

# Coping With the Incompatibility of Urban Form Structure in Cross-Cultural Comparison: A Coordinated Approach Based on Critical Review of Classical Morphology Theories

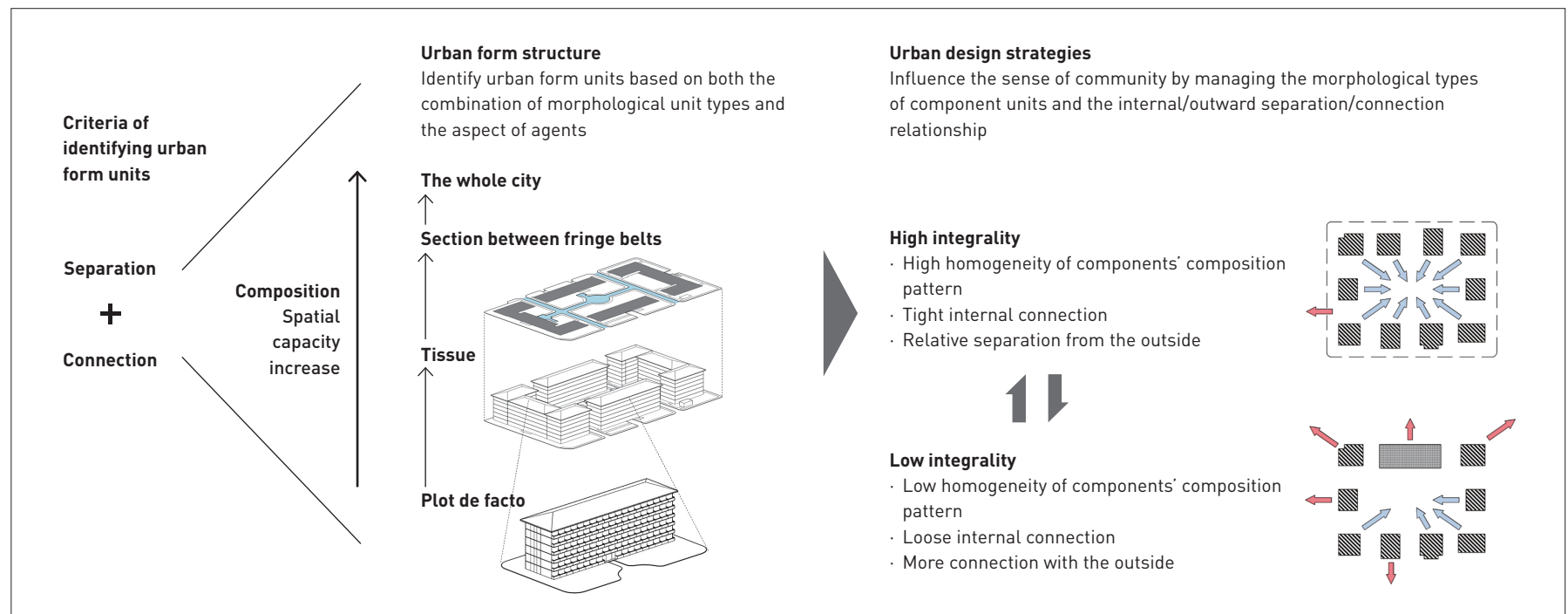
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## GRAPHICAL ABSTRACT



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Urban morphology aims to describe and explain urban form and has the potential to be applied in urban planning and landscape design. However, the Eurocentric perspective of classic theories limits its validity and related design practice in a contemporary multicultural context. The lack of a universal approach to depicting the urban form structure is one of the fundamental aspects of such a theoretical flaw. This article addresses the historical and regional incompatibility of urban form structures and discusses its causes by analyzing the basic standpoints of the historical geography perspective and the construction

perspective in urban morphology. Based on the critical review, “separation” and “connection” are established as two criteria for specifying urban form units, and the compositional nature of the built environment is highlighted. Further, by reconciling the functional and morphological aspects, or that is, linking urban form with the agents that shape it, a coordinated approach is proposed with rational parts from classical theories, and a corresponding quantitative method taking the distribution of different sizes of units as a key indicator is also developed to aid urban form subdivision.

## KEYWORDS

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Urban Morphology; Urban Form; Urban Structure; Incompatibility; Cross-Cultural Comparison

## HIGHLIGHTS

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- Discusses the historical and regional incompatibility of urban form structure in classical theories
- Analyzes urban form structure incompatibility rooted in two basic perspectives of classical theories
- “Separation,” “connection,” and the compositional nature are main criteria for specifying urban form units
- Proposes a coordinated approach and quantitative method to depict diversified built environment

## 1 Introduction

Urban form is an important dimension of the urban landscape. As Michael R. G. Conzen, the German British geographer, stated: “the development of towns is written deeply into the outline and fabric of built-up areas, and the built-up area becomes the accumulated record of the town’s development.”<sup>[1]</sup> Understanding and guiding the urban form are fundamental concerns of several disciplines, including urban geography and urban planning. As an organized body of knowledge, urban morphology has already been applied in the planning practice of several cities, including Rome and Palermo, Italy<sup>[2-3]</sup>. The urban form structure, referring to the way how morphologists subdivide urban area into smaller components or combine smaller units to larger urban form, is central to describing, interpreting, and planning the urban landscape. However, due to the absence of a compatible urban form structure, it is difficult to compare urban forms generated in different regions and historical periods. Therefore, the application of urban morphology is largely limited to heritage conservation,

and is sometimes even reduced to a design philosophy that borrows from the premodern city<sup>[4]</sup>. Moreover, in non-Western cultures, both modern and traditional local urban forms are distinct from those of traditional European towns. In such cases, a compatible urban form structure is particularly necessary for illustrating the impact of modernization on built environment, providing a reference for addressing planning issues triggered by the clash of cultures.

There exist three widespread theories in the field of urban morphology, corresponding to three types of unique but similar urban form structure. The first is the Conzenian School, founded by Conzen and based on the German historical geography tradition<sup>[5-6]</sup>. By analyzing the process through which urban form is generated and transformed, Conzen delineated multi-tier town plan division in several case studies<sup>[1,7]</sup>. The second fundamental theory, usually called the Muratorian School, was founded by the Italian architect Saverio Muratori and later simplified and transmitted by his assistant Gianfranco Caniggia<sup>[8]</sup>. Caniggia also proposed a multi-layer urban form structure, covering layers from materials to the city. The third theory was proposed by Karl Kropf and was constructed based on the structure of logical type developed by Alfred N. Whitehead and Bertrand A. W. Russell. In fact, Kropf roughly follows the methodology of the Muratorian School, both viewing the built environment through the process of formation<sup>[9]</sup>, hereinafter referred to as “the construction perspective”. Although all three theories face compatibility problem, each lays part of the foundation for urban morphology and may contain reasonable factors for a more compatible model.

