primary idea. What I mean by this is that the experienced designers often need not exert themselves searching for a type from an image, because an image and the desirable type for that image are too familiar to the experts and packaged into one chunk of memory slot.

I added another stage of work in front of the above model because designing is normally an activity for solving the problems of the users. In the design process, there must be an analytical mode of thinking for understanding the problems of the users. Therefore, my proposal for the model of the design process is ANALYSIS - PRIMARY IDEA - GENERATOR - CONJECTURE - TEST. (Fig. 3-1)
FIG. 3-1. A DIAGRAM FOR MY MODEL OF THE DESIGN PROCESS
3 - 2. TYPE & SPACE TYPE

"an architectural 'type' must be treated as a schema of spatial articulation which has been formed in response to a totality of practical and ideological demands"  -- Q.2

The term 'type' has been redefined several times since it was introduced to the architectural field in the late eighteenth century.7) One of the peculiarities of architectural discipline, compared with others, lies in defining a terminology. When a term is introduced to an academic field, it is carefully scrutinised and parsimoniously defined in order to make its boundary conditions explicit. And once accepted, a word is used universally within the field and the meaning of the word is hardly changed. However, in architectural design, words are more like day-to-day words. A new term is accepted without making its boundary conditions clear. A new meaning is attached to an existing word. The same term is often used to convey a different meaning not only in time but also in space. The term 'type' is a typical example of this kind.

The definition of the term, 'type' in relation to its history is beyond this thesis. The following statements about the type are introduced in order to avoid possible misunderstanding. Most of them are quoted directly from reference materials.
An architectural type is dependent on the formal and functional 'common character' of the architectural object as a whole, but it is also vague or general enough not to directly affect the design of buildings or their formal quality.  

It is a complex form that lives within a social body: a knowledge, familiar to a group of people by common experience. The concept of type is closely related to a shared image. And it can be recognized immediately by the people who know that type.

As for me, the conception of type seems to come from the abstraction of the principles in organizational properties of the architectural object. One might say that an architectural type is a body of organizing principles followed by the alternative schemes to be developed. Even though these inner principles must tell us about the formal configurations, they should be general enough to contain the possibilities of infinite variations and to exclude the specific formal quality.

In the previous section I tried to implicitly define the role of architectural type by thinking about its place in the architectural design process. When I introduced the term 'generator' in my design process model, I was referring to the point in the design process at which the designer's thinking about the design task as a whole is saturated and he feels confident about the direction along which he plans to move. The distinction between generator and type comes from the fact that a type
must live within a social body. An architectural type is always possible to be a generator in the architectural design process. However, a generator with new sets of design principles cannot always become an architectural type. To do so, the generator should firstly not be confined to specific design problems. Secondly, the generator must convey a whole image. I believe these are two necessary conditions to make a generator a candidate of a type. The actual implementation of this candidate in design practice and its acceptance in a social body are, of course, the final conditions for the new type.

Conceiving a 'new type' or rather a candidate for a new type to be precise, is theoretically possible without going through the conjecture-test cycle. However, I am skeptical about the possibility of this happening because of many practical reasons. I believe that design discoveries come necessarily from doing the design conjecturing and its successive modifications.

By defining that a type precedes a design conjecture, in other words, that a general picture of the design tasks is a necessary condition for the first part of the designing, I consider designing basically as a topdown process, going from the general to the specific.

In the beginning, I wanted to make a support design for multi-story housing where each unit contains different space heights. So, I started with the type, 'differential-level' which I thought to be most promising at that time. (ref. chapter 4) In considering that in multi-story housing, a unit
is normally composed of two bays, I pushed my design conjecture further over the boundary of this type and I got into new territory.

The Transformation of the design conjecture was the major source of my discovery. One strategy, which I think to be of great importance for my design process, was to make only one design problem for each design move. When I had several objectives to achieve, I chose the primary one, 'the difference of the space height in a unit of multi-story housing'. After that I confined myself exclusively to that aspect and tried to connect it to a tangible space form. From this endeavor, the idea of sectional space typology came up to me. (ref. Chapter 4)

After choosing the type of differential-level, I posed another question; Can I position a high space in other vertical zones of a section? This question made me undertake a design move shown below.

