Dissertation

A Comparative Study on the Facades and the Floor Plans of Traditional Town Houses in Taiwan by Shape Grammars with Selected Examples from Steyr and Innsbruck in Austria

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Abstract

A comparative study of traditional town houses is significant and useful for the preservation of cultural assets in many European and Asian countries. The most interesting fact is that the traditional town houses, both in Taiwan and Austria are representative of the features of indigenous folk culture, dwelling styles and businesses. They were located all over in the old towns and played an important role in offering commercial space for almost all historical communities.

Taiwan, a small country with a history of only four hundred and fifty years, demonstrates the influences of Europe, Japan and China in her traditional town houses. Traditional town houses from four Taiwanese historical areas extending north to south have been chosen, which are Dihwa street in Taipei, Daxi, Lukang and Xinhwa, for the purpose of performing comparisons. Austria has a brilliant architectural tradition and heritage which is not only evident in public architecture but also represented well in its traditional town houses. In this comparative study, some traditional town houses from Steyr (Upper Austria) and Innsbruck (Tyrol) have been selected as examples.

The main methodology used is shape grammar, which can analyze form and style by applying shape language. Shape grammar is a branch of architectural morphology which is a study that analyzes forms and spaces in architecture. Shape grammar has been applied to explain the facades and floor plans of traditional town houses with chosen examples. It is presented in a series of rules that are derived from considerations of traditional processes of design and construction as well as from cultural influences. In this research we see that geometry has acquired the same scientific significance that has been processed by mathematics, which can also support architectural taxonomy.

The historical and geographical backgrounds have been retraced as overtures to the study of the traditional town houses. The literary review in Chapter 2 helps us to build up a good understanding of traditional town houses from the existing researches. In this research, the elements to be compared in the facades and floor plans of traditional town houses would be set up as rules for these shape grammars. The shape grammars for the facades and floor plans of Taiwanese traditional town houses will be first developed in Chapter 3 and 4, and subsequently for Austria in Chapter 5. The results of the comparisons of the facades and floor plans will be precisely listed in tables.

This research brings us into a world of shape language which is better than text to explain architectural forms and also provides concepts for projects while also being free to be generated by all architects themselves. This can be practical for recording and rebuilding the models of the architectural tradition. Therefore I believe this is the mystery, charm and satisfaction of carrying out architectural design and research with individual shape language. Through this language, it is easier to pursue both modern as well as traditional architecture.

Zusammenfassung

Ein Vergleich historischer Stadthäuser ist wichtig und sinnvoll zur Erhaltung des kulturellen Erbes in vielen europäischen und asiatischen Ländern. Die interessante Tatsache dabei ist, dass sich an traditionellen Stadthäusern, sowohl in Taiwan als auch in Österreich, Kennzeichen der einheimischen Volkskultur, des Wohnstils und der Wirtschaft ablesen lassen. Diese Häuser sind an vielen Plätzen in historischen Städten zu finden und boten Raum als Handelsplätze für fast alle historischen Gesellschaften.

Taiwan - ein kleines Land mit einer Geschichte von nur 450 Jahren - zeigt europäische, japanische und chinesische Einflüsse in seinen historischen Stadthäusern. Für die folgende Arbeit wurden historische Stadthäuser von geschichtsträchtigen Regionen, welche sich von Norden bis Süden des Landes erstrecken, ausgewählt. Es wurden die "Dihwa street" in Taipeh, sowie die Städte Daxi, Lukang und Xinhwa zum Vergleich herangezogen. Österreich hat eine sehr reiche architektonische Tradition und ein bedeutendes historisches Erbe, welches sich nicht nur in der öffentlichen Architektur, sondern auch an historischen Stadthäusern zeigt. In dieser Studie wurden die Städte Steyr (Oberösterreich) und Innsbruck (Tirol) als Beispiele ausgewählt.

Die dabei angewandte Methodologie wird unter dem Begriff "Shape-Grammar" (Formgrammatik) zusammengefasst. Mit Hilfe dieses Ordnungssystems können Form und Stil durch eine angewandte "Shape Language" (Formsprache) analysiert werden. "Shape Grammar" ist ein Zweig der Architekturmorphologie, welcher sich mit der Anaylse von Formen und Räumen in der Architektur befasst. "Shape Grammar" wurde hier angewandt, um Ansichten und Grundrisse von traditionellen Stadthäusern anhand angewandter Beispiele zu erklären. Die Darstellung erfolgt anhand einer Reihe von Regeln, die sowohl von der Betrachtung traditioneller Prozesse von Design und Konstruktion als auch kultureller Einflüssen abgeleitet werden. In dieser vorliegenden Studie stellt sich heraus, dass Geometrie die selbe wissenschaftliche Bedeutung zukommt, wie Mathematik, welche auch als Unterstützung der architektonischen Taxonomie dienen kann.

Der Forschungsansatz besteht darin, die historischen und geographischen Hintergründe anhand der Stadthäuser zurück zu verfolgen. Das Literaturverzeichnis in Kapitel 2 soll zum besseren Verständnis von historischen Stadthäusern - ausgehend von der bereits vorhandenen Literatur zu diesem Thema - helfen. In dieser Studie werden Fassadenelemente und Stockwerkspläne von historischen Stadthäusern als Regelwerk für diese "Shape Grammar" herangezogen. Diese "Shape Grammar" wird für die Fassaden und Stockwerkspläne Taiwanesischer historische Stadthäuser in den Kapiteln 3 und 4 erarbeitet und für Österreich im Kapitel 5. Die genauen Ergebnisse dieses Vergleiches von Fassaden und Stockwerksplänen werden in Tabellen genau aufgelistet.

Die folgende Studie ist als eine Einführung in die Welt der Formgrammatik zu verstehen. Sie ist deshalb einem Text vorzuziehen, weil sie die Unterschiede in der Architektur besser erklärt und gleichzeitig Konzepte für Projekte bereitstellt, welche außerdem auch von Architekten für eigene Projekte generiert werden können. Somit ist sie anwendbar für die praktische Arbeit des Erfassens und Umwandelns von Modellen der Architekturgeschichte. Dies ist gleichzeitig Geheimnis und Charme, welche dem architektonischen Design und der Forschung an der "Shape Grammar" entspringen einer Sprache, welche das Erfassen moderner und historischer Architektur erleichtert.

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Mr.Scheifele of the Bundesdenkmalamt deserves much gratitude for allowing access to Bundesdenkmalamt for around two weeks that enabled me to make the much needed digital photographs of the old drawings of the facades & floor plans of traditional town houses in Krems, Steyr, Salzburg and Innsbruck. Many thanks again to Mag. Ulrike Pfau, Bundesdenkmalamt Abt. f. Inventarisation u. Denkmalforschung who provided invaluable assistance in checking out the histories of the traditional town houses in Steyr.

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Yuchen Sung
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Chapter 1

Introduction

1.1 The motive and the purpose of this research

Ever since the time of Vitruvius, there has been a recorded tradition of spatial studies in architectural form. In Roman times, much of the scientific interest in the arrangement of spatial elements resided in analogy with musical phenomena. These studies were revived during the Italian Renaissance by the theoretical writings of Alberti. The architect Palladio made use of these concepts in creating a unique corpus of work in his villa project. Da Vinci explored the configurational possibilities of central-plan churches and in doing so he identified two broad equivalence classes - the Cyclic and Dihedral. On the basis of this, he has been attributed with the discovery of the point-symmetry groups in the plane. By specifying an angle between two lines and shapes, Da Vinci fixed the rules for generating central-plan building designs. He looked past a particular solution to a vista of equivalence classes in a typology.

Somehow there is a kind of graphical language which is better than text to illustrate architecture, which is able to demonstrate the differences between different kinds of architecture, making it possible to organize a structural system for a project. This enables it to be practical in recording and rebuilding the models of traditional architecture that can be freely available to be generated by all architects themselves. Therefore, I believe this is the mystery and charm of the world of architectural design. With this language it is possible to pursue both modern as well as old town housing architecture.

Modern shopping malls are very popular in metropolitan areas such as Los Angeles, New York, Toronto, Tokyo and Hong Kong, yet people are fascinated and drawn by traditional small shops in historical areas such as Vienna, Munich, Florence and Kyoto. While the former provides bright and fluent spatial forms with elevators and skylights, the latter spaces reveal to us a dream and a story of good old times through the historical spatial forms that connect cultures, festivals and memories.

That the 'boxes' in which human life evolved is the product of culture, economics and technology is presented in the architectural history. This can be observed in the transitional phase in which our culture passed from an agricultural to industrial society, that will aid us in our discussions and point to a relation between historical influence and form, between scientific technique and form and between form and formalism. Most of the time, current trends emerge and attempt to furnish us order and criteria of procedure. By day, structuralists created the structure of meaning and pondered over the meaning of structure. By night, deconstructionists pulled the cortical edifice down. And the next day the structuralists start all over again. Some of us either followed the above, or were confused and some even fed up with it. There is no way whatsoever to avoid the fashions of architectural compounds, for it is evident in high multi-storied structures in the cities and in endless new communities in the suburbs of towns. However we should examine and discern what and where these currents come from and how. Most of them are just historical cycles. The same pattern languages, by changing combinations, were analyzed and applied again.

For several centuries, many dwelling styles have existed all over the west and the east. They lent prosperity to the cities and towns, played an important role for the local trade, assisted children to grow up and set perfect environments for social lives of aged people. Preservation of traditional town houses has been an important issue in the conservation of cultural assets in many European and Asian countries. The most interesting thing is that the traditional town houses are representative of folk culture both in Austria and in Taiwan, especially traditional town houses with shops. They were spread out all over in old towns and played a very important role in commercial space in all historical communities.

The purpose of this dissertation is to develop a kind of shape grammar for traditional town houses in Taiwan as well as in Austria. A series of shape grammars for traditional town houses will be analyzed and developed for the purpose of comparisons of facades, floor plans, spatial characteristics and successive developments. It will provide an insight into important issues and possible solutions in preserving spatial images in old town houses while enabling creation of new town houses using old spatial concepts.

1.2 The methodology of this research

Architectural Morphology

Architectural morphology is a branch of study that analyzes forms and spaces in architecture. It helps us to figure out the spatial forms as well as to classify the architectural style in existing architecture. This method can be tracked back to biology and linguistics. Biologists try to arrange a systematic table for sorting creatures according to the principle of transformation and combination.

Shape Grammar

A shape grammar, which can exemplify and visually explain the style of traditional town houses, will be presented in the form of rules that are derived from considerations of traditional processes of design and construction as well as from cultural influences. Shape

grammars are significantly different from symbolic grammars. Shape grammars transform shapes in two or three dimensions differently than symbolic grammars transform strings of symbols in one dimension. (See Chapter 3.1.1)

Mathematics

Like many other things, the modes of design are changing from the ground upwards. Geometry has acquired the same scientific significance as processed by mathematics, physics and chemistry and has become the support to taxonomy of shapes. Like taxonomy itself, geometry can be said to have become a tool of analysis, verification and operational methods. Geometry actually seems to have become a common denominator of all of the above, rendering them common and inter-dependent.

A shape is a finite set of maximal lines, where each line is specified by the coordinates of its end points. A shape is rational if its lines have endpoints given by rational coordinates. A shape in three dimensions can also be presented by coordinates or matrix. We will begin with a mathematical system of shapes, one that is sensitive to our spatial intuitions about designs and at the same time is a formal and precise system. This mathematical system involves the sub-shape relation, which partially orders shapes, operations and operational analysis. It includes shape union (+), shape difference (-) and shape multiplication (x); and the similarity transformations.

In this research we are comparing the facades and floor plans using shape grammars, so we will illustrate and describe all the facades and floor plans with the help of shape grammars and compare the differences and the similarity in the derivations of the same series of rules.

1.3 The contents of this research

From the north to the south of Taiwan, four historical areas which are: Dihwa Street in old Taipei City, Daxi in Taoyuan County, Lukang in Changhua and Xinhwa in Tainan, have

been chosen. The traditional town houses in these areas represent the epochs of differentiation and impacts of diverse cultures.

From the middle to the west of Austria, traditional town houses from two historical cities, Steyr and Innsbruck were chosen as the selected examples.

Data Collection

The contents of this research include literary reviews of Taiwan and Austria, investigation of the present status, collection of old drawings and photographs of the town houses related to four historic areas in Taiwan and two cities in Austria.

To build our shape grammars

The procedure that has been used is to successively analyze facades and floor plans. Ten facades from each area and floor plans of one representative house from each town will be chosen as examples. Then a system of rules for the shape grammar of these town houses will be developed. Because the composition of shape grammars concerns the visualization of forms, the shape grammar for the facades will be first developed and subsequently the floor plans.

Instead of passive observation, the right attitude for researchers would be to remain involved and operate each step as an artisan would, in building a house himself in any remote and ancient time.

Comparison

All the facades and the floor plans have been illustrated using shape grammar individually and the results listed in Tables. This will provide not only comparisons of the facades and floor plans but also some important pattern languages for traditional town houses.

Chapter 2

The development of traditional town houses in Taiwan

2.1 General background of traditional town houses in Taiwan

2.1.1 Historical and geographical background of Taiwan

History

The styles of Taiwanese town houses are very diverse as is Taiwanese architecture and culture. This becomes obvious from the chronological history of Taiwan.

Initially the Portuguese discovered Taiwan and named her "Iiha Formosa" in 1557 (Figure 2.1). Subsequently when the Dutch arrived in 1624, they built a town in South Taiwan. The Spaniards arrived in 1642, building two towns in North Taiwan.

For centuries Taiwan was known as Formosa on Western maps. In the 17th century the Dutch East India Company developed the island into a major international trade post. (Courtesy of SMC Publishing Inc.)

Figure 2. 1 Map of Taiwan in the 17th century

Eventually the Dutch defeated the Spaniards and governed Taiwan until 1662. They established schools and churches in Taiwan extensively. Many historical sites that still exist provide a vivid reminder of the relics and influences of the Dutch and Spanish era.

From 1662, the Chinese governed Taiwan until 1895, when it handed over Taiwan to Japan as a colony after the 'Sino-Japanese War'[1] The Japanese constructed modern cities and built numerous public buildings. After the end of the Second World War in 1945, Japan returned Taiwan to China. For four years from 1945-1949, both China and Taiwan remained democratic when the Communists came to power in mainland China. However, Taiwan still continued to remain a democracy.

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[1] Sino-Japanese War: 1894-1895 China and Japan conflicted for advantage in Korea. After Japan defeated China in 1895, they made the "Treaty of Shimonseki". According to this treaty China gave Japan Taiwan, Peng Hu Archipelagoes, Liao Dong Peninsula and admitted that Korea was independent.

Geography

Taiwan is a medium-sized archipelago in East Asia, located at 23°30N, 121°00E and running through the middle of the Tropic of Cancer (23°5N). It is located 150km (95 miles) off mainland China and is the largest part of the Republic of China. The main island is Taiwan island, which comprises about 98 percent of the current jurisdiction of the Republic of China; the remaining 2 percent comprise the smaller islands of Lanyu, and the Pescadores, along with the tiny islets of Green Island, Liuchiu, and Wuchiu. Taiwan island is separated from the mainland China by the Taiwan Strait and borders the South China Sea and Philippine Sea to the south, the East China Sea in the north, and the Pacific Ocean in the west.

Taiwan covers an area of 35,980 km² out of which 32,260 km² is land and 3,720 km² comprises of territorial water claims. It is 394 km (244 miles) long and 144 km (89 miles) wide. It has a coastline of 1,566 km and claims an exclusive economic zone of 200 nautical miles (370 km) with territorial seas of 12 nautical miles (22 km).

The general marine climate on the island varies widely by season. From June to August is the rainy season when monsoons are most likely to hit. In the northern part of Taiwan, cloudiness is persistent and extensive during the year. In the south, however, the rainy days are almost always in summer and 90 percent of the annual rainfall is calculated during this period. The annual rainfall normally exceeds 2500 mm.

The terrain in Taiwan is divided into two parts: the flat to gently rolling plains in the west, where 90 percent of the population lives, and the mostly rugged forest-covered mountains in the eastern two-thirds. The highest elevation in Taiwan is the Jade Mountain (*Yu Shan*) at 3,997 meters.

Natural resources

Natural resources on the islands include small deposits of gold, copper, coal, natural gas, limestone, marble, and asbestos. The island has 55 percent forests and woodland (mostly on the mountains) and 24 percent arable land (mostly on the plains), with 15 percent available for other purposes. Five percent comprises of permanent pastures and one percent is utilized for permanent crops.

Natural hazards and environmental issues

Earthquakes and typhoons are the two major natural hazards on the island. On 21 September 1999, an earthquake devastated the center of Taiwan. The death toll in this catastrophe reached more than 2,000. Additionally, mudslides resulting from intensive rain or typhoons often lead to disaster.

Current environmental issues include: air pollution; water pollution from industrial emissions and raw sewage; contamination of drinking water supplies; trade in endangered species; and low-level radioactive waste disposal. Though regulation of sulfate aerosol emissions from petroleum production is becoming stringent, acid rain remains to be a threat to the health of the residents and the forests. Scholars in Taiwan point out that more than half of its acid rain is actually brought by monsoon rains from mainland China.

2.1.2 The surroundings of traditional town houses in Taiwan

Taiwan, a small island, originated as dwelling clusters along seashores and rivers for the convenience of transport. Traditional town houses which were long and narrow as a planned structure were originally developed along markets and streets. The typical traditional town house had three blocks, the front block, the middle block and the inner block, which was connected by inner courts, verandahs or side chambers. (Figure 2.2)

Arcade	Shop	Court 1	Living room	Court 2	Bedrooms

The front block   The middle block   The inner block
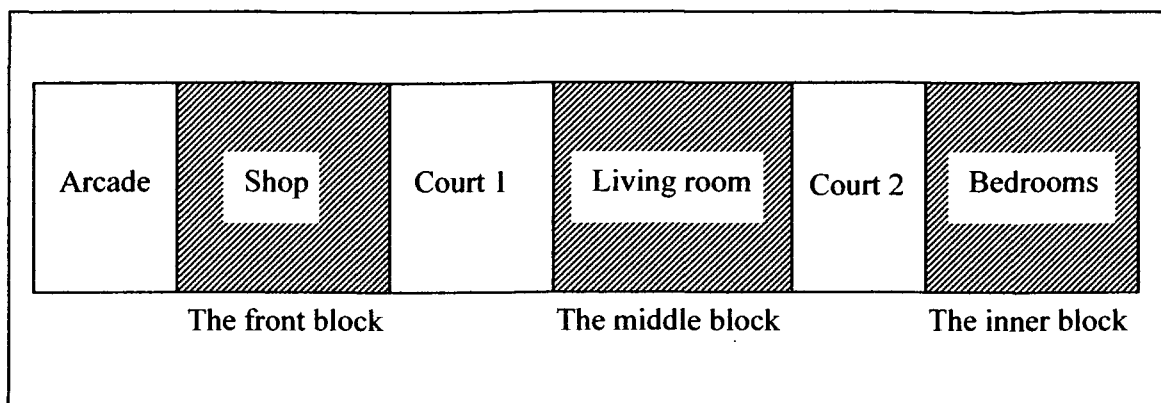
Figure 2. 2   Site plan of a typical Taiwanese town house

Typically, an arcade adorns the front of a town house, being most suited to prevailing climatic conditions. It was originally based on the layout of Ming-Nan style that was then prevalent in the south Mainland. Subsequently, it evolved with the skill and experience of the inhabitants as well as the influence and characteristics of diverse cultures and the various governments and traders. These influences had a profound impact on the evolution of styles of traditional Taiwanese town houses. The following five points characterize traditional Taiwanese town houses:

1. The Chinese influence

The ancestors of most present-day Taiwanese came to the island between a hundred and three hundred years ago, mainly from the provinces of Fukien and Kwangtung, two provinces in the south-eastern part of mainland China. (Figure 2.3)

China had governed Taiwan for more than two centuries and the proximity of the Taiwanese island to China geographically enabled Chinese immigration to Taiwan continuously for hundreds of years.
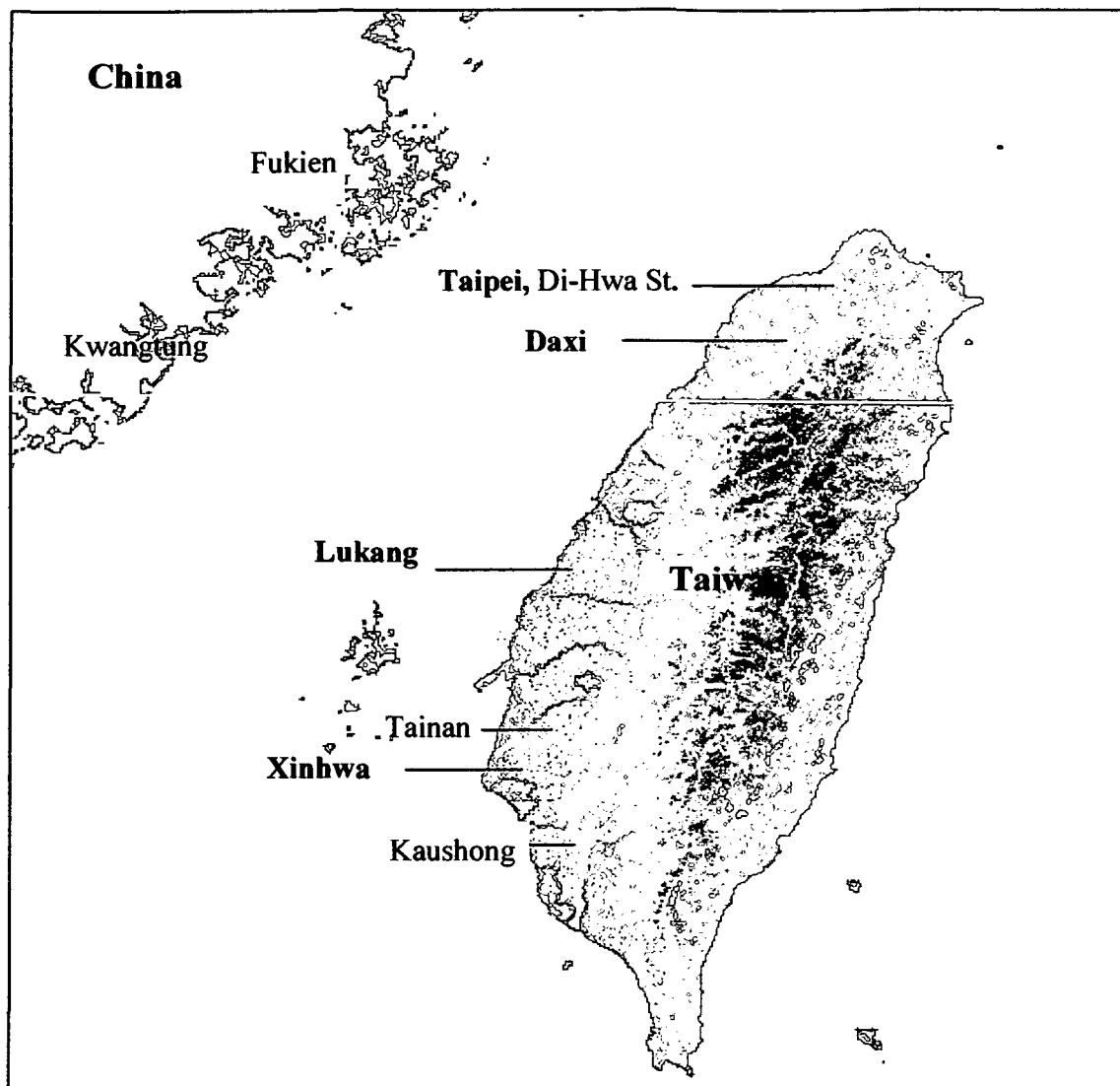
Figure 2. 3 Fukien, Kwangtung and the locations of traditional town houses in Taiwan: Taipei, Dihwa street; Daxi; Lukang; Tainan,

Andrew Boyd asserts: the plan of a little homestead, the layout of a temple, a palace or a city ensemble. These were: a) a walled enclosure, b) axiality, c) north-south orientation, d) the courtyard.[2] Essentially the house was a walled enclosure composed of one or more courtyards, each with lesser and lower buildings on the east and west sides of each courtyard [3] besides the traditional Chinese family hierarchy: e) inner and outer, f) senior

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[2] Andrew Boyd, Chinese Architecture and Town Planning 1500B.C.-A.D.1911, 1962, p.49
[3] Andrew Boyd, Chinese Architecture and Town Planning 1500B.C.-A.D.1911, 1962, pp.76-79

and junior, g) social status: high and low, also influenced the layout of the traditional Taiwanese town houses. [4]

2. Influence from other countries

The famous East India Company and the Dutch successfully operated their business in south Asia including Taiwan, tremendously influencing the politics, economy and culture, until China drove the Dutch out of Taiwan. After the Chin Dynasty was defeated at the end of 19th century, all the major foreign companies especially the British, Dutch and Spanish flourished. They constructed buildings for their representative branches that were symbolic of their own countries' styles, especially the British companies who erected a number of commercial buildings. After 1895, the Japanese architects also imported into Taiwan numerous European and Japanese styles for designing architecture. The earliest architectural regulation[5] was issued in Taipei in 1896 by the Japanese rulers in Taiwan. From 1900 to 1936 the Japanese rulers issued several local urban regulations that greatly influenced the design of Taiwanese town houses. In 1936, the Japanese rulers in Taiwan pronounced an urban regulation[6] concerning the facade and the arcade of the town houses.

Nowadays from the north to south Taiwan, many old town houses still exist that are mixtures of Chinese, Western and Japanese styles especially in areas such as: North-Taiwan's Dihwa street, Sanxia, Daxi, Middle-Taiwan's Lukang, South-Taiwan's Xinhwa, Tainan and Kaushong. (Figure 2.3)

3. Suitability of architectural styles of traditional town houses for Taiwanese climate and local customs

It is evident that all imported architectural styles were modified to suit the subtropical climate, geographical conditions, local customs and culture. An arcade is a very important and necessary element for a traditional town house in Taiwan. It not only provides people a

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[4] Tung-Ming Lee, Study for Architecture Style and Reuse of Traditional Town- Houses in Taiwan, 2002, p.27

[5] Building Regulation, 家屋建築規則, Nov. 25, 1896, Taipei County; then Taiwan Building Regulation, 台灣家屋建築規則, Aug. 12, 1900, Taiwan. 見：蔡之豪，1999，日治時期台灣都市計劃法制歷程之研究

[6] Taiwanese Code of Urban Planning, 台灣都市計劃令, Aug. 27, 1936, Taiwan. 見：蔡之豪，1999，日治時期台灣都市計劃法制歷程之研究

more practical and comfortable environment for shopping, such as protection from rain or excess heat but also space for loading or unloading goods and merchandise. In the 19th century, there existed a street in middle-Taiwan's Lukang town, called "No Sky"[7], where the arcades were extended as a roof to the street.

The site plan of a Taiwanese traditional town house is normally characterized as a long and narrow pattern, since in the ancient times the government levied tax on a shop according to the width of the shop. The emigrants from south China also brought their own customs for businesses and dwellings into Taiwan.

2.2 A literary review of Taiwanese traditional town houses

A number of researches and publications on Taiwanese traditional town houses have already been carried out. Apart from the historical background, the focus of this chapter will be on the analysis and discussion of the typology of special forms in Taiwanese traditional town houses.

Lee Tung-Ming ("*Study for Architecture Style and Reuse of Traditional Town-Houses in Taiwan*"[8] 2003), divided the traditional town houses in Dihwa street into five groups which are "Min-Nan Style", "Imitating Western Style", "Western Style", "Baroque Style" and "Modern Architecture Style".

Chan Sen-Yi ("*A Preliminary Study on the Changes of the Construction Type of the Town House in Taiwan*"[9] 1999), analyzed the construction types of the traditional town houses in Taiwan. He undertook case analysis by typology and morphology.

Ngoi, Hang Chong, ("*The Grammar of the Traditional Street-Houses in Lukang*"[10] 1995); this thesis analyses the morphological structure of floor plans of the traditional street

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[7] In ancient Taiwan they called a street with a roof "No Sky", which was like a mall at present time. The most famous "No Sky" was in Lukang which was the second biggest city in Taiwan..

[8] The original name: 李東明，台灣傳統街屋建築空間形式與再利用之研究，內政部建築研究所研究報告

[9] The original name: 鄭森毅，台灣傳統街屋構造類型變遷之初探，國立雲林科技大學工業設計研究所碩士論文

houses in Lukang through the application of shape grammar. Twenty-two different sizes of traditional street-house plans in Lukang have been collected. Based on the sixteen "tan-kai-chean" (one bay) street-house plans, the grammar of traditional street houses in Lukang has been presented.

Chen Z-H, Liou S-R and Lee W-Y (*"An Analysis of Facade Composition of Street-Houses on Ho-Ping Road at Ta-Chih"* [11] 1995); this paper analyses the morphological structure of the facades of traditional street houses in Daxi.

Lin, Hui-Ch'eng , (*"The Investigation and Research for the facade of the traditional town houses at Daxi in Taoyuan, Shanxia in Taipei and Hukou in Xinzhu"* [12] 1989), established the resources of the historical town houses during the Japanese colonial period. It focused on a survey of the facade and the decoration while recording the historical background.

Han, Pao-Te, (*"The Research of Lukang's Features in Old Time"* [13] 1978) classified town houses into shop houses and dwelling houses. Furthermore, shop houses were divided into three types according to the scale.[14]

Town house
— Shop house —
— Large: 3 blocks; the 3rd block: family rooms (ta), bedrooms (fang).
— Typical: 2 blocks; the 1st block: shop (dn), living room (ta); the 2nd block: family room (ta), rooms (sh).
— Small: 1 or 2 blocks; the 1st block: shop (dn) without a living room (ta)
— Dwelling house
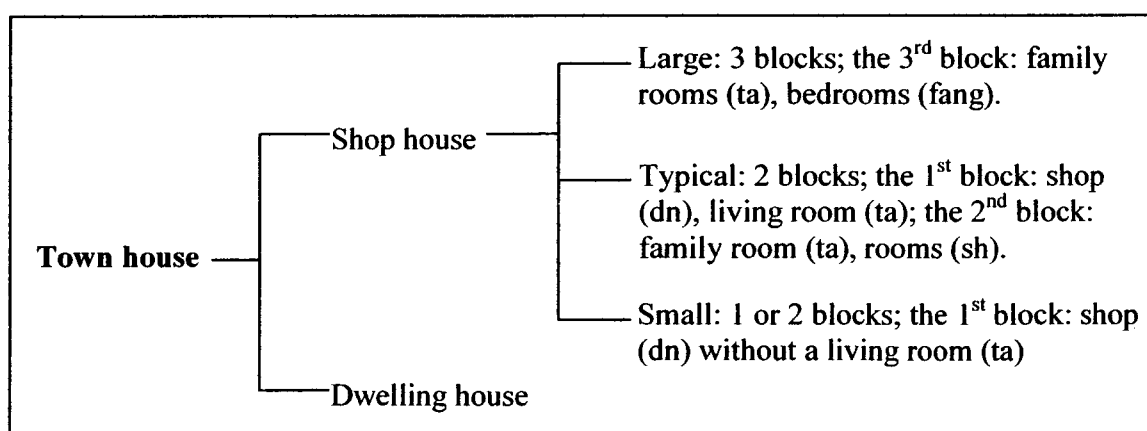
Table 2. 1 Classification of Taiwanese town houses by Han, Pao-Te

[10] The original name: 倪漢忠，鹿港傳統街屋的型態構成，東海大學建築研究所碩士論文

[11] The original name: 陳志宏、劉舜仁、李威儀，1995，"大溪和平路街屋立面構成分析"，第八屆建築成果發表會論文集，中華民國建築學會，pp.535-540

[12] The original book name: 桃園縣大溪老街、臺北縣三峽老街、新竹縣老湖口老街街屋立面調查與研究，行政院文建會

[13] The original book name: 鹿港古風貌之研究, 境與象出版社

[14] The phonetic spellings of traditional Taiwanese spaces: " tan" is a hall or a living room. See Table 4-2

Lee Chian-Lang, (*"The Pattern Language of Traditional Taiwanese Architecture Applied to Modern Architectural Space---Taiwanese Town Houses as an example"*[15] 1982); this article classified Taiwanese Town Houses into three types: a) one bay, three blocks and two courtyards. b) two bays, a big shop or two shops. c) three bays, the facade appearing as a grand facade of a large dwelling house.

Xia, Shu-Jiu, (*"The Research of Taiwanese Traditional Long- Shape Town Houses"*[16] 1985), built a research model of a traditional town house in Lukang in Taiwan. This model includes main house, affiliated house and courtyard, modified by five variables as: a) orientation, b) kinetic approach, c) the dialectic of inside and outside, d) centering, e) adaptability to physical requirements. The main house consists of one shop, halls, rooms and balconies etc. The affiliated house consists of kitchen, corridor and service rooms. The courtyard consists of a patio and additional rooms.

Kwan, Hwa-San, (*"Two subjects about Taiwanese Traditional Town Houses"*[17] 1979) illustrated the orientation of a town house. Some town houses oriented streets at both front and rear ends. Some of them had the shop side facing the front street and the rear side next to a harbour. The other subject concerned the atrium which normally exists above a public space, such as the first floor of a shop or a living room in the first block. Occasionally there was a bedroom or storage room next to the atrium in the first block.

Lin,Heng-Tao, (*"The Historical Research Commission of Taiwan Province"*[18] 1977) divided Taiwanese traditional town houses into the late Qing dynastic type and early Japanese colonial type. The floor plans of the former have been set up symmetrically. The courtyards of the latter are partially divided by occasional service spaces on the sides.

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[15] The original book name: 現代房屋空間運用中國傳統建築空間語彙可行性之探討---以台灣街屋爲例之初步分析, 傳統建築, 北屋出版社
[16] The original book name: 台灣傳統長形連棟式店鋪住宅之研究, 台大土木所都計室
[17] The original book name: 談台灣傳統街屋二題, 民居與社會文化 1989 明文書局
[18] The original book name: 台灣勝蹟採訪冊, 台灣文獻委員會

2.3 Classification of Taiwanese traditional town houses

There are at least two kinds of methods to classify Taiwanese traditional town houses, as explained below:

2.3.1 Classification by form

The styles of Taiwanese traditional town houses based on form, can be categorized into five groups, which are 1. "Min-Nan Style", 2. "Imitating Western Style", 3. "Western Style", 4. "Baroque Style", and 5. "Modern Architecture Style".[19]

1. Min-Nan Style: This is the traditional architectural style from the south region of Fu-Jian Province, China. The appearance of this style was around 1750, the golden age was 1850-1870.

2. Imitating Western Style: The Imitating Western Style was just an ornamental facade imitating the looks of western style commercial buildings typical of European companies. For example, in Dihwa street, this style appeared in the 1870's, and its golden age was in 1870's.

3. Western Style: The Western style reflected a brick patterned construction that retained the rectangular brick grooves which was typical in Western countries at the time. Examples of these styles appeared in Dihwa street, in the 1890's.

4. "Baroque" Style: The Baroque style is a brick and reinforced concrete (R.C.) building with Baroque style decorations on its facade. In Dihwa street, the appearance of this style was evident in the 1900's, and the golden age dominated around 1910-1920.

5. Modern Architecture Style: The modern architecture style is the reinforced concrete (R.C.) building with simple and few decorations. In Dihwa street, the appearance of this style was in 1910's, and the golden age was around 1930 to 1940.

2.3.2 Classification in construction of Taiwanese traditional town houses

The styles of Taiwanese traditional town houses based on construction, can be categorized into four groups:

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[19] Lee Tung-Ming, Study for Architecture Style and Reuse of Traditional Town-Houses in Taiwan, 李東明, 台灣傳統街屋建築空間形式與再利用之研究,2003, pp.115-143

1. Traditional Taiwanese wood roof truss:

The traditional Taiwanese wood roof truss inherited the basic form of the traditional Chinese wood roof truss from south- east China. Traditional town houses with this type of construction were very common during the period of Chinese rule in Taiwan, being both economical and practical. However, it had to be torn down due to wood decay, changes of urban planning and other issues of urban renewal.

2. Wood roof truss from Japanese style:

During the Japanese colonization of Taiwan, Japanese architects brought in this Japanese wood roof truss which actually combined the traditional Japanese wood roof truss and western roof truss. This style was soon replaced by the load-bearing wall system designed for bricks and the skill of knitting bricks became common in Taiwan.

3. Load-bearing wall system:

The traditional town houses with this type of construction were the most widely used in traditional Taiwanese town houses. Normally, the bay of a traditional town house was as narrow as 3.6m or 4.2m, which was convenient and workable for constructing town houses using a load-bearing wall system. The form of such traditional town houses flourished with diverse decorated archways which included imitations of western styles and the baroque style. During 1900-1936, the Japanese government in Taiwan issued an urban regulation entitled: "The reformed planning of urban streets"[20] and subsequently many of traditional town houses remodeled their facades into decorated archways.

4. Modern construction system:

Due to the application of concrete and concrete reinforced bricks, the modern construction system integrated the frame system. This was also influenced by modernism. The system envisaged the requirement of storied town houses. This modern construction system was very widely used and broadly covers the rest of the traditional town houses under this

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[20] the Japanese government in Taiwan issued

classification. It was developed later and the issues of urban planning promoted the same.[21]

The classification of Taiwanese traditional town houses from construction

| 1. Traditional Taiwanese wood roof truss | 2. Wood roof truss from Japanese style | 3. Load-bearing wall | 4. Modern construction system |
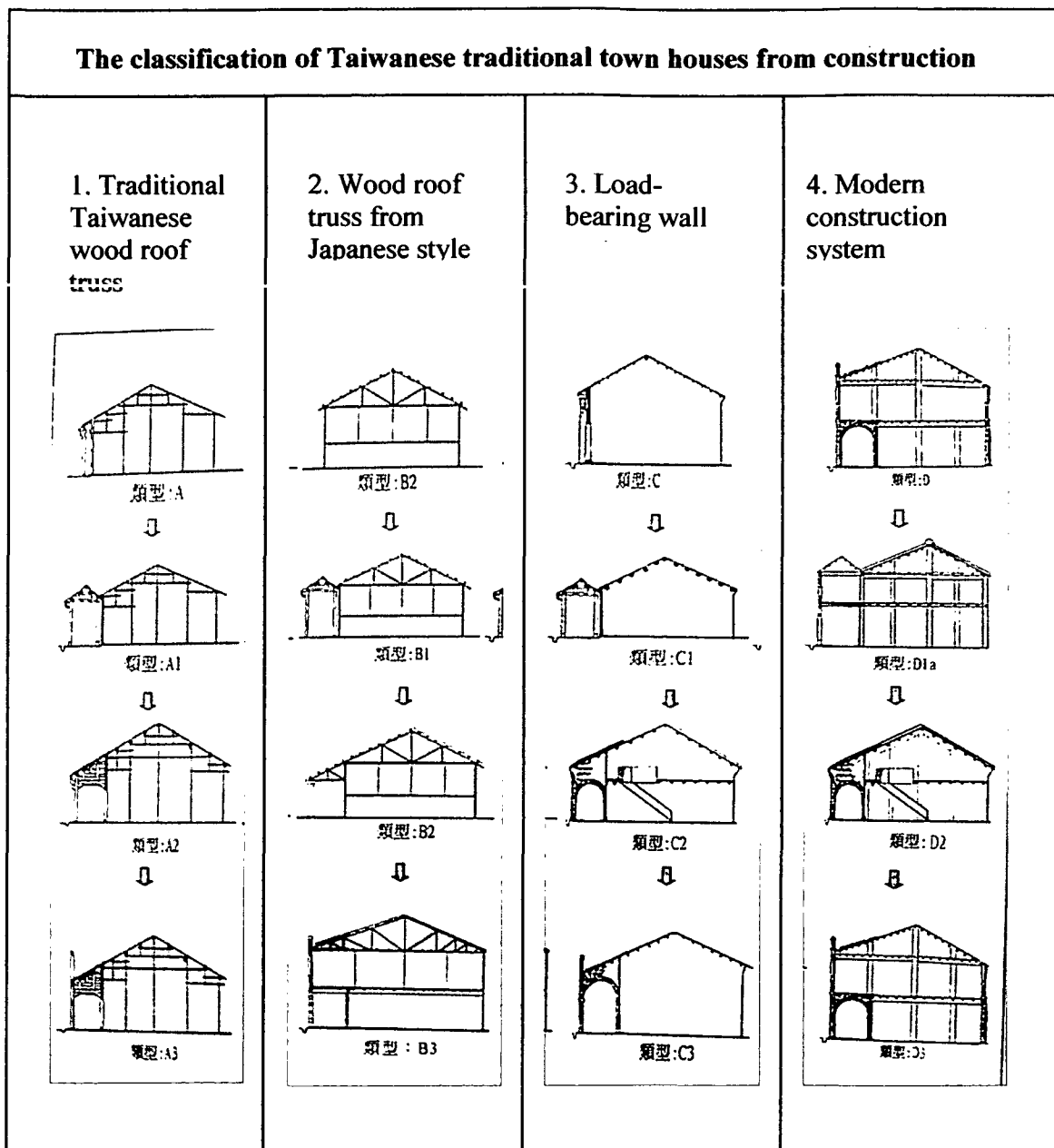
Figure 2. 4   Taiwanese traditional town houses categorized into four groups based on construction

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[21] Chan Sen-Yi, <u>A Preliminary Study on the Changes of the Construction Type of the Town House in Taiwan[21]</u> 1999; 鄭森毅，<u>台灣傳統街屋構造類型變遷之初探</u>, p.4-3

2.4 The historical and geographical background of Dihwa Street, Daxi, Lukang and Xinhwa

The historical and geographical background of these four historic areas will be considered before we begin to explore the town houses.

2.4.1 General historical background for these areas:

1. Late Chin Dynasty 1851-1895:

This original town house style from China dates back to the late Qing dynasty. This style can also be seen in Macao, Singapore, Malaysia and Chinatowns all over the world. Subsequent to the Qing dynasty government's defeat by the united armies of western countries[22], Taipei's Danshui and Tainan's Ampin were opened as harbours for free trade to foreigners as concluded by the Tianjin Treaty of 1858 and Beijing Treaty of 1860.

2. Japanese main occupation period: 1895-1930:

When Taiwan became a colony of Japan, the government started pushing all western traders out from the Taiwanese market and pronounced a series of laws to dominate architecture and business. The Japanese companies set up a number of branches in Taiwan. The foreign trade areas were transformed into local markets which were led by Taiwanese businessmen. Many of them cooperated well with Japanese companies. In order to monopolize Taiwanese production, the government issued new policies as follows: a. to rectify and reorganize the transport system in Taiwan;   b. to investigate private and public lands; c. to unify the currency;   d. to expel all western commercial branches; e. to provide Japanese traders preferential treatment; f. to monopolize the authority for exporting production from Taiwan. [23]

3. Late Japanese occupation period: 1931-1945:

Since Japan planned to enlarge her territory into China, the development of Taiwanese economy focused on industry, especially defense industry. Supporting the war was the first

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[22] Britain, France in 1858; Russia, America, Britain and France in 1860

[23] The transformation of an urban at Di-hwa street in Taipei, 陳章瑞,台北大稻埕的都市轉化, 1989 Thesis, National Taiwan University

priority for the government. Somehow the government developed this island not only to empower and promote Japanese traders with the objective of extracting their profits but also for the ideological restoration through political authority.

4. The recovery period after the Second World War: 1945-1965:

Chiang Kai-Shi's government took Taiwan over from Japan in 1945. A severe inflation struck the whole island during 1948-1949 with private enterprises in economic crisis. From 1950s to 1960s the Taiwanese government depended on the help of foreign countries for loans and technology to develop her business and industry. Currently the Taiwanese economy flourishes in technology sectors; however it does not help the traditional businesses in these historical districts.

2.4.2 Dihwa Street in Taipei City:

Dihwa street is an area close to a harbor which is along Danshui River in Taipei (Figure 2.5). The condition of businesses and local politics in this area has influenced the development of the urban form of Taipei city and the special forms of the local traditional town houses.

1. The origin of this area: In 1851, a businessman named Lin Lam-Ten built three town houses in the present Dihwa street. In 1853, another businessman, Lin Yo-Zhou started a shop called "Lin-I-Shen". The origin of Dihwa street was around these shops. After 1860, many of the foreign branches were set up in the area of Dihwa Street. Tea, sugar and camphor were the main trading articles. In 1870, there were six British companies set up in this area.[24] Hong Kong & Shanghai Bank provided funds for traders since Taiwan was under the influence of British imperialism. Late in 1870s, Taiwan became the first export harbour for tea and camphor in the world. In 1885, there were 252 tea shops in this area.

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[24] Dodd &Co. and Brown & Co. were founded in 1869. Tait &Co. , Boyd & Co., Jardine Matheson & Co. and Elles &Co. were founded in 1872
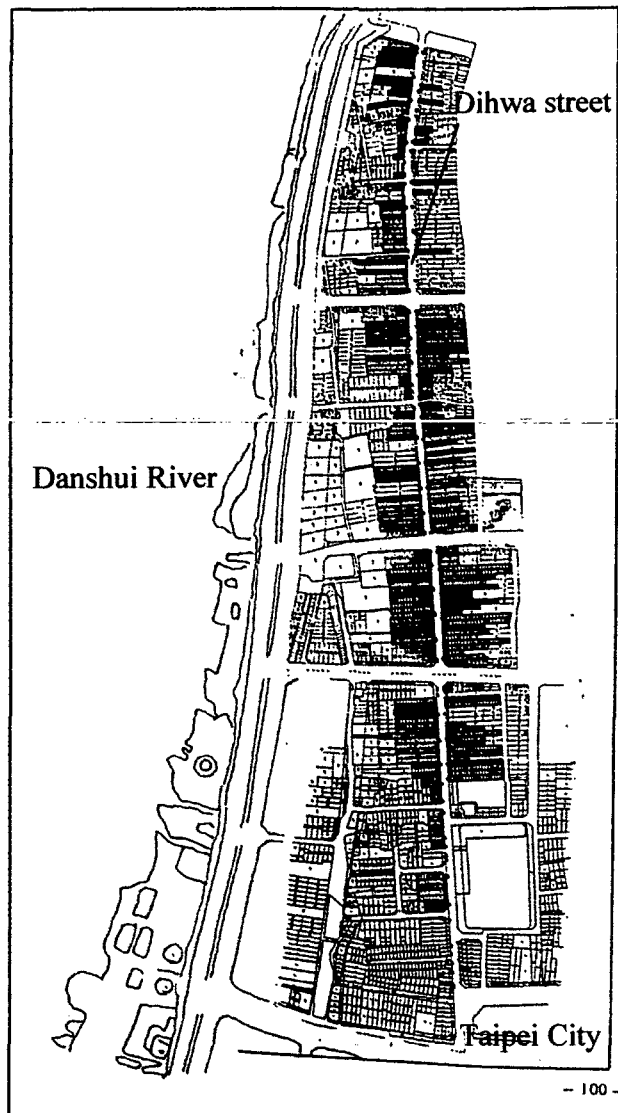
Figure 2. 5 The historical area in Dihwa Street, Taipei

2. Japanese influence: Due to the colonial policy, many Taiwanese businessmen had to cooperate with Japanese companies. A rice market was started in Dihwa street area during the world economic depression of 1929, which changed the commercial structure of the rice and tea market in this area. As a local commercial center, textile goods, Chinese medical goods, show business, and service businesses were also blooming in this area. Gorgeous facades with baroque decorations or traditional Chinese decorations, such as

birds, flowers and beasts, became the important symbol for the commercial and show business in Taipei as well as the whole island.

3. **The transition of businesses**: Food processing, light industry, wholesale trading in Chinese medicine and tea, show business and service business helped this area move forward to a convenient and accessible business center. The role of commercial activities formed a new social style in urban space. The festival of the Sha-hai temple became an important meeting place for businessmen and retailers. The stands before the temple and its customers were a part of daily life in this area. A number of public buildings such as churches, theatres, schools and police stations were built here.

4. **The present situation**: In 1960, Dihwa street was still the busiest commercial area in Taipei city. Office and business space became more important than light industry. However late in 1960s, Taipei grew and emerged gradually as an international city. New commercial centers were constructed in line with the new urban planning in Taipei. This caused a gradual downfall of Dihwa street area and presently is a famous market for Chinese medicine and sundry goods as well as a historical area.

2.4.3 Daxi in Taoyuan:

Daxi area is located approximately 50 km southwest of Taipei in northern Taiwan. It is made up of low lying plains, interconnected hills and plateaus. It is inclined in a long and narrow southeast-to-northwest direction, with the southeast in the mountains and the far end at the shore of the Taiwan Strait. Daxi was called "Takoham" in original Taiwanese. Originally it was the area of the Kaidagolen and the Taija tribes. The branches of the Danshui and Dahan rivers flow through it. (Figure 2.6)
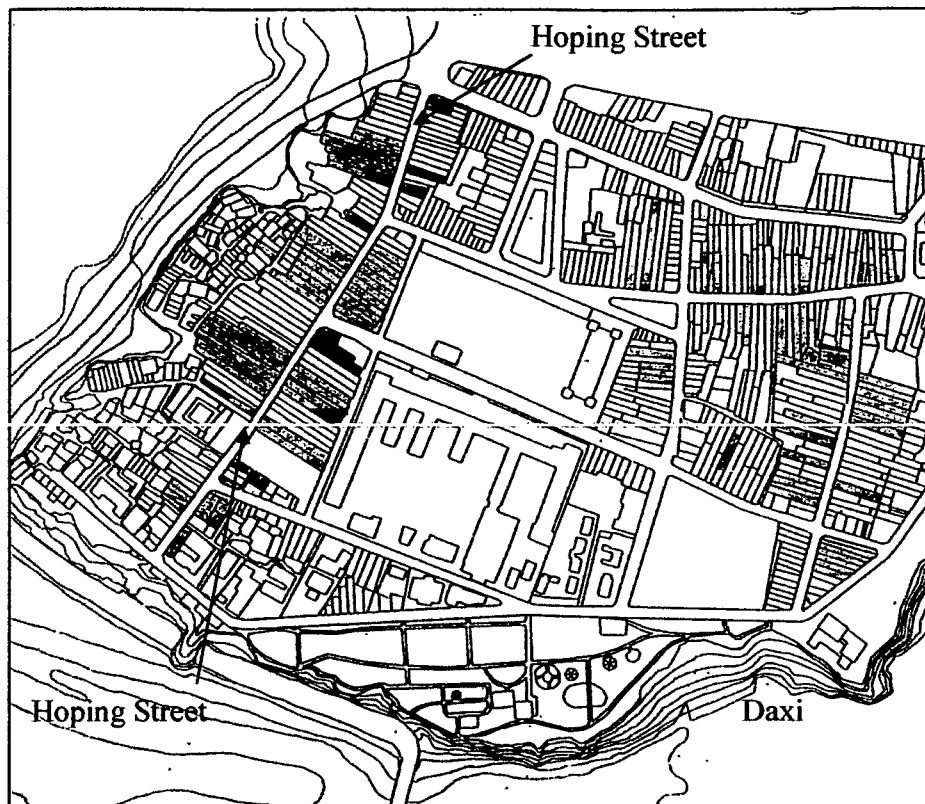
Figure 2. 6 The historical area in Daxi's downtown

1. Qing dynasty: 1813-1895: Chinese people from Fukien province moved here and built the Fuzen Temple in 1813. The famous family Lin Ben-yen in Taiwan cultivated land and developed this area after 1818. The Taiwanese government of Qing dynasty stationed the army and governed the natives in this district in 1886. As a quiet and peaceful area, trade in products like tea, camphor, coal and wood flourished. This also appealed to a number of foreign companies to set up their branches at Daxi. There were more than three hundred shops in this area.

2. Main Japanese occupation period: 1895-1920: The local Taiwanese army from Daxi and Sanxia fought as a coalition against the Japanese army as a result of which the downtown was severely damaged. Subsequently, the colonial government promoted the local business and brought in numerous Japanese companies to set up their branches. Tea, sugar and coal business was blooming again. There was an average of two hundred and fifty ships docking at the harbour daily. The main streets were widened by the colonial

government in 1919 and most of the facades of town houses were torn down to be rebuilt with gorgeous baroque decorations.

3. Late Japanese occupation period: 1921-1945: Due to the development of agriculture in the Taoyuan county, since 1923 the water of Dahan river was diverted to irrigate the farmland. This decreased the water in Dahan river and affected the shipping severely. New modes of transportation such as railways and roads, also replaced the Dahan river transport. The idleness of the harbour resulted in the decline of the downtown. Presently Daxi is an old small town in north Taiwan.

2.4.4 Lukang in Changhua:

Lukang is situated in the mid-western part of Taiwan island, in Changhua county. The Dadu stream in the hills on its eastern side forms the border between Changhua and Nantou counties. The southern border of Changhua county is marked by the Jhuoshui stream which separates Yunlin county from the south. And Lukang faces the vast Taiwan straits in the west.

During the Qing dynasty, local residents copied house plans from their homes in south China. In the early times, Lukang was a place steeped in rich literature and tradition with romantic literati reciting poems under the starry night or sipping tea in the moonlight. The owner of the famous 'Ten-Entertainment' building was a gentleman of great hospitality. He built a corridor between two buildings which enabled his guests to watch the moon from the heights, leaning on the balustrade.

1. Qing dynasty: 1784-1895: Lukang originated as a business harbour in 1784. From 1785 to 1850 Lukang enjoyed a golden period of trade and commerce which was the second biggest city in Taiwan. The businessmen were well organized and combined eight associations together called 'Ba-jiao'[25], which was a commercial organization in charge of

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[25] Ba-jiao was the eight associations of business in old Lukang, in Chinese is "八郊".

import and export. A shop, especially a harbour shop,[26] was a basic member in 'Ba-jiao'. These associations widely influenced the layout of dwelling clusters, the function of markets, religion and local politics. The goods included cloth, dye, oil, sugar, fish, wood and rice etc, since Lukang housed a big trade market and a large population. There were around 50,000 residents according to the late Qing dynasty estimate[27]. (Figure 2.7)
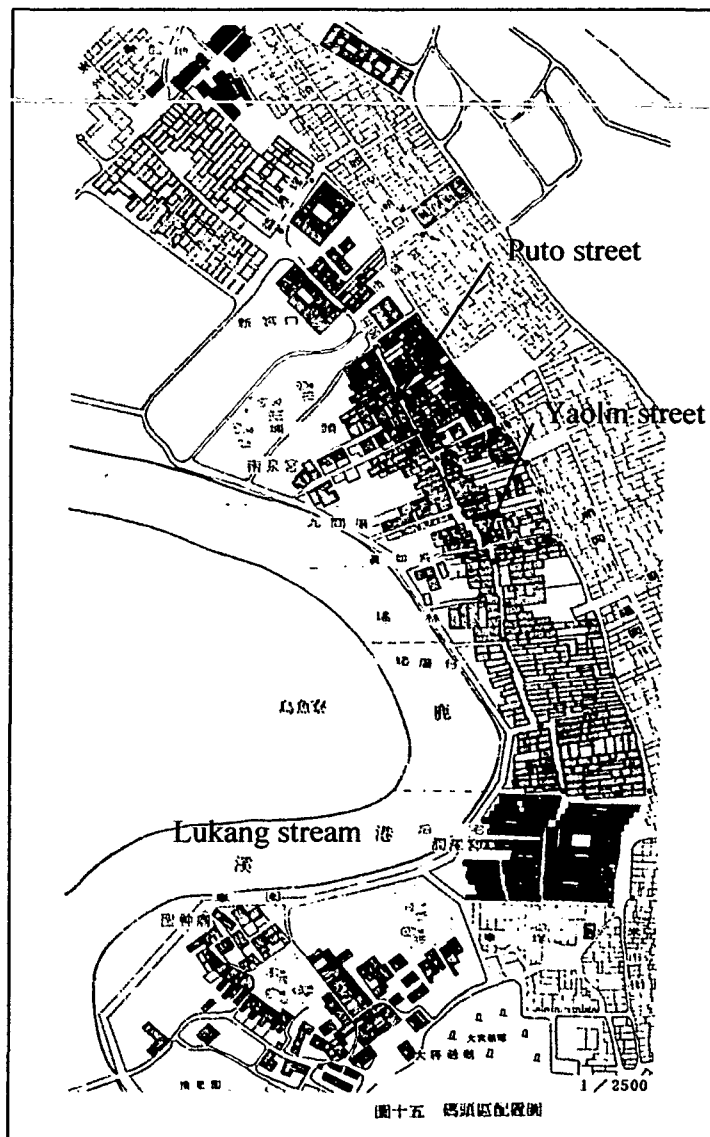
Figure 2. 7 The historical Area in Lukang

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[26] A shop faces to a commercial street on the front and to a river at the back for unloading. It is called "船頭行" in Chinese.

[27] Lin,Hui-Ch'eng, The layout of dwellings and streets of Lu-kang at late Qing dynasty, 清末鹿港街鎮結構, 1983, P.20

2. Japanese main occupation period: 1895-1945: During the Japanese rule of Taiwan, the colonial government stationed the army and the navy to guard the coastline and imposed taxes on all non-Japanese imported and exported goods. This negatively affected the business of this commercial harbour and this city to a great extent. Furthermore, the Jhuoshui and the Lukang streams were choked with silt gradually. The colonial government did not undertake dredging operations and thereby silt began to accumulate. Without a busy trade, the downtown of Lukang deteriorated. As a Japanese colony, eventually after some time, around half of residents moved out of Lukang.

Presently, Lukang is a small historical town in central Taiwan. However there are still a number of old town houses whose facades and floor plans appear in the Chinese image of "Min-Nan Style".

2.4.5 Xinhwa in Tainan:

Xinhwa is situated in the center of the largest part of the Chianan plain in southwest Taiwan. Located at the foot of a hill and beside the sea, Tainan county rises high in the east and becomes flat in the west. It is situated in the front area of the central range to the east and borders the Taiwan Strait to the west. It adjoins Chiayi county to its north and neighbors Tainan city and Kaohsiung county to the south. Tainan is the largest county in terms of an arable area of more than 90,000 acres and the eighth largest county in terms of population of 1.1 million.

Tainan county was also the first area to be brought under cultivation in Taiwan. As early as 400 years ago, the Dutch occupied a beachhead in Anping harbour of Tainan. It was the first foothold established as a result of colonialism and imperialism by the West. About 360 years ago, one of the Ming dynasty loyalists, Cheng Cheng-kung, drove away the Dutch and successfully opened up Taiwan to greater numbers of Chinese settlers. Therefore, Tainan could be said to have marked the beginning of Taiwan's history.

1. **Qing dynasty: 1850-1895:** Xinhwa was a small village which included a temple, a market and some bungalows. It was called "Da-mu-jiang"[28] at that time.
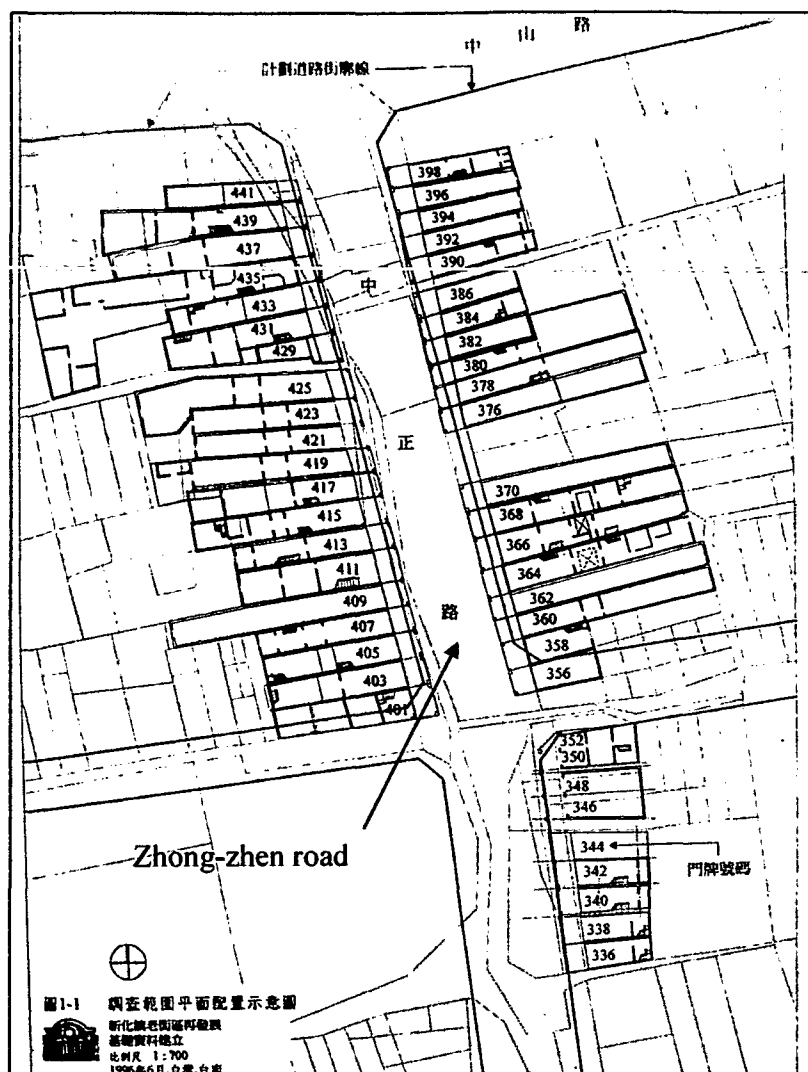
Figure 2. 8 The historical Area in Zhongzhen Road in Xinhwa

2. **Japanese main occupation period: 1895-1945:** People called the streets in this small area as "Xinhwa streets". The colonial government officially established a Xinhwa county[29] here in 1920. A businessman, Mr. Lin, who lived in No. 435 Zhongzhen road hired constructors to build the first town house with "Baroque Style" facade at Xinhwa

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[28] "Da-mu-jiang" in Chinese is: 大目降.

[29] The original Taiwanese name of Xinhwa County at that time is 新化郡.

in 1921. The neighbors, impressed with his house, imitated his style and before long the whole street had a beautiful facade of baroque decorations. Unlike Lukang, Daxi and Dihwa street which had many foreign branches of companies, Xinhwa's trade and business were and are mainly for the local market. Besides, the colonial government widened Zhongzhen road in 1937, as a result of which some town houses were rebuilt. The architectural image of the street almost remains intact today.

Chapter 3

Comparison of facades of traditional town houses in Taiwan using shape grammar

3.1 Architectural Morphology:

Architectural morphology is a study of analyzing and classifying architectural forms and spaces. The origin of this study can be tracked back to biology and linguistics. The theory of architectural morphology uses the biological taxonomy to classify architecture and the linguistic theory of signs to explain architecture.[1] Biologists perform taxonomy through the transformation and combination of principles and shapes to classify creatures into diverse species and families. The linguist Ferdinand de Saussure[2] pointed out that languages are kinds of sign systems and split the variable "word" into signifier (sfr) and signified (sfd), creating two dimensions from one dimension. The publication of Charles Morris,[3] *"Foundations of the Theory of Signs"*, maintained that semiotics included three parts, semantics, syntactics and pragmatics. Chomsky[4] enhanced syntactics into a structural

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[1] P. Steadman, 1983, Architectural Morphology, London, Pion

[2] Ferdinand de Saussure a Swiss linguist, A course of general linguistics

[3] Morris is most noted today for his monograph, Foundations of the Theory of Signs (1938), which was the first volume of the grand project for the International Encyclopedia of Unified Science. In this work he proposed his threefold divisions of a sign as consisting of sign vehicle, designatum, and interpreter, and of semiotics as consisting of syntactics, semantics, and pragmatics.

[4] Noam Chomsky, 1957, Syntactic Structures, Hague Mouton

system which can operate language and signs. Architectural scholars applied these linguistic theories to explain architectural shapes and forms as architectural semiotics, such as Peter Eisenman[5] and Norberg-Schulz[6]. However the main theory of architectural morphology is to analyze and classify architecture through application of biological taxonomy.[7]

Latest trends in the research of architectural morphology are inclined to a relational and constructive approach. Relational approach emphasizes a single element, between elements and between single element and context. Every property in architecture can be discussed independently, such as: the form of a corridor, the connection of main space and subsidiary space and proportions in various floor plans. This relational approach often discussed geometric construction, balance, symmetry, rhythm, gradation, axis and proportion. Although this does not describe the process of architectural form, it does help us to find out morphological principles in architecture. [8] A constructive approach describes the procedure of design by steps. A formal theory of spatial design in Alberti's sense was well-founded, based on this constructive approach. This theory provides a syntactic procedure for the creation of designs, but more importantly, it formalizes the intuitive appreciation of grammars and languages shown by distinguished artists and designers. In its semantic mood, this work on shape and spatial systems offers translation possibilities from one description to another description thus extending French mathematician and inventor of descriptive geometry, Monge's more specific achievements in descriptive geometry. [9] The theory does not impose itself on us. It gives us license to choose the language games we wish to play.

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[5] Mario gandelsonas & David Morton, 1972, "On reading architecture" Progressive Architecture, Mar., pp.58-87

[6] Christian Norberg-Schulz, 1966, Intentions in architecture, Oslo: Scandinavia Univ., p.167

[7] P. Steadman, 1998, "Sketch for an archetypal building", Environment and Planning B: Planning and Design, Anniversary Issue, pp. 92-105

[8] Liou S-R. And Vakalo, E.G.,1991, "The Study of Architectural Morphology through Shape Grammar", Proceeding of the Association of Collegiate School of Architecture, (ACSA) South- West Region Annual Meeting,119

[9] The application to the interesting particular case of ellipsoid was first made by Monge in a paper in 1795

3.1.1 Shape Grammar:

Shape grammars perform computations with shapes in two steps: recognition of a particular shape and its possible replacement. Rules specify the particular shapes to be replaced and the manner in which they are replaced. Underlying the rules are transformations that permit one shape to be part of another.

Wittgenstein said, "If you play a game, keep to its rules. And it is an interesting fact that people set up rules for the fun of it, and then keep to them." [10]

This game has been started with shapes, spatial relation, rules, grammars, transformations and principles, by a number of scholars in the field of shape grammar, such as: G. Stiny, T. W. Knight, U. Flemming and W.J. Mitchell. The first papers was formally presented by George Stiny in 1971 and published in the following year. [11] He pioneered the field of shape grammars, opening numerous lines of research in shape computation, design, and aesthetic and stylistic analysis which were new ways to look at things at that time. [12] Ms. Knight has published numerous papers on shape grammars [13]. She developed color grammars [14], a generalization of shape grammars which incorporates non-compositional aspects of designs. Her earlier work provided ideas for transformations of design language and development of rules for the process of design. [15] Her recent work examines the practical and theoretical issues involved in implementing shape grammars in design practice. Flemming's research was initially focused on generative design systems, where he made contributions not only

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[10] Wittgenstein, 1956, Remarks on the Fundatins of Mathematics, Oxford, p.193

[11] G. Stiny & J. Gips, 1972, "Shape Grammars and the Generative Specification of Painting and Sculpture", in C V Freiman (ed), 1972, Proceedings of IFIP Congress 71

[12] G. Stiny, 1998, "New ways to look at things", Environment and Planning B: Planning and Design, Anniversary Issue, pp. 68-75; 1994, "Shape rules: closure, continuity, and emergence", Environment and Planning B: Planning and Design, 21, pp. 49-78

[13] T. W. Knight, 1980-1999, Environment and Planning B: Planning and Design 7-26 The newest one is: "Shape grammars: Six types", Environment and Planning B: Planning and Design 26, pp. 15-31

[14] T. W. Knight, 1994, "Shape grammars and color grammars in design", Environment and Planning B: Planning and Design 21, pp.705-735

[15] T. W. Knight, 1983, "Transformations of languages of design: part I, II &III", Environment and Planning B: Planning and Design 10, pp.125-177; 1995,"Constructive symmetry", Environment and Planning B: Planning and Design 22, pp.419-450

to the geometry of layouts, but also to the application of shape grammars to the analysis of corpora of designs in that early phase where this applicability needed to be established[16].

Shape grammar is a kind of study of constructive approach towards researching space or shape. This method was applied to the analyses and evaluation of geometric sculptures, paintings and architecture, such as Stiny and Mitchell who analyzed floor plans of the Palladian villa using the method of shape grammar and developed 210 derivations. [17]

3.1.2 The conditions to define shape grammars

Shape grammar contains four sets of conditions to define space:
- S. (shape);
- L. (symbol);
- R. (rule);
- I. (initial form).

S.   Shape grammar can grow and transform in a limited geometrical pattern which is contained in Cartesian coordinate system.

L.   Shows the function and the attribute of a space. It also shows the geometrical attribute, such as corner, center or end point. These symbols influence the construction of a shape. They are removed, when a shape has been formed.

R.   Shape rule schemata describe the rules of the process that initial form transforms into sub-shapes, then a project.

I.   Initial form can be a geometrical pattern or symbol, which is catalyzed of a shape. A segment of line is a basic element in shape grammar.

Initial Form ←(rules)→ Project

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[16] U. Flemming, 1987, "The role of shape grammars in the analysis and creation of designs" in Kalay Y E (ed.) *Computability of Designs* (New York: John Wiley amp; Sons) 245-272

[17] W. J. Mitchell, 1990, The Logic of Architecture, Cambridge: MIT Press, pp.174-178

Within the process there are many steps. If we see one step as a rule, then at two ends of a rule there are two related shapes that are variables. The right-side form contains the geometrically comparable figure of the left-side form. This implies mathematic transformations which are translation, mirror, rotation, scaling.

Form 1$\leftarrow$rule1$\rightarrow$ Form 2, Form 2$\leftarrow$rule2$\rightarrow$ Form 3, Form 3$\leftarrow$rule3$\rightarrow$ Form 4, ...,
Form N$\leftarrow$rule N$\rightarrow$ Project

There are two methods for grammar to analyze this process:" bottom-up" or "top-down". "Bottom-up" is to define all single elements in entirety and then added up. Within the process of constructing a shape, all single elements, positions, and attributes are produced and organized gradually. "Top down" is to cut into parts and build up a whole framework, then to develop single elements and spaces in the possible shapes of this framework, such as Palladian grammar that was developed by Stiny and Mitchell. Palladian grammar first had a grid system of 5*3, and then they built rooms and rearranged walls, entrances, windows and decorations. Finally they produced 210 substitute plans for this Palladian Villa.

3.1.3 "Bottom up" for analyzing traditional town houses:

We know that several basic spatial units of oblong space form the traditional house in China as well as in Taiwan. Though these oblong construction units may differ in size, yet with their structure, diameter and material, they look quite similar to each other. This unit 'Jian' is the single element that forms Chinese and Taiwanese architecture.[18] Although the approach of shape grammar attaches importance to the organization and composition of architectural space, we must consider the best way to describe a project by shapes effectively. Some notions, for example: gradation and arrangement of ideas should be presented in this shape grammar clearly. Precise shapes, actual symbols and logical rules are very vital to the result of the analyses.

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[18] Li Yu-Su, 1990, 李允鉌，華夏意匠，天津大學出版社，中國建築是由基本的單元空間，"間" 做累積
組合成的, p.130

From the simplest to the most complex, we can quantify the resulting behavior from the forces in both opposite procedures, from the project to the components and vice versa. The Italian architect, Vittorio Giorgini gave us an idea for the relationship between an existing project and analysis[19] as:

Project $\rightleftharpoons$ Analysis
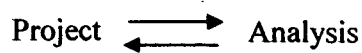
3.2 Shape Grammar composition in the facades of Taiwanese town houses:

Shapes are normally defined by means of visual and spatial differentiation. In this dissertation, the shape grammar of Taiwanese traditional town houses will be composed first from the facades, since the process of composition and using a shape grammar corresponds very much to the visual implementation.

While we develop shape grammar for traditional town houses, we should also try to build it up from the perspective of an artisan in ancient times. Normally the users of shape grammar form a town house from the bottom upwards. In this research we are comparing the facades by shape grammars, so we will just illustrate and describe all the facades by shape grammars and compare the differences in the derivations of the same series of rules.

3.2.1 The logical phases to develop a shape grammar

The process of developing and using a shape grammar can be divided into several logical phases.

1. Creating and modifying the shape grammar: The designer creates the rules and initial form, and verifies or changes the spatial and logical constrains.

2. Compiling the grammar: While converting the grammar into internal form, the system checks that each rule applies in only a finite number of ways.

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[19] Vittorio Giorgini, 1995, Spatiology: The Morphology of the Natural Sciences in Architecture and Design, Milan, Italy, p.70

3. Exploring the language of designs defined by the grammar: The designer explores the language of designs, imposing additional constraints, halting the generation process, backtracking to a previous design, or saving the current state. The designer may interpret the resulting designs in a curve linear mode and use them as the basis for a design. [20]

This shape grammar can deal with the generation of architectural facades, a geometric pattern, which determines certain global characteristics of the facades and guides, and also the development of some of their local properties.

3.2.2 The initial shape

A shape is a finite set of straight line segments such that any two of these segments which belong to the same straight line have no points in common; the elements in a shape are called maximal lines and specified, for example, through the coordinates of their end points in a Cartesian coordinate system. A shape containing no maximal lines is called the empty shape and denoted by the symbol Sø. A labeled point has the form 'p: L', where 'p' is a point, and 'L' is a symbol or label attached to that point. A labeled shape is given by the pair

< S, P>, where S is a shape, and P is a finite set of labeled points. [21]

The initial shape 'I' is expressed by an empty shape, Sø and a set of coordinate points:

$\{(0,0,0): P (X,Y,Z) \mid X=1, Y \leq 3, Z \leq 2\}$ [22]

I=<Sø, $\{(0,0,0): + (0,0,0), \{(0,0,0): P (X,Y,Z) \mid X=1, Y \leq 3, Z \leq 2\}\}$>

Sø: the empty shape.

+: a point on an absolute coordinate

P: labeled points on the labeled shape

X=1: It can only generate one bay.

[20] M Tapia, 1999, "A visual implementation of a shape grammar system", Environment and Planning B: Planning and Design, Volume 26, pp. 59-73

[21] U Fremming, 1981, "The structure in bungalow plans", Environment and Planning B, Volume 8, pp.393-404

[22] F Downing, and U Fremming,1981, "The Bungalows of Buffalo", Environment and Planning B, Volume 8, pp. 269-293

Y=1: It can only generate one block. (Y=3 at the third block)

Z=1: It can only generate one floor. (Z=0 on ground floor, Z=2 on the second floor)

Special cases of labeled shapes are given by < Sø, P>, a shape containing no maximal lines.

The initial shape of this facade which contains one bay and three stories can be illustrated below.

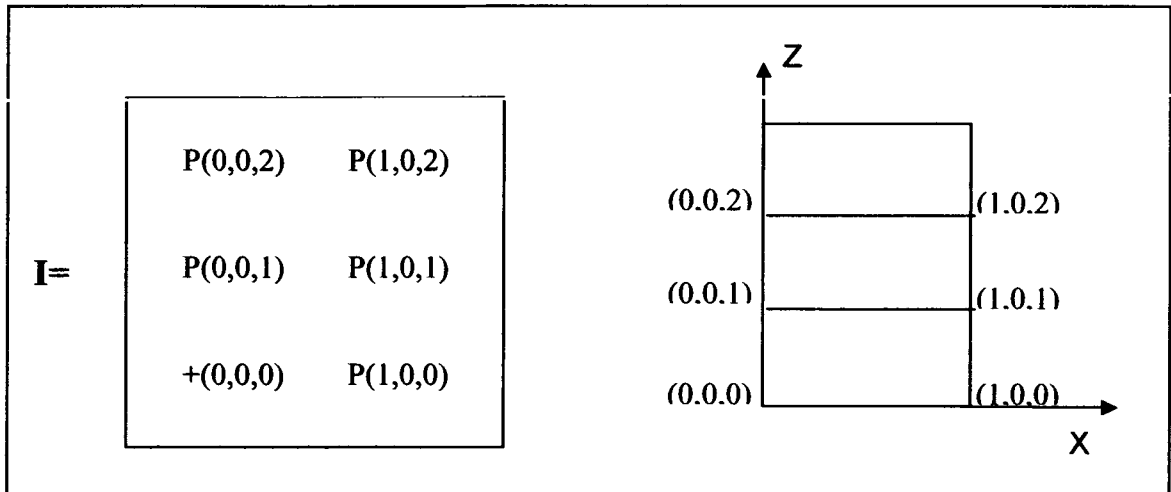**Figure 3. 1 Indicating the initial shape of a facade which contains one bay and three floors**

3.2.3 Compiling the grammar

The overall impression given by a town house in our example is that of a rectangular box. This step defines the external walls that form the enclosure for this type of structure; the lines with endpoints g and s mark, respectively, its ground line and skyline. It will be given in a coordinate, X (bay), Y (block), Z (floor) (Figure 3.2).

In the traditional town houses of both Taiwan and Austria, the elements of a facade can be defined as four parts: arcade (ground floor), body (1st –n floor), head (roof) and friezes between the three parts. To illustrate this, suppose there is a diagram of a facade on a coordinate, it can be represented as below:
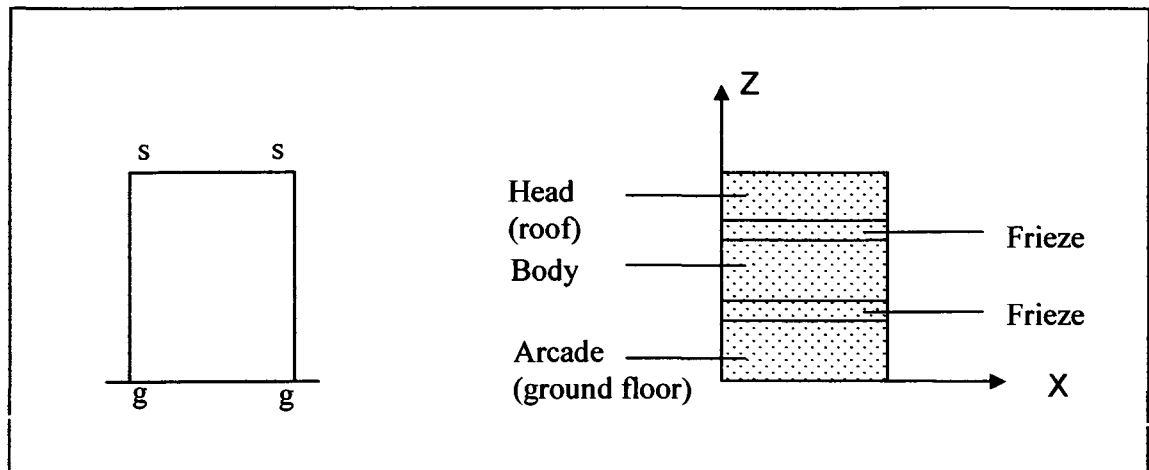
Figure 3. 2   Diagram of a facade on coordinates

All four of the parts have different versions. All these different versions were formed by local architects or artisans reflecting their respective special social and economic contexts and features.
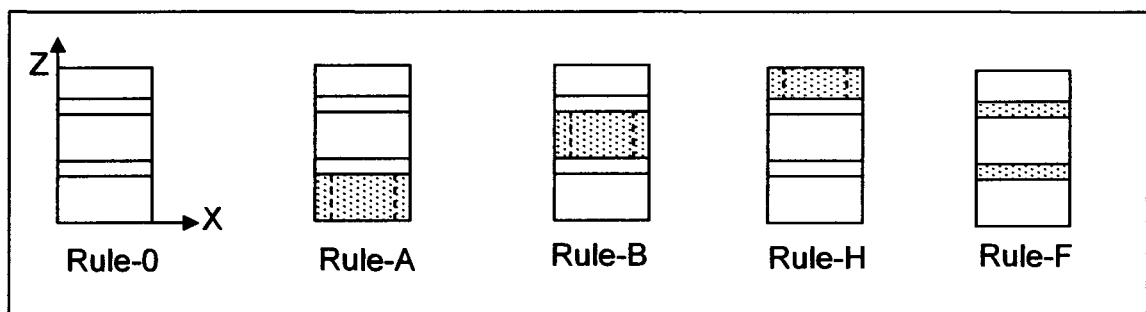
Figure 3. 3   Series of rules for a facade

We will now illustrate the generation process of the shape grammar and the derivations of the facades of the traditional town houses in Taiwan. We can compile the grammar as: the series of Rule A for arcades, the series of Rule B for bodies, the series of Rule H for heads and the series of Rule F for friezes (Figure 3.3).