## 2 Different Perspectives and Structures

### 2.1 Historical Geography Perspective

Conzen regards townscape as a combination of town plan, pattern of building forms, and pattern of urban land use. Further, town plan contains three distinct complexes of plan elements: streets and their arrangement in a street-system, plots and their aggregation in street-blocks, and block-plans of buildings<sup>[1]</sup> (Fig. 1). By analyzing the development history of a certain settlement, areas that have a unity in respect of their plan elements that distinguish them from surrounding areas are delineated as morphological regions<sup>[10]</sup>. Following this time series analysis and clustering method that characterize geographical research, the plan of a town can be divided into several orders of plan-division. The first-order plan division follows the boundary of the old town and the inner fringe belt. The second-order plan division refers to fringe belts—the remnants of the former urban fringe characterized by large

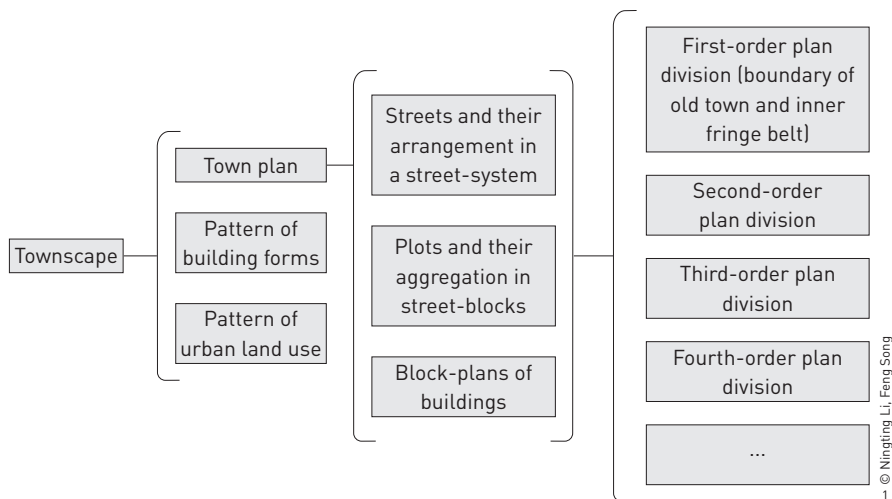


Fig. 1 Tripartite division of townscape proposed by Conzen.

and irregular plots and wrapped by later expansion of residential areas. Although focusing on urban form, Conzen emphasizes the functional aspect of the built environment and introduces the concept of agents—individuals and institutions that shape the urban form, including royal authority, urban planners, property owners, and architects<sup>[11-12]</sup>.

In general, the historical perspective focuses on what different cases really are and scrutinize their own historical process. Although Conzen identifies several universal morphological phenomena, there are no fixed correspondences between four tiers of urban subdivision and specific phenomena. Besides, Conzen mainly focuses on residential buildings but pays little attention to institutional buildings, such as castles, schools, and factories. Moreover, Conzen separates town plan and building fabric and relies heavily on the former. These basic settings are problematic in different cultures.

## 2.2 Construction Perspective

Although the Muratorian School claims to be inspired by Biology, actually both Caniggia and Kropf take a construction perspective that rooted in the architects' daily work. Caniggia breaks up building components into four scales: systems organism, structure systems, elementary structures, and elements. Each term interrelates with others on an immediately larger or smaller scale, forming a component-compound relationship<sup>[13]</sup>. At the building scale, the four terms correspond to building materials, structures (e.g., floor, wall), rooms, and buildings, while at the city scale, they correspond to buildings, tissues, districts and parishes, and city<sup>[13]</sup>. With the common layer of "building," the entire hierarchy contains seven layers (Table 1). However, in a more diverse built

Table 1: Urban form structure proposed by Caniggia

Layer	Scale		Corresponding elements
	City	Building	
1	Systems organism	—	City
2	Structure systems	—	District, parish
3	Elementary structures	—	Tissue
4	Elements	Systems organism	Building
5	—	Structure systems	Room, staircase, etc.
6	—	Elementary structures	Floor, wall, partition, roof, etc.
7	—	Elements	Material (bricks, beams, etc.)

environment, the conflation of scales arises: one layer may contain several types of form units with different complexity; for example, both a single terrace house and an entire terrace can be regarded as the term of "building." Besides, the definition of higher layers above tissue is rather vague. In different cases, the top two layers could be quarter and city, or city and territory<sup>[9]</sup>. Similar to Conzen, Caniggia also lays aside special buildings and mainly focus on residential buildings.

In order to improve Caniggia's theory, Kropf attempts to entirely separate the functional and morphological aspects and examines the urban form in terms of a rigid part-to-whole relationship. This results in the proposal of a more consistent hierarchy containing at least nine layers<sup>[9,14]</sup> (Table 2). Kropf's theory demonstrates the advantages of form-based planning due to its consistency. However, it encounters an incompatibility problem between different types of urban form. As amendments, the "coextensive layer" and "intermediate layer" are introduced, the former applies to forms that occupy several layers, such as a one-room building that occupies a room layer and a building layer simultaneously; while the latter is a layer that lies between two major layers.

Despite several differences in detail, both Conzen and Caniggia build their theories on European medieval towns and seek to understand how they came to be<sup>[9]</sup>. However, due to the differences

**Table 2: Urban form structure proposed by Kropf**

Layer	Term	Corresponding element
1	<i>Complures</i>	Combinations of objects from layer sedes
2	<i>Sedes</i>	Combinations of plan-units
3	<i>Textus</i>	Tissue/plan-units
4	<i>Sertum</i>	Plot series/block/street
5	<i>Fines</i>	Plot
6	<i>Aedes</i>	Building
7	<i>Tectum</i>	Room
8	<i>Statio</i>	Structural element
9	<i>Materia</i>	Building material

in how urban space is organized in different cultures, urban structures extracted from traditional European towns may not be compatible with other cultures. Kropf develops classical theories and inherits such a Eurocentric and nostalgic standpoint, which is the cause of the compatibility crisis.

To eliminate the particularity of specific culture, and derive a more general rule, Conzen emphasizes cross-cultural comparison<sup>[7]</sup>. However, overcoming the cultural unconsciousness is never easy.

### 3 The Challenge of Cross-cultural Comparison

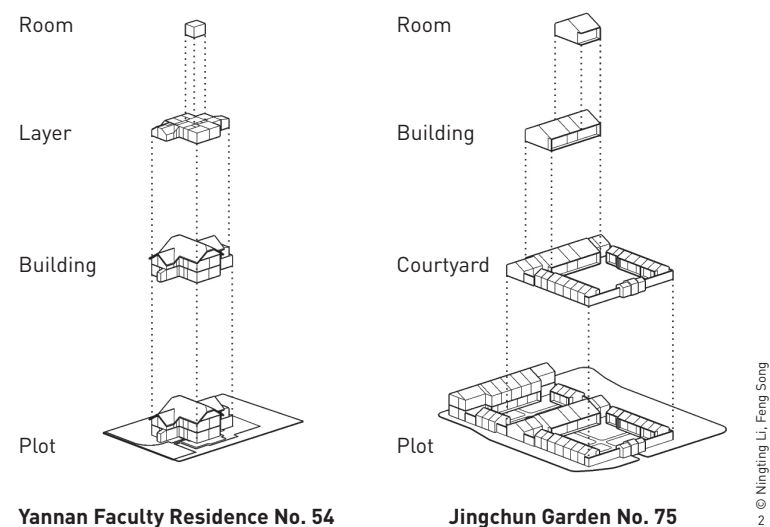
The cultural difference lies in the distinct ways through which people in different regions and historical periods have organized spaces to fulfill their functional demands. Although form and function are interdependent, form does not necessarily follow function at fine scales once a structure has been built<sup>[15]</sup>. The complex relationship between form, culture, and function gives rise to the intricate nature of morphology theory. However, several hints for a potential solution could be found in the incompatibility of classical frameworks and their setting.

#### 3.1 The Historical and Regional Incompatibility

In the regional dimension, even in the same historical period, towns in different regions can vary from each other<sup>[16]</sup>. Taking a Western European detached house and a traditional Chinese

residence (a case from Peking University campus) as examples, the former usually consists of a single building on a plot, which expands vertically to accommodate the whole family (Fig. 2), while the latter consists of several courtyards, expanding horizontally to reach equivalent capacity. In terms of complexity, the “courtyard” in Chinese residence roughly corresponds to the “building” in the Western context, but according to commonly accepted concepts, “building” in both cases should be at the same level. Since building techniques and traditions differ across cultures, similar paradoxes may exist in other regions as well.