![Figure 3-2. A Design Move in My Design Process](image)

SECTION - 1

SECTION - 2

FIGURE 3-2. A DESIGN MOVE IN MY DESIGN PROCESS
After that, I noticed that the new section gave me three sectional units, each of which has different potential for a dwelling unit. Each of the sectional units was tested by reading its capacity for a unit of multi-story housing. At that stage, the problem was how I could compensate the inequality caused by the split-level floor. In order to solve this problem, I turned to the another dimension of the space, the longitudinal direction of a building. By adjoining two different sectional units longitudinally, I entered a new area of exploration.

Through this way of one-by-one process, I arrived at my support design. The first design conjecture conveying the stepped-level type did not have two different bay sizes. However, following the above strategy, I got to know that this space type could be transformed to accommodate two alternative bay sizes, which was shown in the examples of the previous chapter. I am still facing that the further design exploration of this architectural type and I hope future study will eventually lead us to another new space type for our field.

Introducing the term, 'space-type' intends to emphasize that the physical space must be the primary tool to formulate the architectural type. The term came from my experience of discovering. When I discovered this space type, the spatial morphology and its capacity study dominated other design variables and I want to emphasize this aspect in the architectural type and in the title of my thesis.
4. OBSERVATIONS

"Although the type may not easily lend itself for
description it does, however, reveal itself in language.

----When the words fade we can be sure that the
forms are soon to disappear as well" ---- Q.3

4 - 1 TAXONOMY OF SPACE TYPES

We are interested in the variety of space height in multi-story housing. I
categorize multi-story housing into two groups: the first group has
uniformity in the height of spaces, and the other one has variety in the
height of spaces.

The former one is further classified into two well known sectional space
types: 'FLAT' type and 'SKIP-LEVEL' type. The variety group is, in turn,
classified into three types. The first one gives us the most freedom to vary
space height. I named it 'LOFT' type, and it has the same sectional
configuration as the flat type except that the height of this type is greater
than that of the flat. A space of this type can be sectionally divided into two
to make a mezzanine floor if the height is high enough. However, the
sectional divisor could also be an access floor or a ceiling. A space of this
type can be used as one space or can be sectionally divided into more
than two. The other two types both have the predefined floors. One type
which I named 'DIFFERENTIAL-LEVEL' is sometimes used in housing in
order to get a higher space. The principle of this type is that one vertical
zone of the cross section keeps the normal space height * and the other
vertical zone offers the higher spaces. We can have a set of variations in this type as shown in Fig. 4-4.

The space type which I propose is the last one which I name 'STEPPED-LEVEL' type. In this type the higher space does not stay in one vertical zone of the section but it moves from one zone to another zone. The principles to produce this type will be introduced in the next chapter. (ref. chapter 5)

* normal space height: I am referring to the dimension of the space height which the architects usually choose when they design the multi-story housing of uniform space height, that is, flat type and skip-level type.
FIGURE 4-1. TAXONOMY OF SPACE TYPES AND THEIR GROUPS
4 - 2  UNIFORMITY GROUP vs VARIETY GROUP

After the division of labor and its specialization had introduced the benefits of uniformity for mass production, we must find how we satisfy our basic needs for variety. This becomes the primary task of the design field in general. Since the purpose of architectural design is to provide three dimensional space, designing concerns both the horizontal and vertical variety of the space. Many striking concepts and designs in relation to the horizontal dimensions of the spaces in a unit have been introduced in multi-story housing. Gaudi's design of the Casa Mila is an extreme example.

The combination of the variety of unit plans with the variety of 'public access types' has formed the major source for designing the multi-story housing. I want you to recall Moshe Safdi's design of Habitat and his principle for multi-story housing that every unit should have its own outdoor garden. This is not only because his design was an excellent example for the above assertion but because his concept helps me to make my own principle that every unit should have a higher space for the general purpose space.

The elimination of vertical variety in unit spaces contributes to the efficiency, not only of the actual production of multi-story housing but also of its designing. However, the quality of space inherently depends on both horizontal and vertical dimensions. The horizontal dimension of the space
is critical to its actual use, but the quality of space depends more on the vertical dimension and the connection of its variations. I value the spatial variety which the relations of different space heights give us.

