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Abstract.

China has a history that is documented over four thousand years with a rich cultural tradition and a large land mass. From archeological evidence, Chinese traditional architecture may be traced back at least seven thousand years[14]. The Chinese nation is made up of over fifty different nationalities. Despite this rich history and marked diversity of architecture in the various regions in China, Chinese traditional buildings are highly grammatical.

Architectural historians have classified Chinese traditional architecture, along geographically determined boundaries, into several categories, for example, the Northern style, the Southern style, and so on. These different styles share some basic characteristics. Wong and Chung[18] identify continuity, uniqueness of style, and diversity in architectural design as the three fundamental characteristics; according to them, traditional architecture in China *has managed to follow an unbroken line of development. Based on the needs of the people, and assimilating beneficial experiences and influences from various source, it has evolved independently with its own tenor from beginning to end. It is this very continuity, independence and adaptability that constitute the characteristics of the classical traditional.*

A parametric shape grammar[15, 16] for the Southern style of Chinese traditional dwellings has been presented in [3]. In this paper we outline some of the considerations for developing a grammar of Chinese architecture ranging from orientation to a framework of spatial organization that exemplifies axial planning and modular design and concluding with a description of some of the main rules of composition.

The Chinese have long been accustomed to take into account the cosmic aspect of nature; for instance, cities and important buildings represented ideal images. It was natural to choose a site that looked towards the sun — namely, the south or southeast — as these directions were considered to be the best orientations both practically and spiritually. The ancient cities of Xian, Beijing, and Nanjing are good examples where the city roads ran mostly along north–south and east–west directions, and where the main entrances of buildings and courtyards usually faced south.

As it is north of the equator, China, for the most part, has a prevailing southeasterly wind, cold in the winter and warm in the summer. By orienting buildings towards the south or southeast, the Chinese could take advantage of the wind and sunshine to provide for courtyards with a pleasant micro–climate. This basic idea of orientation developed into a special branch of Chinese philosophy called *feng–shui*, or geomancy. In *feng–shui* it is believed that each place on earth has special topographical features, both natural and artificial, that indicate [or modify] the universal spiritual life breath, *qi*.

This paper focuses on the traditional style of architecture found in Taiwan which has the best preserved examples of Southern style traditional dwellings.

The phonetic spellings for Chinese words in this paper are taken from Learner's Chinese English Dictionary and correspond to the Pinyin system.

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Literally, *feng* is wind, and *shuǐ* is water.

Qì (breath), if it rides the wind, would be scattered, but it would stop at water. Ancient people would concentrate qì, so this was called wind and water, or feng-shuǐ.

—Guō Pú (276–304 AD)

... for a grave, a wide river in front, a high cliff behind, with enclosing hills to the right and left, would constitute a first class feng-shuǐ position.

—Wáng Jí (10th Century)

The concept of the *jiān* appears to date back to the Shāng dynasty (circa 1766–1122 BC). In excavations at Yīn-xu, the Shāng capital at Ān-yáng, over ten buildings having rectangular foundations were discovered. On the foundations, laid out in straight lines and set at equal intervals, were bases for columns made of large, round stones bearing copper plates. Wood ash was found on copper plates, some of which were carved in a thunder-and-cloud design. The excavations at Ān-yáng proved that during the Shāng dynasty, both *jiān* and wood framing were used in building construction. The findings also indicate the beginning of standardization in building construction[130].

Feng-shuǐ is the art of adapting a building to harmonize with its local environment and climatic condition; Joseph Needham in his classic *Science and Civilisation in China* refers to *feng-shuǐ* as a pseudo-science. The concept is based on the idea that people should live and work in harmonious surroundings. It was believed that

a site should be surrounded on three sides by higher land, like the crook of the elbow in a curved arm, to provide protection from inclement weather or an enemy. The lie of the land should be gently sloping and, if possible, there should be a river or valley nearby to allow surface water to drain easily.

—Lawrence Liu, 1989 [13]

Feng-shuǐ was almost universally considered, applied in all localities and to different building types. It is still in use today.

Modules

Chinese traditional dwellings comprise two types of buildings, arranged orthogonally to the other: main and secondary buildings. Main buildings are placed transversely to the orientation. The spatial organization and planning of these buildings centers around the concept of a *jiān*. This involves the use of a *jiān*: bay, the basic area unit in a building, as a standard which may be expanded or repeated to form either individual buildings or groups of buildings. The *jiān* is a rectangular space or room which may be enclosed by walls, or defined by columns that separate it from its adjacent spaces or rooms. The *jiān* can be extended to form a building by extending the *jiān* along a vertical or horizontal axis, see Figure 1. Buildings can be grouped around courtyards to form different types of building combinations.

In traditional dwellings a main building has, at a minimum,

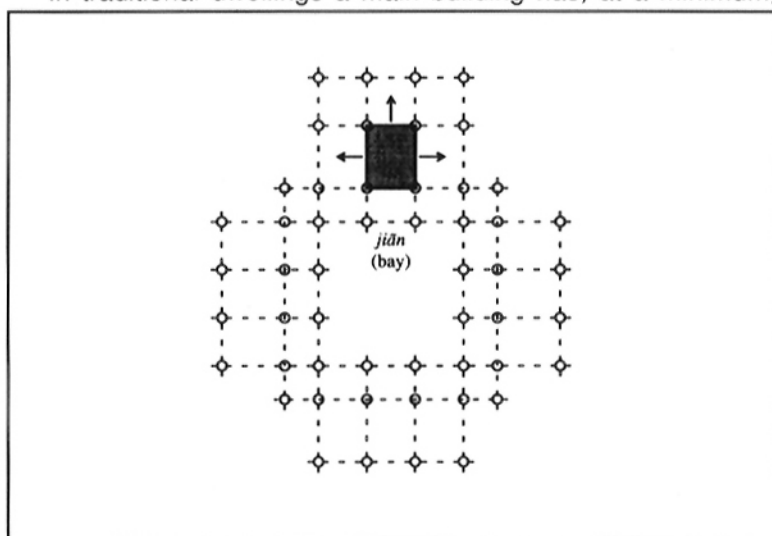


Figure 1. *Jiān*, the unit of spatial organization[10]

three *jiāns*. Typically, each space in a main building has a unique name: the central space is *míng*: light, the two rooms next to *míng* are *cì*: secondary, the rooms next to *cì* are *shāo*: tip or end, and the rooms next to *shāo* are *jìn*: finished. The widths of each *jiān* are not necessarily equal. In general, *míng* is at least as wide as *cì*, which in turn is at least as wide as *shāo*, which is at least as wide as *jìn*. The *míng jiān* is thus the spatial unit by which the width of a building was determined.

Apart from a few exceptions, most main buildings have an odd number of *jiāns*: bays and number between one and nine, and never exceed eleven. Typically, nine and, on a very few occasions, eleven bays were reserved for the imperial palace. There are three possible explanations why main buildings have an odd number of bays.

Firstly, most main buildings are bilaterally symmetric, and the central room is located on the axis of symmetry. Secondly, the Chinese believe(d) that odd is *yáng* and even is *yīng*. Thirdly, in the *Lú-bān Jīng*[11], it was defined that a building with three, five, seven or nine rooms was considered fortunate, but with one, two, four and six rooms, it was not.

Jià, literally meaning purlin, is the unit by which the depth of a *jiān* and/or building is determined. In general, most traditional buildings have an odd number of *jiàs*.

In ancient China, a building's *jiān* and *jià* indicated its owner's social or political status. Table 1 illustrates typical values for building *jiāns* and *jiàs* for different levels of officers stipulated by the regulations during the Qing dynasty[8]. For houses for common people, these values could not exceed three *jiāns*, and in the case of temples and palaces, nine and eleven respectively[5].

By the Táng dynasty (618–907 AD), the Chinese had devel-

The traditional street house, *jiē-wu*, in general, had only a single *jiān*.

Nine was considered as the limit of nature's numbers. In China, nine *jiāns* traditionally implied a building belonging to the emperor. However, in Taiwan, there are traditional buildings with nine *jiāns*. In the case of houses, these were mansions owned by individuals of privilege and status.

Lú-bān is regarded the first carpenter of China and is credited with the invention of the system of measurement, described in the *Lú-bān Jīng*, upon which the fortunate dimensions of traditional buildings were determined, see [2].

The officers' hierarchy was called *pīn* and numbered from one to nine. A mayor was usually a seventh *pīn*, while dukes and princes are higher than the first and second *pīn*.

Officer Hierarchy	Entrance Hall	Principal Building
First and Second <i>pīn</i>	3 <i>jiān</i> , 5 <i>jià</i>	7 <i>jiān</i> , 9 <i>jià</i>
Third to Fifth <i>pīn</i>	3 <i>jiān</i> , 3 <i>jià</i>	5 <i>jiān</i> , 7 <i>jià</i>
Sixth to Ninth <i>pīn</i>	1 <i>jiān</i> , 3 <i>jià</i>	[3 <i>jiān</i> , 5 <i>jià</i>]

Table 1. Building *jiāns* and *jiàs* during the Qing dynasty

oped a modular construction system with cross-sectional measurements for each timber calculated for the desired width and depth of the *jiān*[14]. During the Sòng dynasty(960-1279 AD), instructions became much more precise and were recorded in the *Yíng-zào fā-shì*, Building Standards from 1103 AD.

The Entrance Hall is the front-most main building for which the *míng jiān* served as entrance. The Principal Building is the rear-most main building where the altar was usually located.