In the historical dimension, firstly, with the increasing division of labor, institutional plots or special building such as shopping malls, office buildings, and hospitals appear in large numbers in modern cities, to which both Conzen and Caniggia pay little attention. Secondly, progress in modern building technology and social organization enables human to reorganize space at a larger scale, creating new urban form entities such as megastructures, gated communities, and “danwei”<sup>①</sup>, which cannot be accommodated within the classical urban form structures. It is difficult to determine whether the area within a danwei should be counted as a single plot or several plots, or whether there is any difference between the traditional houses and modern row apartment buildings or megastructures (Fig. 3). Thirdly, Conzen builds his theory mainly on the development of the town plan over time, but in modern cities,



**Fig. 2** Comparison between a detached house and a traditional Chinese residence.

① “Danwei” is also known as the “work unit,” which used to be the basic unit of social organization and urban form in China. It is usually an integrity of workplace and living space.

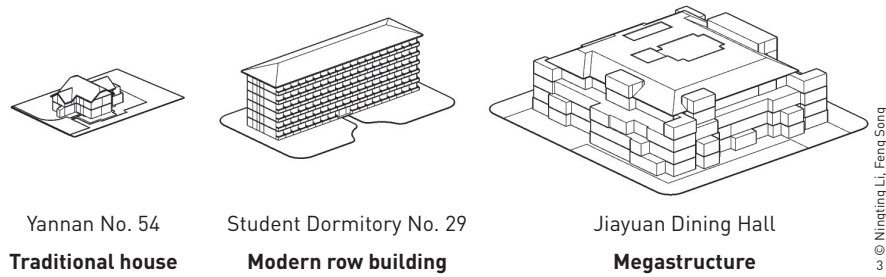


Fig. 3 Morphological entities of different size and complexity.

construction is under strict planning control, and the evolution of urban form mostly happens inside buildings, while the buildings' appearance and their footprint on the town plan remain relatively stable. Therefore, town plan analysis alone may fail to capture the actual development of modern cities.

Furthermore, numerous individual and small-group actions that accumulate to form the city are governed by cultural traditions and shaped by social and economic forces<sup>[17]</sup>. As development paths vary across regions, the resulting urban form structure seems disparate. From the perspective of historical geography, cities with longer histories may generate more complicated urban forms and therefore have more layers of urban form subdivision. Besides, in developing countries, modern urban form originating from Western culture replaces original local built environments in less consistent ways<sup>[18-19]</sup>. Especially in China, public ownership of land enables the replacement of original urban form with less resistance, facilitating the amalgamation and subdivision of plots as well as large-scale redevelopment<sup>[20]</sup>. Urban forms generated in that way usually contain heterogeneous patches in urban tissue. Given the variety of historical process, without several robust and reasonable benchmarks, it is difficult to compare various morphological regions.

### 3.2 The Paradox of the Definition of Layer

As for incompatibility, the notion of layer concentrates most of the conflict. The cause of this problem is rooted in the paradox that urban form units, such as city, plot, building, and room, are defined not only by part-to-whole relationships but also by their concrete functions. Most morphologists take these units as universal layers, build their theories directly upon them, and regard them as fundamental elements with general consensus<sup>[14,17]</sup>, yet still encounter incompatibility problems. In certain cultures, these layers are taken for granted, while in others they differ significantly (Fig. 4). Kropf recognizes this problem but moves to the other

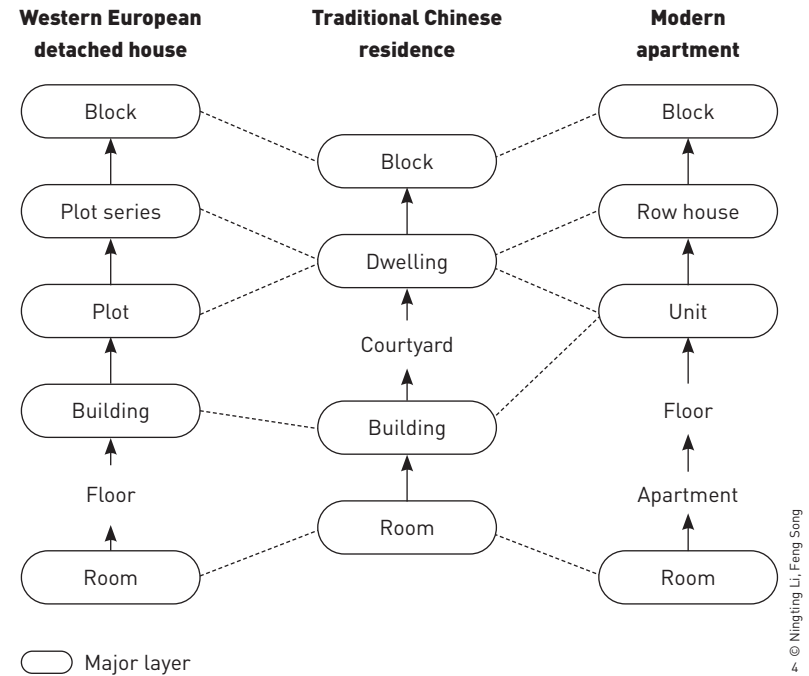
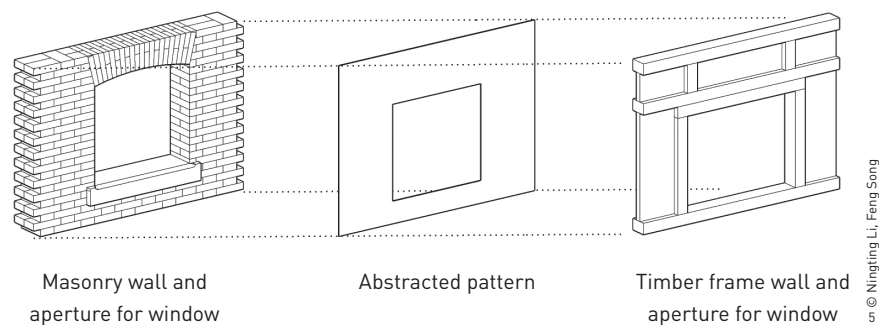


Fig. 4 Actual compositions of layers of different urban form entities.

extreme by attempting to eliminate the functional aspect entirely in the definition of layers. To alleviate the tension caused by rigid definitions in cross-cultural comparison, Kropf defines layers solely by part-to-whole relationships, introduces “coextensive layer” and “intermediate layer,” and regards a “layer” as a position to be occupied<sup>[9]</sup>. Although being feasible, this rectification obscures the meaning of each layer and leads to arbitrariness in layer setting. By analogy, if elements in layer A are composed of elements from layer B, and the same applies between layers B and C, then elements in layer A could also be viewed as compositions of elements from layer C directly, making the necessity of layer B questionable, especially in the case of coextensive layers. Conversely, there could be numerous layers between any two layers. To better resolve this paradox, the relationship between form and function should be reconciled.

### 3.3 The Mismatch of Construction Perspective

Besides the definition of layers, the construction perspective breaks urban form into building structures and materials. However, different building materials construct rooms in distinct ways according to their physical properties, generating another type of incompatibility. For example, in wooden structures, apertures such as windows and doors are constructed using wooden frames, while in masonry structures they are formed directly by materials (Fig. 5). Despite these structural differences, the spaces that fulfill human needs, such as doorway, room, and building, remain consistent.



**Fig. 5** Wall and aperture in different building systems.

Although workers use building materials to construct structures, the enclosed space is the true purpose of construction. In Chinese, “space” is translated as “emptiness in-between (空间),” which better illustrates the nature of the built environment. Although materials and structures are important elements of morphological analysis<sup>[10,21]</sup>, it is more appropriate to categorize them under aspects such as technique or decoration rather than urban form structure.