FIGURE 4-2. SECTIONAL DIAGRAM FOR THE TYPES OF UNIFORMITY GROUP

\[
H = h_1 + h_2
\]

\[
h_1 = h_2
\]
Units belonging to the free group have a high-enough space height in all areas. This is a support structure which can be divided sectionally according to spatial demands. Two merits of this type are to be distinguished. One is the maximum flexibility for choosing the proper height of the space. The other one, which is more valuable in organising the whole plan, is that the given height does not pose any constraints for the positions of the different spaces. However, this type has severe disadvantages, unlike the planar support system. Spaces must have a certain height for a person to inhabit. Because of this basic ergonomic requirement, most of the spaces above the ceiling or below the floor must be devised to be storage spaces. The difficulties of using these dead spaces still question the effectiveness of this type as the popular type for multi-story housing. However, we can see the uses of this type in the interior renovation of warehouses. I think that it is fair to say that this type appeals exclusively to those who can afford this flexibility.

In contrast, we have the two unit types with different predefined space heights. The disadvantage of this type group is that it confines certain spaces to certain positions in a unit plan. Its advantage is that it can minimise the loss of spaces and achieve the variety in elevation. I believe that this group is valuable enough to attract further design research, not only because the cost for sectional space variety is visibly low enough to make this type the most prospective candidate for the multi-story housing
of the next generation, but also because I believe the constraints on the position of spaces can be successfully overcome by using the horizontal dimensions of the space.

FIGURE 4-3. SECTIONAL DIAGRAM FOR LOFT TYPE

H1, H2, H3: the height of the loft space

h: the normal space height

LOFT TYPE
4 - 4  **DIFFERENTIAL-LEVEL vs STEPPED-LEVEL**

The space type 'differential-level' is composed of a set of its variations. The principle of this type is that one vertical zone of the section keeps the normal space height and the other vertical zone is sectionally divided in a different way. (ref. Fig. 4-3)

When we make these variations we can see that there are the constraints for getting the height of the high spaces. The height of the high spaces can be represented with the following equation:

\[ H = \frac{h \cdot n-1}{n-2} \]

- \( H \) = the floor-to-floor height of high space
- \( h \) = the floor-to-floor height of normal space
- \( n-1 \) = the number of the normal spaces which are considered to be a package.
- \( n-2 \) = the number of high spaces which result from the division of the sectional space package.

When the normal space height is fixed, the height of the high space as well as the level difference are automatically decided. 2.6M is generally considered as the minimum dimension of the floor-to-floor height for normal space in multi-story housing. From this we can calculate the minimum level difference for each variation of this type as shown in Table 4.
Chapter 4

VARIATION - 1
H1, H2, H3, H4: the height of high space
h: the height of normal space

VARIATION - 2

VARIATION - 3

VARIATION - 4

FIGURE 4-4. A SECTIONAL DIAGRAM FOR THE VARIATIONS OF THE DIFFERENTIAL-LEVEL TYPE
Chapter 4

VARIATIONS OF THE TYPE

MINIMUM LEVEL DIFFERENCES BETWEEN HIGH AND NORMAL SPACES

<table>
<thead>
<tr>
<th>VARIATION - 1</th>
<th>MINIMUM LEVEL DIFFERENCES BETWEEN HIGH AND NORMAL SPACES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>THE HEIGHT OF NORMAL SPACE = H</td>
</tr>
<tr>
<td></td>
<td>H = 2.6 M</td>
</tr>
<tr>
<td>VARIATION - 1</td>
<td>0</td>
</tr>
<tr>
<td>VARIATION - 2</td>
<td>1/2H</td>
</tr>
<tr>
<td>VARIATION - 3</td>
<td>1/3H, 2/3H</td>
</tr>
<tr>
<td>VARIATION - 4</td>
<td>1/4H, 1/2H, 3/4H</td>
</tr>
</tbody>
</table>

TABLE 4. THE MINIMUM LEVEL DIFFERENCES BETWEEN HIGH SPACE AND NORMAL SPACE

This principle obviously constrains designers to receive certain level difference between the high space and the normal one. However, confining the spaces of the same height in a certain vertical zone clearly provides this type with a better potential for actual production, in comparison with the 'stepped-level' type.