3.2.4   Exploring the language of designs defined by the grammar

The ground floor in a Taiwanese traditional town house normally combines with the arcade. Basically the shop owners prefer to extend their shopping area to include the arcade. But also due to the Taiwanese weather conditions and architectural regulations, arcades are

very common for Taiwanese traditional town houses.[23] In the Taiwanese language, an arcade is called "Ding-a-ka" which means "under a pavilion".

The body of a Taiwanese traditional town house can be a single floor up to three floors, seldom more than four floors. Some traditional town houses have been structured in long narrow and slender construction morphology. Furthermore, the diverse cultures of businessmen and colonial governments introduced new building materials and new techniques. A new code of regulations strictly defined the building act. The roof style in Taiwanese traditional dwellings could represent the owner's social position. Some roofs of the same type often appeared in different variations. In Taiwanese traditional town houses, the roof took a simple form but included diverse decorations on the parapets of the main facade.

Through more details and backgrounds from the examples of Taiwanese town houses, the design language defined by the grammar will be established. The following part deals with exploring the shape grammars of the facades for traditional town houses in Taiwan.

3.3 Application of shape grammar for facades of Taiwanese traditional town houses:

3.3.1 To compose the shape grammar for the facade of the traditional town house Dihwa St.71:

In the below example of composition of shape grammar, a representative Taiwanese town house facade of Dihwa St.71 in Taipei has been applied.

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[23] During the Japanese colonial period (1895-1945), the government pronounced a "Building Regulation" in 1900 and a "Code of Urban Planning" in 1911. Both of them stated a requirement of an arcade for a local town house.

Figure 3. 4 Facade of Dihwa St.71

In accordance with the former explanation of an initial form, the initial form of the facade at Dihwa St.71 will be written as the same as Figure 3.5, since the facade contains one bay and three floors.
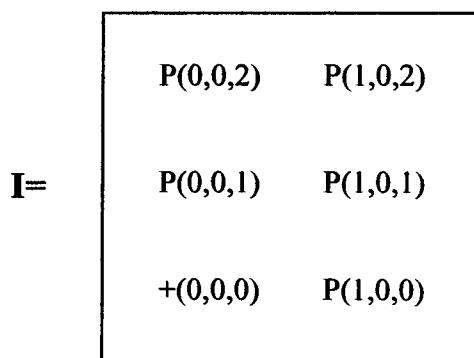
$$
\mathbf{I} = \begin{array}{ll} P(0,0,2) & P(1,0,2) \\[1.5em] P(0,0,1) & P(1,0,1) \\[1.5em] +(0,0,0) & P(1,0,0) \end{array}
$$

Figure 3. 5 Initial shape of the facade at Dihwa St.71 in Taipei

From +(0,0,0) to P(1,0,0) there is a line segment which presents the width of the facade and from +(0,0,0) to P (0,0,1) and P(0,0,2) a line segment which presents the height of each floor. The term 'width' is used to refer to the measurement of bays of a facade, whereas the term 'height' is used to refer to dimensions measured perpendicular to this direction. In ancient

Taiwan the artisan would have computed the fortune dimensions[24] for these measurements. The usage of fortune numbers in measurements was among the factors that influenced the design of the Taiwanese traditional town houses.[25] It was important in the design of traditional Taiwanese buildings to employ 'lucky' dimensions or measurements. Equally important were the measuring instruments like rulers that were used to measure these dimensions. In Taiwanese traditional architecture, there were at least five kinds of rulers and measuring systems used in design and construction. The first general ruler that artisans used was the 'Lu Ban ruler'.

Secondly, the language of designs defined by the grammar in this traditional town house will be compiled and explored. An arcade will be a starting pattern in the elements of this facade. The schema below also presents an internal, main entrance that is an opening on the facade.

1. **The arcade as Rule A:** The ground floor based on the fortune measurements, a front arcade and a main entrance is developed first by Rule A. Here we define an arcade with a rectangular opening as Rule A-a. This rules only apply at the first block of the ground floor, ($Xn=1$, $Yn=1$, $Zn=0$).
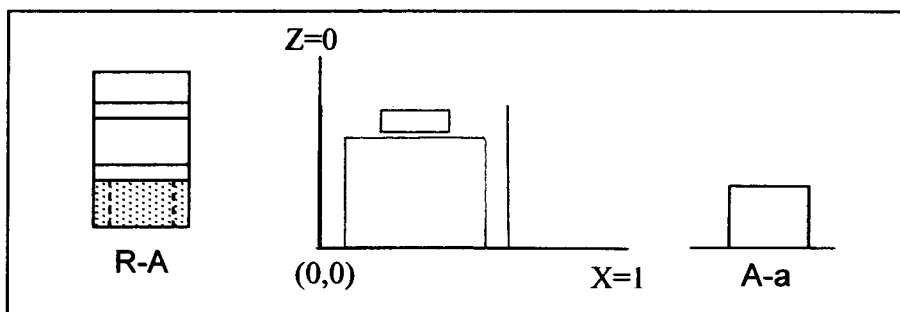

Figure 3. 6   Rule A for the facade in Dihwa St. 71

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[24] Fortune dimensions or 'lucky numbers', S-C Chiou and R. Krishnamurti, 1995, "The fortune dimensions of Taiwanese traditional architecture", Environment and Planning B: Planning and Design, Volume 22, pp. 547-562

[25] Lin Hui-Ch'eng, 1995, The handbook of traditional Taiwanese architecture; 傳統建築手冊，藝術家出版社，pp.34-35

2. The body as Rule B: The first floor which includes three windows on a narrow and long balcony and four ornate columns are added up by Rule B. The balcony on a main facade is often only an embellishment. The openings and columns are placed on the main facade symmetrically. We will define this part of a facade with three same- size windows as B-3a. Here one long balcony which cover three windows is defined as "t", so this body will be written as B-3a+t. (Xn=1, Yn=1, Zn=1)

The second floor which includes three multi-sided windows and a round transom are also added up by Rule B. We will define this part of the facade as B-3s+cs. (Xn=1, Yn=1, Zn=2) So we can now define the body of this facade as B-3as+cs+t. (Figure 3.7)

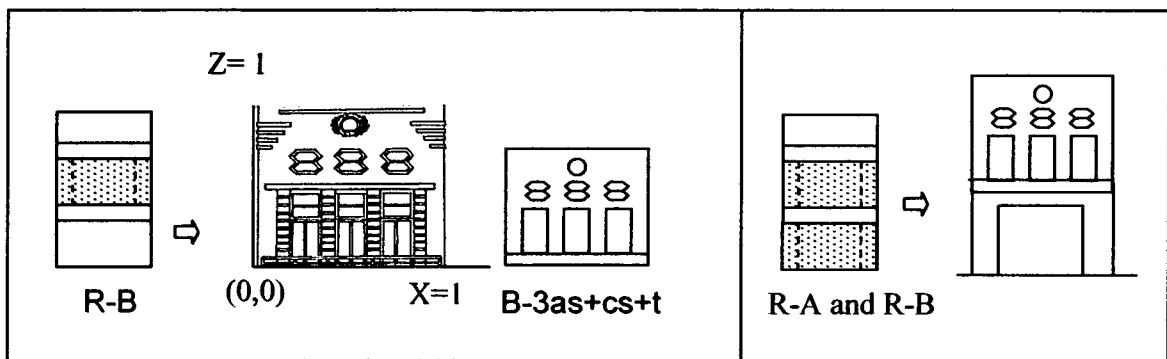**Figure 3. 7   Rule B for the facade in Dihwa St. 71**

3. The roof as Rule H: The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade is developed by Rule H. We define a rectangular and flat parapet as Rule H-a, although it is decorated in a stair-shape. (Figure 3.8)
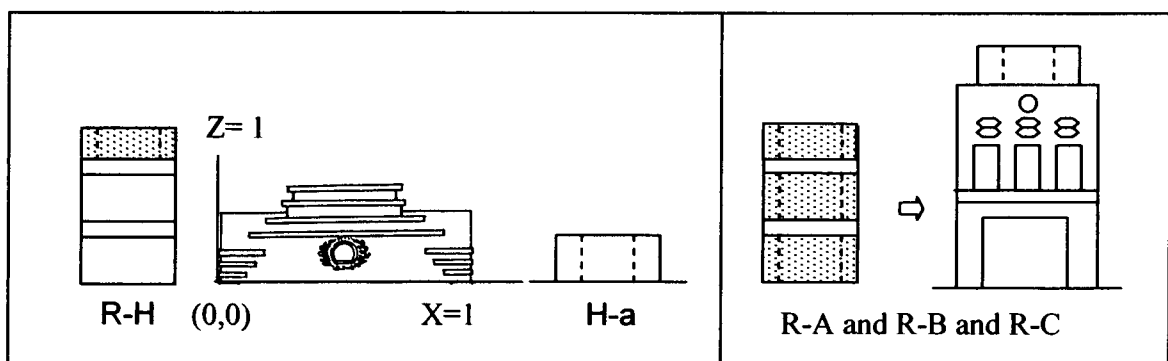

Figure 3. 8   Rule H for the facade in Dihwa St. 71

4. The frieze as Rule F: Friezes can exist between a base and a body, a body and a head or both. In rule F it will be shown: "f1" for the frieze between a base and a body; "f2" for the frieze between a body and a roof and so on. If it is an arc frieze, it is added "r" as "rf". In this case there is no frieze.

5. The terrace as Rule T: If one balcony or terrace is almost as wide as the bay of the facade, then it is defined as "t". Sometimes terraces or balconies on the facade are just used as a decoration. If one balcony or terrace is similar in width as a window, it is defined as "at". If the main elevation of one balcony or terrace is an arc, "r" is added before "t" or "at" which would then read as "rt" or "rat". Rule T can be combined with Rule B. In this case it can be written with Rule B as B-3as+cs+t.

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment of the arcade, the body and the head. The common material used on the facade of Taiwanese traditional town houses was wood (w) and brick (b) from the Qing dynasty until 1895; pebble dash (e), painting (p), stone (s) and brick during the Japanese colonial period. The rule in this case can be described as e-s-s. The facade has pebble dash on the ground floor and stone on the first and the second floors.
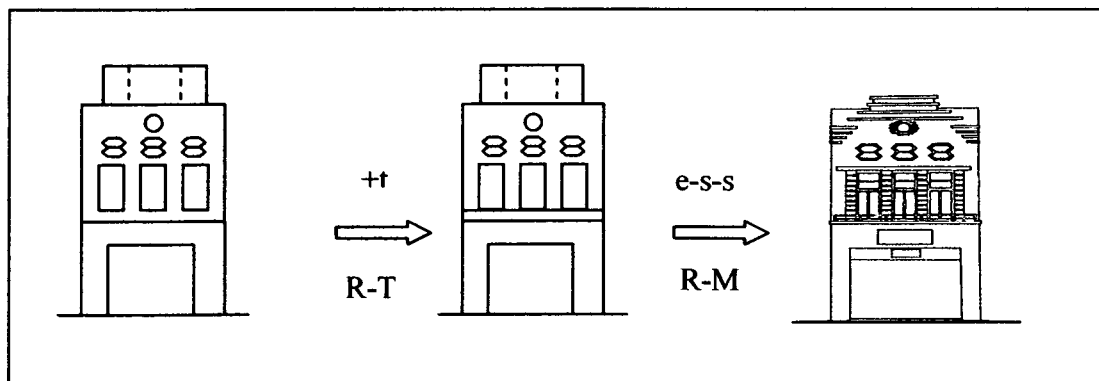

Figure 3. 9   Rule T and Rule M for the facade in Dihwa St. 71

7. The termination of the shape language of facades : After the facade has been described, all labels and coordinates can be removed from the process and the components.

If we are regenerating a facade or a floor plan, it should be noted that a label must be removed only if the size and dimensions of that component satisfy minimal requirements. Below the facades of Taiwanese town houses in Taipei will be illustrated by this shape grammar.

3.3.2 Applications of shape grammars in the facades of the traditional town houses in Dihwa street in Taipei:

Our first sample is admittedly small, and the facades we are willing to compare in traditional Taiwanese town houses should be considered more extensively. There are representative town houses from four famous historic areas in Taiwan which are illustrated below by this shape grammar.

The following figure which is shown on two pages represents ten facades of Taiwanese town houses. They are located near the Danshui river at Dihwa street in Taipei which was a river harbour area. Nine of these ten town houses are at section 1 of Dihwa street, No. 24, 44, 71, 114, 131, 133, 135, 148 and 152 which were built during the Japanese occupation period 1895-1945 and house No. 352 was built between the Opium war and Japanese occupation period, 1840-1895.

No.24	No.44	No.71	No.114	No.352
Cloth Shop	Food Wholesale	Chinese Medicine	Trade Company	Private Residence

No.135	No.133	No.131	No.148	No.152
Chinese	Chinese	Chinese	Snack	Chinese
Medicine	Medicine	Medicine	whole sale	Medicine

Figure 3.10 The ten facades of traditional town houses in Dihwa Street

1. **The arcade as Rule A:** The ground floor based on the fortune measurements, a front arcade and a main entrance is developed first by Rule A. We define rules as:

   - an arcade which has a rectangular opening as Rule A-a;

   - a rectangular opening with modified corners as Rule A-b;

   - a rectangular opening with two columns as Rule A-e;

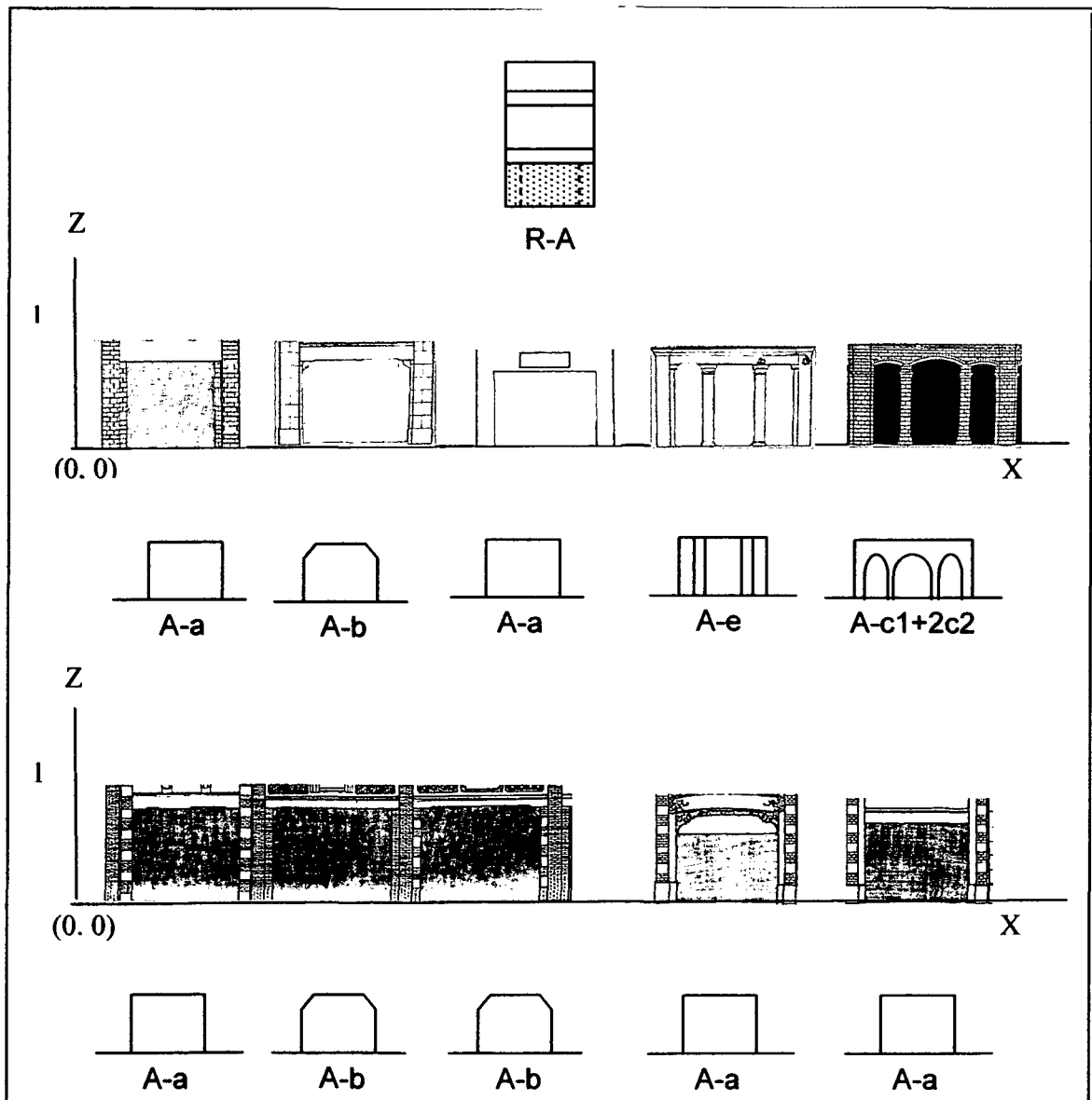   - an arcade with one big arch and two smaller arches as Rule A-C1+2c2. These rules only apply at the first block and the ground floor, $(Xn=1, Yn=1, Zn=0)$.

Figure 3. 11   Rule A for the facades of traditional town houses in Dihwa Street

2. **The body as Rule B**: The first floor and the second floor will be described together as Rule B. We define rules according to the various kinds of openings.

   – The body of house No. 24 which contains one wide window between two narrow windows on both first and the second floor is defined as Rule B-3bx2.

   – The body of No. 44 and No. 135 which include three same-size windows on the first and the second floors symmetrically is defined as Rule B-3ax2.

   – The body of No. 114 which contains one arch window between two smaller arch windows and one small balcony for each window is defined as Rule B-3br+3at.

   – The body of No. 352 which has one wide window between two narrow windows symmetrically is defined as Rule B-3b.

   – The body of No. 133 which contains one wide window between two narrow windows at the first floor, one bigger arch window between two small arch windows on the second floor and an arc terrace is defined Rule B-3b+3rb+rt.

   – The body of the No. 131 which contains one wide window between two narrow windows on both the first and the second floors and one arc terrace is defined as Rule B-3bx2+rt.

   – The body of No. 148 which contains five windows on the first floor, three arch windows on the second floor and both floors are on an arc wall is defined Rule B-r(3b+3rb).

   – The body of No. 152 which includes three same-size windows on the first and three same-size arch windows on the second floors symmetrically is defined as Rule B- 3a+3ar.

The balcony on the main facade is often only an embellishment. Besides No. 352 all of these facades are with a lot of decorations. These rules are only applied on the body of a facade. (Xn=1, Yn=1, Zn=1,2)
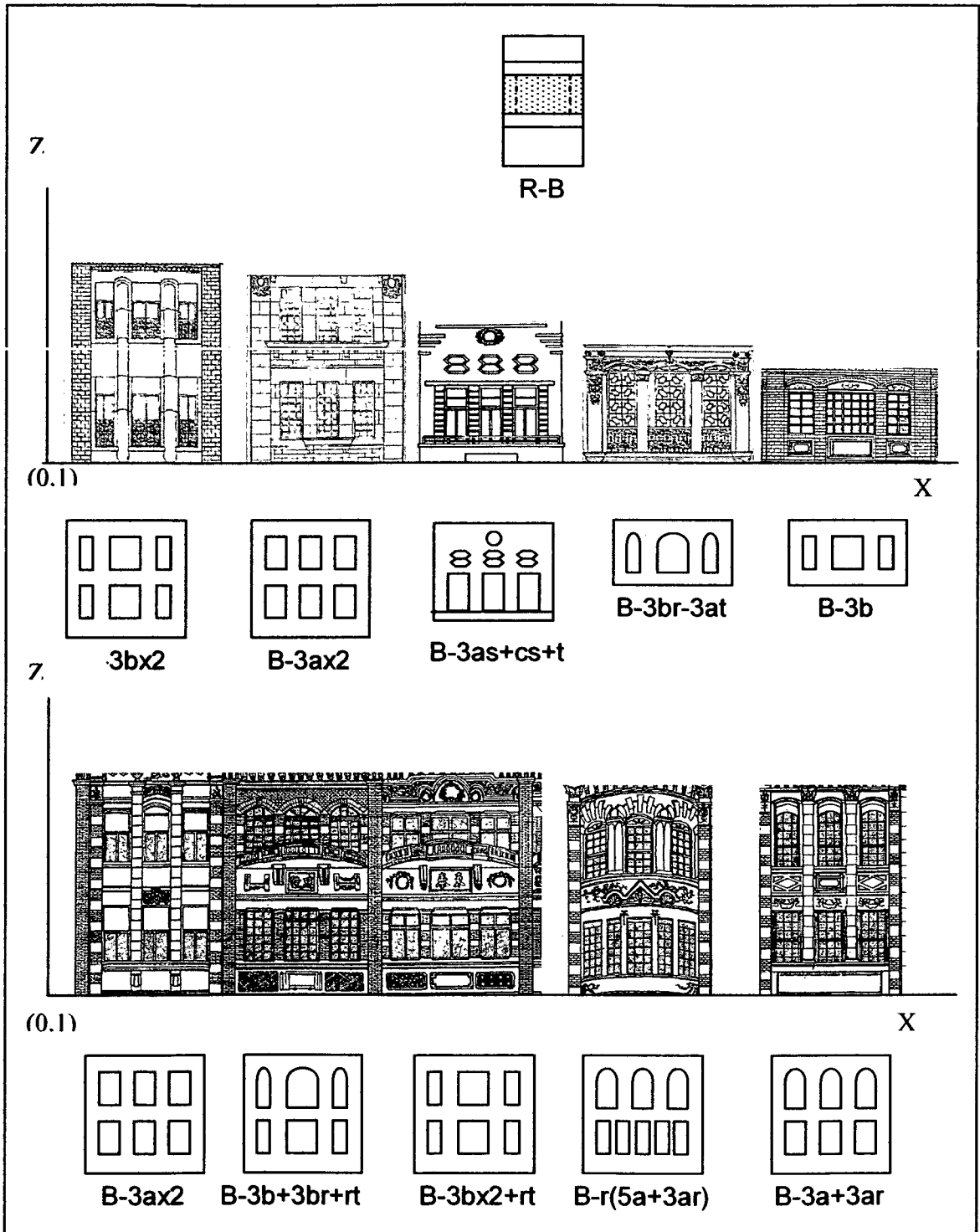
Figure 3. 12   Rule B for the facades of traditional town houses in Dihwa Street

3. **The roof as Rule H:** The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade, are developed by Rule H.

- The head of the No. 24 which contains one circle shape in a flat parapet is defined as Rule H- a2+d.

- The head of the No. 44 which includes one triangle shape in a flat parapet is defined as Rule H- a2+b↓.

- The head of the No. 114 which contains one triangle shape in a prominent step of the parapet is defined as Rule H- a2+b↑.

- The head of the No. 352 which is a rectangular and flat parapet with some decoration is defined as Rule H- a.

- The head of the No. 131, 133, 135, 148 and 152 which contains a semicircle on a flat parapet with some decorations is defined as Rule H- a2+c↑.

These rules are only applied at the head of a facade. (Figure 3.13)
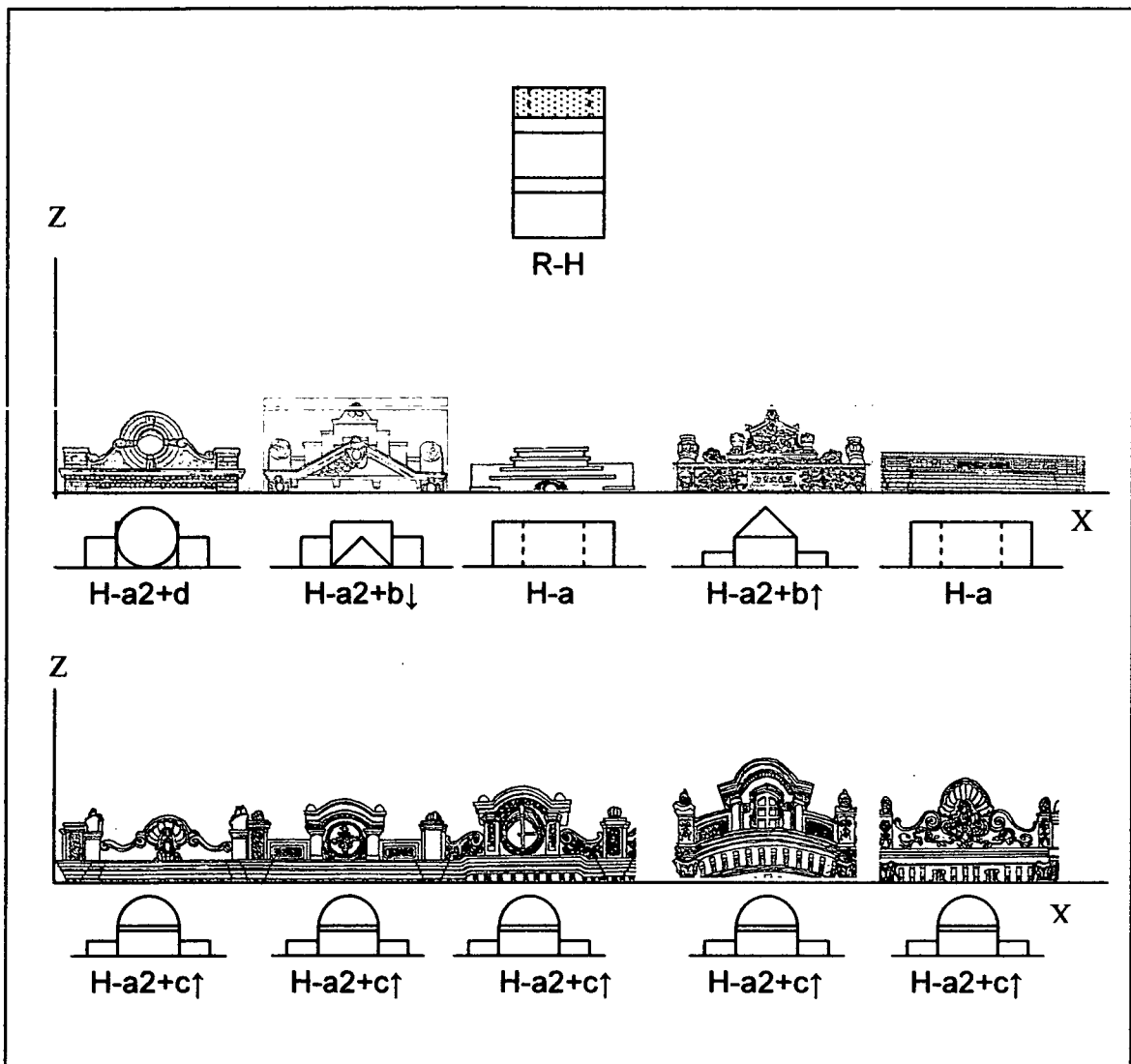
Figure 3. 13 Rule H for the facades of traditional town houses in Dihwa Street

4. The frieze as Rule F: Friezes can exist between a base and a body, a body and a head or both. In rule F it will be shown: f1 for the frieze between a base and a body; f2 for the frieze between a body and a roof and so on. If it is an arc frieze, "r" is added as "rf1" and "rf2". The facade of No. 24 and No. 44 has f2, No. 114 and No. 352 have both f1 and f2, No. 131, No. 133, No. 135 and No. 152 have only f2 and No. 148 has a gorgeous rf2.

5. The terrace as Rule T: If one balcony or terrace is almost as wide as the bay of the facade, then it is defined as "t". If one balcony or terrace is similarly as wide as a window, it is defined as "at". If the main elevation of one balcony or terrace is an arc, "r" is added

before "t" and "at". It is therefore written as "rt" and "rat". The facade of No. 114 contains one terrace for each of the three windows, so it is defined as "3at". The facade of No. 131 and No. 133 both contain an arc terrace or "rt". This can be combined with Rule B.

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment of the arcade, the body and the head. The common material used on the facade of Taiwanese traditional town houses was wood (w) and brick (b) from the Qing dynasty until 1895; pebble dash (e), painting (p), stone (s) and brick during the Japanese colonial period. The material of the facade No. 24 is pebble dash and brick, so it is written "eb-eb-e". The others will be listed on the following table.

7. The termination of the shape language of these facades: The shape language for the facades of ten Taiwanese town houses at Dihwa Street in Taipei is listed below in Table 3.1.

	Rule No.	Rule A	Rule B	Rule F	Rule H	Rule M	T
DIHWA STREET I	No.24	A-a	B-3bx2	f2	H-a2+d	eb-eb-eb	—
	No.44	A-b	B-3ax2	f2	H-a2+b↓	e-e-e	—
	No.71	A-a	B-3as+cs+t	—	H-a	e-e-e	t
	No.114	A-e	B-3br+3at	f1,f2	H-a2+b↑	e-e-e	3at
	No.352	A-c1+ 2c2	B-3b	f1,f2	H-a	b-b-b	—

DIHWA STREET II	No.135	A-a	B-3ax2	f2	H-a2+c↑	eb-eb-e	—
	No.133	A-b	B-3b+3br+rt	f2	H-a2+c↑	eb-eb-e	rt
	No.131	A-b	B-3bx2+rt	f2	H-a2+c↑	eb-eb-e	rt
	No.148	A-a	B-r(5a+3ar)	rf2	H-a2+c↑	e-e-e	—
	No.152	A-a	B-3a+3ar	f2	H-a2+c↑	e-e-e	—

Table 3. 1 Shape grammars for the ten facades at Dihwa Street in Taipei

3.3.3 Applications of shape grammars in the facades of the traditional town houses in Daxi:

The following figure which is shown on two pages represents ten facades of Taiwanese town houses. They are located near the Dahan River in Daxi, which was a river harbour area. These ten town houses are at the Hoping Road in Daxi, No. 48, 48-1, 49, 50, 81, 84, 86 and Zhong Shan Road No. 12, 13 and 15 which were built around 1910 during the Japanese occupation period.

In accordance with the rules and the examples described above, the shape language of these ten town houses is as follows:

No.48-1	No.48	No.49	No.50	No.81
Coffee Shop	Office	Pharmacy	Private Residence	Rice cake Shop
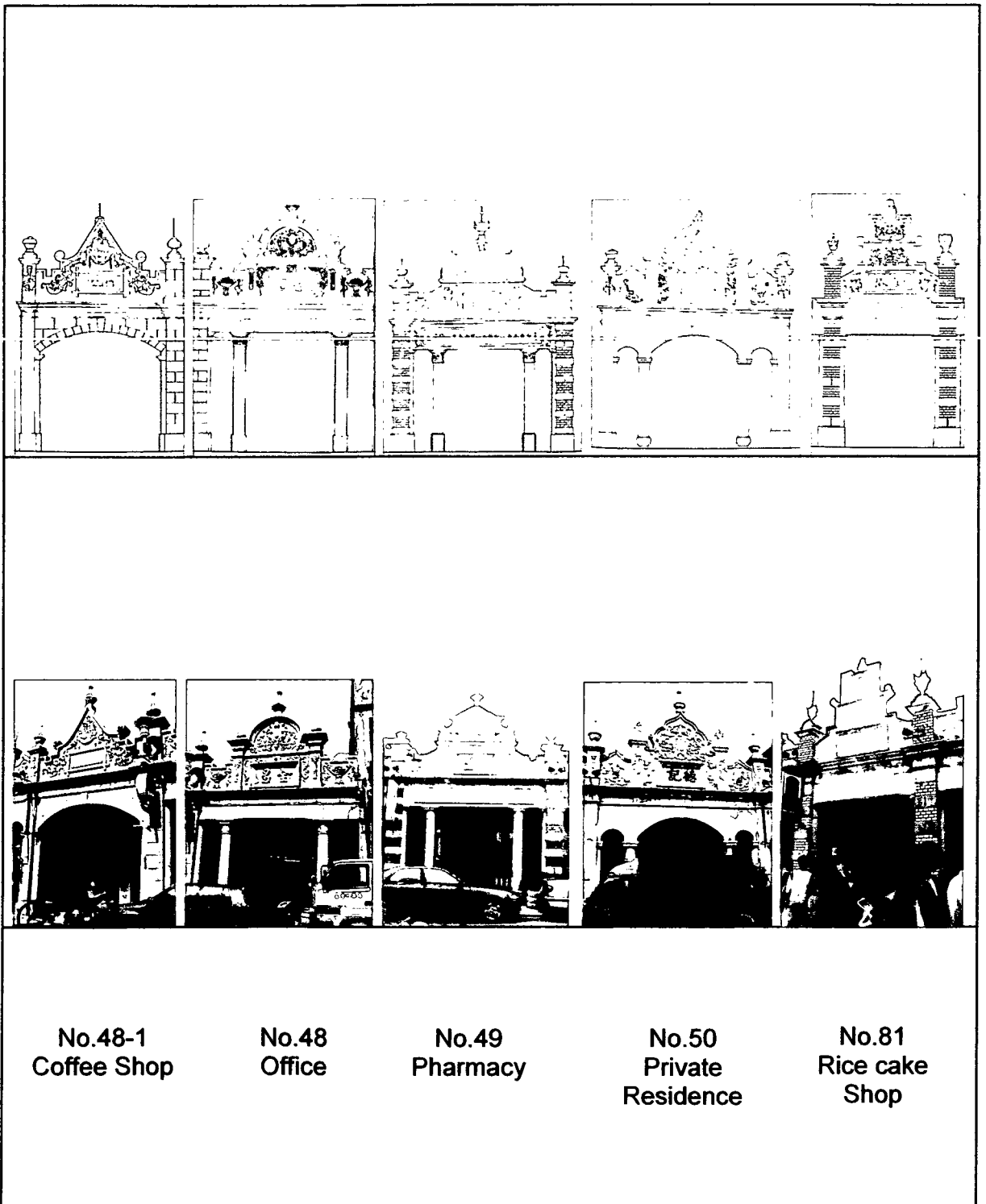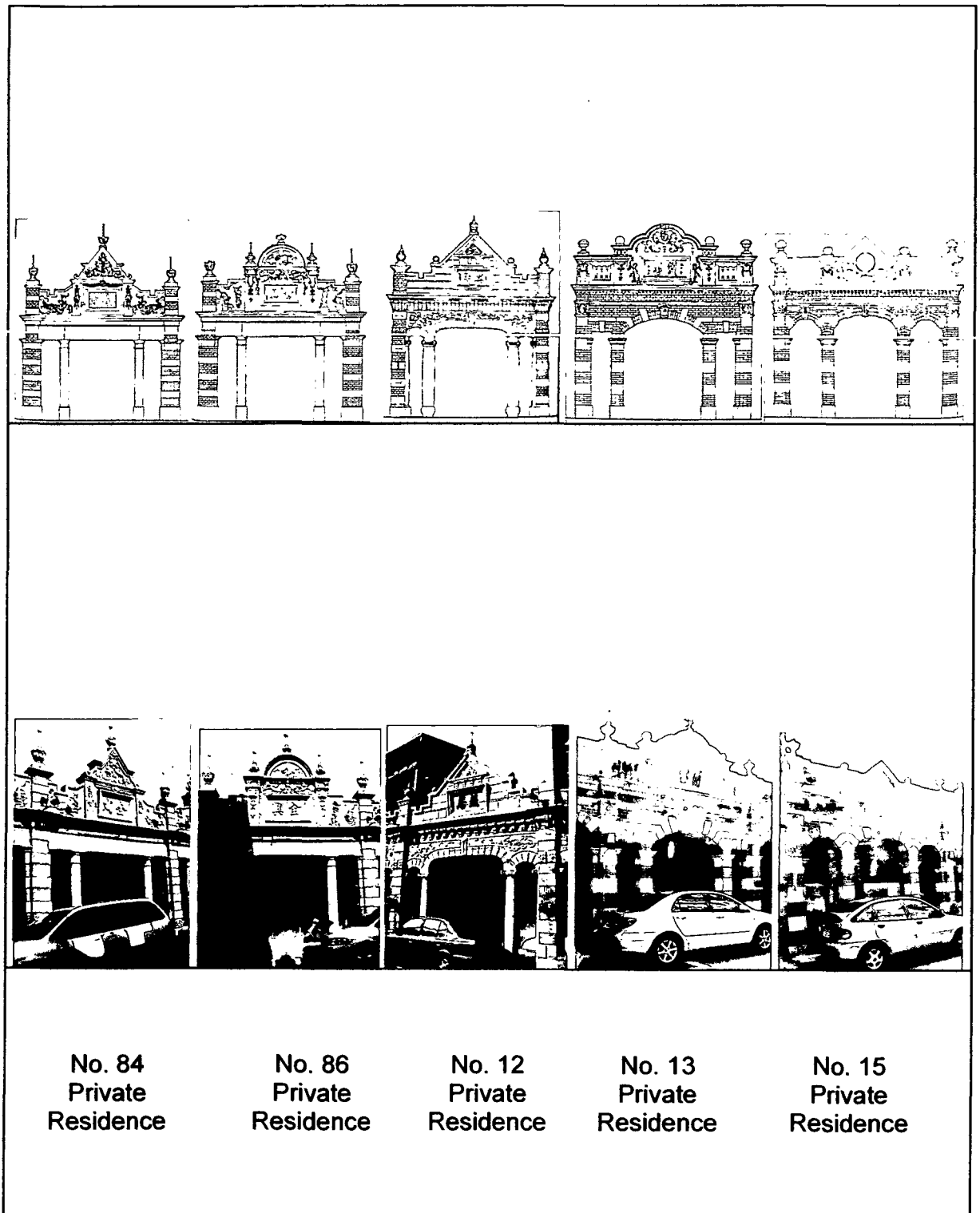
Figure 3. 14 The ten facades of traditional town houses in Daxi

1. **The arcade as Rule A:** A ground floor based on fortune measurements, a front arcade and a main entrance are now being developed using Rule A first. We define rules as:

   – an arcade which has a arch opening as Rule A-c;

   – a rectangular opening with two columns as Rule A-e;

   – an arcade with one bigger arch and two small arches as Rule A-C1+2c2

   – an arcade with two modified corners as A-b.

   These rules only apply at the first block and the ground floor, ($Xn=1$, $Yn=1$, $Zn=0$).
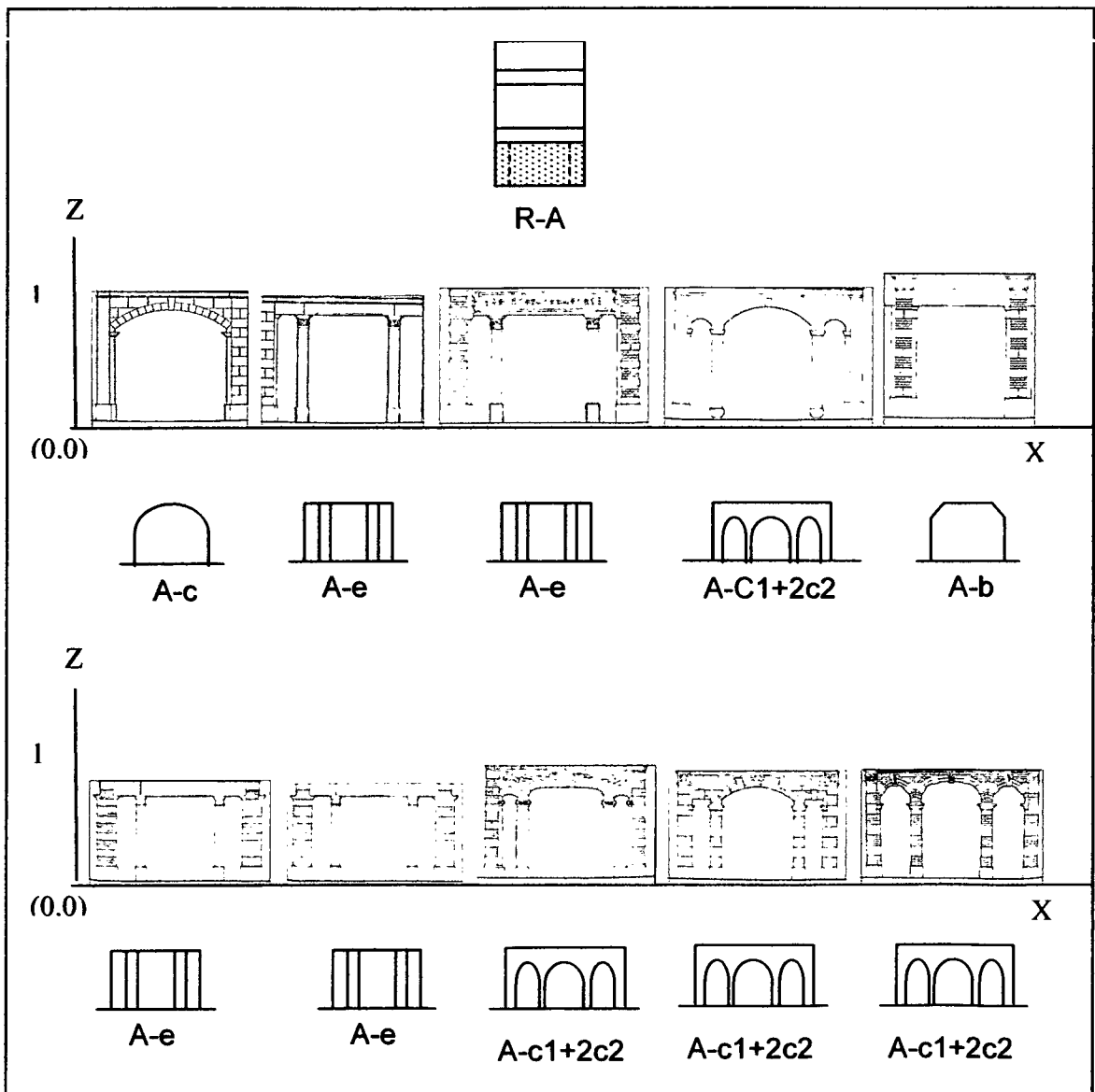
Figure 3. 15   Rule A for the ten facades of traditional town houses in Daxi

2. The body as Rule B: The majority of traditional town houses in Daxi were built only as bungalows. Since there are no first floors in the town houses at Daxi, Rule B is not applicable.

4. **3. The roof as Rule H:** The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade, are developed by Rule H.

- The head of No. 48-1 , No. 50, No. 81, No. 84 and No. 12 and 15 at Zhong Shan Road which contain one triangular shape in a prominent step of the parapet is defined as Rule H- a2+b↑.

- The head of No. 48, No. 49 and No. 86 which includes one semicircular shape in a flat parapet is defined as Rule H- a2+c↑.

- The head of the No. 13 at Zhong Shan Road which contains one shape with three segments in a prominent step of the parapet is defined as Rule H- a2+3c↑.

These rules are only applied at the head of facades. (Figure 3.16)
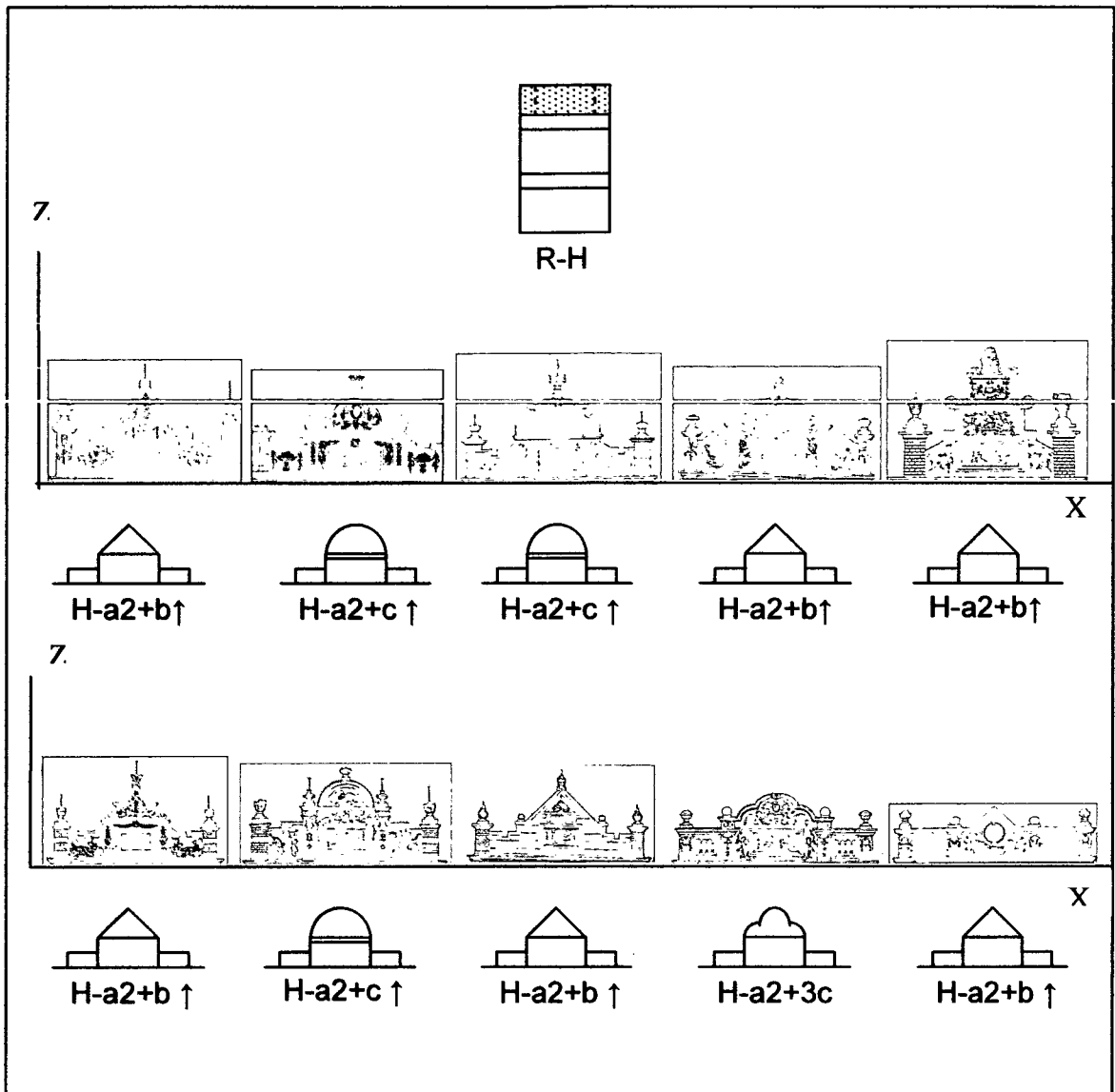
Figure 3. 16   Rule H for the facades of ten traditional town houses in Daxi

4. The frieze as Rule F: Friezes can exist between an arcade and a body, a body and a head or both. In rule F it will be shown: "f1" for the frieze between an arcade and a body; "f2" for the frieze between a body and a roof and so on. If it is an arc frieze, "r" is added and written as "rf". The facade of these ten town houses all have friezes between an arcade and a body. It is written as f1.

5. The terrace as Rule T: The majority of the traditional town houses in Daxi have no balcony on the facade. These ten town houses have no balcony, hence the Rule T is not applicable.

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment of the arcade, the body and the head. The common material used on the facade of Taiwanese traditional town houses was wood (w) and brick (b) from the Qing dynasty until 1895; pebble dash (e), painting (p), stone (s) and brick during the Japanese colonial period. The main material of the facade of the town houses in Daxi is pebble dash and brick. These ten facades will be listed in the following table.

7. The termination of the shape language of these ten facades: The shape language for the facades of ten Taiwanese town houses in Daxi is listed below in Table 3.2.

	Rule No. \ Rule	Rule A	Rule B	Rule F	Rule H	Rule M	T
DAXI I	No.48-1	A-c	—	f1	H-a2+b↑	e-e	—
	No.48	A-e	—	f1	H-a2+c ↑	e-e	—
	No.49	A-e	—	f1	H-a2+c ↑	be-e	—
	No.50	A-c1+2c2	—	f1	H-a2+b↑	e-e	—
	No.81	A-b	—	f1	H-a2+b↑	be-be	—

		Rule A	Rule B	Rule F	Rule H	Rule M	T
DAXI II	No.84	A-e	—	f1	H-a2+b ↑	be-e-be	—
	No.86	A-e	—	f1	H-a2+c ↑	be-e-be	—
	No.12	A-c1+2c2	—	f1	H-a2+b ↑	be-e-be	—
	No.13	A-c1+2c2	—	f1	H-a2+3c	be-b-e	—
	No.15	A-c1+2c2	—	f1	H-a2+b ↑	be-b-e	—

Table 3. 2   Shape grammars for the ten facades of the traditional town houses in Daxi

3.3.4   Applications of shape grammars in the facades of the traditional town houses in Lukang:

The following figure which is shown on two pages represents ten facades of traditional Taiwanese town houses. They are located in Lukang, Changhua which was a harbour area near to the vast Taiwan straits. These ten town houses are No. 6, 7, 16, 17, 18, 25 at Yaolin Street, No. 19 and No. 55 at Puto Street, which were built during the Qing dynasty between 1820 and 1895. Although Zhongshan Road No. 147 and 149 were also built during Qing dynasty, the shop side of these two houses was built during the Japanese occupation period. The back side of Zhong Shan Rd. 147 and 149 was called Shi Yi Lo, which was the famous meeting place in middle Taiwan at that time for the literati.

In accordance with the rules and the examples described above, the shape language of these ten town houses is as follows:

Yaolin St.6	Yaolin St.7	Yaolin St.17	Yaolin St.18	Yaolin St.16
Handicraft	Residence	Handicraft	Handicraft	Residence

| Yaolin St. 25 Private Residence | Puto St.19 Private Residence | Puto St. 55 Private Residence | Zhong Shan Rd.147 Spectacles Shop | Zhong Shan Rd.149 Grocery |
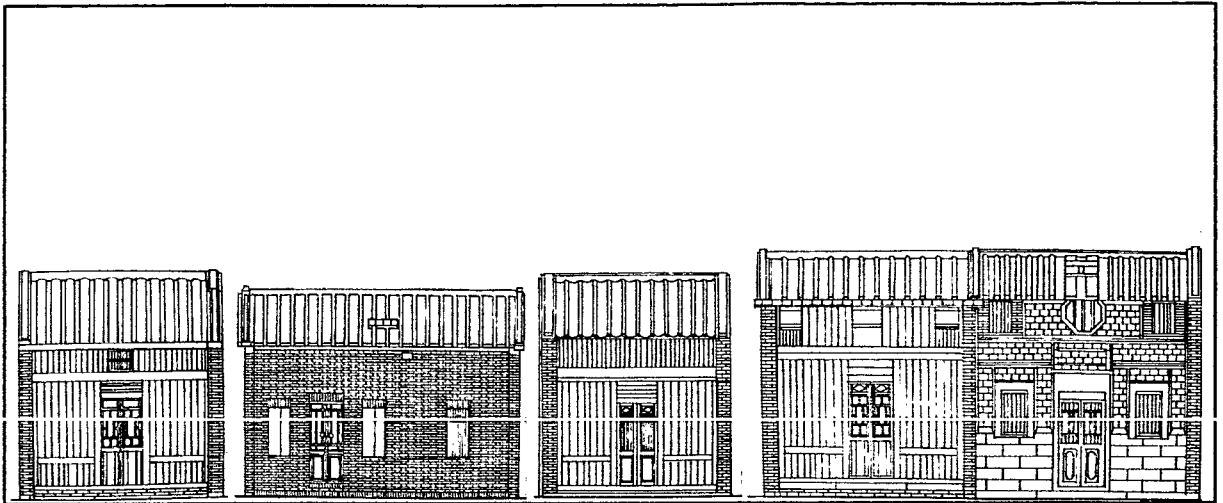
Figure 3. 17   Ten facades of traditional town houses in Lukang

1. The arcade as Rule A: The ground floor based on fortune measurements, a front arcade and a main entrance will be developed first by Rule A. We define an arcade which has one rectangular opening with two modified corners as A-b. ($Xn=1$, $Yn=1$, $Zn=0$).
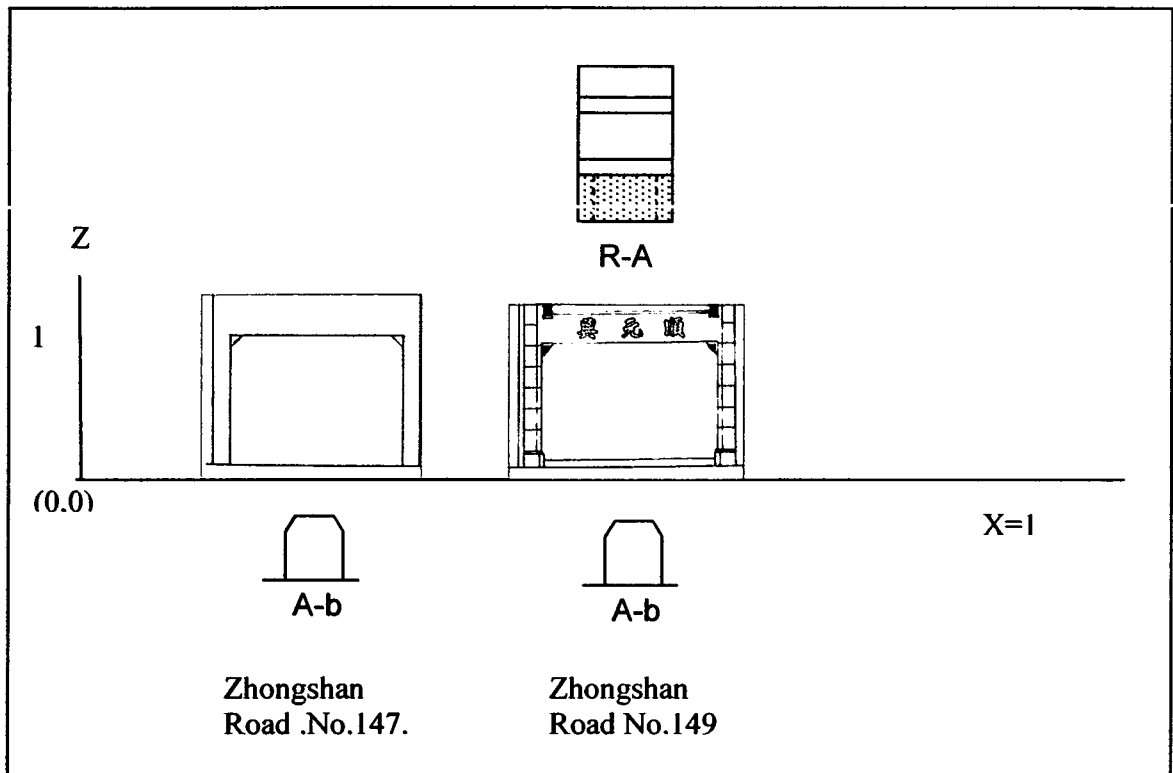
Figure 3. 18   Rule A for the ten facades of traditional town houses in Lukang

2. The body as Rule B: The first and the second floor will be described together as Rule B. We define rules as:

–   The body of No. 6 which contains one middle door and a fanlight is defined as Rule B-1+cs.

–   The body of No. 7 which includes one door between two same-size windows at the left side and one window at the right side is defined as Rule B-0100.

–   The body of No. 17 and No. 55 at Puto Street which have only one middle door is defined as Rule B- 1.

–   The body of No. 18 which has one middle door and three fanlights in the attic symmetrically is defined as Rule B-1+3cs.

- The body of No. 16 which contains one middle door between two windows on the first floor and an octagon fanlight between two fanlights on the attic is defined as Rule B-010+3cs.

- The body of No. 25 which contains one middle door between two windows is defined as Rule B-010.

- The body of No. 19 at Puto Street which contains one door between two windows on the right side and one small window on the left side is defined Rule B-0010.

- The body of No. 147 at Zhongshan Road which includes one middle door between two windows and one middle balcony for the middle window is defined as Rule B- 3a+1at.

- The body of No. 149 at Zhongshan Road which includes one middle door between two windows and one balcony for three of them at both the first and the second floor is defined as Rule B- 2(3b+t).

These rules are only applied at the body of a facade. (Xn=1, Yn=1, Zn=1,2) (Figure 3.19)
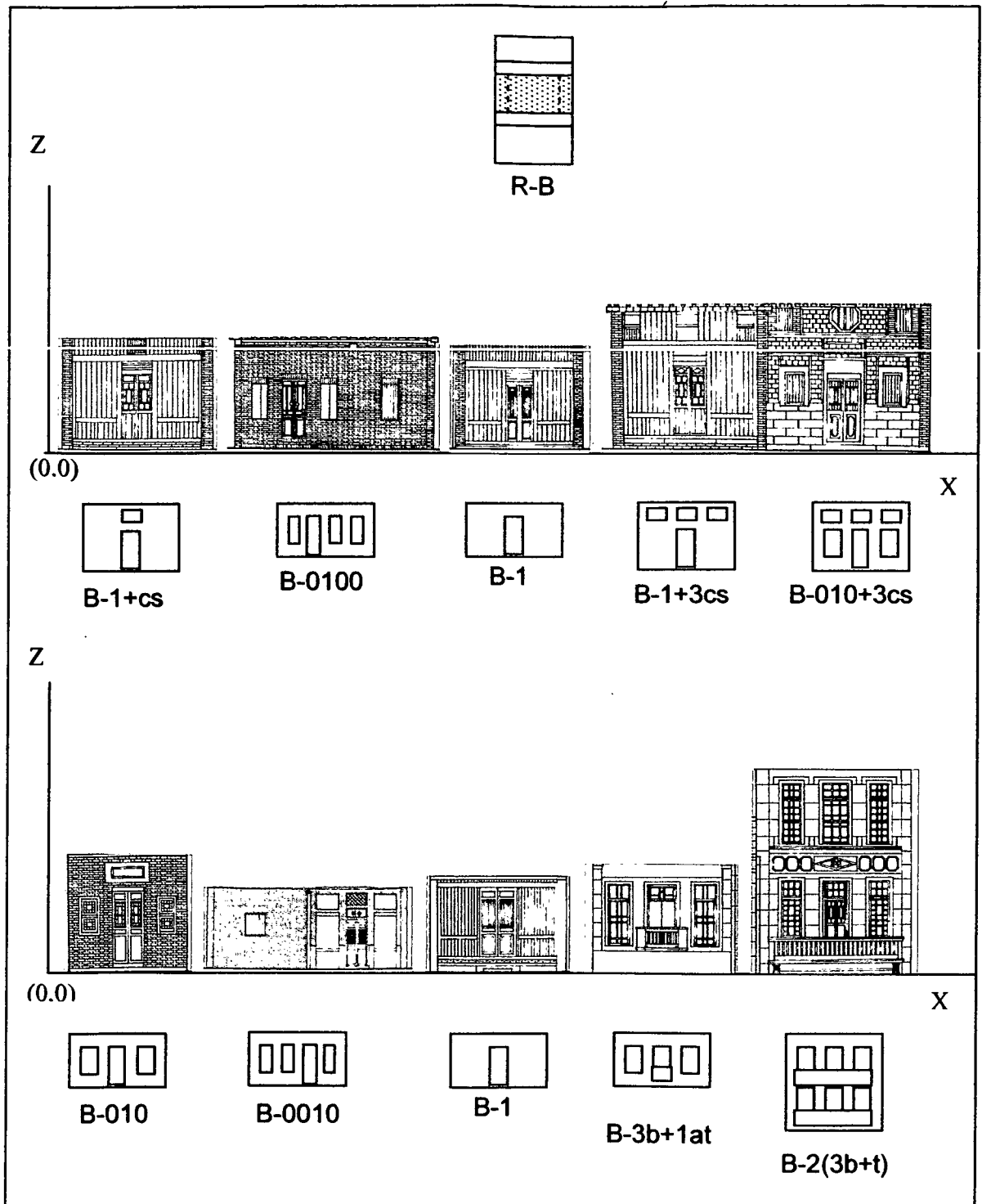
Figure 3. 19   **Rule B for the ten facades of traditional town houses in Lukang**

3. The roof as Rule H: The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade, are developed by Rule H.

- The head of No. 6, No. 7, No. 17, No. 18 and No. 25 at Yaolin Street, which have one simple gable roof are defined as Rule H- af.

- The head of No. 16 at Yaolin Street and No. 55 at Puto Street which include one gable roof and one fanlight on the roof is defined as Rule H- af+w.

- The head of the No. 19 at Puto Street which contains one gable roof and two fanlights on the roof t is defined as Rule H- af+2w.

- The head of the No. 147 and No.149 at Zhongshan Road which are a rectangular and flat parapet is defined as Rule H- a.

These rules are only applied at the head of a facade. (Figure 3.20)
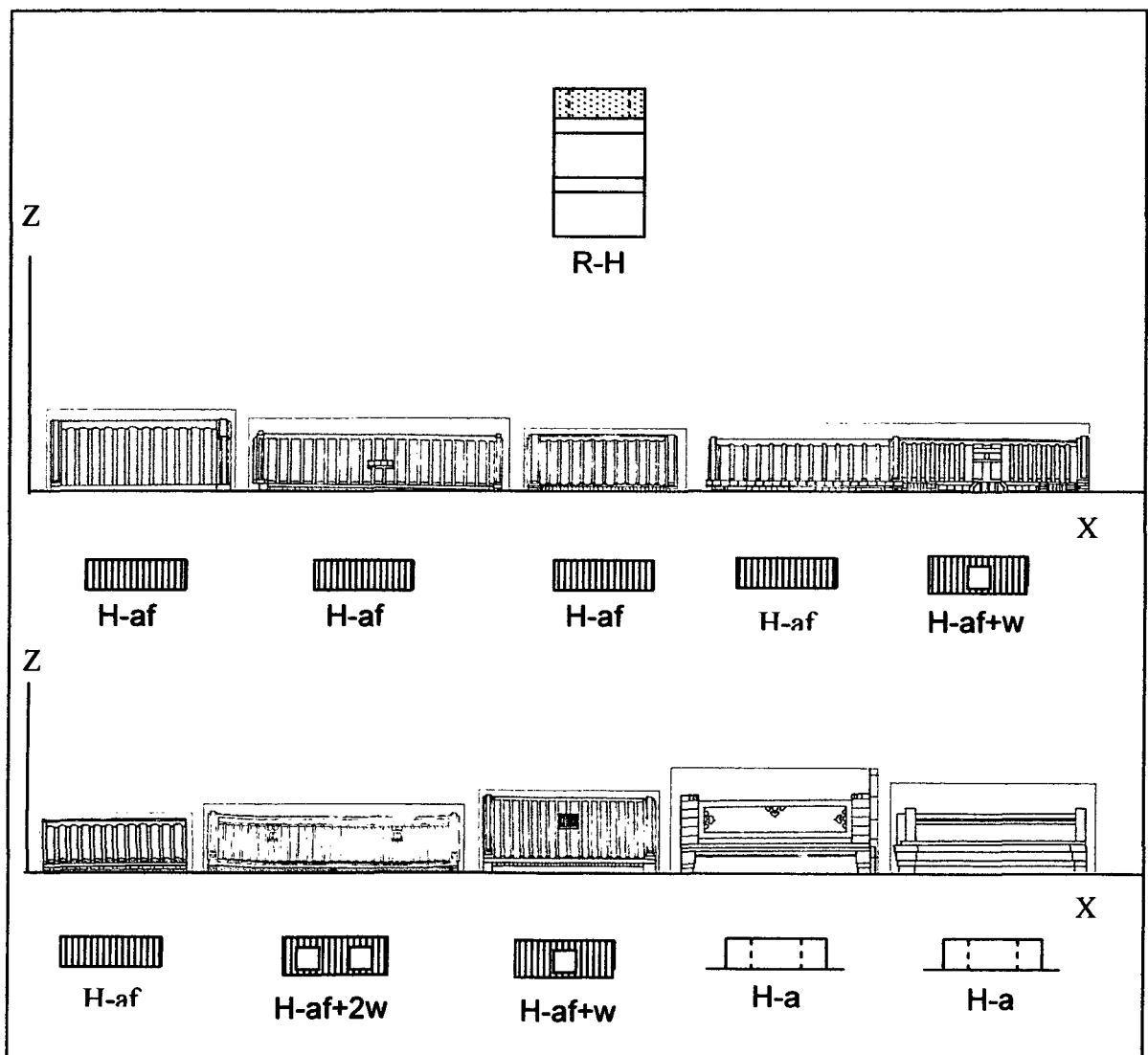
Figure 3. 20   Rule H for the ten facades of traditional town houses in Lukang

4. The frieze as Rule F: Friezes can exist between an arcade and a body, a body and a head or both. In rule F it will be shown: "f1" for the frieze between an arcade and a body; "f2" for the frieze between a body and a roof and so on. The facade of No. 147 at Zhongshan Road has f2 and the facade of No.149 at Zhongshan Road has f2.

5. The terrace as Rule T: If one balcony or terrace is almost as wide as the bay of the facade, then it is defined as "t". If one balcony or terrace is similar in width as a window, it is defined as "at". The facade of No. 147 at Zhongshan Road which contains one terrace as wide as the middle door is defined as "at". The facade of No. 149 which contains one balcony and one terrace as wide as the facade is defined as "2t". This can be combined with Rule B.

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment of the arcade, the body and the head. The common material used on the facade of Taiwanese traditional town houses was wood (w) and brick (b) from the Qing dynasty until 1895; pebble dash (e), painting (p), stone (s) and brick during the Japanese colonial period. The main material of the facade of the town houses in Lukang is wood, brick and pebble dash. These ten facades will be listed in the following table.

7. The termination of the shape language of these ten facades: The shape language for the facades of ten Taiwanese town houses in Lukang is listed below in Table 3.3.

	Rule No. Rule	Rule A	Rule B	Rule F	Rule H	Rule M	T
LUKANG I	No.6	—	B-1+cs	—	H-af	wb-bw	—
	No.7	—	B-0100	—	H-af	b-bw	—
	No.17	—	B-1	_	H-af	wb-bw	—
	No.18	—	B-1+3cs	—	H-af	wb-bw	—
	No.16	_	B-010+3cs	—	H-af+1w	b-bw	—

	No.25 Y.	—	B-010	—	H-af	bw-bw	—
LUKANG II	No.19 P.	—	B-0010	—	H-af+2w	bc-bw	—
	No.55 P.	—	B-1	—	H-af+w	wb-bw	—
	No.147Z.	A-b	B-3b+at	f2	H-a	e-e-e	at
	No.149Z.	A-b	B-2(3b+t)	f1, f2	H-a	e-e-e	2t

Table 3. 3 Shape grammars for ten facades of the traditional town houses in Lukang

3.3.5 Applications of shape grammars in the facades of the traditional town houses in Xinhwa:

The following figure which is shown on two pages represents ten facades of Taiwanese traditional town houses which are located in Xinhwa, Tainan. These ten town houses are No. 338, 401, 403, 405, 407, 409, 411, 413, 415 and 435 at Zhongzhen Road which were built around 1920 during the Japanese occupation period.

In accordance with the rules and examples applied above, the shape language of these ten town houses is as follows:
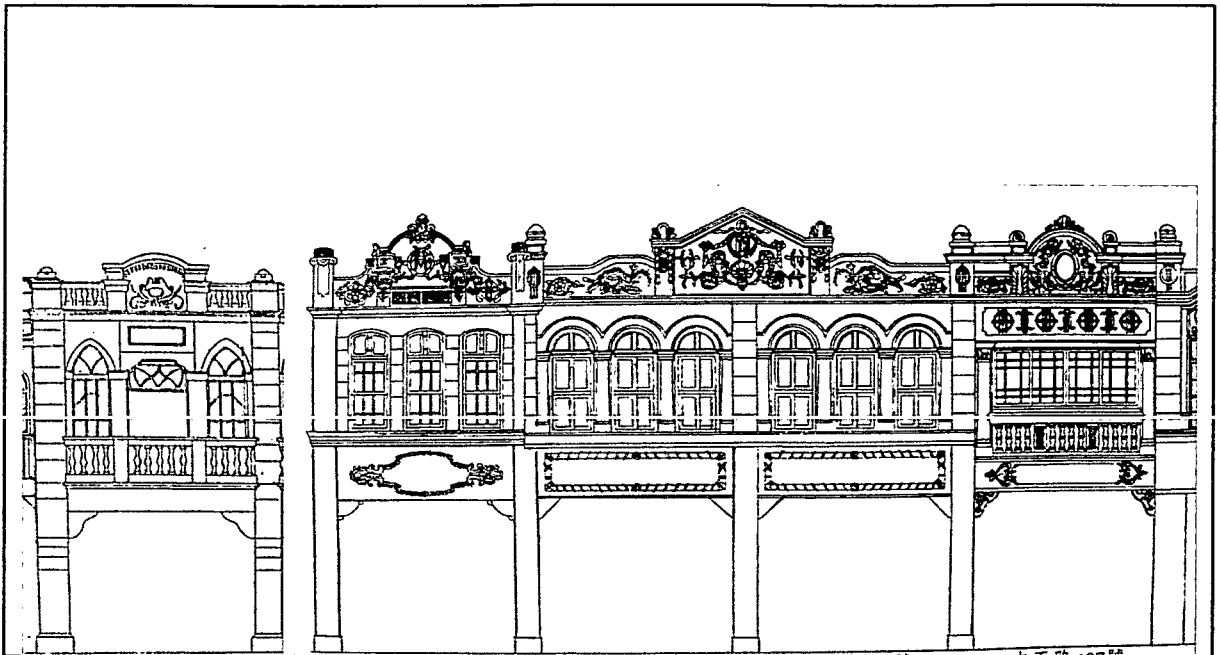
No.338	No.401	No.403	No.405	No.338
Grocery	Incense Shop	Bakery	Hardware Store	Chinese Medicine

No.135	No.411	No.413	No.415	No.152
Chinese	Laundry	Hardware	Clothing	Chinese
Medicine		Store	Shop	Medicine
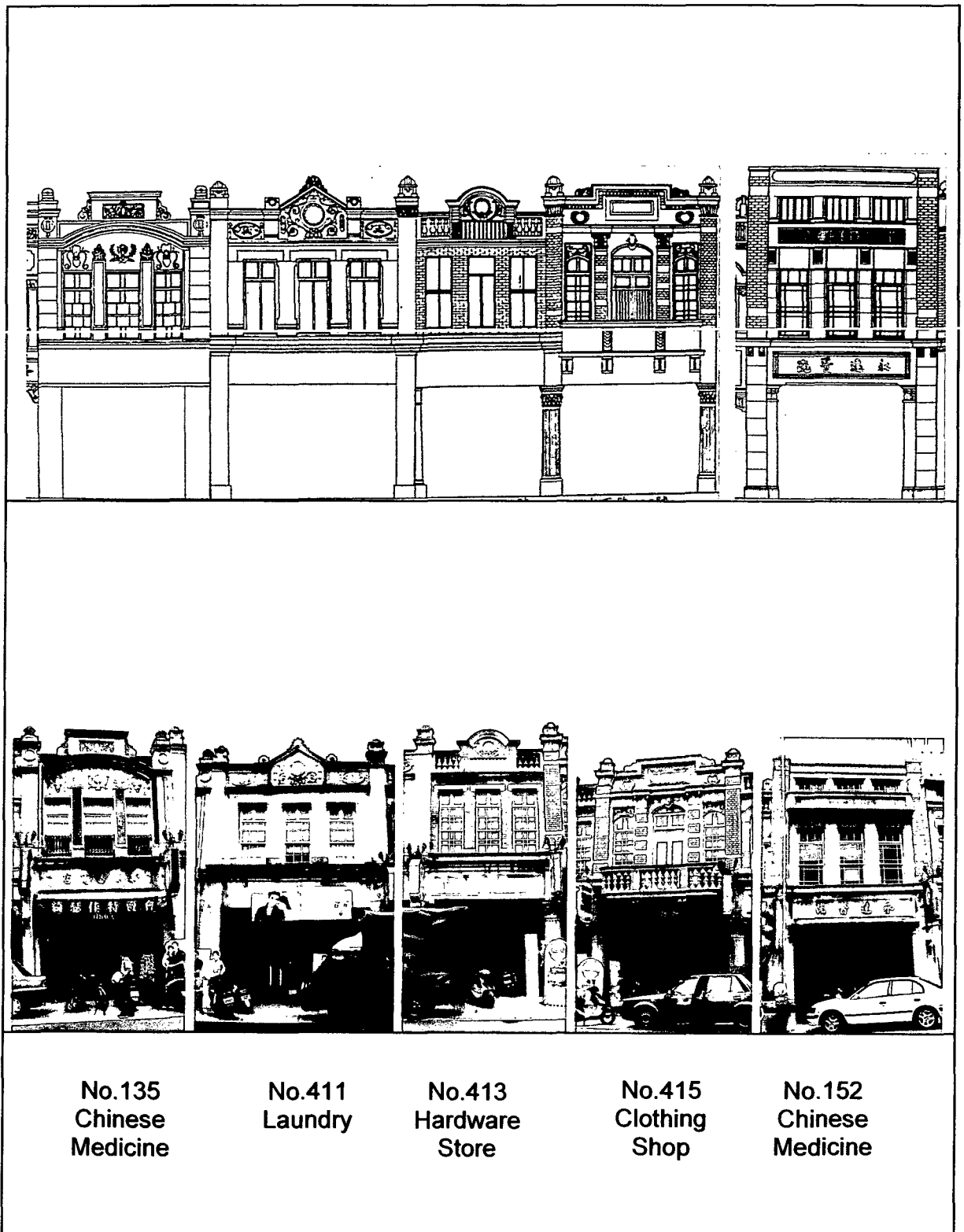
Figure 3. 21 Ten facades of Taiwanese traditional town houses in Xinhwa

1. The arcade as Rule A: The ground floor based on fortune measurements, a front arcade and a main entrance will be developed by Rule A first. We define rules as:

- – an arcade which has a simple rectangular opening as Rule A-a ;

- – an arcade with two modified corners as A-b.

These rules apply only at the first block and the ground floor, (Xn=1, Yn=1, Zn=0).
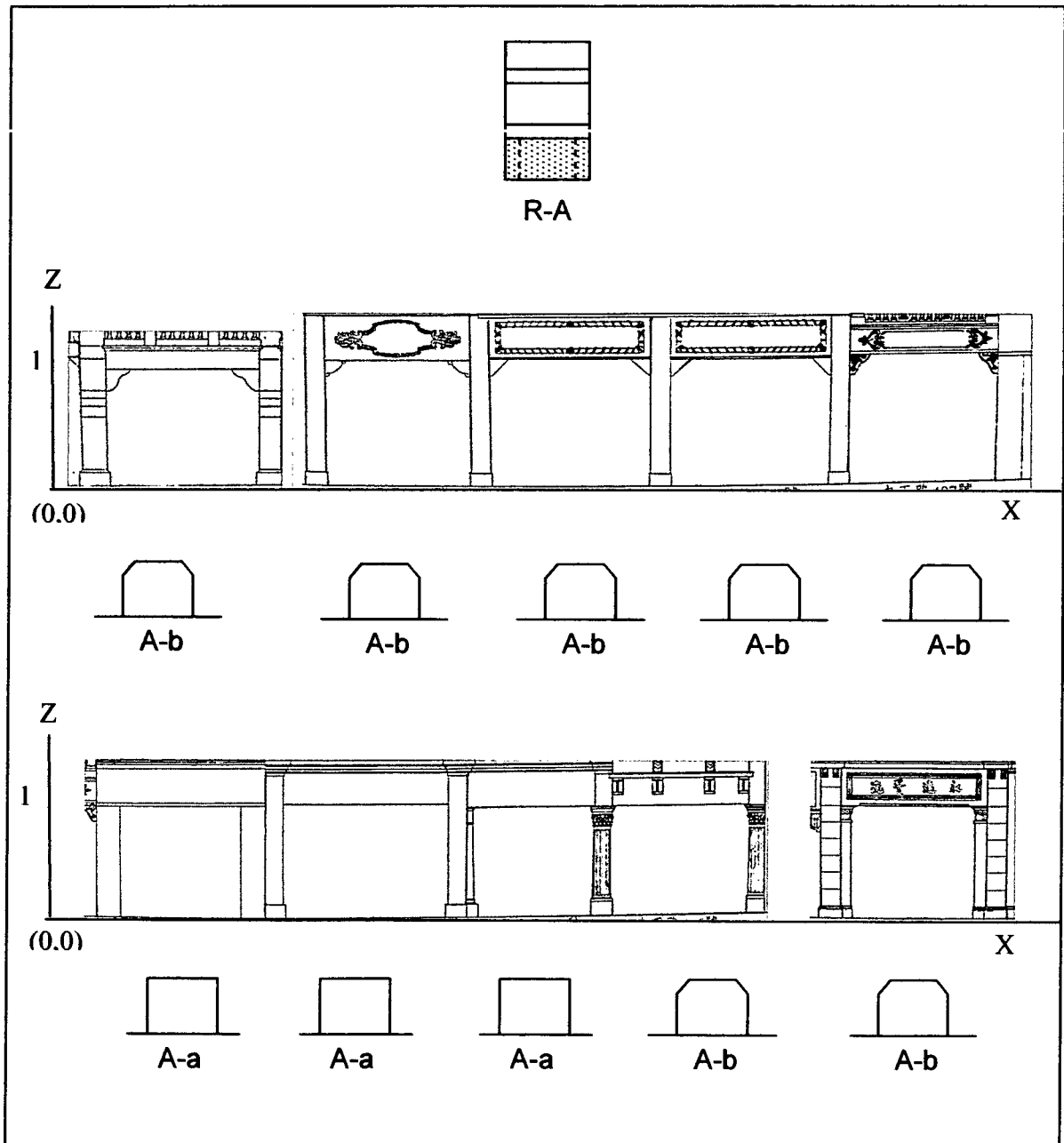
Figure 3. 22   **Rule A for ten facades of traditional town houses in Xinhwa**

2. The body as Rule B: The first floor and the second floor will be described together as Rule B.

- The body of No. 338 which contains one arch door between two windows with a terrace is defined as Rule B-3br+t.

- The body of No. 401, No. 403 and No. 405 which have three same-size windows for each facade are defined as Rule B-3ar.

- The body of No. 407 which includes only one big door window and one terrace is defined as Rule B- 0+t.

- The body of No. 409 which has one window between two narrower windows symmetrically is defined as Rule B-3b.

- The body of No. 411 and No. 413 which contain three same-size windows symmetrically for each facade is defined Rule B-3a.

- The body of No. 415 which contains one middle arch door between two arch windows and one terrace is defined as Rule B-3br+t.

- The body of No. 435 which includes three same-size windows on the first floor and another set of three same-size windows with a terrace on the second floor are defined as Rule B- 3ax2+t. The height of the second floor of this house was reduced after a severe earthquake which badly damaged this floor.