***Cái**, the standard timber for all construction, is graded into eight classes. The depth of each **cái** is divided into fifteen **fens**; 10 **fens** gives the thickness of **cái**. The proportion of every part of the building is thus measured in terms of the **fen**.*

—Liang and Fairbank[7]

In the Canon of Changes, *Yi-jing*, *yin* and *yáng* are the two opposing principles in nature; the former meaning feminine, negative and death, the latter masculine, positive and living. The Chinese distinguish(ed) between the two forms of construction: *yin* and *yáng* buildings — at the same time identifying them as dwellings of darkness and dwellings of light respectively and linking the two together in a single system. There is a strong relationship between *yin*, *yáng* and *feng-shuǐ*.

It is very important to grasp the idea that in the Chinese view a building is not simply something that sits upon the ground to serve as a convenient site for human activity. It is an intervention in the universe; and that universe is composed of the physical environment and men and the relationships among men. Men are bonded to the physical environment, working good or ill upon it and being done good or ill to by it. Modifications in the landscape reverberate. So that, in principle, every act of construction disturbs a complex balance of forces within a system made up of nature and society, and it must be made to produce a new balance of forces lest evil follow. Chinese are frightened by the act of building — and they are wary, too, of the tricks that carpenters and masons can play on them.

— Maurice Freedman, 1964 [13]

In general, the nature of the building — house, temple, government office, official building or palace — and its dimensional scale expressed by the number of *jiāns* and *jiàs* would suffice in determining the necessary grade of *cái*. The width, depth, height of the building, the dimensions of every structural members, the rise and curve of the roof line would then all be measured in terms of the *fen* of the grade of *cái* used.

During the Qing dynasty, another modular system, *dōu-kōu*, was invented. The *Gōng-bù gōng-chéng zùo-fā zé-lì*, Structural Regulations of 1734 AD state that:

*The width and depth are determined by the collection of bearing blocks called **zân**. A **zân** equals eleven times the size of **dōu-kōu**.*

That is, given the size of *dōu-kōu*, we have:

zân = 11 *dōu-kōu*;

width of *míng* = 7 **zân** = 77 *dōu-kōu*;

width of *cì* = 6 **zân** = 66 *dōu-kōu*;

width of *shǎo* = 5 **zân** = 55 *dōu-kōu*..

Consequently, every detail and measurement of a building can be determined by the width of *dōu-kōu*.

Axial planning

The symmetrical and orthogonal structuring of the plan and elevation was almost certainly intended as a direct representation of the Chinese cosmos. Unlike Western axial planning, the Chinese placed all main buildings and courtyards along a longitudinal axis or path in a strictly orthogonal fashion. The main buildings are separated from each other by a courtyard which functions not only as an area of traffic between buildings, but also as a place for outdoor activities. The courtyard was considered to be a major space in composition where many important rituals took place. It was thus regarded as an extension or addition to the buildings[10, 14).

The longitudinal axis is considered to be the major axis along which the main buildings are placed, see Figure 2. This axis also indicates the orientation of a group of buildings made up of a main building and several secondary buildings. Each building group may have precisely one courtyard; an entire dwelling though may be formed by several such courtyard groups. Each such courtyard group is called a *jìn*: enclosure. The front-most main building is the first *jìn*. The rear-most main building or the last *jìn* is referred to as the principal building. In the Southern style as typified by Taiwanese traditional houses, one or two *jins* were most popular;

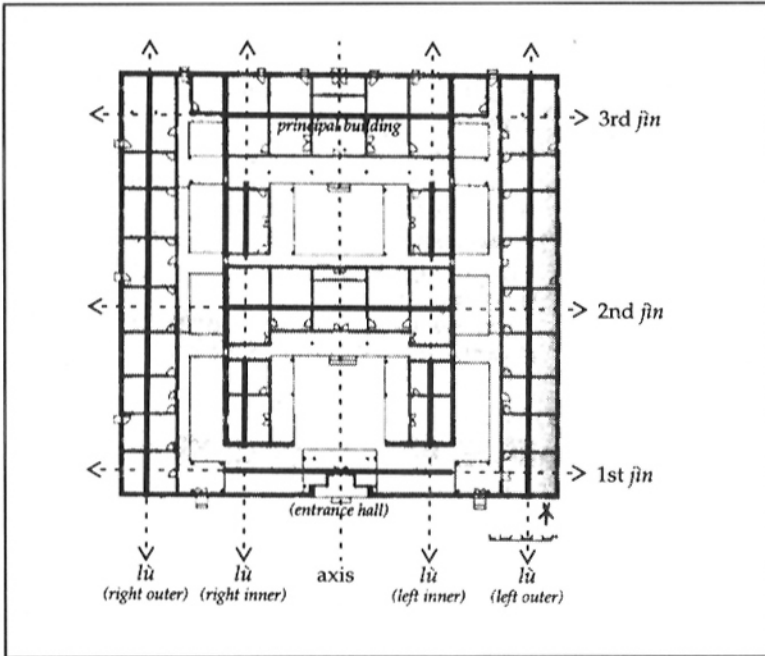


Figure 2. *Jin*, the enclosure, and *lù*, rout [6]

any dwelling with more than three *jins* was considered to be a mansion or great house. There is a saying in Taiwan to describe one's dream of a great house —

A mansion is nine embodying five, three luò (jin), one hundred and twenty doors.

The secondary buildings are placed on axes called *lù*:

In the Qing dynasty (1644–1911 AD), a purlin, *lǐng*, was a *jià*; however, during the Sòng dynasty, the distance between two purlins was called a *bù-jià* or steps of purlins. If we assume that each step is equivalent among the different buildings, those with a larger number of *jiàs*, clearly, have greater depth.

Nine embodying five has two interpretations. One interpretation is the rear-most main building, the last *jin*, has nine rooms, *jiāns*, and the first one, the front-most main building, has five rooms. Another interpretation is the last *jin* has nine rooms and its outermost secondary buildings have five rooms each.

Some refer to *luò* as a hall, *táng*, and *lù* as transverse, *héng*. Therefore, the simplest enclosure–courtyard, *sān-hé-yuàn*, an inverted U-shape is made up of a single hall, *táng*, and two transverses, *héngs*.

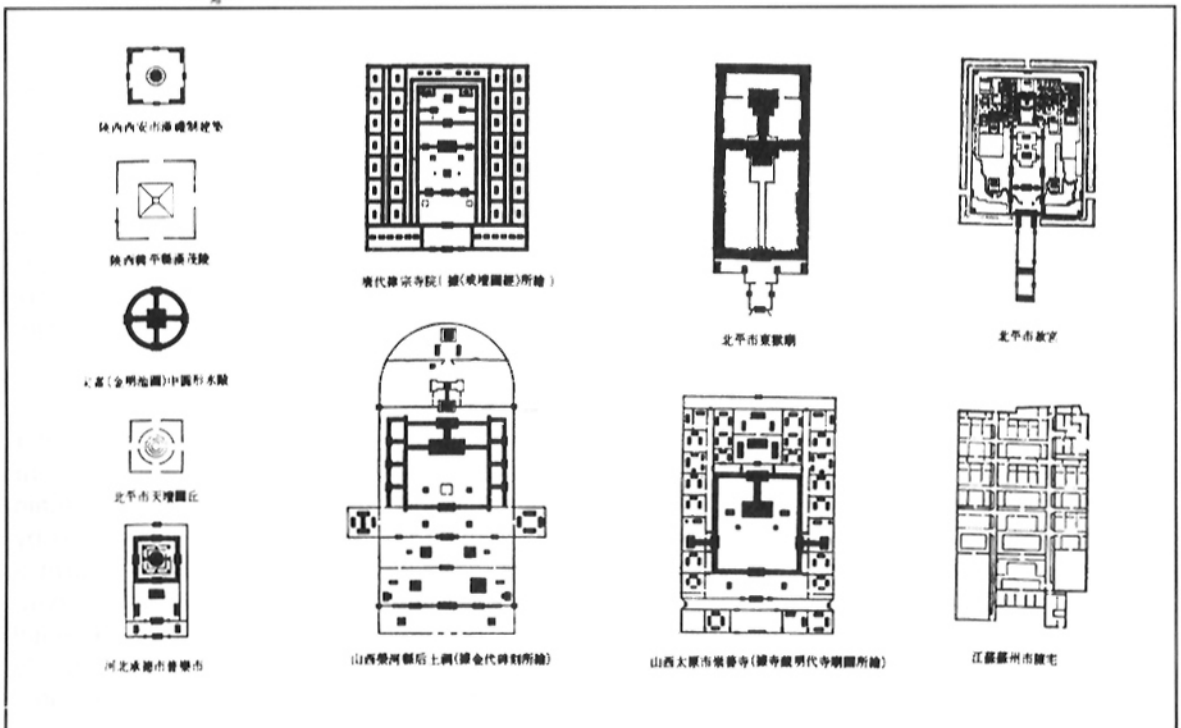


Figure 3. Axial planning and spatial organization[9]

route, which are parallel to the major axis. Some researchers treat the courtyards along the main axis as the **zhōng-lù** or central route[14]. However, this seems redundant. In each courtyard, the main building is the place of honor; in each large complex, the main axis is the most honored, and along each route, the principal courtyard ranks the highest. Usage is allocated according to seniority and rank, related closely to the prevailing family hierarchical system and social order[14]. There are three basic arrangements used in Chinese axial planning. See Figure 3.

CENTRAL AXIS ARRANGEMENT: This is the most common form of arrangement where a main building [or the principal building] is placed symmetrically about the major axis. Secondary buildings are located to the left and right of this main structure, and main buildings in front and to the back of it. As a result, one or more **hé-yuàn**, horseshoe shaped enclosure courtyards, are formed. Sometimes another main building might be located to the front-most courtyard, allowing an enclosed courtyard to be formed by four buildings and the walls that connect them. The most basic Chinese courtyard forms are grouped in this manner.