The freedom to choose any level difference between the high space and normal one is the definite merit of the 'stepped-level' type. The other merit is that because the floor lines do not run continuously in a longitudinal direction of the building and the designers can manipulate those lines to a
certain extent, this type conveys more potential for variety in the elevation in comparison with the 'differential-level' type. In addition to the comparative difficulty in construction, there is one debatable disadvantage to this type. Because the high space does not stay on one side of the section, this may force the general purpose space to go where the higher space is. Where there is a strong convention for placing the spaces in relation to the sun, this could be a problem.
5. THEMATIC PRINCIPLES OF THE STEPPED-LEVEL TYPE

"The type is to be acted upon, not to be described." --- Q.4

The key idea of making this type came from the recognition of the fact that most of the dwellings are composed of two bays. When you first see the section package on the left without the above notion, you may be sceptical about its usefulness as a space type for multi-story housing. This negative feeling comes from the deficient spatial characteristics inherent in the sectional unit in the middle.

* sectional unit: A sectional unit refers to the formal configuration of a unit for both longitudinal and vertical dimensions of a building. In the vertical dimension, a sectional unit is a component of a section package. In the longitudinal dimension, the floor profile within a sectional unit is constant normal to the cross section. A sectional unit of the stepped-level type must have both high space and normal space.

* section package: In the vertical stacking of sectional units, the sectional units between two same floors must be considered as a group because of its repeatability. This set is named as section package. The sectional units in a section package cannot not have the same configurations, because the same sectional units must produce the same floors.
The preconception behind this scepticism is that each of the sectional units should, by itself, serve for a dwelling unit. In fact, the sectional units in the section package-1, have unequal potential for multi-story housing. The upper sectional unit and the lower one have the high space in alpha zone, but the middle sectional unit has the high space in the beta zone. So, the upper and the lower sectional units can invite more natural light than the middle sectional unit can. In addition to this, the level difference in the floor, in contrast to a difference in ceiling height, makes it possible for the area of normal space height in the upper sectional unit to be visually more private relative to the higher space.

The different configurations of sectional units must result in the differentiated spatial properties. From the spatial characteristics discussed above, I would conclude that in the
sectional units of section package-1, the upper sectional unit has the most benefited space properties for multi-story housing and the middle sectional unit has the most detracted space properties.

We can find a way to compensate this inequality when we are considering the new section package which will adjoin the existing one. By joining the outward sectional unit* to the inward sectional unit*, we can balance the inequality between the sectional units. (ref. Diagram 3,4)

It is worth noting that an outward sectional unit in a section package has, by itself, sufficient spatial properties for a one-bay dwelling unit.

* an outward sectional unit is a sectional unit which has the high space in alpha zone.

* an inward sectional unit is a sectional unit which does not have the high space in alpha zone and has the high space in beta zone.
This point helps us to explore sector combinations in support design of this type.

*Search for a section package of differentiated sectional units and join two section packages considering the connectivity between two adjacent sectional units.*

Making the stepped-level type necessarily requires these two operations. We can search for a section package either by dividing the whole configuration of the section package with split-level floors, or by stacking up the different sectional units into a section package. Firstly, I will start to divide the rectangular section packages in order to introduce several configurations of sectional units, and considering the vertical stacking of the sectional units and the section packages, I will generalize the operation of searching for a section
package into a geometry of reference lines. Secondly, I will discuss the operation of compensation, that is, the combination of section packages in the longitudinal dimension of a building.

We can divide a rectangular section package into different sectional units by positioning the high space in the different zones of a sectional unit. We may think of the different sizes of the rectangular section packages, each of which will be divided into two or more sectional units. (See Diagram 5)

In order to divide a rectangular section package into two sectional units, this section package must have the height of three horizontal bands which are of two kinds. One kind is the band of normal space height which is notated as 'a', and the other one is the band of the level...
D.7 THE RELATION BETWEEN THE HEIGHT BANDS
\((a = b + c)\)

D.8 THE DIFFERENT SECTION PACKAGES FROM THE SAME SECTIONAL UNITS

D.9-1 A SECTION PACKAGE OF TWO SECTIONAL UNITS

difference which is notated as 'b'. It is noted that the b-band must be positioned between two a-bands. (See Diagram 6-1,2)

In the rectangular section package of three sectional units shown in Diagram 6-3, three kinds of height bands appear. Two of them are a- and b-bands and the other band is another kind which is notated as c-band. There is a strict relation between the heights of a, b and c-bands. The height of the a-band must be the sum of the b-band height and the c-band height. (See Diagram 7) It is noted that a c-band must be positioned between two b-bands.