At the other end, the definition of higher layers is also unclear. Following the part-to-whole relationship, the hierarchy could theoretically extend infinitely in either direction<sup>[9]</sup>. Under this assumption, several layers may exist above the block layer; however, their specific meanings and morphological boundaries remain vague. This mismatch stems from the separation between form and the mechanisms that shape it. From the perspective of morphogenesis, higher layers are usually designated by administrative structures or emerge from the convergence of adjacent lower-level divisions, which is beyond the control of a single household.

An extreme construction perspective that excludes functional aspects also leads to the neglect of connective spaces (e.g., streets). Street system plays a key role in Caniggia’s case studies and is regarded as a driving force in the development of the built environment. However, it is not incorporated into the urban form subdivision, and the underlying connective relationship is not fully integrated into the theoretical framework. Since streets cannot be subdivided into smaller components and do not fit the part-to-whole structure, they are sometimes treated as residual spaces of plots.

## 4 Reconciling Form and Function

### 4.1 The Entangled Functional Aspect

Built elements are the result of interactions between humans

and the environment<sup>[9]</sup>. Urban form is therefore permeated with function from the outset, making it untenable to remove the functional aspect from the definition of form. In everyday usage, function is usually understood as the demand for activities to be located within a certain environment<sup>[15]</sup>, e.g., residential, commercial, administrative functions, and is therefore often treated as a topic of economic geography. In the field of urban morphology, the autonomy of form is underlined, and there is a common tendency to separate functional and morphological aspects. For example, Aldo Rossi criticizes naïve functionalism and stresses the persistence of form regardless of changes in function<sup>[22]</sup>. Indeed, with shifts in spatial demand, a detached house can be transformed into an apartment or hotel, and a warehouse into a shopping mall. Conzen also separates town plan from patterns of urban land use. However, as discussed in Section 2.2, this separation is never fully realized in classical theories, since function is already embedded in the definition of urban form units. Once Kropf attempts to separate further, other problems arise.

To construct a compatible urban form structure, the relationship between functional and morphological aspects should be reconciled, and the way in which function is involved in defining urban form units should be carefully examined. In the most fundamental sense, function could be viewed as the potential to fulfill human needs, while distinctions such as residential or commercial are secondary. What morphologists such as Rossi tend to overlook is that the persistence of form is also sustained by its capacity to accommodate diverse human activities, where deeper aspects of function are involved. Building upon this understanding, a more reasonable approach can be constructed by focusing on the basic spatial demands of agents (i.e., individuals or organizations that create or use urban space).

### 4.2 Separation, Connection, and Composition

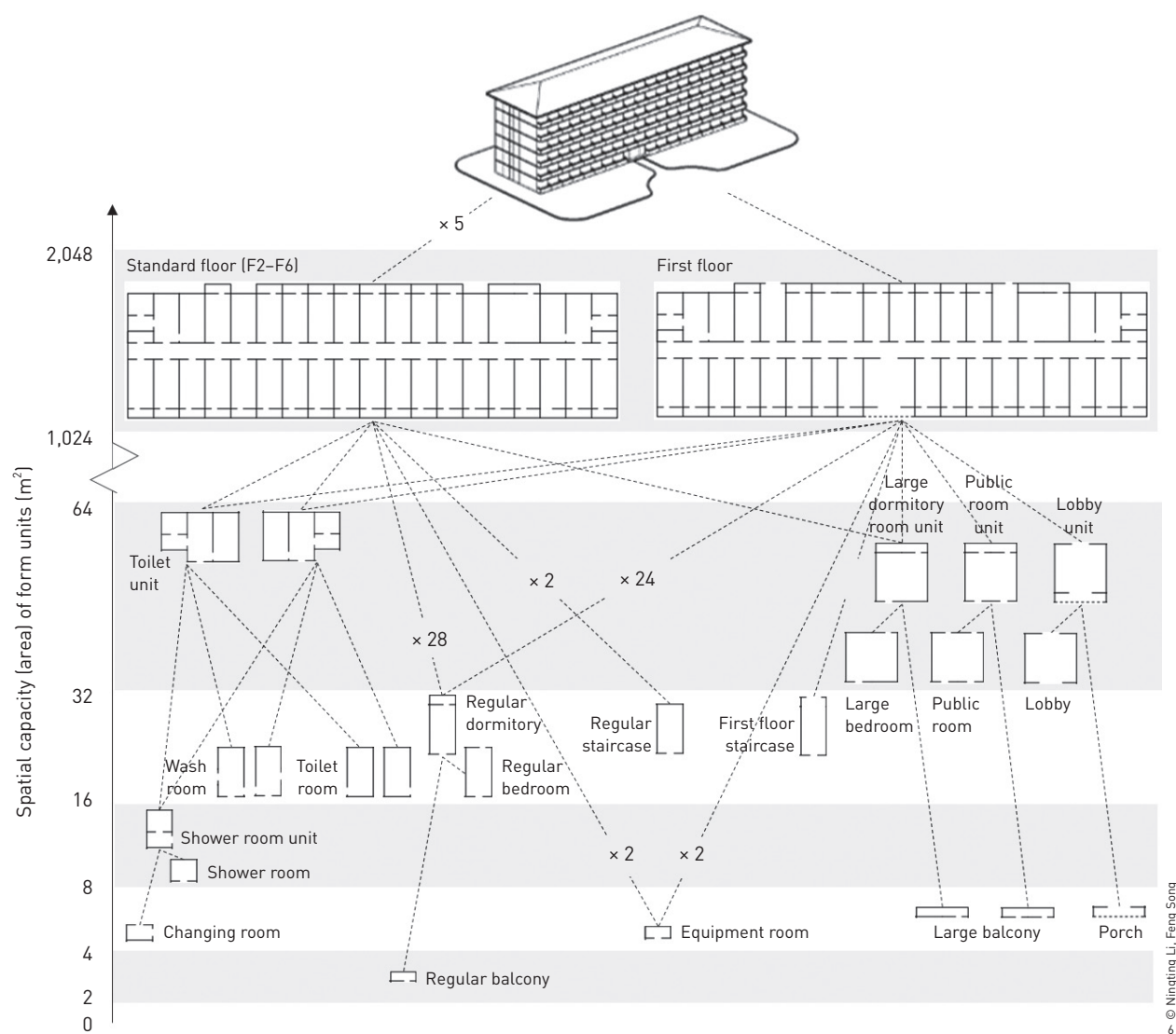
Regardless of several defects, the basic part-to-whole principle of the construction perspective is instructive. Although the visual image of cities can be greatly alternated, the basic pattern whereby small spaces aggregate to form the larger settlements remains unchanged. Settlements across regions and historical periods allocate land to individual agents for construction, while agents construct buildings with distinct combination of rooms according to their spatial demand. This composition pattern reflects the organization of human society. As social beings, humans aggregate into communities following certain patterns (e.g., family, company). Despite technological advances that give rise to megastructures, the compositional nature of human society remains unchanged.

Within this compositional relationship, separation and connection are essential properties of any aggregation. Smaller form units should be separated from the outside to ensure the exclusive use, while simultaneously connected to each other to generate larger forms that accommodate broader spatial demands. At smaller scales, the internal-external interfaces are delineated by walls, roofs, and plots. For example, a room is enclosed by walls, while maintaining connections to the outside through apertures like doors and windows. Similarly, floors are physically separated but connected via staircases. Introducing the criteria of separation and connection may make up for the logic flaw in fine-scale form subdivision. Any morphological entity that is internally well connected yet relatively isolated externally should be identified as a unit. Notably, connection is an indispensable requirement: space entirely inaccessible to uses, such as enclosed terraces, should not be considered effective spatial units.

Another issue related to connection concerns types of passage.