A variation of this arrangement, **láng-yuàn**, verandah courtyard, is formed by the same layout, in which the main building is placed symmetrically about the major axis with two secondary buildings to its right and left, but with covered verandahs instead of connecting these buildings directly to the main building. This composition was widely used in China beginning with the Hàn dynasty (206 BC – 220 AD) and endured until the Táng and Sòng dynasties. After the Sòng dynasty, very few structures were built using this form[10]. However, it is still one of the typical layouts for Taiwanese traditional temples.

PARALLEL AXES ARRANGEMENT: When more rooms were needed, minor longitudinal axes are established parallel to the main axis. Thus, instead of one longitudinal extension, more than two groups of buildings were established. In order to have transport facilities and fire prevention, there were paths between each group. This type of extension was developed, during the Táng dynasty, for palaces, temples, official buildings, and large complex houses.

DOUBLE SYMMETRY ARRANGEMENT: This type of arrangement is popular for the layout of monuments, especially after the Hàn dynasty. The composition, based upon perpendicular axes, places the main building at the intersection of the main and minor axes. The whole group is surrounded on all sides by minor buildings, verandahs, and other buildings to form a square or circular layout. In this way, a building group is symmetrical along both the longitudinal and latitudinal or horizontal axes. **Tiān-tán:** The Altars of Heaven of the Míng dynasty (1368–1644 AD) is an example of this type of spatial planning.

If all of the main openings faced the courtyard, it was referred to as a **sì-hé-yuàn**; otherwise, it was a **sān-hé-yuàn**. The front-most main building in a **sì-hé-yuàn** was called **dào-zuò**, inverted seat.

In most regions, Chinese traditional architecture relied upon wood-frame construction. Brick and stone structures were not widely adopted. The reader is referred to the literature, such as [10], for possible explanations on why wood construction became mainstream in Chinese traditional architecture.

There were two main types of wood framing systems — **chuān-dōu**: column-and-tie system and **tái-liáng**: column-beam-and-strut system. **Chuān-dōu** is the most common for dwellings in which the pillars and transverse beams are tied together, Figure 4. **Tái-liáng** is a pillar-and-beam construction in which two pillars are posted onto the transverse beam directly, Figure 5. **Tái-liáng** is popular in temples and palaces.

Dié-dōu is another wood framing system similar to the **tái-liáng**, but with the transverse beam posted onto the

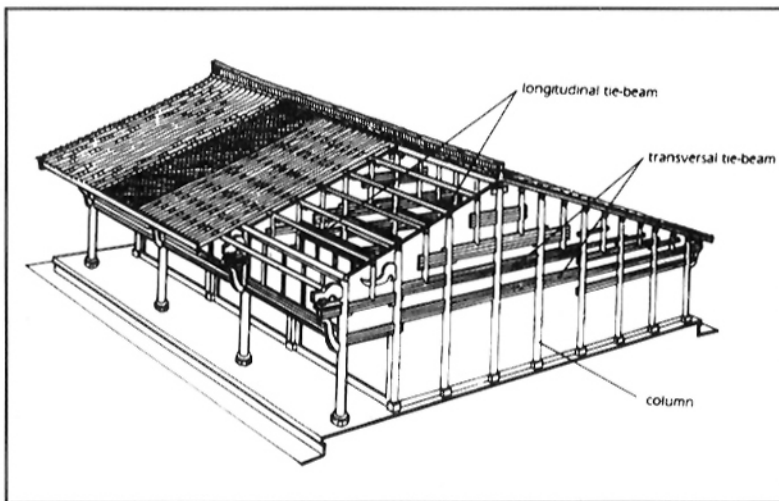


Figure 4. *Chuān-dōu* wood framing system [14]

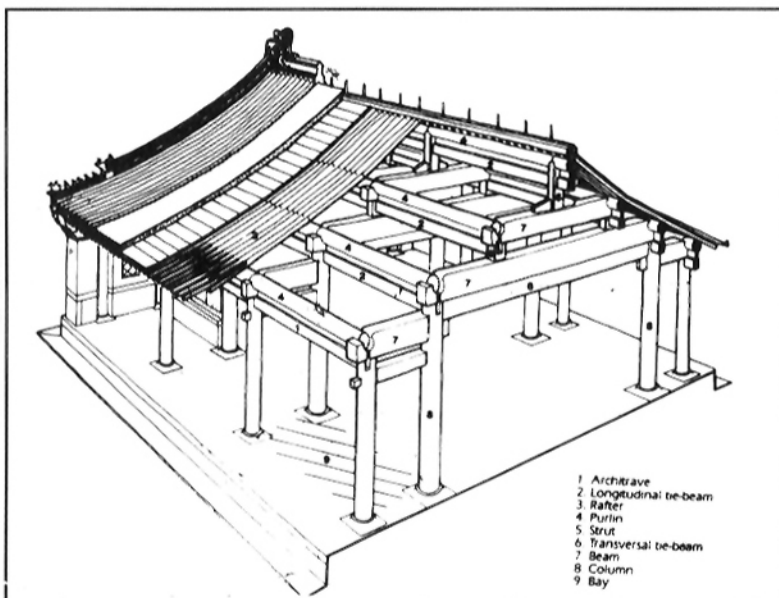


Figure 5. *Tái-liáng* wood framing system [14]

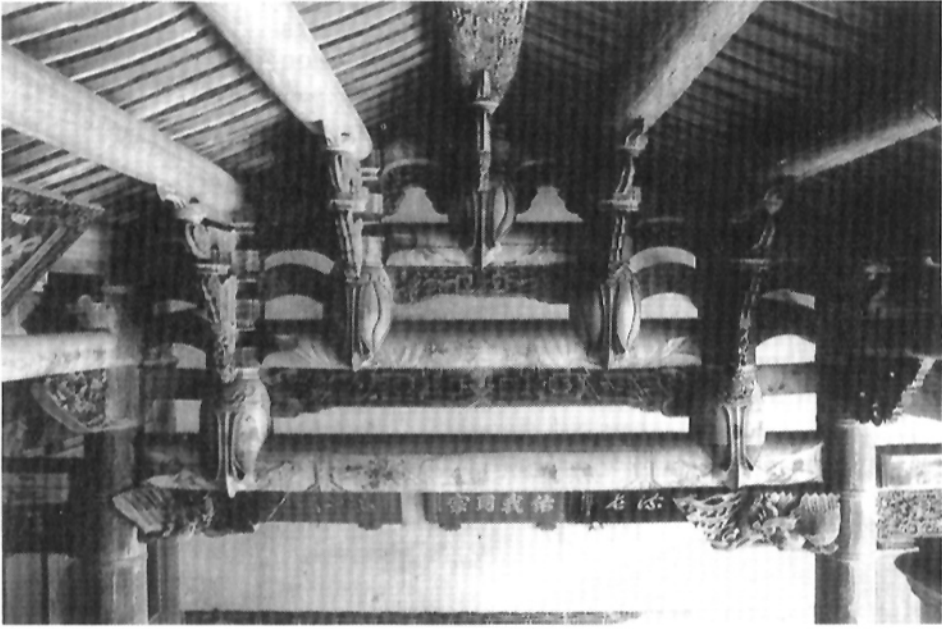


Figure 6. Dié-dôu wood framing system [8]

dôu-gongs: eaves brackets or bracket set which are on the top of the pillars. **Dié-dôu**, see Figure 6, is more decorative than **tái-liáng**. Other minor wood framing systems such as **jīng-gàn** and **mì-liáng píng-dīng**: purlin-and-rafter flat roof type, are not that important to mainstream Chinese traditional architecture.

The **chuān-dôu** and **tái-liáng** are used in traditional buildings with gabled roofs. The **tái-liáng** style, widespread in cen-

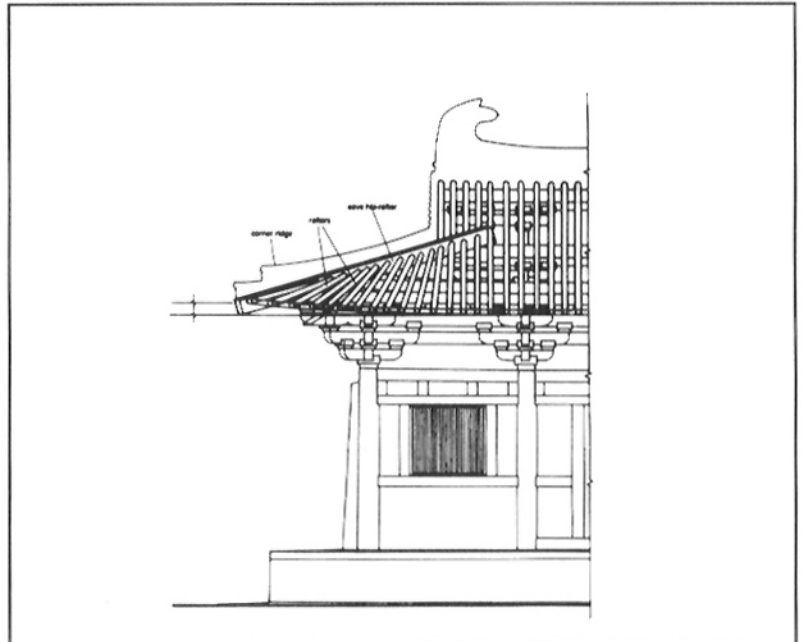


Figure 7. An elevation of a Chinese traditional building [14]

tral, northern, northwestern, and northeastern China, is the most popular. The *chuān-dōu* type is prevalent in eastern, southern, and southwestern China; however, even in these regions, important Buddhist and Taoist monastery halls as well as private and official residences are generally built in the *tái-liáng* method[14].