In the rectangular section package of four sectional units shown in Diagram 6-4, a different combination of three height bands appears without introducing a new band.
From the above explorations we can recognize that there will be only three kinds of horizontal height bands even if we explore further divisions. Now we recognize that three kinds of height bands and the positioning rules between them can be sufficient to search for a section package.

It is worth noting that a section package is distinguished in the vertical concatenation of sectional units because of its repeatability. A section package need not have the rectangular configuration. When we stack up two same rectangular section packages, we can see that another group of sectional units can be considered as a section package as well. (See Diagram 8) We can also make a section package in which all of the sectional units does not have unbroken floors. (See Diagram 9) However, following the definition of the section package in
the first page of this chapter, the top and bottom floors of a section package always must be the same to allow for continuous stacking. The rectangular section package is just one specific configuration of a section package.

In order to generalize the positioning rule of the height bands, we have to also think about the vertical stacking of section packages. We can stack up a section package on another section package if the adjoining floor has the same configuration. When we stack up two same rectangular section packages, we can see that it is possible to have one $a$-band vertically adjacent to another without a $b$-band between. From the above explorations, I formally enumerate the minimum set of positioning rules of the height bands as below.
Rule 1. Height bands should not be positioned vertically adjacent to one another except two successive a-bands.

Rule 2. The c-band must be positioned between two b-bands. In the other way of saying, the a-band and the c-band should not be vertically adjacent.

We have to keep in mind the fact that we are trying to design valuable spaces for people to inhabit through sectional units, but not to make an interesting shape of sectional units by itself. We have to think about the zones and margins which are critical in a plan layout. The zones and margins run in the longitudinal direction of a building and can be represented as the vertical bands in the section package. Now we have the full set of reference lines to design a section package.

We can recognize that the zones and margins, force us to position the level splits within the bands of margins. The
a-band including some parts of either upper b-band or lower b-band can make a sectional unit, and the a-band including some parts of both upper and lower b-band can make a sectional unit. The c-band must include some part of both upper b-band and the lower b-band in order to make a sectional unit. The b-bands convey, to a certain extent, the meaning of the margin which is indivisible. The level splits cannot appear in a- and c-bands. The level splits must appear in b-band.

Probably, you have already noticed that there are two strategies to make a section package from the height bands. One is to start with two continuous floors, in other words, two double a-bands. The other is to start with two b-bands. (See Diagram 12)

I believe that the two directional reference lines and the above simple knowledge about height bands are enough for designers to start
designing a section package of the stepped-level type.

The operation of compensation is to design another section package which will join the known section package in the longitudinal dimension of a building. We need another layer of reference lines which will overlap the existing layer. We do this process because we feel that the inward sectional unit does not have the sufficient spatial properties for multi-story housing by itself. The inward sectional unit must be joined with an outward sectional unit, which can compensate the negative properties of the inward sectional unit. So, we, first, have to find out the inward sectional units in the existing layer. We can read the positions of the inward sectional units quite quickly because the inward sectional units usually appear with \( c \)-band.

In the process of compensation, we
have to keep in mind the accessibility of the floors of one sectional unit from those of another sectional unit which is longitudinally adjacent. We must try to avoid unnecessary level splits. There are two possible ways of making the new section package in relation to the existing section package. One is to find the right alignment of the height bands of two layers using preconceived sectional units. The other is to first decide on the proper positions of the height bands and find the configuration of the sectional unit. However, these are not two diverging ways which we cannot alternate once we take one, but two converging lines which we may take alternatively.

Let me take an example of the section package in Diagram 15 to explain about the process of compensation. From this example, we can set up several rules to determine the systems we want to work on. I will start from the simplest case.
The first rule of the first system is that the level splits are allowed only on one center line of each margin. (See Diagram 17)

In the first step, we can find only one inward sectional unit in the middle. Within the above rule, the \(c\)-band cannot make an outward sectional unit. Now we can recognize that there are only two alternative ways of positioning the new reference lines of \(a\)-bands in relation to the existing reference lines of the inward sectional unit as shown in Diagram 18. At this moment, We can think of the several configurations of outward sectional units. Let me take the simple one shown in Diagram 19. Now we can think of two possible longitudinal combination of the sectional units. (See Diagram 20) In the example-1, there exists a case of inaccessibility between two adjacent spaces and somebody may think that three floor levels in a two-bay dwelling unit goes
too far. I think the example-2 is the more plausible solution. (See Diagram 21) From this first sectional unit, we can stack up the sectional units in the new layer in relation to the counterpart sectional units in the existing layer. We could make various kinds of compensating section packages. However, I will show you the way to find the specific section package which can be packed with the known section package into a block of section packages. This block concept has special importance because, by staking up and longitudinally attaching the same blocks repetitively, we can make a whole building of multi-story housing.