These rules are only applied on the body of a facade. ($X_n=1$, $Y_n=1$, $Z_n=1,2$) (Figure 3.23)
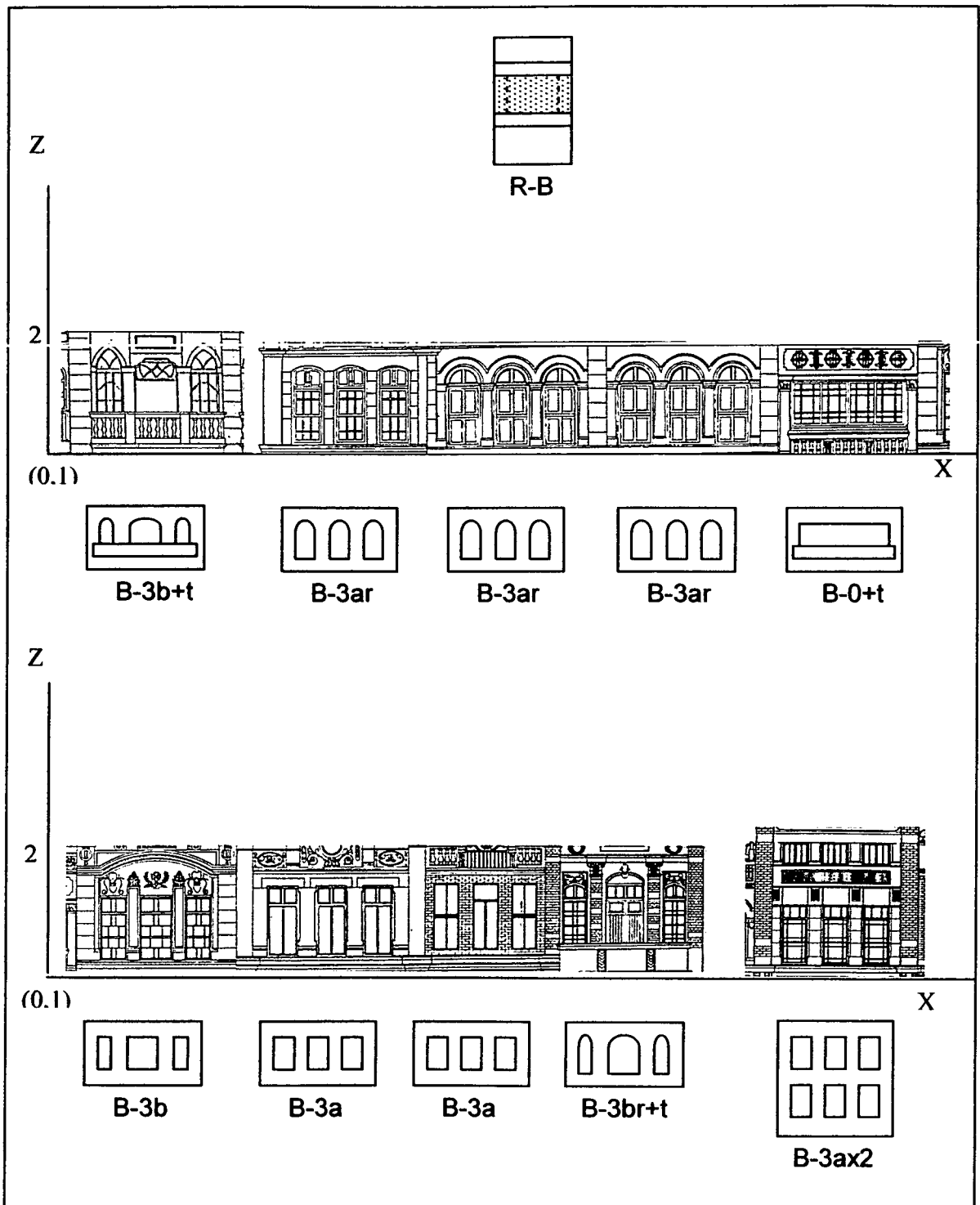
Figure 3. 23   Rule B for ten facades of traditional town houses in Xinhwa

3. The roof as Rule H: The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade, are developed by Rule H.

- The head of No. 338, No. 401, No. 407 and No. 413 which contain one circle shape on a prominent step in a flat parapet is defined as Rule H- a2+c↑.

- The head of both No. 403 and No. 407 which share just one triangular shape on a parapet together is defined as Rule H- (a2+b↑)/2.

- The head of No. 409 which contains an arc on the parapet is defined as Rule H- a2+c↓.

- The head of No. 411 which has a triangular shape on a flat parapet is defined as Rule H- a2+b↑.

- The head of the No. 415 which contains a prominent step on a rectangular parapet is defined as Rule H- b2.

- The head of No. 435 which contains a simple rectangular parapet is defined as Rule H- b.

These rules are only applied at the head of a facade. (Figure 3.24)
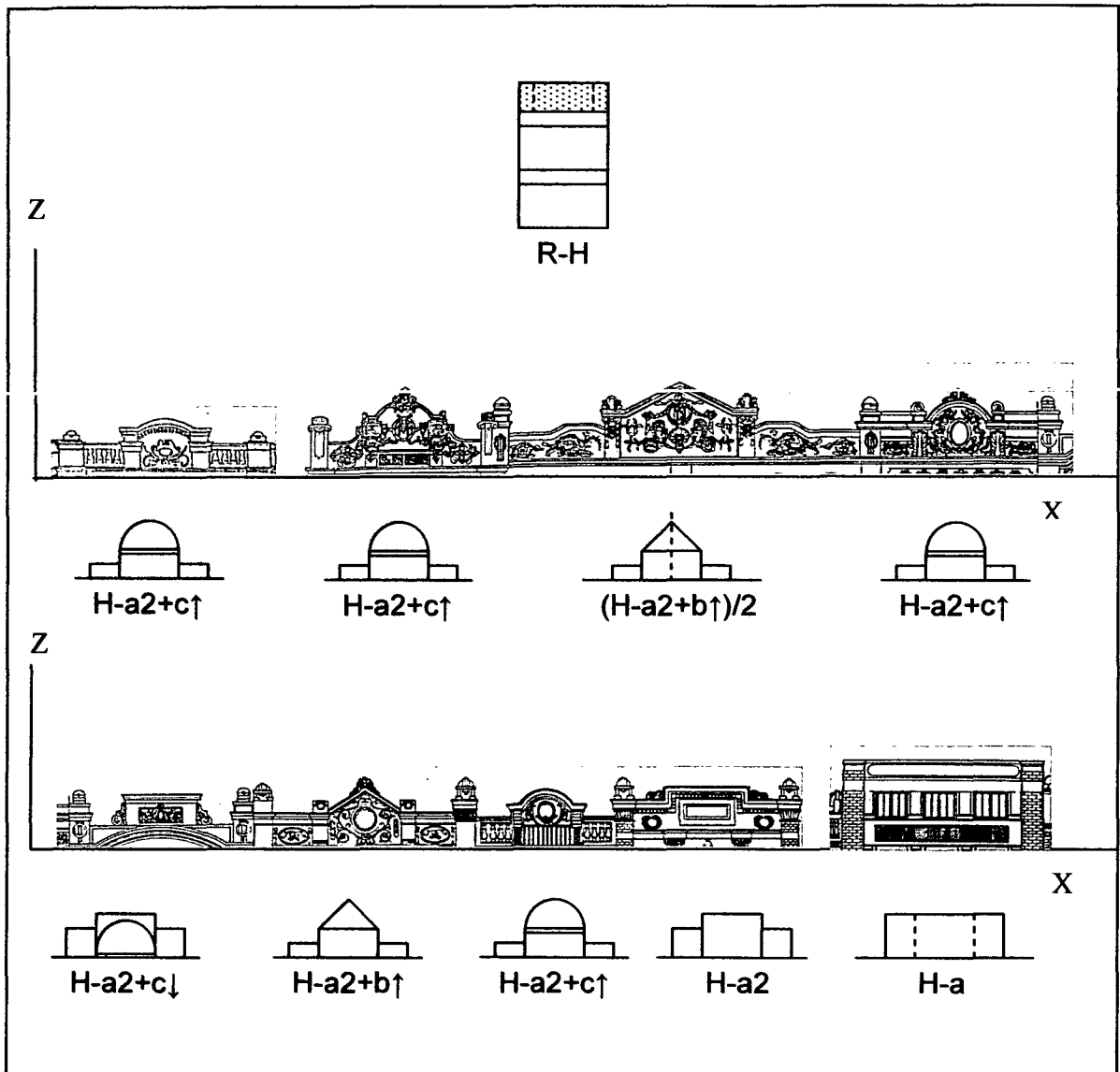
Figure 3. 24   Rule H for ten facades of traditional town houses in Xinhwa

4. The frieze as Rule F : Friezes can exist between an arcade and a body, a body and a head or both. In rule F it will be shown: "f1" for the frieze between an arcade and a body; "f2" for the frieze between a body and a roof and so on. The facade of No. 338, No. 407 and No. 415 have f2. The facade of No. 409 has f1 and f2. The facade of No. 435 has f1 and f2. The facade of No. 401, No. 403, No. 405, No. 411 and No. 413 have f1 and f2.

5. The terrace as Rule T: If one balcony or terrace is almost as wide as the bay of the facade, then it is defined as "t". If one balcony or terrace is similar as wide as a window, it

is defined as "at". The facade of No. 407, No. 415 and No. 435 which contain one terrace as wide as the facade is defined as "t". The facade of No. 338 which contains one arc terrace as wide as the facade is defined as "rt". This can be combined with Rule B.

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment of the arcade, the body and the head. The common material used on the facade of Taiwanese traditional town houses was wood (w) and brick (b) from the Qing dynasty until 1895; pebble dash (e), painting (p), stone (s) and brick during the Japanese colonial period. The main material used for facades of the town houses in Xinhwa is brick and pebble dash. The materials used for these ten facades will be listed in the following table.

7. The termination of the shape language of these ten facades: The shape language for the facades of ten Taiwanese town houses in Xinhwa is listed below in Table 3.4.

	Rule No.	Rule A	Rule B	Rule F	Rule H	Rule M	T
XINHWA I	No.338	A-b	B-3br+rt	f2	H-a2+c↑	be-be-e	rt
	No.401	A-b	B-3ar	f1,f2	H-a2+c↑	e-e-e	—
	No.403	A-b	B-3ar	f1,f2	(H-a2+b↑)/2	e-e-e	—
	No.405	A-b	B-3ar	f1,f2	(H-a2+b↑)/2	e-e-e	—
	No.407	A-b	B-0+t	f2	H-a2+c↑	e-e-e	t

XINHWA II	No.409	A-a	B-3b	f1,f2	H-a2+c↓	e-e-e	—
	No.411	A-a	B-3a	f1,f2	H-a2+b↑	e-e-e	—
	No.413	A-a	B-3a	f1,f2	H-a2+c↑	e-be-e	—
	No.415	A-b	B-3br+t	f2	H-a2	e-be-be	t
	No.435	A-b	B-3ax2	f1	H-a	e-be-be	—

Table 3. 4   Shape grammars for ten facades of traditional town houses in Xinhwa

3.4 Conclusions

3.4.1 Rules of shape grammars for facades of traditional town houses in Taiwan

The rules of shape grammars for the façades of traditional town houses in Taiwan

Figure 3. 25 Rules of shape grammars for facades of traditional town houses in Taiwan

3.4.2 The Comparison of facades of traditional town houses in Taiwan

Although the results of these shape grammars are limited by the examples that we chose from these four historical areas, the characteristics of the facades in these four areas can be still interpreted and compared by these shape grammars. Now the difference and the similarity among them are more clearly demonstrated in the following table.

1. Rule A - the derivations of arcades on facades:

DIHWA STREET				DAXI			
No.	Rule A	No.	Rule A	No.	Rule A	No.	Rule A
No.24	A-a	No.135	A-a	No.48-1	A-c	No.84	A-e
No.44	A-b	No.133	A-b	No.48	A-e	No.86	A-e
No.71	A-a	No.131	A-b	No.49	A-e	No.12	A-c1+2c2
No.114	A-e	No.148	A-a	No.50	A-c1+2c2	No.13	A-c1+2c2
No.352	A-c1+ 2c2	No.152	A-a	No.81	A-b	No.15	A-c1+2c2

XINHWA				LUKANG			
No.	Rule A	No.	Rule A	No.	Rule A	No.	Rule A
No.338	A-b	No.409	A-a	No.6	—	Y. No.25	—
No.401	A-b	No.411	A-a	No.7	—	P. No.19	—
No.403	A-b	No.413	A-a	No.17	—	P. No.55	—
No.405	A-b	No.415	A-b	No.18	—	Z. No.147	A-b
No.407	A-b	No.435	A-b	No.16	—	Z. No.149	A-b

Table 3. 5 Rule A of shape grammars for facades of traditional town houses in Taiwan

2. Rule B - the derivations of bodies on facades:

DIHWA STREET			
No.	Rule B	No.	Rule B
No.24	B-3bx2	No.135	B-3ax2
No.44	B-3ax2	No.133	B-3b+3br+rt
No.71	B-3as+cs+t	No.131	B-3bx2+t
No.114	B-3br+3at	No.146	B-r(5a+3ar)
No.352	B-3b	No.152	B-3a+3ar

DAXI			
No.	Rule B	No.	Rule B
No.48-1	—	No.84	—
No.48	—	No.86	—
No.49	—	No.12	—
No.50	—	No.13	—
No.81	—	No.15	—

LUKANG			
No.	Rule B	No.	Rule B
No.6	B-1+cs	Y. No.25	B-010
No.7	B-0100	P. No.19	B-0010
No.17	B-1	P. No.55	B-1
No.18	B-1+3cs	Z. No.147	B-3b+at
No.16	B-010+3cs	Z. No.149	B-2(3b+t)

XINHWA			
No.	Rule B	No.	Rule B
No.338	B-3br+rt	No.409	B-3b
No.401	B-3ar	No.411	B-3a
No.403	B-3ar	No.413	B-3a
No.405	B-3ar	No.415	B-3br+t
No.407	B-0+t	No.435	B-3ax2

Table 3. 6   Rule B of shape grammars for the facades of traditional town houses in Taiwan

3. Rule H - the derivations of heads on facades:

DIHWA STREET			
No.	Rule H	No.	Rule H
No.24	H-a2+d	No.135	H-a2+c↑
No.44	H-a2+b↓	No.133	H-a2+c↑
No.71	H-a	No.131	H-a2+c↑
No.114	H-a2+b↑	No.148	H-a2+c↑
No.352	H-a	No.152	H-a2+c↑

DAXI			
No.	Rule H	No.	Rule H
No.48-1	H-a2+b↑	No.84	H-a2+b ↑
No.48	H-a2+c ↑	No.86	H-a2+c ↑
No.49	H-a2+c ↑	No.12	H-a2+b ↑
No.50	H-a2+b↑	No.13	H-a2+3c
No.81	H-a2+b↑	No.15	H-a2+b ↑

LUKANG			
No.	Rule H	No.	Rule H
No.6	H-af	Y. No.25	H-af
No.7	H-af	P. No.19	H-af+2w
No.17	H-af	P. No.55	H-af+w
No.18	H-af	Z. No.147	H-a
No.16	H-af+1w	Z. No.149	H-a

XINHWA			
No.	Rule H	No.	Rule H
No.338	H-a2+c↑	No.409	H-a2+c↓
No.401	H-a2+c↑	No.411	H-a2+b↑
No.403	(H-a2+b↑)/2	No.413	H-a2+c↑
No.405	(H-a2+b↑)/2	No.415	H-a2
No.407	H-a2+c↑	No.435	H-a

Table 3. 7   Rule H of shape grammars for the facades of traditional town houses in Taiwan

4. Rule F, M &T - the derivations of friezes, materials and terraces on facades:

DIHWA STREET							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.24	f2	eb-eb-eb	—	No.135	f2	eb-eb-e	—
No.44	f2	e-e-e	—	No.133	f2	eb-eb-e	rt
No.71	—	e-e-e	t	No.131	f2	eb-eb-e	rt
No.114	f1,f2	e-e-e	3at	No.148	rf2	e-e-e	rt
No.352	f1,f2	b-b-b	—	No.152	f2	e-e-e	—

DAXI							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.48-1	f1	e-e	—	No.84	f1	be-e-be	—
No.48	f1	e-e	—	No.86	f1	be-e-be	—
No.49	f1	be-e	—	No.12	f1	be-e-be	—
No.50	f1	e-e	—	No.13	f1	be-b-e	—
No.81	f1	be-be	—	No.15	f1	be-b-e	—

LUKANG							
No.	Rule F	Rule M	T	No.	Rule f2	Rule M	T
No.6	—	wb-bw	—	Y. No.25	—	bw-bw	—
No.7	—	b-bw	—	P. No.19	—	bc-bw	—
No.17	—	wb-bw	—	P. No.55	—	wb-bw	—
No.18	—	wb-bw	—	Z. No.147	f2	e-e-e	—
No.16	—	b-bw	—	Z. No.149	f2	e-e-e	—

XINHWA							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.338	f2	be-be-e	rt	No.409	f1,f2	e-e-e	—
No.401	f1,f2	e-e-e	—	No.411	f1,f2	e-e-e	—
No.403	f1,f2	e-e-e	—	No.413	f1,f2	e-be-e	—
No.405	f1,f2	e-e-e	—	No.415	f2	e-be-be	t
No.407	f2	e-e-e	t	No.435	f1	e-be-be	—

Table 3. 8   **Rule F, M & T of shape grammars for the facades of traditional town houses in Taiwan**

3.4.3 Comments for comparison

The advantage of shape grammar is that everyone can find the similarity and the difference from the rules in the above tables. I will just write a few comments as examples:

Similarities

- There is normally only one bay in traditional town houses in Taiwan.

- A rectangular opening (A-a) or a rectangular opening (A-b) with modified corners was very often applied.

- Three columns of windows are the most common style of openings on the facades in the areas of Dihwa street and Xinhwa. It showed B-3a, B-3b or the similar derivations.

- The traditional town houses in Daxi have only one floor with an elaborately decorated facade.

- The roof style which was structured in the shape of a semicircle or a triangle on its parapet, H-a2+c↑ and H-a2+b↑, were applied very often in the areas of Dihwa street, Daxi and Xinhwa. The facades in these areas reflected Western style, "Baroque" style and Imitating Western style (See 2-3-1) in common, so we can see how an artisan borrowed a form of an element from European traditional town houses at that time.

- The roof style which is basically a gable roof, H-af, was applied frequently in the traditional town houses in Lukang.

- Terraces and balconies are infrequently used on the facades of traditional Taiwanese town houses.

- The general material on the facades of traditional town houses in Taiwan is pebble dash, brick.

Dissimilarities

- The traditional town houses in Lukang, which were influenced by the Chinese 'Min-Nan' style, seldom have arcades. Many of them provide cantilever eaves instead of arcades.

- The traditional town houses in Daxi have two columns which are quite often either functional or decorative on the arcades. It showed A-e or A-C1+ 2C2. This is very different from the other areas. It may be influenced by Japan who governed Taiwan at that time.

- The openings of facades in Lukang are very different from the other facades in Dihwa street, Daxi and Xinhwa. The basic mode of openings is B-1 or B-010 which has the Chinese dwelling style influence.

- The style of roof which is normally a gable roof, H-af in Lukang is also very different from the other facades in Dihwa street, Daxi and Xinhwa. The latter were decorated with gorgeous ornaments, geometric shapes and curves.

- Wood was only used in traditional town houses in the Lukang area due to the Chinese influence.

Chapter 4

Comparison of floor plans of traditional town houses in Taiwan using shape grammar

4.1   Shape grammar composition for the floor plans of Taiwanese traditional town houses:

Shape grammar, as we know, has been applied for some time to the analyses and critique of geometric sculptures, paintings and in generating floor plans. In 1980, G. Stiny published the 'Kindergarten Grammars'.[1] In 1981, U. Flemming and F. Downing used it successfully to analyze the bungalows in Buffalo[2] and it was used widely to compose shape language for floor plans. The former published an application of shape grammars for developing floor plans for the early design stage.[3] By Palladian grammar, 210 substitute plans were produced for this Palladian villa. Futhermore, it was also practical to illustrate the spatial form of 'Si

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[1] G. Stiny,1980b,"Kindergarten Grammars: designing with Froebel's building gifts", Environment and Planning, B7, pp.409-462

[2] F. Downing and U. Flemming, 1981, "The Bungalows of Baffalo", Environment and Planning, B8, pp.269-293; U. Flemming, 1981, "Structure in Bungalow plans", Environment and Planning, B8,

[3] U. Flemming, 1998, "Living with walls", Environment and Planning Anniversary issue, pp.76-85

He Yuan of Beijing' in 1990[4] and subsequently the Taiwanese traditional vernacular dwellings in 1995 and 1996.[5]

Based on the achievements of these researches, a shape grammar can be developed to analyze and compare the floor plans of traditional town houses in Taiwan. There is a difference between just generating floor plans and comparing floor plans. What is going to be compared should be what is important in floor plans. All of these main points will be defined and classified in the rules of shape language in this chapter.

In this case, the rules of this shape grammar will be defined in accordance with the characters and the elements of the spatial forms in Taiwanese traditional town houses.

According to the four sets of conditions of shape grammar that we mentioned in Chapter 3.1, we shall now begin to define and develop the shape grammar for our floor plans:

- S. (shape);

- L. (symbol);

- R. (rule);

- I. (initial form).

S.   Shape grammar can grow and transform in a limited geometrical pattern, which is contained in Cartesian coordinate system.

L.   Shows the function and the attribute of a space. It also shows the geometrical attribute, such as corner, center or end point. These symbols influence the construction of a shape. They are removed, when a shape has been formed.

R.   Shape rule schemata describe the rules of the process that initial form transforms into sub-shapes, then a project.

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[4] Liou S-R, Vakalo E G, Lee Y-C, 1990,"The Si He Yuan of Beijing" in Proceedings of the IAPS 11th International Conference 2: 362-371

[5] S-C Chiou and R. Krishnamurti, 1995, "The grammar of Taiwanese traditional vernacular dwellings", Environment and Planning B: Planning and Design, Volume 22, pp. 689-720

S-C Chiou and R. Krishnamurti, 1996, "Example Taiwanese traditional houses", Environment and Planning B: Planning and Design, Volume 23, pp. 191-216

I. Initial form can be a geometrical pattern or symbol, which is catalyzed of a shape. A segment of line is a basic element in shape grammar.

Initial Form ←(rules)→ Project

There are two methods for grammar to analyze this process: "Bottom up" or "Top down". We again choose "Bottom up" to define all single elements in entirety. Within the process of constructing a shape, all single elements, positions, and attributes are produced and organized gradually. Although substitute forms will not be produced here, the shape grammar for the floor plans of these chosen traditional town houses will be developed and built up for the purpose of comparing the floor plans among these town houses.

4.1.1 Basic symbols and rules in floor plans of Taiwanese traditional town houses:

This part deals with composition of the shape grammars for the floor plans of town houses. Firstly, the coordinates and matrix will indicate the capacity of a house. There are some basic symbols and rules in the shape grammar for traditional town houses. The X, Y and Z-axis in the coordinates present the width of the bay, blocks (e.g. the front block, the middle block and inner block) and floors. For example, if a town house has one bay, three blocks and two floors, it will be presented as follows:

$(X, Y, Z) = (1, 3,$ and $2)$

The space of the first bay, first block and first floor will be written as:

$(X_n, Y_n, Z_n) = (1, 1,$ and $1)$

The space of the first bay, second block, and first floor will be written as:

$(X_n, Y_n, Z_n) = (1, 2, 1)$ .... and so forth.

The logical process of developing and using a shape grammar[6] that we have mentioned in Chapter 3 will be divided into three parts in accordance with the alignment of generating a floor plan.

1. The labels and symbols will be defined. The rules and the initial form will start from absolute coordinates.

2. All the bays, blocks and spaces will be produced orderly. The shape grammar regarding unit pattern will be compiled at this point.

3. All the units in part 1 will be connected by corridors, inner courts and some in-between spaces. The shape language of connections between spaces will be compiled and explored here.

Finally, all the symbols and help lines should be removed and the plan finished.

In Chapter 2, it was indicated that the typical traditional town house had three blocks, the front block, the middle block and the inner block, all of which were connected by inner courts, verandahs or side chambers. The rules of this shape grammar will be defined according to the characters and the elements of the spatial forms in Taiwanese town houses.

In figure 4.1 we see the definitions of the schemata for forming a floor plan.

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[6] M Tapia, 1999, "A visual implementation of a shape grammar system", <u>Environment and Planning B:</u> <u>Planning and Design</u>, Volume 26, pp. 59-73
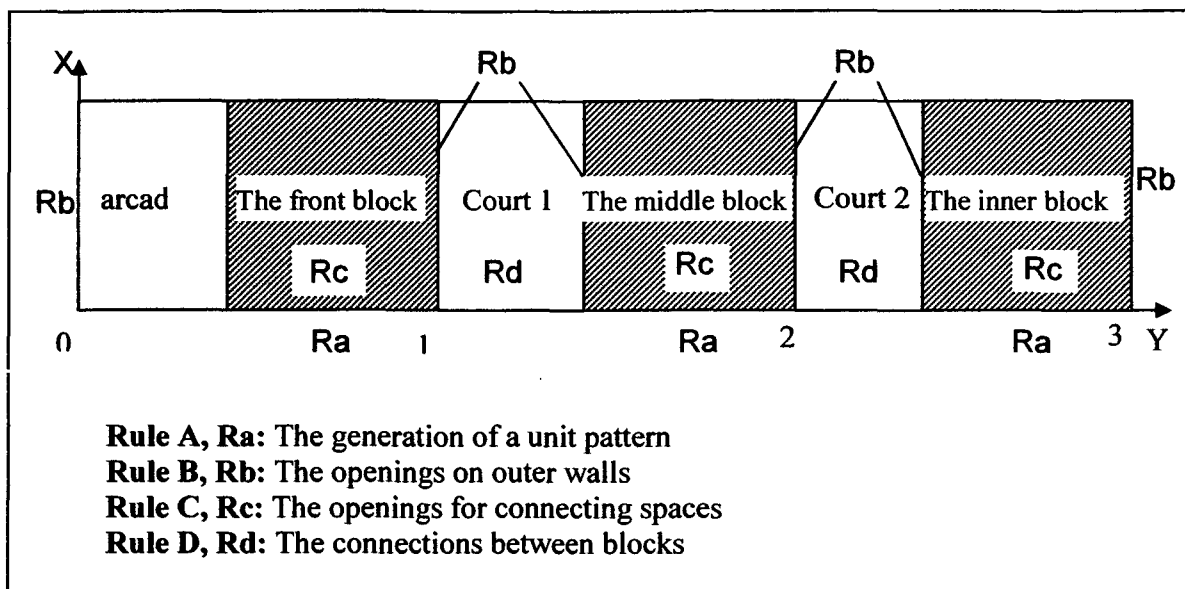
Figure 4. 1   Series of rules for a floor plan

4.1.2 Traditional names in the form floor plans of Taiwanese town houses:

There are a lot of traditional names for the spatial forms in traditional Taiwanese town houses. These names and its meanings generally indicate the function and components of all these spaces. Taiwanese traditional town houses were made up of "Zheng-shen" (main building), "Yuan-lou" (courtyard) and "Fu-ti" (secondary building). A Zheng-shen includes some units, which will be listed in the table below. A "Fu-ti" is a group of attached space elements.

Basic building	Basic unit	The Principle of Units
'Zheng Shen' A block or a building	Ta Dn Sh Lj Bk	Hall: A main space of a building Shop: A main space of a building Room: A main room behind a hall. It can be divided into small rooms and a corridor. Inner court: It is normally built above the shop at the first floor. Balcony: at rear or front elevations
'Yuan Lou' A courtyard	Ten Jin Ks	A courtyard between two buildings. The balcony to a courtyard
'Fu Te' An appendix	Ft	The additional rooms attach to a main building, zheng shen, or to a courtyard.

Table 4. 1   **Taiwanese traditional town houses made up of "Zheng-shen", " Yuan-lou" and "Fu-ti".**

English Name	Abbreviation for Label	Chinese Name	The Phonetic Spelling	Abbreviation for Label
Hall, Living room	hl	廳堂	Ting tang	ta
Shop	sp	店	Dian	dn
Arcade	ac	亭	Tin	ti
Room	rm	室	Shi	sh
Corridor	cr	走道	Jou tou	jt
Balcony	bc	步口	Bu ko	bk
Small room	sr	房	Fang	fg
Court	ct	天井	Tian jin	tj
Inner court	ic	樓井	Lou jin	lj
Porch	po	過水	Kou shui	ks
Staircase	sc	樓梯	Lou ti	lt
Additional room	ar	附體	Fu te	ft

Table 4. 2 The names of spaces in traditional town houses in Taiwan

4.2   Development of the rules of shape grammar for floor plans:

4.2.1   Part I: Initial shape of shape grammar in traditional town house Diwha St.71:

The initial shape (I) is expressed by an empty shape, Sø and a set of coordinate points:

$\{(0,0,0): P(X,Y,Z) \mid X=1, Y\leq3, Z\leq2\}^7$

I=<Sø, {(0,0,0): + (0,0,0), {(0,0,0): P (X,Y,Z) | X=1, Y≤3, Z≤2}}>

The symbol Sø: A shape containing no maximal lines is called the empty shape.

+: a point on an absolute coordinate

P: labeled points on the labeled shape

X=1: It can only generate one bay.

Y≤2: It can only generate two blocks.

Z≤2: It can only generate three floors. (Z=0 on ground floor)

A labeled shape is given by the pair <S,P>, where S is a shape, and P is a finite set of labeled points; an element in P does not have to belong to a maximal line in S. Special cases of labeled shapes are given by < Sø, P> , a shape containing no maximal lines, and < S, ø>, a shape containing no points. A labeled point 'P' has the form 'p: l', where 'p' is a point, and 'l' is a symbol or label attached to that point. In both Taiwanese and Austrian traditional town houses there are some special symbols which present different spatial forms and functions.

Below we use a representative town house floor plan, at Dihwa St.71 in Taipei (Figure 4.1) as an example to find its initial shape.

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[7] F Downing, and U Fremming,1981, "The Bungalows of Buffalo", <u>Environment and Planning B</u>, Volume 8, pp. 269-293
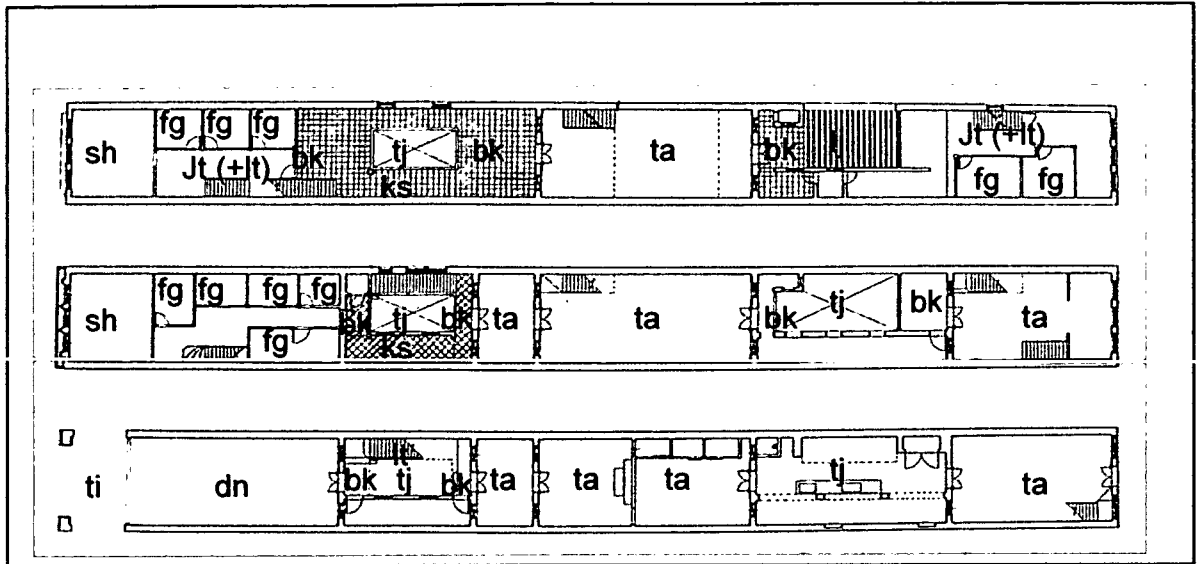
Figure 4. 2   Floor plans at Diwha St.71

In Figure 4.2, we see an initial shape of the town house at Diwha St.71. It has one absolute coordinate and 9 labeled points on this labeled shape. This indicates a town house with one bay, three blocks and three floors.

$$P(1,1,2)\quad P(1,2,2)\quad P(1,3,2)$$

$$P(1,1,1)\quad P(1,2,1)\quad P(1,3,1)$$

$$+(0,0,0)\quad P(1,1,0)\quad P(1,2,0)\quad P(1,3,0)$$
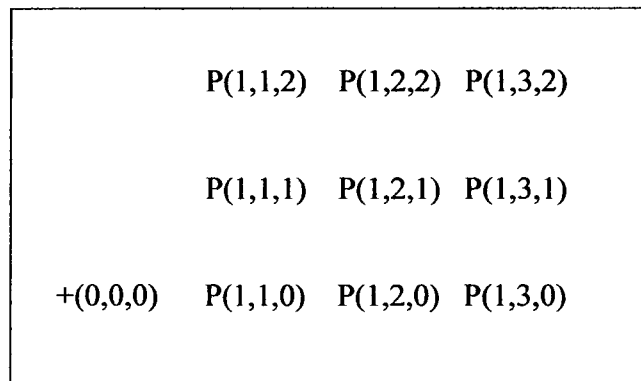
Figure 4. 3   Initial form for the floor plans of No. 71 at Dihwa street

The term "width" is used to refer to the measurement of bays of a block, whereas the term length is used to refer to dimensions measured perpendicular to this block. In ancient Taiwan the artisan would have computed the fortune dimensions for these measurements.[8]

All labels that show the sequence, e.g. front, rear, inside, outside, can be expressed on axis. The front is '+', the rear is '-', inside is '+' and 'outside is '-'.

4.2.2 Part II: Rule A: Generation of a unit pattern by shape grammar

These shape grammars will deal with the generation of architectural plans created in Part II that determine certain global characteristics of the plans and guides and also the development of some of their local properties. The overall impression given by a town house in our example is that of a rectangular box covered by a large, pitched roof. Schema 1 defines the external walls that form the enclosure for this type of structure, the lines with endpoints f (front) and r (rear) labels respectively.

According to the elements in Taiwanese town houses, we shall generate a starting pattern 'ta'. The schema also generates an internal, load-bearing wall that divides the enclosed area into two parallel zones. The term "width" is used to refer to dimensions which are measured parallel to the front or rear of a plan, whereas the term length is used to refer to dimensions measured perpendicular to this direction. In ancient Taiwan, the artisan would have computed the fortune dimensions for the width, length and height.

We shall begin to develop the first block in accordance with the elements of the floor plans in Taiwanese town houses.

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[8] Lin Hui-Ch'eng, 1995, The handbook of traditional Taiwanese architecture; 傳統建築手冊，藝術家出版社，pp.34-35; S-C Chiou and R. Krishnamurti, 1995, "The fortunate dimensions of Taiwanese traditional architecture", Environment and Planning B: Planning and Design, Volume 22, pp. 547-562

1. The Ground Floor: Rule a-1a to Rule a-3a, based on the fortune measurements, we shall develop the first block. The first block contains a shop [dn], a front arcade [ti]and a balcony [bk]. The rules, Ra-1a that forms from an empty shape to a shop [dn], Ra-2 that adds a shop and an arcade together and Ra-3a that adds a shop and a balcony together are applied to the first block on the ground floor. $(Xn=1, Yn=1, Zn=0)$. (Figure 4.4)
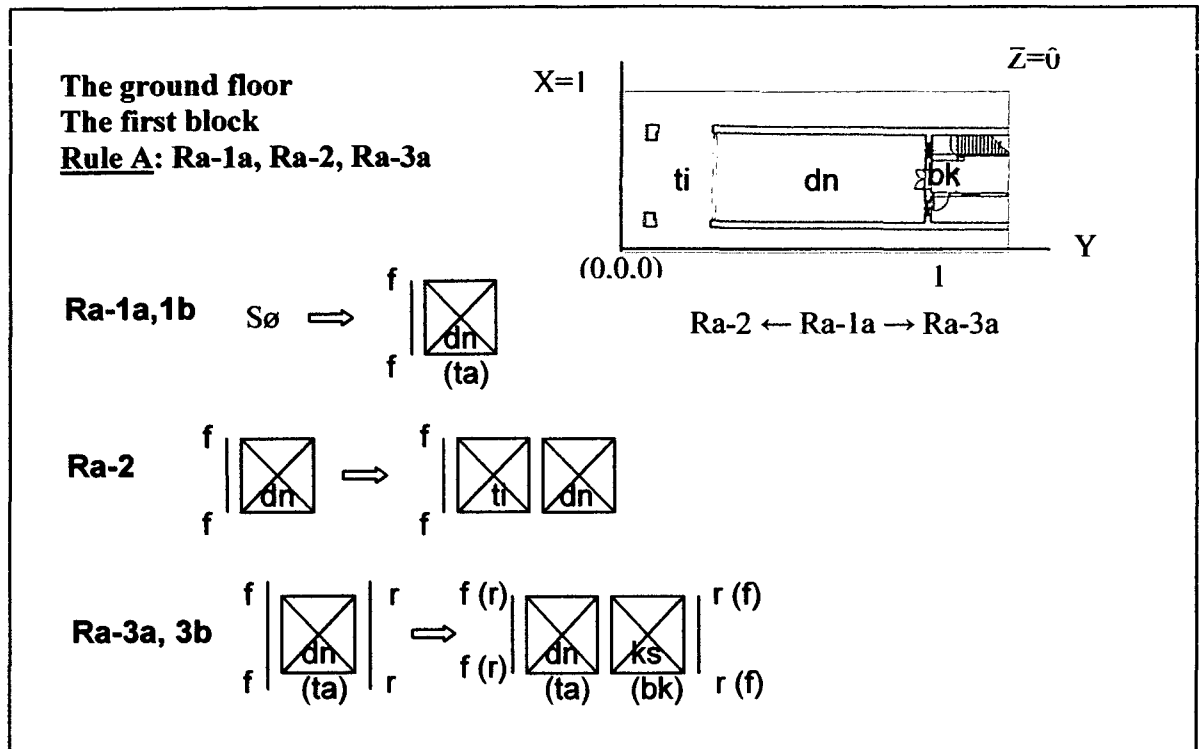
Figure 4. 4   Rule A for the first block on the ground floor at No. 71 Dihwa St

The second block: Rule a-1b, Rule a-3b and Rule a-4b, the second block will now be developed. It includes a balcony 'bk', three main spaces 'ta', another balcony 'bk. The Rule Ra-4a adds a hall and a shop together and Ra-4b forms two halls together. (Figure 4.5)
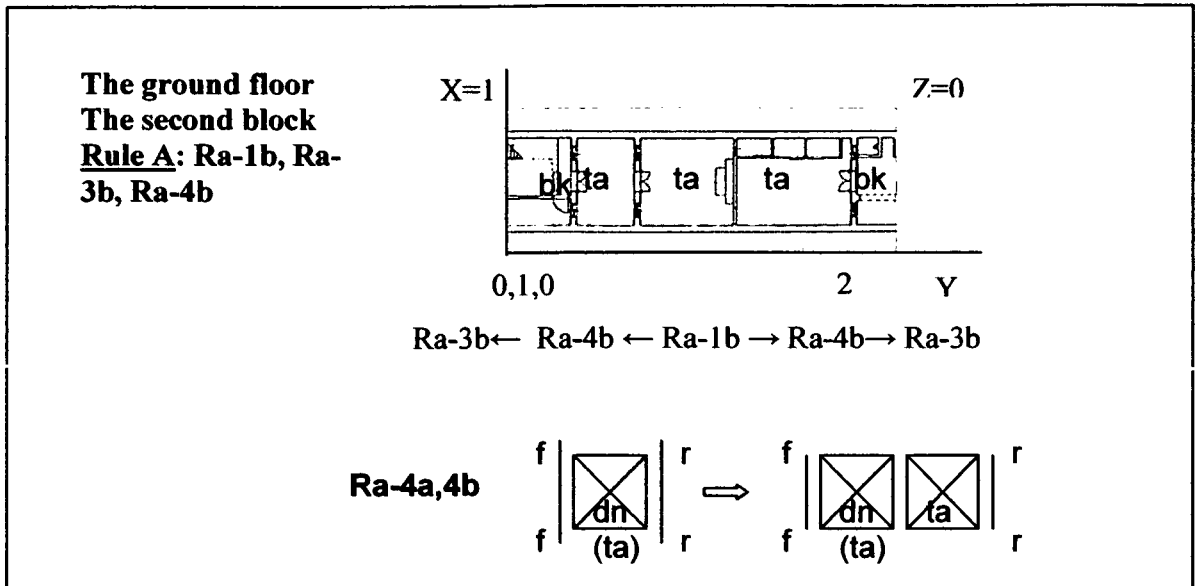
Figure 4. 5 Rule A for the second block on the ground floor at No. 71 Dihwa St

The third block, Rule a-1b and Rule a-3b , the third block that includes a balcony [bk] and a main space [ta] will now be developed. (Figure 4.6) Ra-1b forms from an empty shape to a main space [ta] and Ra-3b adds a main space [ta] and a balcony [bk] together, are applied at the third block on the ground floor. Subsequently the ground floor will be created according to Ra-1~Ra-4. (Figure 4.6)
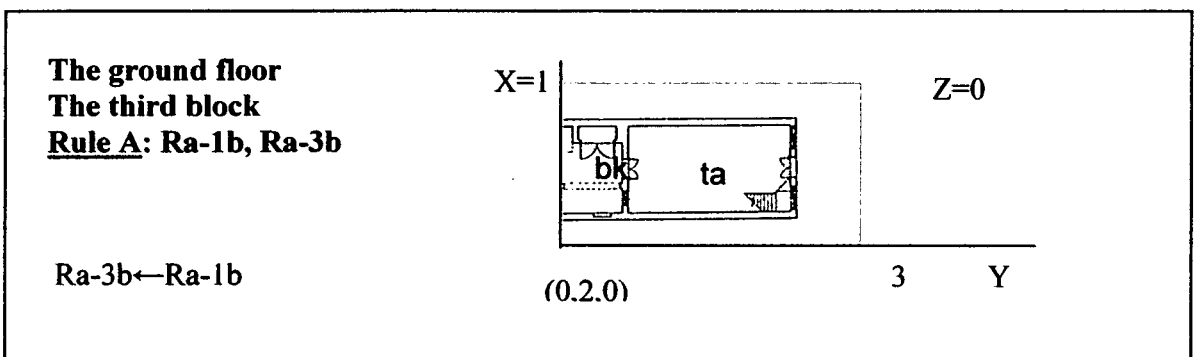
Figure 4. 6 Rule A for the third block on the ground floor at No. 71 Dihwa St

The ground floor
Rule A: Ra-1a,1b,Ra-2a, Ra-3a, 3b, Ra-4b

X=1   Z=0

ti   dn   bk tj bk ta   ta   ta   bk tj bk   ta

(0.0.0)   1   2   3 Y

Ra-2a ← Ra-1a → Ra-3a   Ra-3b← Ra-4b ← Ra-1b → Ra-4b→ Ra-3b   Ra-3b←Ra-1b
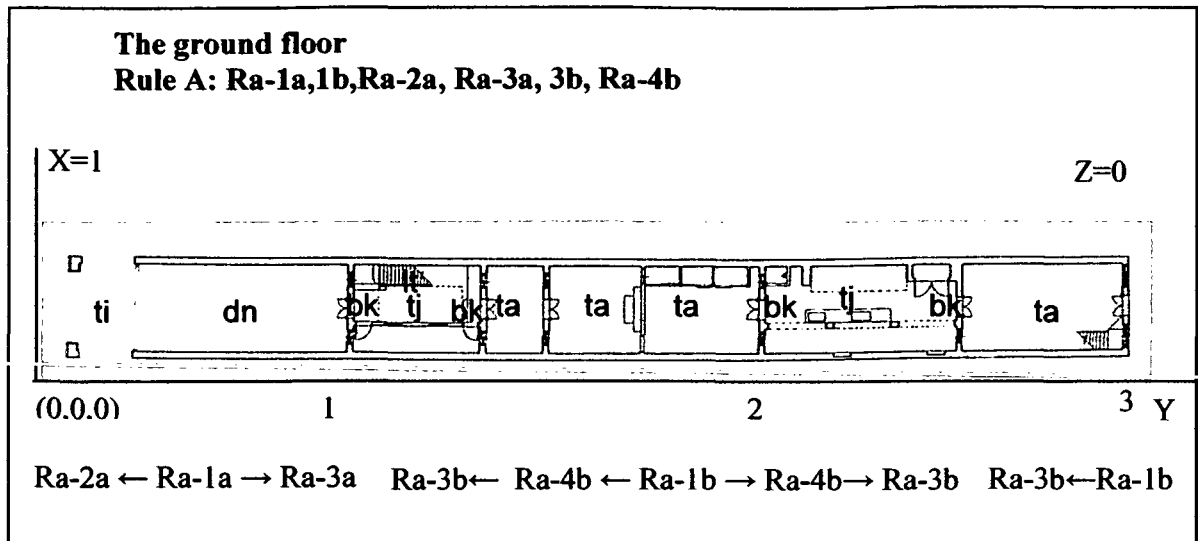
Figure 4. 7 Rule A for the first block on the ground floor at No. 71 Dihwa St

2. The First Floor: From the labeled point P (0,0,1) the first floor will be formed. Rule a-1c and Ra-6b, the first block which includes six rooms [sh], a corridor [jt], a staircase [lt], a and balcony [bk] will be illustrated.

Rule a-1b, a-3b and a-4b, the second block which includes two main spaces [ta] and a balcony [bk] will be illustrated.

Rulea-1b and a-3b, the third block which includes a balcony [bk] and a main space [ta] will be described. Then the first floor will be formed according to Rule a-1, a-2, a-3, a-4 and a-6. (Figure 4.8)
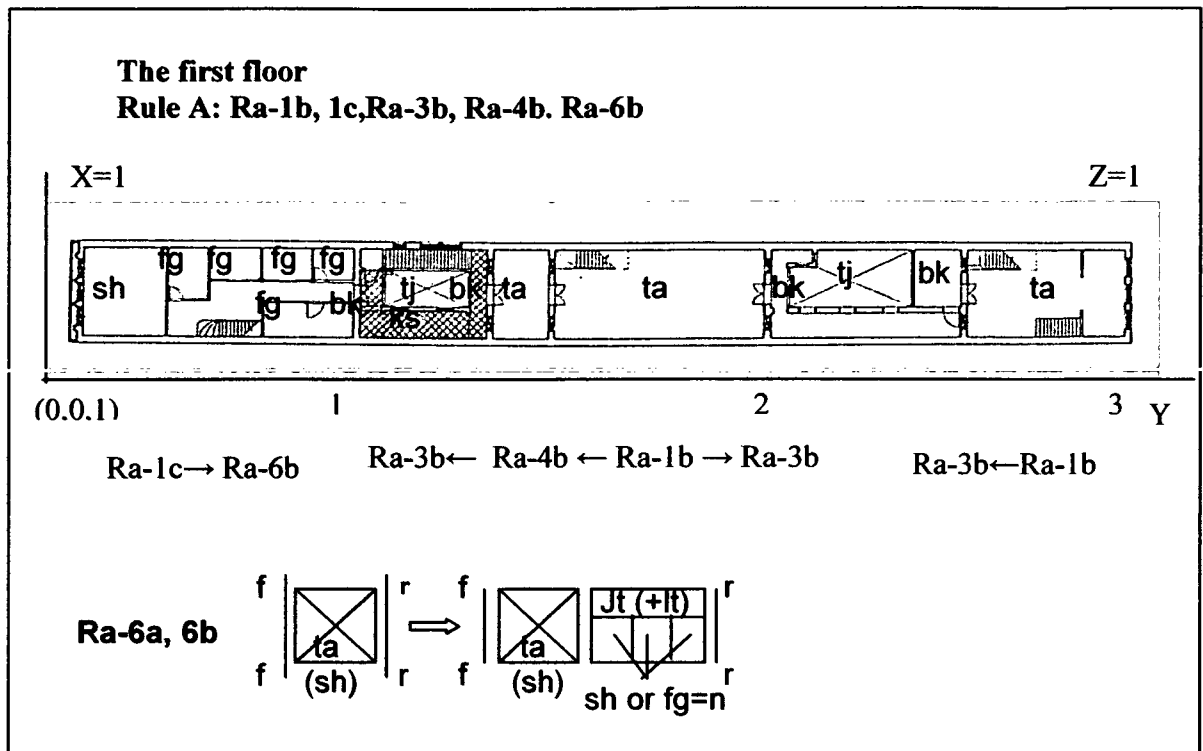
Figure 4. 8 Rule A for the first floor at No. 71 Dihwa St

3. The second floor: From the labeled point P (0,0,2) the artisan can develop the second floor. Rule a-1c and a-6b, the artisan generates the first block that includes one room [sh], four small rooms [fg], a corridor [jt], a staircase [lt] and a balcony [bk].

Rule a-1b and a-3b, the second block which includes one main space [ta], a staircase [lt] and a balcony [bk] will be developed.

Rule a-1c and a-6b, the third block which includes one room [sh], two small rooms [fg], a corridor [jt], a staircase [lt] and a balcony [bk] will be developed. Subsequently the second floor will be formed according to Rule a-1b,1c, a-3b and a-6b. (Figure 4.9)

The second floor
Rule A: Ra-1b, 1c, Ra-3b, Ra-6b

X=1

Z=2

(0.0.2)   1   2   3

Y

Ra-1c→ Ra-6b   Ra-3b← Ra-1b → Ra-3b   Ra-6b←Ra-1c
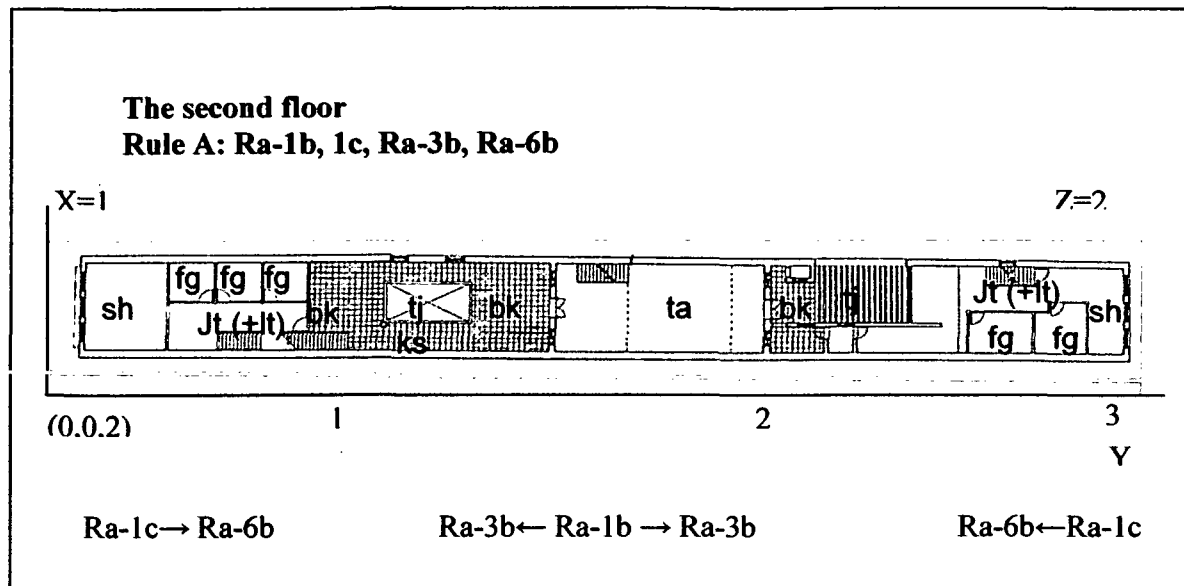
Figure 4. 9 Rule A for the first block on the ground floor at No. 71 Dihwa St

Through this process, Ra-1a, 1b, 1c, Ra-2a, Ra-3a, 3b, Ra-4b, Ra-6b were found in the series of Rule A. The floor plans of the town house at Diwha St.71 have been illustrated as well as analyzed according to this shape grammar. All these shape grammars will be listed below. (Figure 4.10)

The Shape grammar for illustrating a unit pattern for floor plans
at Dihwa St.71
Ra-1a, 1b, 1c, Ra-2a, Ra-3a, 3b, Ra-4b, Ra-6b
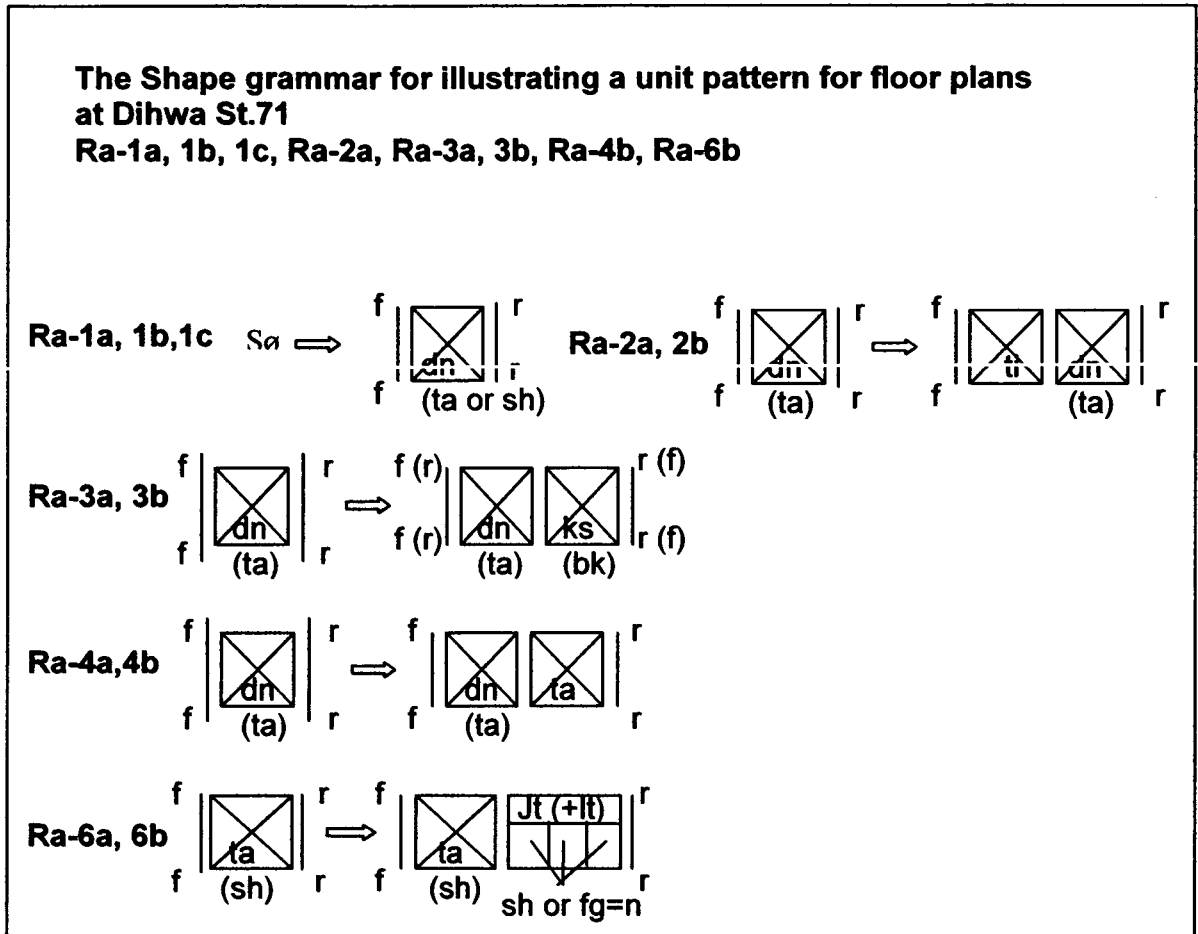
Figure 4. 10 Rule A to illustrate a unit pattern for floor plans at Dihwa St.71

4.2.3 Part III: Rule B: The openings on outer walls

This section of grammar consists of schemata that illustrate connections between spaces and the outside, in the form of entrances or windows as well as connection between pairs of spaces in the form of doors or openings.

The openings in traditional Taiwanese town houses have some basic principles. Normally there is no opening on common walls between two neighbouring houses. Windows are indicated by label 'w', doors indicated by label 'd' and doorways without doors are indicated by label 'dw'. The main doors are always located on the axis of symmetry and the front of the shop or hall, in the first block. The openings on the main facade are placed symmetrically.

The other openings can be the walls of the hall [ta], shop [dn], room [sh], small room [fg] and staircase [lt].

In the below schemata of Rule B, the ground floor has seven kinds of openings for outer walls which are shown in Figure 4.11. 'CC' represents corners and 'S' represents an indoor space. Rb-0a represents the opening at arcade. Rb-0b is the typical opening for the main entrance of a shop with an arcade. Rule b-2a is one window and one door on a wall. Rb-2c two windows on a wall. Rb-3c is one door between two windows on a wall and Rb-3e three large openings on a wall. Rb-4a represents two windows between two doors.
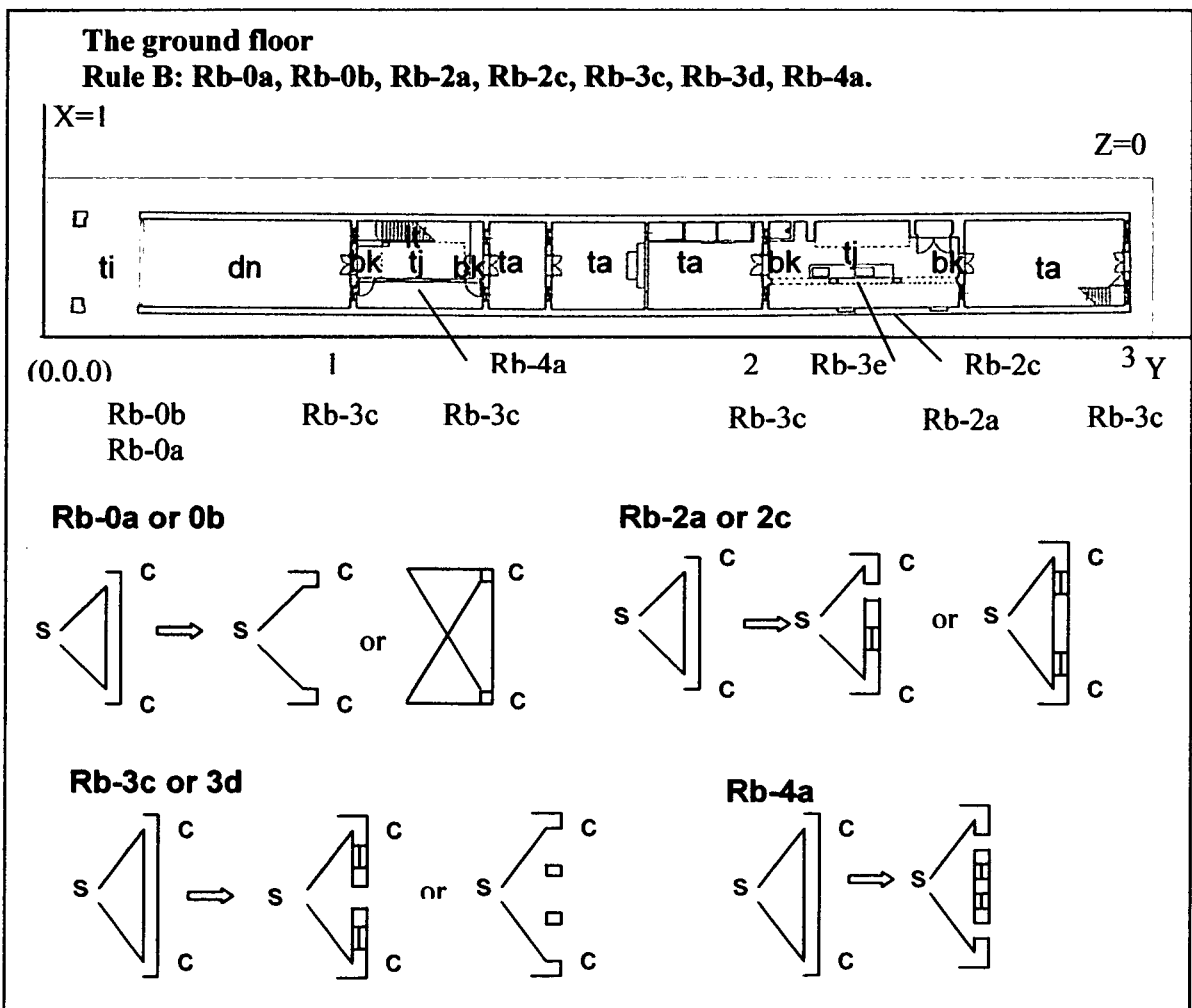
Figure 4. 11 Rule B for the ground floor at Dihwa Street No. 71

There are five kinds of schemata for the first floor as follows:

- Rb-0c represents the parapet on the balcony;

- Rb-1b denotes only one door without windows on the wall;

- Rb-2c represents two windows on the wall;

- Rb-3a represents three windows on the wall (this rule was applied quite often on the facades of traditional town houses in Taiwan as well as in Austria);

- Rule b-3c is very common in traditional town houses. (Figure 4.12)
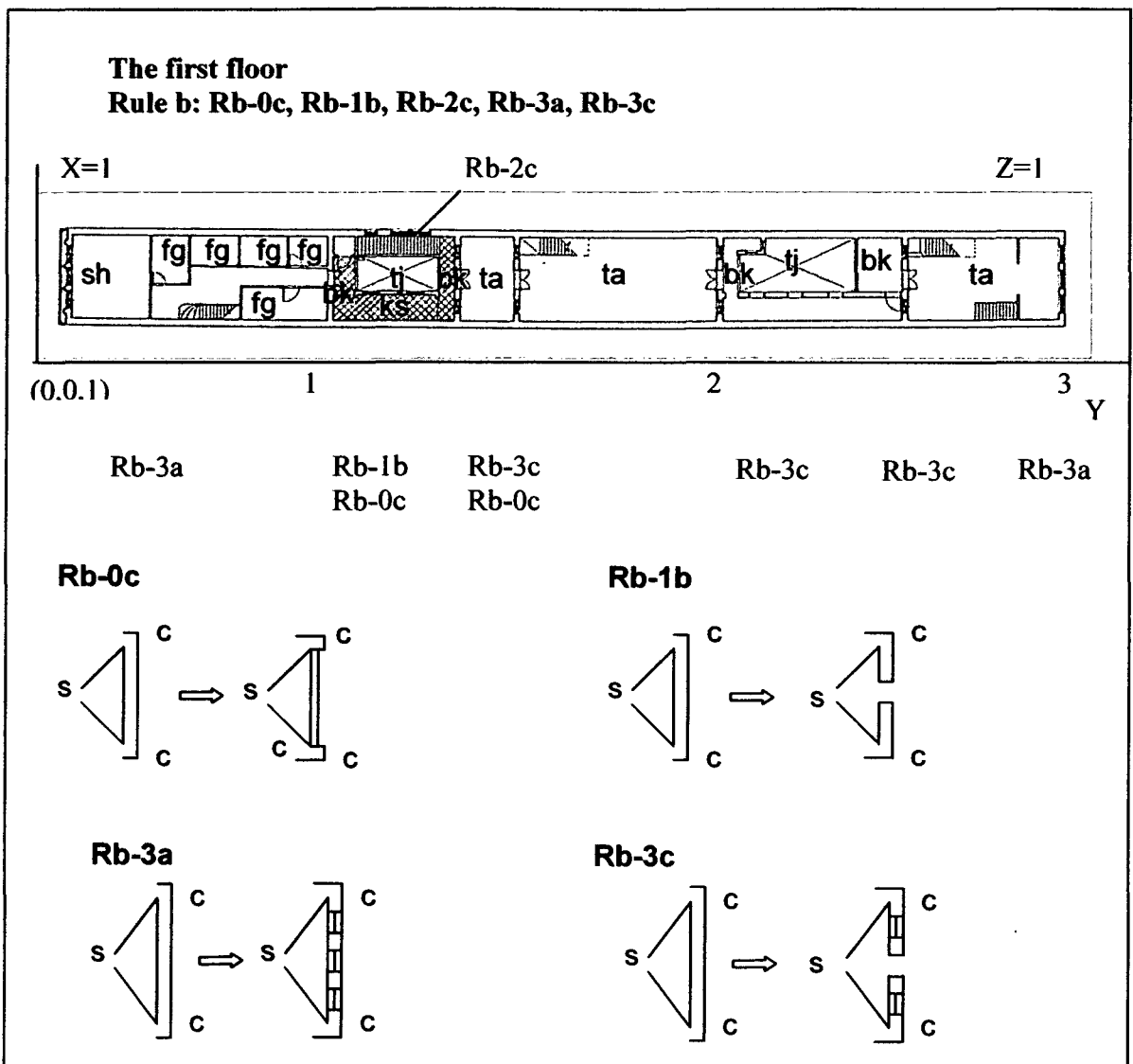
Figure 4. 12   Rule B for the first floor at Dihwa Street No. 71

On the second floor there are seven kinds of schemata, Rb-0c, Rb-1a, Rb-1b, Rb-2a, Rb-2c, Rb-3a and Rb-3c. Rb-1a represents one window on the outer wall. The openings on outer walls on the second floor have been described below. (Figure 4.13)
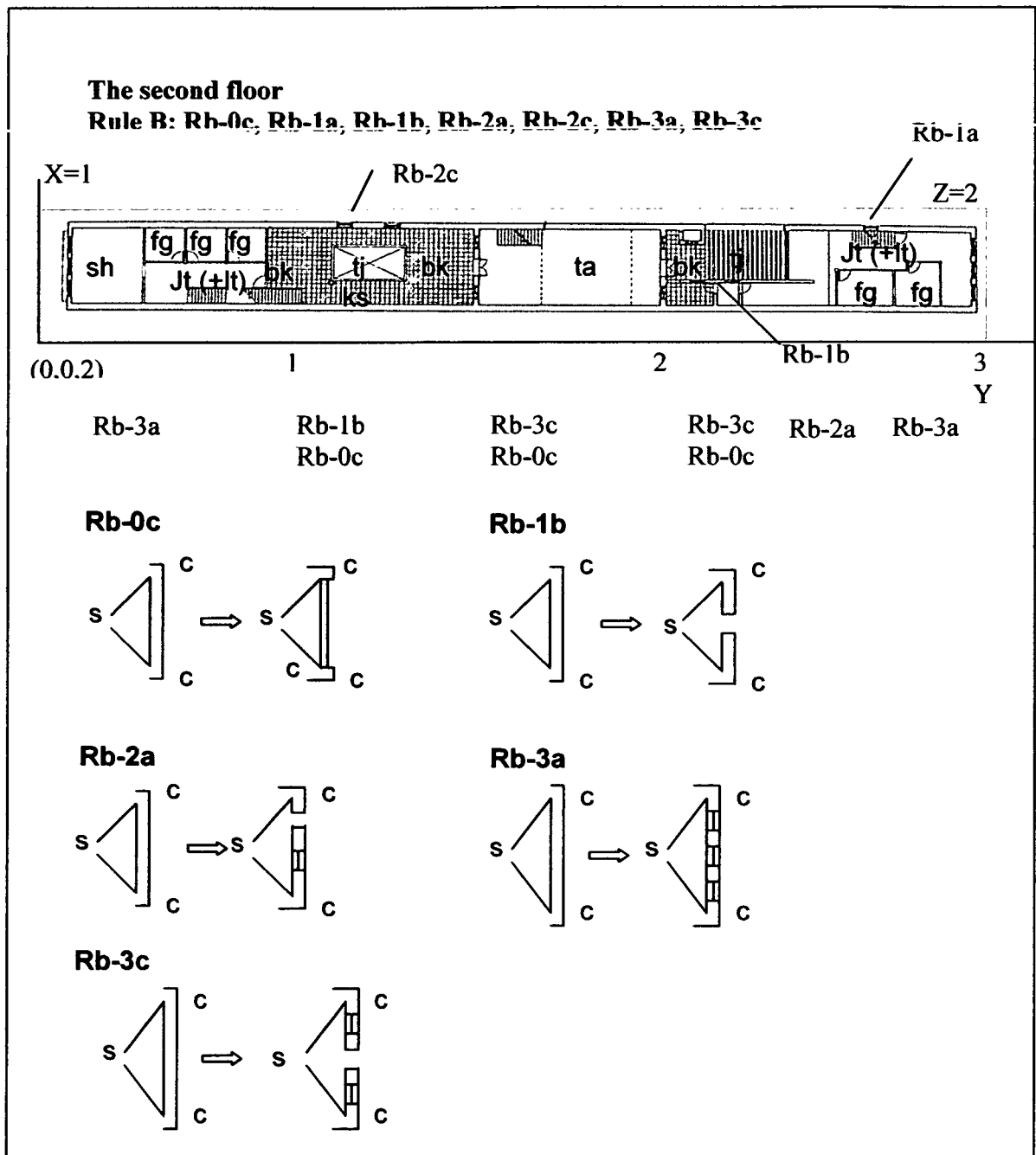
Figure 4. 13 Rule B for the second floor at Dihwa Street No. 71

Through the above process in the series of Rule B, the openings of outer walls at Diwha St.71 have been found. These schemata of the shape grammar are listed below (Figure 4.14)
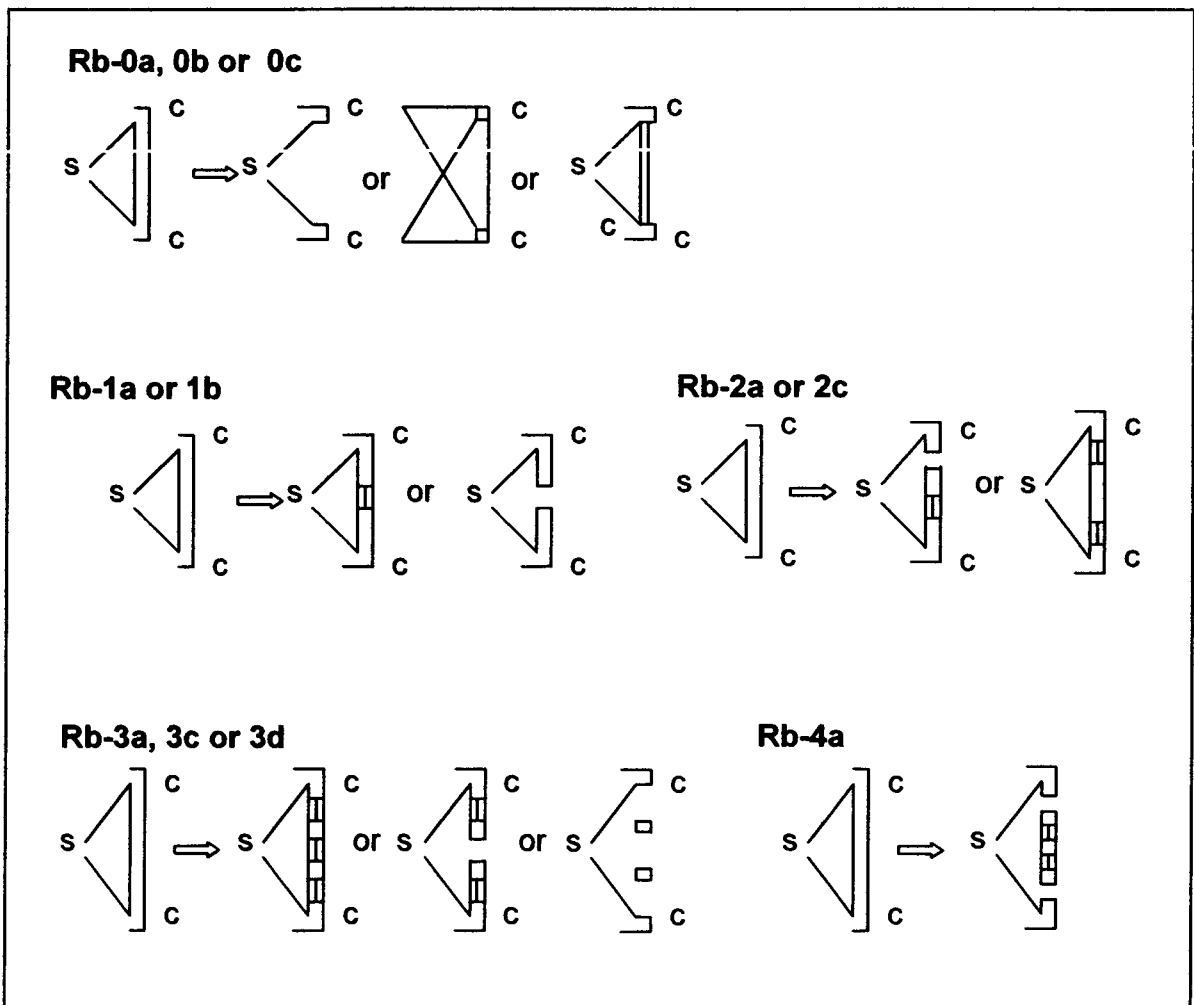
Figure 4. 14   Rule B for illustrating the openings on outer walls for floor plans at Dihwa St.71

4.2.4 Part IV: Rule C: the openings for connecting spaces

1. The ground floor: The openings for connecting spaces are classified in the series of Rule C. These schemata for the ground floor at No. 71 of Dihwa Street have two kinds of openings for connecting spaces that are shown in Figure 4.15. The label 'S' represents an indoor space.

– Rc-2b represents two openings on the wall for connecting spaces;

– Rc-3b represents one door between two windows on the inner wall. This is applied quite often not only to an inner but also on an outer wall.
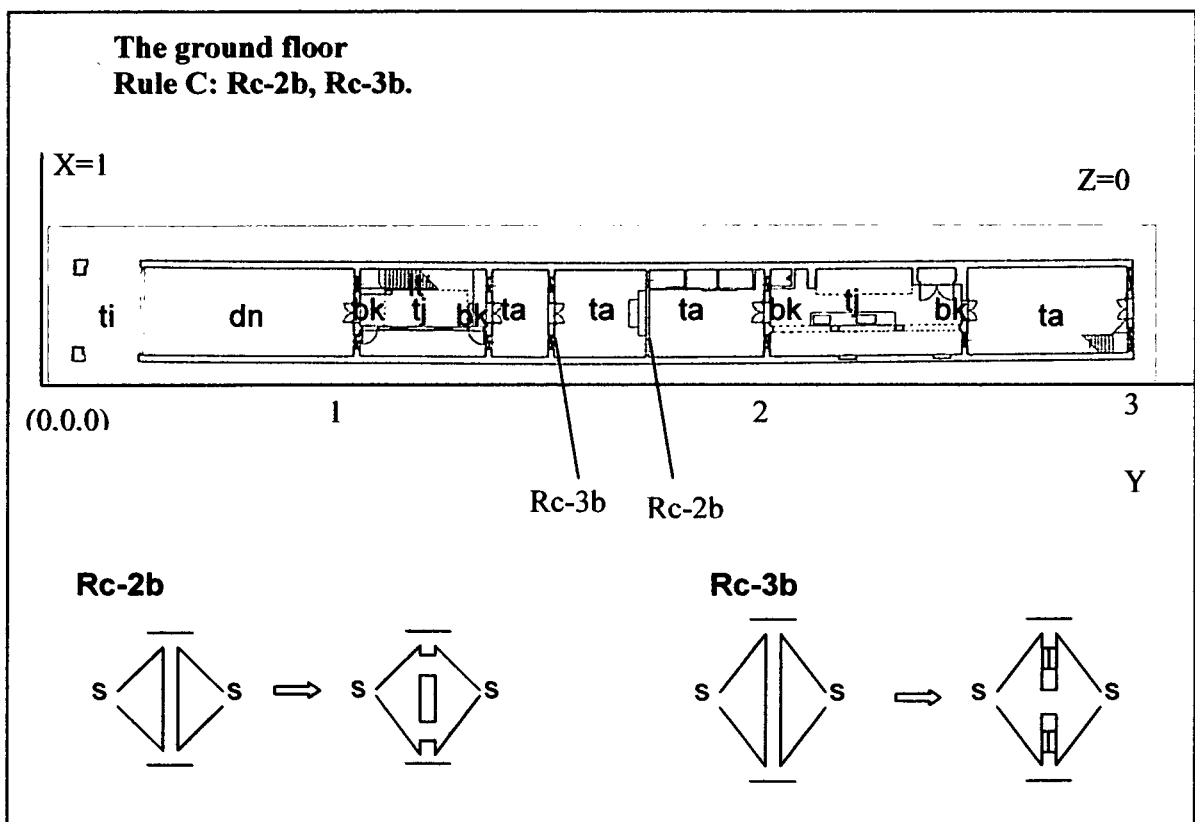
Figure 4. 15 Rule C for the ground floor at Dihwa Street No. 71 in Taipei.

2. The first floor : There are three kinds of schemata in the series of Rule C for the inner connections on the first floor.

– Rc-3b has already been explained above;

- Rc-1a represents only one door in the middle of an inner wall;

- Rc-1c represents one door at a side of an inner wall (Figure 4.16).

Figure 4. 16   Rule C for the first floor at Dihwa Street No. 71 in Taipei

3. The second floor : There are three kinds of schemata in the series of Rule C for the inner connections on the second floor.

- Rc-1a has already been explained above;

- Rc-1b means represents only one window on the middle of the inner wall;

- Rc-2a represents one door and one window on an inner wall (Figure 4.17).

The second floor
Rule C: Rc-1a, Rc-1b, Rc-2a

X=1

Z=2

sh	fg	fg	fg					ta				Jt (+lt)	
	Jt (+lt)	bk	tj	bk					bk			fg	fg
		ks											

(0.0.2)   1   2   3

Rc-1a   Rc-2a   Rc-1b   Y

Rc-1a, 1b

s ⟹ s or s

Rc-2a

s ⟹ s

Figure 4. 17   Rule C for the second floor at Dihwa Street No. 71

Through this process the series of Rule C, the opening of outer walls at Dihwa St.71 has been found. These schemata of the shape grammar are listed at below. (Figure 4.18)
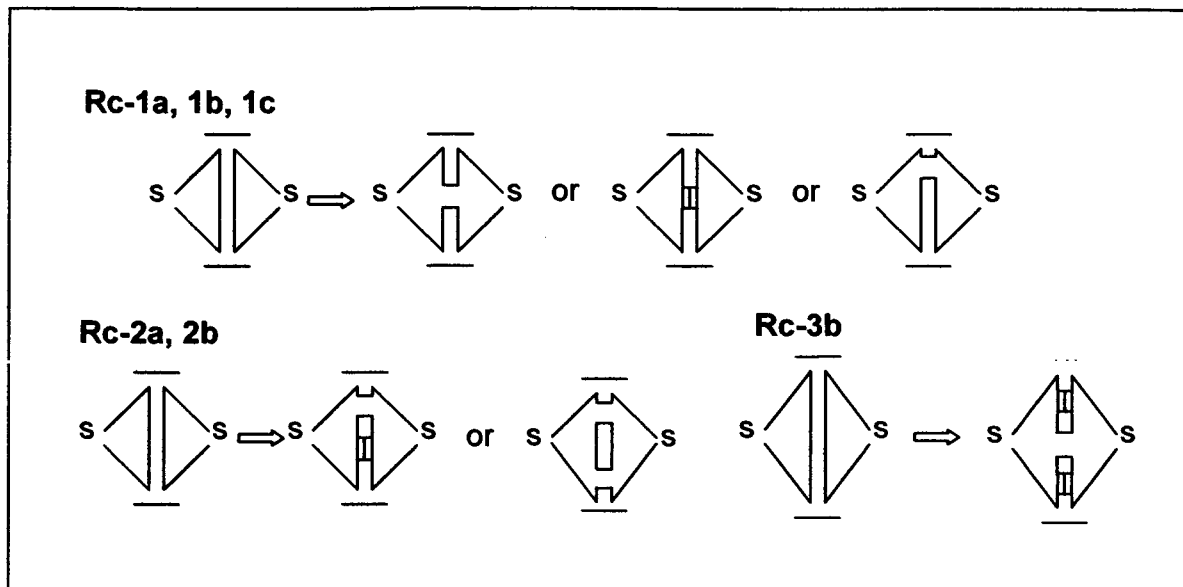
Figure 4. 18   **Rule C for illustrating the openings on inner walls for floor plans at No. 71 Dihwa St**

4.2.5   Part V: Rule D: Connections between blocks

The openings for connections between blocks are classified in the series of Rule D. In traditional Taiwanese town houses, courtyards are the connections between blocks. Courtyards are indicated by label 'ti' and sidewalls are indicated by label 'w'.