Several researchers[9, 14, 18] have observed a number of important architectural features found in Chinese traditional buildings, see Figure 7, that resulted from or were facilitated by the use of wood frame construction.

- The structure is divided into three identifiable parts: platform, body or building proper, and roof.
- Roofs have concave surfaces with corners that curve upwards.
- The use of *dōu-gōng*: bracket set.
- The concept of *jiān* as a unit in a modular system of designing and planning. The column grids can be varied, allowing omission or shift of column supports. Other parameters such as the width of the bays and the height of the floor can also be varied to satisfy diverse functional demands.
- The ease with which interior spaces can be divided.
- Paintings and color decorations which are important aspects of Chinese traditional architecture.
- The flexibility of the structure to adapt to different climates.
- The reduction in damage due to earthquakes.
- The ease of material support.

Spatial Organization

Apart from some regions inhabited by minority nationalities, there are few examples of large single traditional buildings composed of rooms for multiple uses; typically, a single story dwelling arranged around a private courtyard prevails[14]. This is known as a *hé-yuàn*: courtyard enclosure. Traditionally, in a *hé-yuàn* the spaces bordering the enclosure have openings facing the courtyard. The axis of symmetry bisects the main central hall. All of the other spaces are developed through this central hall. Starting with the *táng-wu*: main building, also referred to as *tíng-táng*, which includes the hall, two *xiāng-fángs*: secondary buildings, are generated. These two *xiāng-fángs* are also basic elements of the *hé-yuàn*. It is clear that a traditional building is the combination of several *hé-yuàn*s.

According to the literature and practice, based on field studies and information from artisans, a traditional building was planned or designed, in general, by the following process.

STEP ONE: Checking the site, and deciding upon the orientation and axes — Deciding upon a fortunate orientation was

The process described here pertains to Taiwanese traditional architecture; however, there is no reason to suppose that Chinese traditional architecture did not have similar processes.

A geomancer could be a skilled professional with extensive knowledge of geomancy, an artisan who had learned geomancy through practice, or a god, as interpreted through a priest or spirit writing, *ji-tóng* or *fú-luán*. It was common for gods to decide their own temple site, orientation, artisans, and design details.

The master artisan was not solely hired for his technical ability but also for his honesty and reliability. The design of a traditional building was a collaborative effort by the owner and master artisan in that the customs, taboos, and fortunes of the owner played a considerable role.

always the first step in the traditional design process; here, *feng-shuî* played an important role. The owner would consult a geomancer to check the site before the start of design and construction. The geomancer when checking the site would also decide upon the orientation that best suited the owner. Typically, the geomancer would mark two points on the site. One located the ming: central hall of the principal building in which the altar would be; the other located the front of the intended building layout. These two marks indicated the main axis and orientation.

In this stage, the *master* artisan would decide upon the general layout and style, that is the numbers of *jins*: enclosures, *lùs*: routs, *jiāns*: bays, and so on. This information would help the master artisan to *design* the whole building.

STEP TWO: Determining the measurements of the central room — The next step was to decide upon the module and the dimensions for the height, width, and depth of the *ming jiān*: central bay or central room. The master artisan might even have followed *chî-bái/cùn-bái* and used the corresponding procedures described in [2] to compute the fortunate dimensions.

STEP THREE: Designing the main frames — The artisan usually drew a sketch of the longitudinal frames which might include the partitions between *ming* and *cì* of the central room. There were a number of issues that the artisan would have dealt with.

- 1. *yin-yáng-biān*. The roof has two parts: the *yáng* side: front roof eaves, which is higher than the *yin* side: rear

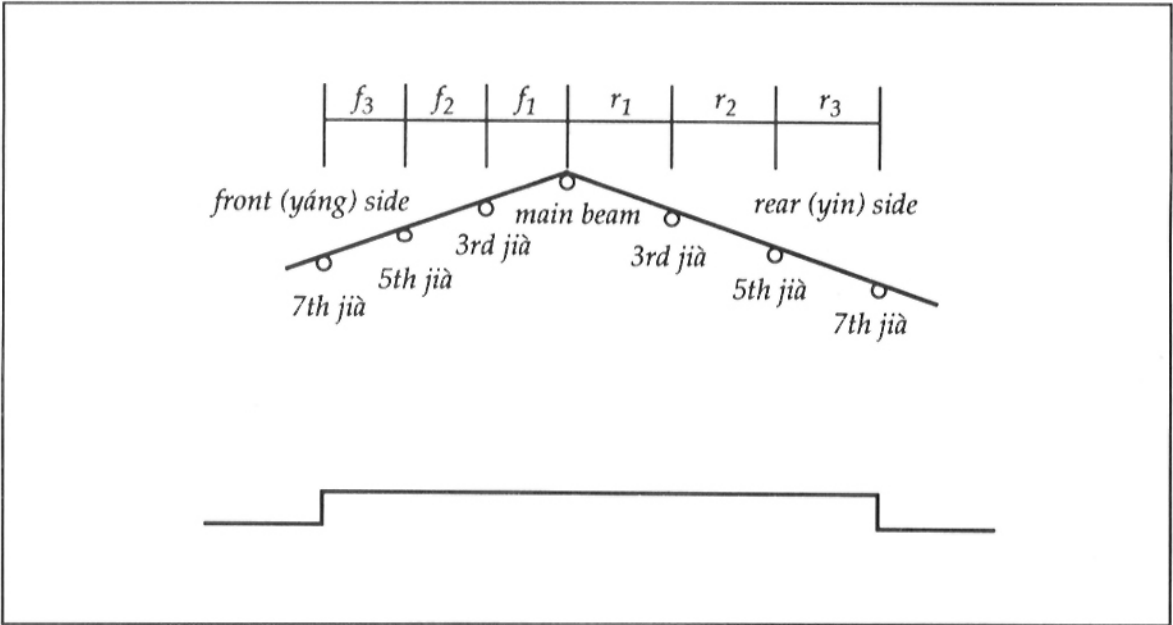


Figure 8. The arrangement of *jiá*

roof. In traditional architecture, the slopes of the front and rear sides of the roof, in general, were the same; as a result, the main beam was positioned towards the front of the building, and hence, was not coincident with the center line. In Taiwanese traditional houses, the pitch of the roof is approximately 0.35 (33%–40%) and the horizontal difference between the *yin* side and the *yáng* side is 4 to 12 *Lû Băn* inches[1]. In general, the pitch of the roof for temples is steeper than for houses. It was believed that a temple with steep roofs bestowed prosperity, but steep roofs for a house would drain money away and leave the owner poorer.

2. The arrangement of *jià*. The number of *jiàs* had to be odd. There are four possible ways of arranging the *jiàs*: purlins, see Figure 8.

The steps: *bù-jià* were equivalent on each roof side, that is,

$$f_1 = f_2 = f_3; \quad r_1 = r_2 = r_3. \quad (1)$$

The nearer the step to the main beam, the greater its length, that is,

$$f_1 > f_2 > f_3; \quad r_1 > r_2 > r_3. \quad (2)$$

Corresponding steps on both sides of the roof were equivalent, that is,

$$f_1 = r_1; \quad f_2 = r_2; \quad f_3 = r_3. \quad (3)$$

Corresponding steps on the rear side were greater than those on the front side, that is,

$$r_1 > f_1; \quad r_2 > f_2; \quad r_3 > f_3. \quad (4)$$

3. Taboos on *jià*. There were two general taboos on the arrangement of purlins.

- The front–most step, f_3 in Figure 8, must be greater than the width of the door. In other words, there was no purlin above the trace of the door opening.
- The rear–most step, r_3 in Figure 8, must be greater than the depth of the altar. That is, there was no purlin above the altar.

4. *Săn-hé*. This is a restriction on the relationship between the main beam, light beam, and main entrance. Basically, this restriction constrains the position of the light beam and the height of the main entrance. See Figure 9.

In Taiwanese traditional architecture, the main beam and light beam are two holy dominants that have special

A *Lû Băn* foot measures approximately 29.69 cms. There are 10 *Lû Băn* inches to a *Lû Băn* foot.

The number of *jiàs*, generally, was determined by the depth of the central room, or by the regulations. In Taiwanese traditional houses, it was common for the main building to have nine to thirteen *jiàs*, and each step, *bù-jià*, was approximately 2–2.5 *Lû Băn* feet.

One may find that the number of *jiàs* in Taiwanese traditional architecture exceeded the regulations. One reason for the smaller *bù-jià*, as compared to Chinese traditional architecture, was that longer timbers were not easy to obtain in Taiwan.