We know that a continuous floor can

*a block is distinguished from other sectional units because of its repeatability in both vertical dimension and the longitudinal dimension. The necessary condition to make a block is to have the two same configurations of the floors at the bottom and the top. In other words, in order to make a block, we need two section packages of the same height.*
appear only between two $a$-bands.
So, we have to have an $a$-band on the first sectional unit in the new layer.
(See Diagram 22) On the top of this $a$-band, we can have only a $b$-band
because three successive $a$-bands is not allowed. In order to make a block
the height of two section packages must be the same. From this, we can easily find out the height bands below the first sectional unit. You may recall the strategy of making a section package: we can make a section package between two $b$-band or between two double $a$-band at the top and bottom of a section package. In this system, the $c$-band makes only two kinds of sectional units. Because of the floor of the first sectional unit, the $c$-band should make the sectional unit of the configuration shown in Diagram 22. In order to make a section package of three sectional units, the upper sectional unit must have the configuration shown Diagram 22.
Within this rule, I will show you the way to make another kind of a block. Let me flip the upper sectional unit in the new layer and stack up three more sectional units and make a section package of six sectional units as shown in Diagram 24. The situation is now reversed. We have to put down the layer of the section package of six sectional units and overlap the layer of the known rectangular section package. Following the same process as the above, we can easily find out a block of twelve sectional units. (See Diagram 24, 25, 26) This is because a section package normally has another section package of flip-image. (ref. Diagram 27) The exception of the flip-image phenomenon is the case of the section package which has only symmetrical sectional units. (See Diagram 6-1,2, 9-2)

From this, we learned that a block can be made of a section package of one layer and two section packages of the
other layer. Even though it depends on the ratio between the $b$-band height and the $c$-band height, I can feel that there could be other combinations of section packages which can make a block. This area is not yet explored.

I want to give you another case of a system from the same example to demonstrate the variety of this space type. The rule of the system is that the level splits must appear on both ends of two margins which are wide enough to make it possible to connect the two spaces of a sectional unit diagonally. (See Diagram 29) The critical difference from the previous system is that we can have the pattern of $c$-band and $b$-band alternating successively. I want to introduce a special kind of a block which has a similar section package of the first case as shown in Diagram 28. The process of compensation is just same as the above case. First we have to find the inward sectional unit of the existing
layer. You may start with \( a \)-band like the two precious cases. However, within this rule, we can also make four outward sectional units with the \( c \)-band as shown in Diagram 30. In consideration of the accessibility of the inward sectional unit, I think the sectional unit of Diagram 30-4 is the most proper. From this, we can easily make a section package of three sectional units and a block of six sectional units. (See Diagram 33, 34) Somebody may argue that the spatial configuration of the two middle sectional units is too singular to use as a dwelling. But I really value this spatial configuration as a dwelling unit. I can feel the dynamics of the space stream in this spatial configuration. (See Diagram 32)

From the explorations of this type, I can say that making a block is an efficient way of designing with this space type for multi-story housing. However, I believe that, while working
with several layers and going through the successive process of compensation between two longitudinally adjacent sectional units without making a section package, we can also complete a design. That must be a rewarding act of designing.

It is worth noting that both the section package and the block are just an exploration tool to coordinate the large amount of sectional units. This concept is really helpful to understand the whole structure of the sectional units. However, you must not accept a section package or a block as an indivisible part of a building. The configuration of the roof of a multi-story building need not be the same as that of the ground floor of that building.

From a six story block we can make five story building or two story, or ten story and whatever you want, simply by adding or subtracting sectional units. (See Diagram 35)
The conventional way of designing pushes us to project the volume vertically from the plan sketch, on the other hand, designing a section package pushes us to project the volume longitudinally. I explained about the additive way of designing with this space type for a block of the sectional units of two layers. However, the concept of the block need not be confined to two layers. You can also consider the section packages of three layers as a block.