This schemata, Rule D, for the floor plans at No. 71 of Dihwa Street have five kinds of connections among blocks that are shown in Figure 4.19.
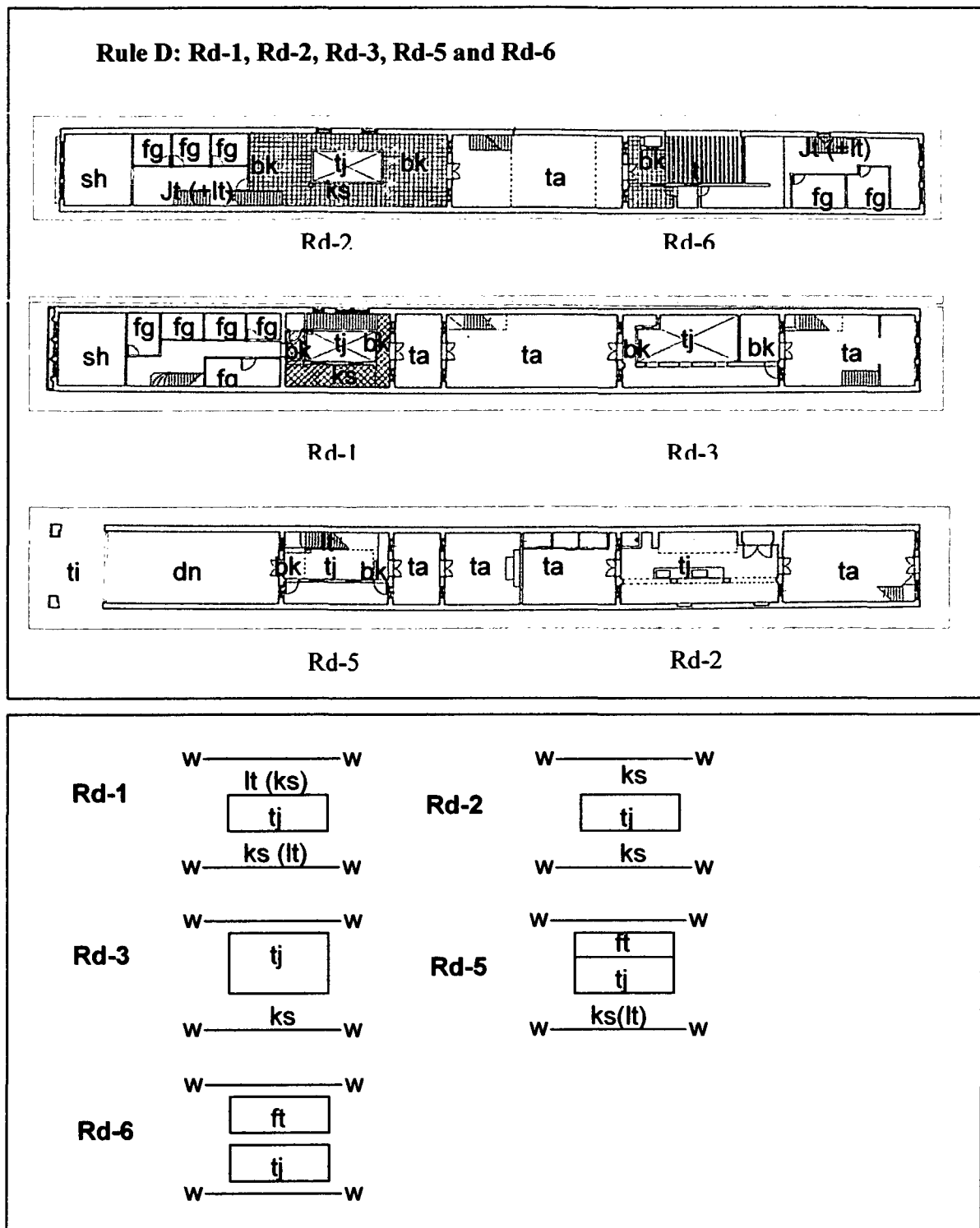
Figure 4. 19 Rule D for illustrating the connections among blocks for floor plans at No. 71 Dihwa St

The shape language for the floor plans at Dihwa St. 71, Rule A, Rule B, Rule C and Rule D, have been formed. Subsequent to the application of these rules in developing models of floor plans, all labels can be removed from the components or corners. We will continue to illustrate as well as analyze the floor plans of the traditional town houses in Taiwan in accordance with this shape language.

4.3 The applications for other traditional town houses in Taiwan:

Our first and the only example of Diwha St.71 is limited in scope and therefore requires a wider range of shape language for performing a comparative analysis in traditional Taiwanese town houses. Besides the example of Diwha St.71, there are three representative town houses from three famous old towns in Taiwan that have been developed below by the same method of shape grammar.

4.3.1 Hopin Road No. 86 in Daxi in north Taiwan:

All the traditional town houses on Hopin Road were preserved by the Taiwanese government as a cultural relic and heritage. This house No. 86 is a very typical style in this old town.

1. To build an initial shape in this town house: (Figure 4.20)

+(0,0,0)   P(1,1,0)   P(1,2,0)   P(1,3,0)   P(1,4,0)
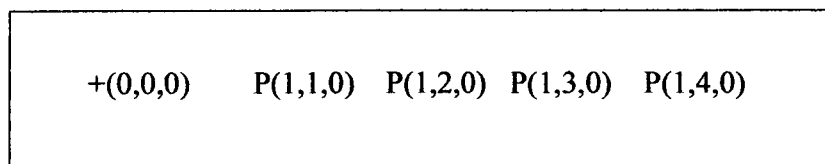
Figure 4. 20 The initial shape of Hopin Rd. No. 86 in Daxi

2. The generation of a unit pattern - Rule A: The traditional town house at Hopin Rd. 86 in Daxi is used here for analyzing the development of unit patterns by shape grammar.

The Ground Floor: Based on the fortune measurements, the first block will be formed by Ra-1a, Ra-2, Ra-5 and Ra-9. The first block contains a shop [dn], a front arcade [ti] a balcony [bk] and two small rooms [fg] between a corridor [jt]. The second block that contains a main space [ta], a room [sh], a corridor [jt] and two balconies [bk] can be described by Ra-1b, Ra-3b, Ra-6b and Ra-9. The third block that includes two rooms [sh], a corridor [jt] and two balconies [bk] can be described by Ra-1c, Ra-6b and Ra-9. The fourth block that includes a

main space [ta], a small room [fg], a corridor [jt] and one balcony [bk] and one courtyard [ti] is formed by Ra-1b, Ra-3b, and Ra-4b. The rules, Ra-1a, 1b, 1c, Ra-2a, Ra-3b, Ra-5, Ra-6b and Ra-9, are applied in this case (Xn=1, Yn=4, Zn=0).
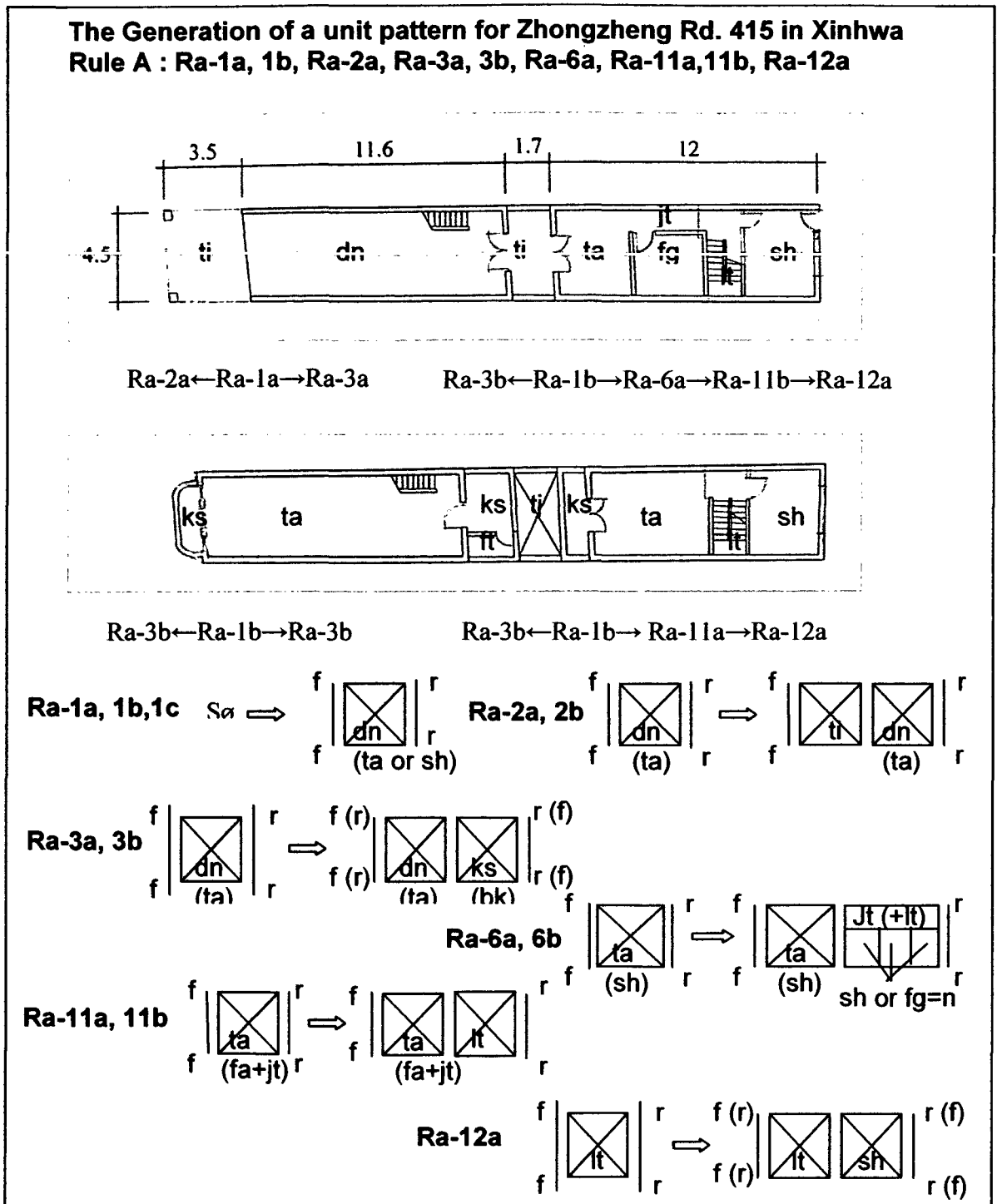
(Figure 4.21)

The Generation of a unit pattern for Hopin Rd. No.86 at Daxi
Rule A : Ra-1a, 1b,1c, Ra-2a, Ra-3b, Ra-5, Ra-6b, Ra-9

Ra-2a←Ra-1a→Ra-5→Ra-9   Ra-9←Ra-1c→Ra-6b→Ra-9

Ra-3b←Ra-1b→Ra-6b→Ra-9   Ra-3b←Ra-1b→Ra-4b→Ra-3
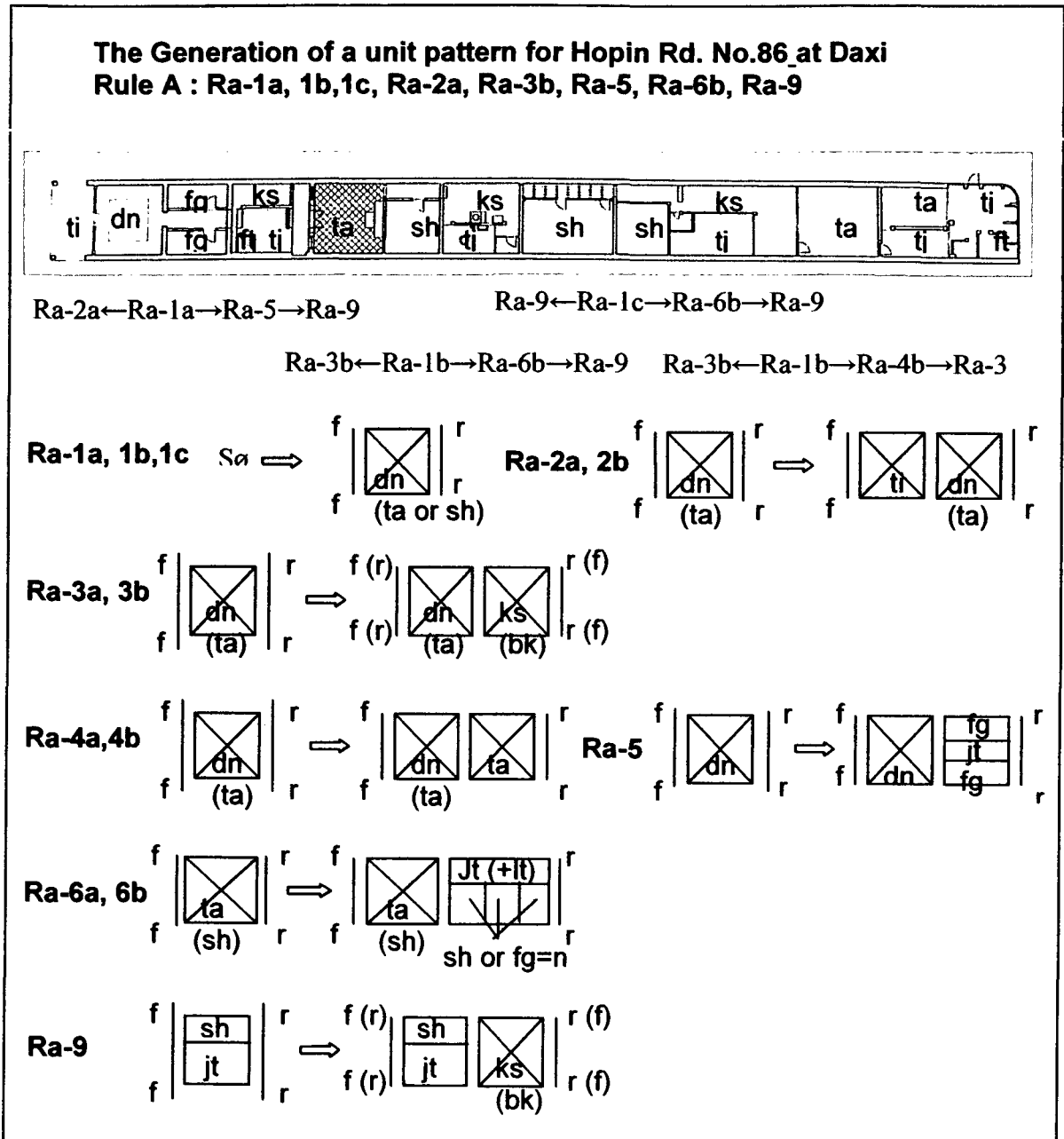
Figure 4. 21 Rule A for illustrating the generation of a unit pattern for floor plans at Hopin Rd. 86 in Daxi

3. The openings on outer walls – Rule B

In the below schemata, Rule B, for the ground floor has seven kinds of openings for outer walls which are shown in Figure 4.22. 'CC' represents corners and 'S' represents an indoor space.

- Rb-0a represents the opening at arcade;

- Rb-0b is the typical opening for the main entrance of a shop with an arcade;

- Rule b-1b is one door on the wall;

- Rb-1c one side window on a wall;

- Rule b-2a is one window and one door on the wall;

- Rb-3c means one door between two windows on the wall.
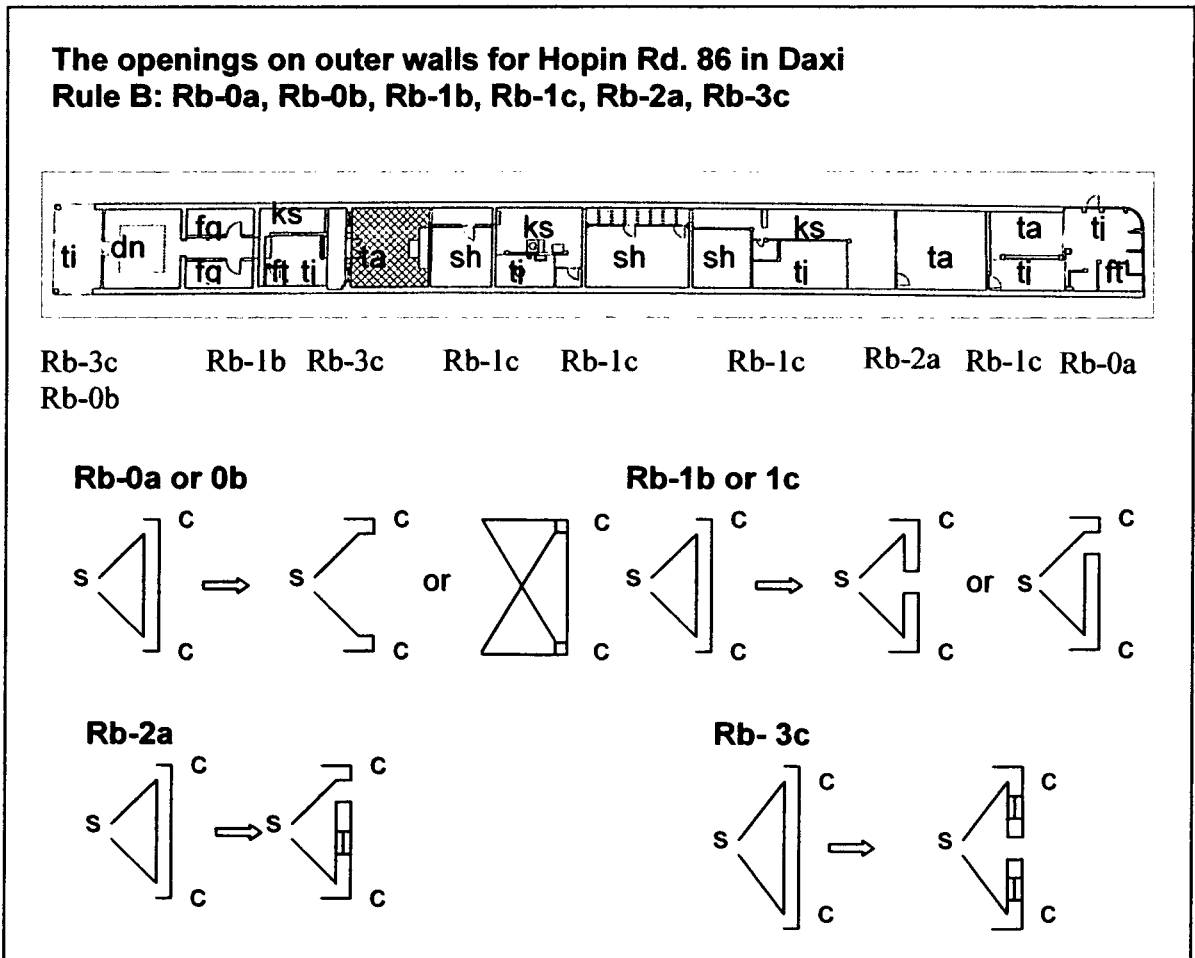
Figure 4. 22   Rule B for illustrating the openings on outer walls for floor plans at Hopin Rd. 86 in Daxi

4. Openings for connecting spaces – Rule C

This schemata, Rule C for the ground floor at No. 86 Hopin Road in Daxi has three kinds of openings for connections that are shown in Figure 4.23. The label 'S' presents an indoor space.

- Rc-1a represents one opening between two spaces;

- Rc-1c one side opening between two spaces. This is applied quite often not only on an inner wall but also on an outer wall;

- Rc-2b represents two openings on the wall for connecting spaces. This section of grammars consists of schemata, Rule C, which connects between spaces indoors.
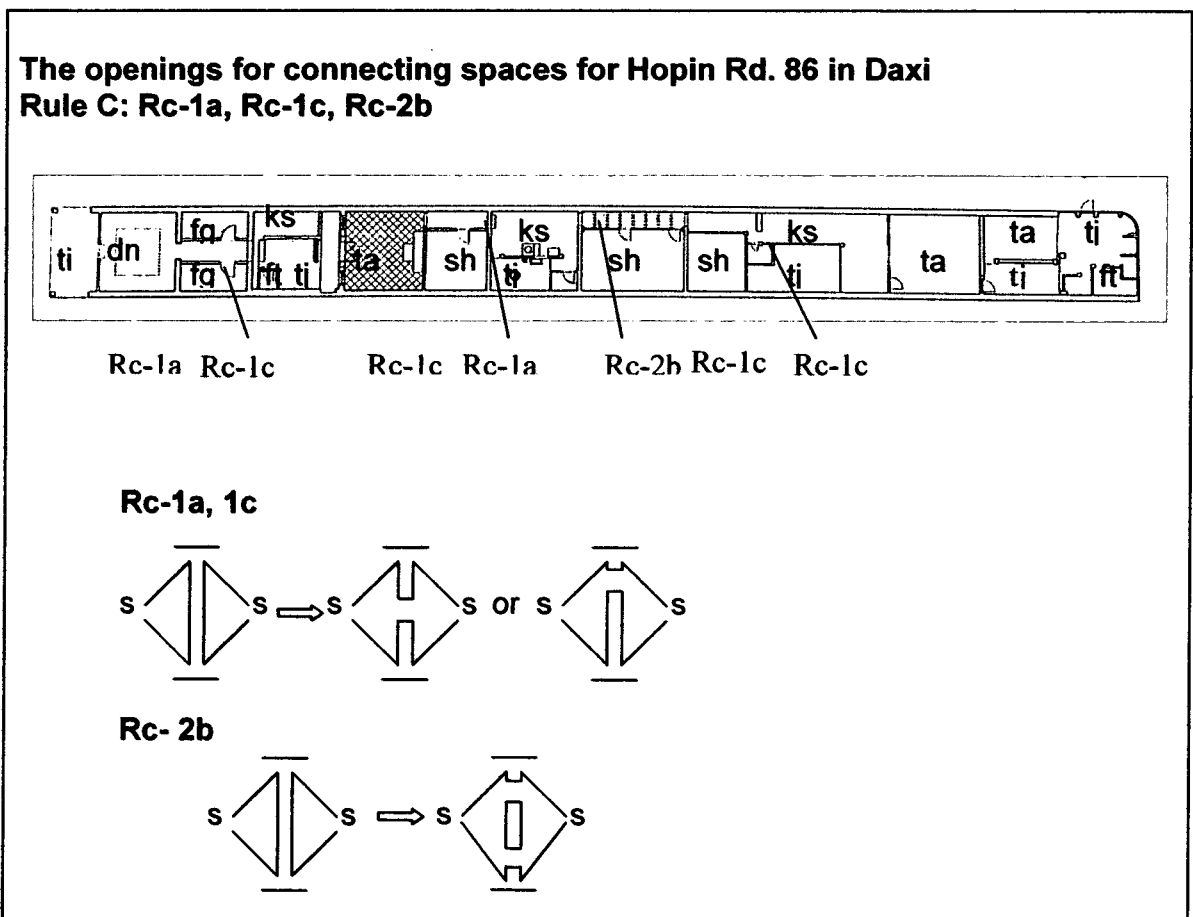
Figure 4. 23 Rule C for illustrating the openings on inner walls of floor plans at Hopin Road 86 in Daxi

5. The openings for connecting between blocks - Rule D:

Courtyards are the connections among blocks in traditional Taiwanese town houses. Here a courtyard is indicated by label 'tj' and sidewalls are indicated by label 'w'.

This schemata, Rule D, for the floor plans at No. 86 Hopin Road in Daxi has four kinds of connections between blocks that are shown in Figure 4.24.
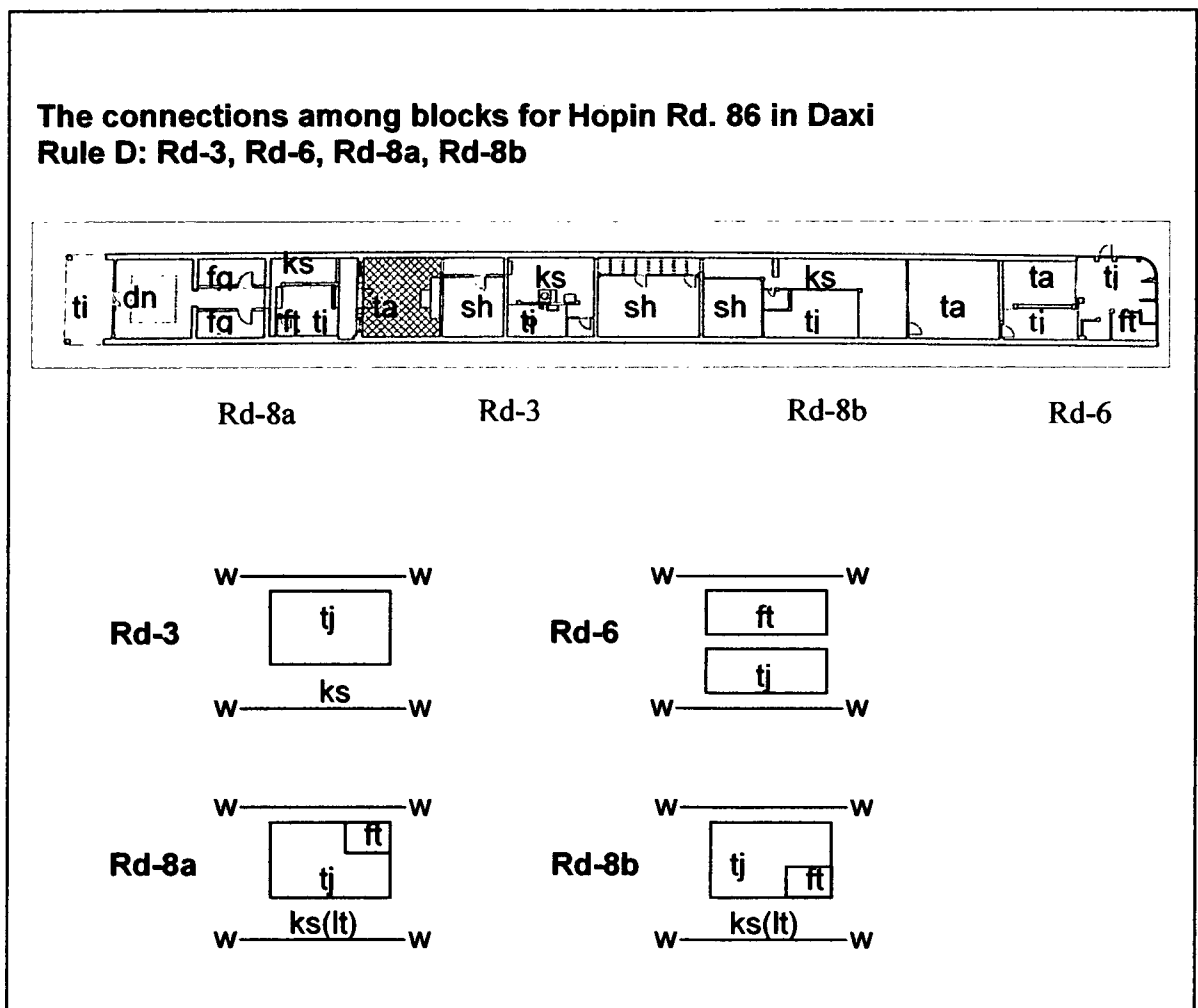
Figure 4. 24   Rule D for illustrating the connections between blocks of floor plans at Hopin road 86 in Daxi

4.3.2 Zhongshan street No. 121 in Lukang in middle Taiwan:

Most of this area in Lukang was preserved by the Taiwanese government as a cultural relic of traditional town houses. The house at Zhong Shan St.121 is a very typical traditional town house in this old town and we will now analyze shape grammars for this house below:

1. To build an initial shape in this town house: (Figure 4.25)

P(1,1,1)   P(1,2,1)   P(1,3,1)

+(0,0,0)   P(1,1,0)   P(1,2,0)   P(1,3,0)
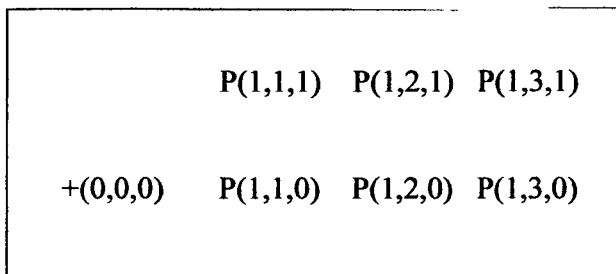
Figure 4. 25 The initial form of Zhong Shan St.121 in Lukang

2. The generation of a unit pattern - Rule A : The traditional town house at Zhong Shan St.121 in Lukang is used here for analyzing the development of unit patterns by shape grammar.

The Ground Floor: Based on the fortune measurements, the first block can be formed by Ra-1a, Ra-2, Ra-4a, 6a and Ra-9. The first block contains a shop [dn], a front arcade [ti] a room [sh], a corridor [jt] and a balcony [bk]. The second block that contains a main space [ta], a room [sh], a corridor [jt] and two balconies [bk] can be described by Ra-1b, Ra-3b, Ra-6b and Ra-9. The third block which includes a main space [ta] and two balconies [bk] can be described by Ra-1c, Ra-6b and Ra-9. The appendix at the ground floor, which is connected to the second and the third blocks of the main house can be formed by Ra-10 and Ra-13.

The First Floor: The first block that contains a main space [ta], a room [sh], an atrium [lj] and a balcony [bk] is formed by Ra-1b, Ra-3b, Ra-7 and Ra-8. The second block which has a main space [ta], a balcony [bk] and a small room for appendix [ft] was developed by Ra-1c, Ra-3b and Ra-13.

The rules, Ra-1a,1b, Ra-2, Ra-3b, Ra-4a, Ra-6a, 6b, Ra-7, Ra-8, Ra-9, Ra-10 and Ra-13 , are applied in this case (Xn=1, Yn=3, Zn=1) (Figure 4.26).

**The Generation of a unit pattern for Zhong Shan St.121 at Lukang
Rule A : Ra-1a,1b, Ra-2a, Ra-3b, Ra-4a, Ra-6a, 6b, Ra-7, Ra-8, Ra-9, Ra-10. Ra-13**

Ra-10←Ra-13→Ra-10

Ra-2a←Ra-1a→Ra-4a→Ra-6a→Ra-9

Ra-9←Ra-6b←Ra-1b→Ra-3b   Ra-10←Ra-13

Ra-3b←Ra-1b→Ra-3b

Ra-8←Ra-7←Ra-1b→Ra-3b   Ra-3b←Ra-1b ↑ Ra-13

Ra-1a, 1b,1c   Sa ⇒

Ra-2a, 2b

Ra-3a, 3b

Ra-4a,4b

Ra-6a, 6b

Ra-7
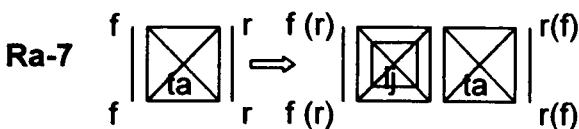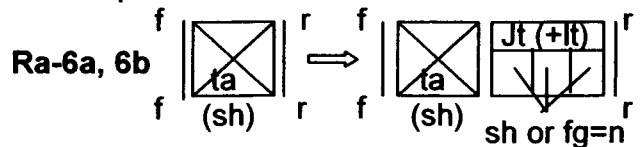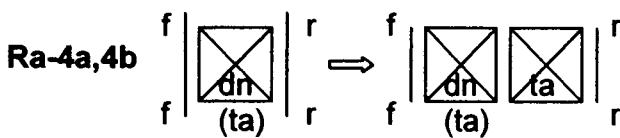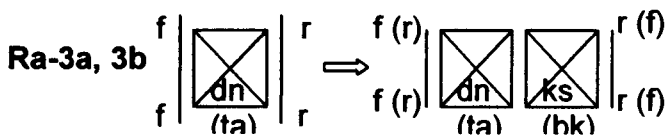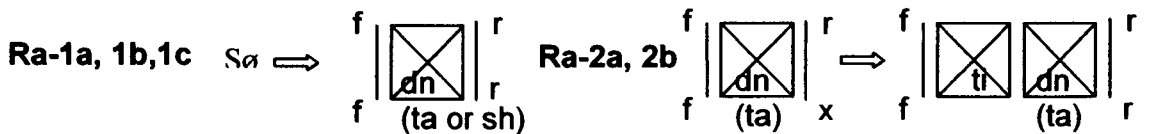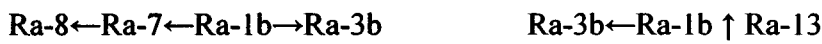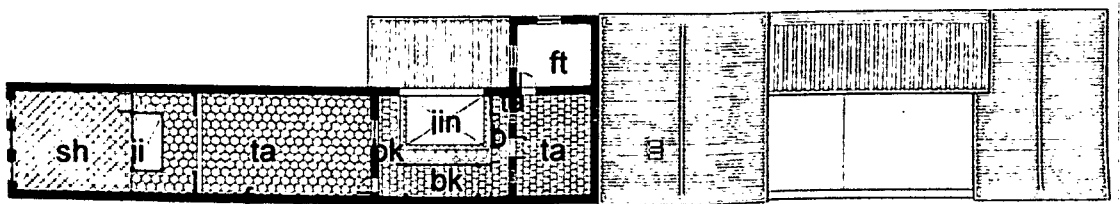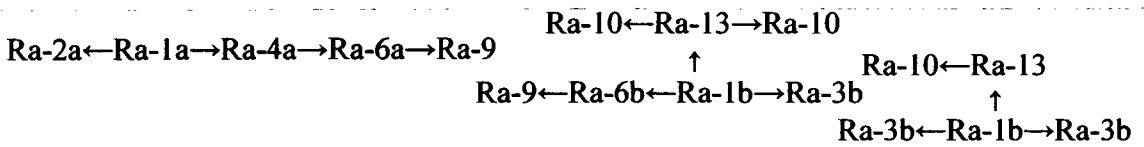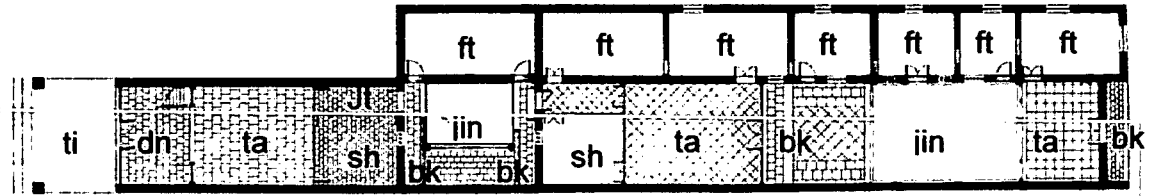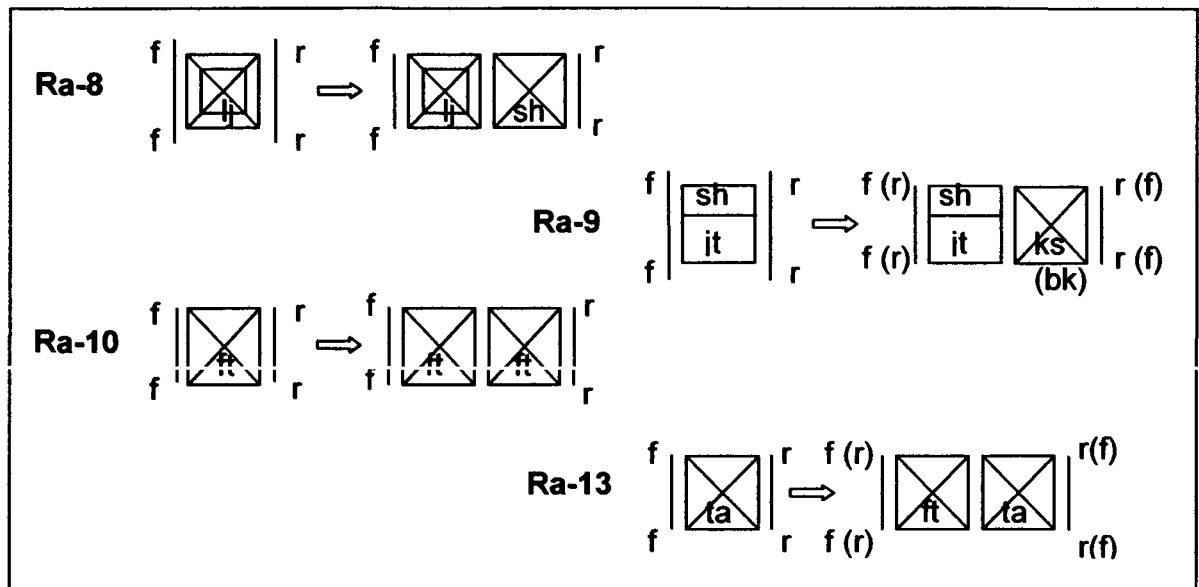
Figure 4. 26 **Rule A to illustrate the generation of a unit pattern for floor plans at Zhong Shan St.121 in Lukang**

3. Openings on outer walls – Rule B

In the below schemata, Rule B, this example has ten kinds of openings for outer walls which are shown in Figure 4.27. 'CC' represents corners and 'S' represents indoor space.

–   Rb-0a represents the opening at an arcade;

–   Rb-2d represents two identical openings on the wall. This rule is applied quite often in large traditional Taiwanese town houses.
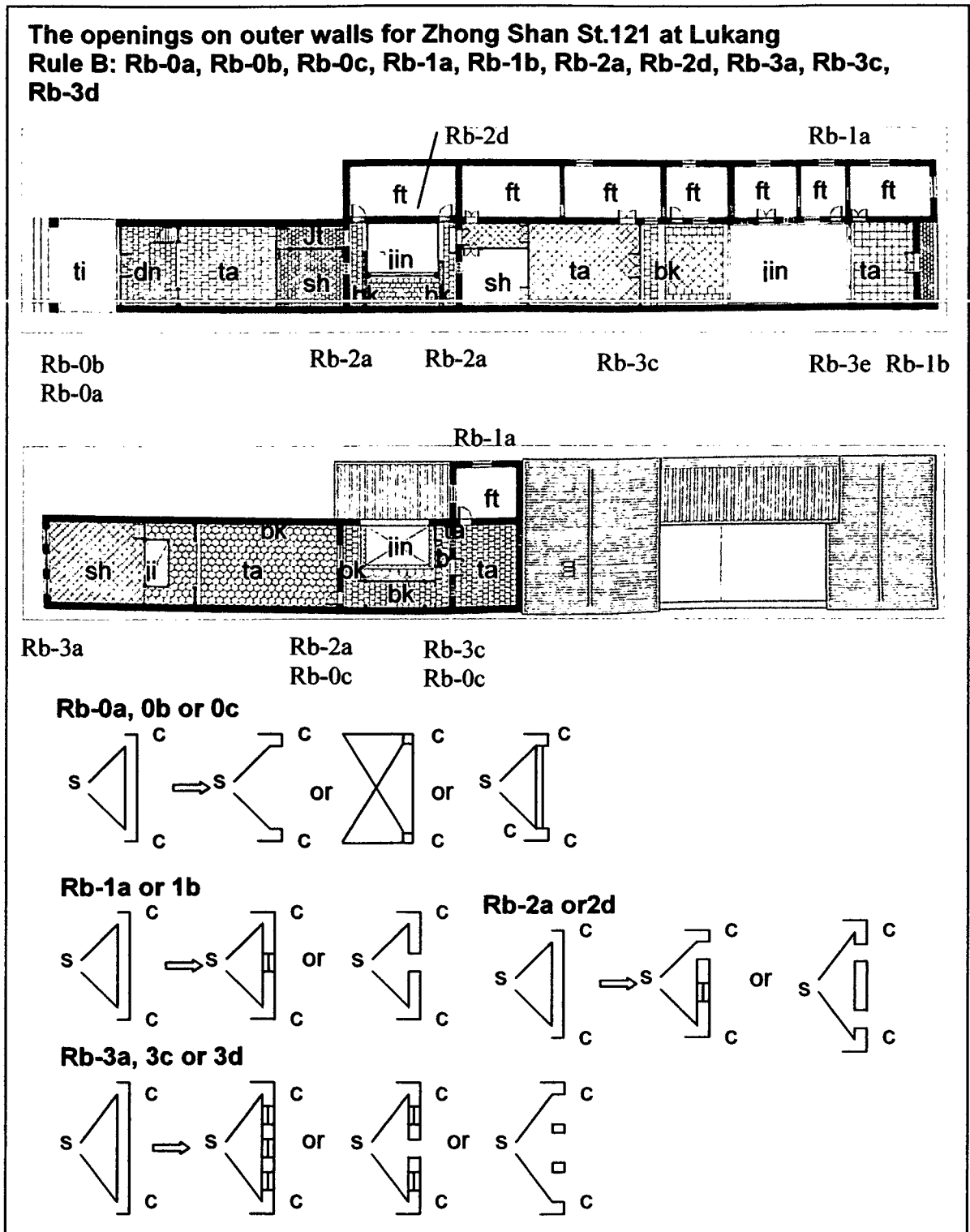
Figure 4. 27 Rule B for illustrating openings on outer walls of floor plans at Zhong Shan St.121 in Lukang

4. Openings for connecting spaces – Rule C

In the below schemata, Rule C, this example at Zhong Shan St.121 in Lukang has three kinds of openings for connecting spaces which are shown in Figure 4.28. The label 'S' represents indoor space.

-    Rc-1d represents one side window between two spaces;

-    Rc-1e means one large opening between two spaces. This is applied to connect two large indoor spaces. This part of grammar consists of schemata, with connections between spaces indoors.
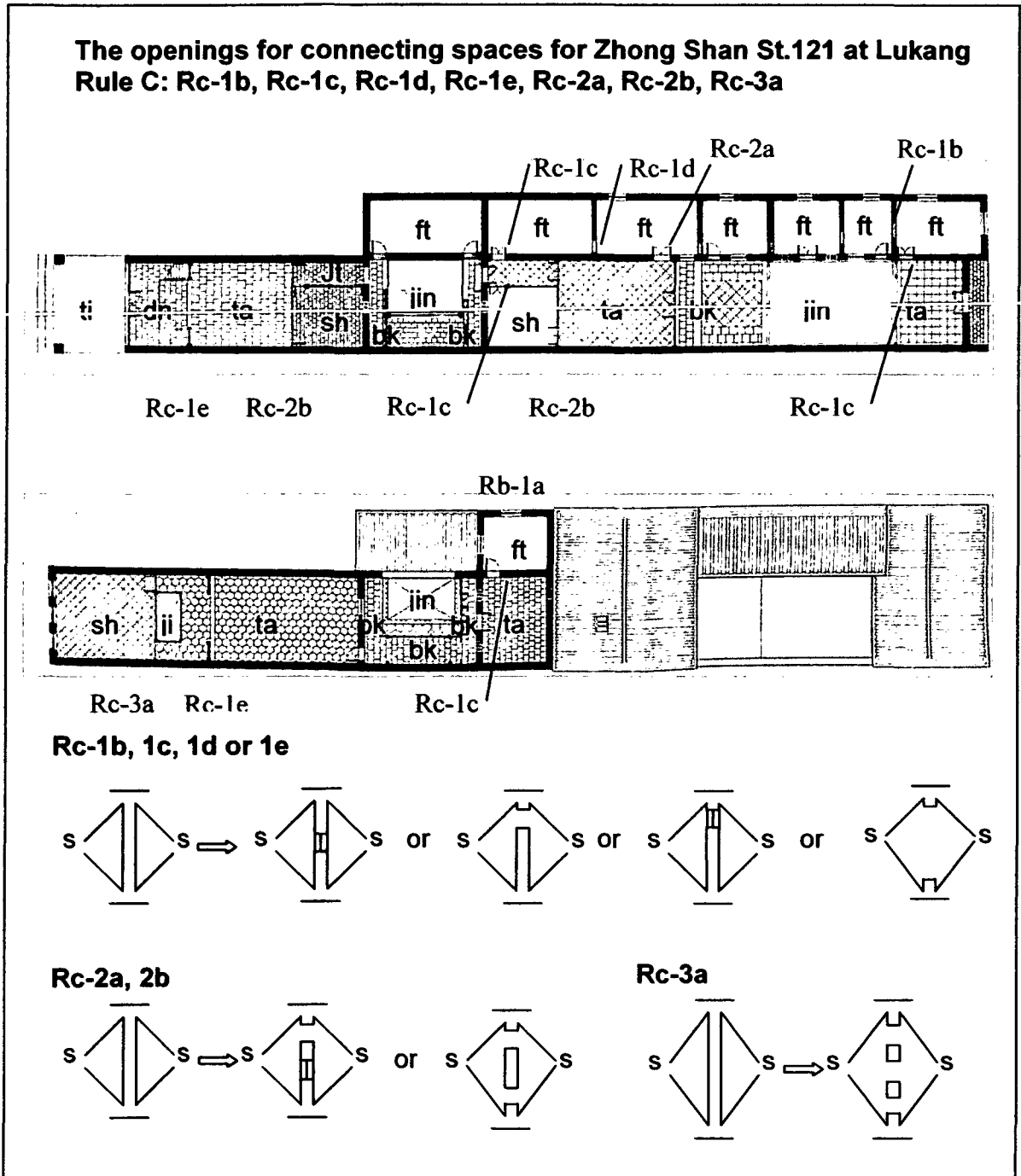
Figure 4. 28   Rule C to illustrate the openings on inner walls of floor plans at Zhongshan St.121 in Lukang

5. The openings for connections between blocks - Rule D:

Courtyards are the connections between blocks in traditional Taiwanese town houses. Here a courtyard is indicated by label [tj] and sidewalls are indicated by label [w].

In the below schemata, Rule D, this example of the floor plans at No. 121 on Zhong Shan Road in Lukang has three kinds of connections between blocks that are shown in Figure 4.29.
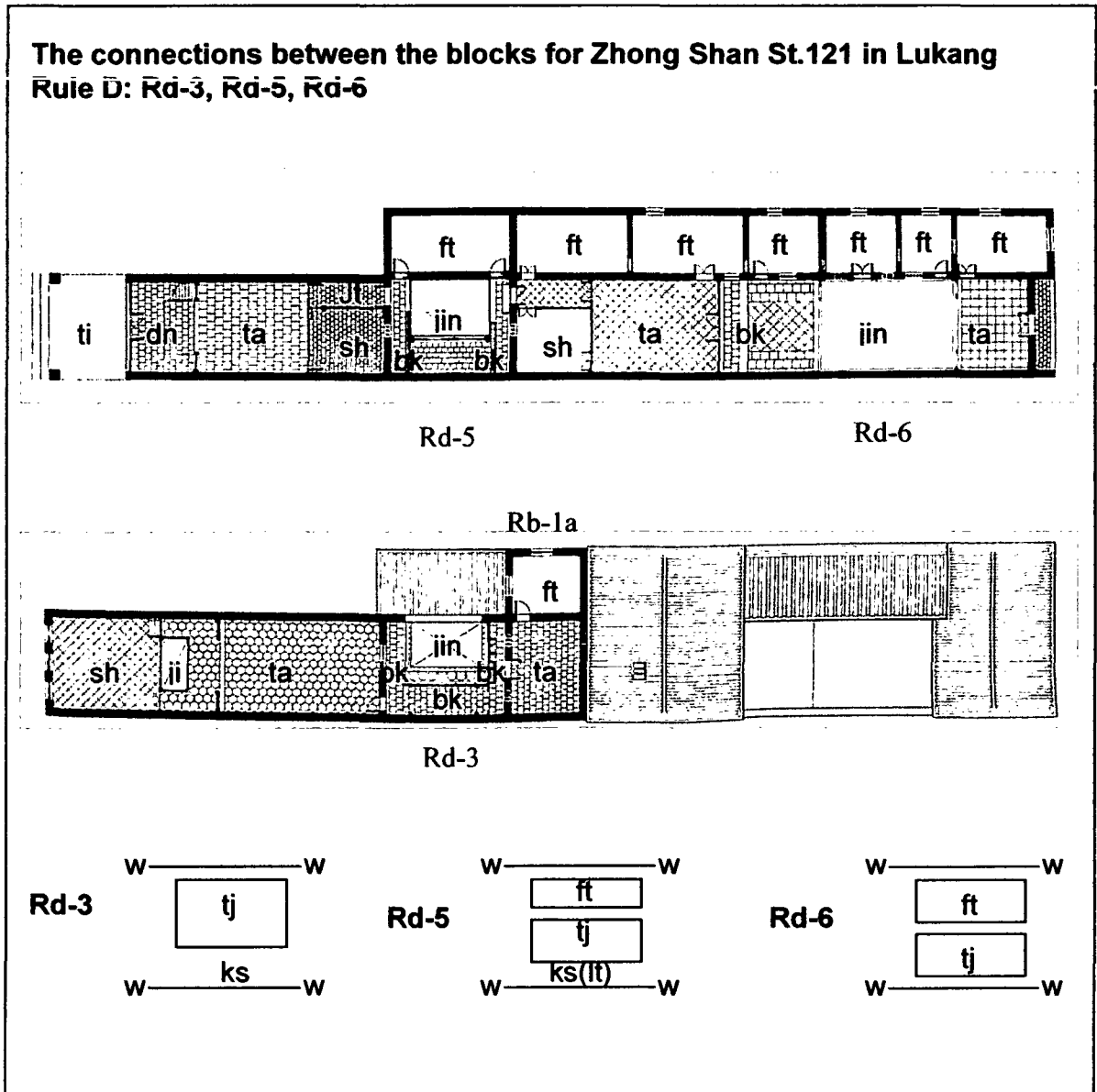
Figure 4. 29   Rule D to illustrate the connections between blocks of floor plans at Zhongshan St.121 in Lukang

4.3.3 Zhongzheng road No. 415 in Xinhwa in south Taiwan:

Most of the town houses on Zhongzheng Road were built around 1920, when Japan occupied Taiwan. The style is indicative of the strong Japanese influence and the present Taiwanese local government has preserved these old town houses as historical relics and heritage. This house, Zhongzheng Rd. 415,F is a very typical traditional town house in this old town and we will now analyze shape grammars for this house below.

1. To build an initial shape in this town house: (Figure 4.30)

```
        P(1,1,1)   P(1,2,1)


+(0,0,0)    P(1,1,0)   P(1,2,0)
```
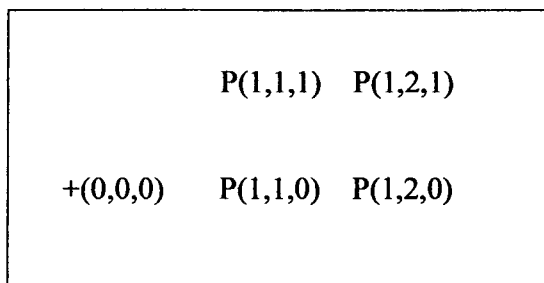
Figure 4. 30 The initial form of Zhongzheng Rd. 415 in Xinhwa

2. The generation of a unit pattern - Rule A : The traditional town house at Zhongzheng Rd. 415 in Xinhwa is used here for analyzing the development of unit patterns by shape grammar.

The Ground Floor: Based on the fortune measurements, the first block can be developed by Ra-1a, Ra-2 and Ra-3a. The first block contains a shop [dn], a front arcade [ti] and a balcony [bk]. The second block that contains a main space [ta], a small room [fg], a corridor [jt],a staircase [lt], a room [sh] and a balcony [bk] can be described by Ra-1b, Ra-3b, Ra-6a, Ra-11b and Ra-12.

The First Floor: The first block which contains a main space [ta] and two balconies [bk] can be developed by Ra-1b and Ra-3b. The second block that has a main space [ta], a staircase [lt], a room [sh] and a balcony [bk] can be developed by Ra-1b, Ra-3b,Ra-11a and Ra-12.

The rules, Ra-1a,1b, Ra-2, Ra-3a, 3b, Ra-6a, Ra-11b and Ra-12 , are applied in this case (Xn=1, Yn=2, Zn=1) (Figure 4.31).

The Generation of a unit pattern for Zhongzheng Rd. 415 in Xinhwa
Rule A : Ra-1a, 1b, Ra-2a, Ra-3a, 3b, Ra-6a, Ra-11a,11b, Ra-12a

3.5   11.6   1.7   12

4.5   ti   dn   ti   ta   fg   sh

Ra-2a←Ra-1a→Ra-3a   Ra-3b←Ra-1b→Ra-6a→Ra-11b→Ra-12a

ks   ta   ks   ti   ks   ta   sh

Ra-3b←Ra-1b→Ra-3b   Ra-3b←Ra-1b→ Ra-11a→Ra-12a

Ra-1a, 1b,1c   Sa ⟹   f [dn] r / f (ta or sh) r

Ra-2a, 2b   f [dn] r ⟹ f [ti][dn] r / f (ta) r   f (ta) r

Ra-3a, 3b   f [dn] r / f (ta) r ⟹ f(r) [dn][ks] r(f) / f(r) (ta)(hk) r(f)

Ra-6a, 6b   f [ta] r / f (sh) r ⟹ f [ta][Jt(+lt)] r / f (sh) sh or fg=n r

Ra-11a, 11b   f [ta] r / f (fa+jt) r ⟹ f [ta][lt] r / f (fa+jt) r

Ra-12a   f [lt] r / f (fa+jt) r ⟹ f(r) [lt][sh] r(f) / f(r) (r) r(f)

Figure 4. 31   **Rule A for illustrating the generation of a unit pattern of floor plans at Zhongzheng Rd. 415 in Xinhwa**

3. The openings on outer walls – Rule B

In the below schemata, Rule B, this example at Zhongzheng Rd. 415 in Xinhwa has seven kinds of openings for outer walls which are shown in Figure 4.32. 'CC' represents corners and 'S' represents indoor space. All of these schemata in Rule B have been explained earlier.
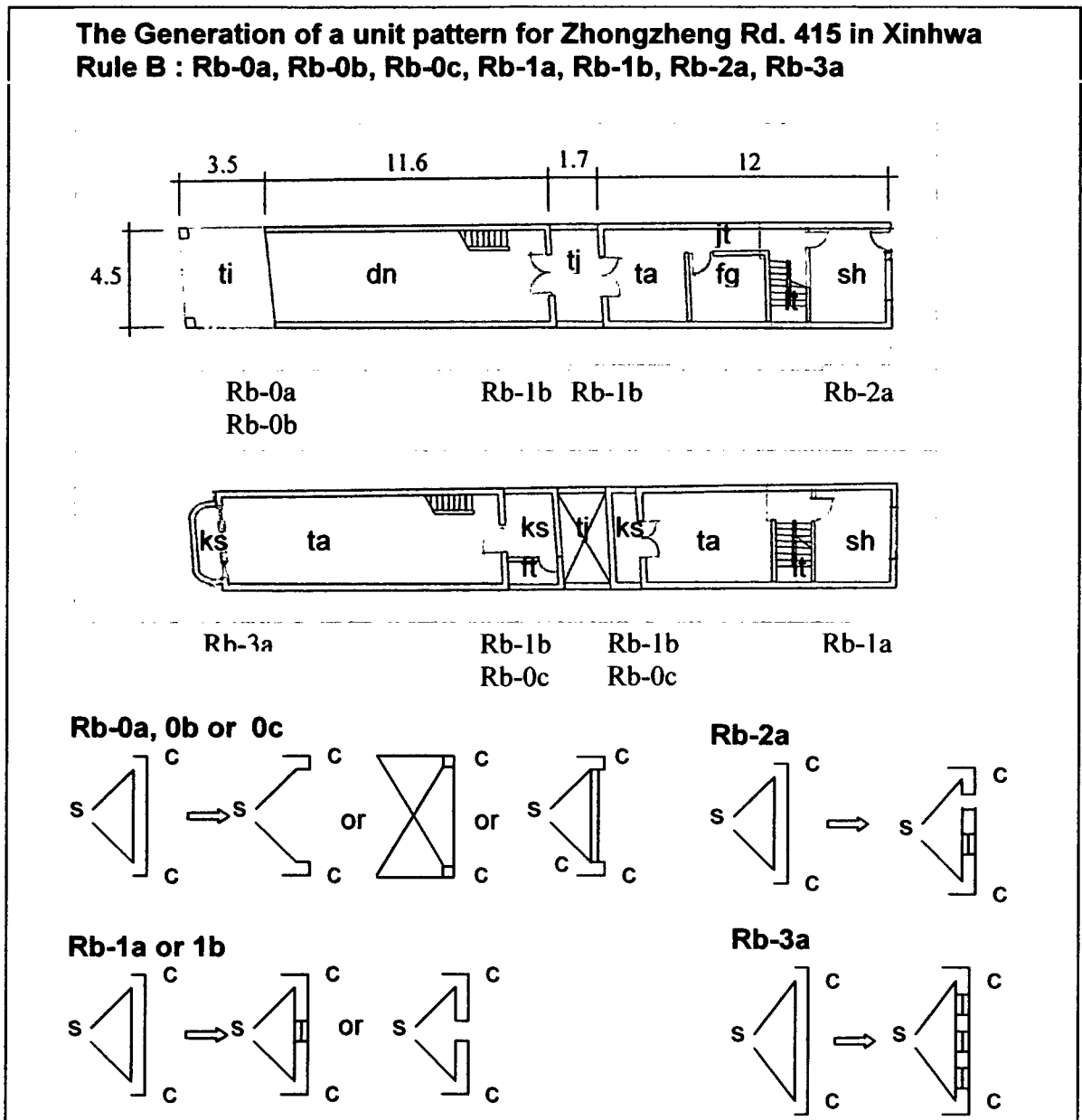
Figure 4. 32   Rule B for illustrating the openings on outer walls of floor plans for Zhongzheng Rd. 415 in Xinhwa

4. The openings for connecting spaces – Rule C

In the below schemata, Rule C, this example at Zhongzheng Rd. 415 in Xinhwa has only one kind of opening for connecting spaces which is shown in Figure 4.33. The label 'S' represents indoor space. This schema in Rule C has been explained earlier.
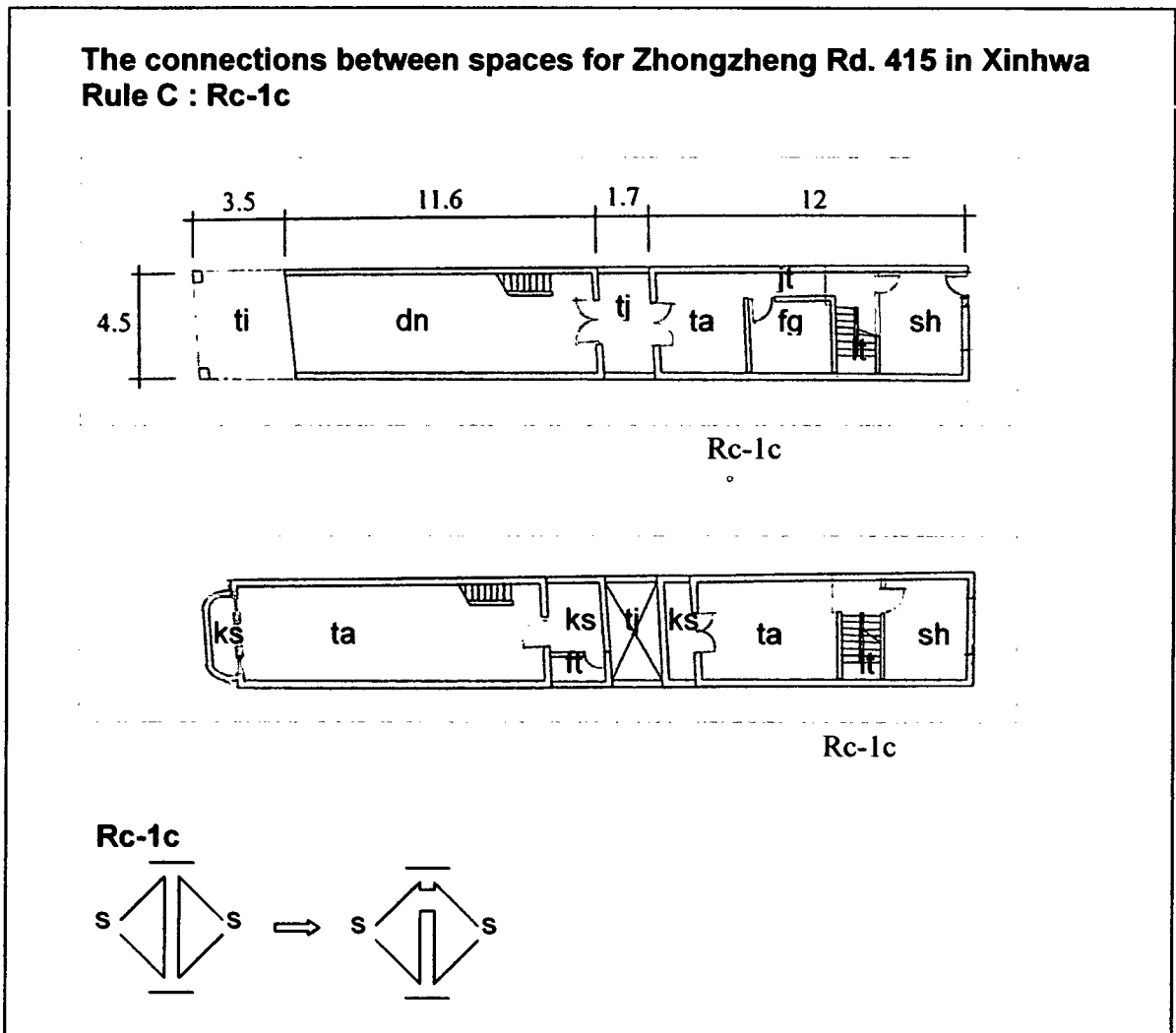
Figure 4. 33   Rule C for illustrating openings on inner walls of floor plans at Zhongzheng Rd. 415 in Xinhwa

5. The openings for connections between blocks - Rule D:

Courtyards are the connections between blocks in traditional Taiwanese town houses. Here a courtyard is indicated by label 'tj' and sidewalls are indicated by label 'w'.

This schemata, Rule D, of the floor plans at Zhongzheng Rd. 415 in Xinhwa has only one kind of connection between blocks and is shown in Figure 4.34.
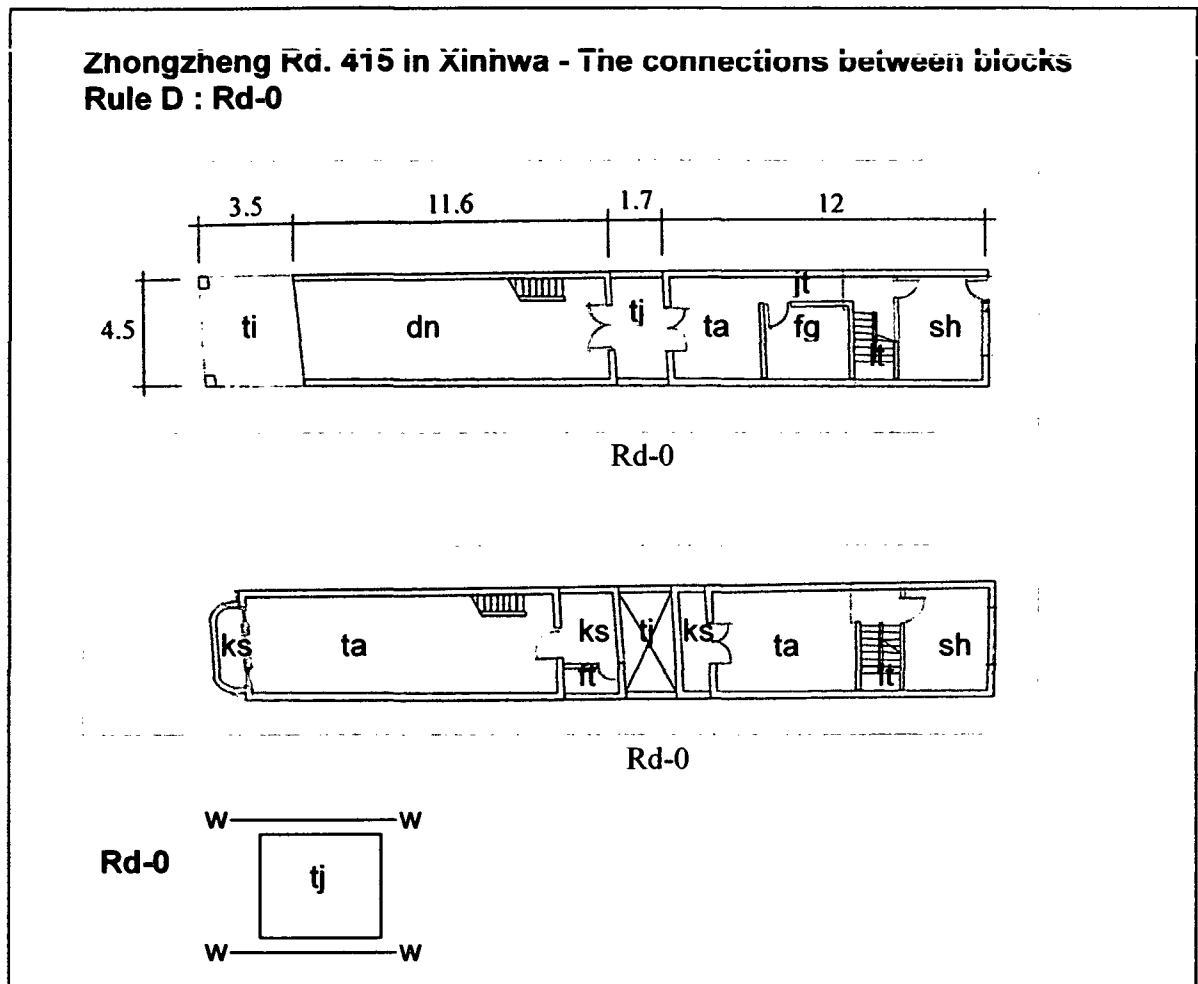
Figure 4. 34   **Rule D for illustrating openings on inner walls of floor plans at Zhongzheng Rd. 415 in Xinhwa**

4.4   Conclusions
4.4.1   Rules of shape grammars for floor plans of traditional town houses in Taiwan

Rule A: The Generation of a unit pattern
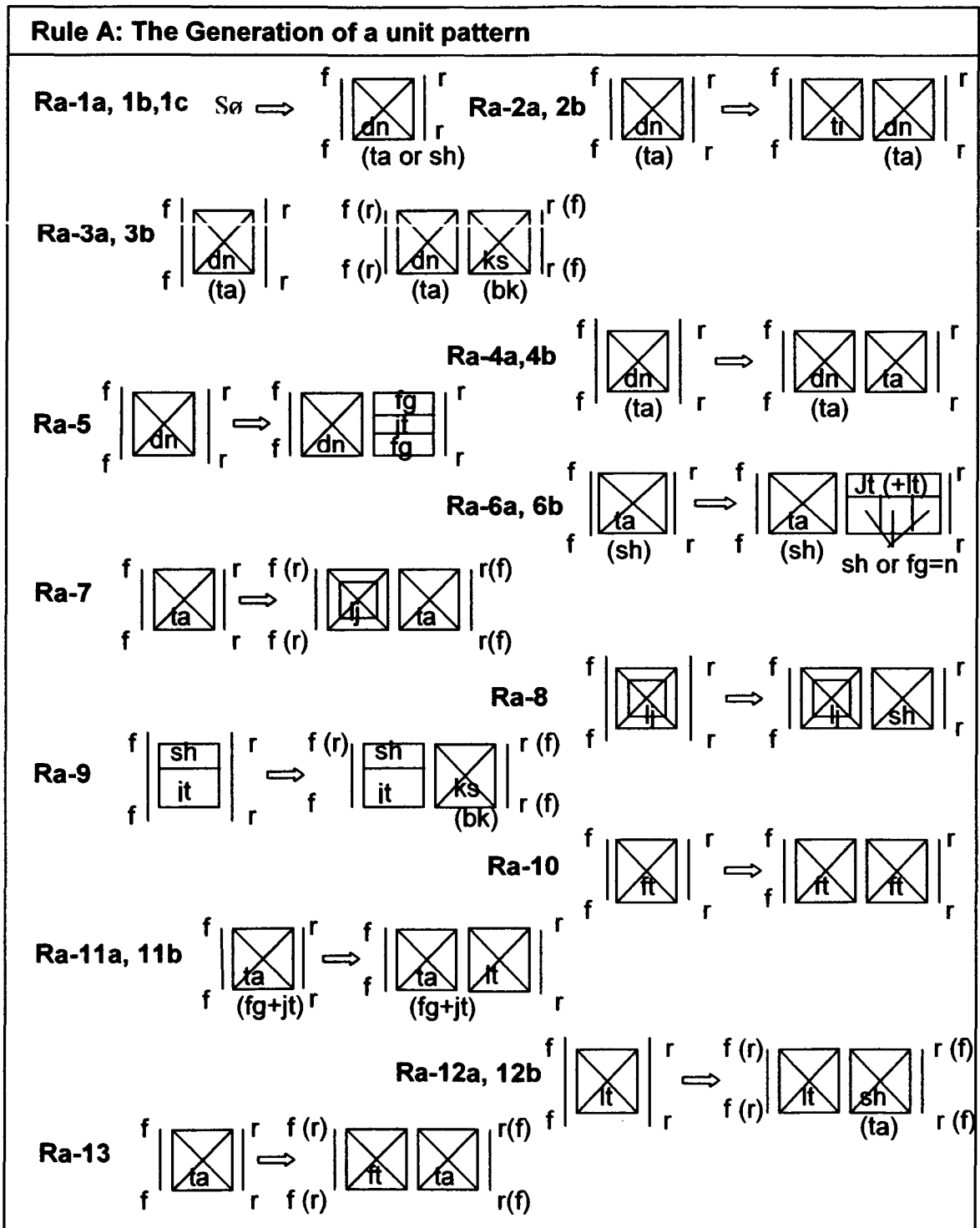
Rule B: Openings on outer walls

Rb-0a, 0b or 0c
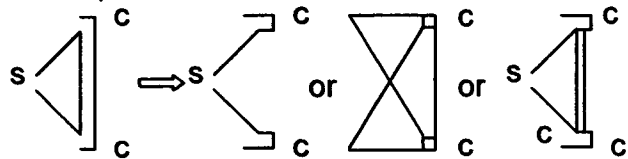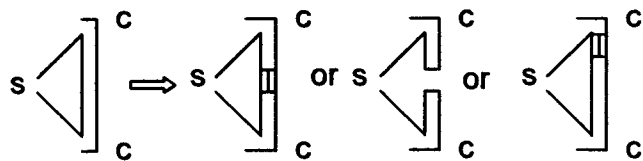
Rb-1a, 1b or 1c

Rb-2a, 2c or 2d
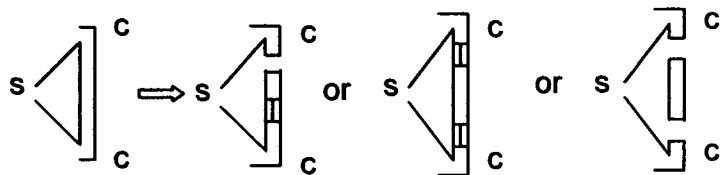
Rb-3a, 3c or 3d
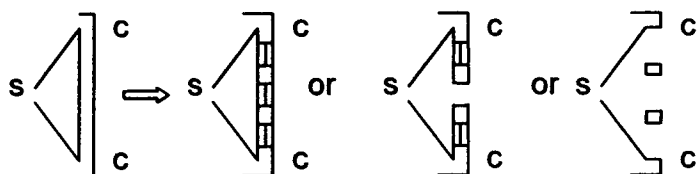
Rb-4a
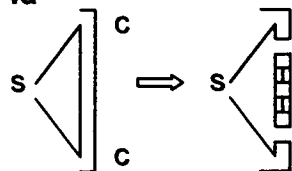
Rule C: Openings for connection of spaces

Rc-1a, 1b or 1c
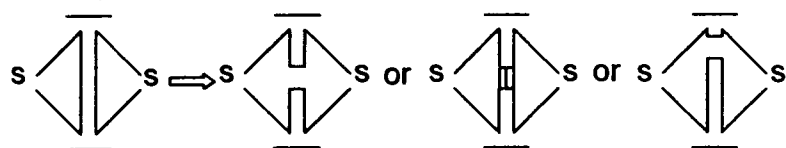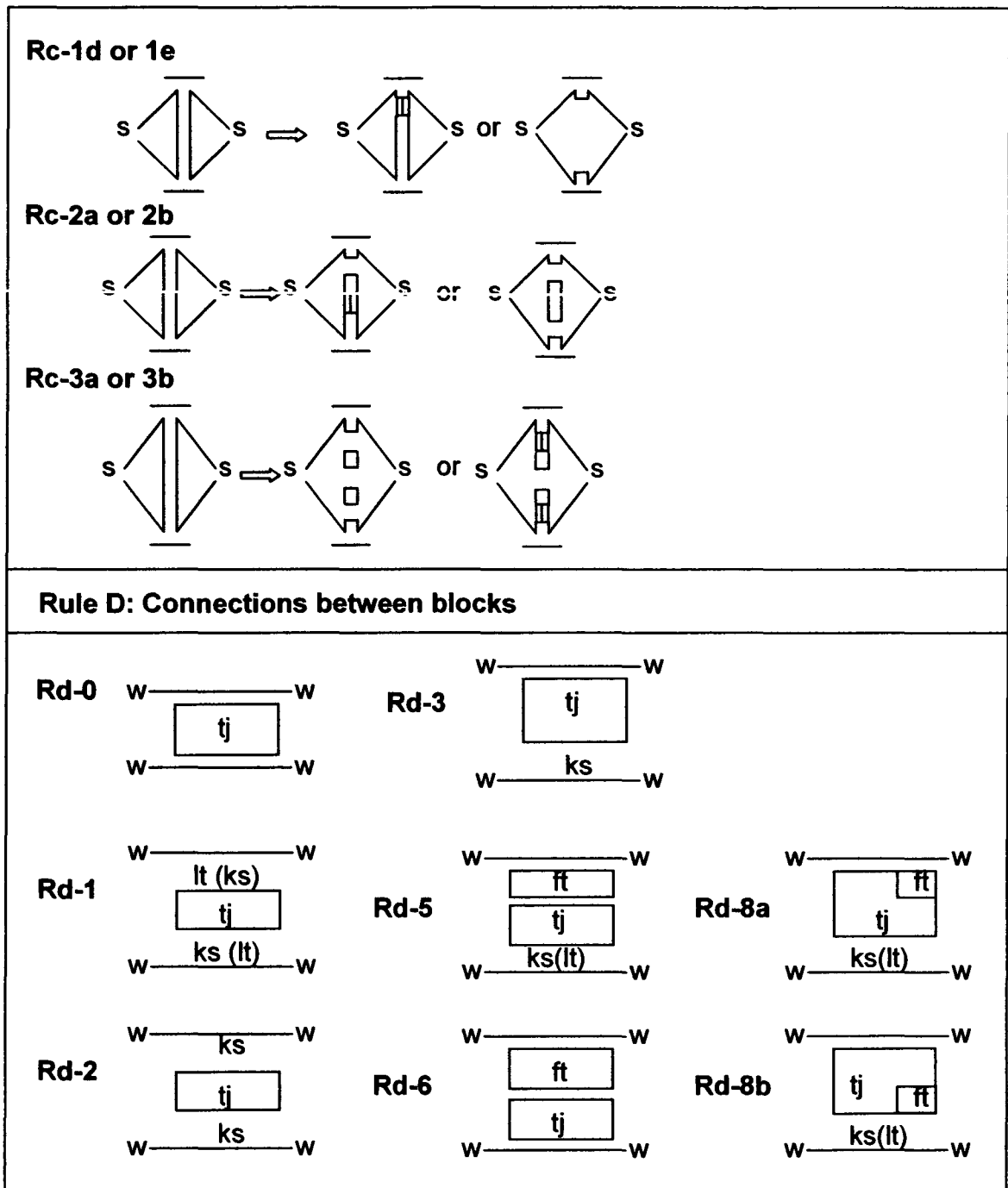
Figure 4. 35   **Rules of shape grammars for the floor plans of traditional town houses in Taiwan**

4.4.2 Comparison of the floor plans in traditional town houses in Taiwan

1. Rule A

Rule A: The Generation of a Unit Pattern								
	Ra-1a	Ra-1b	Ra-1c	Ra-2a	Ra-2b	Ra-3a	Ra-3b	Ra-4a
Dihwa St.	x	x	x	x		x	x	
Daxi	x	x	x	x			x	
Lukang	x	x		x			x	x
Xinhwa	x	x		x		x	x	

Rule A							
	Ra-4b	Ra-5	Ra-6a	Ra-6b	Ra-7	Ra-8	Ra-9	Ra-10
Dihwa St.	x			x				
Daxi		x		x			x	
Lukang			x	x	x	x	x	
Xinhwa			x					

Rule A						
	Ra-11a	Ra-11b	Ra-12a	Ra-12b	Ra-13	Ra-14
Dihwa St.						
Daxi						
Lukang					x	
Xinhwa	x	x	x			

Table 4. 3   Rule A for comparison of the floor plans of traditional town houses in Taiwan

2. The Rule B

Rule B: Opening on outer walls								
	Rb-0a	Rb-0b	Rb-0c	Rb-1a	Rb-1b	Rb-1c	Rb-2a	Rb-2b
Dihwa St.	x	x	x	x	x		x	
Daxi	x	x			x	x	x	
Lukang	x	x	x	x	x		x	
Xinhwa	x	x	x	x	x		x	

Rule B								
	Rb-2c	Rb-2d	Rb-3a	Rb-3b	Rb-3c	Rb-3d	Rb-4a	Rb-4b
Di-hwa St.	x		x		x	x	x	
Daxi					x			
Lukang		x	x		x	x		
Xinhwa			x					

Table 4. 4 Rule B for comparison of the floor plans of traditional town houses in Taiwan

3. The Rule C

Rule C: Openings for connection of spaces							
	Rc-1a	Rc-1b	Rc-1c	Rc-1d	Rc-1e	Rc-2a	Rc-2b	Rc-2c
Dihwa St.	x	x	x			x	x	
Daxi	x		x				x	
Lukang		x	x	x	x	x	x	
Xinhwa			x					

Rule C			
	Rc-3a	Rc-3b	Rc-4a
Dihwa St.		x	
Daxi			
Lukang	x		
Xinhwa			

Table 4. 5   Rule C for comparison of floor plans of traditional town houses in Taiwan

4. The Rule D

Rule D: Connection between Blocks											
	Rd-0	Rd-1	Rd-2	Rd-3	Rd-4	Rd-5	Rd-6	Rd-7a	Rd-7b	Rd-8a	Rd-8b
Dihwa St.		x	x	x		x	x				
Daxi				x			x			x	x
Lukang				x		x	x				
Xinhwa	x										

Table 4. 6   Rule D for comparison of floor plans of traditional town houses in Taiwan

4.4.3 Comments for comparison

The advantage of shape grammar is that it is possible for anyone to find the similarities as well as the dissimilarities from the rules as per the above tables.   A few examples could be listed as follows:

Similarities

– Rule Ra-1a,1b, 2a and 3b are the common rules on the floor plans of these four areas. It means that a shop with an arcade and a hall or living rooms with a veranda are the general patterns in the traditional Taiwanese town houses.

– Rule Rb-0a, 0b,1b, 2a were all applied on the floor plans of these four areas. It says that one door in the middle and one door and one window together on a wall are the most ordinary rules about the openings on outer walls besides the full opening of a shop.

– Rule Rc-1c is the only one common rule for openings for connection of spaces. It represents the general connecting opening which is the one door located on the side of an inner wall.

– Rule Rd-3 and 6 were applied in the areas of Dihwa street, Daxi and Xinhwa. It shows that a courtyard with a side veranda and a courtyard with a side appendix are the common patterns for connections between blocks in Taiwanese traditional town houses.