Conzen distinguishes the pseudo-streets from regular ones. The former emerge from plot subdivision, linking the new land-use units inside the original plots<sup>[1]</sup>. This distinction implies that pseudo-streets are usually private, while streets are generally public. In contemporary contexts, this private-public distinction can be extended to other morphological entities like multi-story buildings or large danwei. In these cases, the connection space (e.g., corridors, staircases, internal roads) are restricted to specific user groups, namely residents and danwei staff. When defining urban form units, such quasi-private passages should be viewed as indispensable parts of the entities they connect from the inside.

According to the criteria of separation and connection, the composition pattern of Student Dormitory No. 29 can be illustrated (Fig. 6). On each floor, every regular dormitory is separated by walls, but connected with corridor through the room door. Likewise, the regular dormitory can be further subdivided into a regular bedroom and balcony, which are separated by wall yet



**Fig. 6** Composition pattern of Student Dormitory No. 29.

connected through the balcony door. For each floor, the central corridor connects smaller units such as dormitories, toilet units, and staircase and makes them an integrated unit, while staircases connect adjacent floors to form the whole dormitory building. Due to insufficient separation, corridors cannot be recognized as form units; however, they should still be counted in the floor's area. Follow this method, the dormitory building plot can be divided into a hierarchical pyramid, with different units sorted by their area. Considering that the combination of smaller units often leads to a doubling of the total area, the Y-axis uses an exponential scale to cluster different units into several groups, better illustrating the spatial structure.

At scales above plot, the situation differs. Major roads, usually public, facilitate connections between plots while also acting as barriers or borders. In planning practice, highways are deliberately designed as buffers to ensure the physical and social integrity of each neighborhood<sup>[23]</sup>. However, except for roads, there are rarely other explicit boundaries at higher scales. To define higher-level urban form units, it is necessary to reintegrate the functional aspect and refer to the concepts of "type" and "prototype," which are closely related to agents.

#### 4.3 Agents, Types, and Prototypes

Urban forms are the products of interactions among multiple types of agents. Caniggia's basic division, which regards buildings and the whole city as two scales, reflects the long-lasting administrator-resident dichotomy. Administrative agents, e.g., royal and ecclesiastical authority, divided land into plots, built castles, street system, and city walls, and regulated land sales and utilization through legislation, setting the framework for subsequent development<sup>[11]</sup>. Other agents, mainly residents, built within this framework, leading to diversified urban forms. Although Conzen notes that the defining characteristics of the higher-order groups have not been established, and no other specific characteristics are cited in the definition other than the relative internal homogeneity of plan morphology<sup>[9]</sup>, the top two tiers of plan divisions are clearly related to the role of administrators. With the periodical expansion of settlements, concentric structures emerge in the built environment, where each circle is the product of town-wide rearrangement led by administrators. Hence each circle in this structure should be viewed as a distinct unit, corresponding to the second-tier division.<sup>[24]</sup> Jeremy W. R. Whitehand further reveals the link between the periodic accretion of settlements and the development of transportation methods<sup>[24]</sup>, which could serve as a benchmark for cross-cultural comparison, since most

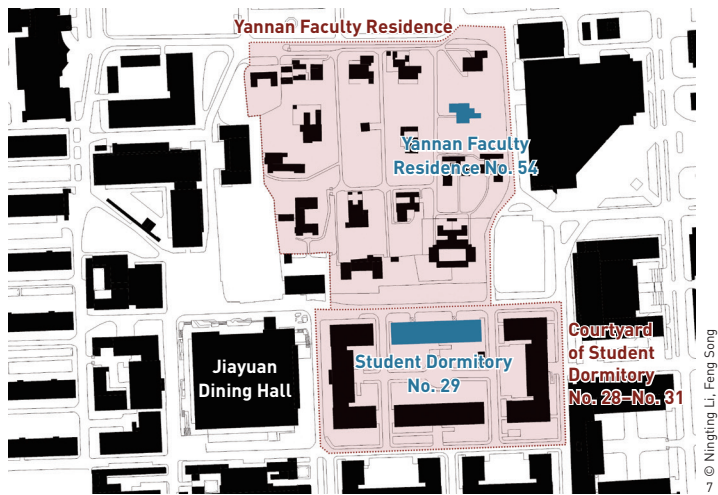
parts of the world have undergone several stages of transportation development. This second-tier subdivision also follows the perspective of connection, as different means of transportation represent distinct modes of connection and may leave traces in the composition patterns of the built environment.

The administrator-resident dichotomy is still valid in the contemporary context. However, technological development has enabled large enterprises and property developers to exert control over large land parcels such as large factory, residence community, and danwei. In terms of land ownership, such areas belong to a single plot but are equivalent to much larger areas consisting of several plots in traditional settlements. The latter are usually identified by developers as types and used as prototypes in construction. As a result, these areas are also organized in a plot-like way. For example, in Peking University, the land around Yannan Faculty Residence is fully owned by the university and has never been subdivided into smaller plots, yet the actual construction resembles traditional towns; the same applies to the courtyard of Student Dormitory Nos. 28-31 (Figs. 7, 8). According to the criteria of separation and connection, these larger units consist of several "plot de facto," which are enclosed by continuous open space or outer walls and directly connected to public streets. Moreover, some of these areas may have tight internal connections between de facto plots with similar composition patterns but limited outward connections, thereby forming an integrated region and distinct tissues. Apart from large enterprises and property developers, urban planning and design institutions, as another type of agent, are also involved in the construction of these larger areas. Following prototypes such as neighborhood and cluster, urban planners assign development permissions and thereby shape the built environment.

During the development of settlements, agents shape the built environment according to their own spatial demands within the overall framework of the settlement, and adapt existing forms under cultural shifts. Over time, urban form is continuously shaped, identified, and reshaped, and the intersection of historical urban form units at different scales generates current urban form units. In general, administrators and residents (or users and developers responsible for individual plot de facto) remain the most universal agents across different regions and historical periods.

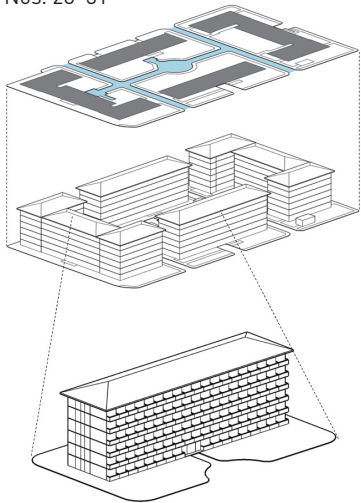
## 5 A Coordinated Approach

Based on the above discussion, it is possible to construct a coordinated approach using reasonable elements of classical theories (Fig. 9). First, the composition pattern, developed from the