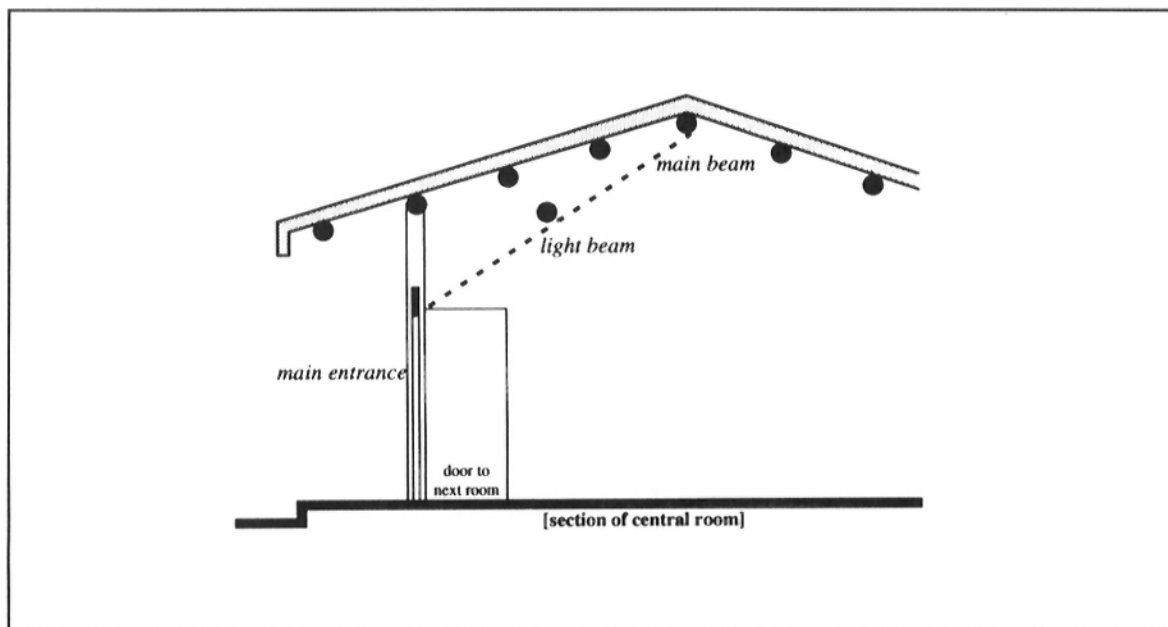


Figure 9. *Sǎn-hé*, the relation between the main beam, the light beams, and the main entrance.

In Taiwanese, the pronunciation for light and boy, *dīng*, is the same. The light beam is treated as the demarcation between gods and ghosts in a house. The Taiwanese believed that the proper positioning of the light beam was important for the birth of a boy in the house.

The construction ruler, *gāo-chī*, was different for each building. It was analogous to a set of working drawings. In fact, artisans did not produce construction drawings. The artisan marked all the measurements for the buildings on this ruler. No one other than the artisan could understand the marks.

meaning. In order to protect these two important features, the artisan traditionally positioned the upper frame of the main entrance, the main beam and the light beam on a straight line, namely, *sǎn-hé*. In addition to the *sǎn-hé*, there was one other restriction or taboo on the positioning of the light beam. It was believed by some that the light beam could not be placed directly under a purlin, that is, it had to lie within a step: *bù-jià*.

In order to sketch details of the main frame, the artisan also had to decide on the framing system: *chuān-dōu* or *tái-liáng*. He could then arrange the columns, struts, pillars, and ties or traverse beams. Generally, in Taiwanese traditional houses, the framing system *chuān-dōu* was employed and in temples, *tái-liáng*.

According to this sketch, the artisan made a special construction ruler: *zhàng-gāo* or *gāo-chī*, — a stick — and marked all the details on it. Using this ruler, the artisan could design the whole building. He could also then determine how much material was needed for construction.

STEP FOUR: Extending the hall to form a main building — According to the measurements of the central *jiān*, the main building could be extended by adding two more *jiāns* to the central *jiān* laterally till the total number of *jiān* in the main building was equal to the intended *jiāns*. Usually the width of each added *jiān* was less than the central *jiān*. The dimensions of the added rooms usually satisfied the following constraints.

1. Each *jiān* was no wider than the central *jiān*. The width of the chamber was between 0.8 and 0.9 times that of

Type	<i>jìn</i> and <i>lù</i>	Cases	$\frac{cì}{míng}$	$\frac{shǎo}{cì}$	$\frac{jìn}{shǎo}$	$\frac{shǎo}{míng}$	$\frac{jìn}{míng}$	$\frac{jìn}{cì}$
	1 <i>jìn</i>	6	0.77	1.23	0.94	0.95	0.98	1.16
	1 <i>jìn</i> 2 <i>lùs</i>	9	0.69	1.20	0.85	0.83	0.70	1.02
7 <i>jiāns</i>	1 <i>jìn</i> 3 <i>lùs</i>	2	0.70	1.23	0.85	0.86	0.73	1.05
	1 <i>jìn</i> 4 <i>lùs</i>	5	0.68	1.08	0.90	0.73	0.66	0.97
	1 <i>jìn</i> 5 <i>lùs</i>	1	0.78	1.03	0.81	0.80	0.65	0.83
	2 <i>jìns</i> 2 <i>lùs</i>	1	0.58	1.02	1.28	0.59	0.76	1.31
	1 <i>jìn</i>	2	0.82	1.14		0.93		
5 <i>jiāns</i>	1 <i>jìn</i> 2 <i>lùs</i>	5	0.69	1.22		0.84		
	1 <i>jìn</i> 3 <i>lùs</i>	1	0.67	1.46		0.98		
	Average		0.71	1.19	0.90	0.84	0.77	1.01

Table 2. The proportions of the room widths in a main building, Xin-pú, Taiwan, see [1]

the *míng jiān*. Typical values for the width were between 9 and 11 *Lù Bān*. The width of the end room was usually equal to *míng jiān*. Table 2 shows a statistics of typical proportions of room widths.

2. With the exception of the *míng jiān*, the height of each *jiān* was determined by the adjustments on the roof which lifts up and drops down. Typically, the roof drops down at the fifth and ninth *jiāns*, and lifts up at the third and seventh *jiāns*. The lift and drop depends on the type of roof type selected. Figure 10 illustrates the roof form of a main building with five *jiāns*.

STEP FIVE: Extending the main building group by adding a courtyard and/or secondary buildings to form an enclosure courtyard — the organization of a *sān-hé-yuàn* is as follows:

1. The addition of a courtyard was based on the axis. Typically, its width and depth were an odd number of strides: *bù-fā*. A stride measures about 45 *Lù Bān* inches (1.336m). The depth of a courtyard is between seven and eleven strides. In fact, the depth and the number of *jiāns* of the secondary buildings that enclose the courtyard influence each other. A courtyard that is seven strides deep, 31.5 *Lù Bān* feet, is enclosed by secondary buildings with three *jiāns*.
2. A secondary building generally had two fewer *jiāns* than its main building. Thus, for a main building with five *jiāns*, the secondary building had two or three *jiāns*; with seven *jiāns*, the secondary had three or five *jiāns*; and with nine *jiāns*, the secondary building had five or seven *jiāns*.
3. In general, the measurements of each *jiān* in a secondary building were smaller than corresponding mea-



Figure 10. The roof form of a main building with five *jiāns* [6]

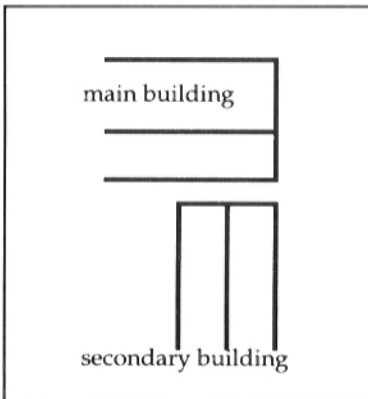


Figure 11. Separated connection

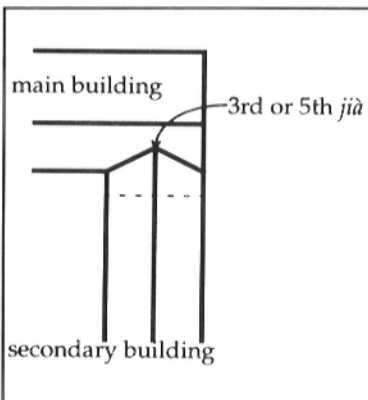


Figure 12. Joined connection

surements in its main building. The height of the secondary building depended on how its roof connected with the roof of the main building.

4. The depth of a secondary building was generally smaller than that of its main building; its number of *jiās* was correspondingly less.
5. The depth of a secondary building also depended on the width of the courtyard because the rear wall of the secondary building and the side wall of its main buildings were collinear. In addition, there was the following taboo, namely, that the drop line of the roof of a secondary building could not fall within the range of the opening of its main building.
6. There were two basic ways to connect the roofs of a secondary building and its main building. These are illustrated in Figures 11 and 12. In one instance, the roofs were separate, in the other the roof of the secondary building is extended to join the main building roof at its front third or fifth *jiā*.

STEP SIX: Extending the building groups — There are three ways to extend a building group into a larger building complex.

1. Longitudinal extensions. The axis is extended and courtyards and building groups are placed alternatively along this axis, forming a series of building groups and courtyards. This type of longitudinal extension was first discovered in the palace remains of the Shāng dynasty.
2. Latitudinal extension. New, outer secondary, buildings or building groups were added along axes parallel to

the main axis.

3. Two-way extensions. As suggested, building complexes are extended along both the horizontal and vertical axes. The Forbidden City, the Zî-jìn Chéng Former Palace, from the Míng and Qíng dynasties, was extended in this manner.

In Taiwanese traditional architecture, a building complex was usually designed as a series of enclosure courtyards. Subsequent extensions were lateral with symmetrical placed outer secondary buildings, the length of which did not exceed the original building group. These secondary buildings were connected to their building group through passing rooms, *guò-shuǐs*, which were semi-open spaces with corridors. Extensions were subject to the following two constraints.

1. The dimensions of new main buildings were less than those of any existing main buildings. In other words, the rear-most *jìn* was always higher than any other building.
2. Newly added secondary buildings were higher than any existing secondary buildings, but lower than the rear-most *jìn*. It was believed that this form would protect the life breath, *qì*.