I recommend that the designers who want to use this space type should start from the zones and margins not only because when we cannot read the space in the plan we cannot design a building, but also because you can easily lose your way in the midst of designing a section package.

One distinguishable merit of this section study is that we can figure out the elevation and its potential
fenestration directly in relation to the section package exploration. The reference lines of the horizontal height bands are the possible positions of the floors. I believe that this design approach helps us consider more design variables of the elevation in a coordinated way. The successful design, of course, would require the incessant switch from the plan to the section.
6. SUPPORT DESIGNS
   of stepped-level type
   for multi-story housing
6-1 Gallery Access Type
PLAN FOR A BLOCK

SECTION PACKAGE - 1

SECTION PACKAGE - 2

\[ a = 2.7 \text{M} \]
\[ b = 0.9 \text{M} \]

SECTION PACKAGE - 1

SECTION PACKAGE - 2
SECTION PERSPECTIVE
OF THE UPPER DWELLING UNIT FROM THE ABOVE

LAYOUT PLANS
VARIATION - 1, 2
FOR THE UPPER DWELLING UNIT
LAYOUT PLANS
VARIATION - 3, 4
FOR THE UPPER DWELLING UNIT

LAYOUT PLANS
VARIATION - 5, 6
FOR THE UPPER DWELLING UNIT
SECTION PERSPECTIVE
OF THE MIDDLE DWELLING UNIT FROM THE ABOVE

LAYOUT PLANS
VARIATION - 1, 2
FOR THE MIDDLE DWELLING UNIT
LAYOUT PLANS
VARIATION - 1, 2
FOR THE MIDDLE DWELLING UNIT
SECTION PERSPECTIVE
OF THE LOWER DWELLING UNIT FROM THE ABOVE

LAYOUT PLANS
VARIATION - 1,2
FOR THE LOWER DWELLING UNIT
LAYOUT PLANS
VARIATION - 3, 4
FOR THE LOWER DWELLING UNIT

LAYOUT PLANS
VARIATION - 5, 6
FOR THE LOWER DWELLING UNIT
LAYOUT PLANS
SECTOR VARIATIONS
ONE-BAY AND THREE-BAY DWELLING UNITS
FROM THE LOWER SUPPORT
6-2 Hall Type
SUPPORT OF THE UPPER DWELLING UNIT

LAYOUT PLANS
VARIATION - 1,2
FOR THE UPPER DWELLING UNIT
LAYOUT PLANS
VARIATION - 3,4
FOR THE UPPER DWELLING UNIT
SUPPORT OF THE MIDDLE DWELLING UNIT

LAYOUT PLANS
VARIATIONS -1,2
FOR THE MIDDLE DWELLING UNIT
LAYOUT PLANS
VARIATIONS - 3, 4
FOR THE MIDDLE DWELLING UNIT
LAYOUT PLANS
VARIATIONS - 3, 4
FOR THE LOWER DWELLING UNIT
Appendix

Expectations

Even though I am completing my thesis here, I feel that the research on the stepped-level type has just started. This is not only because the design research in general does not have a closed end, but also because I can see that some areas of the stepped-level type have not been explored thoroughly and some areas have not even been entered. I want to tell about these points. I hope this will give some help to the people who value this space type and want to explore it further for their own purpose.

This space type originates from the needs of height variety in multi-story housing. However, the stepped-level type is not confined to multi-story housing. As any architectural type, it transcends the specific functional typology of the building. After the design implementation of this space type for various kinds of functional buildings, such as housing, educational facilities, department stores, office and etc., I believe a society will accept this space type as a live type.

In this thesis, I propose a tool of searching for the section package: two directional reference lines. One comes from the
vertical zones & magazines, and the other comes from the horizontal height bands. In the operation of compensation, the rules for making the new reference lines in relation to the existing reference lines, I believe, can be searched more explicitly and these will guide our designing with this type in a more coordinated way.

Designing with the plan of a building is usually the conventional approach for the building, and designing with the cross section of a building is another way which I am proposing. From this, we can also think of designing with the longitudinal section of a building. This is closely related with the operation of compensation. In my thesis, I confined myself to additive designing in the longitudinal direction of a building. I believe that successful designing with the stepped-level type necessarily requires a general picture about the longitudinal section of a building. When we are working with the longitudinal section, the longitudinal dimensions of the sectional units appear and attract our direct attention. This area waits further explorations.
Appendix

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Appendix


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