#### Tissue

Courtyard of Student Dormitory  
Nos. 28–31



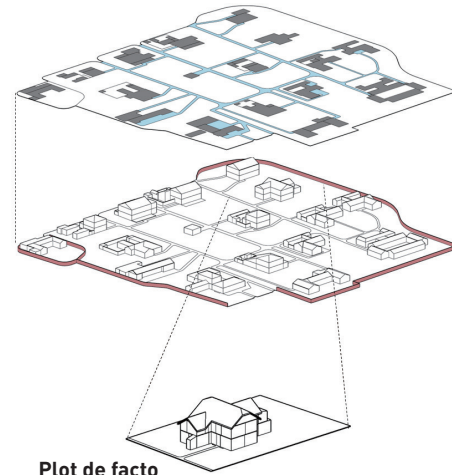
#### Plot de facto

Student Dormitory No. 29

Internal road    Courtyard wall    Block-plan of building

#### Tissue

Yannan Faculty Residence



#### Plot de facto

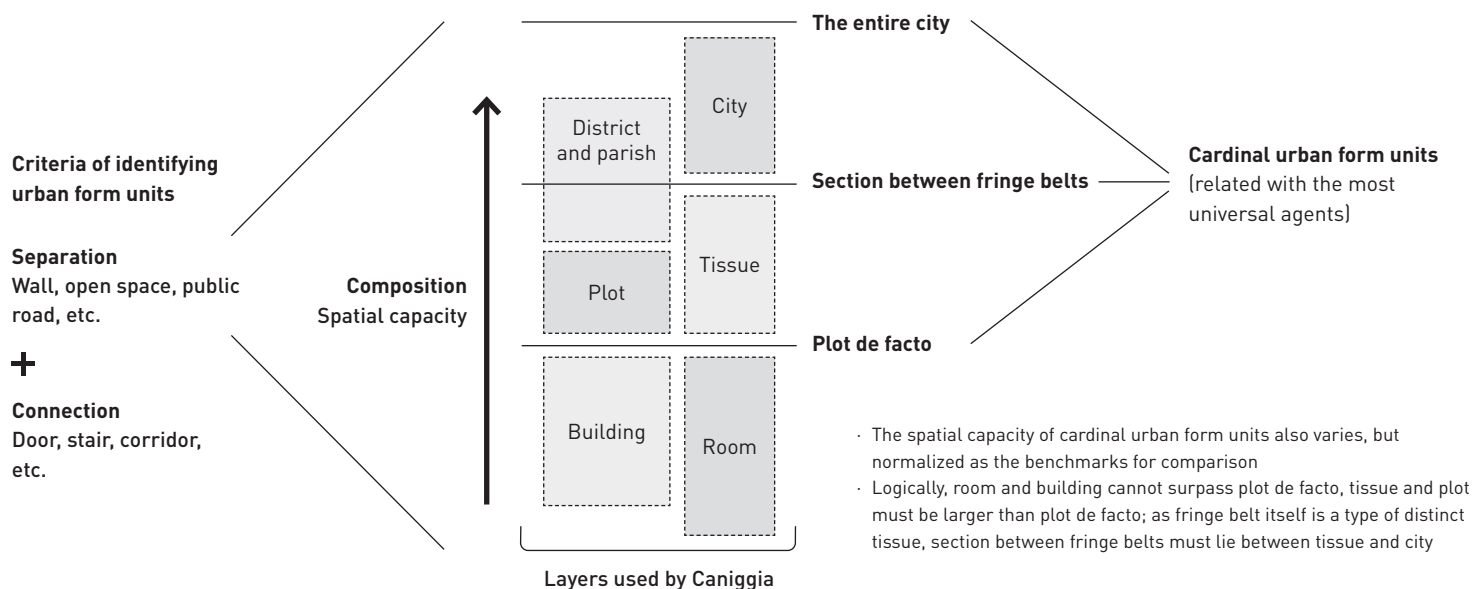
Yannan Faculty Residence No. 54

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construction perspective, can be established as the basic setting of the urban form structure; that is, smaller urban form units combine with each other in specific ways to form larger units. In specifying these urban form units, such as rooms, buildings, and plots, separation and connection are two criteria. Materials and structures, the first two layers in the construction perspective, should be excluded from the urban form structure, as they do not meet these criteria. Moreover, the whole city, sections between fringe belts, and plot de facto, which are extracted from the historical perspective and related to the most universal agents, can be established as cardinal urban form units to link high-level units with the forces that shape them and to set benchmarks for cross-cultural comparison.

### 5.1 Composition Pattern

Given the large differences in the way urban form units aggregate in different cultural backgrounds, it is necessary to discard preconceived morphological hierarchies or fixed layers, and instead focuses on composition patterns. Although this approach looks similar to the construction perspective that follows the way materials construct a building, the composition perspective instead focuses on the composition of space that accommodates human activities and emphasizes that the size of urban form units may affect their role in the built environment. Compared with a rigid layer hierarchy, the composition pattern allows a more flexible structure. The components of certain urban form units may not span all layers, and units at a given layer are not necessarily composed of units from the next lower layer. Besides, the diversity of urban form structures means that the spatial capacity of preconceived concepts



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**Fig. 7** Building footprints of buildings in and around Yannan Faculty Residence.

**Fig. 8** Two typical tissues on the campus. Both examples consist of several parts that are similar in composition pattern and connected closely with each other, to fit the spatial demand of certain groups.

**Fig. 9** The conceptual diagram of the coordinated approach.

covers a relatively large range, and different concepts may overlap in capacity, as shown in Fig. 9.

Compared with the historical geography perspective, the coordinated approach based on composition patterns is more integrated. Conzen's tripartite division is essentially a description of composition patterns in different dimensions: the pattern of building fabric reflects the connection between buildings and vacant areas inside plots, and the pattern of plots as well as the street system reflects the connections between plots. Therefore, through the analysis of composition patterns, building fabric can be integrated with plan analysis in a systematic way. Nevertheless, Conzen's emphasis on the town plan indicates the importance of the footprint of urban form units. Given the effect of gravity, humans live on flat surfaces; the town plan forms the inescapable framework for man-made features and provides the physical link between them<sup>[1]</sup>. Therefore, it is appropriate to use the area of each form unit, rather than volume, as an indicator of spatial capacity.

## 5.2 Agent-Referred Division

Since urban form is resulting from human activities, when specifying urban form units, the agents that shape the form should also be considered. Theoretically, there are two types of urban form unit: 1) intentional units, which are created by deliberate design or control over a large land parcel; and 2) emergent units, which are adjacent areas built at the same time or under the same constraints, or shaped by a common process of transformation<sup>[17]</sup>. For intentional units, administrators of the entire city and the residents or users of single plots (plots de facto) are the most common agents. Regardless of regions or historical periods, towns and cities follow an administrator-resident dichotomy as living spaces of groups for people. Therefore, the whole city and the fringe belts shaped by administrators, as well as the single plot de facto that shaped by residents or users, are established as cardinal urban form units. In addition to these cardinal units, there may be non-universal units, such as danwei, gated community, and neighborhood, which lie between cardinal units. When comparing urban forms across different cultural backgrounds, cardinal urban form units from different cases should be placed in parallel positions.

It should be emphasized that, in terms of morphology per se, every urban form unit has its own particular morphological characteristics. Urban form subdivision should be based on both the agents and the similarity of urban form structures. Especially when historical records concerning agents are insufficient, the analysis of urban form characteristics per se is more reliable.

Generally speaking, emergent units are characterized by similarity among plots or plot de facto, while intentional units usually consist of different types of urban form units combined according to specific patterns. Furthermore, to assist the demarcation of urban form types, a quantitative analysis method based on the composition patterns can be constructed, as discussed below.

## 5.3 Capacity-Quantity Plot and Matrix

Traditional urban form research relies on qualitative analysis and depends heavily on researchers' experience. However, in cross-cultural comparison, differences in cultural background and the unprecedented size of modern cities may reduce the reliability of manual analysis. Since the 2013 International Seminar on Urban Form (ISUF) conference, the application of quantitative analysis techniques has been regarded as one of the paths to further develop urban morphology. From 2010 to 2019, the continuous publication of articles and monographs marks the growing momentum of quantitative analysis<sup>[25]</sup>. In this field, space syntax is the forerunner, but in modern society, where the scale of space is largely reorganized, its reliance on topology and neglect of distance and scale can be misleading under certain conditions<sup>[26]</sup>. Most other current morphometrics are based on public appearance features extracted from satellite images and OpenStreetMap data<sup>[27]</sup>. However, as mentioned above, a large part of urban form evolution in modern times is not reflected in appearance, so these metrics may miss implicit morphological differences.