There are some extant traditional buildings that violate this constraint. On the whole, artisans believed that the outer secondary buildings had to be higher than inner ones.

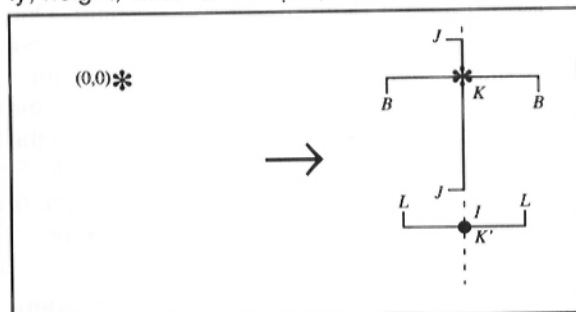
Grammar

Although artisans did not produce architectural plans or working drawings, one can imagine how they might have designed and build traditional buildings. We do so through the eyes of the artisan and grammatically. A shape grammar for Taiwanese traditional dwellings is given in [3] For our purpose here, we identify some combinations and/or simplifications of the more salient rules described therein.

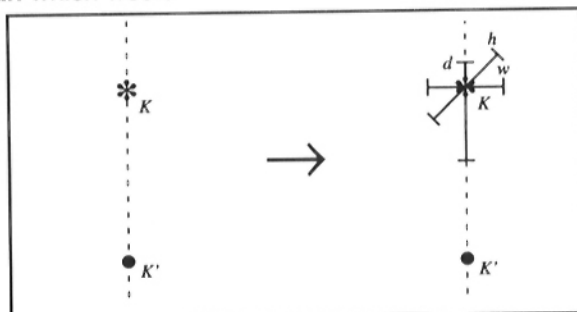
One may assume that the artisan starts with a site which we can indicate by an asterisk that marks the key brick, *hé-zhuān*, a location that the geomancer determines as fortunate for the owner. This is the initial shape. It is ultimately where the altar in the principal building, rear-most *jìn*, is placed.

The first step is, clearly, to define the orientation *KK'* and to identify the parameters of the building complex, namely, the number of *jíns* *J*, *lùs* *L*, and *jiāns* *B* of the principal building, rule 1.

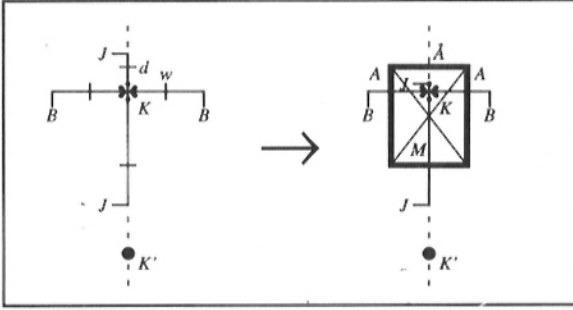
The next step is to establish the fortunate dimensions, namely, height, width and depth, of the central room, *jiān* which would



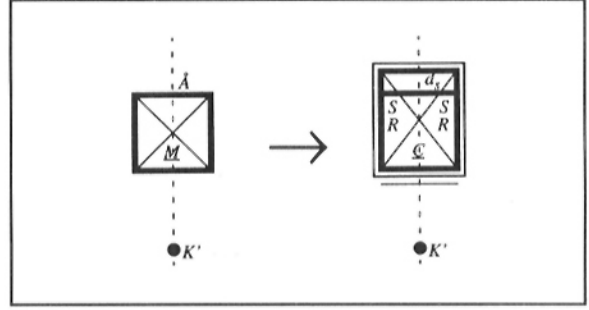
Rule 1. Determine orientation



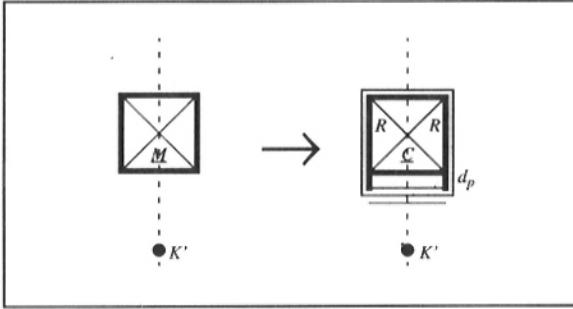
Rule 2. Establish fortunate dimensions



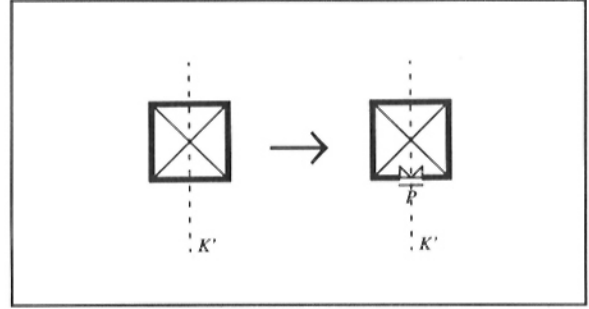
Rule 3. Determine central room



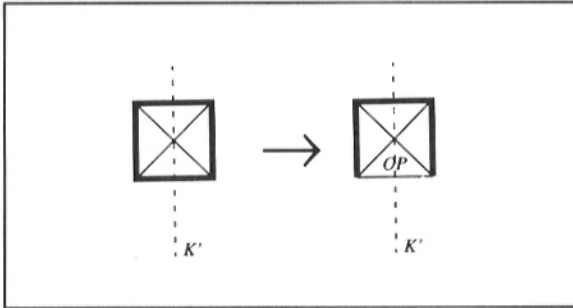
Rule 4. Create platform for the building



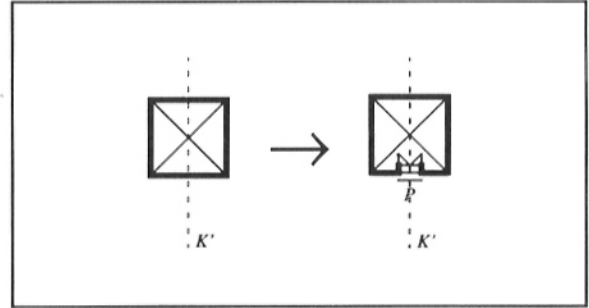
Rule 5. Increase by depth of porch



Rule 6. Insert swing door



Rule 7. Insert porch and swing door



Rule 8. Insert opening without door

be located on the axis, rule 2. These values were likely determined by *chī-bái/cùn-bái* and the corresponding procedures.

From the fortunate measurements for the width w and depth d , the first room, or central *jiān*, of the principal building can be outlined, rule 3. The key brick is located inside this room.

At this stage one creates a platform for the building. One might also decide whether the room has storage space or a front porch. If the former, one extends the room to the back with a small space for storage, and increases the total length of the central *jiān* by d_s , rule 4. In the latter case, the total length of the central *jiān* is increased by the depth of the porch, d_p , rule 5. The depth of the porch is usually less than a stride. There are, of course, other design choices, for example, a front corridor or no additions or extensions to the central room.

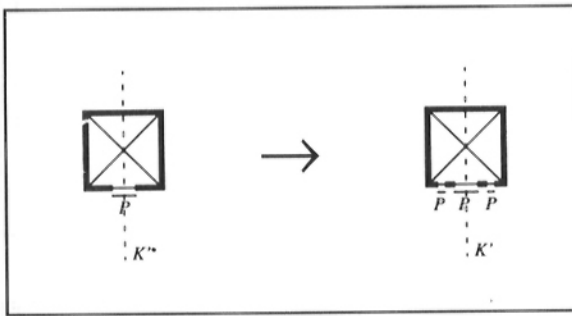
One might further refine the central *jiān* by inserting openings. There are a number of possibilities. For instance, the main

entrance at the front may have a two-way swing door, rule 6, a small porch with a two-way swing door, rule 7, or an opening, without doors and windows, rule 8. The main entrance, two-way swing door, would have to satisfy the constraints for *sân-hé*, as shown in Figure 9.

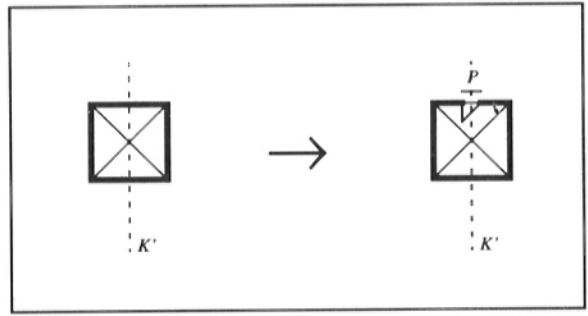
Two windows may be added to the front wall, rule 9. At the rear wall, one might create a single door, rule 10, two doors, rule 11, or two windows, rule 12. Two windows are added only to the central room of the principal building. All measurements are according to the opening ruler[2]. If the room opens out to a storage space at the rear, one would place a door, rule 13, two doors, rule 13 twice, a single opening, rule 14, or two openings, rule 14 twice. All double openings are symmetrically located about the axis.