Dissimilarities

– Rule Ra-7 and 8 were only applied on floor plans in Lukang. It explains that an atrium connecting a living room or normal rooms are special patterns for the generation of a unit pattern in the Lukang floor plans that we selected.

– Rule Rb-2c and 4a were only used on floor plans of the case on Dihwa street. It shows that two windows on the wall and two windows between two doors symmetrically are special rules for the openings on outer walls in context of the floor plans that we selected on Dihwa street.

– Rule Rc-1c and 3a only associated to the floor plans in Lukang. This indicates that one large opening or three openings in a row is only applied on the floor plans that we selected in Lukang.

– Rule Rd-8a and 8d were only applied on floor plans in Daxi. This shows that an appendix in the courtyard is a special rule on the floor plans that we selected in Daxi.

Chapter 5

Applications of comparison for traditional town houses in Austria

5.1   The geographical and historical background for Innsbruck and Steyr

5.1.1   The geographical and historical background of Austria

Geography:

Austria (German: Österreich*)* is a landlocked country in central Europe. It borders Germany and the Czech Republic to the north, Slovakia and Hungary to the east, Slovenia and Italy to the south, and Switzerland and Liechtenstein to the west. The German name Österreich can be translated into English as the "eastern realm", which is derived from the old German *Ostarrîchi.* "Reich" could also mean "empire," and this connotation is the one that is understood in the context of the Austrian/Austro-Hungarian Empire, German Empire, "Third Reich," or Holy Roman Empire, although not in the context of the modern Republic of "Österreich."

Austria is a largely mountainous country due to its location in the Alps. The central eastern Alps, northern limestone Alps and southern limestone Alps are all partly in Austria. Of the total area of 84,000 km², only about a quarter can be considered low lying, and only 32% of the country is below 500 meters. The high mountainous Alps in the west of Austria flatten somewhat into low lands and plains in the east of the country. Among

these mountains and hills there are rivers, e.g. Danube River, Salzach River, Inn River, Enns River, Drau River and a lot of lakes. These rivers and lakes were instrumental in breeding many of its cities and towns.[1] (Figure 5.1; Table 5.1)
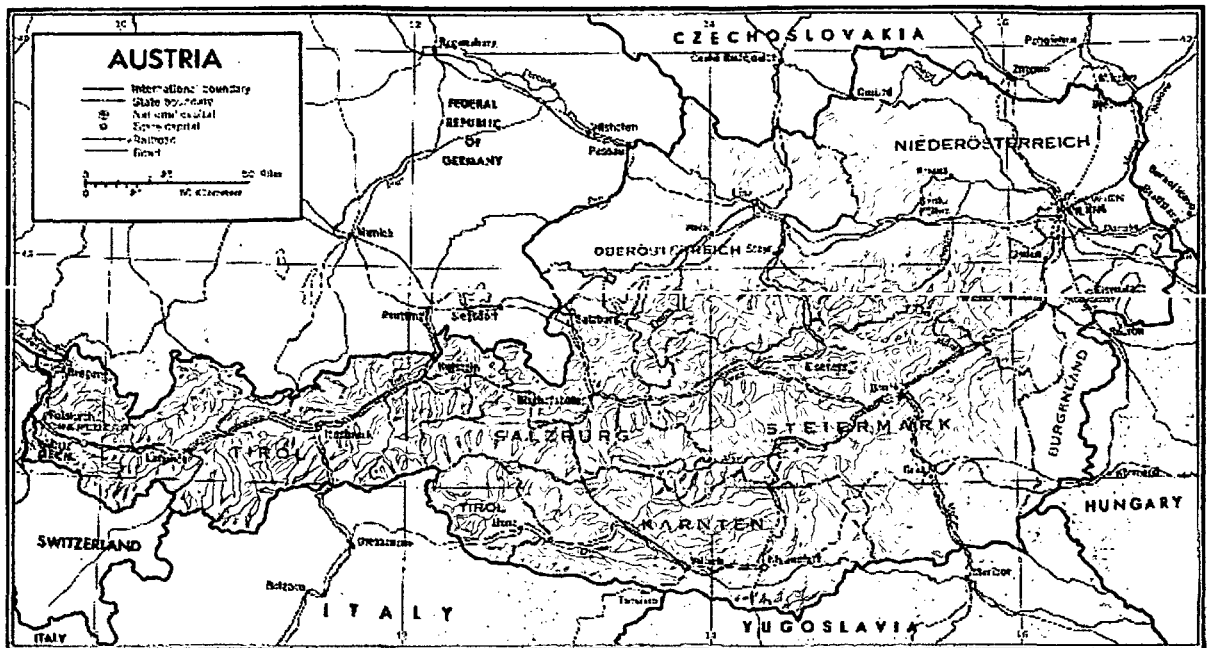
Figure 5. 1 Austrian map

In English		In German	
State	**Capital**	**State**	**Capital**
1 Burgenland	Eisenstadt	Burgenland	Eisenstadt
2 Carinthia	Klagenfurt	Kärnten	Klagenfurt
3 Lower Austria	St. Pölten	Niederösterreich	St. Pölten
4 Upper Austria	Linz	Oberösterreich	Linz
5 Salzburg	Salzburg	Salzburg (Land)	Salzburg
6 Styria	Graz	Steiermark	Graz
7 Tyrol	Innsbruck	Tirol	Innsbruck
8 Vorarlberg	Bregenz	Vorarlberg	Bregenz
9 Vienna	Vienna	Wien (Land)	Wien

Table 5. 1 Austrian states and their capitals

The greater part of Austria lies in the cool and temperate climate zone in which humid westerly winds predominate. With over half of the country dominated by the Alps the

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[1] Hans Koepf, Stadtbaukunst in Österreich, 1972, Salzburg, p.5

alpine climate is the predominant one. In the East, the climate shows continental features with less rain than the west alpine areas with high rainfall averages.

History

Austrian towns and dwelling places originated from the time of the ancient Roman Empire. Emperor Augustus occupied this area in 15 B.C. During the time of Emperor Claudius until A.D.54, it became an official province of the Roman Empire. There were some small villages along the Danube River between the Vienna forest and Inn. They were built in the Roman style and were connected by a road system.

Under Emperor Claudius, a part of south Tyrol and north Tyrol, Voralberg, Bodensee, and north Klagenfurt were developed into the embryos of towns. Along the south bank of the Danube river, several military bases were built as well as the Carnuntum castle located between Hainburg and Petronell.

A model city in the Roman Empire included an administration center, forums, exhibition halls, temples, churches and residential areas for officers. Basically the embryos of Austrian cities were developed according to this trend. Inhabitants gathered in present-day Vienna, Klosterneuburg, Tulln, Mautern, St. Pölten, Melk, Pöchlarn, Enns and Wels. Wels had been the capital town of this north province of the Roman Empire. [2]

Between the 8th and the 11th centuries, many villages flourished around castles and churches. Eferding, Traismauer, Salzburg, Linz, Steyr, Krems and Ybbs were born during this time. Markets appeared around the castles and villages, normally on the main street. The first record showing the name Austria is 996 where it is written as Ostarrichi, referring to the territory of the Babenberg March.

Between the 12th and 14th centuries, the raster street system, grid residential plan, squares and plazas were made popular in cities. The development of cities and towns were blooming in Austria after the Hungarians fled from Austria in 1246. The ransom of the English emperor Richard the Lionheart sponsored the building of Wiener Neustadt.

With the short exception of Charles VII Albert of Bavaria, Albert II of Habsburg held the position of German Emperor from 1438 until the end of the Holy Roman Empire. There

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[2] Gerhard Stenzel, <u>Von Stadt zu Stadt in Österreich</u>, 1979, Verlag Kremayr & Scheriau, Wien, p.8

were eighty-four cities in the territory of the present-day Austria, governed by Emperor Friedrichs III in 1493. It was the golden time of development of construction in the Middle Ages, all cities were surrounded by city walls, which were erected by the dukes or noblemen.

During the 14th and 15th centuries, Austria continued to expand its territory until it reached the position of a European superpower by early 18th century. The Habsburg monarchy ended in 1918. Between the 15th and 18th centuries the inhabitants were released from feudalism, churches, the slave system and the monarchy of the middle ages. People could move freely and the social position of citizens was promoted, so the new middle class appeared between the nobles and poor folk. Consequently, a number of businessmen and craftsmen had their own houses and shops. Citizens could develop cities and constructions freely. [3]Gothic style gave rise to a cramped city space and narrow facades. The majority of the traditional town houses were built during this time.[4]

Austria became part of Germany in 1938 (the *Anschluß*). After the end of the Second World War the Allies governed Austria until 1955, when the country became a fully independent Republic under a condition of neutrality. In the same year Austria also became a member of the United Nations. After the collapse of communism in Eastern Europe, Austria became increasingly involved in European affairs, and in 1995, Austria joined the European Union, and the European monetary union in 1999.

The present urban form of cities in Austria was modeled during Baroque period. Baroque style brought in much decoration and frescoes for buildings. Even in urban planning it represented a tremendous, gorgeous and splendid urban form and urban landscape. The facades of traditional town houses were widened and decorated increasingly by Baroque.[5]

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[3] Reiner Reinish, Altstadt in Österreich, Zukunft für die Vergangenheit, 1985, Christian Brandstätter Verlag & Edition Ges.m.b.H. & Co. KG, pp.36-52

[4] Gerhard Stenzel, Von Stadt zu Stadt in Österreich, 1979, Verlag Kremayr & Scheriau, Wien, pp. 7-16

[5] Reiner Reinish, Altstadt in Österreich, Zukunft für die Vergangenheit, 1985, Christian Brandstätter Verlag & Edition Ges.m.b.H. & Co. KG, pp.56-60

5.1.2 The great Movement " Stadtbauaufnahme-Aktion Österreich" [6]

Concerning Austrian traditional town houses there was a great Movement during 1960s, which cannot be ignored. Prof. Koepf, who was the Director of the Institute of History and Theory of Architecture and Historic Building Survey of the Vienna University of Technology at the time, led this Movement. It began with a brilliant idea of this scholar, that spread among numerous students who joined this Movement together with many local officials who were in charge of urban planning and urban construction. Through the media and exhibitions, it created a great influence, attracting public attention to the traditional houses and buildings as well as urban planning and renewal, influencing trends in countries like Italy, Germany and France etc.

1. The aim of this Movement

The aim of this Movement included three parts:

− A Concept:	To build up documentation of an artistically valuable architectural city and townscape for the future from the dwindling inventory which was being continuously demolished and gradually disappearing
− A Reality:	To survey and to record exactly the basic planning measurements for the urban renewal and new transportation.
− An Education:	To confront students with the precious traditional architectural art and to recognize the regional or local architectural style while resisting and countering the increasing international architectural trends. [7]

2. The important features of this Movement

It often happened that some old houses were about to be demolished, since they hindered new urban or transportation plans. A number of urban renewals, urban remodeling and new transportation planning were under way, especially in upper Austria in the 1960s. In contribution towards this great Movement, both architectural preservation and urban

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[6] Hans Koepf, Stadtbauaufnahme-Aktion Österreich, 1970, Wien
[7] Hans Koepf, Stadtbauaufnahme-Aktion Österreich, 1970, Wien, p.14

renewal were considered and seriously observed. Through this survey, it revealed the location of valuable architectural properties and buildings including the protection of surrounding areas.

Before they began to record and survey the objects, all students received a common memorandum, which reminded them of some key points and a uniform style of drawing or presentation. This survey project was organized by a card system according to the criteria of name of provinces, towns and streets. All students could freely choose the city they would be involved in. If there was a big group, they could record some large sections of a long street. Quality was more important than quantity while dealing with vagueness and ambiguity. The Institute made up a procedure for resolving uncertainties and correcting errors and also developed a process to verify the facade in an area. The drawings were completed by cross checking and were integrated into a card system. In the era where there were no computers, it was an excellent way to record architecture and urban planning in the whole country.

Although every city had its own inherent character, initially the plan of every surveyed city was drawn on a scale of 1:1000. The streets and houses were marked in the plan. They were surveyed appropriately and clearly so as to be consolidated later. The findings of the survey were re-checked using photographs and documents. If there were some queries, they were limited to its area and which would be resolved back at the Institute.

Every year, more than one hundred and fifty students in around one hundred towns worked for this Movement. Initially, the Institute had no adequate financial resources or budget to provide boarding and lodging for these students. For students to apply the theoretical knowledge into practice in such a short time was extremely difficult. However in effect, it appeared that the hearts of this young generation were touched as they recorded the form, construction and the history of traditional Austrian town houses. They photographed and sketched details, e.g. roofs, doors, decorations, consoles and material. They gained considerable experience and studied architecture in a very practical way.

3. The achievement of this great Movement

The most exciting consequence was that some senior officials and mayors took notice of this Movement and were highly interested in the achievements. They offered support and cooperated with the schedule of this survey and even provided some help in their respective cities and towns. One mayor even wanted to exhibit these drawings in the city hall in order to prevent the city councilors from altering the urban plans, which would damage the city form including the precious old traditional houses. Through mass media and public invitations a number of exhibitions were held in many cities, e.g. Vienna, Graz, Linz, Dresden, Innsbruck, Feldkirch and Gorizia etc. Subsequently, numerous records of this great and tremendous Movement were published.

In reviewing the literature of traditional town houses in Austria, if I skip over this great Movement, I would miss this most important and precious reference. I am much obliged to Prof. Koepf for leading this great Movement and proud to use the fruit of his efforts for my research.[8]

4. The cities that were recorded in this great Movement

According to the book, "Stadtbauaufnahme-Aktion Österreich", there were around 90 cities, which were recorded as listed below.[9]

Niederösterreich	Baden, Bruck/Leitha, Brunn/Geb.,Dürnstein,Eggenburg, Emmersdorf, Gmünd, Gumpoldskirchen, Hainburg, Herzogenburg, Horn, Hollabrunn, Krems, Kirchberg/Wagram, Langenlois, Mödling, Neunkirchen, Perchtoldsdorf, Retz, St. Pölten, Stein, Traismauer, Tulln, Wilhelmsburg, Waidhofen/Ybbs,Wiener Neustadt, Zwettl
Oberösterreich	Aschach, Braunau, Eferding, Enns, Freistadt, Gmunden, Grein, Hallstadt, Linz, Lambach, Obernberg, Ried/Innkreis, Schärding, Steyr, Vöcklabruck, Wels, Weyer
Steiermark	Bruck/Mur, Eisenerz, Friedberg, Graz, Hartberg, Judenburg, Leoben, Mürzzuschlag, Murau, Radkersburg, Voitsberg

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[8] Hans Koepf, <u>Stadtbaukunst in Oberösterreich</u>, 1972, pp.7-9

[9] Hans Koepf, <u>Stadtbauaufnahme-Aktion Österreich</u>, 1970, Wien, p.34

Kärnten	Bleiburg, Friesach, Hermagor, Klagenfurt, Gmünd, St.Veit/Glan, St.Andrä/Lavanttal, Villach, Völkermarkt, Wolfsberg,
Salzburg	Golling, Hallein, Mauterndorf, Radstadt, Salzburg, Seekirchen, Tamsweg, Werfen
Tirol	Hall, Innsbruck, Kitzbühel, Lienz, Matrei/Brenner, Rattenberg, Reutte, Schwaz
Burgenland	Eisenstadt, Illmitz, Mörbisch, Rust
Vorarlberg	Bludenz, Bregenz, Dornbirn, Feldkirch
Wien	Wien

Table 5. 2 The cities and towns that were recorded in "Stadtbauaufnahme-Aktion Österreich"

5. The main publications of this great Movement

Title of publication	Year
Stadtbauaufnahme-Aktion Österreich	Wien 1970
Stadtbaukunst in Österreich	Salzburg 1972
Stadtbaukunst in Oberösterreich	Linz 1972
Stadtbaukunst in der Steiermark und in Kärnten	Wien- New York 1974
Stadtbaukunst in Salzburg	Salzburg 1975
Stadtbaukunst in Tirol	1980
Stadtbaukunst in Innsbruck	Innsbruck 1976
Stadtbaukunst in Niederösterreich	1977
Stadtbaukunst in Linz	1975
Die Zukunft der alten Städte, Jahrbuch des Österreichischen Gewerbevereins	1975
Die Zukunft der alten Städte, Handbuch des Österreichischen Wirschaftskomitees für das Denkmaljahr	1975
Zukunft der alten Städte, Texte und Thesen	Zürich 1976
Stadterhaltung, Stadtgestaltung I & II	Wien 1976
Die Rettung der Altstädte, Jahrbuch des Österreichischen Gewerbevereins	1977
Stadtbaukunst in Österreich I, Heraklith- Rundschau	1969
Stadtbaukunst in Österreich II, Heraklith- Rundschau	1970
Städtebauliche Bestandsaufnahme in Österreich, Berichte zur Raumforschung und Raumplanung, 15 Jh.	1971
Stadtbauaufnahmen in Vorarlberg Jahrbuch des Vorarlberger Museumsvereins	1970

Stadtqualität, Zeitschrift für Stadtgeschichte, Stadtsoziologie und Denkmalpflege	1974
Problematik und legistische Schwierigkeiten bei der Wiedergewinnung wertvoller Bausubstanz im Bereich der Salzburger Altstadt, alte und moderne Kunst	1975

Table 5. 3 The main publications of "Stadtbauaufnahme-Aktion Österreich"

5.1.3 The Historical and Geographical Background in Innsbruck

The name Innsbruck (in 1167 mentioned as *"Inspruk"* for the first time) derives its name from the bridge over the river Inn, which was first built in the middle of the 12th century. It is also symbolic of its historical assignment and the destiny for the centuries. It consequently remained as the heraldic symbol in the seal and coat of arms of Innsbruck to this day.
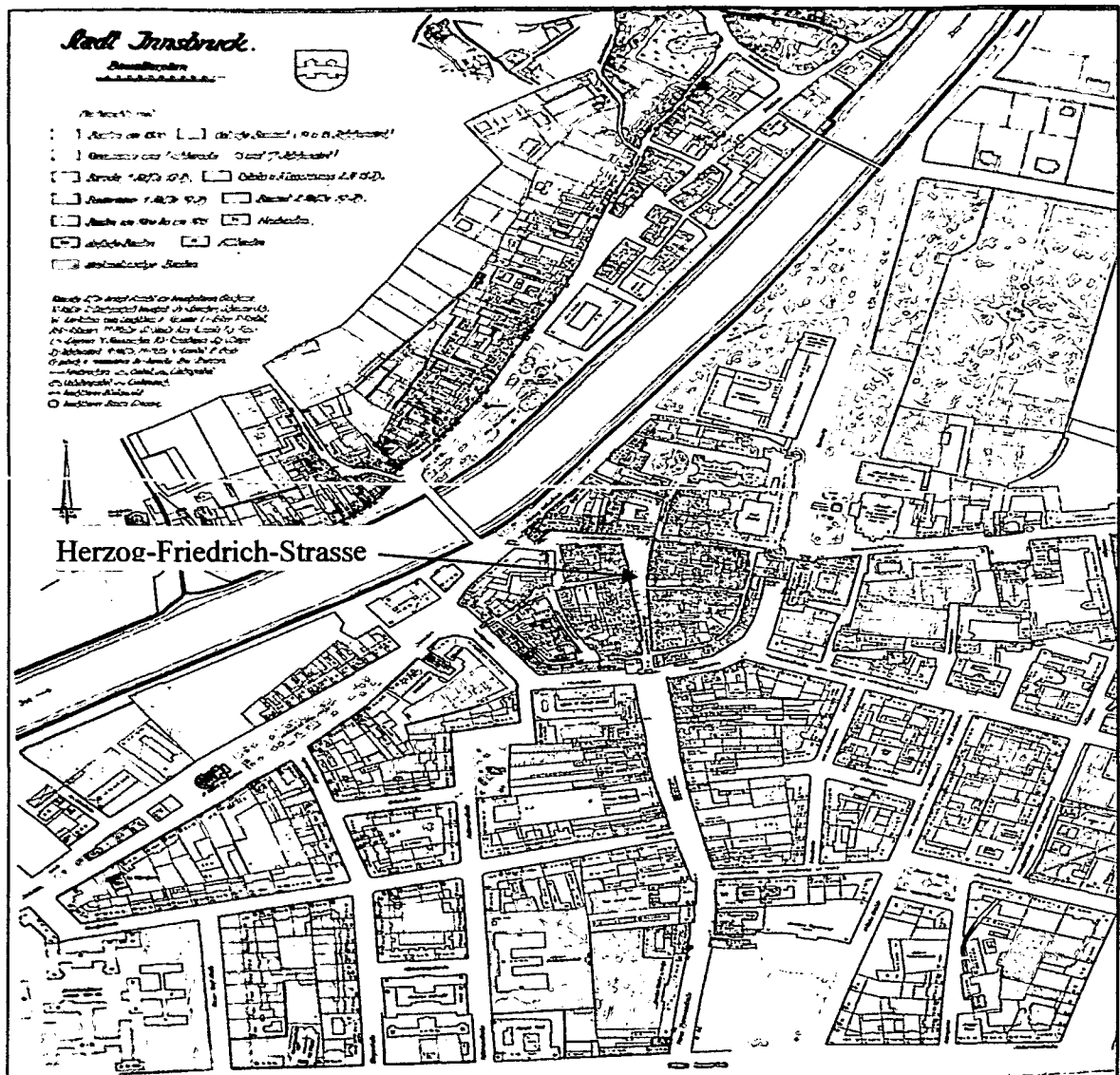
Figure 5. 2 The main area of the traditional town houses in Innsbruck

Excavations and finds have provided proof of settlement of the Innsbruck region even from the time of the Stone Age. The region where the road that leads out of the Brenner area reaches the Inn valley and then divides itself, a small fortified castle at Veldidena and Teriolis (the present day Innsbruck district of Wilten and Zirl) was established by the Romans around 15th century B.C. The Romans had consolidated the central Alpine and the areas leading to the Alps into the province called Raetia (*Rätien*). [10]

The Innsbruck basin which unites to a large extent the streets leading out of Germany and continues over the Brenner through the lowest pass of the main Alpine mountain access

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[10] Franz Huter, 1967, <u>Historische Städtebilder aus Alt-Tirol</u>, Verlagsanstalt Tyrolia Ges. m. b. H., Innsbruck, pp 69

further to the south, profited from the very beginning by the favourable traffic and geographical situation. Innsbruck always and still remains, in fact a north-south and east-west traffic junction, which is not entirely seen as a blessing today due to the heavy load of transit traffic. [11]
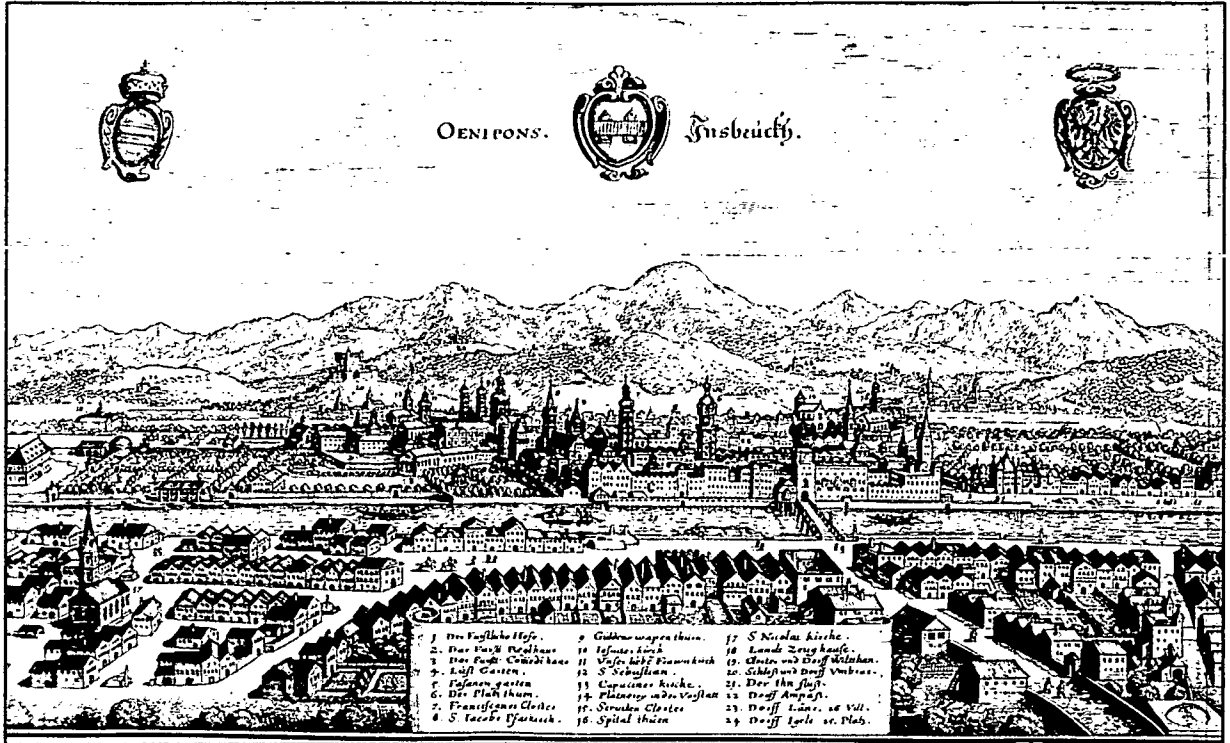
Figure 5. 3 The old map of Innsbruck in 1649, by Matthaeus Merian[12]

The history of Innsbruck brightens around 1133, as the Bavarian counts of Andechs setup a market on the orographically suitable left side of the shore of Inn River (today district St. Nikolaus). In 1180, Markgraf Berthold V of Andechs Istrien from the monastery of Wilten purchased property located on the right shore of the Inn river and set up a town protected by a ditch and city walls and further surrounded by gates that opened to other markets and trading centers which is today's old town. [13] The elevation to the status of a town came with the awarding of municipal rights became a reality between 1187 and 1204. The first town expansion took place in 1281 (Neustadt, today's Maria Theresien street). In 1363, Innsbruck became part of the county of Tyrol through the Dukes of

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[11] Österreichischer Städteatlas, 5 Lieferung, 1. Teil, 1996, Wissenschaftliche Gesamtleitung: Felix Czeike, Renate Banik-Schweitzer, Ferdinand Opll, Redaktionelle Leitung: Michaela Laichmann, Susanne Claudine Pils, Franz Deuticke Verlagsgesellschaft m.b.H., Wien, „Verkehrsgeographische Lage"
[12] Österreichischer Städteatlas, 5 Lieferung, 1. Teil, 1996
[13] Dehio-Handbuch, Die Kunstdenkmäler Österreichs, Tirol, bearbeiter von Gret Ammann, Erich Egg, Johanna Felmayer, Josef Franckenstein, Wolfram Helke, Horst R. Huber, Herta Öttl, Meinrad Pizzinni, Verlag Anton Schroll & Co. Wien , p.6

Austria. Friedrich IV chose Innsbruck in 1420 as the new royal seat. This resulted in an absolute prosperity of the town that reached its peak under Emperor Maximilian (1459 - 1519). The emblem of Innsbruck, the world-famous Golden Roof in the Innsbruck old town area, reminds us of Emperor Maximilian I. Maximilian maintained close connections with Innsbruck as a seat of royal residency. Innsbruck was center of activity of the Europe of those days.

A European character and primarily the blossoming of music in Innsbruck from the 15th up to the 18th century characterized the town and especially in the cultural and architectural sense the city certainly remains an important influence until today. Innsbruck is also an international center for the old style of music. The epoch of Emperor Maximilian I stood at the turn of an era. He was the last knight and simultaneously the first ruler who belonged historically to a new time. He was the first Habsburg who turned from a Central European orientation to a Western European one. His first marriage with Maria of Burgundy brought in the present-day territories of Belgium and the Netherlands as well as parts of north France as revenue - and together with it, the enmity with France. The contact with Bianca Maria Sforza paved the way to Italy for him. Through Maximilian's marriage politics the Spanish line of succession was finally brought over into the house of the Habsburg.[14]

"Tyrol is a rustic farmer's overall but he warms well", was what Emperor Maximilian said about his favorite place Tyrol. In 1490, after he was handed over land from his uncle Sigmund also known as the "coin-rich", Maximilian made Tyrol the center of his political and military plans and the turntable of his Italian politics. The silver and copper of the mines in Schwaz promised wealth.

In order to secure the independence for the Tyroleans, Kaiser Maximilian acceded the privilege of "Landlibell" to his Tyroleans in 1511, by which they were only obliged to defend the limits of their own borders. The Tyroleans did not fight in the other wars of the Habsburgs.

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[14] Franz Huter, 1967, Historische Städtebilder Aus Alt-Tirol, Verlagsanstalt Tyrolia Ges. m. b. H., Innsbruck, pp 70-71

From 1806 to 1814 Tyrol, together with Bavaria Innsbruck was at the center of the "Bergisel" freedom struggle under the leadership of Andreas Hofer (1767 - 1810). In 1849 Innsbruck dissolved Meran officially as the provincial capital. From 1938 to 1945, Austria, including Innsbruck was incorporated into the national socialist powers of Germany. The town was struck and heavily destroyed by the twenty-two allied bombing raids of 1943.

The reconstruction of Innsbruck proceeded rapidly again due to the blossoming of tourism and the economy. Innsbruck became an international center for winter sports in 1964 and 1976 as venue of the Olympic Winter Games and at present is also experiencing a cultural Renaissance as a city.[15]

The traditional town houses in Innsbruck were located in the old downtown that is the north - south from the inner Maria- Theresien-Strasse along Herzog-Friedrich-Strasse to Inn River and the east- west is from Marktgraben to Hofburg. It is around the old city center. [16]

The arcades and roofs of the townhouses in Innsbruck are unique in style and character as compared to the forms of the traditional town houses in other provinces of Austria. The forms of arcades are diverse in arches, pointed arches and arcs with constructive and decorated ribs.[17] The traditional town houses in Innsbruck have Italian influences, since the region of Innsbruck was once a province of Italy.[18] The traditional town houses, which were chosen from Innsbruck as selected examples here are located at the Herzog-Friedrich-Strasse as following:

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[15] Österreichischer Städteatlas, 5 Lieferung, 1. Teil, 1996, Wissenschaftkiche Gesamtleitung: Felix Czeike, Renate Banik-Schweitzer, Ferdinand Opll, Redaktionelle Leitung: Michaela Laichmann, Susanne Claudine Pils, Franz Deuticke Verlagsgesellschaft m.b.H., Wien

Franz Huter, 1967, Historische Städtebilder Aus Alt-Tirol, Verlagsanstalt Tyrolia Ges. m. b. H., Innsbruck, pp 72-73
  Links: Tiroler Landesarchiv / Wissenswertes über Innsbruck

[16] Hans Koepf, Stadtbaukunst in Tirol, 1980, pp.61-63
[17] Schuster Max Eberhard, Das Bürgerhaus im Inn- und Salzachgebiet, 1964, Tübingen, pp.42-43
[18] In old maps: F. W. Putzger, Historischer Weltatlas zur Allgemeinen und Österreichischen Geschichte, 1971, Hölder- Pichler- Tempsky Österreichischer Bundesverlag; Werner Trillmich und Gerhard Czybulka, 1953, Westermanns Atlas zur Weltgeschichte, Teil III, Berlin/ Hamburg/ München/ Kiel/ Darmstadt

No. 10: Helblinghaus:	It was built around 1730 at the corner of Herzog-Friedrich-Strasse. The original owner was Anton Gigl. The facade is with rich decorations, which has luxurious colorful leaf motifs and an eastward curved gable with crowned vases.
No. 12 A gable house:	It was rebuilt in 1937 with a quakeproof design and a fresco from Ernst Nepo. The arch of the portal is round and in segments at the arcade.
No. 14 Happ:	Franz Baumann rebuilt it in 1937 with the old inner part and the fresco from Erich Torggler.
No. 16 Katzunghaus:	It was built around 15th century at the corner of Seilergasse and Herzog-Friedrich-Strasse with polygonal windows and relief from 1530s. The original owner was Gregor Türing. The facade was restored in 1967.
No. 18:	The original house was built in 15th century, but it was renewed with a quakeproof design in the 20th century.
No. 20 Vogelsangerhaus:	A double house with two different forms of roof, 'Grabendächer', was built in the 15th century.
No. 22 Trautsonhaus:	The front house was built by Gregor Türing in 1541 and connected to the back house, which was built in 15th century.
No. 23 Tschurtschenthalerhaus:	The arcade with pointed arches dates to the 15th century. It was rebuilt according to the original form in 1949.
No. 25 Winklerhaus:	It was rebuilt according to the old form after the World War II.
No. 35 Kohleggerhaus:	It was built in the 15th century and reconstructed in the 16th century.
No. 39 Zur Goldenen Rose:	A house at the corner of Stiftgasse and Herzog-Friedrich-Strasse was built in 1678 by Hans Jakob Pfaundler and restored in 1908.[19]

5.1.4 The historical and geographical background in Steyr

[19] Dehio-Handbuch, Die Kunstdenkmäler Österreichs, Tirol, bearbeiter von Gert Ammann, Erich Egg, Johanna Felmazer, Josef Franckenstein, Wolfram Helke, Horst R. Huber, Herta Öttl, Meinrad Pizzinni, Verlag Anton Schroll & Co. Wien, pp. Innsbruck.23-28
Hans Koepf, Stadtbaukunst in Innsbruck, 1976, Buch- u. Offsetdruckerei Holzwarth & Berger Ges. M. b. H., Wien, pp. 10-12;
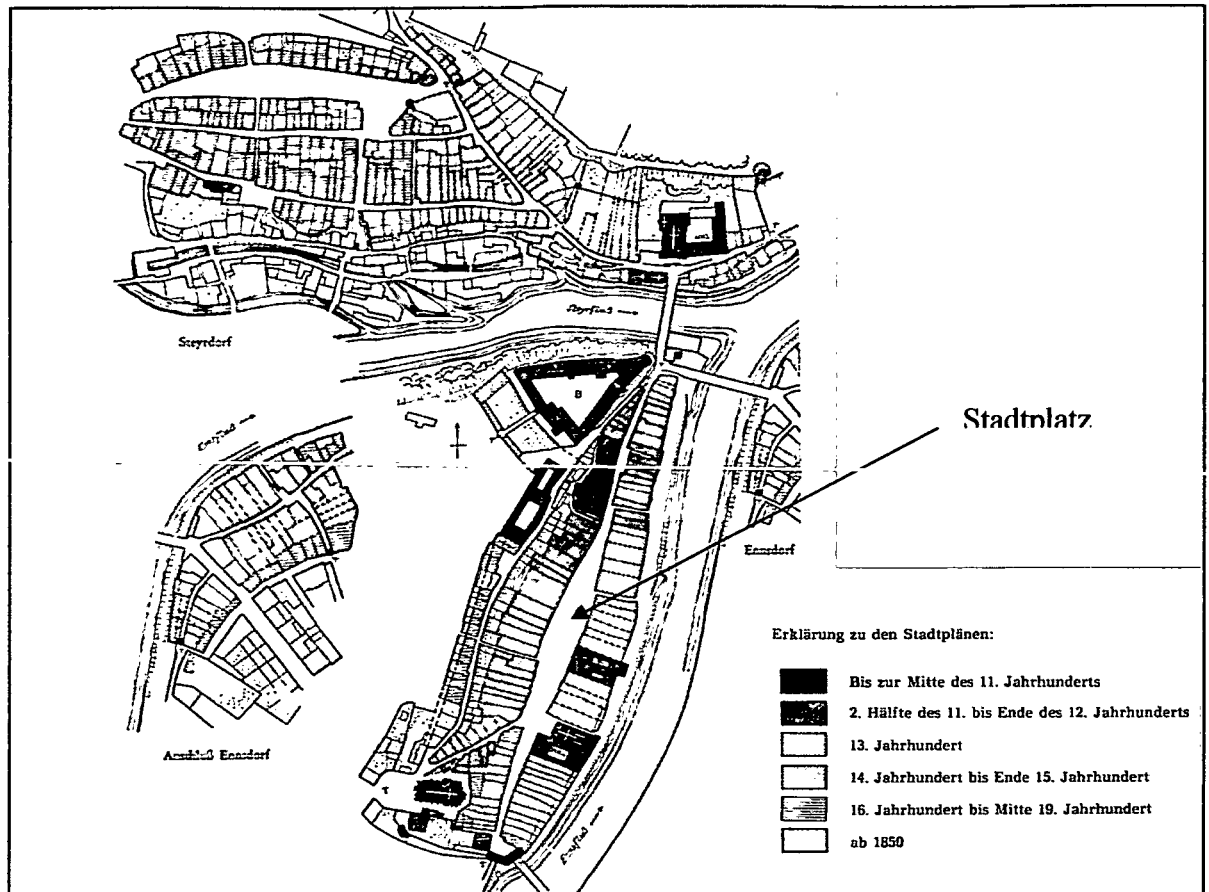
Figure 5. 4 The main area of traditional town houses in Steyr

Numerous finds of straw showed that the area was settled around Steyr already from a very early time although a prehistoric settlement cannot be proved in the municipal area. Around 600 B.C. the Celts immigrated here and they extracted the iron from the mountains rich in iron ore. The name Steyr originates from the Celtic language (Stiria) and describes the river of the same name. The Romans transported the iron that they called "Norische" via the old Eisenstrasse to their factory of shields in "Lauriacum". Presumably there stood a Roman watchtower on the rock over the confluence of the river, which until today is called "Römerturm". In the 6th century, the area was occupied by Bavarian tribes, which later were dismissed by the Bavarian Duke Tassilo who also established the Monastery "Kremsmünster". In order to protect the empire from the ideas of the Hungarians, in 900 AD, two well-fortified castles were built, the first castle at the mouth of the Enns and the second called "Styraburg" which was documented for the first time in year 980. The builders of the castle were the Counts of Wels-Lambach, who possessed properties in the Traungau and in the Karantanischen Mark (upper Styria).

The inheritance of the "Otakare" tribes who were descendants of the Chiemgau began in 1055. The heraldic animal of the Otakare was the white panther. Through inheritances and clever marriage politics (Otakare II married into the Babenberger family) the Otakare considerably expanded their possessions in Styria. The valuable mountain containing ore that was intensively exploited by the Otakares were also located here. The splendid court audiences could see the glory and power of the Otakare. The Styraburg was not only the scene of knightly life but also place of the culture of noble arts. In the two epic poems written in middle high German, "Biterolf and Dietleib" and "King Laurin" a literary monument was established in the depiction of the castle in Steyr. In 1180, Otakar IV who was the only survivor in the line was promoted to the level of Duke by the emperor Frederick Barbarossa. In 1186, Otakar IV, plagued with illness and childless, finally bequeathed to the Babenbergers territories extending from Georgenberg to Enns castle including control of Steyr in a solemn contract of inheritance. [20]

The location of Steyr lost its meaning as the seat of the Duke, but its role however as a center of processing and trading of the "Innerberger" iron, remained unchanged. The iron ore that was developed in Innerberg as the "black metal" began its course through the valley of the Enns to the Danube already in the early Middle Ages and in doing so, gave birth to one of the oldest industrial landscapes of Europe called the "Eisenwurzen". Favored by its unique favorable transportation facilities and its meaning as a residence under the Otakaren, Steyr developed into an economic and cultural centre of this early medieval industrial area. The ascent of the town into the iron metropolis north of the Alps was carried out under the rule of the Babenbergers. Craftsmen, primarily weapons and blacksmiths manufacturing arms, had found shelter, protection and livelihood at the foot of the castle. In 1170 Steyr was described as "Urbs", a municipal settlement.

After the time of the Babenbergers in 1246, hard times began for the town. In 1254, under the Habsburgers, as a result of the Peace treaty of Ofen, Steyr was separated from its symbol of success and consequently detached from its economic base, the ore

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[20] Wilhelm Rausch, Städte im Traun-Enns- Winkel, 1976, Österreichischer Arbeitskeis für Stadtgeschichtsforschung gemeinsam mit der Ludwig-Boltzmann- Forschungsstelle für Stadtgeschichte, pp.18-20

mountain and thus partitioned it was finally attached to the area on the far side of the Enns.

On 23rd August 1287, Duke Albrecht I confirmed the old rights to the town concerning trade and in the processing of the Innerberger iron. In this special privilege the so-called "Stapelrecht" was offered to the Steyr citizens, among others, relating to wood and iron. As per this special privilege, for three days these raw materials had to be offered to the Steyr citizens at a preferential price before they were allowed to continue on their way to the Danube. This made the town and its citizens rich and enabled them to invite important artists from Germany, Bohemia and Italy to build and create works of art. Commercial relations of the Steyr iron dealers with Germany and Eastern Europe dates back to 1190. Trade with Venice played a special role. At that time, Steyr was part of those nine German towns, which had an independent trade office in Venice. Steyr iron goods were popular in the big Venice market and the symbol of the Steyr panther was a sign for quality "Made in Steyr" at that time. The rapid blossoming of the town in the 14th century promoted the influx of craftsmen mainly from Nuremberg. Besides armor-makers and blade blacksmiths it was primarily the Messerers (knife makers) who's Guild Charter of 1406 belongs to one of the oldest in Austria. The knife makers of Steyr set the tone in the entire South German region. In the middle of the 15th century the town reached its economic peak. At the time Steyr was the most prosperous and most distinguished town of Austria besides Vienna. [21]

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[21] Österreichischer Städteatlas, 7. Lieferung 2002, "Grundzüge der Siedlungsentwicklung", "Die Entwicklung der Vorstädte Steyrdorf und Ennsdorf sowie der Vororte und Befestigungsanlagen", "Wirtschaftlich und kulturelle Entwicklung der Stadt"
Wilhelm Rausch, Städte im Traun-Enns- Winkel, 1976, pp.18-23
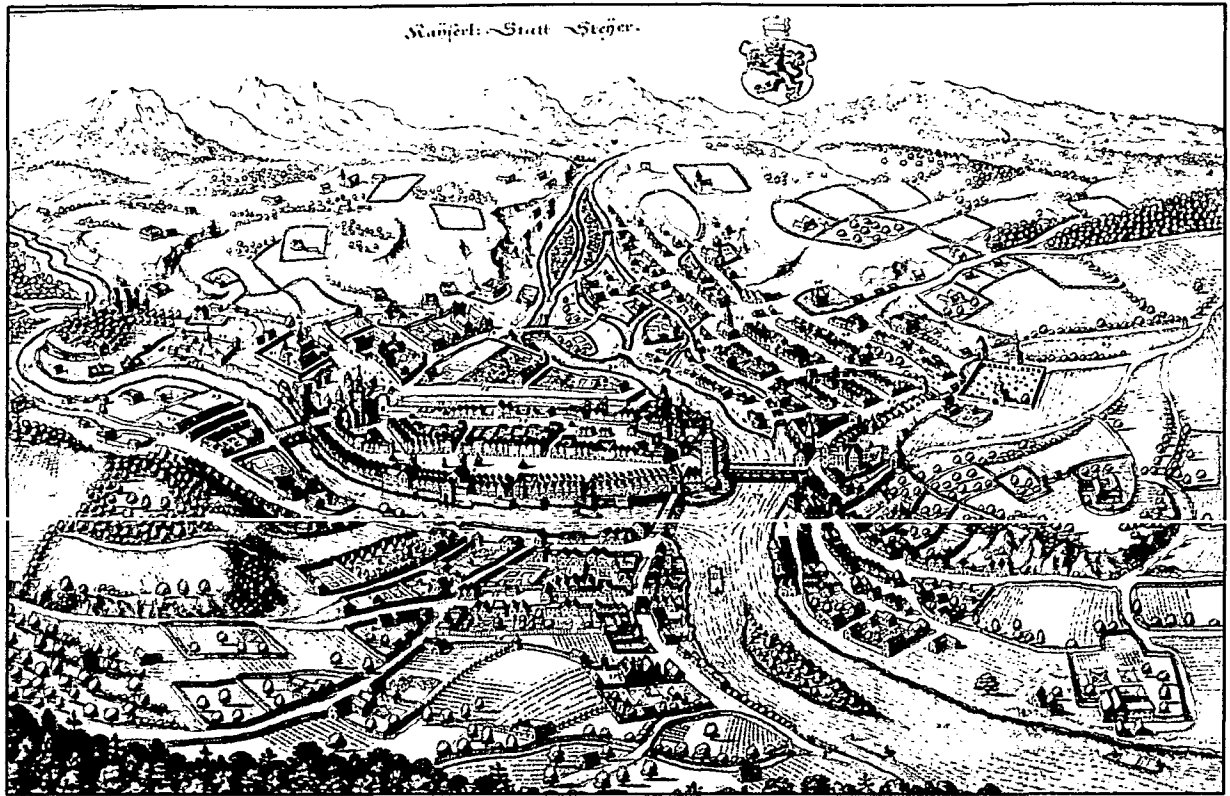
Figure 5. 5 The old map of Steyr in 1649 by Mathaeus Merian[22]

The far-reaching and intimate commercial relations that Steyr exercised with the most important trade centers of Europe exposed susceptibility of the residents to new ideas and way of thinking. Steyr experienced a cultural blossoming at this time and was part of those few Austrian towns where poetry of the mastersingers flourished but ceased only in the confusion of the Counter-Reformation.

With the arrival of Baroque, the town experienced a new blossoming. The wholesale trade with the iron had dwindled, however, the processing of the Steyr iron persisted. Some interesting buildings came into existence in Steyr, like the Michaelerkirche or the Pilgrimage Church of Christ child (Christkindl) located at the edge of the town. An upward economic trend manifested itself in Steyr during the time of Josefine which was highlighted by the demolitions of monasteries. By the transformation of existing handicraft-level establishments and the foundation of new workshops, a foundation stone was laid for the eventual industrialization of the town.

[22] Österreichischer Städteatlas, 7. Lieferung 2002, Wissenschaftliche Gesamtleitung: Felix Czeike, Renate Banik-Schweitzer, Gerhard Meißl, Ferdinand Opll, Redaktionelle Leitung: Susanne Claudine Pils, Wiener Stadt- und Landesarchiv, Wien- Österreichischer Arbeitskreis für Stadtgeschichsforschung, Linz

A devastating fire struck Steyr on August 29th, 1727, which not only destroyed large portions of the old town, but also the Styraburg with its gables, towers and bays. The baroque castle Lamberg arose from the ruins of the medieval castle like the bird Phoenix from the ashes. Subsequently the favorable development of the economy of Steyr was interrupted suddenly during the time of the French wars. Within a span of 10 years, the French occupied Steyr three times in 1800, 1805 and 1809.

The cradle of big industry in Steyr lies in the intricate system of the river courses at the estuary of the Steyr, laid out in the Middle Ages. In the 18th century, the then resident middle-class skilled craftsmen started producing sabers, bayonets and gun components. Leopold Werndl set up a business in 1830 in which he produced gun components with the help of 450 workers. The son Josef Werndl, succeeded following the big footsteps of the simple businessman into a great industrialist. Within few years he expanded the factory of his father to one of the largest and most modern weapon factories of the world.[23] Thus the above brief history of Steyr indicates a rich tradition of skilled labour combined with industry, which lays the foundations to the architectural achievement over time. One of the unique features of the traditional town houses in Steyr was the strategic location beside the river Enns with back doors facing towards the river for convenient loading of iron and goods.

The majority of the most beautiful traditional town houses in Steyr are located at the Stadtplatz, Grünmarkt and Engengasse. Some of the special characteristics that can be noticed in the town houses in Steyr are the form of roofs "Krüppelwalmdach", which is a kind of half-hipped roof.[24] This kind of half-hipped roof originated from Gothic period and demonstrated Gothic style.[25] Another characteristic is 'Laubenhof', an atrium with arcades that can be seen all over in the traditional town houses. Also seen on the facades are kinds of cantilever arcades, which extend the business space for shops.

The traditional town houses below which were chosen from Steyr as selected examples

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[23] Handbuch der Historischen Stätten Österreichs, 1970, 1, Bd., Stuttgart,
Links: Weitere Informationen: Geschichte, Fotos, Kultur usw.: http://www.upperaustria.org/region/steyr
Fremdenverkehr. http://www.tiscover.com/steyr
[24] Hans Koepf, Stadtbaukunst in Oberösterreich, 1972, pp.29-30
[25] Johann Kräftner, Bürgerhäuser: Ensembles, Einzelbauten und Details in Österreich und den angrenzenden Gebieten seiner Nachbarländer , 1984, Wien; München: Herold, pp.17-19

are at the Stadtplatz and Grünmarkt as follows:

No. 9 at the Stadtplatz:	This house was built in 17th century. There is a renaissance arcade with Tuscany columns in the veranda of the court.
No. 19 at the Stadtplatz:	This house was built in 17th century.
No. 21 at the Stadtplatz:	This house was recorded since 1634.
No. 32 at the Stadtplatz:	Called the Bummerlhaus that was a well-preserved town house of the late Gothic style and built in 1497. The facade was restored in 1954.
No. 35 at the Stadtplatz:	This house was built in 16th century.
No. 40 at the Stadtplatz:	Called the Vorderhaus which was also a late Gothic town house built before 1525.
No. 42 at the Stadtplatz:	This house was built in 1456.
No. 44 at the Stadtplatz:	This house was built between late 15th and the first half of the 16th century. The interior construction dates between 1522 and 1543 and built by Wolfgang Freinberger.
No. 4 at the Grünmarkt:	This was built in the 16th century. The facade dates back to 1766.
No. 10 at the Grünmarkt:	This construction dates back between 1597 and 1609. The courtyard is decorated with pillar arcades .

5.2 Applications for the facades of traditional town houses in Austria

In order to achieve ideal comparisons, a range of selected examples of Austrian traditional town houses that we are willing to analyze should be considered. The representative traditional town houses from Innsbruck and Steyr in Austria are illustrated below by shape grammar.

5.2.1 In Innsbruck, Tyrol

In accordance with the former rules and examples, the ten traditional town houses below have been chosen in order to develop shape grammars for comparison. These ten town houses are as follows: At Herzog-Friedrich-str. 10, 12, 14, 16, 18, 20, 22, 23, 25, 35 and 39 in Innsbruck (Figure 5.6).
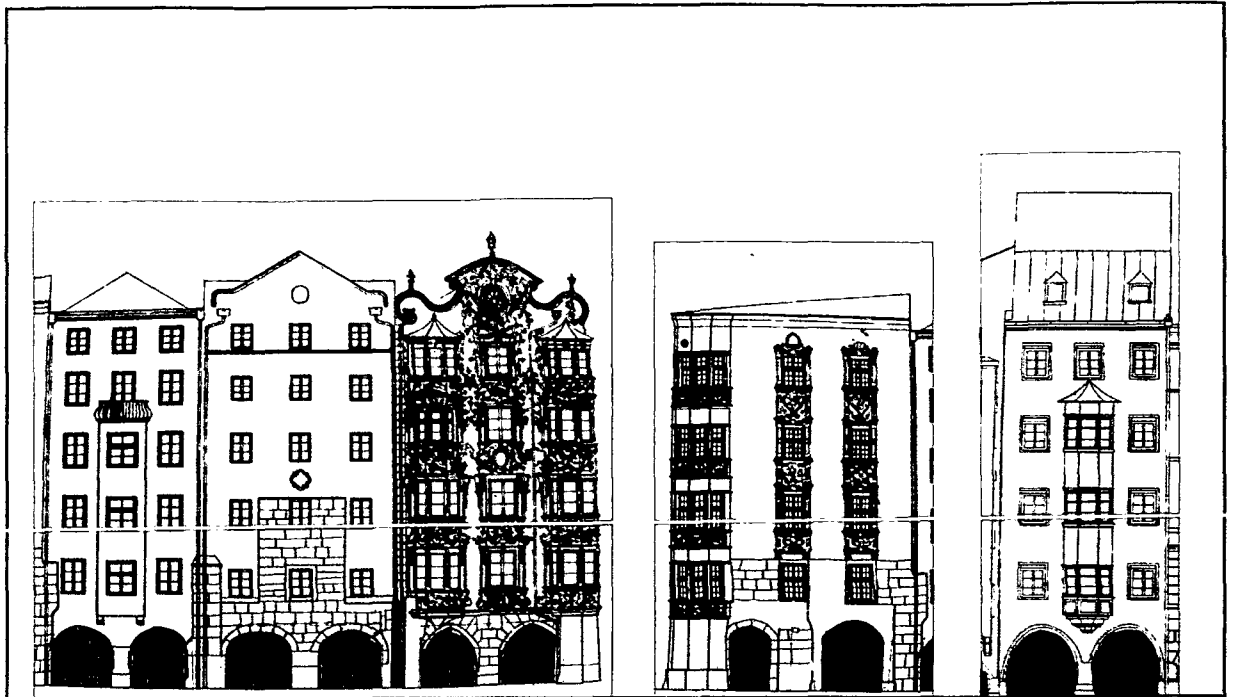
| Herzog-
Friedrichstr.14
Restaurant | Herzog-
Friedrich str.12
Restaurant | Herzog-
Friedrich str.10
Restaurant | Herzog-
Friedrichstr.16
Café | Herzog-
Friedrichstr.35
Mcdonald |

Figure 5. 6 The ten facades of traditional town houses in Innsbruck

1. The Arcade as Rule A: The ground floor based on the fortunate measurements, a front arcade and a main entrance will be developed first by Rule A. We shall define:

- an arcade which has two arch openings as Rule A-2c;

- an arcade with one arch opening and a smaller arch opening as A-c1+c2;

- an arcade with two point arch openings as Rule A-2d;

- an arcade with three point arch openings as Rule A-3d;

- an arcade with two arc openings as Rule A-2br.

This rule only applies at the first block and the ground floor, (Xn=1, Yn=1, Zn=0).
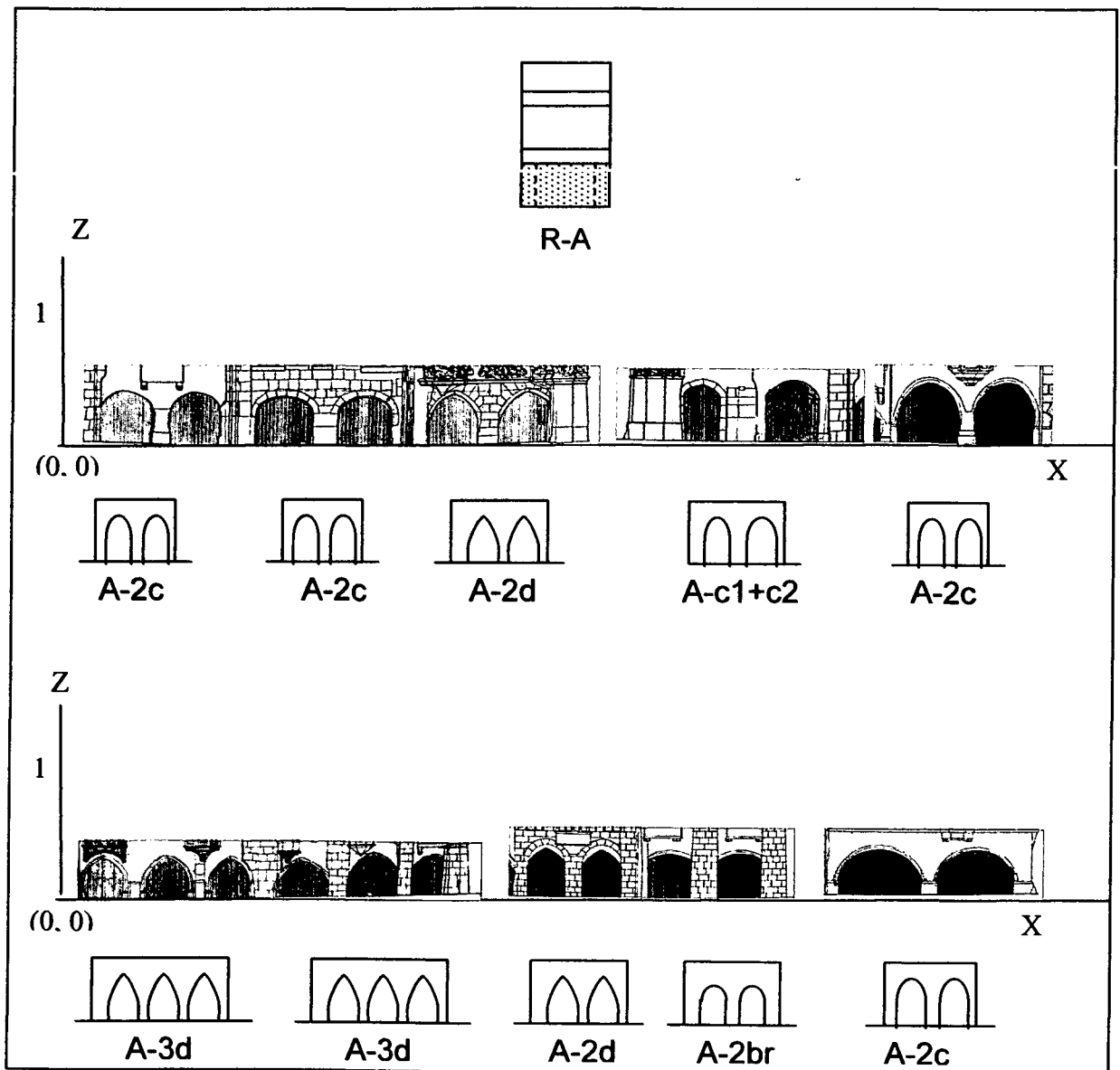
Figure 5. 7   Rule A for the ten facades in Innsbruck

2. The body as Rule B: The first floor to the top floor will be described together as Rule B.

- The body of the No. 10, which contains one window between two hexagonal windows from the first to the fourth floor, is defined as Rule B-(a+2hb)x4.

- The body of No. 12, which includes three same-size windows at each floor for five floors symmetrically, is defined as Rule B-3ax5.

- The body of No. 14 which contains one hexagonal window between two smaller windows for the first three floors, one small terrace which ends the hexagonal windows and three same-size windows on the fourth and the fifth floors is defined as Rule B- (2a+hb)x3+3ax2+1at.

- The body of No. 16, which has one hexagonal window and two smaller windows from the first to the fourth floors, is defined as Rule B-(hb+2a)x4.

- The body of No. 35, which contains one hexagonal window between two smaller windows for the first three floors and three same-size windows on the fourth floor, is defined Rule B-(2a+hb)x3+3a.

- The body of the No. 18-20, which combines one window between two hexagonal windows and a window beside a larger cubic window together from the first floor to the fourth floor, is defined as Rule B-(2(hb+a)+b)x4.

- The body of No. 22 which contains one larger hexagonal window and then one hexagonal window between two smaller windows from the first to the third floor and four smaller windows on the fourth floor is defined Rule B-2(hb+a)x3+4a.

- The body of No. 23, which includes one cubic window between two smaller windows on the first three floors and three smaller windows at the fourth floor symmetrically, is defined as Rule B- 3bx3+3a.

- The body of No. 25, which includes one smaller window between two cubic windows on the first three floors and three smaller windows on the fourth floor symmetrically, is defined as Rule B- 3cx3+3a.

- The body of No. 39, which includes three smaller windows, one hexagonal window then a smaller window on the first three floors and five smaller windows at the fourth floor symmetrically is defined as Rule B- (3a+hb+a)x3+5a. The majority of these facades are with a lot of decorations. These rules are only applied at the body of a facade. (Xn=1, Yn=1, Zn=4 or 5) (Figure 5.8)
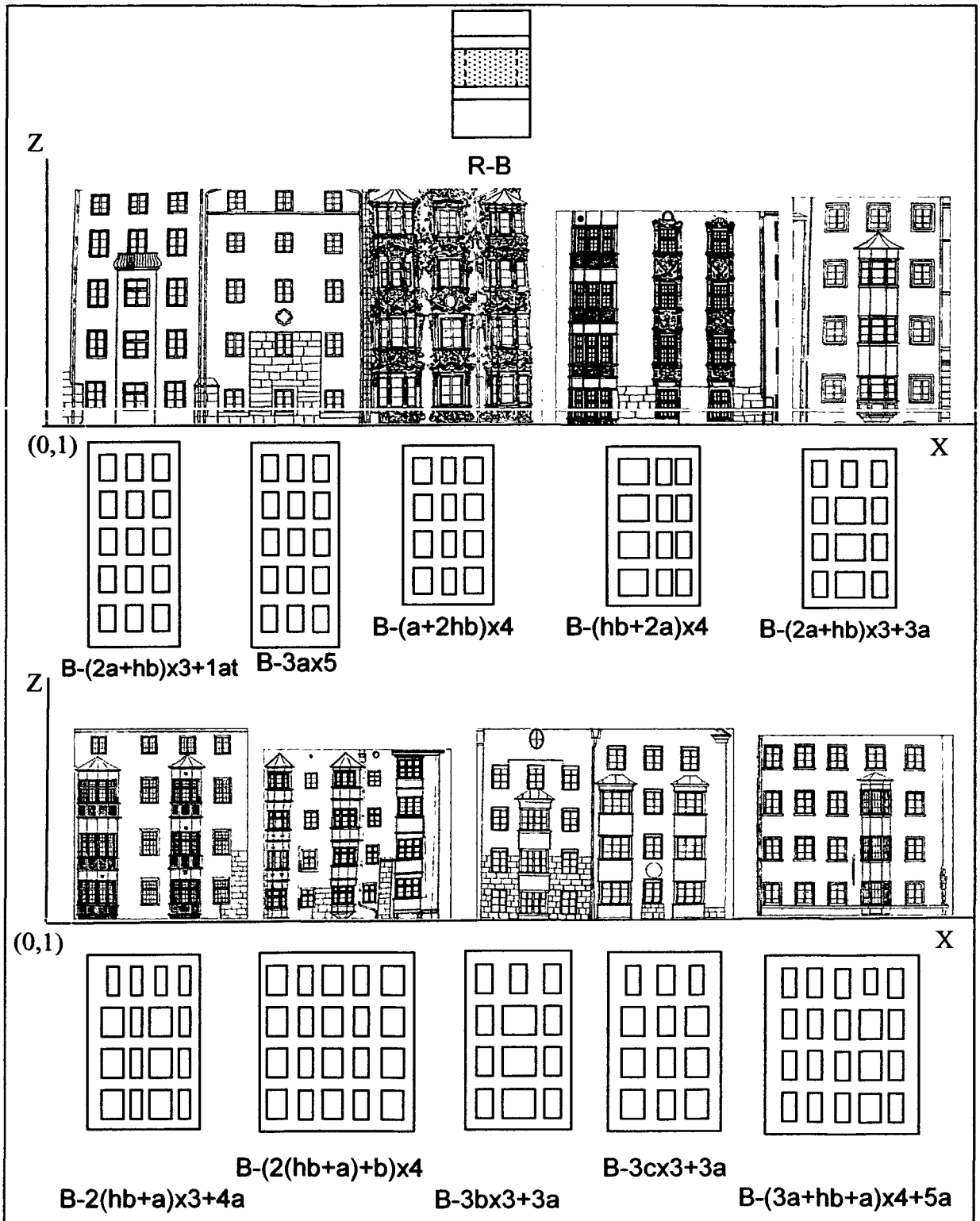
Figure 5. 8   Rule B for the ten facades in Innsbruck

3. The roof as Rule H: The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade, are developed by Rule H.

- The head of the No. 10, which contains rich decorations, which has luxurious colorful leaf motifs and an eastward curved gable with crowned vases, is defined as Rule H- a2+c↑.

- The head of the No. 12, which includes one gable with a round transom, is defined as Rule H- a2+b↑.

- The head of the No. 14 and 39, which have simple hip roofs, is defined as Rule H- bf.

- The head of the No. 16, which includes one sector on the parapets, is defined as Rule H- a+c→.

- The head of the No. 35, which includes a slope side of the gable roof with two transoms, is defined as Rule H- af+2w.

- The head of the No. 18-20, which includes irregular polygonal shapes on the parapet, is defined as Rule H- 2b+b/2.

- The head of the No. 22, which includes a slope side of the modified gable roof, is defined as Rule H- a4.

- The head of the No. 23, which includes one curved gable, is defined as Rule H- c1+2c2.

- The head of the No .25, which includes one gable with a small hip roof on the top, is defined as Rule H- b+f.

These rules are only applied at the head of facades. (Figure 5.9)
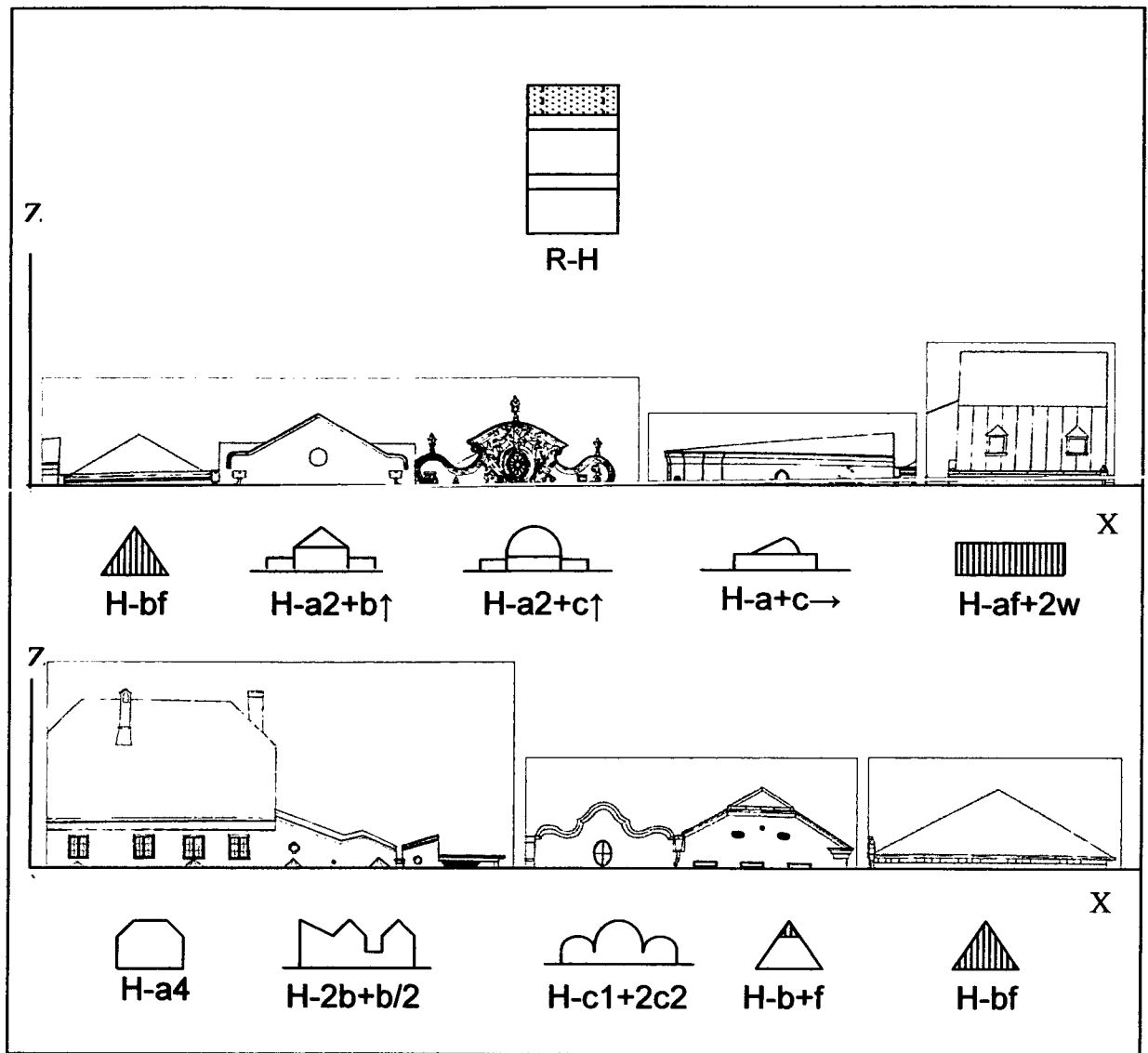
Figure 5. 9   Rule H for the ten facades in Innsbruck

4. The frieze as Rule F: Friezes can exist between an arcade and a body, a body and a head or both. In rule F, it will be shown: "f1" for the frieze between an arcade and a body; "f2" for the frieze between a body and a roof and so on. If it is an arc frieze, "r" is written as "rf". The facades of No. 10, 22 and 39 have f1, which is between an arcade and a body. The facades at No. 10, No. 14, No. 16, No. 35 and No. 39 have f2, which is between a body and a head.

5. The Terrace as Rule T: The majority of the traditional town houses in Innsbruck have no balcony or terrace on the main facade. The facades at No. 14 have a terrace as a foot stop after a column of three cubic windows. It is written as "+1at".

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment: the arcade, the body and the head. The main material of the facade of the town houses in Innsbruck is paint and stone. These ten facades will be listed in the following table.

7. The termination of the shape language of these facades: The shape language for the facades of ten town house in Innsbruck is listed in the below Table.

Rule No.	Rule A	Rule B	Rule F	Rule H	Rule M	T
No.14	A-2c	B-(2a+hb)x3+1a̸	f2	H-bf	p-p-p	ia̸
No.12	A-2c	B-3ax5	—	H-a2+b↑	s-p-p	—
No.10	A-2d	B-(hb+2a)x4	f1, f2	H-a2+c↑	p-p-p	—
No.16	A-c1+c2	B-(hb+2a)x4	f2	H-a+c→	s-sp-p	—
No.35	A-2c	B-(2a+hb)x3+3a	f2	H-af+2w	p-p-p	—

(rows above grouped under **INNSBRUCK I**)

Rule No.	Rule A	Rule B	Rule F	Rule H	Rule M	T
No.22	A-3d	B-2(hb+a)x3+4a	f1	H-a4	sp-p-p	—
No.20-18	A-3d	B- (2(hb+a)+b)x4	—	H-2b+b/2	sp-p-p	—
No.23	A-2d	B-3bx3+3a	—	H-c1+2c2	s-sp-p	—
No.25	A-2br	B-3cx3+3a	—	H-b+f	sp-p-p	—
No.39	A-2c	B-(3a+hb+a)x3+5a	f1, f2	H-bf	p-p-p	—

(rows above grouped under **INNSBRUCK II**)

Table 5. 4 The shape grammars for ten facades in Innsbruck

5.2.2 In Steyr, Upper Austria :

In accordance with the former rules and examples, we have chosen ten town houses including the example to development our own shape grammar. These ten town houses

are as following: at Herzog-Friedrichstr. 10, 12, 14, 16, 18, 20, 22, 23, 25, 35 and 39 in Innsbruck (Diagram 5.10).

Stadtplatz 19	Stadtplatz 21	Stadtplatz 32	Stadtplatz 35	Stadtplatz 40
Shoe shop	Pizzeria	Bank	Travel Agency/ Restaurant	Hotel

| Stadtplatz 44 Clothing shop | Stadtplatz 42 Restaurant | Stadtplatz 9 Bank | Grunmarkt 10 Clothing shop | Grunmarkt 4 Carpet shop |
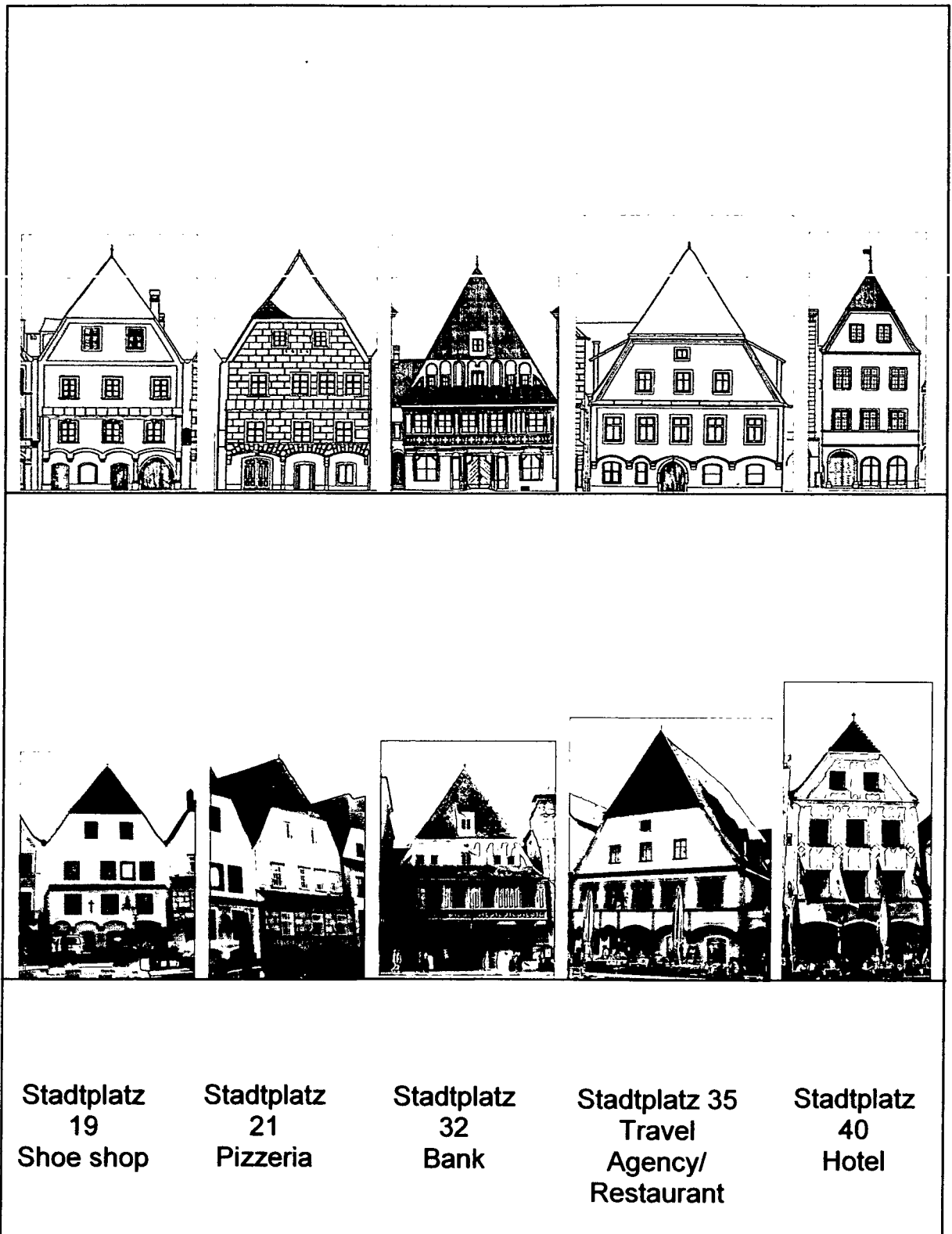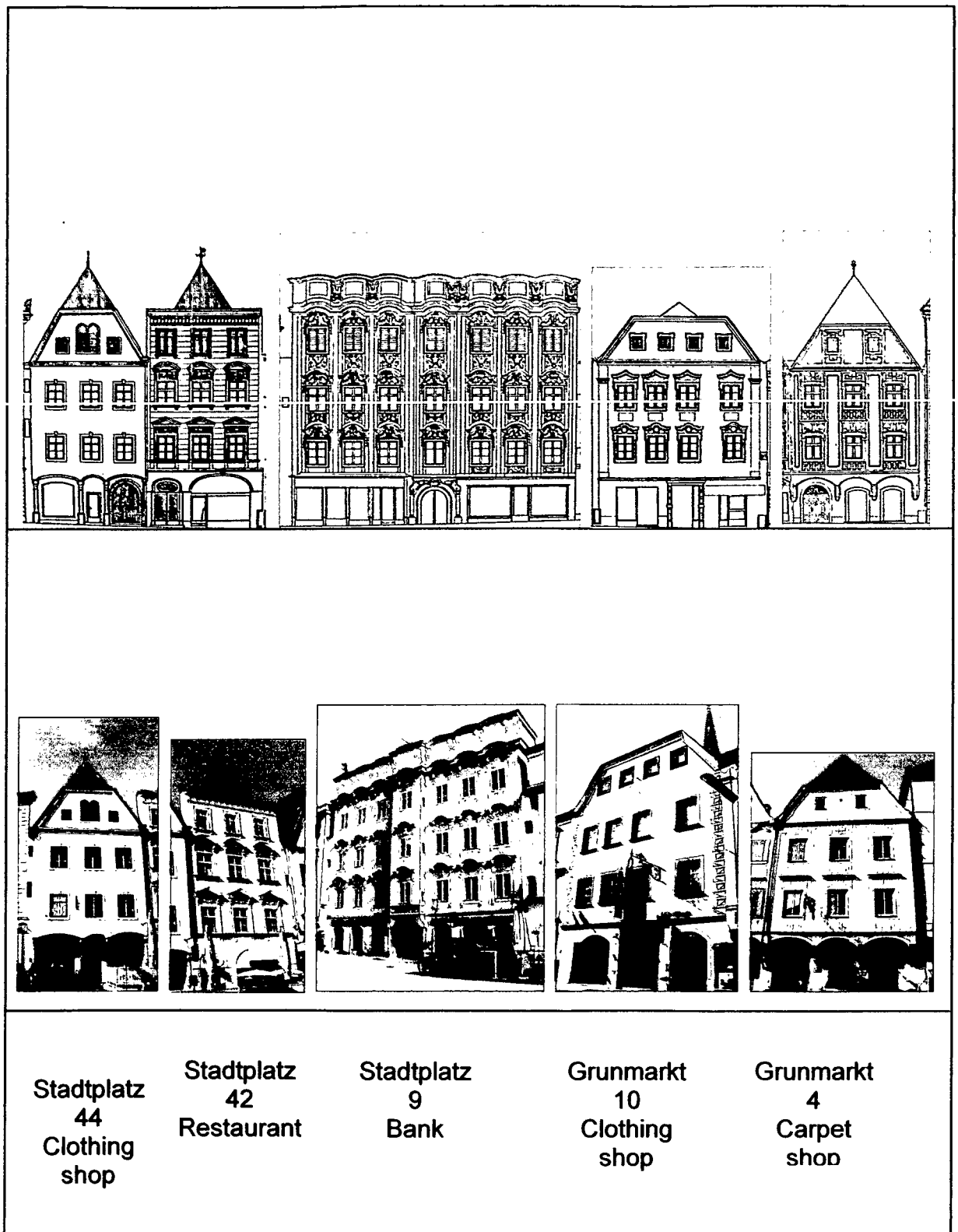
Figure 5. 10 The ten facades of traditional town houses in Steyr

1. The Arcade as Rule A: The ground floor based on the fortunate measurements, a front arcade and a main entrance is developed first by Rule A. The traditional town houses in Steyr have the characteristic hip roof form or "*Krüppelwalmdach*" and the kind of

cantilever arcades that extend the business space for the shops. Here this kind of arcade is considered as a kind of space between an arcade and the entrance of a house. We will define:

- the facade of No. 19 which has three cantilever arches, one window between two doors then a bigger arch opening as Rule AB-4c1011;

- the facade of No. 21 which has three cantilever arcs, two openings and a window as AB-3br110;

- the facade of No. 32 which has three cantilever rectangulars and one door between two windows as Rule AB-3b010;

- the facade of No. 35 which has five cantilever arches, one door in the middle and two windows for each side as Rule AB-5c00100;

- the facade of No. 40 which has three cantilever arcs, one door and two windows as AB-3br100, the facade of No. 42 which has one door and one large window with only arch friezes instead of cantilever part as Rule AB-10;

- the facade of

- No. 44 which has three cantilever arcs, one door between two windows as Rule AB-4c010;

- the facade of No. 9 which has seven arcs, one door and three windows for each side as AB-7br0001000;

- the facade of No. 4 at Grünmarkt which has three arcs, one door and two windows for each side as Rule AB-3br00100;

- the facade of No. 9 at Grünmarkt, which has three arches, one door and two windows as Rule AB-3c100.