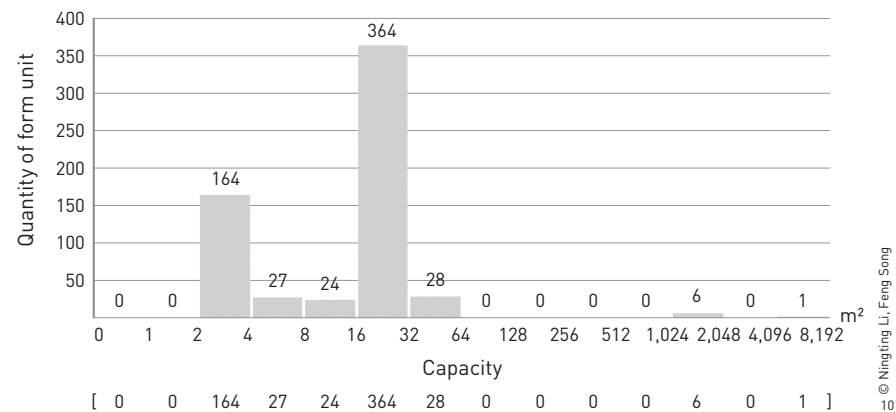
According to the compositional nature of urban form, it is possible to propose a new metric to make up for the shortcomings of current methods. Given that the differences in urban form mainly depend on the composition patterns of form units with different capacities, it is feasible to use the quantity of form units within different area ranges as an indicator. Due to the cumulative nature of composition, in which larger units may be several times larger than their components, breakpoints in exponential form may better capture the structure, such as 2, 4, 8, 16, and so on. Given that the plot is a common analytical unit for both research perspectives, the coordinated metric could be mainly based on the cardinal units of plot de facto. Taking the plot of Student Dormitory No. 29 as an example, according to the form subdivision, the area of the smallest units falls within the range of 2–4 m<sup>2</sup>, including 28 regular balconies on each standard floor and 24 regular balconies on the first floor, totaling 164. Likewise, the range of 16–32 m<sup>2</sup> contains the largest number of form units: each floor has 28 dormitories, 28 bedrooms (24 on the first

floor), 2 washrooms, 2 toilet rooms, and 2 staircases, totaling 364. Taking spatial capacity as the horizontal axis and quantity as the vertical axis, a capacity–quantity plot (CQ plot) can be derived from the above calculation. For the convenience of cluster analysis, the chart can also be expressed in matrix form, as shown in Fig. 10.

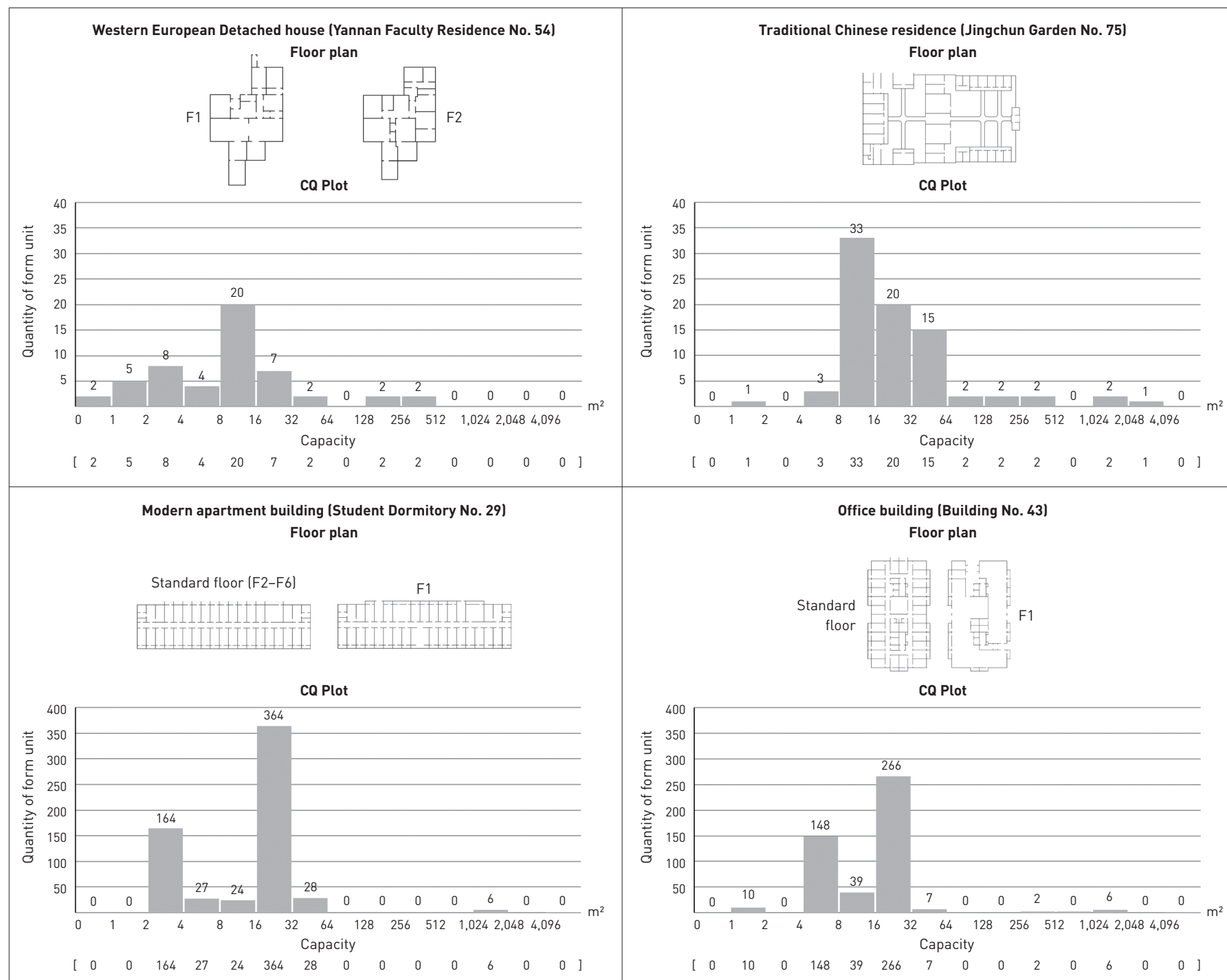
Similarly, the CQ plots and matrices of four typical buildings (each occupying a single plot de facto) can be calculated (Fig. 11). These

**Fig. 10** The CQ Plot and matrix of Student Dormitory No. 29.

**Fig. 11** Typical building styles and their plans, CQ plots and corresponding matrices.



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examples represent four distinct building styles on the campus of Peking University: Western European detached house, traditional Chinese residence, modern apartment building, and office building.

As shown in the chart, the two residential buildings above both have a peak in the CQ plot within 8–16 m<sup>2</sup>, which is suitable for one or two persons. Yunnan No. 54 has more smaller units, whereas Jingchun Garden No. 75 has more larger units such as courtyards. In contrast, Student Dormitory No. 29 and Building No. 43 both have a peak within 16–32 m<sup>2</sup>, which is suitable for more than two persons. In addition, due to their larger capacities and more layers, these two buildings have a longer tail in the CQ plots. By conducting cluster analysis using SPSS, the four buildings are grouped into several clusters (Fig. 12). This result shows similarity within groups but indicates larger differences between traditional residences and modern multi-story buildings. Similar analysis can be applied to smaller units or to larger units separated by public spaces or high-order roads, such as plots, blocks, and danwei.

Similarity between adjacent urban form units is one of the fundamental criteria for demarcating larger urban form units. As shown in Fig. 8, Student Dormitory No. 29 and three neighboring plots de facto, which have similar composition patterns and are closely connected, form a larger homogeneous urban form unit. Likewise, several plots de facto similar to Yunnan No. 54 form the Yunnan Faculty Residence. The clustering results also indicate that there should be a clear boundary between the dormitory courtyard and Yunnan, since the Student Dormitory No. 29 and Yunnan No. 54 are clearly classified into different morphological types.