Once the central room has been designed, one recursively extends the building laterally on either side — by rooms with the

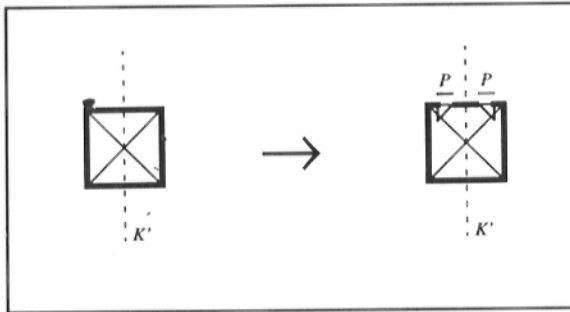
Any label shown underlined is a schema; it represents an element from a set with the given label and an associated superscript. For example, M represents an element from the set, { M, M', M'', M''', ... }. In the case of shape rules 4 and 5 where M is replaced by C, only the label is changed, but the superscript is preserved. That is, if M represents M'', then C represents C''.



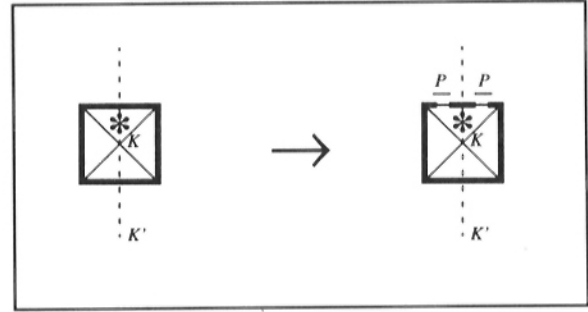
Rule 9. Add windows



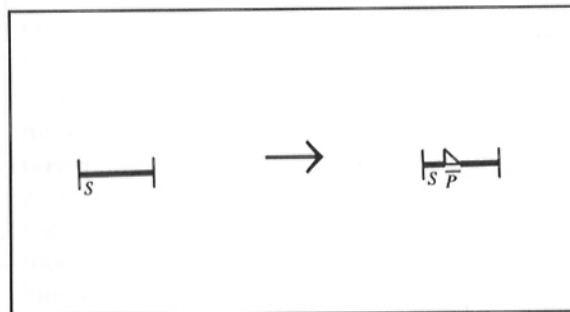
Rule 10. Add single door



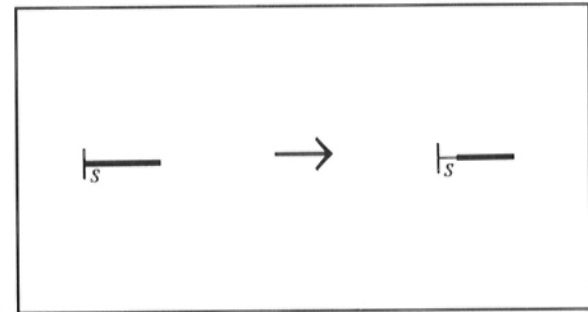
Rule 11. Add two doors



Rule 12. Add two windows



Rule 13. Add door with storage



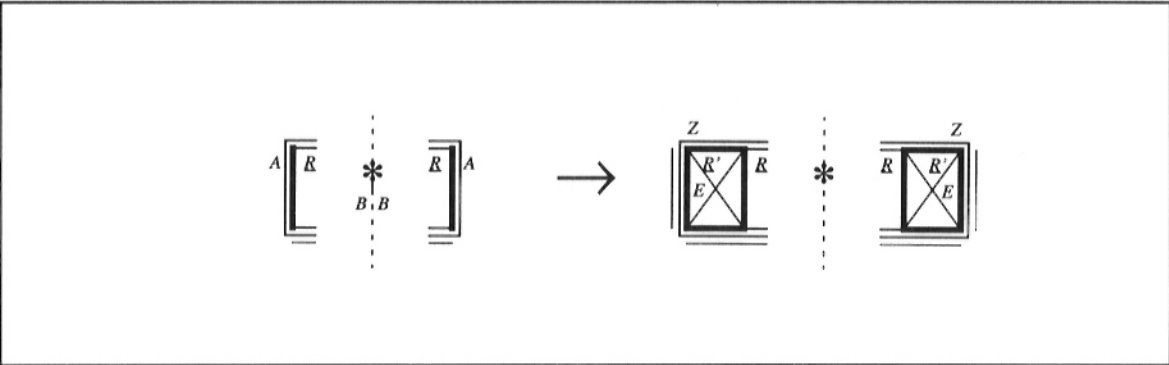
Rule 14. Add opening with storage

In some cases, the rear wall of the central room is not collinear with the rear wall of the other rooms and projected back by the depth of the altar.

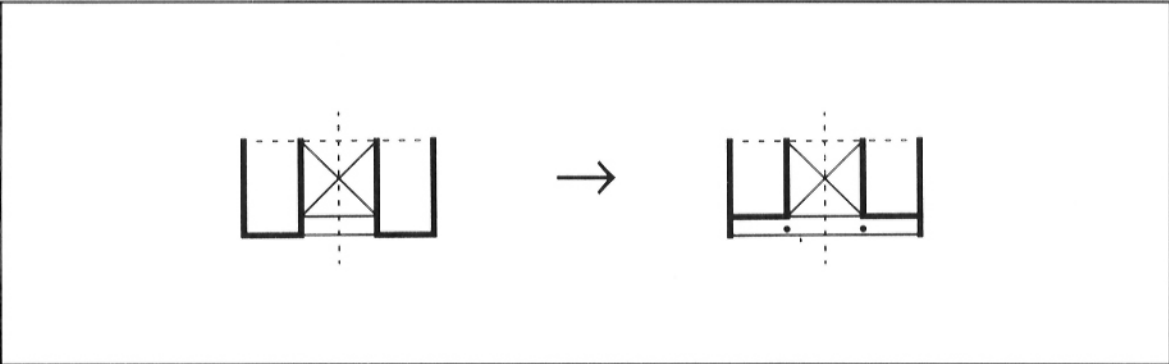
same depth, d , $d+d_p$, $d+d_s$, or $d+d_p+d_s$, with the width not exceeding that of the central *jiān*. The height of each extension depends on the roof form and any adjustments such as drop and lift taken into account — till the total number of *jiāns* in the principal building equals the intended value, rule 15.

The front porch may be extended by a *jiān* on each side, rule 16. The front porch usually extends across one, three, five or seven *jiāns*; or none at all, rule 17. On the other hand, each *jiān* may be subdivided into two spaces depending on whether its adjoining *jiān* has been so divided, rule 18.

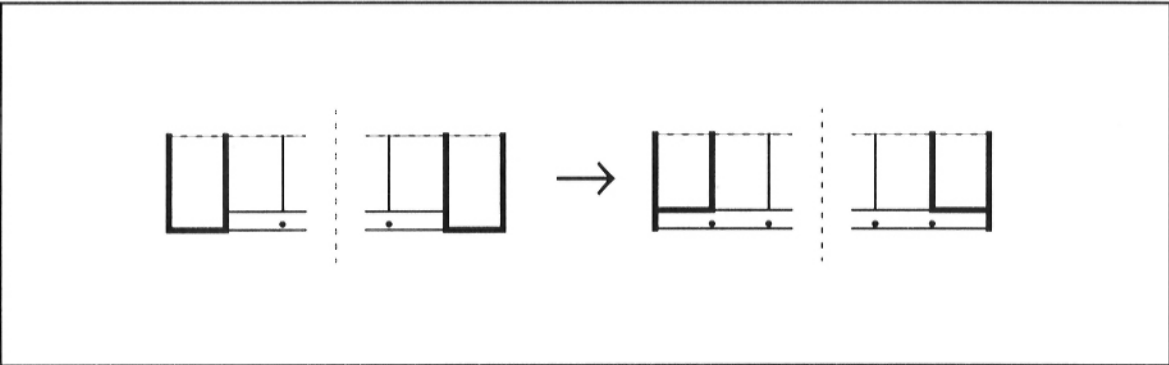
Two adjoining *jiāns* are connected by a door, rule 19, 20 or 21. Rule 19 applies only to the central room; rules 20 and 21



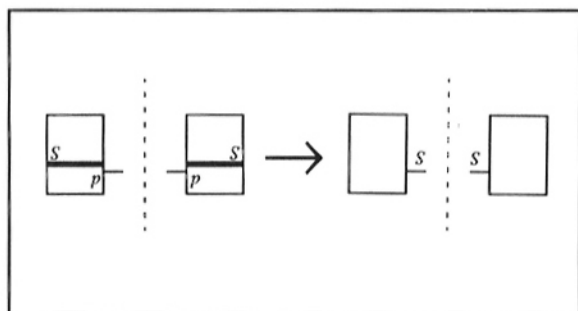
Rule 15. Extending the building laterally



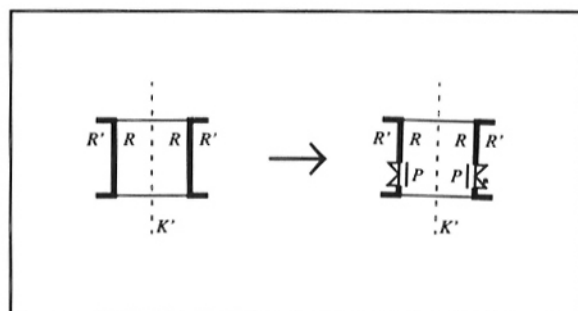
Rule 16. Front porch extension



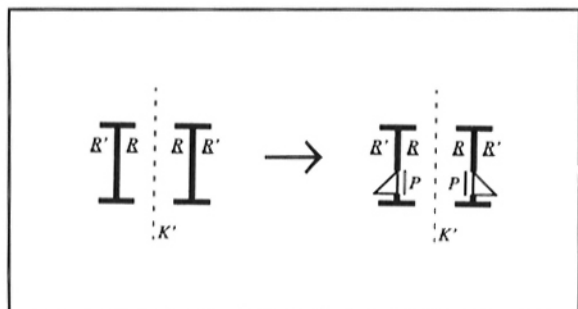
Rule 17. Multiple *jiān* porch extension