These rules only apply at the ground floor, (Xn=1, Yn=1, Zn=0).
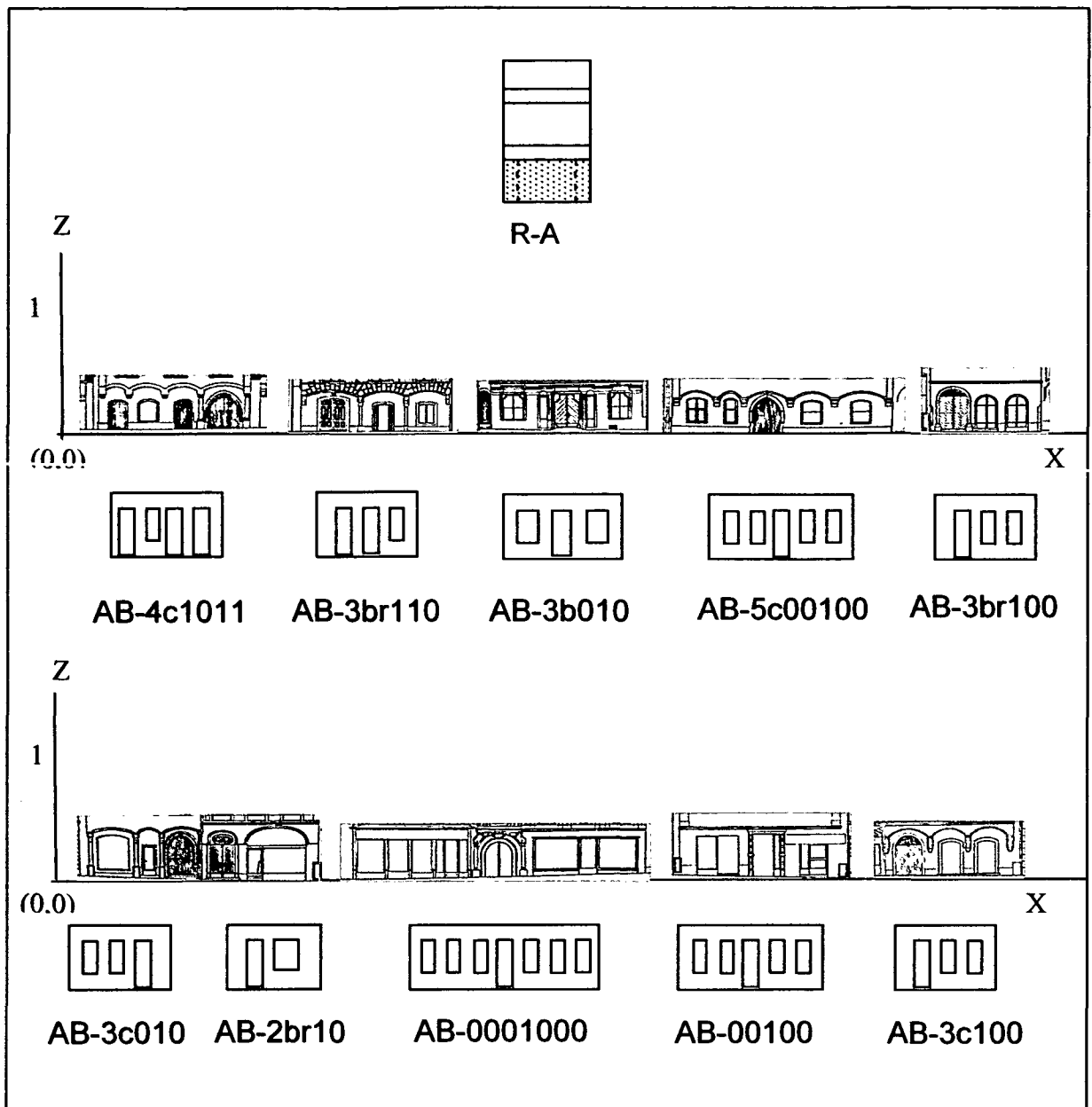
Figure 5. 11 Rule A for the ten facades in Steyr

2. The Body as Rule B: The first floor to the top floor will be described together as Rule B.

- The body of the No. 19, which contains three windows on the first and second floors and the eaves between these two floors, is defined as Rule B-3ax2+f.

- The body of No. 21, which includes three windows on the first floor, four windows on the second floor and the eaves between these two floors, is defined as Rule B-3a+4a+f.

- The body of No. 32, which contains four windows and then one wider window aside, and a terrace as wide as the facade for the first floor is defined as Rule B- 4a+b+t.

- The body of No. 35, which has five windows in a row for the first floor, is defined as Rule B-5a.

- The body of No. 40, No. 44 at Stadtplatz and No. 4 at Grünmarkt which contain three windows on the first and second floors is defined Rule B-3ax2.

- The body of No. 42, which has three windows for the first, second, and third floors is defined as Rule B-3ax3.

- The body of No. 9, which contains seven windows for the first, second, and third floors is defined as Rule B-7ax3.

- The body of No. 10 at Grünmarkt that includes four windows for the first and second floors is defined as Rule B- 4ax2.

The majority of these facades are with a lot of decorations. These rules only apply at the body of a facade. ($X_n=1$, $Y_n=1$, $Z_n=1,2$ or 3) (Figure 5.12)
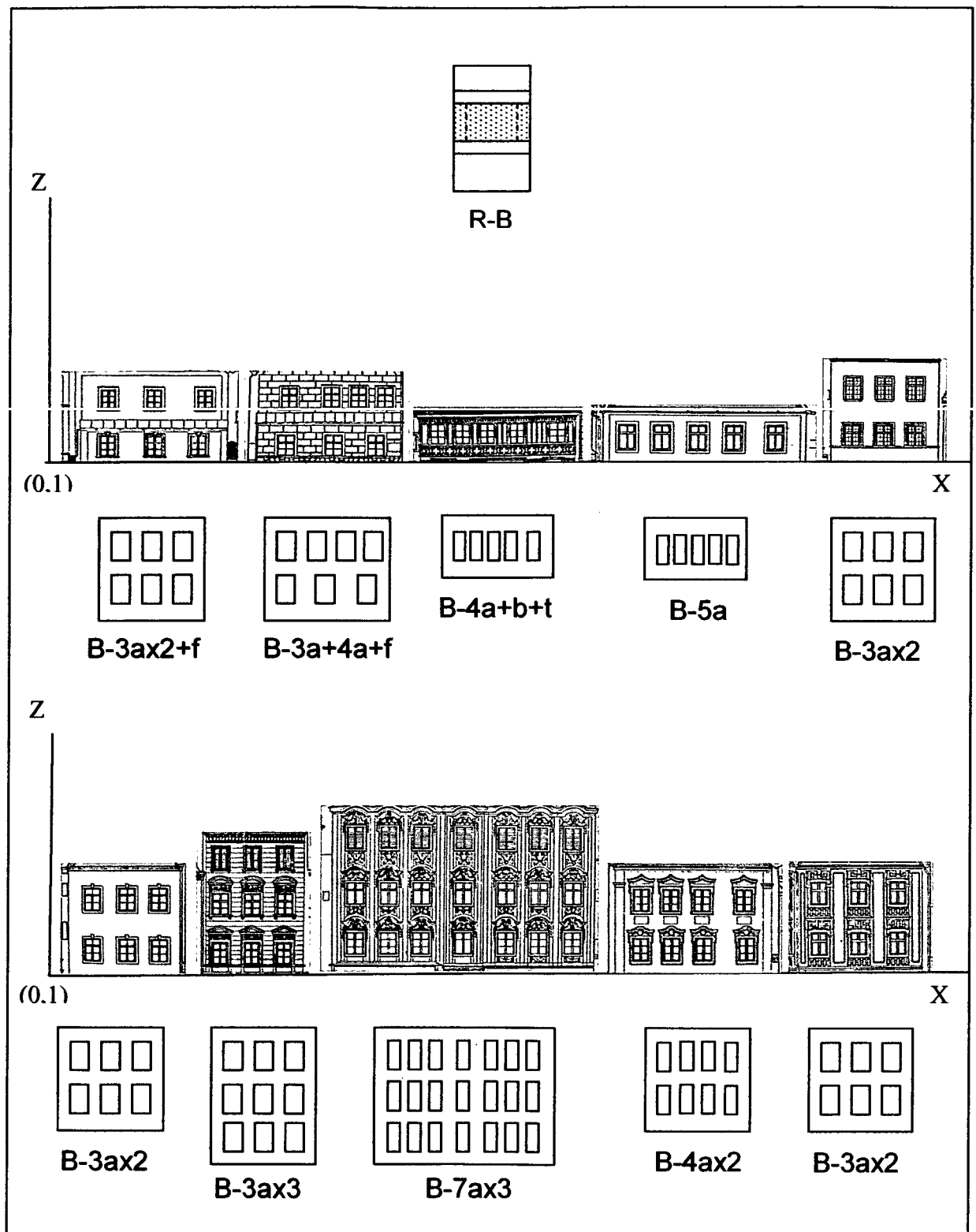
Figure 5. 12   Rule B for the ten facades in Steyr

3. The Roof as Rule H: The roof's shape, eaves and parapets, which illustrate the final skyline of the main facade, are developed by Rule H.

- The head of No. 19, No. 21, No. 40 at Stadtplatz and No. 4 at Grünmarkt, which contain two windows on the gable under a hip roof, is defined as Rule H- b+f+2w.

- The head of No. 32, which includes five windows on the gable between the lower part and a higher part of a hip roof and a transom at the latter, is defined as Rule H- b+2f+5w+cw.

- The head of No. 35, which contains three windows and a middle transom on the gable and under a hip roof, is defined as Rule H- b+f+3w+cw.

- The head of No. 42, which includes a hip roof on a parapet, is defined as Rule H- a+f.

- The head of No. 44, which includes three windows on the gable and under a hip roof, is defined as Rule H- b+f+3w.

- The head of No. 9, which includes a curved parapet with a rich decoration, is defined as Rule H- 7c.

- The head of No. 10 at Grünmarkt, which includes four windows on the gable and a hip roof on the top, is defined as Rule H- a3+f+4w.

These rules are only applied at the head of facades (Figure 5.13).
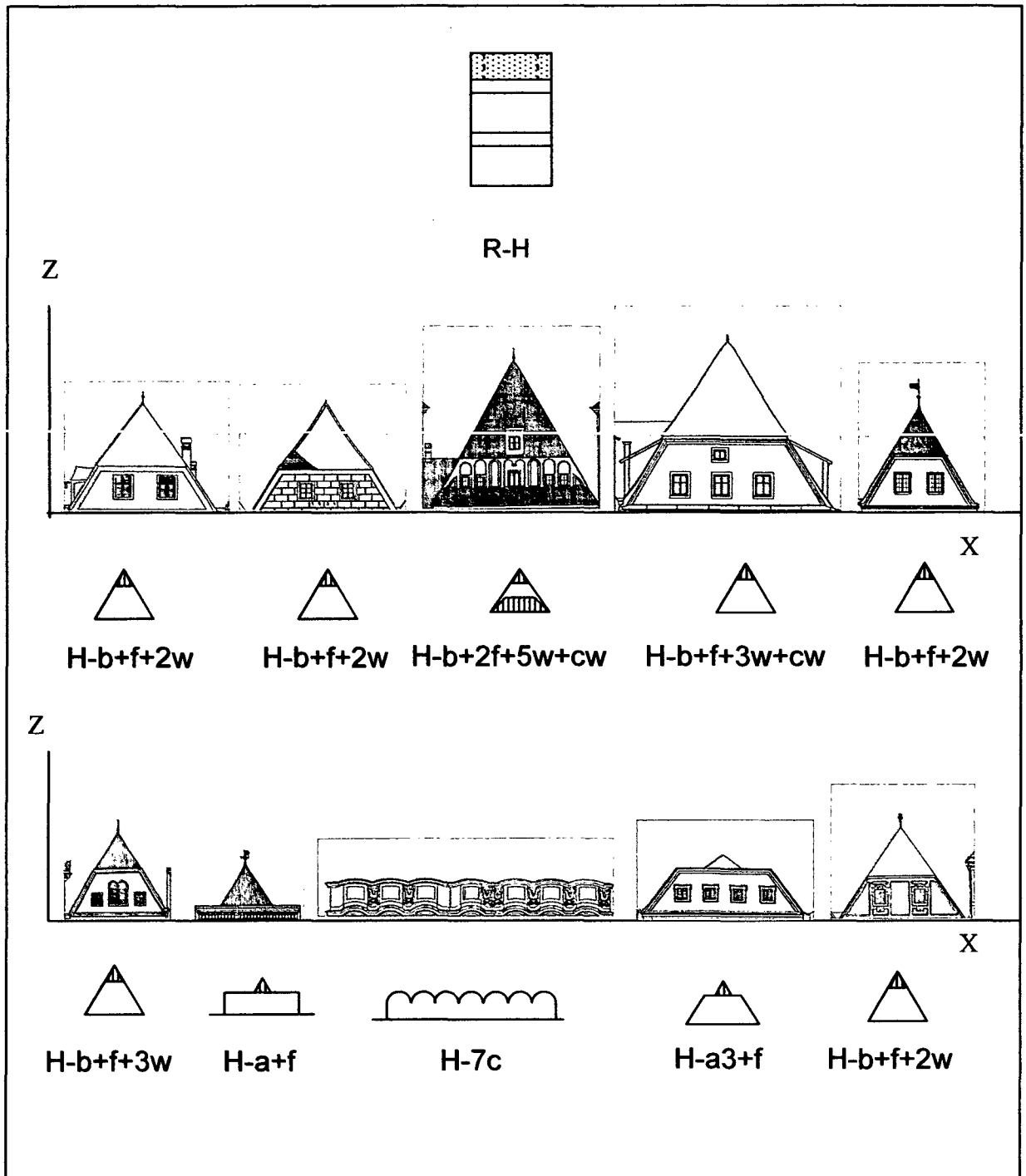
Figure 5. 13   Rule H for the ten facades in Steyr

4. The frieze as Rule F: Friezes can exist between an arcade and a body, a body and a head or both. In rule F it will be shown: "f1" for the frieze between an arcade and a body; "f2" for the frieze between a body and a roof and so on. If it is an arc frieze, "r" is added to read as "rf". Besides No. 44 all the facades have f1, which is between an arcade and a body. Besides No. 19 and No. 21 all the others have f2 which is between a body and a head.

5. The Terrace as Rule T: The traditional town houses in Steyr seldom have a balcony or terrace on the main facade. The facades of No. 32 have a terrace as wide as the facade on the first floor. It is written as "+t".

6. The material on the surface of a facade as Rule M: The material on the surface of a facade will be presented in accordance with the alignment: the arcade, the body and the head. The main material of the facade of the traditional town houses in Steyr is paint and stone. These ten facades will be listed in the following Table.

7. Termination of the shape language of these facades: The shape language for the facades of ten traditional town houses in Innsbruck is listed in Table 5.5 below:

No. Rule	Rule A	Rule B	Rule F	Rule H	Rule M	T
No.19	AB-4c1011	B-3ax2+f	f1	H-b+f+2w	p-p-pb	---
No.21	AB-3br110	B- 3a+4a+f	f1	H-b+f+2w	sp-s-sb	---
No.32	AB-3b010	B-4b+b+t	f1,f2	H-b+2f+5w+cw	p-p-pb	t
No.35	AB-5c00100	B-5a	f1,f2	H-b+f+3w+cw	p-p-pb	---
No.40	AB-3br100	B-3ax2	f1,f2	H-b+f+2w	p-p-pb	---

(STEYR I)

No.	Rule A	Rule B	Rule F	Rule H	Rule M	T
No.44	AB-3c0101	B-3ax2	f2	H-b+f+3w	p-p-pb	---
No.42	AB-2br10	B- 3ax3	f1,f2	H-a+f	p-p-pb	---
No.9	AB-7br0001000	B-7ax3	f1,f2	H-7c	p-p-p	---
No.10 G.	AB-3br00100	B-4ax2	f1,f2	H-a3+f+4w	p-p-pb	---
No.4 G.	AB-3c100	B-3ax2	f1,f2	H-b+f+2w	p-p-pb	---

(STEYR II)

Table 5. 5 The shape grammars for the ten facades in Steyr

5.3 Applications for the floor plans of traditional town houses in Austria:

5.3.1 In Innsbruck, Tyrol in Austria:

1. To build an initial shape in this town house:

In Figure 5.14, we see an initial shape of the town house at Herzog-Friedrich-Strasse No. 20 in Innsbruck in Tyrol. There are one absolute coordinate and 4 labeled points in the shape of this house. This indicates a town house with one bay, one block and four stories.

P(1,1,3)

P(1,1,2)

P(1,1,1)

+(0,0,0)   P(1,1,0)
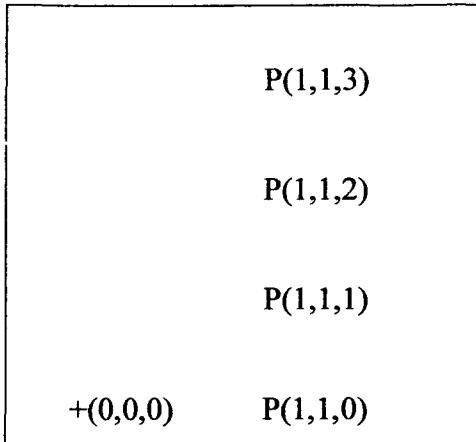
Figure 5. 14   The initial form of the traditional town house at Herzog-Friedrich-Strasse No. 20

2. The Generation of a unit pattern - Rule A : The development of unit patterns by shape grammar is analyzed at Herzog-Friedrich-Strasse No. 20 in Innsbruck.

- The ground floor, based on the fortunate measurements, is developed by Ra-1a, Ra-2, Ra-3b and Ra-4a.

- This floor contains two shop spaces, a hallway, a front arcade and two small halls. The first floor which contains five hallways, two main spaces, halls, four rooms and one staircase can be described by Ra-1b, Ra-4b, Ra-6a, Ra-11a and Ra-12b.

- The second floor which includes five hallways, two main spaces, (halls), four rooms and one staircase can be described by Ra-1b, Ra-4b, Ra-6a, Ra-11a and Ra-12b.

- The third floor which includes six hallways, two main spaces (halls), four rooms and two staircases described by Ra-1b, Ra-4b, Ra-6a, Ra-11a and Ra-12b.

The rules, Ra-1a, 1b, Ra-2, Ra-3b, Ra-4a, 4b, Ra-6a, Ra-11a, Ra-12b, are applied in this case (Xn=1, Yn=1, Zn=3) (Figure 5.15).

The Generation of a unit pattern for Herzog-Friedrich-Strasse No. 20 in Innsbruck
Rule A : Ra-1a, 1b, Ra-2a, Ra-3b, Ra-4a, 4b, Ra-6a, Ra-11a, Ra-12b

GF

Ra-2a←Ra-1a→ Ra-4a
↓
Ra-3b←Ra-4a
↑
Ra-2a←Ra-1a→ Ra-4a

1F

Ra-6a   Ra-4b→Ra-4b
↑   ↑
Ra-4b←Ra-1b→Ra-11a→Ra-12b→Ra-6a
↓   ↓
Ra-6a   Ra-4b

2F

Ra-6a   Ra-4b→Ra-4b
↑   ↑
Ra-4b←Ra-1b→Ra-11a→Ra-12b→Ra-6a
↓   ↓
Ra-6a   Ra-4b

3F

Ra-6a   Ra-4b→Ra-4b Ra-11a
↑   ↑   ↑
Ra-4b←Ra-4b←Ra-1b →Ra-4b→Ra-6a
↓   ↓
Ra-6a   Ra-4b
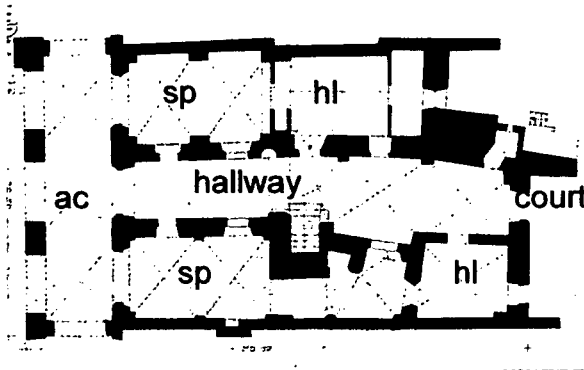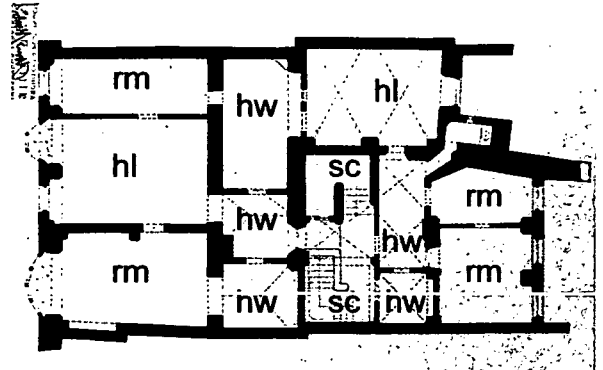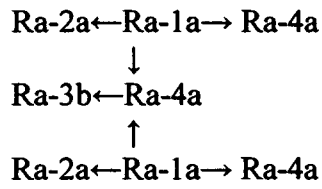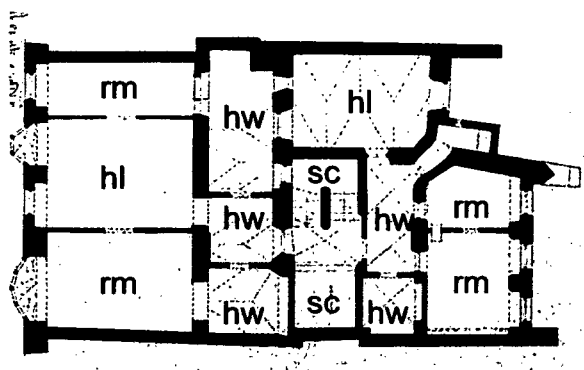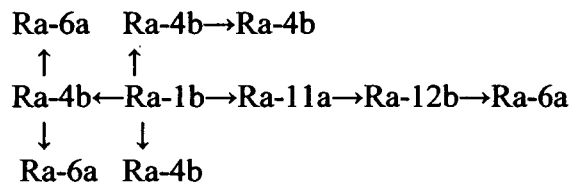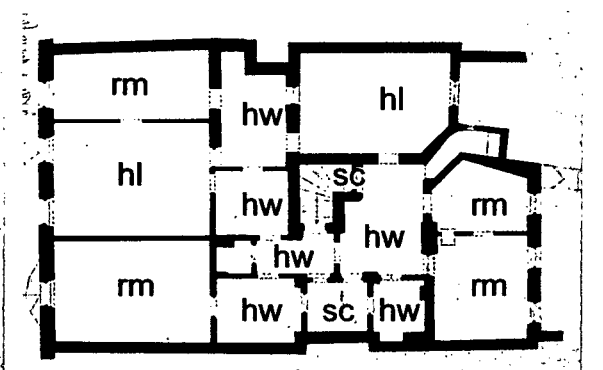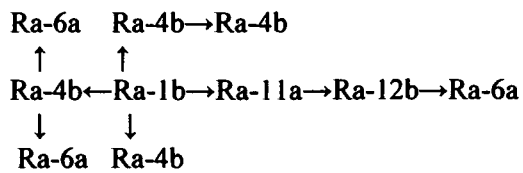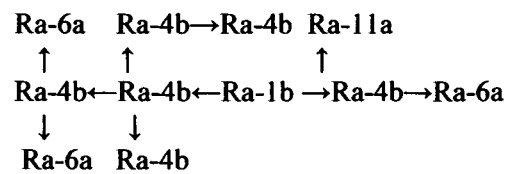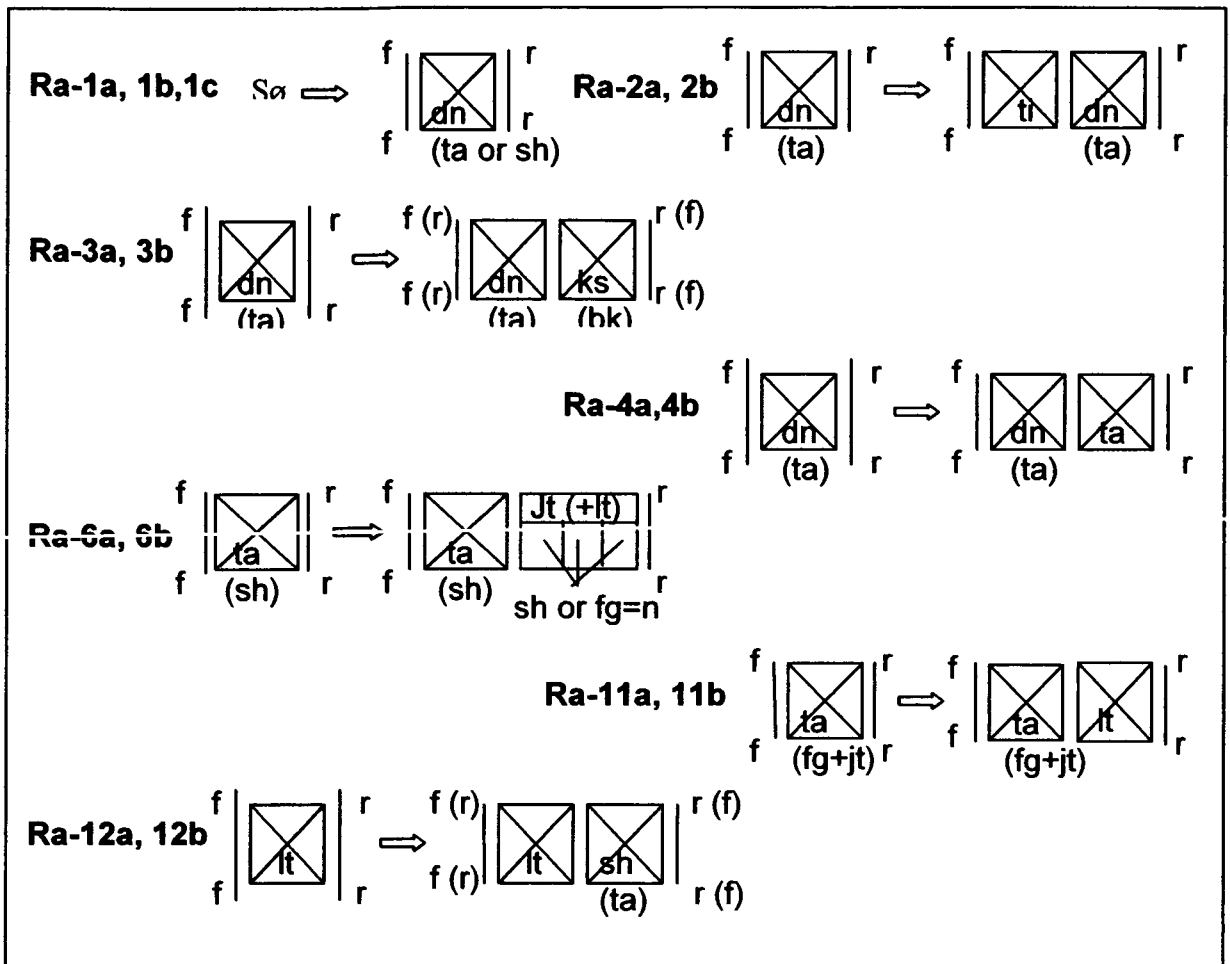
Figure 5. 15   Rule A for floor plans at Herzog-Friedrich-Strasse No. 20 in Innsbruck

3. The openings on outer walls – Rule B

In the below schemata, Rule B, this example has six rules for openings of outer walls which are shown in Figure 5.16. 'CC' presents corners and 'S' presents indoor space. We shall define:

– Rb-3b represents three openings on a wall.

– Rb-4a presents four windows on a wall in a row. This rule was applied quite often in a large traditional Taiwanese houses.
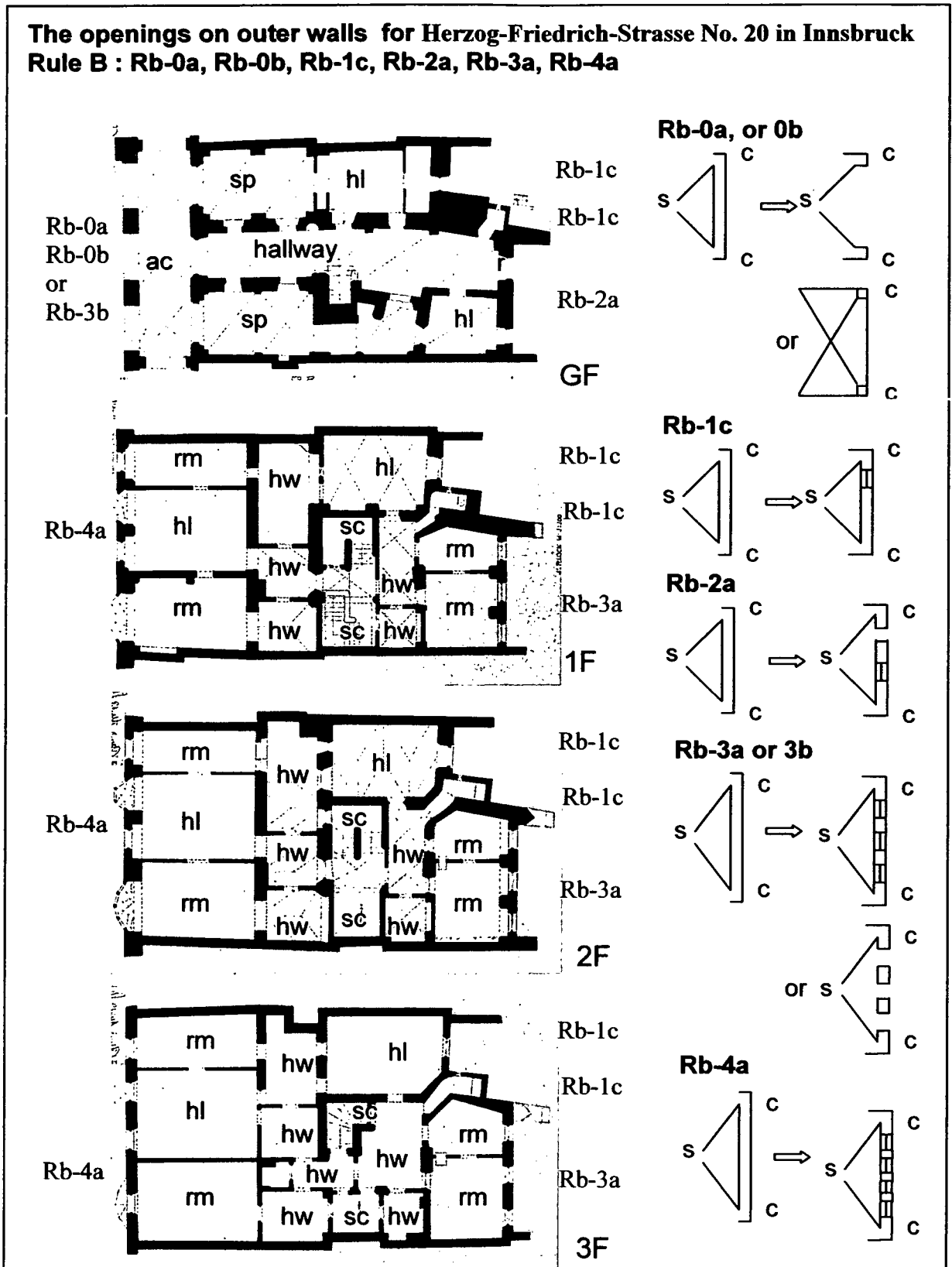
Figure 5. 16   Rule B for floor plans at Herzog-Friedrich-Strasse No. 20 in Innsbruck

4. The openings for connecting spaces – Rule C

This schemata, Rule C for the floor plans at Herzog-Friedrich-Strasse No. 20 in Innsbruck has seven rules for opening of connections, which are shown in Figure 5-17. The label "S" represents an indoor space. Rc-4a represents four openings between two spaces. The others have been explained in former examples. This part of grammar consists of schemata, Rule C, with connections between indoor spaces.

5. The openings for connections between blocks - Rule D:

This house has no courtyard, so the Rule D does not exist in this case.
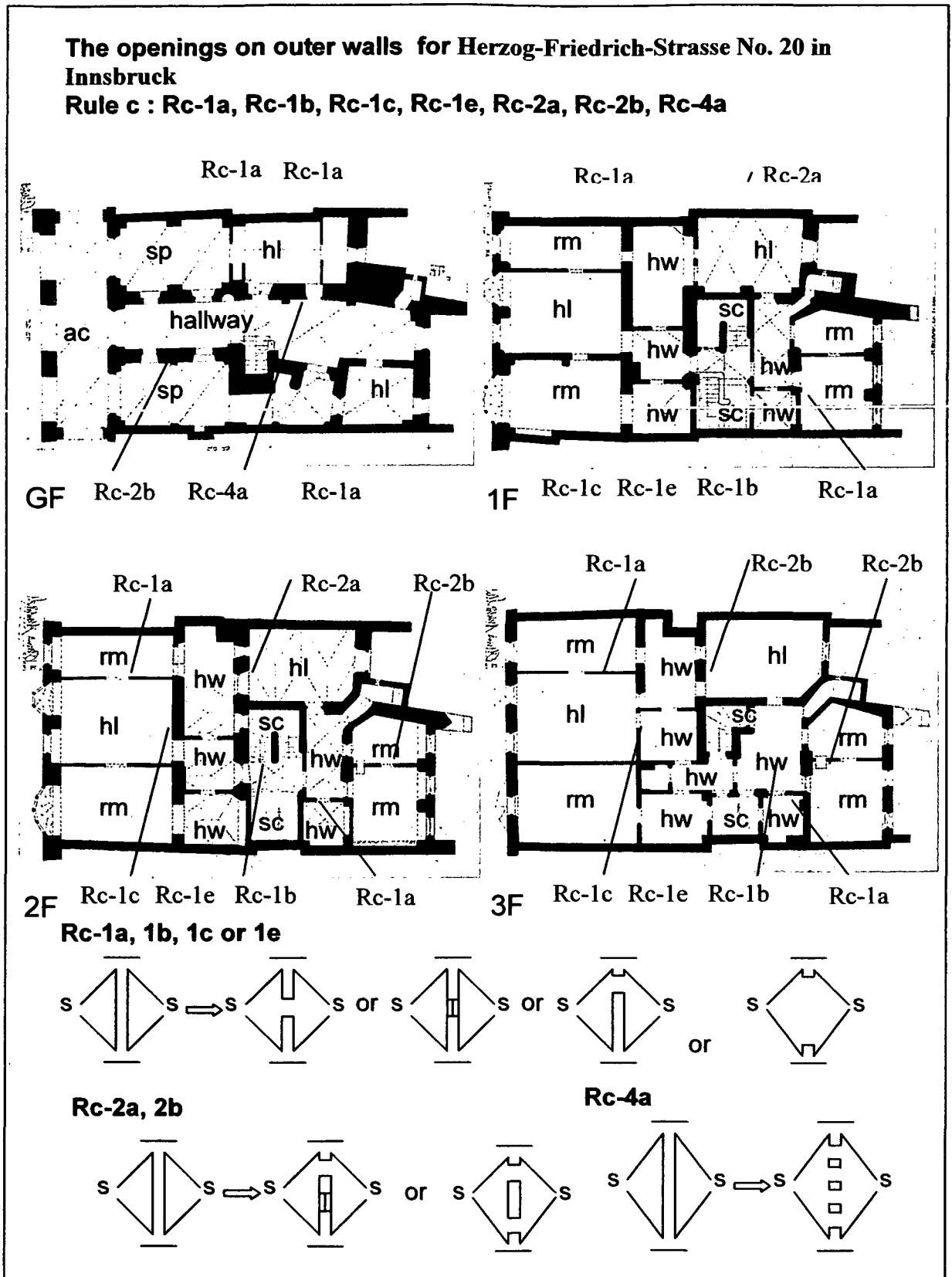
Figure 5. 17   Rule C for floor plans at Herzog-Friedrich-Strasse No. 20 in Innsbruck

5.3.2 In Steyr, Upper Austria:

1. To build an initial shape in this traditional town house:

In Figure 5.18 we found an initial shape of the traditional town house at Stadtplatz No. 21 in Steyr. It has one absolute coordinate and 4 labeled points in the shape of this house. This indicates a traditional town house with one bay, two blocks and three stories.

```
         P(1,1,2)    P(1,2,2)


         P(1,1,1)    P(1,2,1)


+(0,0,0)  P(1,1,0)    P(1,2,0)
```
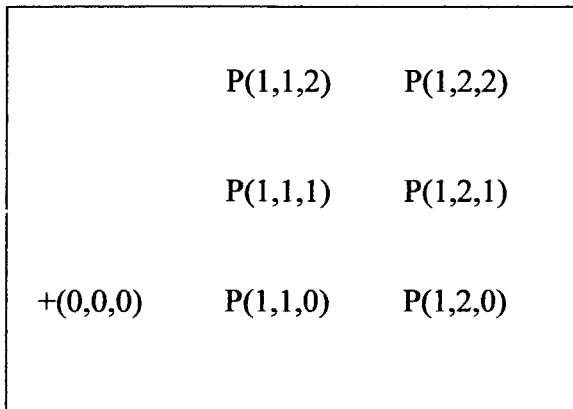
Figure 5. 18 Initial form of the traditional town house at Stadtplatz No. 21 in Steyr

2. The Generation of a unit pattern - Rule A : The development of unit patterns by shape grammar is analyzed at Stadtplatz No. 21 in Steyr.

– The ground floor, based on the fortunate measurements, is developed by Ra-1a, Ra-2b, Ra-4b, Ra-6a and Ra-11a. This floor contains one shop, a hallway, a staircase, an atrium, a parking place (an unloading place) and three rooms.

– The first floor which contains two hallways, two main spaces (halls), nine rooms, three staircases and an atrium have been described by Ra-1b, Ra-4b, Ra-6a and Ra-11a. The second floor which includes three hallways, three main spaces (halls), four rooms and two staircases that are described by Ra-1b, Ra-4b, Ra-6a and Ra-11a.

– The second floor has been divided into two blocks, however this atrium is still an atrium but not a courtyard.

The rules, Ra-1a,1b, Ra-2b, Ra-4a, 4b, Ra-6a, Ra-11a, Ra-14, are applied in this case (Xn=1, Yn=2, Zn=2). (Figure 5.15)

The Generation of a unit pattern for Stadtplatz No. 21 in Steyr
Rule A : Ra-1a,1b, Ra-2b, Ra-4a, 4b, Ra-6a, Ra-11a, Ra-14

GF

Ra-11a Ra-2b
 ↑   ↑
Ra-4a→ Ra-14
 ↑ →Ra-6a
Ra-1a→ Ra-4a→Ra-6a

1F

Ra-11a
Ra-6b←   ↑   → Ra-11a
Ra-4b←Ra-4b←Ra-1b→Ra-4b→Ra-6a
     ↓   ↓   →Ra-11a
   Ra-6b Ra-6b

2F

Ra-11a   Ra-6a
  ↑   ↑
Ra-4b←Ra-1b→Ra-6a   Ra-1b→Ra-4b
 ↑↓   ↓   ↓   ↑
Ra-4b→Ra-4b→Ra-6a   Ra-11a Ra-6a
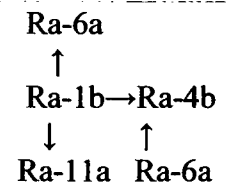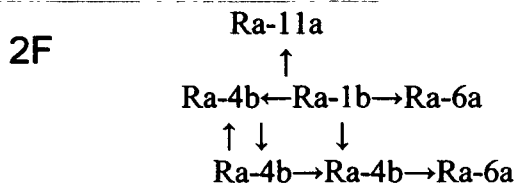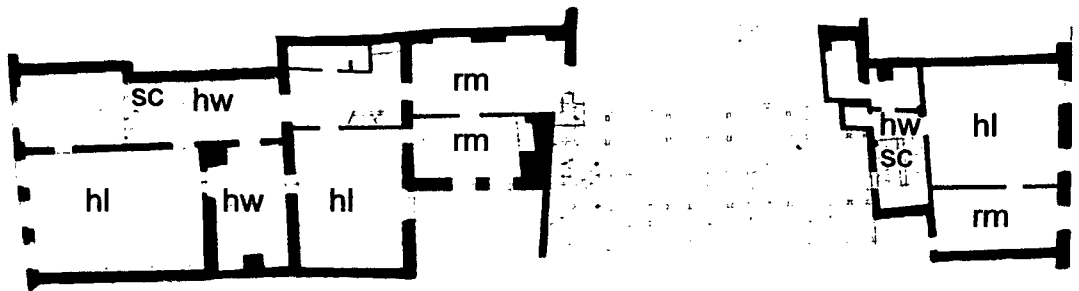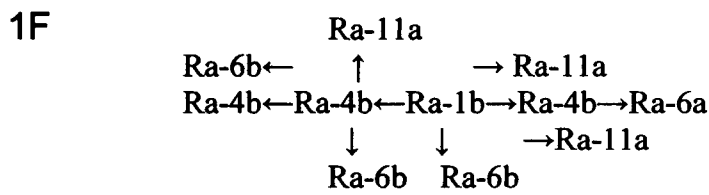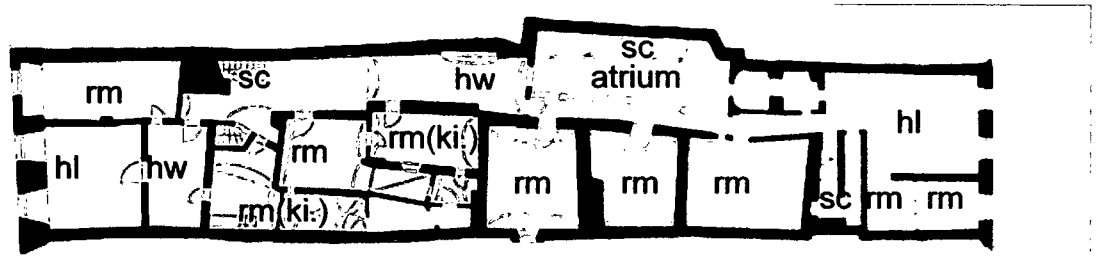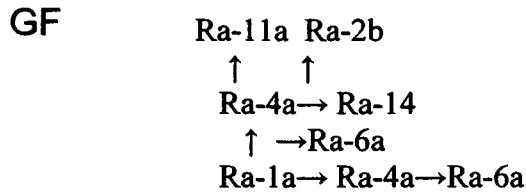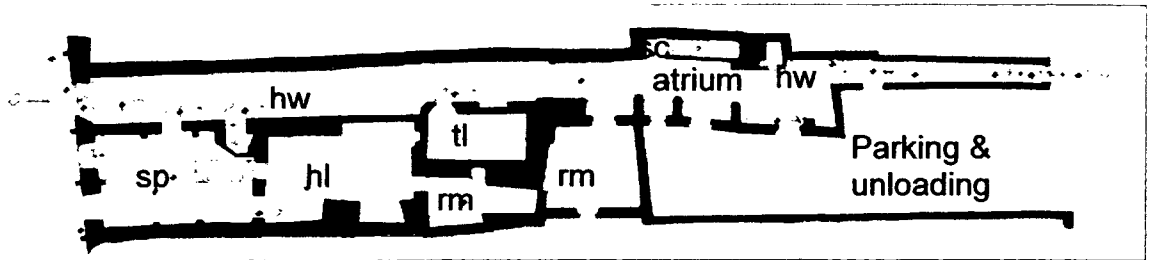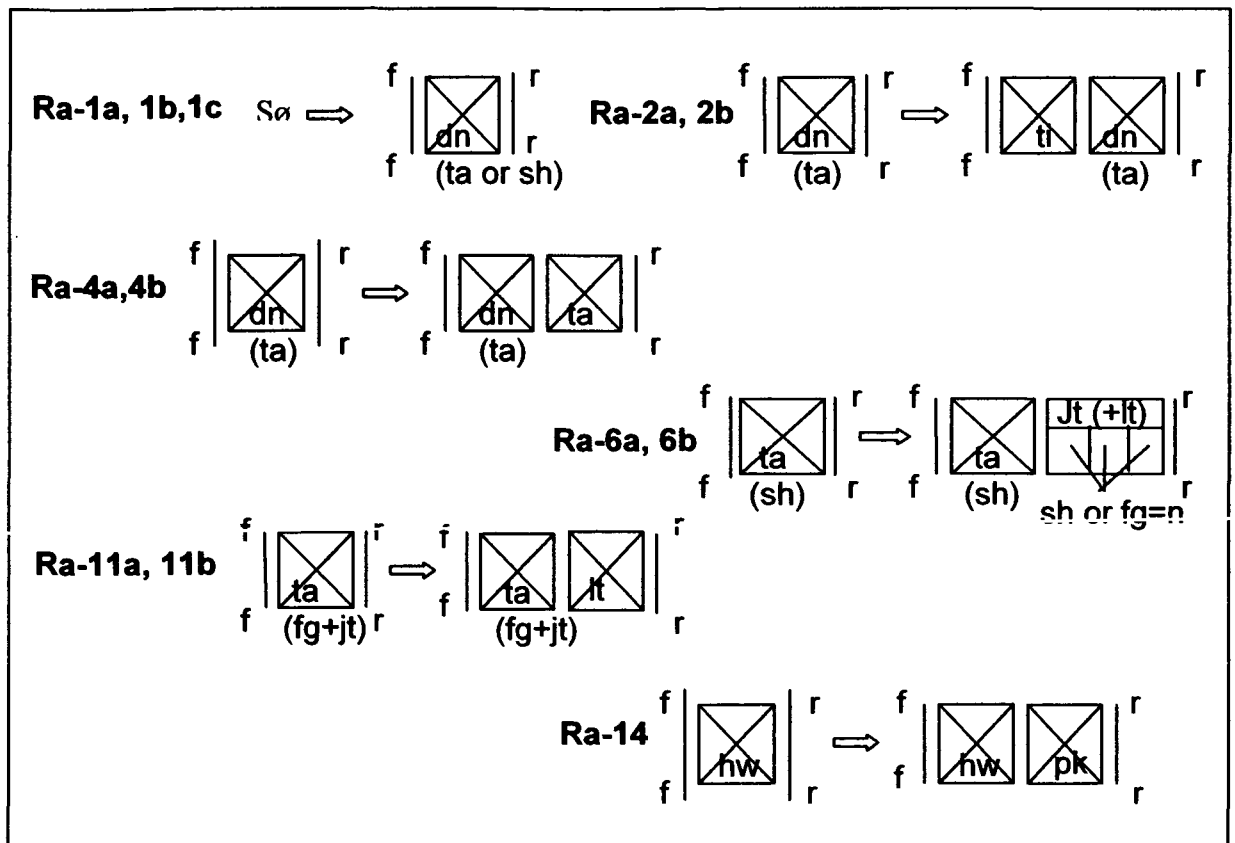
Figure 5. 19 Rule A for the floor plans at Stadtplatz No. 21 in Steyr

3. The openings on outer walls – Rule B

In the below schemata, Rule B, this example has six rules for openings of outer walls which are shown in Figure 5-20. 'CC' represents corners and 'S' represents indoor space. Rb-2e represents a large opening and a small opening on a wall. Rb-4b represents four windows on a wall equivalently. The others have already been explained in the former examples.

The openings on outer walls for Stadtplatz No. 21 in Steyr
Rule B: Rb-0c, Rb-1a, Rb-1c, Rb-2c, Rb-2e, Rb-3a, Rb-4b

Rb-3e

sc

hw

tl

hl

rm

rm

sc

atrium hw

Parking & unloading

Rb-1a

Rb-2e

GF

Rb-0c

Rb-3a

rm

sc

hw

rm(ki.)

sc atrium

hw

hl

rm

hw

rm(ki.)

rm

rm

rm

sc rm rm

Rb-3a

1F

Rb-1a

Rb-4b

sc hw

rm

rm

hl

hw

hl

hw

sc

hl

rm

Rb-3a

2F   Rb-1c   Rb-2c   Rb-1a   Rb-1c
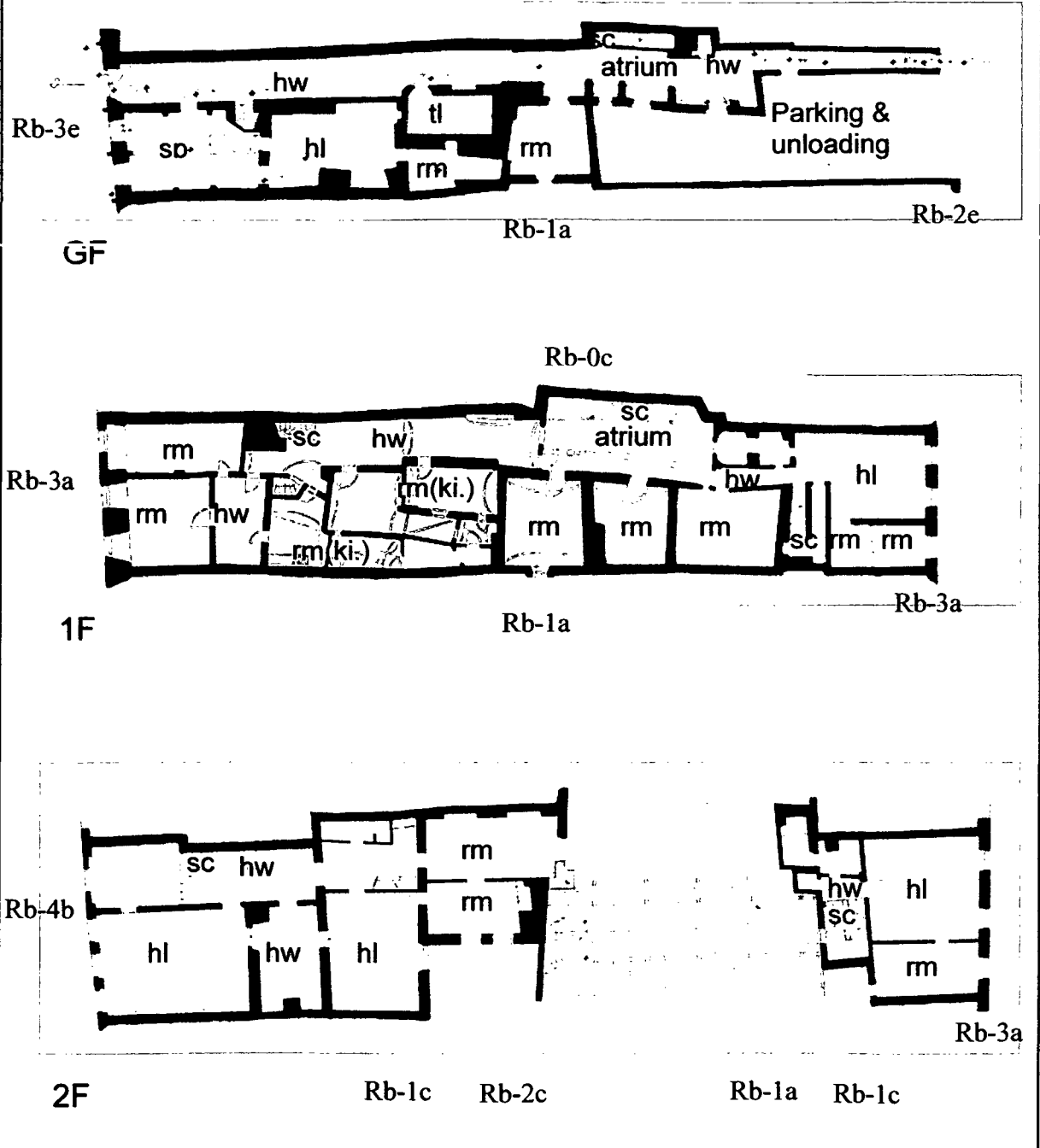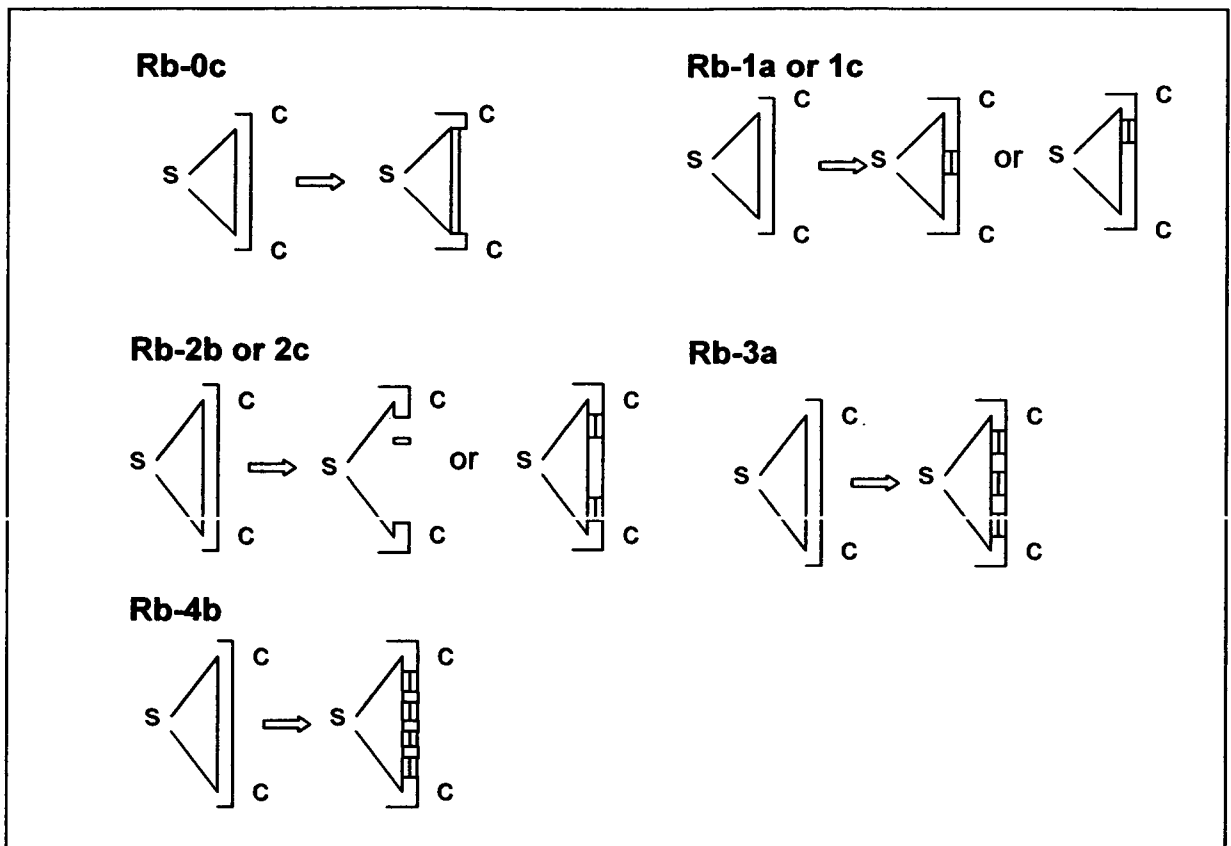
Figure 5. 20 Rule B for the floor plans at Stadtplatz No. 21 in Steyr

4. The openings for connecting spaces – Rule C

In this schemata, Rule C for the floor plans at Herzog-Friedrich-Strasse No. 20 in Innsbruck has seven rules for the openings of connections, which are shown in Figure 5. 21. The label "S" represents an indoor space. All of these rules have been explained in former examples. This part of grammar consists of schemata, Rule C, with connections between spaces indoors.

**The openings for connecting spaces for Stadtplatz No. 21 in Steyr
Rule C: Rc-1a, Rc-1b, Rc-1c, Rc-2a, Rc-2b, Rc-3a, Rc-4a**

GF

1F

2F
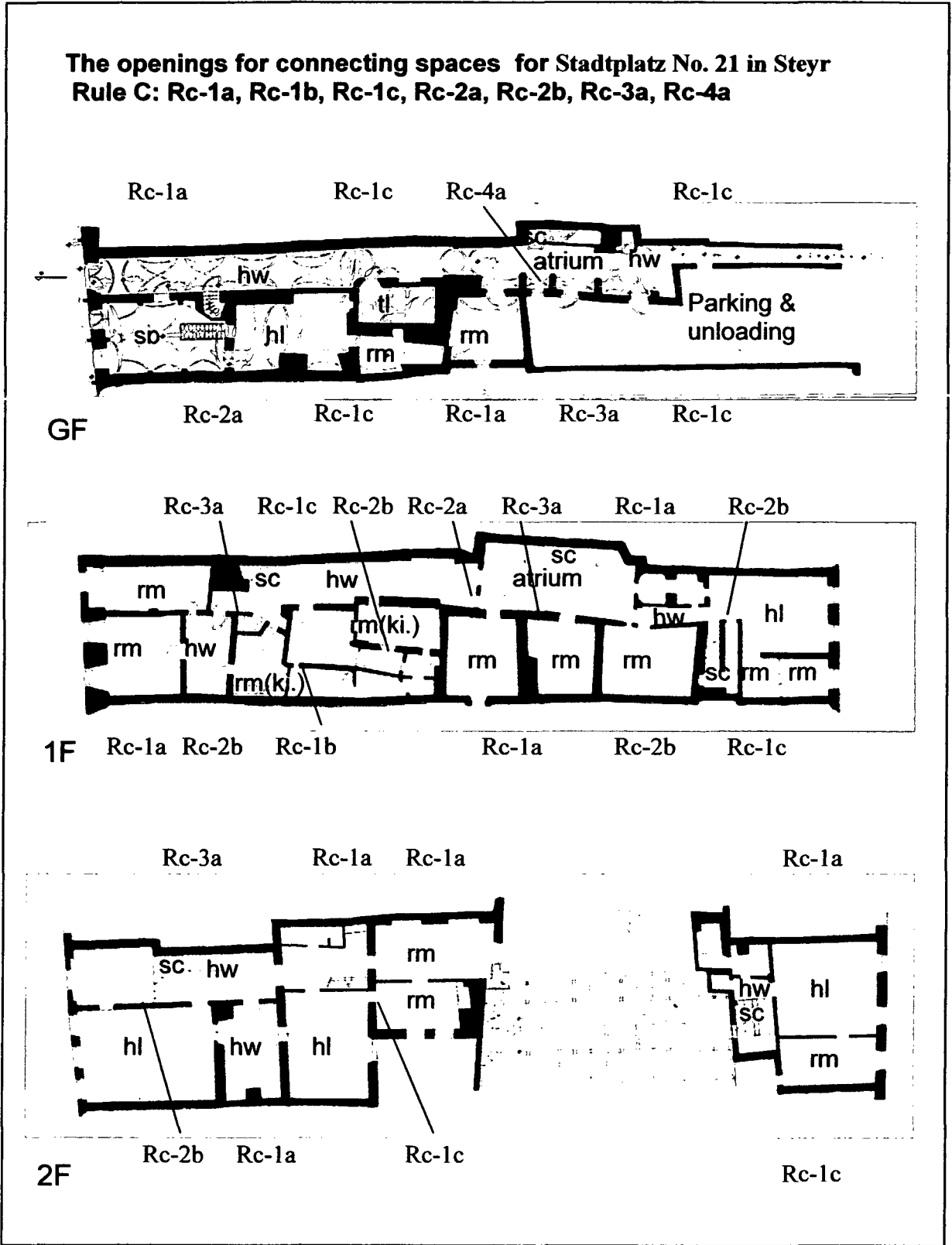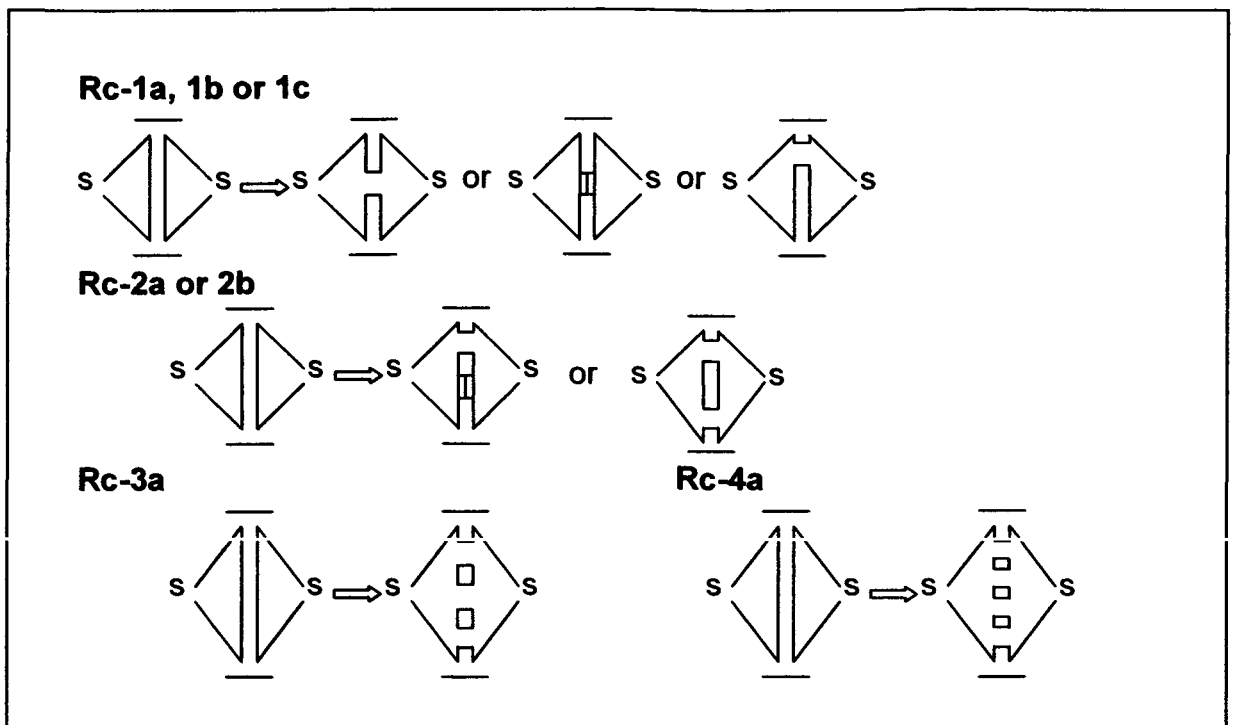
Figure 5. 21 Rule C for the floor plans at Stadtplatz No. 21 in Steyr

5. The openings for connections between blocks - Rule D:

Atriums are connections between blocks in some of the traditional Austrian town houses. Here an atrium is indicated by label 'ct' and sidewalls are indicated by label 'w'.

This schemata, Rule D, for the floor plans at Stadtplatz No. 21 in Steyr has three kinds of connections between blocks and are shown in Figure 5.22.
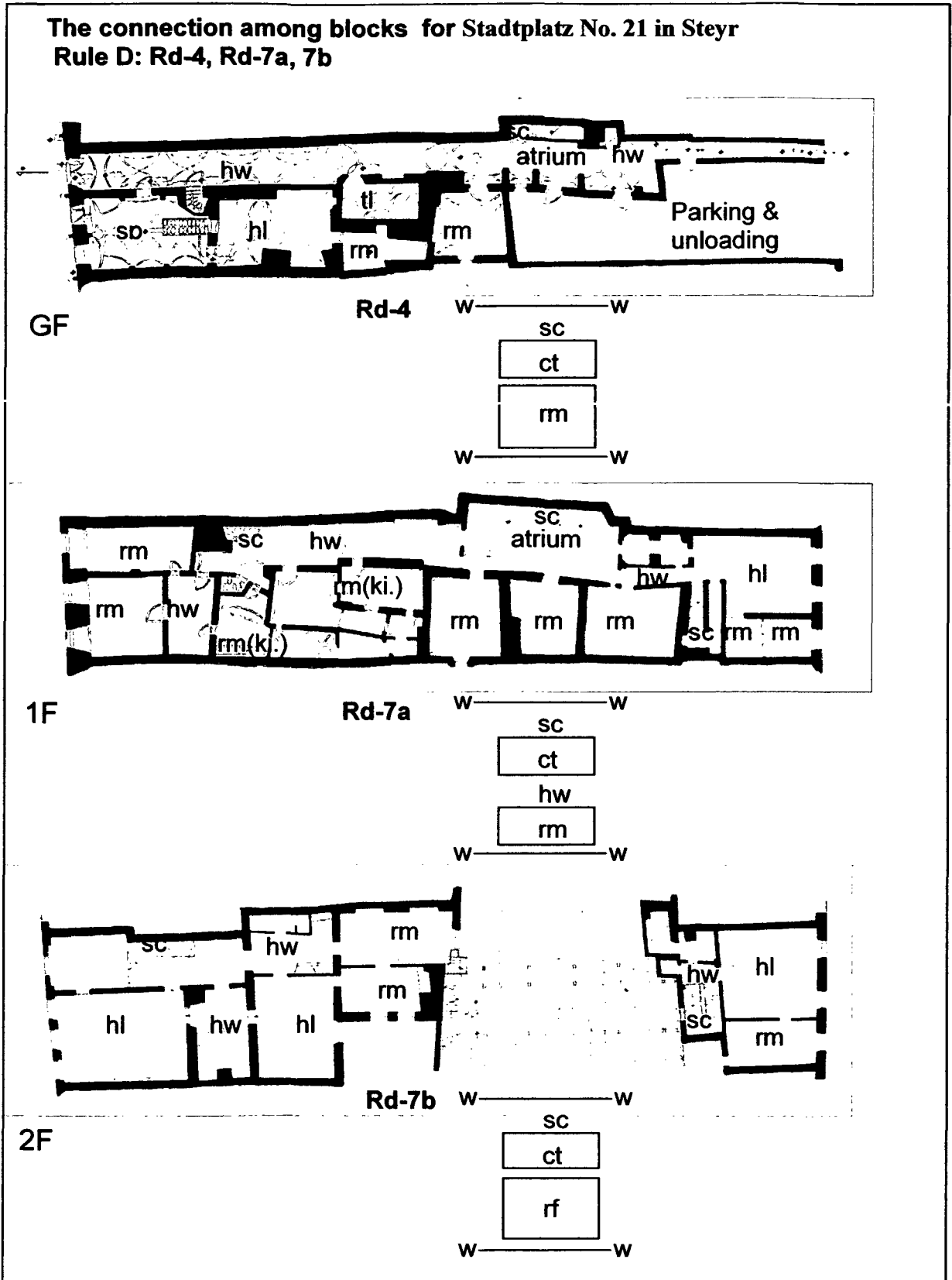
Figure 5. 22 Rule D for the floor plans at Stadtplatz No. 21 in Steyr

5.4   Conclusions

5.4.1   Shape grammars for facades of traditional town houses in Innsbruck and Steyr
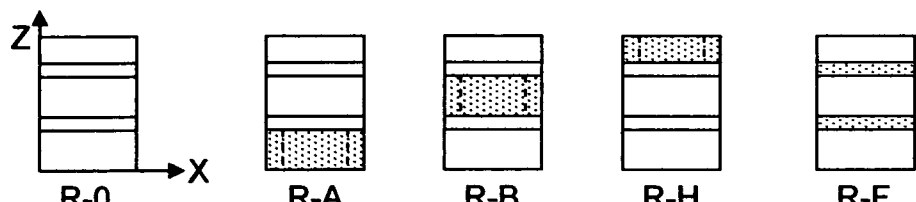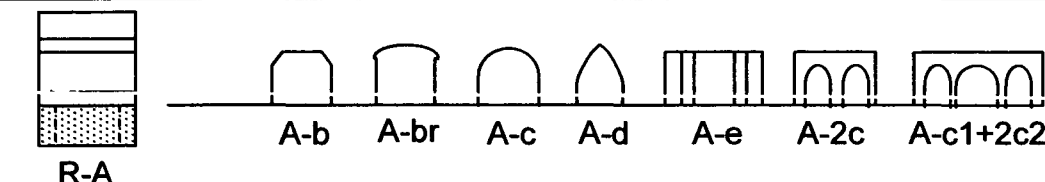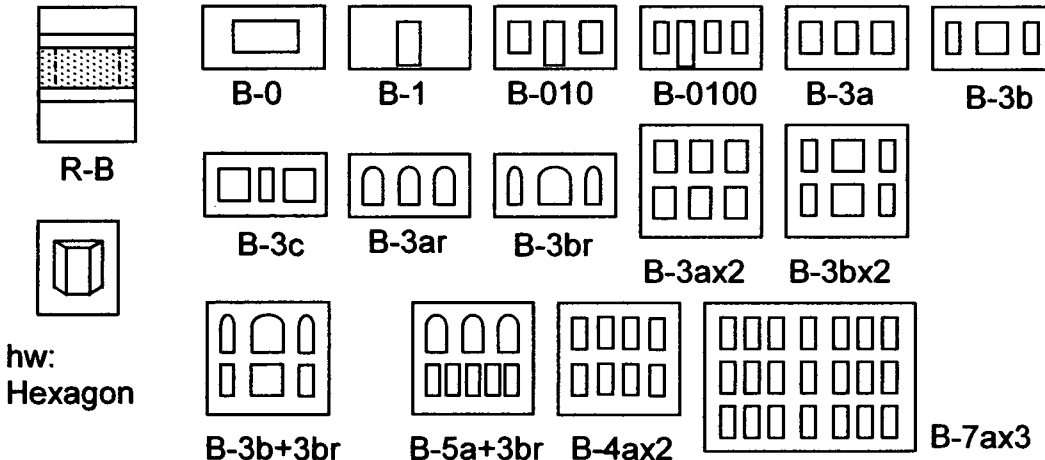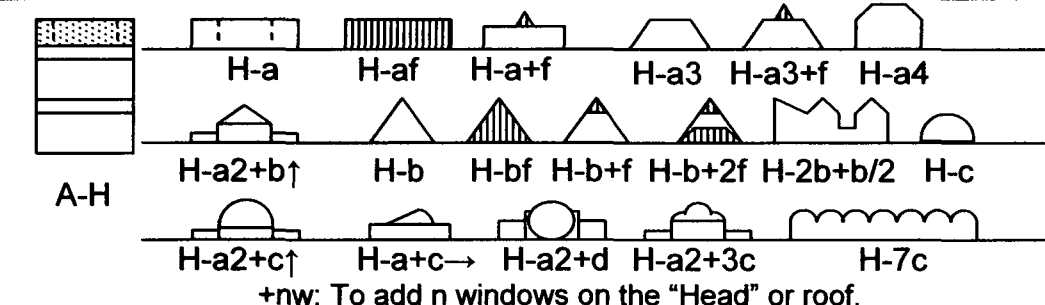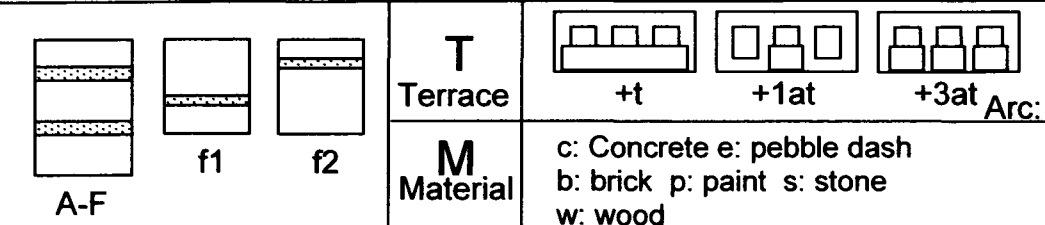
The rules of shape grammars for façades of traditional town houses in Innsbruck and Steyr

R Rule

Z   →X

R-0   R-A   R-B   R-H   R-F

A Arcad

R-A

A-b   A-br   A-c   A-d   A-e   A-2c   A-c1+2c2

B Body

R-B

hw: Hexagon

B-0   B-1   B-010   B-0100   B-3a   B-3b

B-3c   B-3ar   B-3br

B-3ax2   B-3bx2

B-3b+3br   B-5a+3br   B-4ax2   B-7ax3

H Head

A-H

H-a   H-af   H-a+f   H-a3   H-a3+f   H-a4

H-a2+b↑   H-b   H-bf   H-b+f   H-b+2f   H-2b+b/2   H-c

H-a2+c↑   H-a+c→   H-a2+d   H-a2+3c   H-7c

+nw: To add n windows on the "Head" or roof.