#### 5.4 Inspirations for Urban Design

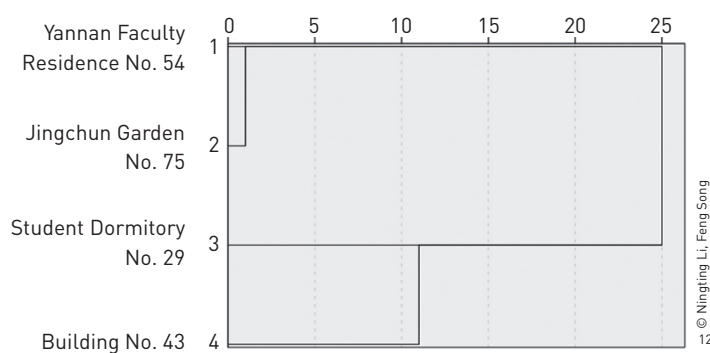
Urban form structure is not only central to describing and interpreting the urban landscape, but also forms the basis for

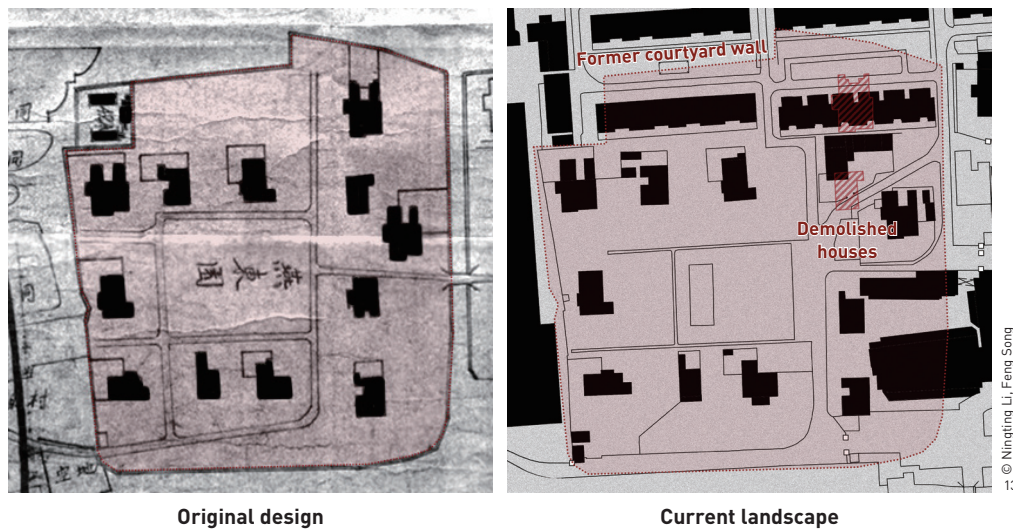
its management. So far, this article has mainly discussed the description and analysis of urban form. In the field of urban design, the coordinated approach can also inform design strategies.

For heritage conservation, widely adopted form-based coding emphasizes the appearance of buildings and streets, but the coordinated approach indicates that the relative homogeneity of smaller components' composition patterns is also important, including the total capacity of plots de facto and their internal structure. Arbitrary alteration of internal structure can also lead to the loss of heritage value. Meanwhile, with the improvement of residents' living standards, increasing conflicts arise between heritage conservation and modern development, including the construction of megastructures and modern apartment buildings. As illustrated by the coordinated approach, to maintain the homogeneity of the whole region, it is necessary to divide large-scale urban form units into several plots de facto. However, this does not mean that authorities should rigidly preserve original internal structures and reject change. Instead, the composition pattern allows a certain degree of variation, and urban form components with similar composition patterns should also be accepted.

Besides, the coordinated approach also indicates that connection and separation are fundamental properties of any urban form units. By enhancing or diminishing these two properties, designers can influence the public perception, and further promote or weaken the sense of community. In cases where integrality needs to be demonstrated, relative separation from the outside and a tight internal connection should be encouraged, such as a denser internal road system, centripetal connection of smaller urban form components, and limited outward entrance/exit. While opposite strategies will weaken the integrality of surrounding area, like adding more outward entrance or cutting down internal roads. In this regard, Yandong Faculty Residence provides a typical example. Similar to Yunnan, it was originally designed as a relatively enclosed courtyard. However, subsequent construction of row apartment buildings, teaching buildings, and a new outward road in the north and east of the site opened the courtyard with multiple new entrances and led to the demolition of most of the courtyard walls. Moreover, the row apartment buildings differ from the original Western detached houses in terms of composition pattern. Consequently, the courtyard is now almost unrecognizable in the current landscape (Fig. 13). From an urban design perspective, such a situation is devastating for similar historical areas and should be carefully avoided. However,

Fig. 12 Clustering result of the four typical buildings in Peking University.





**Fig. 13** The original design and current landscape of Yandong Faculty Residence.

for negative urban spaces, such strategies may help reconnect them to the public and stimulate transformation.

## 6 Discussion and Conclusions

There is a complicated relationship between form and function. Morphologists hope to study the universal laws of urban form separately, but urban form and its evolution are shaped by the spatial demands of human beings in the first place. In different cultures, the composition patterns of form vary. This tension results in the incompatibility of urban form structures. Following the aggregative nature of human society, urban form units of different scales have the potential to meet the demands of groups of different sizes. Based on this understanding, this article revises the classical urban form structure, partly accepts the part-to-whole principle, but modifies the construction perspective to a compositional perspective, where preconceived concepts based on traditional European towns are deemphasized, and the two lowest layers, namely materials and structures, are excluded. Moreover, aside from compositional relationships, the criteria of separation and connection are added to make up for the unclear definition of urban form units and the neglect of roads. Based on the new approach, a quantitative analysis method is also proposed to aid in urban form subdivision.

It should be clarified that form and function are closely related but relatively independent, and the re-integration of function into the definition of form does not mean that morphology has lost its independence as a unique research field. On the contrary, morphological analysis helps researchers understand the shaping factors of urban forms in different periods and regions, as well

as the integration and alienation of specific forms in urban development; it also helps coordinate the tension between shifting needs and relatively stable urban forms. Due to theoretical limitations, the current application of morphology in planning is limited to describing and imitating historical urban forms, whereas morphology would have greater potential if connected with functional aspects. In the future, morphology-based urban landscape design can be further developed through urban form structure and typology analysis.

**Competing interests** | The authors declare that they have no competing interests.

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# 应对跨文化比较中的城市形态结构不兼容性： 基于经典形态学理论批判的协调方法

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## 摘要

城市形态学旨在描述和解释城市形态, 具备应用于城市规划和景观设计的潜力。然而, 经典理论采取欧洲中心视角, 限制了理论的有效性, 进而制约了其在当今多元文化背景下的设计实践。其中, 缺乏普适的城市形态结构刻画方法是这一理论的基本缺陷之一。本文探讨了城市形态结构的跨时空不兼容性, 并通过分析城市形态学的两类基本视角讨论了不兼容性的根源所在。基于对经典理论的批判, 将“隔离”和“连接”确立为识别城市形态单元的两个基本准则, 并强调建成环境的组构特征。在此基础上, 通过调和功能和形态维度(即将城市形态与塑造其形态的操作者相关联), 吸纳经典理论中的合理成分, 本文提出了一种刻画城市形态结构的协调方法及相应的定量分析手段, 即将不同尺寸形态构成单元的数量分布作为辅助城市形态划分的关键指标。

## 关键词

城市形态学; 城市形态; 城市结构; 不兼容性; 跨文化比较

## 文章亮点

- 探讨了经典理论中城市形态结构的跨时空不兼容性
- 从经典理论的两类基本视角出发探讨城市形态结构不兼容性
- “隔离”“连接”及组构特征是识别城市形态单元的基本原则
- 提出了一个刻画多样的建成环境的协调方法和定量分析手段