F Frieze

A-F   f1   f2

T Terrace

M Material

+t   +1at   +3at   Arc: r

c: Concrete   e: pebble dash
b: brick   p: paint   s: stone
w: wood

Figure 5- 23 The rules of shape grammars for facades of traditional town houses in Innsbruck and Steyr

5.4.2 Shape grammars for floor plans of traditional town houses in Innsbruck and Steyr

Rule A: The Generation of a unit pattern
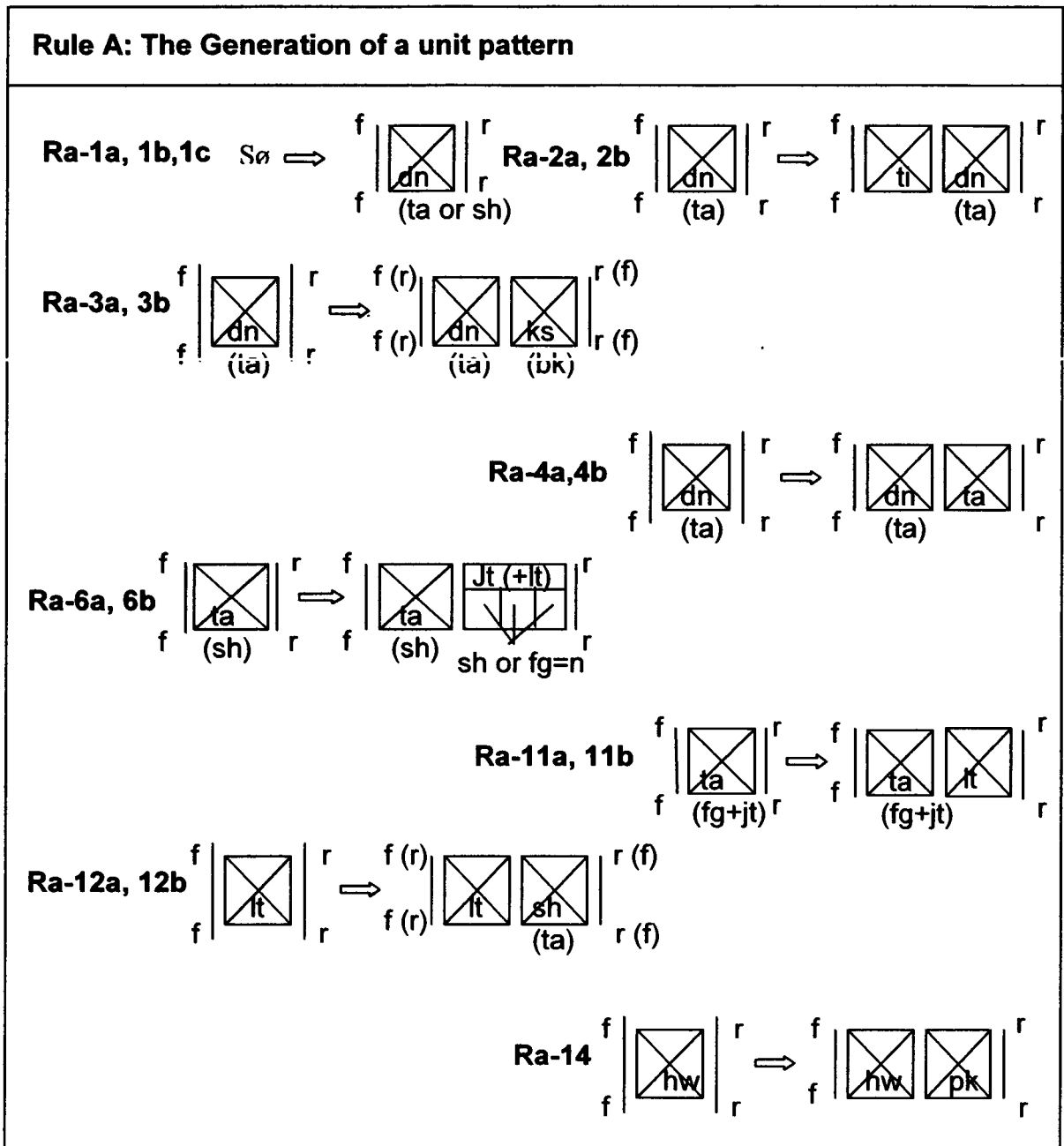
Rule B: Openings on outer walls

Rb-0a, 0b or 0c
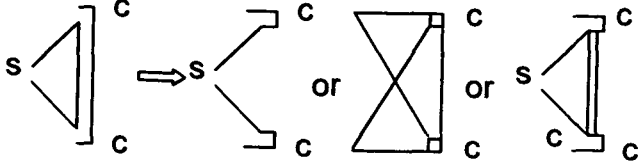
Rb-1a or 1c
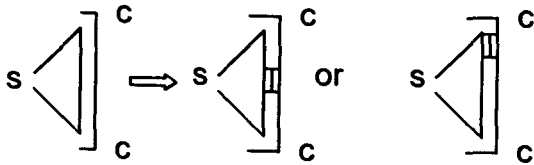
Rb-2a, 2b or 2c
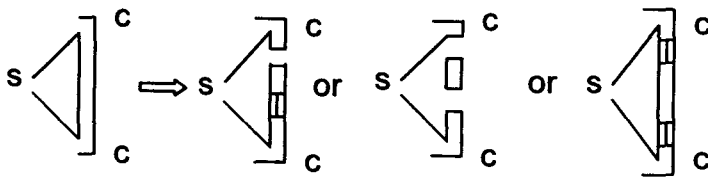
Rb-3a or 3b
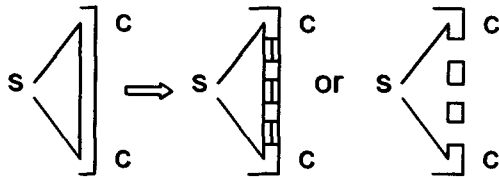
Rb-4a or 4b

Rule C: Openings for connecting Spaces

Rc-1a, 1b or 1c

Rc-1e

Rc-2a or 2b

Rc-3a

Rc-4a

Rule D: The connections between blocks

Rd-4

Rd-7a

Rd-7b
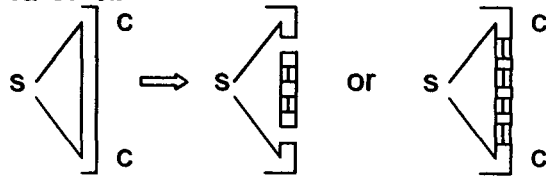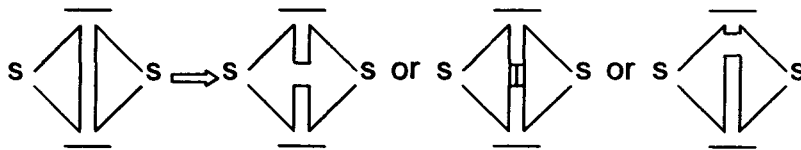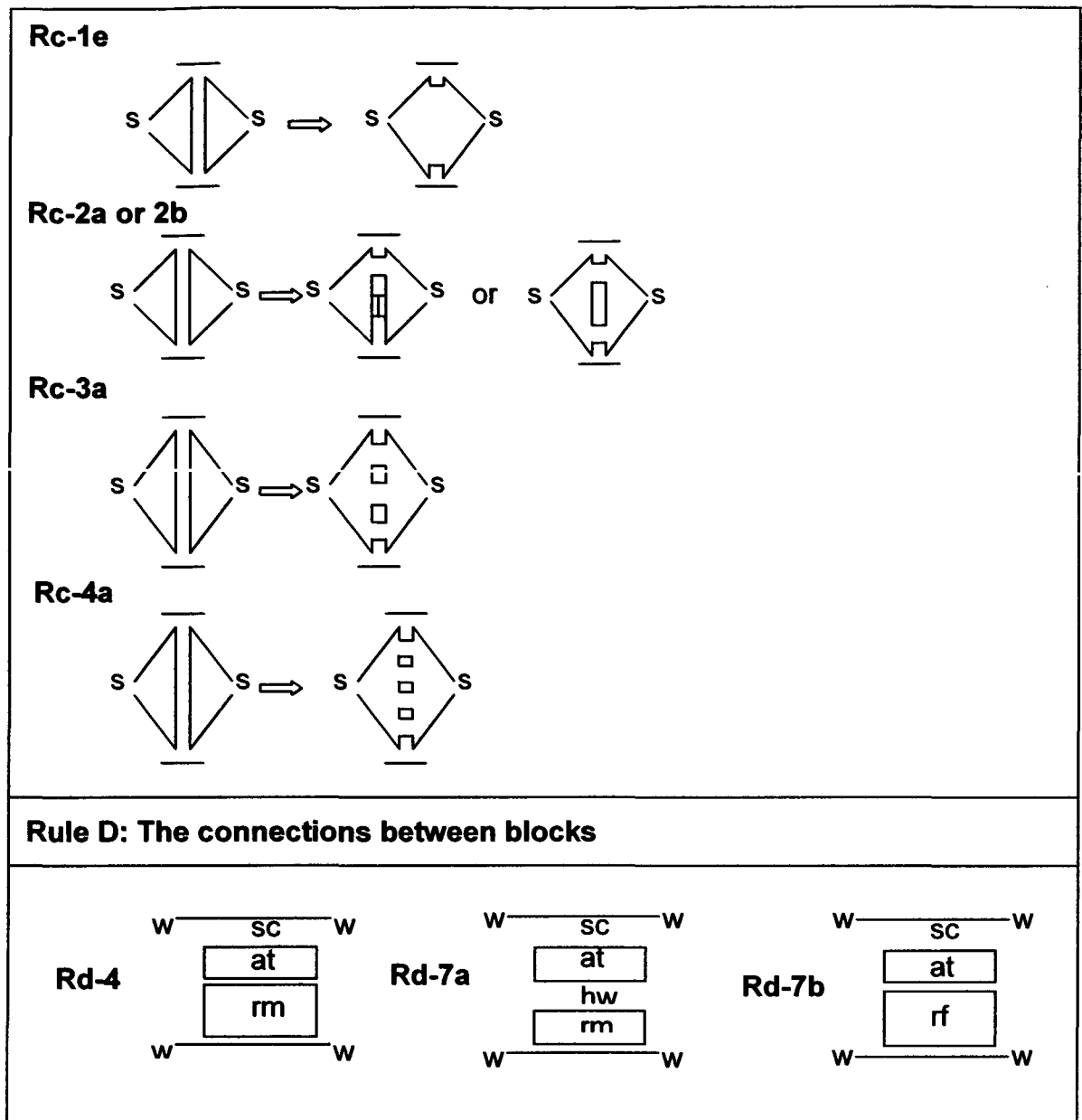
Figure 5. 24   The rules of shape grammars for floor plans of traditional town houses in Innsbruck and Steyr

5.4.3 The shape grammars for facades in Innsbruck and Steyr

	No. Rule	Rule A	Rule B	Rule F	Rule H	Rule M	T
INNSBRUCK I	No.14	A-2c	B-(2a+hb)x3+1at	f2	H-bf	p-p-p	1at
	No.12	A-2c	B-3ax5	---	H-a2+b↑	s-p-p	---
	No.10	A-2d	B-(hb+2a)x4	f1, f2	H-a2+c↑	p-p-p	---
	No.16	A-c1+c2	B-(hb+2a)x4	f2	H-a+c→	s-sp-p	---
	No.35	A-2c	B-(2a+hb)x3+3a	f2	H-af+2w	p-p-p	---

	No. Rule	Rule A	Rule B	Rule F	Rule H	Rule M	T
INNSBRUCK II	No.22	A-3d	B-2(hb+a)x3+4a	f1	H-a4	sp-p-p	---
	No.20-18	A-3d	B- (2(hb+a)+b)x4	---	H-2b+b/2	sp-p-p	---
	No.23	A-2d	B-3bx3+3a	---	H-c1+2c2	s-sp-p	---
	No.25	A-2br	B-3cx3+3a	---	H-b+f	sp-p-p	---
	No.39	A-2c	B-(3a+hb+a)x3+5a	f1, f2	H-bf	p-p-p	---

	No Rule	Rule A	Rule B	Rule F	Rule H	Rule M	T
STEYR I	No.19	AB-4c1011	B-3ax2+f	f1	H-b+f+2w	p-p-pb	---
	No.21	AB-3br110	B- 3a+4a+f	f1	H-b+f+2w	sp-s-sb	---
	No.32	AB-3b010	B-4b+b+t	f1,f2	H-b+2f+5w+cw	p-p-pb	t
	No.35	AB-5c00100	B-5a	f1,f2	H-b+f+3w+cw	p-p-pb	---
	No.40	AB-3br100	B-3ax2	f1,f2	H-b+f+2w	p-p-pb	---

	No.	Rule A	Rule B	Rule F	Rule H	Rule M	T
STEYR II	No.44	AB-3c0101	B-3ax2	f2	H-b+f+3w	p-p-pb	---
	No.42	AB-2br10	B- 3ax3	f1,f2	H-a+f	p-p-pb	---
	No.9	AB-7br0001000	B-7ax3	f1,f2	H-7c	p-p-p	---
	No.10 G.	AB-3br00100	B-4ax2	f1,f2	H-a3+f+4w	p-p-pb	---
	No.4 G.	AB-3c100	B-3ax2	f1,f2	H-b+f+2w	p-p-pb	---

Table 5. 6   The shape grammars for facades of traditional town houses in Innsbruck and Steyr

5.4.4 The shape grammars for floor plans in Innsbruck and Steyr:

1. The Rule A

Rule A: The Generation of a Unit Pattern								
	Ra-1a	Ra-1b	Ra-1c	Ra-2a	Ra-2b	Ra-3a	Ra-3b	Ra-4a
Innsbruck	x	x		x			x	x
Steyr	x	x			x			x

Rule A								
	Ra-4b	Ra-5	Ra-6a	Ra-6b	Ra-7	Ra-8	Ra-9	Ra-10
Innsbruck	x		x					
Steyr	x		x					

Rule A						
	Ra-11a	Ra-11b	Ra-12a	Ra-12b	Ra-13	Ra-14
Innsbruck	x			x		
Steyr	x					x

Table 5. 7 Rule A for the floor plans of traditional town houses in Innsbruck and Steyr

2. The Rule B

Rule B: The Opening on outer walls								
	Rb-0a	Rb-0b	Rb-0c	Rb-1a	Rb-1b	Rb-1c	Rb-2a	Rb-2b
Innsbruck	x	x				x	x	
Steyr			x	x		x		x

Rule B								
	Rb-2c	Rb-2d	Rb-3a	Rb-3b	Rb-3c	Rb-3d	Rb-4a	Rb-4b
Innsbruck			x	x			x	
Steyr	x		x					x

Table 5. 8 Rule B for facades of traditional town houses in Innsbruck and Steyr

3. The Rule C

Rule C: The Opening for Connecting Space								
	Rc-1a	Rc-1b	Rc-1c	Rc-1d	Rc-1e	Rc-2a	Rc-2b	Rc-2c
Innsbruck	x	x	x		x	x	x	
Steyr	x	x	x			x	x	

Rule C			
	Rc-3a	Rc-3b	Rc-4a
Innsbruck			x
Steyr	x		x

Table 5. 9 Rule C for facades of traditional town houses in Innsbruck and Steyr

4. The Rule D

Rule D: The Connection among Blocks										
	Rd-0	Rd-1	Rd-2	Rd-3	Rd-4	Rd-5	Rd-6	Rd-7a	Rd-7b	Rd-8a	Rd-8b
Innsbruck											
Steyr					x			x	x		

Table 5. 10 Rule D for the facades of traditional town houses in Innsbruck and Steyr

5.4.5 Comments on Comparisons

The advantage of shape grammar is that everyone can discover the similarities and dissimilarities from rules indicated in the above tables. I will just write a few comments as examples:

Similarities

− In the facades, Rule A-2c, 2d and 3d were applied frequently on facades in Innsbruck. It illustrates two or three arches in a row, which are a popular pattern of arcades in traditional town houses in Innsbruck.

− In the facades, Rule AB-3c100, 4c1011 or 5c00100 explain a kind of cantilever eave with three, four or five arches instead of arcades. They are applied quite often and look like arcades in the traditional town houses in Steyr.

− In the floor plans, Rule Rb-1c and 3a, which are window on one side and three windows in a row on the wall, were both used for the openings on outer walls on floor plans in Innsbruck and Steyr.

− In the floor plans, Rule Rc-4a, which has four doorways in a row on the wall, is a common rule for the openings for connecting spaces on floor plans in Innsbruck and Steyr.

Dissimilarities

− In the facades, the style of roofs in Steyr, which has basically a triangle shape on the facades, H-b+f or H-b+2f, is special and different from the roofs in Innsbruck or other towns in Austria.

− In the facades, the Rule B-(2a+hb)x3 or B-(2a+hb)x4, which contain hexagonal windows on the facades, were only applied in the traditional town houses in our examples in Innsbruck.

− In the floor plans, Rb-4b that has four windows in a row on the wall is only applied in Steyr.

− In the floor plans, Rd-4, 7a and 7b confirm that an atrium with stairs, room and porch is a special pattern for the connections between blocks. Actually an Austrian traditional town house with an atrium is very different from a Taiwanese traditional town house with one to three courtyards.

Chapter 6

Comparison and Conclusions

6.1 Shape grammars of the traditional town houses in Taiwan and Innsbruck and Steyr in Austria

The logic and clarity of shape grammars make the comparisons and conclusions easy to define as well as comprehend. The simplicity and flexibility of shape grammars make them useful for a diversity of projects with different constraints and goals, making them complementary to a diversity of design methods or philosophies described by different designers. Although shape grammars are used for design theory and method in the design studio, it has been shown as a very useful and practical tool for undertaking a comparative research in morphology and typology of architecture in this research.

6.1.1 Rules of shape grammars for the facades

Figure 6. 1 The shape grammars for facades of traditional town houses in Taiwan and
Innsbruck and Steyr in Austria

6.1.2 Rules of shape grammars for floor plans

Rule B: Openings on outer walls

Rb-0a, 0b or 0c

Rb-1a, 1b, 1c or 1d

Rb-2a, 2b, 2c, 2d or 2e

Rb-3a, 3b, 3c or 3d

Rb-4a

Rule C: Openings for connecting Space

Rc-1a, 1b or 1c

Rc-1d or 1e
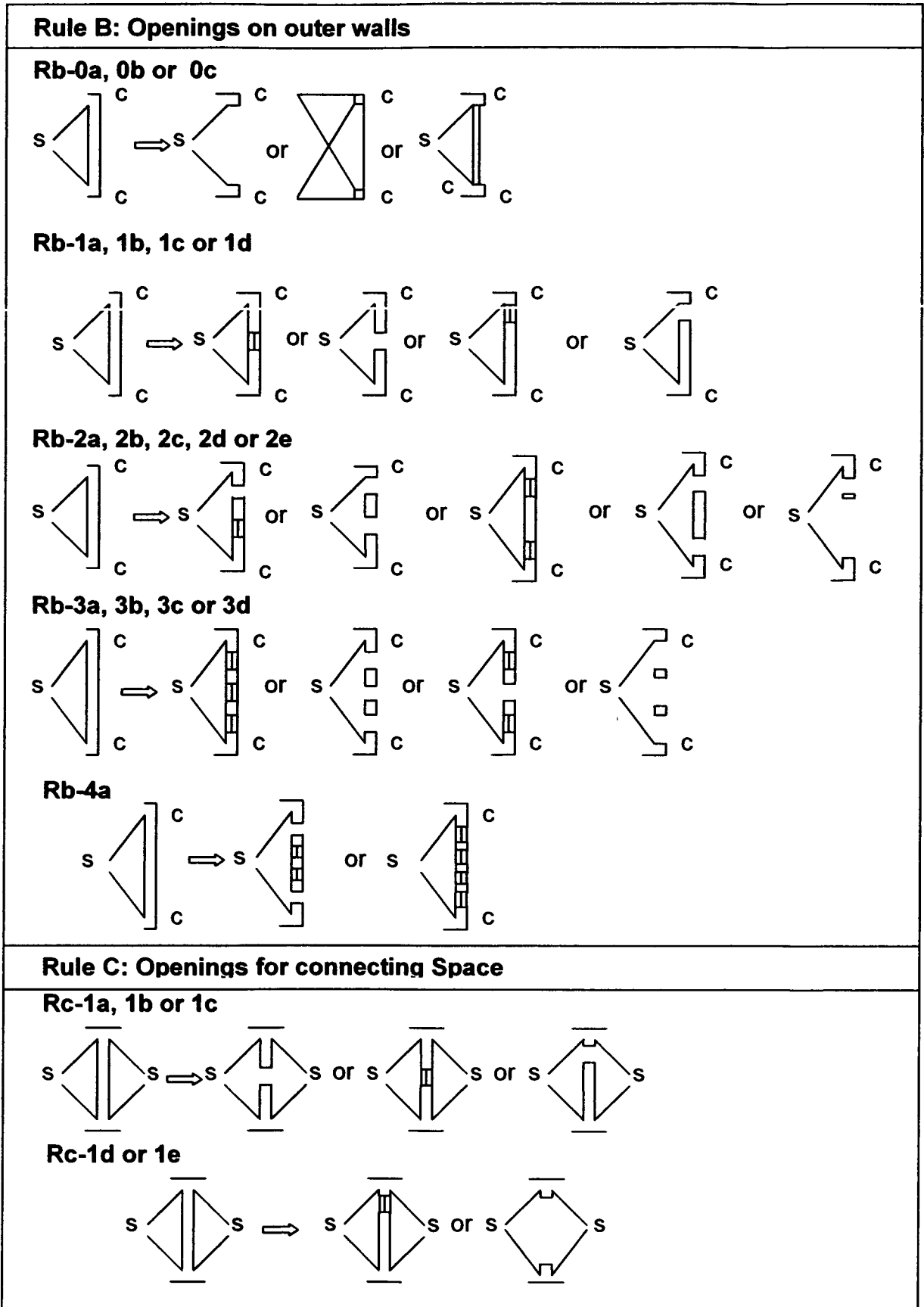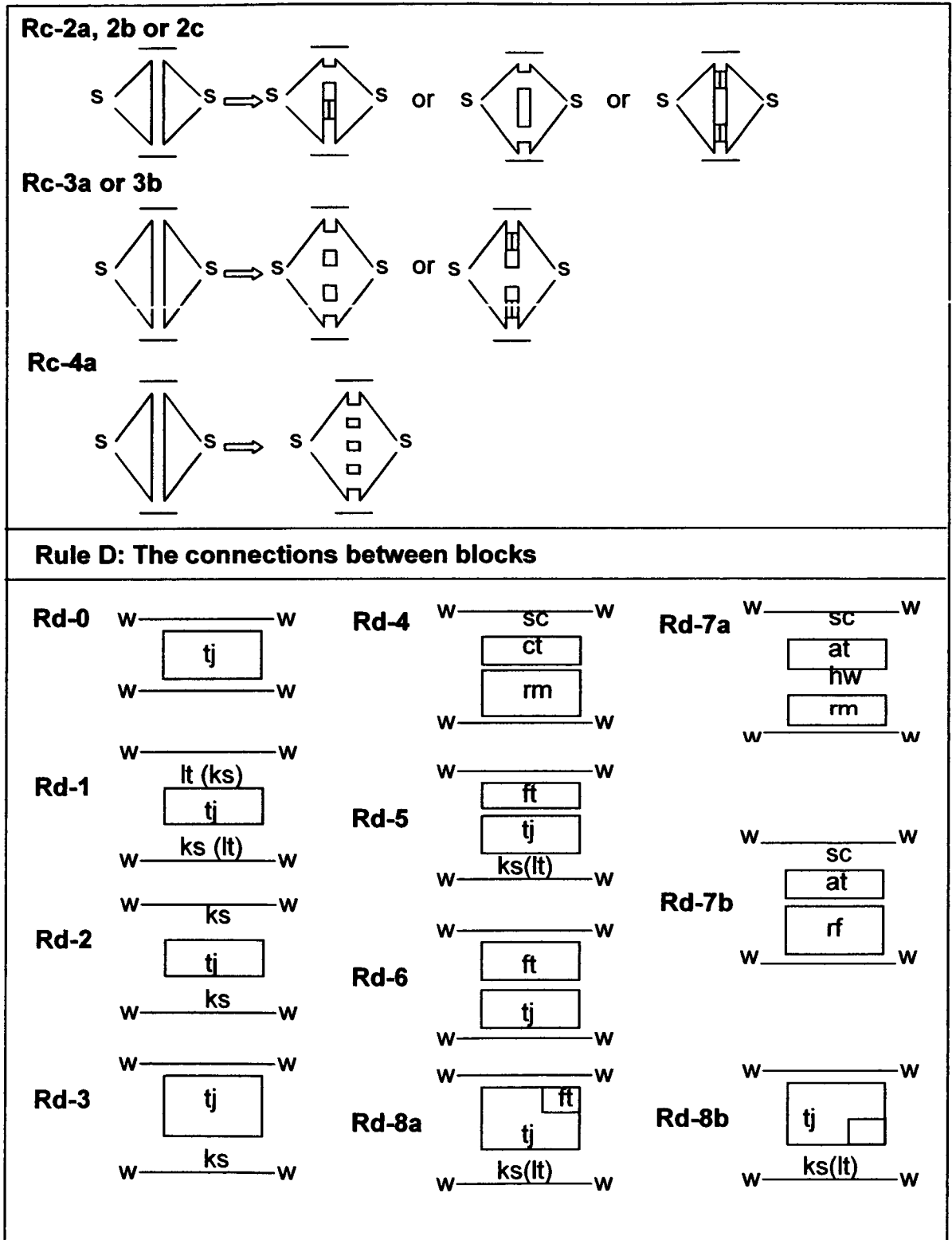
Figure 6. 2 The shape grammars for floor plans of traditional town houses in Taiwan and Innsbruck and Steyr in Austria

6.2 Comparison of traditional town houses between Taiwan and Innsbruck and Steyr in Austria

Through the above shape grammars for these traditional town houses in Taiwan and Austria, all the rules projected the similarities and differences between diverse versions of components in traditional town houses:

1. **The rules of the facades:** The styles of arcades, bodies of houses, parapets, roofs, terraces, friezes and material illustrated the identical, the similar and the dissimilar features and combinations according to our rules. Some of them also reflect the characteristics relative to the historical background, climate and traditions.

2. **The rules of the floor plans:** The derivations for generation of a unit pattern, the openings of outer walls, the openings for connecting spaces and the connections between blocks reveal the characteristics of the floor plans through these rules.

3. **The limit of the rules:** The shapes and rules that we defined limit the shape grammars for traditional town houses. The flexibility of shape grammars is an advantage for designing and accommodating numerous and diverse types of architecture. In contrast, it is also limited by the examples that we choose. The results of comparison have been listed below.

6.2.1 Comparison of facades

1. The Rule A

DIHWA STREET				DAXI			
No.	Rule A	No.	Rule A	No.	Rule A	No.	Rule A
No.24	A-a	No.135	A-a	No.48-1	A-c	No.84	A-e
No.44	A-b	No.133	A-b	No.48	A-e	No.86	A-e
No.71	A-a	No.131	A-b	No.49	A-e	No.12	A-c1+2c2
No.114	A-e	No.148	A-a	No.50	A-c1+2c2	No.13	A-c1+2c2
No.352	A-c1+ 2c2	No.152	A-a	No.81	A-b	No.15	A-c1+2c2

XINHWA					LUKANG			
No.	Rule A	No.	Rule A		No.	Rule A	No.	Rule A
No.338	A-b	No.409	A-a		No.6	---	Y. No.25	---
No.401	A-b	No.411	A-a		No.7	---	P. No.19	---
No.403	A-b	No.413	A-a		No.17	---	P. No.55	---
No.405	A-b	No.415	A-b		No.18	---	Z. No.147	A-b
No.407	A-b	No.435	A-b		No.16	---	Z. No.149	A-b

INNSBRUCK			
No.	Rule A	No.	Rule A
No.14	A-2c	No.22	A-3d
No.12	A-2c	No.20-18	A-3d
No.10	A-2d	No.23	A-2d
No.16	A-c1+c2	No.25	A-2br
No.35	A-2c	No.39	A-2c

STEYR			
No.	Rule A	No.	Rule A
No.19	AB-4c1011	No.44	AB-3c0101
No.21	AB-3br110	No.42	AB-2br10
No.32	AB-3b010	No.9	AB-7br0001000
No.35	AB-5c00100	G. No.10	AB-3br00100
No.40	AB-3br100	G. No.4	AB-3c100

Table 6. 1 Rule A for comparison of facades

2.The Rule B

DIHWA STREET			
No.	Rule B	No.	Rule B
No.24	B-3bx2	No.135	B-3ax2
No.44	B-3ax2	No.133	B-3b+3br+rt
No.71	B-3as+cs+t	No.131	B-3bx2+t
No.114	B-3br+3at	No.148	B-r(5a+3ar)
No.352	B-3b	No.152	B-3a+3ar

DAXI			
No.	Rule B	No.	Rule B
No.48-1	---	No.84	---
No.48	---	No.86	---
No.49	---	No.12	---
No.50	---	No.13	---
No.81	---	No.15	---

LUKANG			
No.	Rule B	No.	Rule B
No.6	B-1+cs	Y. No.25	B-010
No.7	B-0100	P. No.19	B-0010
No.17	B-1	P. No.55	B-1
No.18	B-1+3cs	Z. No.147	B-3b+at
No.16	B-010+3cs	Z. No.149	B-2(3b+t)

XINHWA			
No.	Rule B	No.	Rule B
No.338	B-3br+rt	No.409	B-3b
No.401	B-3ar	No.411	B-3a
No.403	B-3ar	No.413	B-3a
No.405	B-3ar	No.415	B-3br+t
No.407	B-0+t	No.435	B-3ax2

INNSBRUCK			
No.	Rule B	No.	Rule B
No.14	B-(2a+hb)x3+1at	No.22	B-2(hb+a)x3+4a
No.12	B-3ax5	No.20-18	B- (2(hb+a)+b)x4
No.10	B-(hb+2a)x4	No.23	B-3bx3+3a
No.16	B-(hb+2a)x4	No.25	B-3cx3+3a
No.35	B-(2a+hb)x3+3a	No.39	B-(3a+hb+a)x3+5a

STEYR			
No.	Rule B	No.	Rule B
No.19	B-3ax2+f	No.44	B-3ax2
No.21	B- 3a+4a+f	No.42	B- 3ax3
No.32	B-4b+b+t	No.9	B-7ax3
No.35	B-5a	G. No.10	B-4ax2
No.40	B-3ax2	G. No.4	B-3ax2

Table 6. 2 Rule B for comparison of facades

3.The Rule H

DIHWA STREET			
No.	Rule H	No.	Rule H
No.24	H-a2+d	No.135	H-a2+c↑
No.44	H-a2+b↓	No.133	H-a2+c↑
No.71	H-a	No.131	H-a2+c↑
No.114	H-a2+b↑	No.148	H-a2+c↑
No.352	H-a	No.152	H-a2+c↑

DAXI			
No.	Rule H	No.	Rule H
No.48-1	H-a2+b↑	No.84	H-a2+b ↑
No.48	H-a2+c ↑	No.86	H-a2+c ↑
No.49	H-a2+c ↑	No.12	H-a2+b ↑
No.50	H-a2+b↑	No.13	H-a2+3c
No.81	H-a2+b↑	No.15	H-a2+b ↑

LUKANG			
No.	Rule H	No.	Rule H
No.6	H-af	Y. No.25	H-af
No.7	H-af	P. No.19	H-af+2w
No.17	H-af	P. No.55	H-af+w
No.18	H-af	Z. No.147	H-a
No.16	H-af+1w	Z. No.149	H-a

XINHWA			
No.	Rule H	No.	Rule H
No.338	H-a2+c↑	No.409	H-a2+c↓
No.401	H-a2+c↑	No.411	H-a2+b↑
No.403	(H-a2+b↑)/2	No.413	H-a2+c↑
No.405	(H-a2+b↑)/2	No.415	H-a2
No.407	H-a2+c↑	No.435	H-a

INNSBRUCK			
No.	Rule H	No.	Rule H
No.14	H-bf	No.22	H-a4
No.12	H-a2+b↑	No.20-18	H-2b+b/2
No.10	H-a2+c↑	No.23	H-c1+2c2
No.16	H-a+c→	No.25	H-b+f
No.35	H-af+2w	No.39	H-bf

STEYR			
No.	Rule H	No.	Rule H
No.19	H-b+f+2w	No.44	H-b+f+3w
No.21	H-b+f+2w	No.42	H-a+f
No.32	H-b+2f+5w+cw	No.9	H-7c
No.35	H-b+f+3w+cw	G. No.10	H-a3+f+4w
No.40	H-b+f+2w	G. No.4	H-b+f+2w

Table 6. 3 Rule C for comparison of facades

4. The Rule F, Rule M and Rule T

DIHWA STREET							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.24	f2	eb-eb-eb	---	No.135	f2	eb-eb-e	---
No.44	f2	e-e-e	---	No.133	f2	eb-eb-e	rt
No.71	---	e-e-e	t	No.131	f2	eb-eb-e	rt
No.114	f1,f2	e-e-e	3at	No.148	rf2	e-e-e	rt
No.352	f1,f2	b-b-b	---	No.152	f2	e-e-e	---

DAXI							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.48-1	f1	e-e	---	No.84	f1	be-e-be	---
No.48	f1	e-e	---	No.86	f1	be-e-be	---
No.49	f1	be-e	---	No.12	f1	be-e-be	---
No.50	f1	e-e	---	No.13	f1	be-b-e	---
No.81	f1	be-be	---	No.15	f1	be-b-e	---

LUKANG							
No.	Rule F	Rule M	T	No.	Rule f2	Rule M	T
No.6	---	wb-bw	---	Y. No.25	---	bw-bw	---
No.7	---	b-bw	---	P. No.19	---	be-bw	---
No.17	---	wb-bw	---	P. No.55	---	wb-bw	---
No.18	---	wb-bw	---	Z. No.147	f2	e-e-e	---
No.16	---	b-bw	---	Z. No.149	f2	e-e-e	---

XINHWA							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.338	f2	be-be-e	rt	No.409	f1,rf2	e-e-e	---
No.401	f1,f2	e-e-e	---	No.411	f1,f2	e-e-e	---
No.403	f1,f2	e-e-e	---	No.413	f1,f2	e-be-e	---
No.405	f1,f2	e-e-e	---	No.415	f2	e-be-be	t
No.407	f2	e-e-e	t	No.435	f1	e-be-be	---

INNSBRUCK							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.14	f2	p-p-p	1at	No.22	f1	sp-p-p	---
No.12	---	s-sp-p	---	No.20-18	---	sp-p-p	---
No.10	f1, f2	p-p-p	---	No.23	---	s-sp-p	---
No.16	f2	s-sp-p	---	No.25	---	sp-p-p	---
No.35	f2	p-p-p	---	No.39	f1, f2	p-p-p	---

STEYR							
No.	Rule F	Rule M	T	No.	Rule F	Rule M	T
No.19	f1	p-p-pb	---	No.44	f2	p-p-pb	---
No.21	f1	sp-s-sb	---	No.42	f1,f2	p-p-pb	---
No.32	f1,f2	p-p-pb	t	No.9	f1,f2	p-p-p	---
No.35	f1,f2	p-p-pb	---	G. No.10	f1,f2	p-p-pb	---
No.40	f1,f2	p-p-pb	---	G. No.4	f1,f2	p-p-pb	---

Table 6. 4 Rule F, M & T for comparison of facades

6.2.2 Comparison of floor plans

1. Rule A- The generation of a unit pattern:

Rule A: The Generation of a Unit Pattern								
	Ra-1a	Ra-1b	Ra-1c	Ra-2a	Ra-2b	Ra-3a	Ra-3b	Ra-4a
Dihwa St.	x	x	x	x		x	x	
Daxi	x	x	x	x			x	
Lukang	x	x		x			x	x
Xinhwa	x	x		x		x	x	
Innsbruck	x	x		x			x	x
Steyr	x	x			x			x

Rule A							
	Ra-4b	Ra-5	Ra-6a	Ra-6b	Ra-7	Ra-8	Ra-9	Ra-10
Dihwa St.	x			x				
Daxi		x		x			x	
Lukang			x	x	x	x	x	x
Xinhwa			x					
Innsbruck	x		x					
Steyr	x		x					

Rule A						
	Ra-11a	Ra-11b	Ra-12a	Ra-12b	Ra-13	Ra-14
Dihwa St.						
Daxi						
Lukang					x	
Xinhwa	x	x	x			
Innsbruck	x			x		
Steyr	x					x

Table 6. 5 Rule A for comparison of floor plans

2. Rule B- The openings of outer walls:

Rule B: The Openings on outer walls								
	Rb-0a	Rb-0b	Rb-0c	Rb-1a	Rb-1b	Rb-1c	Rb-2a	Rb-2b
Dihwa St.	x	x	x	x	x		x	
Daxi	x	x			x	x	x	
Lukang	x	x	x	x	x		x	
Xinhwa	x	x	x	x	x		x	
Innsbruck	x	x				x	x	
Steyr			x	x		x		x

Rule B								
	Rb-2c	Rb-2d	Rb-3a	Rb-3b	Rb-3c	Rb-3d	Rb-4a	Rb-4b
Di-hwa St.	x		x		x	x	x	
Daxi					x			
Lukang		x	x		x	x		
Xinhwa			x					
Innsbruck			x	x			x	
Steyr	x		x					x

Table 6. 6 Rule B for comparison of floor plans

3. Rule C - The openings for connecting spaces:

Rule C: The Openings for Connecting Spaces								
	Rc-1a	Rc-1b	Rc-1c	Rc-1d	Rc-1e	Rc-2a	Rc-2b	Rc-2c
Dihwa St.	x	x	x			x	x	
Daxi	x		x				x	
Lukang		x	x	x	x	x	x	
Xinhwa			x					
Innsbruck	x	x	x		x	x	x	
Steyr	x	x	x			x	x	

Rule C			
	Rc-3a	Rc-3b	Rc-4a
Dihwa St.		x	
Da-xi			
Lukang	x		
Xinhwa			
Innsbruck			x
Steyr	x		x

Table 6. 7 Rule C for comparison of floor plans

4. Rule D - The connections between blocks:

Rule D: The connections between blocks										
	Rd-0	Rd-1	Rd-2	Rd-3	Rd-4	Rd-5	Rd-6	Rd-7a	Rd-7b	Rd-8a	Rd-8b
Dihwa St.		x	x	x		x	x				
Daxi				x			x			x	x
Lukang				x		x	x				
Xinhwa	x										
Innsbruck											
Steyr					x			x	x		

Table 6. 8 Rule D for comparison of floor plans

6.2.3 Comments for comparison

The advantage of shape grammar is that everyone can find the similarities and dissimilarities from the rules depicted on the above tables. From each series of rules, e.g. Rule A for facades, we can see the diverse editions of arcades both in Taiwan and Austria. In Rule B for floor plans, we can observe diverse patterns of the openings on outer walls also in both Taiwan and Austria. Every reader can discover and interpret his own comments for the comparison. I will just write a few comments as examples:

Similarities

− In the facades, Rule B- 3ax2, which has three columns and two rows of windows, was used in two cases in Dihwa street, one case in Xinhwa and three cases in Steyr.

− In the facades, Rules H-a2+b↑ and H- a2+c↑, which have a similar semicircle or triangle on the parapet, were applied in Dihwa street, Xinhwa and Innsbruck. In general Taiwanese and Austrian traditional town houses have some similar features in the components of roofs which are: to reflect the period it was built, to highlight the infiuences of their styies and sometimes indicate the sociai status of the owners.

− In the floor plans, Rule b-3a, which has three windows in a row for the openings on outer walls on the floor plans, was applied to the examples in Dihwa street, Lukang and Xinhwa in Taiwan and Innsbruck and Steyr in Austria.

− In the floor plans, Rule c-2b, which has a window and a door on a wall for the openings of connecting spaces, was applied to the examples in Dihwa street, Daxi and Lukang in Taiwan and Innsbruck and Steyr in Austria.

− In the floor plans, Rule a-1a, 1b, which are the beginning rules for the generation of a unit pattern, were used in the traditional town houses in Taiwan and in Austria. However, the size of Austrian traditional town houses is generally larger than Taiwanese traditional town houses and the orders and rules for the generation of a unit pattern are still very different.

Dissimilarities

− In the floor plans, the Austrian traditional town houses normally can have three-bay or five-bay wide and two-bay or three-bay long shops. Although this does not translate into rules, we can still see the differences through the process of analysis.

− In the floor plans, Rb-3c, which has one doorway between two windows for the openings for outer walls, was only applied in Taiwan.

- In the floor plans, Rc-4a, which has four doorways for the openings for connecting spaces, was only applied in Austria.

- In the facades, Rule A- arcade, in Taiwan arcades are always used in traditional town houses due to the weather conditions. The use of arcades in Austria is limited to some cities, e.g. Innsbruck.

- In the facades, Rule B- body, the Taiwanese traditional town houses have normally a one-bay body and one-row or three-row windows. The Austrian town houses may have a one-bay to 5-bay body and one-row to seven-row windows.

6.3   The application of this research

Before arriving to the final subsection 6.4 'Conclusions', the following example will demonstrate the steps taken in undertaking a classification and generating 150 derivations for the proposals of a new town-house project on Zhongzhen road in Xinhwa, South Taiwan. This example will also explain and enhance the significance of this paper for future research, preservation and architectural design.

The area where traditional town houses are located on Zhongzhen Road in Xinhwa that we have already mentioned in Chapters 2.4.5; 3.3.5 and Chapter 4.3.3 will be taken as an example. There are forty-seven traditional town houses on this street. Ten facades of these forty-seven houses: No. 338, No. 401, No. 403, No. 405, No. 407, No. 409, No. 411, No. 413, No. 415 and No. 435, have been analyzed using our shape grammars (Figure 6. 3 and Figure 6.4).
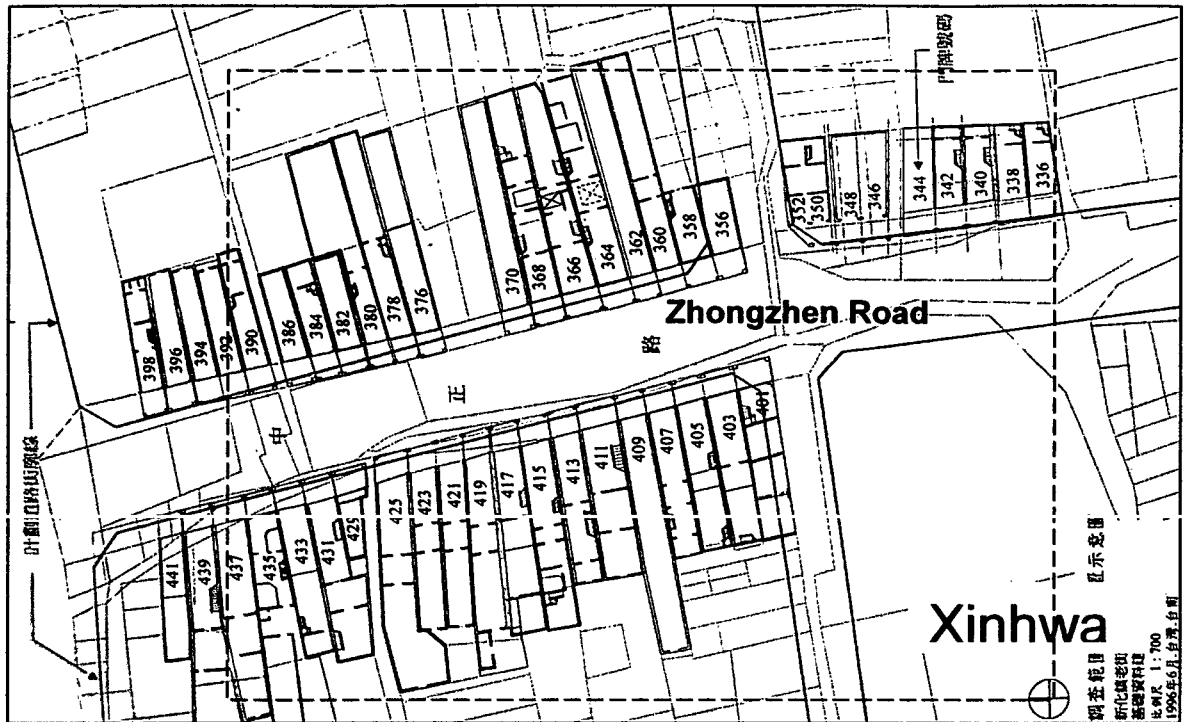
Figure 6. 3 Forty-seven traditional town houses on the Zhongzhen Road in Xinhwa
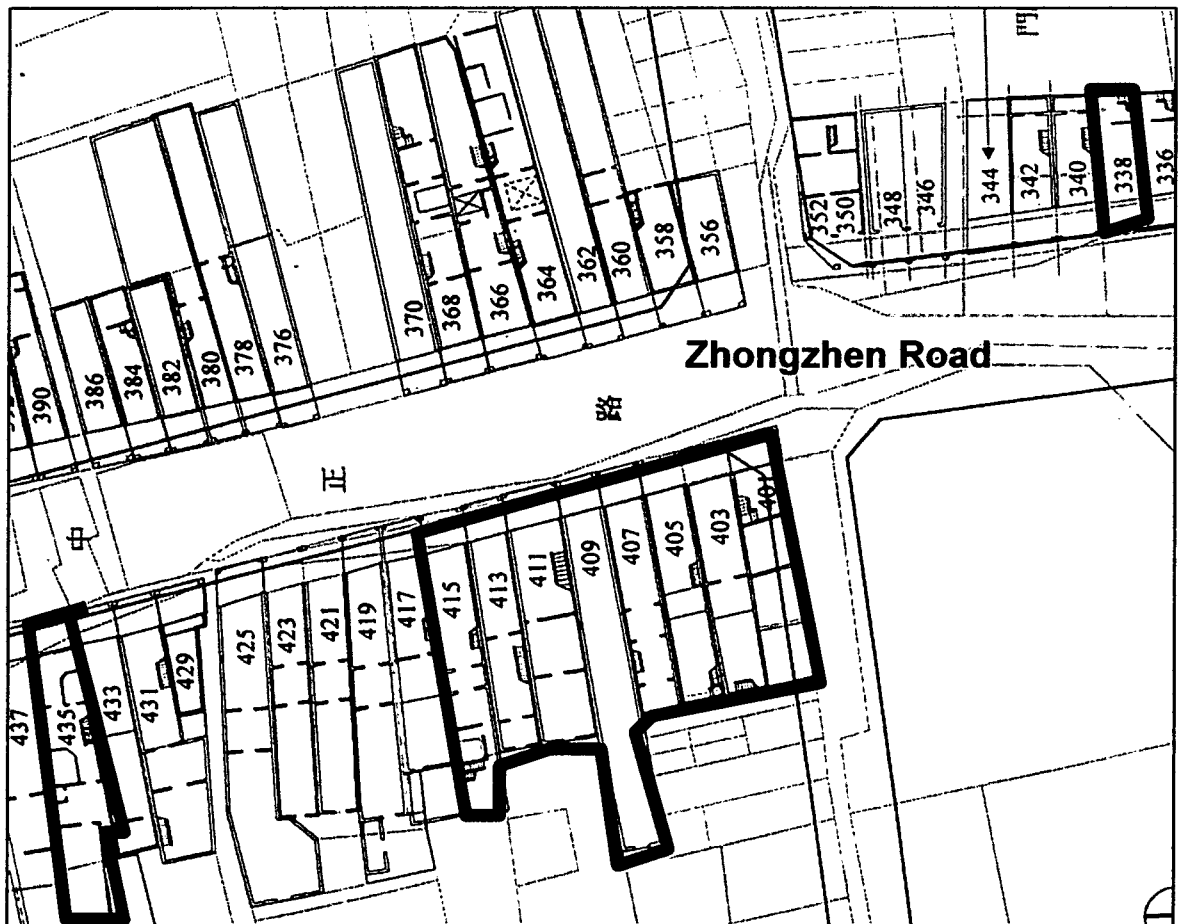
Figure 6. 4 Locations of the ten facades from these forty-seven houses have been analyzed by our shape grammars

6.3.1 Classification

Suppose we are undertaking a new classification of facades of traditional town houses in this area. Firstly, rules would be set up according to the characteristics that we are going to classify. Secondly, these forty-seven houses will be analyzed in accordance with these rules using shape grammars. Thirdly, these houses will then be classified according to their characteristics.

This classification is based on rules we set up for our shape grammars. If we would like to classify houses according to the forms of roofs, then we need to set up more elaborate rules to analyze roofs so as to classify roofs more precisely. If we would like to classify other kinds of architecture, then suitable rules should be set up for the individual features of those types of buildings. For example, rules for facades of temples can be: a.) base, b.) body, c.) roof and d.) material or with additional details. Individuals can set up their own rules for classification and comparison. For example, rules for the plans of atriums in modern shopping centers could be considered as: a.) shape of the opening on the floor, b.) proportion, c.) scale, d.) location of escalators, e.) location of lifts, f.) location of stairs, g.) connection between atriums and shops and h.) sky light, ...etc.

This kind of classification can also be a reference point for prescribing regulations for preservation or urban renewal. Through the analyses of old buildings by shape grammars and statistics of the results after classification, it gives planners an idea in discerning the styles that are important and representative in a historical area.

Now the shape grammars of the ten facades which have been analyzed in Chapter 3.3.5 will be used as an example for classification in Figure 6.5.

Figure 6. 5 Shape grammars of ten facades on the Zhongzhen Road in Xinhwa

For preservation of this area, the forty seven traditional town houses on Zhongzhen Road can be analyzed and classified by shape grammar. The statistics reveal the presence of important styles in this area. Now we will classify and list the characteristics of these ten facades according to rules and shape grammars in Table 6.9 and present the following results:

- the kind of arcade, A-b, which was applied seven times in the ten houses;

- the kind of openings on the facade, B-3ar which was applied three times in the ten houses;

- the kind of head, H-a2+c ↑ , which was applied four times in the ten houses;

- the application of frieze, f1 and f2, which was used six times in the ten houses;

- the combination of material, c-c-c, which was used six times in the ten houses. If the forty seven traditional town houses can be both classified and statistically compiled, the corresponding results would be a useful and powerful reference for planners, architects and the officers who are responsible for preservation of this historical area.

The classification of the ten facades on the Zhongzhen Road according to their shape grammars			
	Characterastics	House Number	Ratio
Arcade	A-b	No. 338, No. 401, No.403, No. 405, No. 407, No. 415, No. 435	7/10
	A-a	No. 409, No. 411, No. 413	3/10
Elody	B-3ar	No. 401, No. 403, No. 405	3/10
	B-3a B-3ax2	No. 411, No. 413, No. 435	3/10
	B-3br+t	No. 338, No. 415	2/10
	B-3b B-0-t	No. 409; No. 407	1/10; 1/10
Head	H-a2+c↑	No. 338, No. 401, No. 407, No. 413	4/10
	H-a2+b↑ H-(a2+b↑)/2	No. 411; No. 403, No. 405	3/10
	H-a2+c↓	No. 409	1/10
	H-a H-a2	No. 415; No. 435	1/10; 1/10
Frieze	f1, f2	No. 401, No. 403, No. 405, No. 409, No. 411, No. 413	6/10
	f2	No. 338, No. 407, No. 415	3/10
	f1	No. 435	1/10
Material	c-c-c	No. 401, No. 403, No. 405, No. 407, No. 409, No. 411	6/10
	c-bc-bc	No. 415, No. 435	2/10
	c-bc-c bc-bc-c	No. 413; No. 338	1/10; 1/10

Table 6. 9 The classification of the ten facades on the Zhongzhen Road according to their shape grammars

6.3.2 Derivations

Suppose we have a new town-house project on Zhongzhen Road (Figure 6.6). We will develope concepts and proposals for the facade of this new project. There will be 150 and even 600 derivations of facades for the proposals of a new town house. These derivations will be generated by combining the shape grammars that have been analyzed and developed from the ten facades on the same street. These shape grammars were listed on Figure 6.5 and Table 6.9.

In this case we use:

- two kinds of arcades,
- five kinds of bodies,
- five kinds of heads, and
- three kinds of friezes

to derive proposals of the facade for a new project which is:

2 x 5 x 5 x 3 = 150

We thus arrive at 150 derivations in this case (Figure 6.7).

But if we add four kinds of material combinations, we will get 600 derivations.

150 x 4 = 600 !!

Similarly the derivations for the proposals of floor plans can also be developed by taking the shape grammars of floor plans as concepts.

This proves that we may consider using shape grammar as a good tool for future research and architectural design.
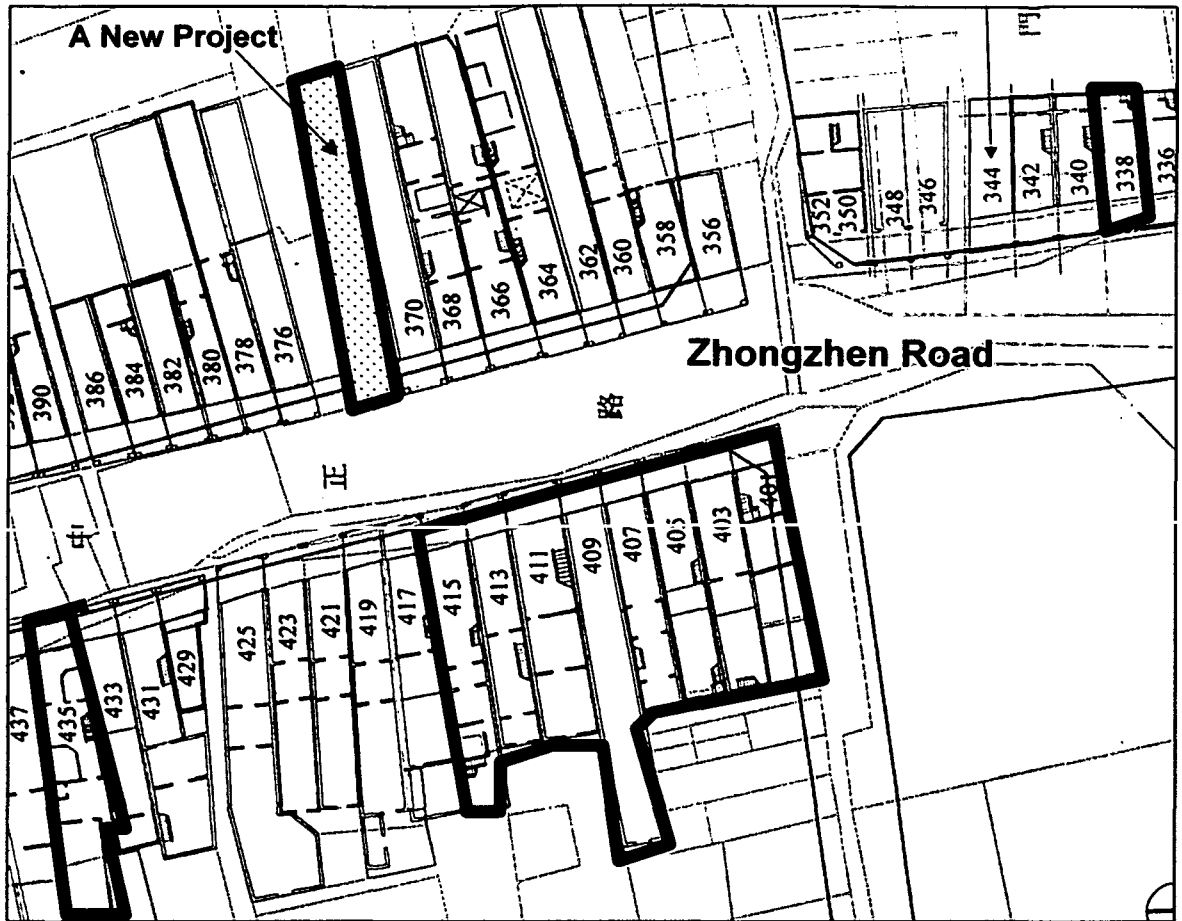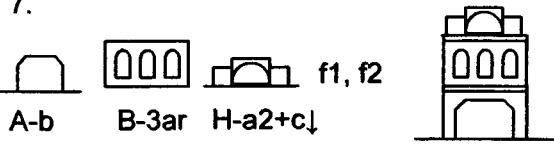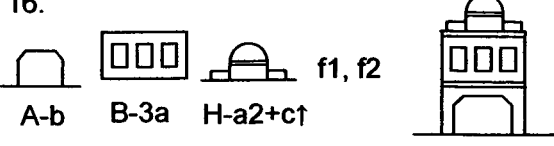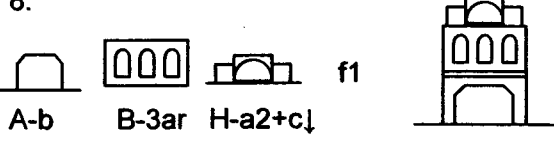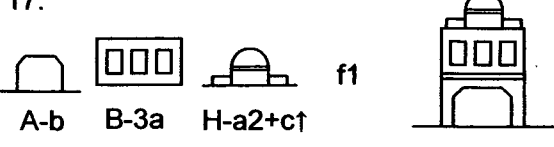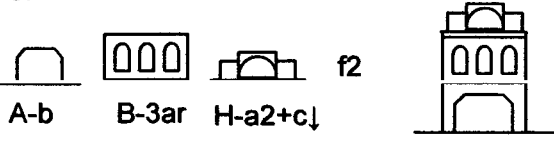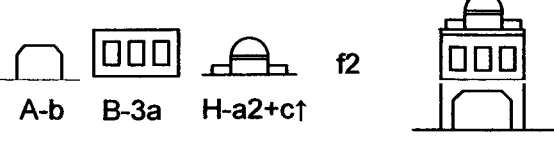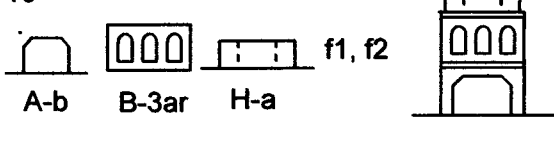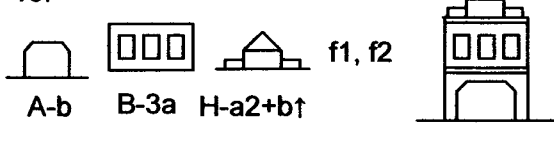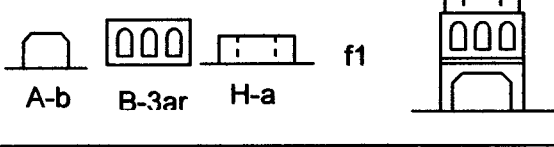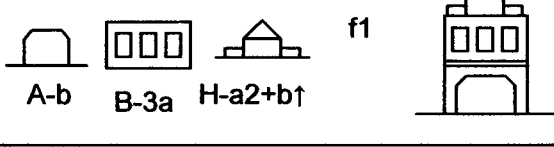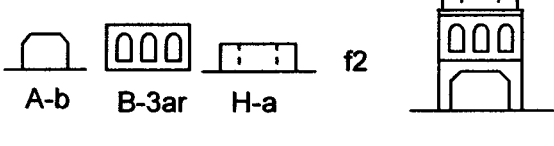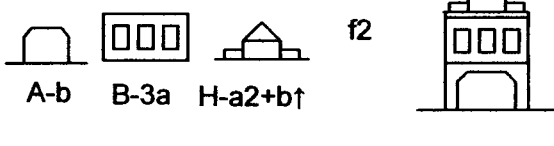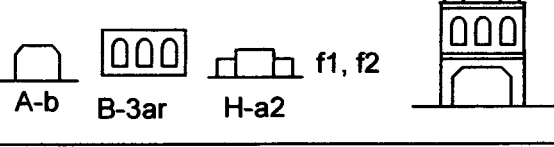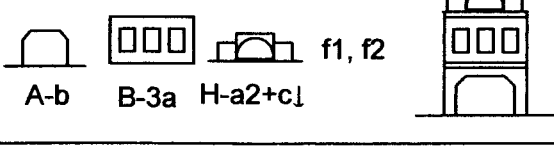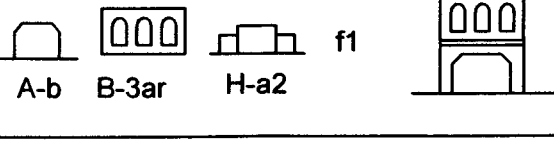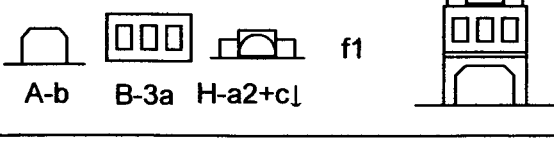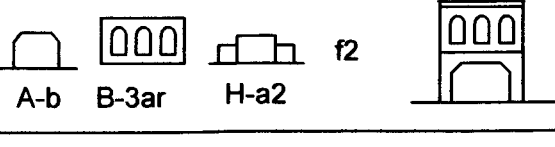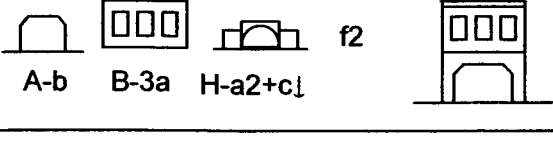
Figure 6. 6 A new Project on this street

150 derivations for the facade of this new project from the shape grammars,Table 6. 9

1.

A-b   B-3ar   H-a2+c↑   f1, f2

2.

A-b   B-3ar   H-a2+c↑   f1

3.

A-b   B-3ar   H-a2+c↑   f2

4.

A-b   B-3ar   H-a2+b↑   f1, f2

5.

A-b   B-3ar   H-a2+b↑   f1

6.

A-b   B-3ar   H-a2+b↑   f2

7. A-b B-3ar H-a2+c↓ f1, f2	16. A-b B-3a H-a2+c↑ f1, f2
8. A-b B-3ar H-a2+c↓ f1	17. A-b B-3a H-a2+c↑ f1
9. A-b B-3ar H-a2+c↓ f2	18. A-b B-3a H-a2+c↑ f2
10 A-b B-3ar H-a f1, f2	19. A-b B-3a H-a2+b↑ f1, f2
11. A-b B-3ar H-a f1	20. A-b B-3a H-a2+b↑ f1
12. A-b B-3ar H-a f2	21. A-b B-3a H-a2+b↑ f2
13. A-b B-3ar H-a2 f1, f2	22. A-b B-3a H-a2+c↓ f1, f2
14. A-b B-3ar H-a2 f1	23. A-b B-3a H-a2+c↓ f1
15. A-b B-3ar H-a2 f2	24. A-b B-3a H-a2+c↓ f2

25. A-b B-3a H-a f1, f2	34. A-b B-3br+t H-a2+b↑ f1, f2
26. A-b B-3a H-a f1	35. A-b B-3br+t H-a2+b↑ f1
27. A-b B-3a H-a f2	36. A-b B-3br+t H-a2+b↑ f2
28. A-b B-3a H-a2 f1, f2	37. A-b B-3br+t H-a2+c↓ f1, f2
29. A-b B-3a H-a2 f1	38. A-b B-3br+t H-a2+c↓ f1
30. A-b B-3a H-a2 f2	39. A-b B-3br+t H-a2+c↓ f2
31. A-b B-3br+t H-a2+c↑ f1, f2	40. A-b B-3br+t H-a f1, f2
32. A-b B-3br+t H-a2+c↑ f1	41. A-b B-3br+t H-a f1
33. A-b B- H-a2+c↑ f2	42. A-b B-3br+t H-a f2

43. A-b B-3br+t H-a2 f1, f2		52. A-b B-3b H-a2+c↓ f1, f2	
44. A-b B-3br+t H-a2 f1		53. A-b B-3b H-a2+c↓ f1	
45. A-b B-3br+t H-a2 f2		54. A-b B-3b H-a2+c↓ f2	
46. A-b B-3b H-a2+c↑ f1, f2		55. A-b B-3b H-a f1, f2	
47. A-b B-3b H-a2+c↑ f1		56. A-b B-3b H-a f1	
48. A-b B-3b H-a2+c↑ f2		57. A-b B-3b H-a f2	
49. A-b B-3b H-a2+b↑ f1, f2		58. A-b B-3b H-a2 f1, f2	
50. A-b B-3b H-a2+b↑ f1		59. A-b B-3b H-a2 f1	
51. A-b B-3b H-a2+b↑ f2		60. A-b B-3b H-a2 f2	

61.				70.			
A-b	B-0-t	H-a2+c↑	f1, f2	A-b	B-0-t	H-a	f1, f2
62.				71.			
A-b	B-0-t	H-a2+c↑	f1	A-b	B-0-t	H-a	f1
63.				72.			
A-b	B-0-t	H-a2+c↑	f2	A-b	B-0-t	H-a	f2
64.				73.			
A-b	B-0-t	H-a2+b↑	f1, f2	A-b	B-0-t	H-a2	f1, f2
65.				74.			
A-b	B-0-t	H-a2+b↑	f1	A-b	B-0-t	H-a2	f1
66.				75.			
A-b	B-0-	H-a2+b↑	f2	A-b	B-0-t	H-a2	f2
67.				76.			
A-b	B-0-t	H-a2+c↓	f1, f2	A-a	B-3ar	H-a2+c↑	f1, f2
68.				77.			
A-b	B-0-	H-a2+c↓	f1	A-a	B-3ar	H-a2+c↑	f1
69.				78.			
A-b	B-0-t	H-a2+c↓	f2	A-a	B-3ar	H-a2+c↑	f2

79. A-a B-3ar H-a2+b↑ f1, f2	88. A-a B-3ar H-a2 f1, f2
80. A-a B-3ar H-a2+b↑ f1	89. A-a B-3ar H-a2 f1
81. A-a B- H-a2+b↑ f2	90. A-a B-3ar H-a2 f2
82. A-a B-3ar H-a2+c↓ f1, f2	91. A-a B-3a H-a2+c↑ f1, f2
83. A-a B-3ar H-a2+c↓ f1	92. A-a B-3a H-a2+c↑ f1
84. A-a B-3ar H-a2+c↓ f2	93. A-a B-3a H-a2+c↑ f2
85. A-a B-3ar H-a f1, f2	94. A-a B-3a H-a2+b↑ f1, f2
86. A-a B-3ar H-a f1	95. A-a B-3a H-a2+b↑ f1
87. A-a B-3ar H-a f2	96. A-a B-3a H-a2+b↑ f2

97.	A-a	B-3a	H-a2+c↓	f1, f2
98.	A-a	B-3a	H-a2+c↓	f1
99.	A-a	B-3a	H-a2+c↓	f2
100.	A-a	B-3a	H-a	f1, f2
101.	A-a	B-3a	H-a	f1
102.	A-a	B-3a	H-a	f2
103.	A-a	B-3a	H-a2	f1, f2
104.	A-a	B-3a	H-a2	f1
105.	A-a	B-3a	H-a2	f2
106.	A-a	B-3br+t	H-a2+c↑	f1, f2
107.	A-a	B-3br+t	H-a2+c↑	f1
108.	A-a	B-3br+t	H-a2+c↑	f2
109.	A-a	B-3br+t	H-a2+b↑	f1, f2
110.	A-a	B-3br+t	H-a2+b↑	f1
111.	A-a	B-3br+t	H-a2+b↑	f2
112.	A-a	B-3br+t	H-a2+c↓	f1, f2
113.	A-a	B-3br+t	H-a2+c↓	f1
114.	A-a	B-3br+t	H-a2+c↓	f2

115. A-a B-3br+t H-a f1, f2	124. A-a B-3b H-a2+b↑ f1, f2
116. A-a B-3br+t H-a f1	125. A-a B-3b H-a2+b↑ f1
117. A-a B-3br+t H-a f2	126. A-a B-3b H-a2+b↑ f2
118. A-a B-3br+t H-a2 f1, f2	127. A-a B-3b H-a2+c↓ f1, f2
119. A-a B-3br+t H-a2 f1	128. A-a B-3b H-a2+c↓ f1
120. A-a B-3br+t H-a2 f2	129. A-a B-3b H-a2+c↓ f2
121. A-a B-3b H-a2+c↑ f1, f2	130. A-a B-3b H-a f1, f2
122. A-a B-3b H-a2+c↑ f1	131. A-a B-3b H-a f1
123. A-a B-3b H-a2+c↑ f2	132. A-a B-3b H-a f2
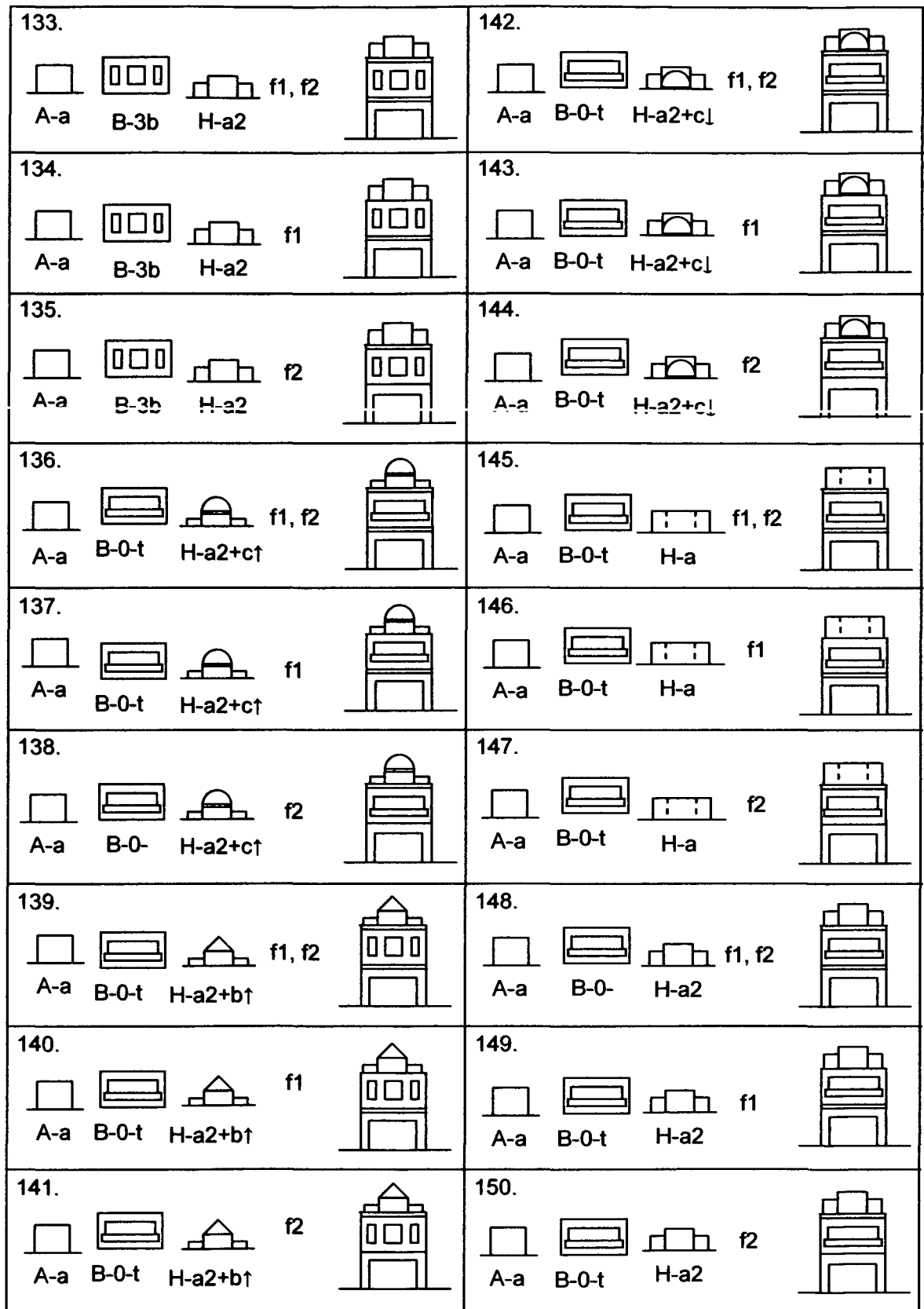
Figure 6. 7 150 derivations for the facade of this new project from the shape grammars

6.4   Conclusions

6.4.1   The contribution of this research work for future research

1. In the field of research of traditional town houses, this paper provides a more comprehensible platform by shape grammars, in performing a comparative research.

2. It provides an idea of how shape grammars can help researchers to illustrate and record an important style that changes chronologically or that varies in different locations of large countries.

3. It gives us a practical tool to distinguish and discern fine differences in styles. Through the shape grammars we have defined, it helps us to see clearly the intricate details of the differences.

4. It is a new perspective in undertaking a new classification of any type of architecture according to the morphology and typology.

5. This method provides a more transparent possibility to compare the facades and the floor plans among diverse architectural types, e.g. church, museum, temple, office and apartment building etc.

6.4.2   The contribution of this research work for preservation of historical architecture

1. It gives an idea how shape grammars can illustrate and record important styles in historical areas and even some houses that have been demolished.

2. It provides a method to restore the models of the valuable architectural relics and heritage.

3. It helps planners and architects to build up concepts for undertaking more suitable urban renewals in a historical area.

4. It helps governments to build up a practical regulation for undertaking repairs and maintenance of houses in a historical area.

6.4.3 The contribution of this research work for architects

1. It can provide architects ample rules from precious architectural heritage to enrich architectural design.

2. In accordance with the principle we mentioned in 3.1.1:

   Form 1 ←rule1→ Form 2, Form 2←rule2→ Form 3, Form 3←rule3→ Form 4,.......
   .... Form N←rule N→Project;

   architects can pick up diverse rules to enhance the concepts of their architecture design.

3. Through the operation of shape grammars, architects can develop additional proposals.

4. It is a new method for designing and planning. Architects can invent their own shape grammars to create their individual design language.

Appendix I

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Appendix II

Source of figures

Figure 3.9   Yu-Chen Sung
Figure 3.10   Pictures: Yu-Chen Sung
                Drawings: No.71: Yu-Chen Sung, the others: 夏鑄九， 1989，迪化街特定專用區現況調查及發展可行性研究
Figure 3.11   Yu-Chen Sung
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                Drawings: 漢寶德，1978，鹿港古風貌之研究
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Figure 5.1   sheff.caeds.eng.uml.edu/ iindiv.htm; sheff.caeds.eng.uml.edu/ icons/austrima.gif

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Figure 5.4   Wilhelm Rausch, Städte im Traun-Enns- Winkel, 1976

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Figure 5.6   Pictures: Yu-Chen Sung
Drawings: Hans Koepf, 1976, Stadtbaukunst in Innsbruck

Figure 5.7   Yu-Chen Sung

Figure 5.8   Yu-Chen Sung

Figure 5.9   Yu-Chen Sung

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Figure 5.24   Yu-Chen Sung

Figure 6.1   Yu-Chen Sung

Figure 6.2   Yu-Chen Sung

Figure 6.3   Yu-Chen Sung (Site plan: 王明蘅、姜渝生、黃昆山，1996)

Figure 6.4   Yu-Chen Sung (Site plan: 王明蘅、姜渝生、黃昆山，1996)

Figure 6.5   Yu-Chen Sung

Figure 6.6   Yu-Chen Sung (Site plan: 王明蘅、姜渝生、黃昆山，1996)

Figure 6.7   Yu-Chen Sung

Appendix III

Shape grammars for facades and floor plans in Taiwan and Innsbruck and Steyr in Austria

Dihwa Street I

H-a2+d   H-a2+b↓   H-a   H-a2+b↑   H-a

B-3bx2   B-3ax2   B-3as+cs+t   B-3br+3at   B-3b

A-a   A-b   A-a   A-e   A-c1+2c2
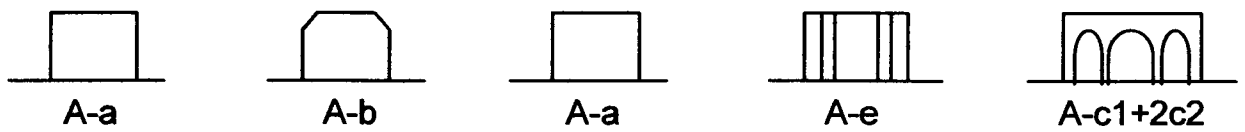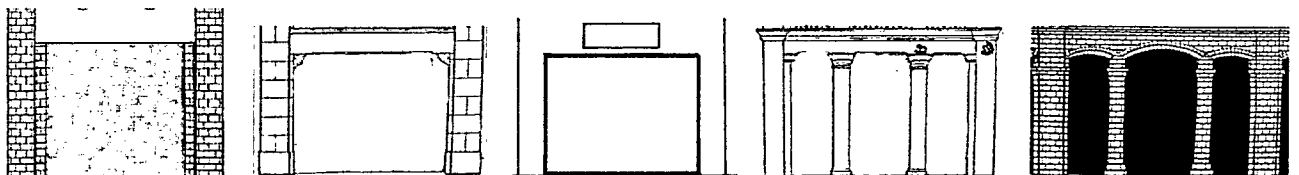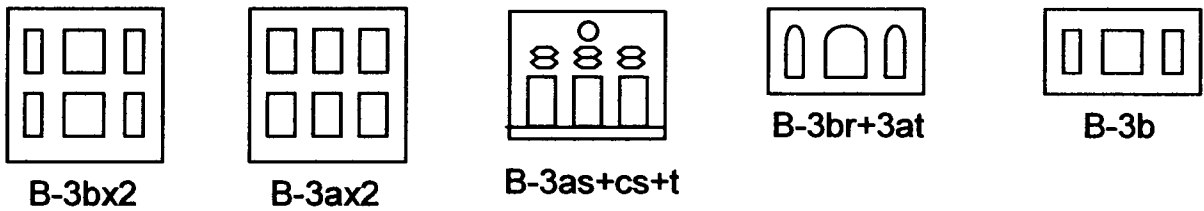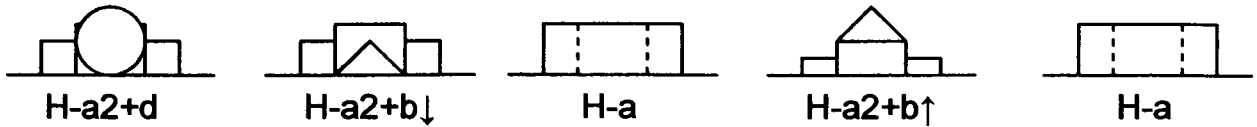
Rule No. \ Rule	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	T
No.24	A-a	—	B-3bx2	f2	H-a2+d	eb-eb-eb	—
No.44	A-b	—	B-3ax2	f2	H-a2+b↓	e-e-e	—
No.71	A-a	—	B-3as+cs+t	—	H-a	e-e-e	t
No.114	A-e	f1	B-3br+3at	f2	H-a2+b↑	e-e-e	3at
No.352	A-c1+ 2c2	f1	B-3b	f2	H-a	b-b-b	—

Dihwa Street II

H-a2+c↑   H-a2+c↑   H-a2+c↑   H-a2+c↑   H-a2+c↑

B-3ax2   B-3b+3br+rt   B-3bx2+rt   B-r(5a+3ar)   B-3a+3ar

A-a   A-b   A-b   A-a   A-a
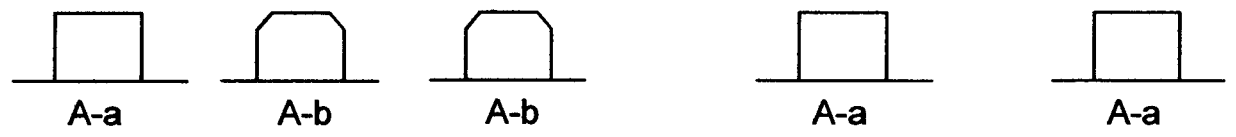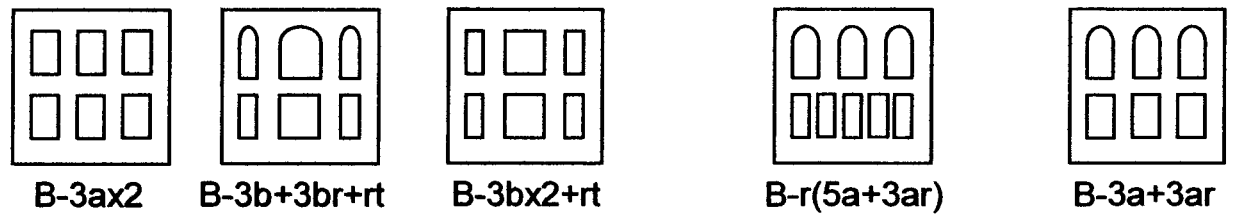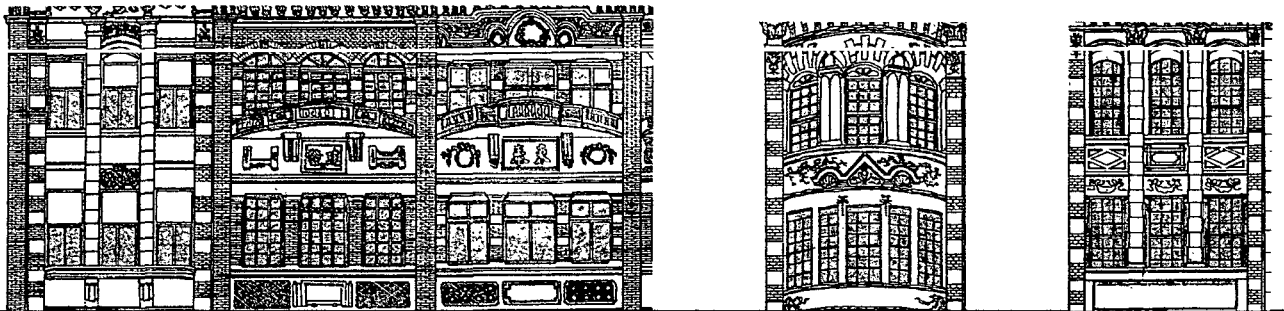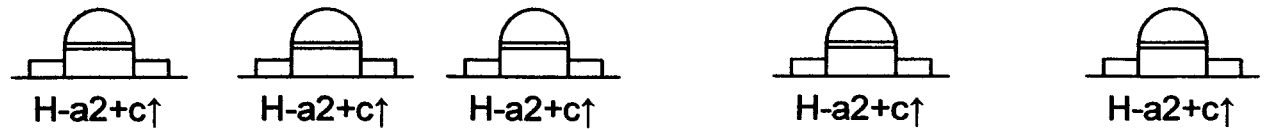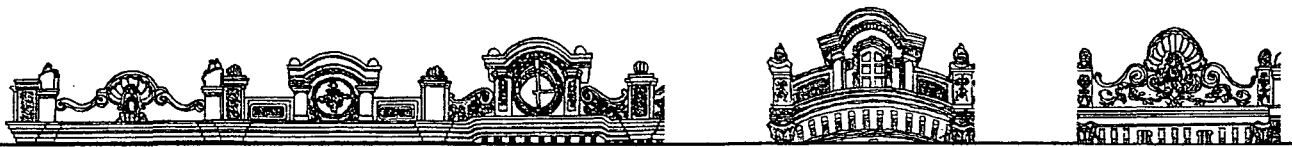
Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	Rule T
No.135	A-a	—	B-3ax2	f2	H-a2+c↑	cb-cb-c	—
No.133	A-b	—	B-3b+3br+rt	f2	H-a2+c↑	cb-cb-c	rt
No.131	A-b	—	B-3bx2+rt	f2	H-a2+c↑	cb-cb-c	rt
No.148	A-a	—	B-r(5a+3ar)	rf2	H-a2+c↑	c-c-c	—
No.152	A-a	—	B-3a+3ar	f2	H-a2+c↑	c-c-c	—

Daxi I
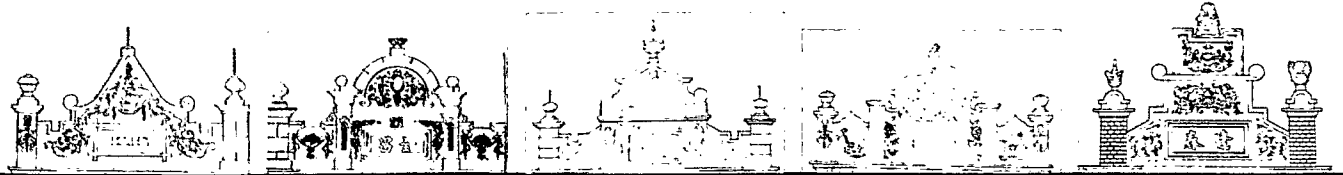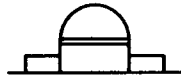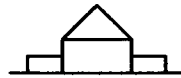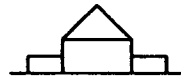
H-a2+b↑	H-a2+c ↑	H-a2+c ↑	H-a2+b↑	H-a2+b↑
f1	f1	f1	f1	f1
A-c	A-e	A-e	A-c1+2c2	A-b
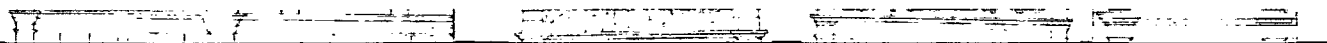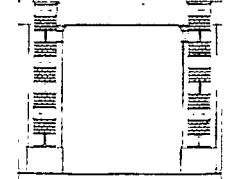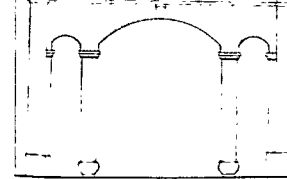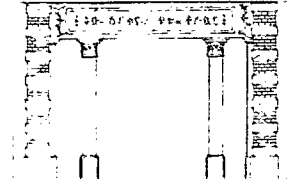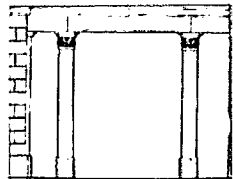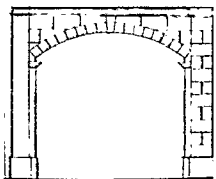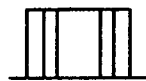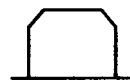
Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	Rule t
No.48-1	A-c	f1	—	—	H-a2+b↑	e-e	—
No.48	A-e	f1	—	—	H-a2+c ↑	e-e	—
No.49	A-e	f1	—	—	H-a2+c ↑	be-e	—
No.50	A-c1+2c2	f1	—	—	H-a2+b↑	e-e	—
No.81	A-b	f1	—	—	H-a2+b↑	be-be	—

Daxi II

| | H-a2+b ↑ | H-a2+c ↑ | H-a2+b ↑ | H-a2+3c | H-a2+b ↑ |

| | f1 | f1 | f1b | f1b | f1b |

| | A-e | A-e | A-c1+2c2 | A-c1+2c2 | A-c1+2c2 |
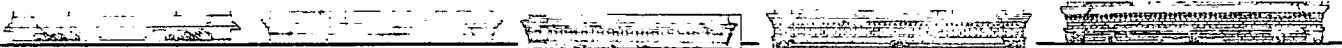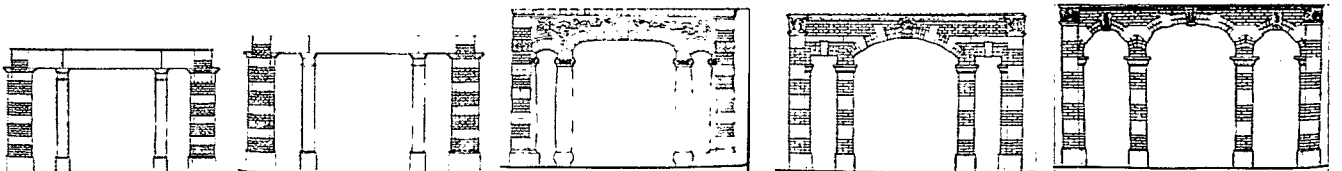
Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	Rule T
No.84	A-e	f1	—	—	H-a2+b ↑	be-e-be	—
No.86	A-e	f1	—	—	H-a2+c ↑	be-e-be	—
No.12	A-c1+2c2	f1	—	—	H-a2+b ↑	be-e-be	—
No.13	A-c1+2c2	f1	—	—	H-a2+3c	be-b-e	—
No.15	A-c1+2c2	f1	—	—	H-a2+b ↑	be-b-e	—

Lukang I

H-af   H-af   H-af   H-af   H-af+w
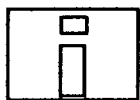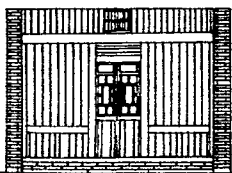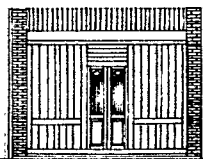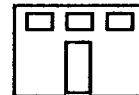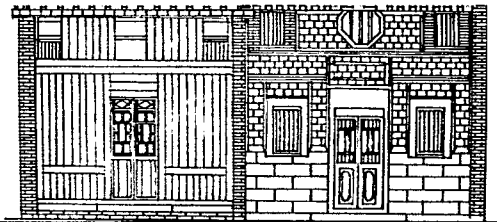
B-1+a/2   B-0100   B-1   B-1+3a/2   B-010+3a/2

Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	Rule T
No.6	—	—	B-1+cs	—	H-af	wb-bw	—
No.7	—	—	B-0100	—	H-af	b-bw	—
No.17	—	—	B-1	—	H-af	wb-bw	—
No.18	—	—	B-1+3cs	—	H-af	wb-bw	—
No.16	—	—	B-010+3cs	—	H-af+1w	b-bw	—

Lukang II
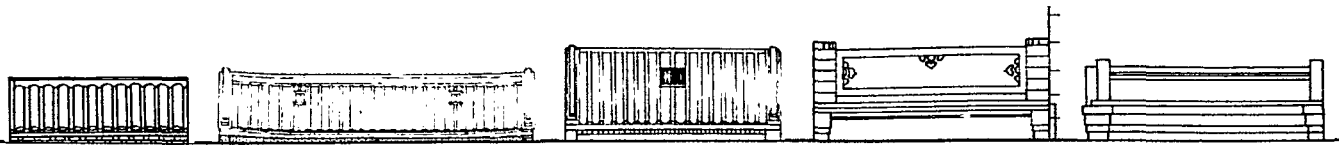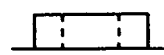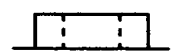
H-af   H-af+2w   H-af+w   H-a   H-a
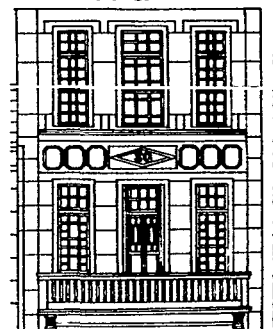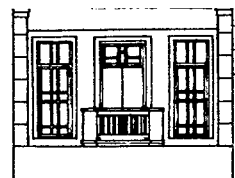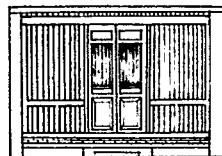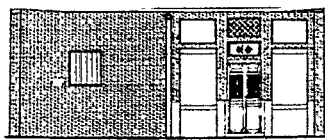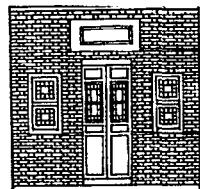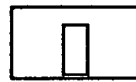
B-010   B-0010   B-1   B-3a+1at   B-2(3b+t)

A-b   A-b

Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	T
No.25 Y.	—	—	B-010	—	H-af	bw-bw	—
No.19 P.	—	—	B-0010	—	H-af+2w	bc-bw	—
No.55 P.	—	—	B-1	—	H-af+w	wb-bw	—
No.147 Z.	A-b	—	B-3a+1at	f2	H-a	e-e-e	at
No.149 Z.	A-b	f1	B-2(3a+t)	f2	H-a	e-e-e	2t

Xinhwa I

H-a2+c↑   H-a2+c↑   (H-a2+b↑)/2   H-a2+c↑
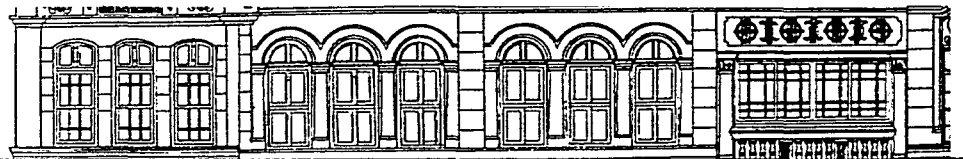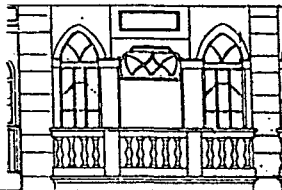
B-3b+t   B-3ar   B-3ar   B-3ar   B-0+t
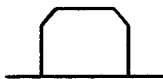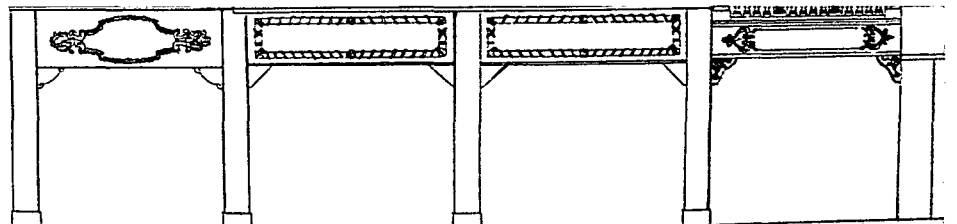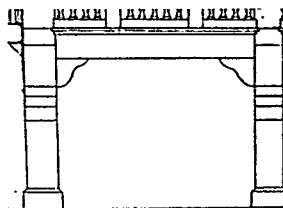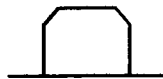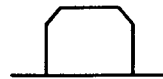
A-b   A-b   A-b   A-b   A-b
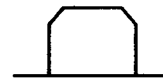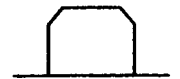
Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	Rule t
No.338	A-b	—	B-3b+rt	f2	H-a2+c↑	be-be-e	rt
No.401	A-b	f1	B-3ar	f2	H-a2+c↑	e-e-e	—
No.403	A-b	f1	B-3ar	f2	(H-a2+b↑)/2	e-e-e	—
No.405	A-b	f1	B-3ar	f2	(H-a2+b↑)/2	e-e-e	—
No.407	A-b	—	B-0+t	f2	H-a2+c↑	e-e-e	t

Xinhwa II
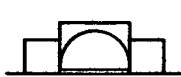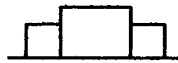
H-a2+c↓   H-a2+b↑   H-a2+c↑   H-a2   H-a
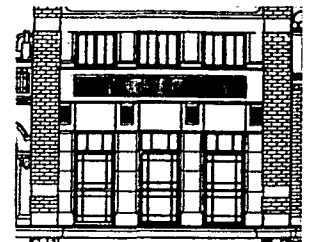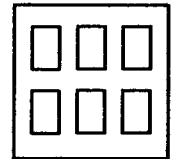
B-3b   B-3a   B-3a   B-3br+t   B-3ax2
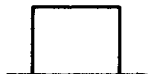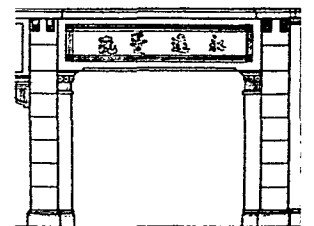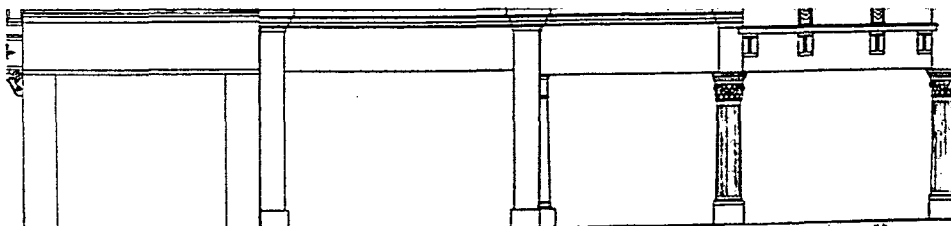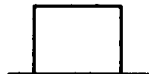
A-a   A-a   A-a   A-b   A-b

Rule No.	Rule A	Rule f1	Rule B	Rule f2	Rule H	Rule M	Rule T
No.409	A-a	f1	B-3b	f2	H-a2+c↓	e-e-e	—
No.411	A-a	f1	B-3a	f2	H-a2+b↑	e-e-e	—
No.413	A-a	f1	B-3a	f2	H-a2+c↑	e-be-e	—
No.415	A-b	—	B-3br+t	f2	H-a2	e-be-be	t
No.435	A-b	f1	B-3ax2	—	H-a	e-be-be	—

Innsbruck I

| H-bf | H-a2+b↑ | H-a2+c↑ | H-a+c→ | H-af+2w |

| B-(2a+hb)x3+1at | B-3ax5 | B-(a+2hb)x4 | B-(hb+2a)x4 | B-(2a+hb)x3+3a |

| A-2c | A-2c | A-2d | A-c1+c2 | A-2c |
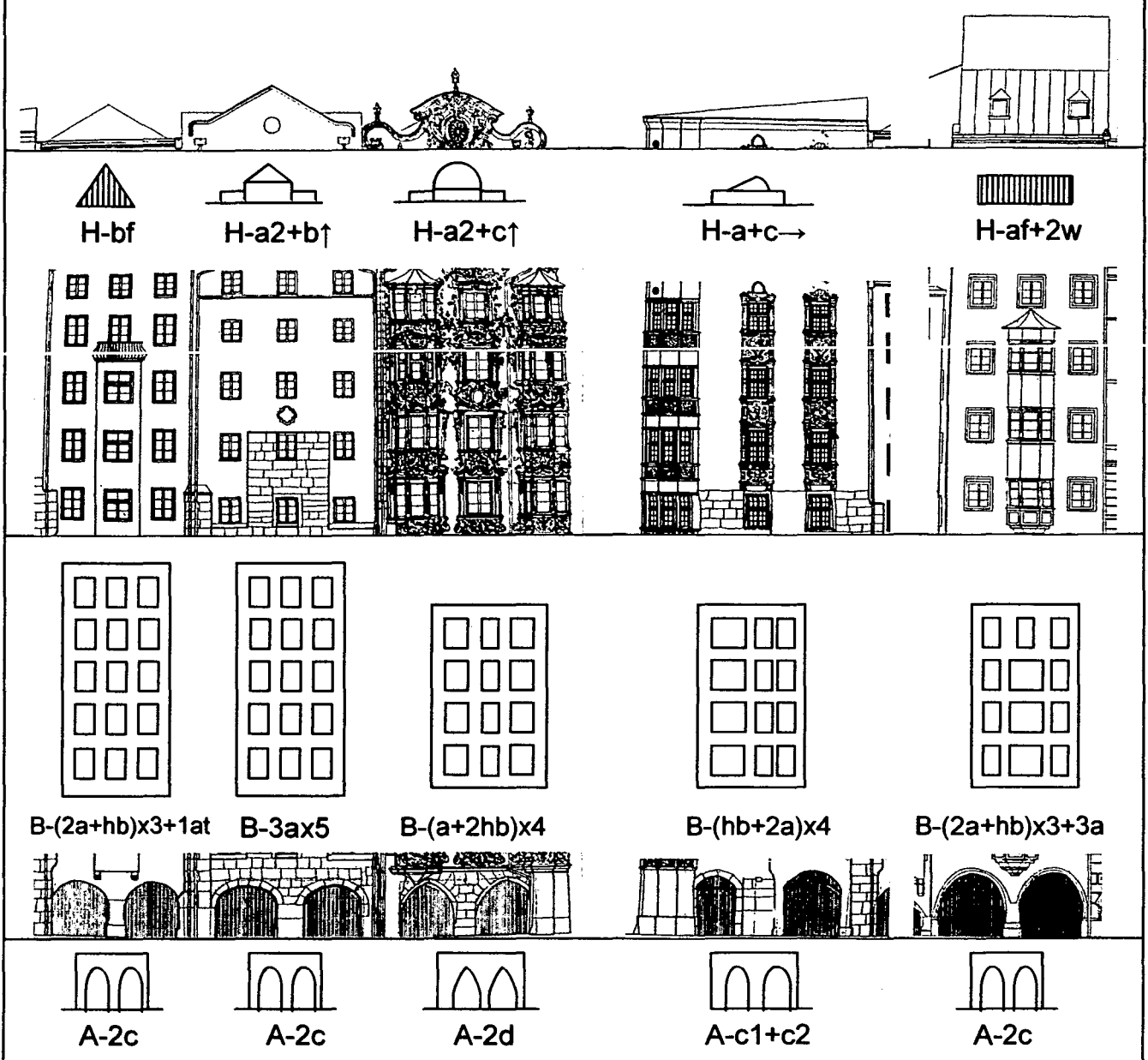
No. \ Rule	Rule A	F1	Rule B	F2	Rule H	Rule M	T
No.14	A-2c	—	B-(2a+hb)x3+1at	f2	H-bf	p-p-p	1at
No.12	A-2c	—	B-3ax5	—	H-a2+b↑	s-p-p	—
No.10	A-2d	f1	B-(hb+2a)x4	f2	H-a2+c↑	p-p-p	—
No.16	A-c1+c2	—	B-(hb+2a)x4	f2	H-a+c→	s-sp-p	—
No.35	A-2c	—	B-(2a+hb)x3+3a	f2	H-af+2w	p-p-p	—

Innsbruck II

H-a4   H-2b+b/2   H-c1+2c2   H-b+f   H-bf

B-2(hb+a)x3+4a   B-(2(hb+a)+b)x4   B-3bx3+3a   B-3cx3+3a   B-(3a+hb+a)x3+5a

A-3d   A-3d   A-2d   A-2br   A-2c

Rule No.	Rule A	F1	Rule B	F2	Rule H	Rule M	T
No.22	A-3d	f1	B-2(hb+a)x3+4a	—	H-a4	sp-p-p	—
No.20-18	A-3d	—	B- (2(hb+a)+b)x4	—	H-2b+b/2	sp-p-p	—
No.23	A-2d	—	B-3bx3+3a	—	H-c1+2c2	s-sp-p	—
No.25	A-2br	—	B-3cx3+3a	—	H-b+f	sp-p-p	—
No.39	A-2c	f1	B-(3a+hb+a)x3+5a	f2	H-bf	p-p-p	—

Steyr I

H-b+f+2w

H-b+f+2w

H-b+2f+5w+cw

H-b+f+3w+cw

H-b+f+2w

B-3ax2+f

B-3a+4a+f

B-4a+b-t

B-5a

B-3ax2

AB-4c1011

AB-3br110

AB-3b010

AB-5c00100

AB-3br100

No.\Rule	Rule A	F1	Rule B	F2	Rule H	Rule M	T
No.19	AB-4c1011	f1	B-3ax2+f	—	H-b+f+2w	p-p-pb	—
No.21	AB-3br110	f1	B- 3a+4a+f	—	H-b+f+2w	sp-s-sb	—
No.32	AB-3b010	f1	B-4b+b+t	f2	H-b+2f+5w+cw	p-p-pb	—
No.35	AB-5c00100	f1	B-5a	f2	H-b+f+3w+cw	p-p-pb	—
No.40	AB-3br100	f1	B-3ax2	f2	H-b+f+2w	p-p-pb	—

Steyr II
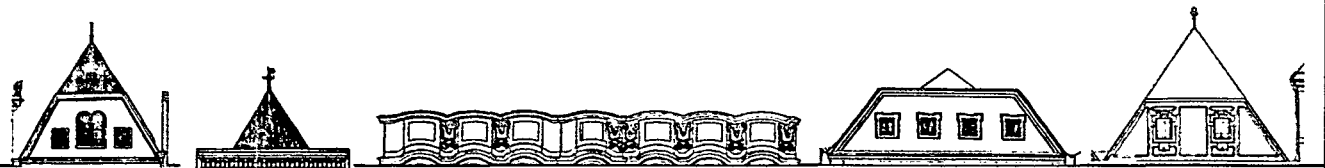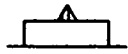
H-b+f+3w   H-a+f   H-7c   H-a3+f   H-b+f+2w
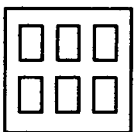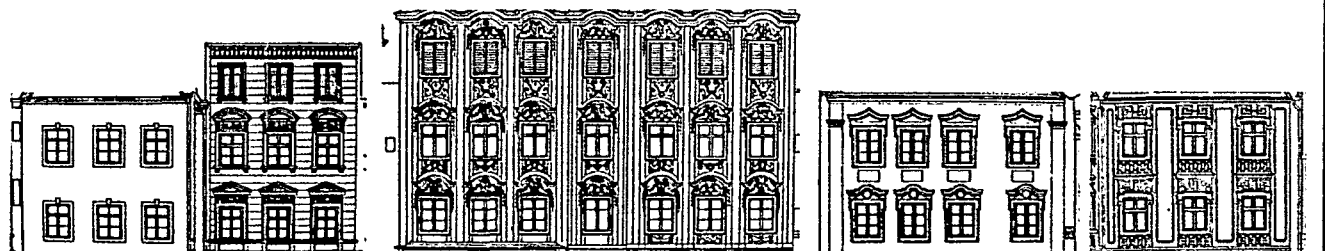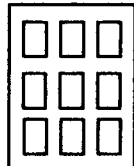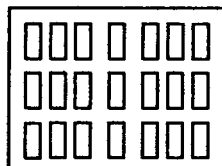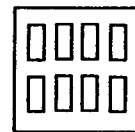
B-3ax2   B-3ax3   B-7ax3   B-4ax2   B-3ax2
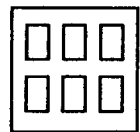
AB-3c010   AB-2br10   AB-0001000   AB-00100   AB-3c100

Rule No.	Rule A	F1	Rule B	F2	Rule H	Rule M	T
No.44	AB-3c0101	—	B-3ax2	f2	H-b+f+3w	p-p-pb	—
No.42	AB-2br10	f1	B- 3ax3	f2	H-a+f	p-p-pb	—
No.9	AB-0001000	f1	B-7ax3	f2	H-7c	p-p-p	—
No.10(g)	AB-00100	f1	B-4ax2	f2	H-a3+f	p-p-pb	—
No.4 (g)	AB-3c100	f1	B-3ax2	f2	H-b+f+2w	p-p-pb	—

Taipei, Dihwa Street No.71
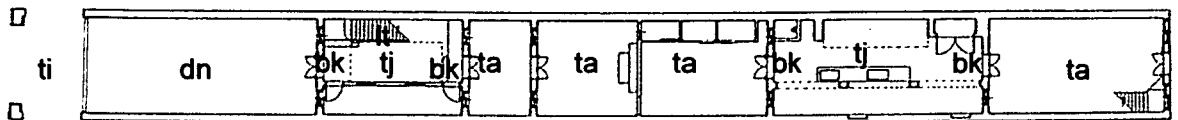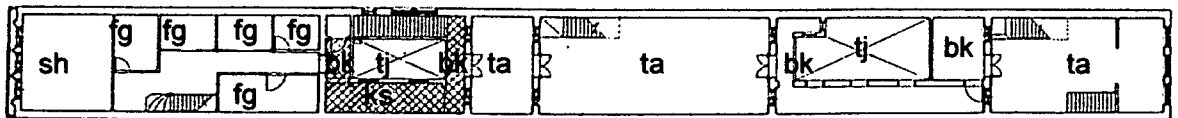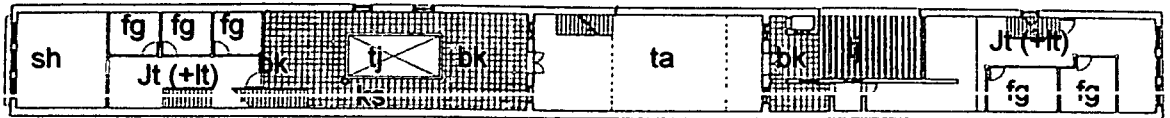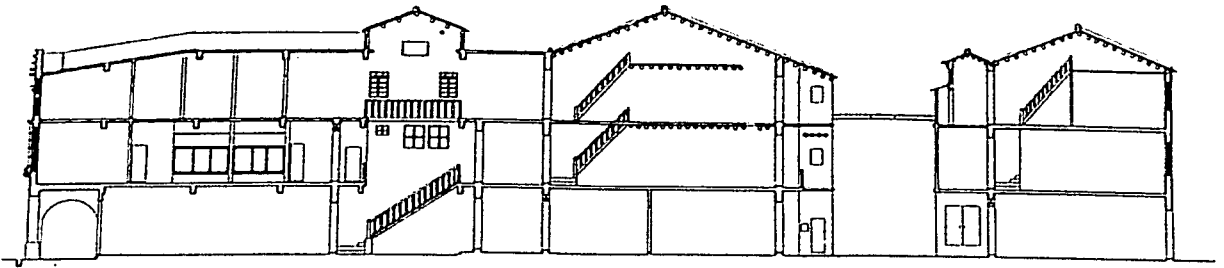
Rule A: The Generation of a unit pattern
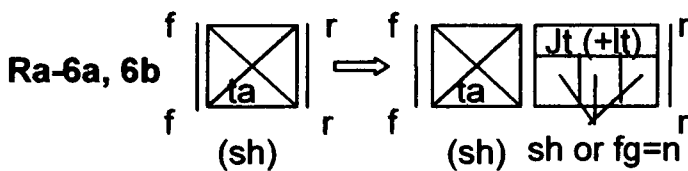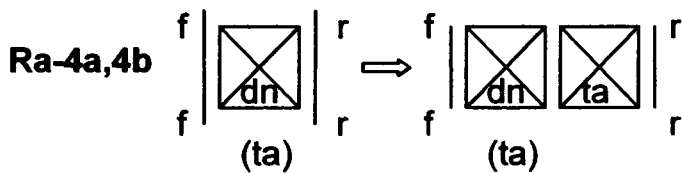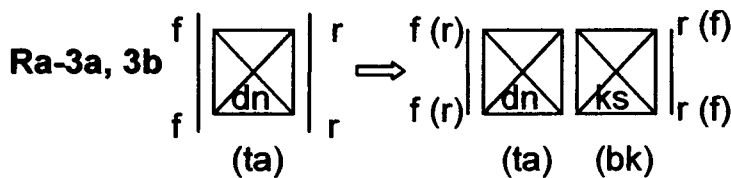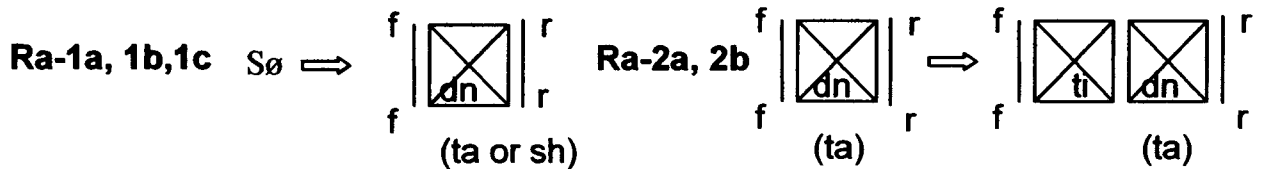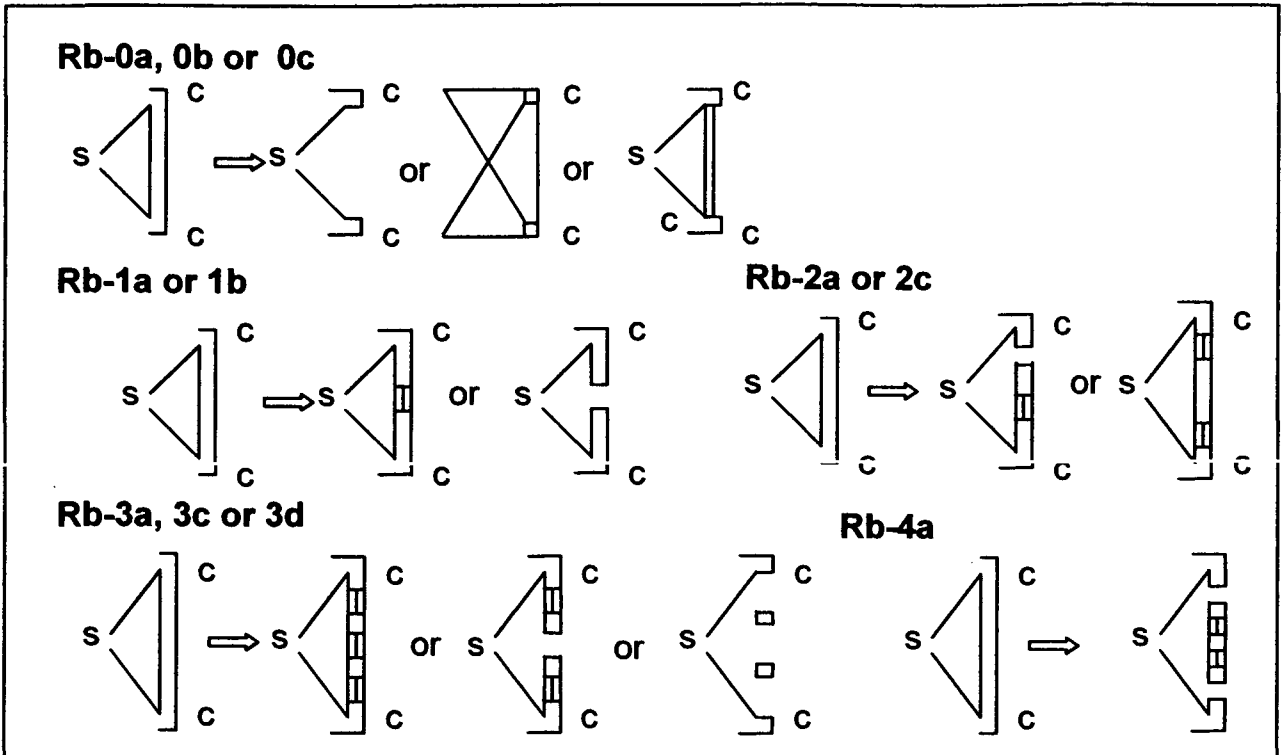
Ra-1a, 1b,1c $S_{\varnothing} \Longrightarrow$ (ta or sh) **Ra-2a, 2b** $\Longrightarrow$ (ta) (ta)

Ra-3a, 3b $\Longrightarrow$ (ta) (ta) (bk)

Ra-4a,4b $\Longrightarrow$ (ta) (ta)

Ra-6a, 6b $\Longrightarrow$ (sh) (sh) sh or fg=n

Rule B: Openings on outer walls

Rb-0a, 0b or 0c

Rb-1a or 1b

Rb-2a or 2c

Rb-3a, 3c or 3d

Rb-4a

Rule c: Openings for connecting Spaces

Rc-1a, 1b, 1c

Rc-2a, 2b

Rc-3b

Rule D: The connections between blocks

Rd-1

It (ks)
tj
ks (It)

Rd-3

tj
ks

Rd-6

ft
tj

Rd-2

ks
tj
ks

Rd-5

ft
tj
ks(It)
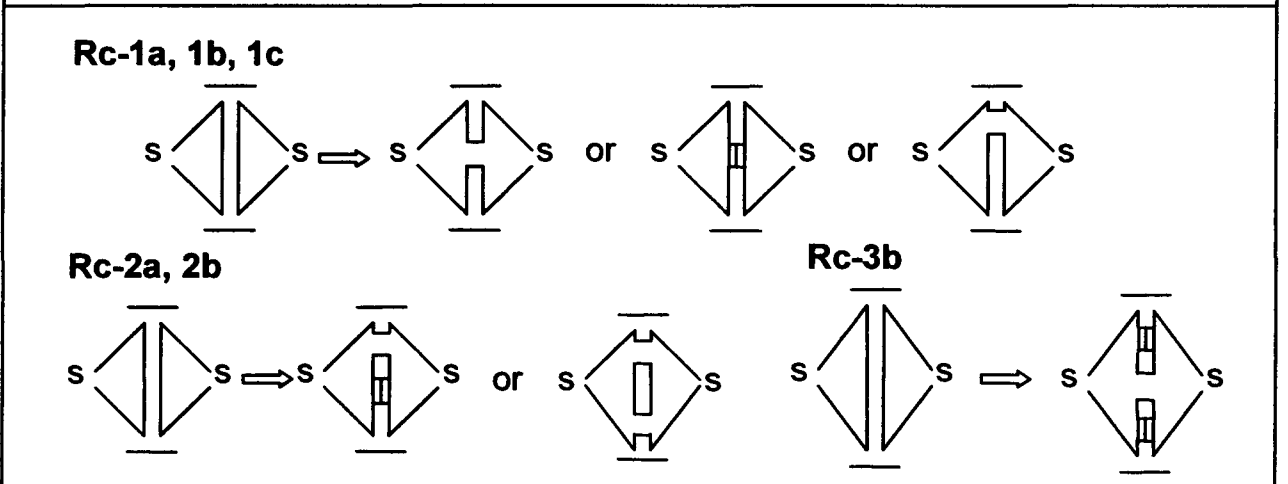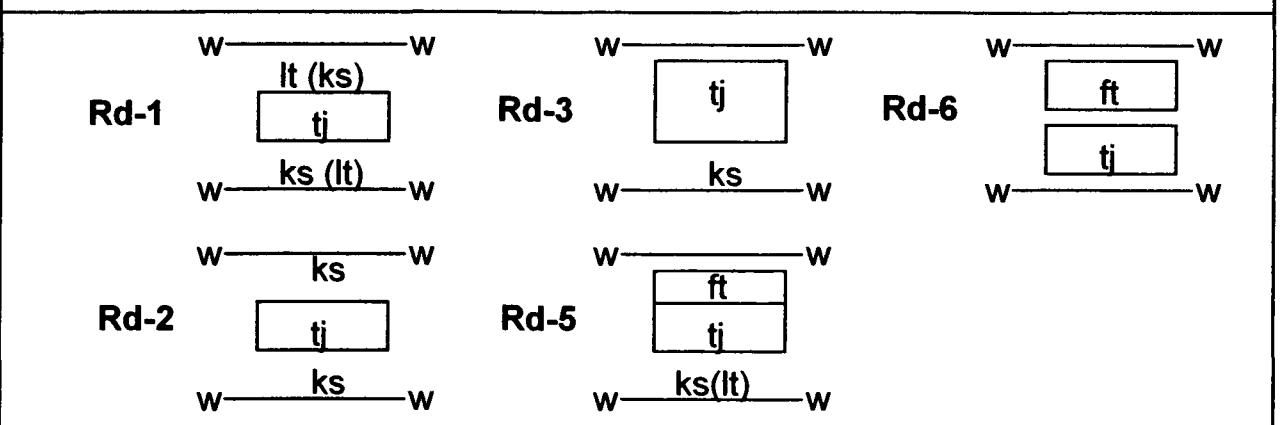
Daxi, Hoping Street No.86

Rule A: Generation of a unit pattern

Ra-1a, 1b,1c Sø ⟹ (ta or sh)

Ra-2a, 2b ⟹ (ta) ... (ta)

Ra-3a, 3b (ta) ⟹ (ta) (bk)

Ra-4a,4b (ta) ⟹ (ta)

Ra-5 ⟹

Ra-6a, 6b (sh) ⟹ (sh) Jt (+Jt) sh or fg=n

Ra-9a, 9b sh jt ⟹ sh jt ks (bk)
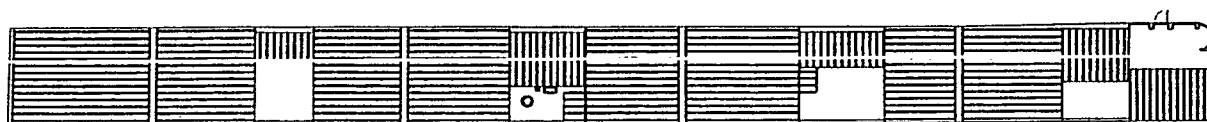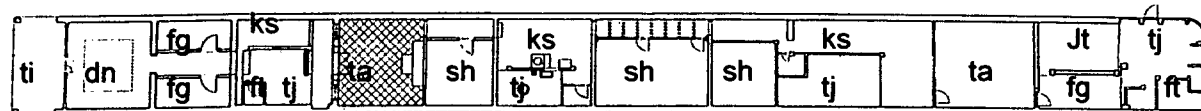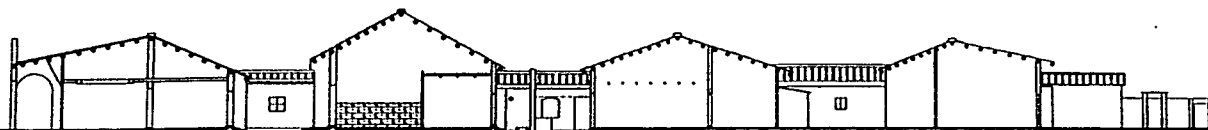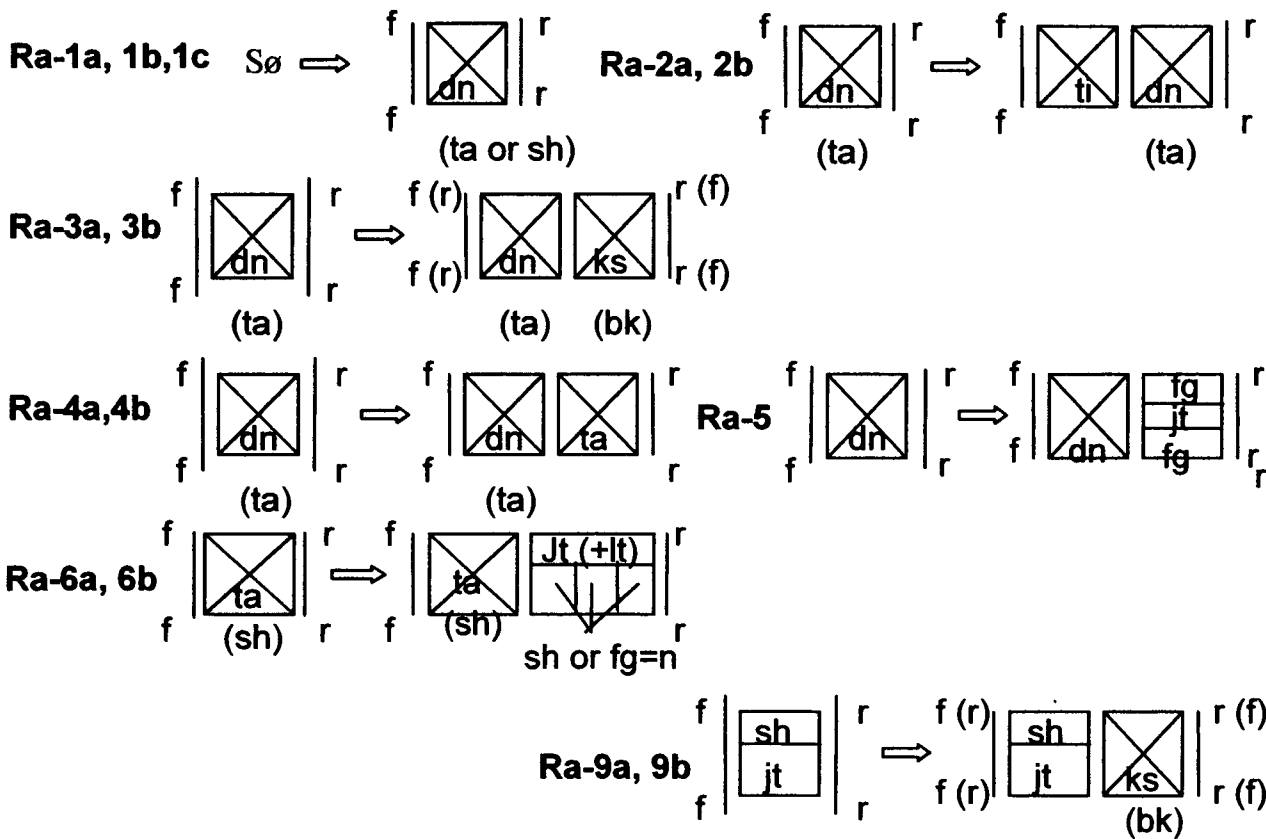
Rule B: The Generation of Connection--- The Opening on outer walls

Rb-0a or 0b
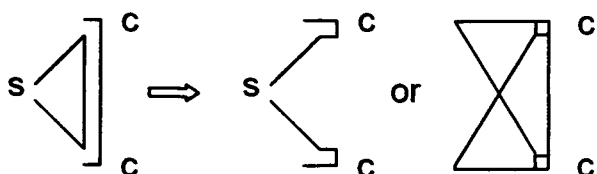
Rb-1b or 1c
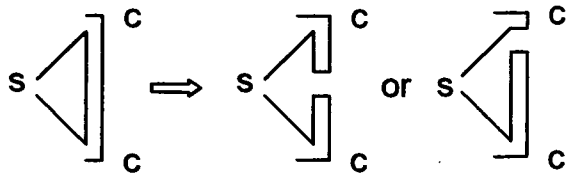
Rb-2a
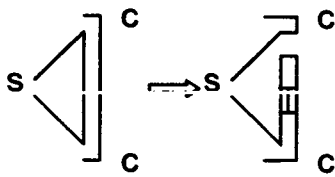
Rb- 3c
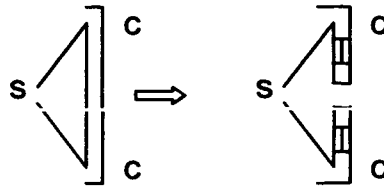
Rule c: Openings for connecting Space

Rc-1a, 1c
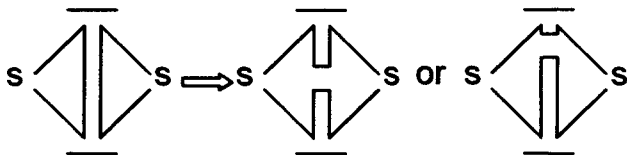
Rc- 2b
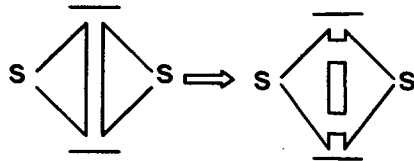
Rule D: The connections between blocks

Rd-3
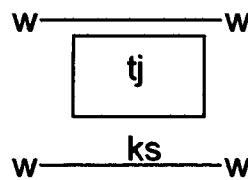
Rd-6
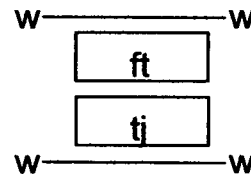
Rd-8a
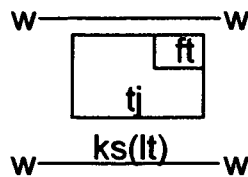
Rd-8b
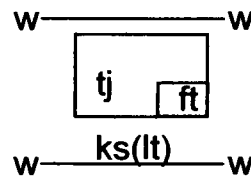
Lukang, Zhongshab Rd. 121
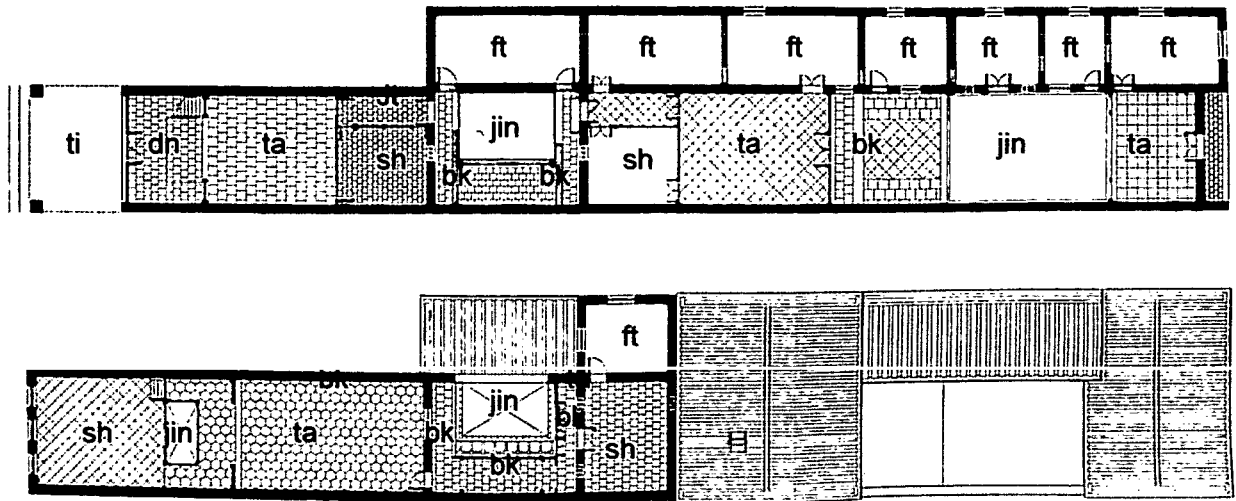
Rule A: The Generation of a unit pattern
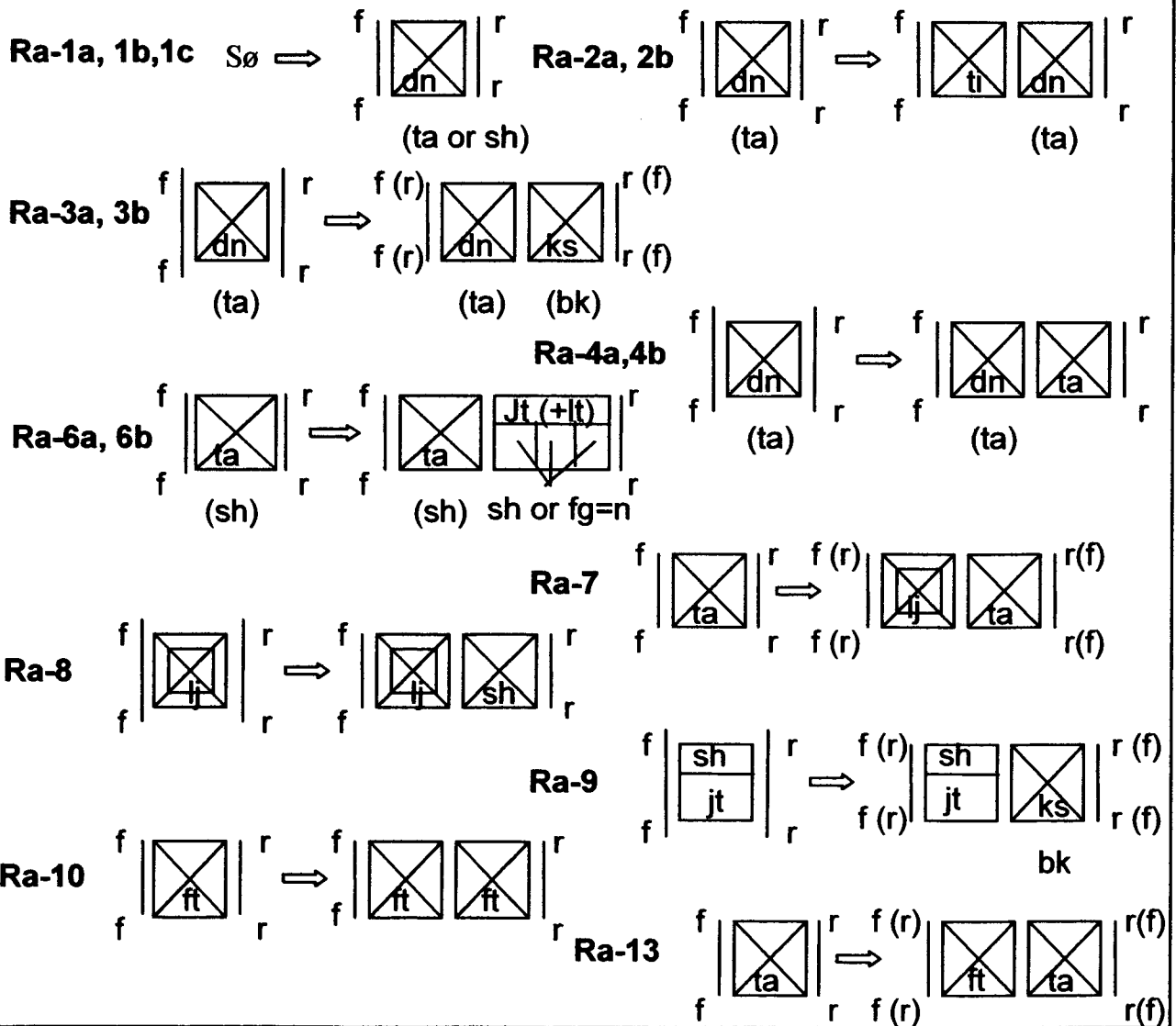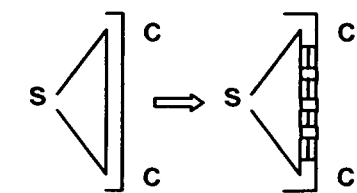
Rule B: Openings on outer walls
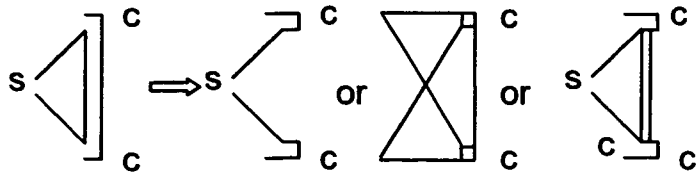
Rb-0a, 0b or 0c
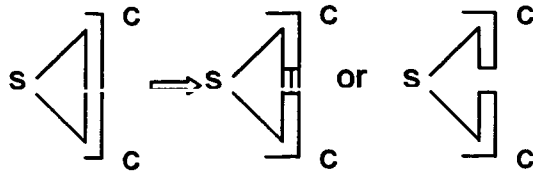
Rb-1a or 1b
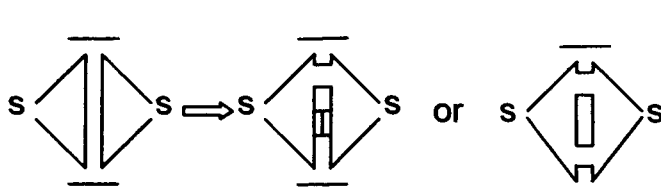

Rb-2a or2d
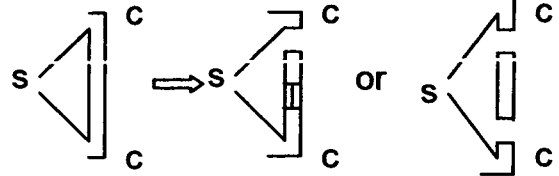
Rb-3a, 3c or 3d
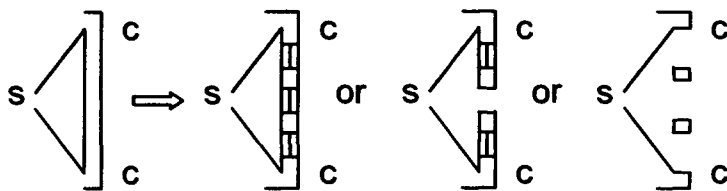
Rule C: Openings for connecting Spaces
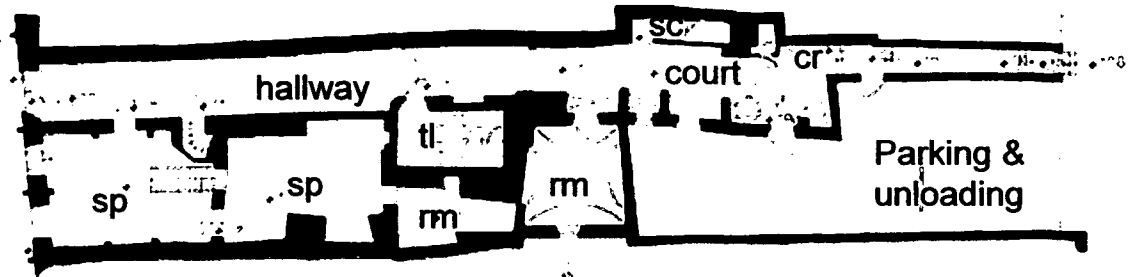
Rc-1b, 1c, 1d or 1e
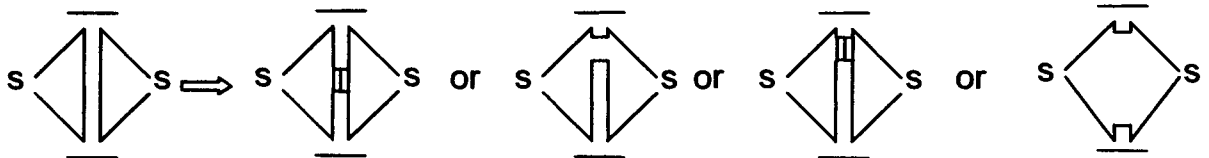
Rc-2a, 2b

Rc-3a

Rule D: The connections between blocks

Rd-3   tj / ks

Rd-5   ft / tj / ks(lt)

Rd-6   ft / tj

Xinhwa, Zhong Zheng Rd. No. 415

Rule A: Generation of a unit pattern

Ra-1a, 1b,1c Sø ⟹ (diagram) (ta or sh)

Ra-2a, 2b (diagram) ⟹ (diagram) (ta) ... (ta)

Ra-3a, 3b (diagram) (ta) ⟹ (diagram) (ta) (bk)

Ra-6a, 6b (diagram) (sh) ⟹ (diagram) (sh) sh or fg=n

Ra-11a, 11b (diagram) (fa+jt) ⟹ (diagram) (fa+jt)

Ra-12 (diagram) ⟹ (diagram)
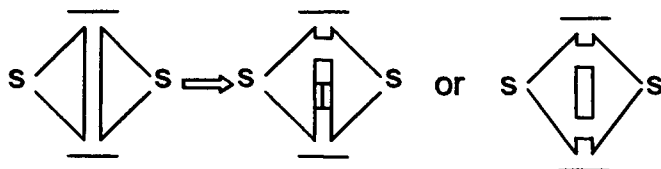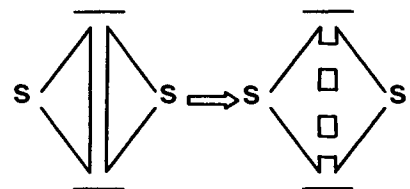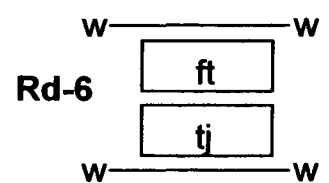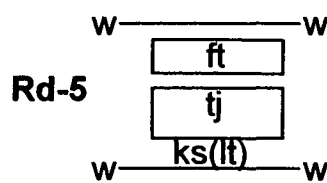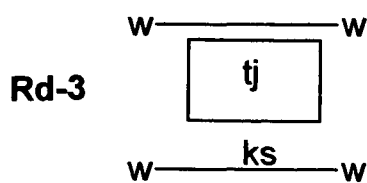
Rule B: Openings on outer walls

Rb-0a, 0b or 0c
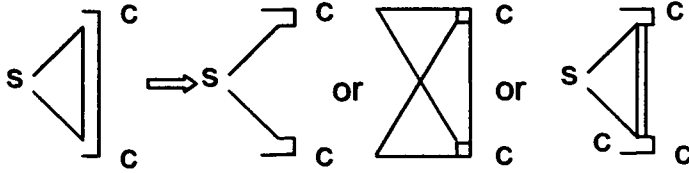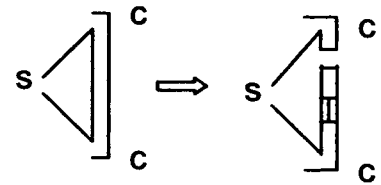
Rb-2a

Rb-1a or 1b
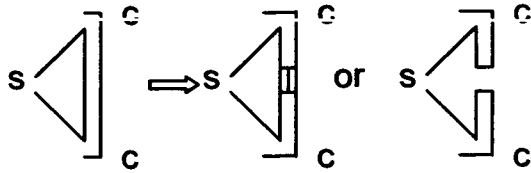
Rb-3a
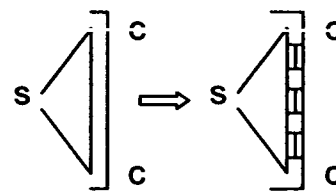
Rule C: Openings for connecting Spaces

Rc-1c
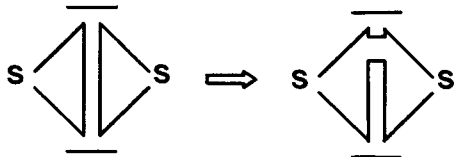
Rule D: The connections between blocks

Rd-0
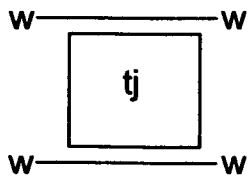
Innsbruck, Herzog-Friedrich-Strasse No. 20
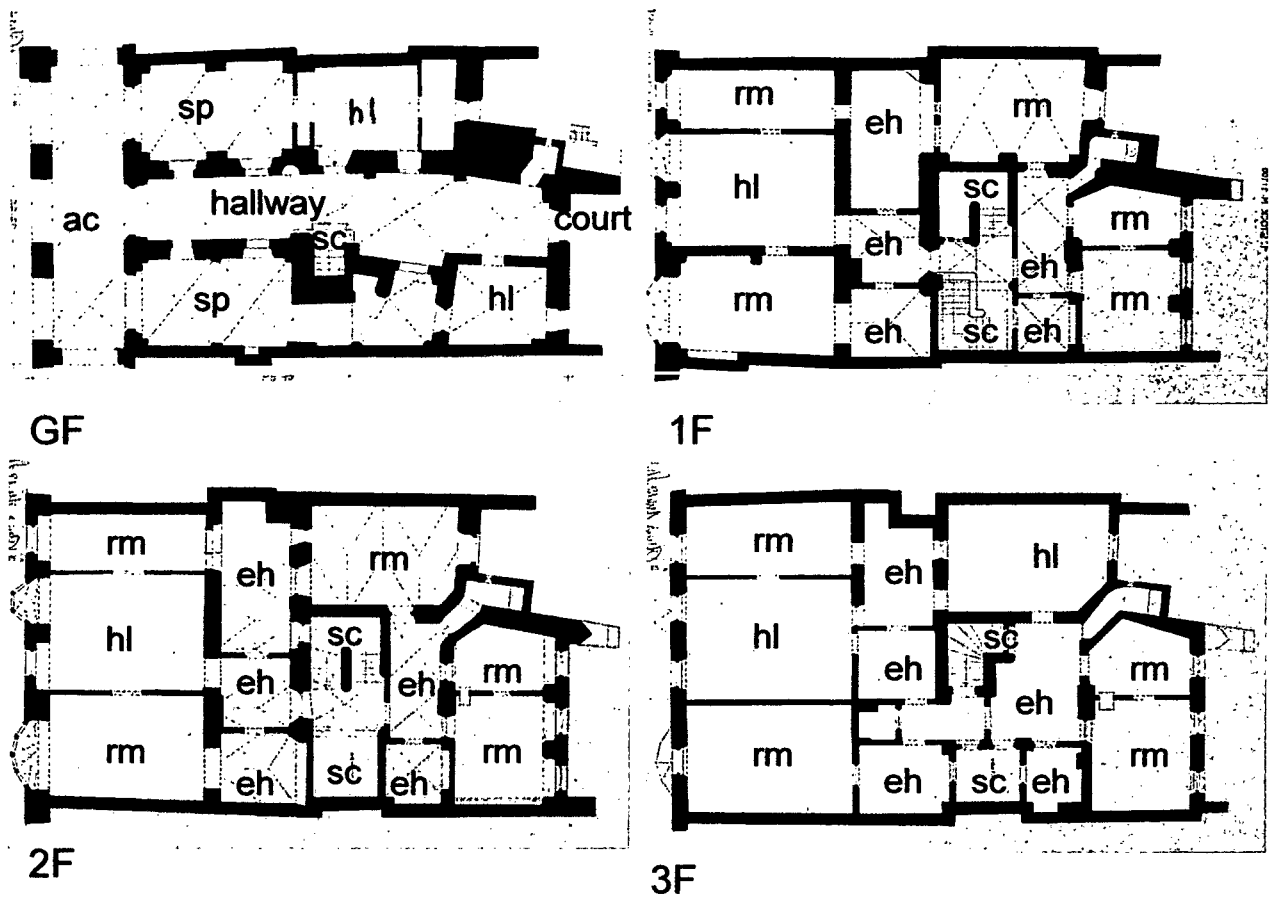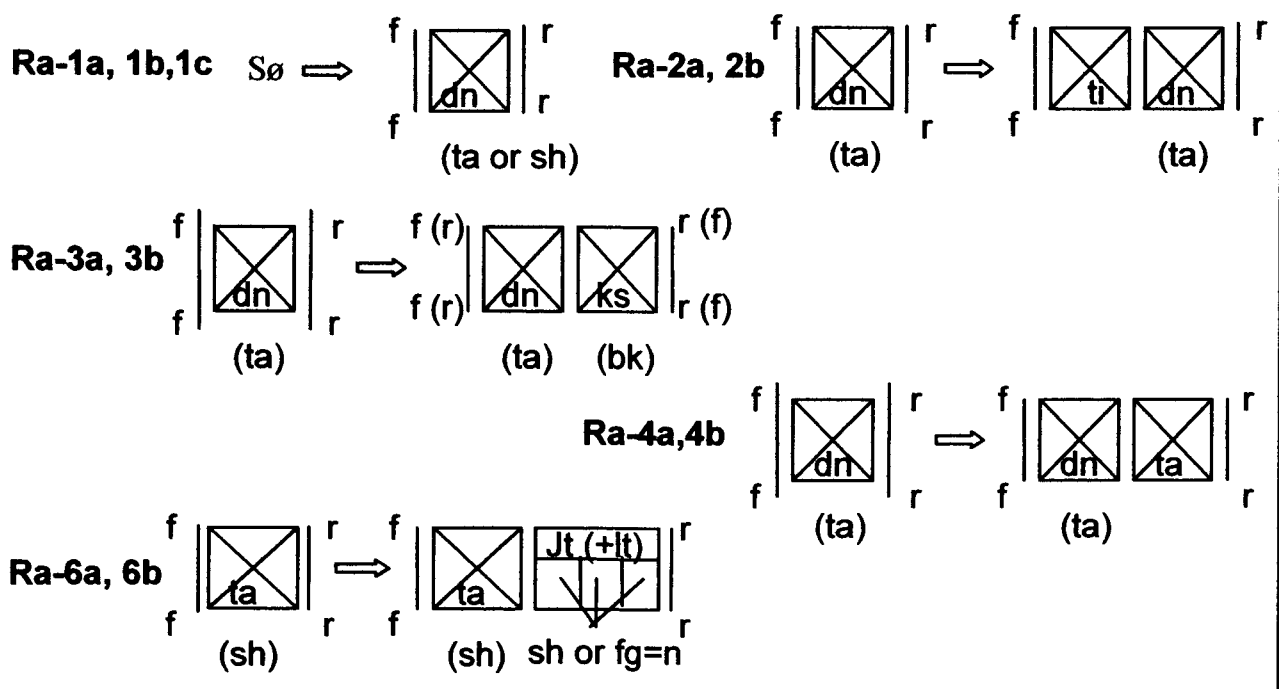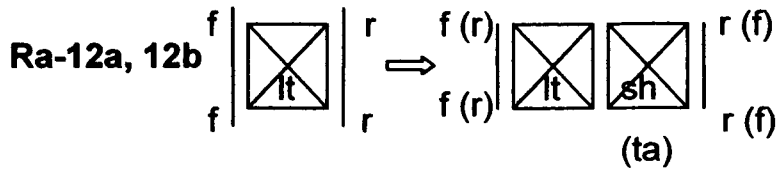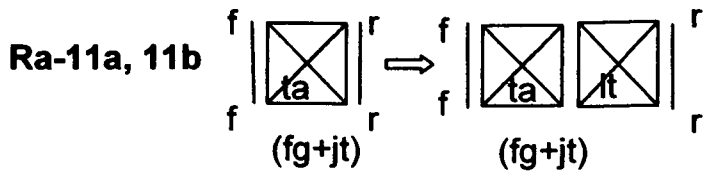
GF

1F

2F

3F

Rule A: Generation of a unit pattern

Ra-11a, 11b

f   r   f   r

ta   ⟹   ta   ft

f   r   f   r

(fg+jt)   (fg+jt)

Ra-12a, 12b

f   r   f (r)   r (f)

ft   ⟹   ft   sh

f   r   f (r)   r (f)

(ta)

Rule B: Openings on outer walls

Rb-0a or 0b   **Rb-1c**

s ⟹ s   or   s ⟹ s

Rb-2a

s ⟹ s

Rb-3a, 3b   **Rb-4a**

s ⟹ s   or   s   s ⟹ s

Rule C: Openings for connecting Spaces

Rc-1a, 1b, 1c or 1e

s ⟹ s   or   s ⟹ s   or   s ⟹ s   or   s ⟹ s

Rc-2a, 2b   **Rc-4a**

s ⟹ s   or   s ⟹ s   s ⟹ s
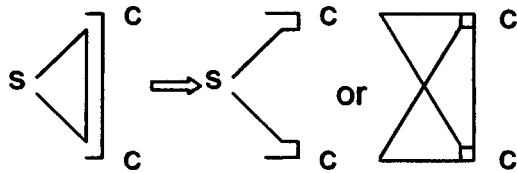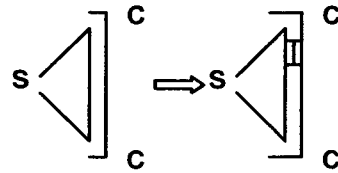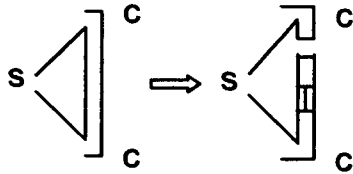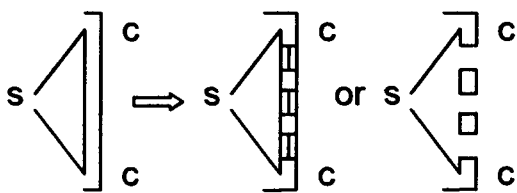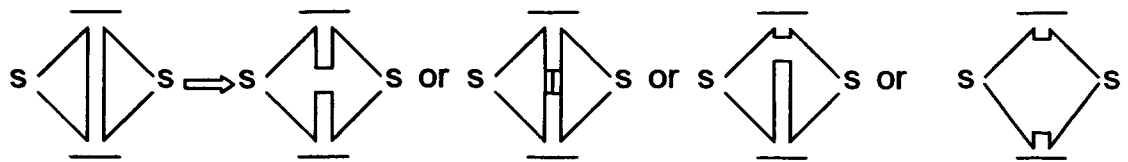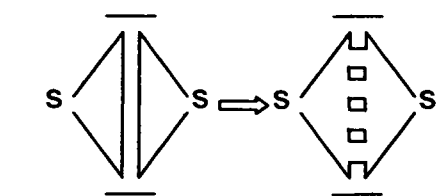
Steyr, Stadtplatz No. 21
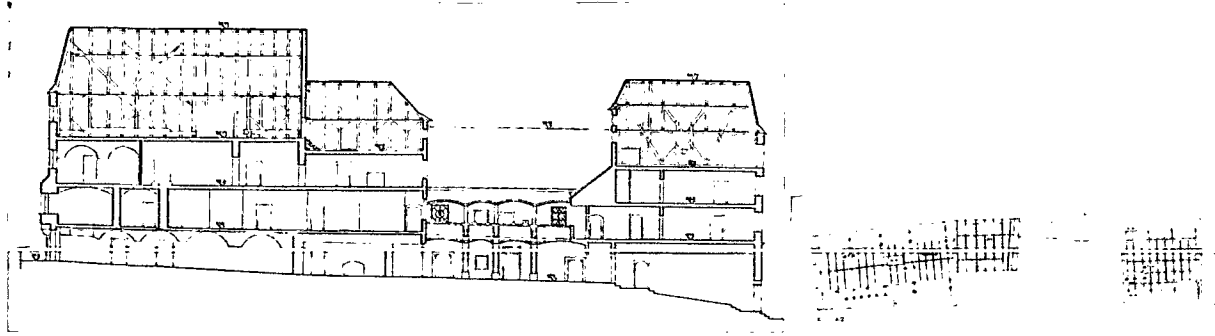
Section

GF

1F

2F

Rule A: Generation of a unit pattern

Ra-1a, 1b,1c Sø ⟹ f |⊠dn| r / f |⊠dn| r (ta or sh)

Ra-2a, 2b f |⊠dn| r ⟹ f |⊠ti ⊠dn| r (ta) / (ta)

Ra-4a,4b f |⊠dn| r ⟹ f |⊠dn ⊠ta| r (ta) / (ta)

Ra-6a, 6b f |⊠ta| r ⟹ f |⊠ta | Jt (+lt) | r (sh) / (sh) sh or fg=n

Ra-11a, 11b f |⊠ft| r ⟹ f |⊠ft ⊠ft| r (tj) / (tj)

Ra-14 f |⊠hw| r ⟹ f |⊠hw ⊠pk| r

Rule B: Openings on outer walls

Rb-0c

Rb-1a or 1c   or

Rb-2c or 2b   or

Rb-3a
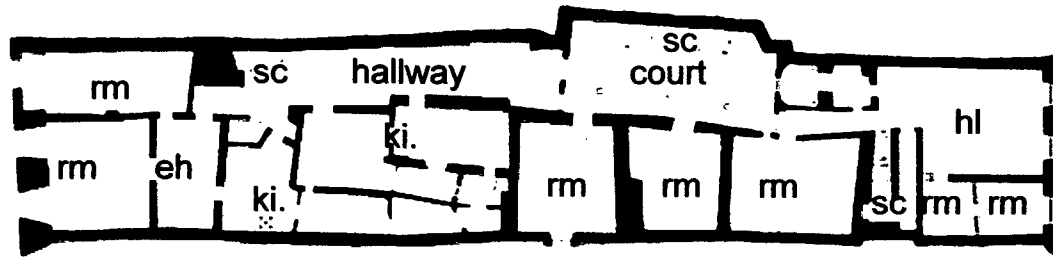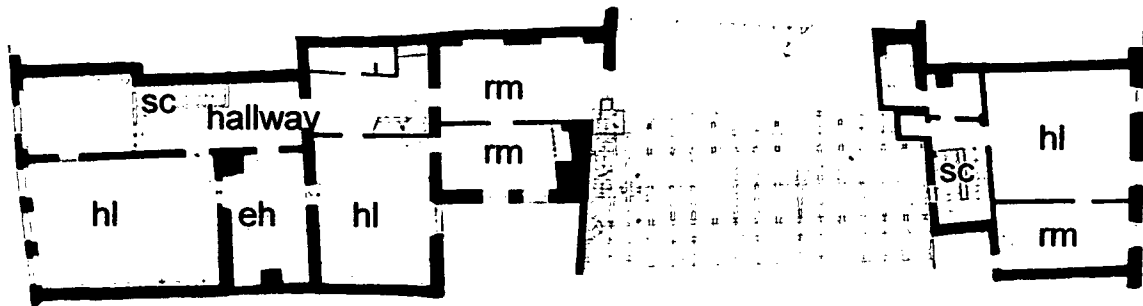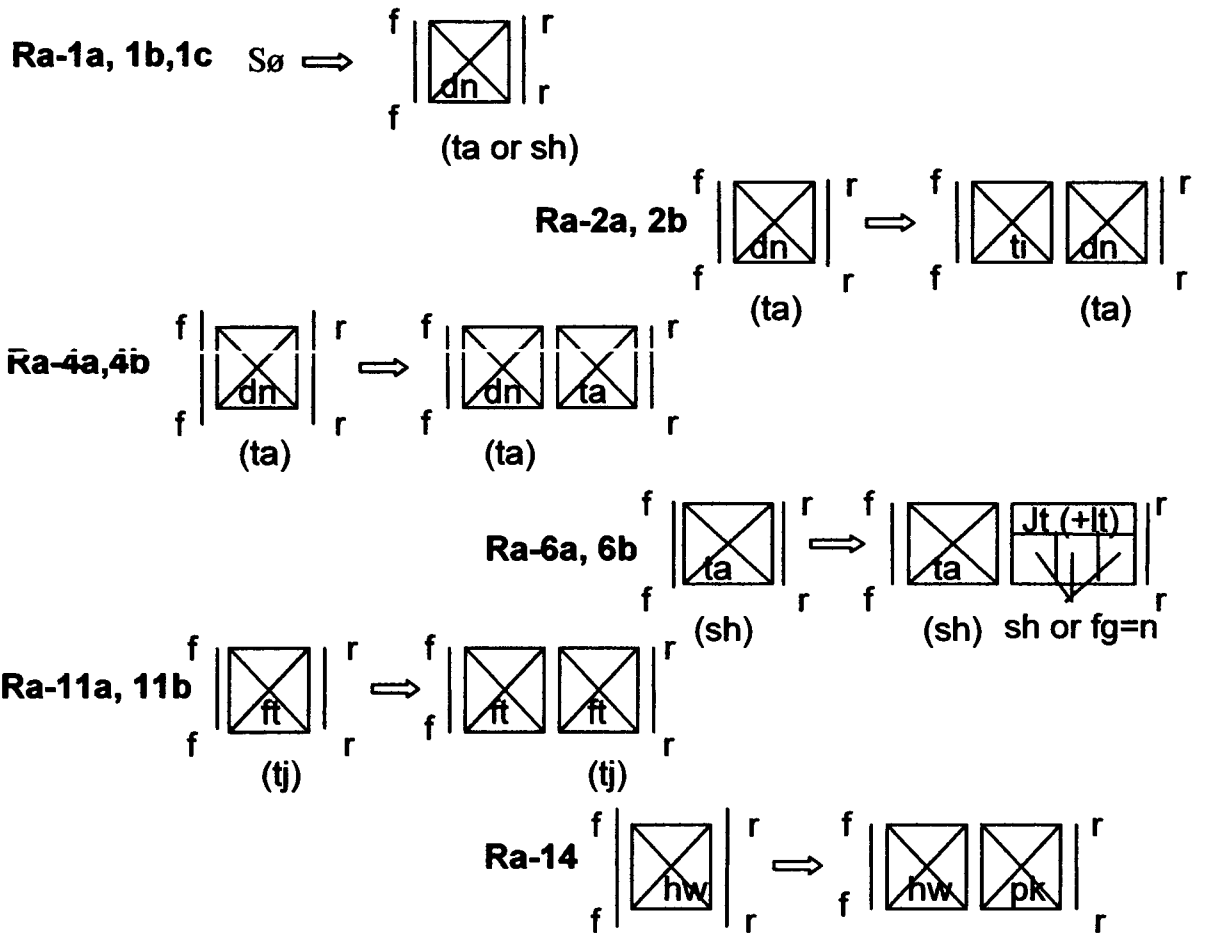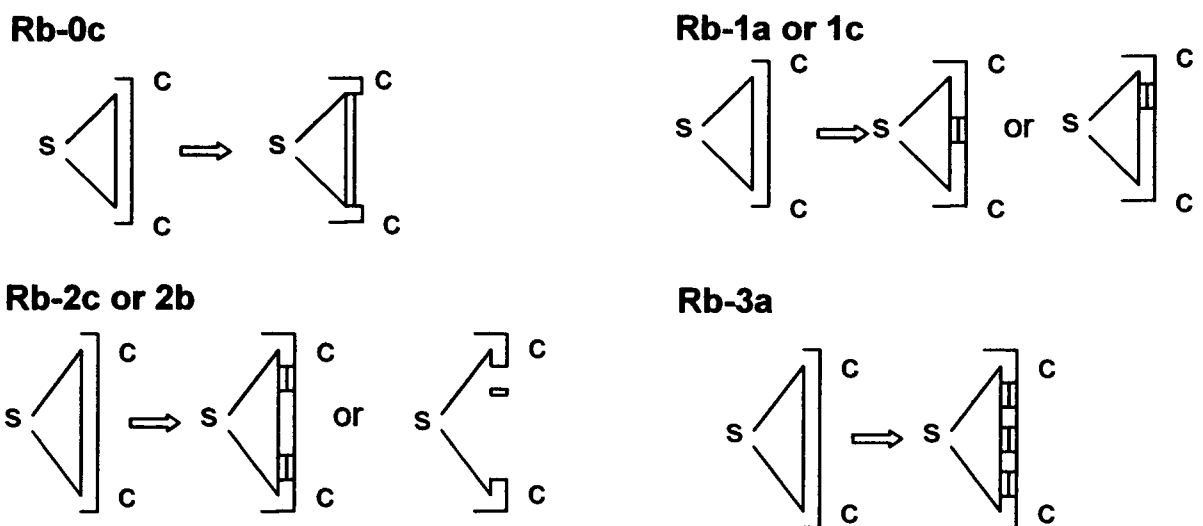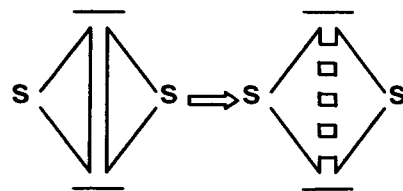
Rb-4b
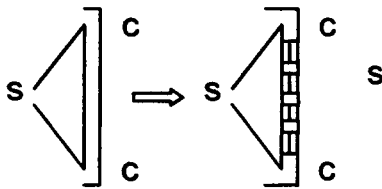
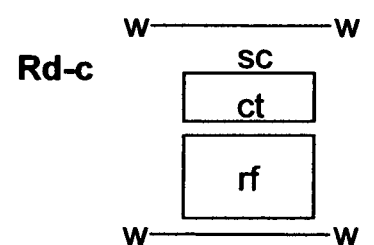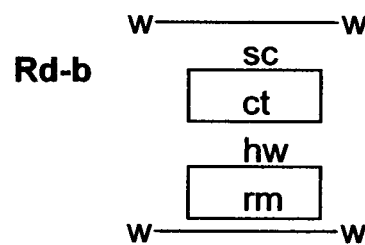## Rule C: Openings for connecting Spaces

Rc-1a, 1b or 1c

Rc-2a or 2b

Rc-3a

Rc-4a

Rule D: The connections between blocks

Rd-a

Rd-b

Rd-c
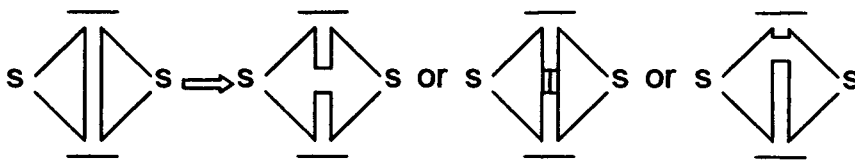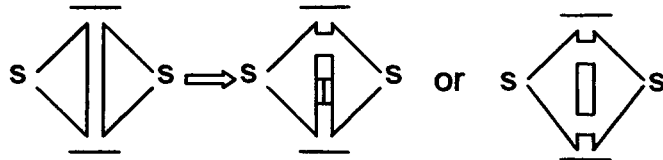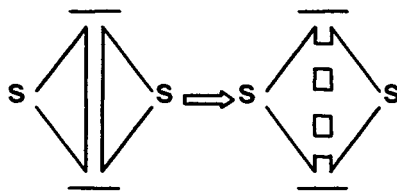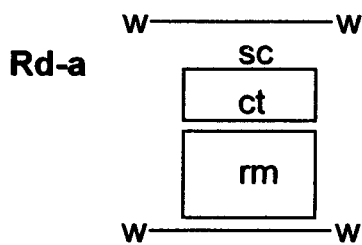
Curriculum Vitae

Yu-Chen Sung
June 12, 1964 in Taipei
24, Alley 227, Chun-ho St., Pei-tun,
Taichung, Taiwan
886-4-22393734
Email: yu-chen.sung@chello.at; yuyusung@hotmail.com

Education

2002 – 2006	Ph.D. Student in the institute of History and Theory of Architecture and Historic Building Survey
1982 – 1987	Feng Chia University, Taichung, Taiwan Architecture Department & Institute
1979 – 1982	Taiwan Provincial Panchiao Senior High School, Panchiao, Taipei, Taiwan
1976 – 1976	Yung-chun Junior High School, Taipei
1970 – 1976	Yung-chi Elementary School, Taipei

Experience

1988 – 1989	Research Assistant, Feng Chia University, Taiwan
1989 – 1991	Teacher, Interior Design Department, Min-Der Vocational School, Taichung, Taiwan
1991 – 1992	Designer, Hsin-Hsiung Architect and Associates
1992 – 1994	Architect, Hung-Kai Architects and Associates
1994 – 2001	Architect, Chief of Design Section, Hung-Kai Architects and Associates

Qualification

|	
1992	Certificate of Qualification, Professional Occupation & Technician High Examination, Examination Yuan, R.O.C.
1993	Practicing Certificate for Architect, Department of Reconstruction Taiwan Provincial Government, R.O.C.
1999	Registration Certificate of Professional Technician for Construction Interior Decoration & Repair, Ministry of the Interior, R.O.C.

Publication

1992	A guide of interior drawing

Language

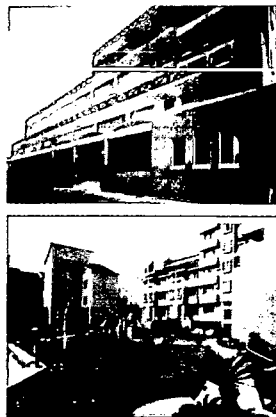|	
	Mother tounge: Chinese Taiwanese
	Foreign language: English, moderate German

Important Projects

1987 Thesis Project: A Proposal in the historical and commercial area of Lungshan Temple- a study for the traditional and historical commercial spaces
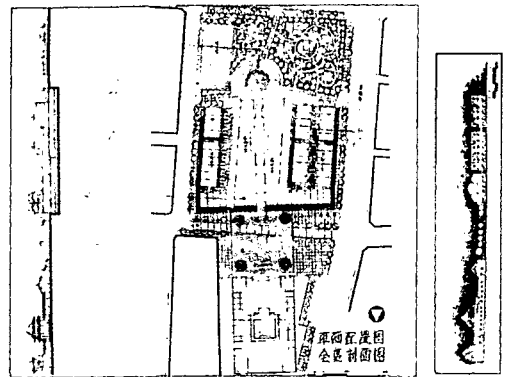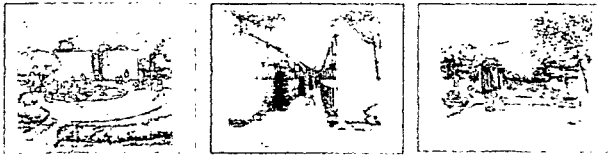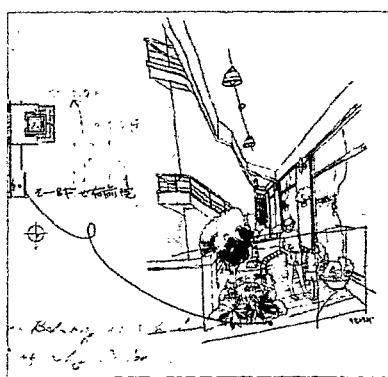

1993 Hungkai Green Villa II   **1994** The Headquarter of Feng-Hsin Iron & Steel Co. LTD.

1996 Kai Zhen Treasure

1995 A proposal for the Third Building of the National Hotel
1997 The New Confucious Apartments (The best Architectural Planning Prize in middle Taiwan-The 13th Taiwanese Architecture Gold Prize)

2000 A proposal for National Shopping Center

1997 Pine Garden Villa
1998- 2000 Long Bon Crown Villa (Competition: First Prize)