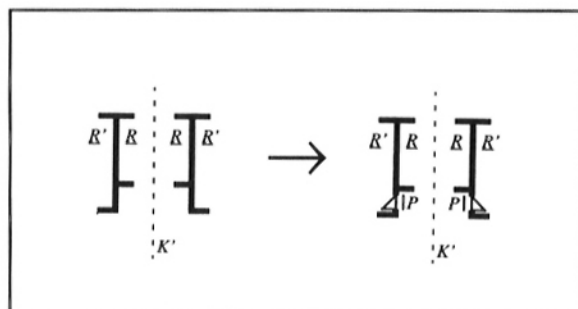
Rule 18. Subdividing a jiān



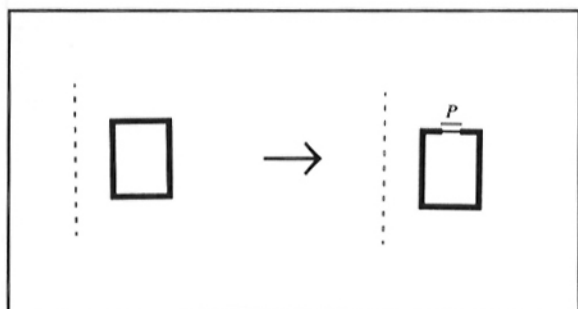
Rule 19. Adding doors between jiāns



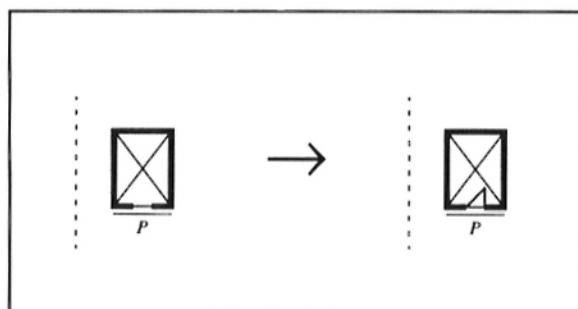
Rule 20. Adding doors adjoining central room



Rule 21. Alternative doors between jiāns



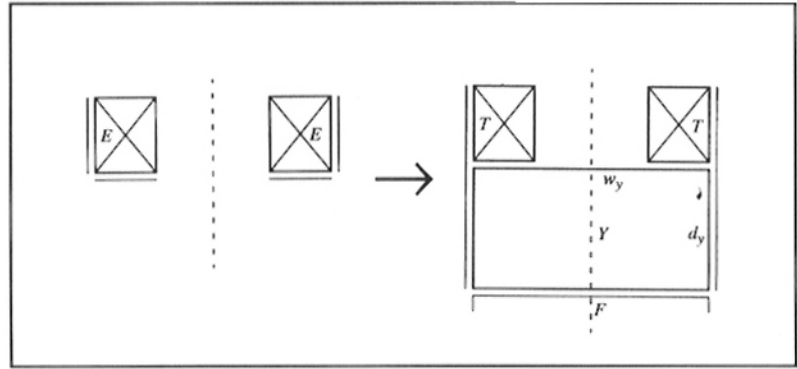
Rule 22. Adding windows



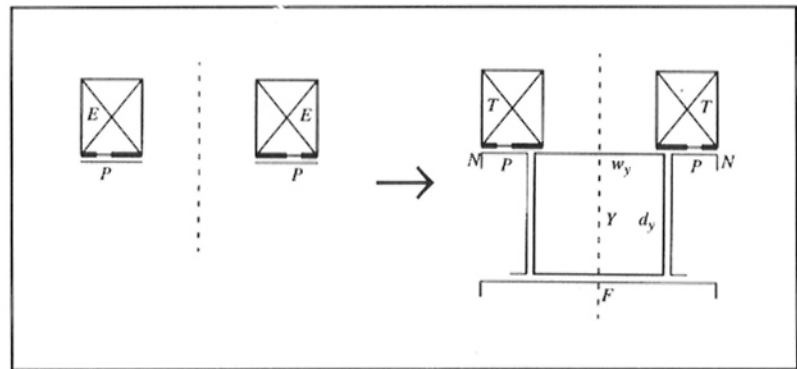
Rule 23. Add door to front wall

apply to all rooms. The doors between the central room and its adjoining rooms should satisfy the constraint that the light beam is not within the range of the door, see Figure 9. To benefit from the sunlight and fresh air, each room may have a window in its front and rear walls, rule 22. Because the end room of the main building generally serves as the kitchen or for storage, it usually had a door in its front wall instead of a window, rule 23.

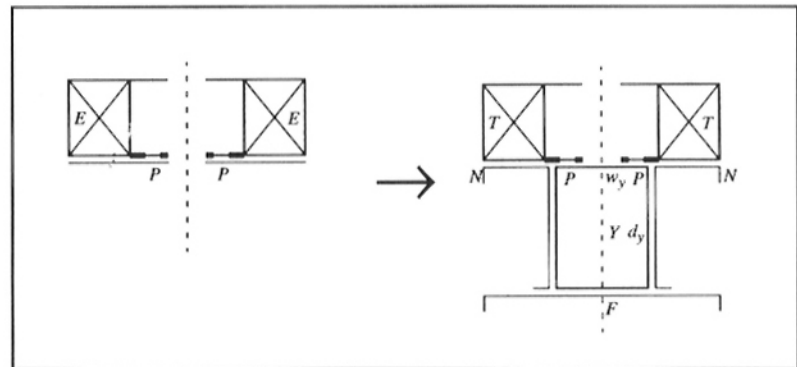
Once a main building has been designed, one would begin to mark a courtyard in front. The courtyard may be as wide as the building, that is there are no secondary buildings connected to its two end rooms, rule 24. Or, one may plan to build two inner secondary buildings and connect them to both end rooms of the main building. We ignore the situation where secondary buildings are not designed as a pair. In this case, these three buildings enclose a courtyard, one of rules 25–28. The widths and depths of the courtyard are measured by odd number of strides.



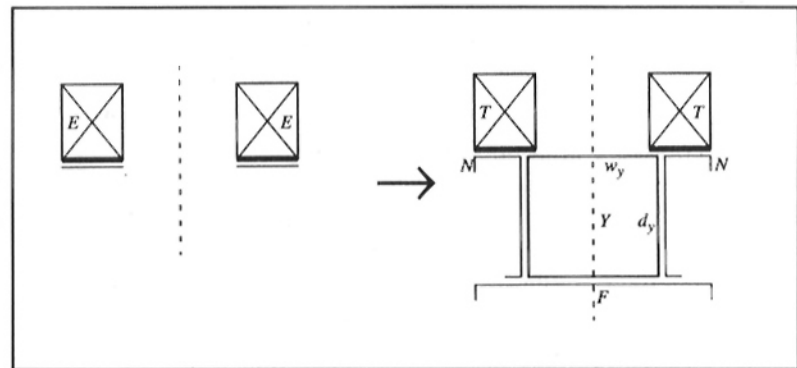
Rule 24. Adding full width connecting courtyard



Rule 25. Alternative connecting courtyard



Rule 26. Alternative connecting courtyard



Rule 27. Alternative connecting courtyard

Glossary:

BÚ-JIÀ: steps of purlins, the distances between two adjacent purlins, a standard unit of measure for a *jian*.

BŪ-FÀ: stride, about 45 *Lŭ-bàn* inches

CÀI: the standard timber for all construction which is graded into eight classes.

CHI-BAI: instructions for measuring *Lŭ-bàn* feet

CHUĀN-DŌU: column-and-tie framing system; pillar and transverse tie beam construction

CI: secondary rooms next to *míng*.

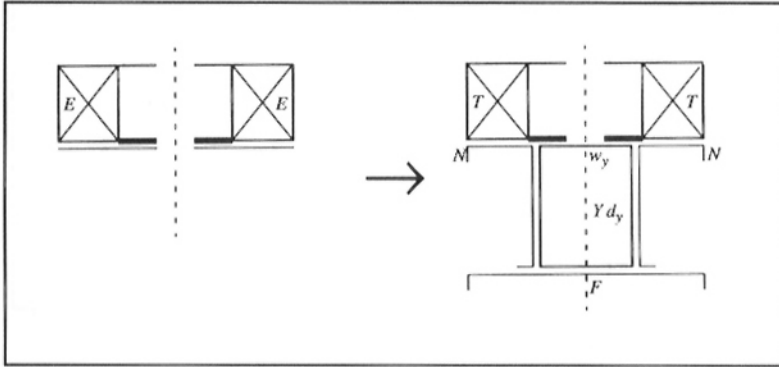
CUN-BAI: instructions for measuring *Lŭ-Bàn* inches

DÀO-ZUO: inverted seat, the front main building of *sí-hé-yuàn*

DIÉ-DOU: a framing system similar to *tái-liang*, but with the transverse beam posted onto the *dou-gōngs*

DOU: bearing blocks

DOU-GONG: eaves brackets or bracket set



Rule 28. Alternative connecting courtyard

If secondary buildings are added, the front edge of its eaves must not be within the range of any opening in the main building.

The secondary buildings are designed on the basis of the depth of the courtyard. In general, the rear wall of the secondary building and the side wall of the main building are collinear. In practice, the artisan divides the length of the secondary building into segments — usually two or three for inner secondary buildings — and each segment is as wide as the rooms. One starts to design the secondary building with the room that connects to the main building vertically, rule 29 or 30. One continues to add *jiāns* based on the segment, rule 31 or 32. The secondary building may have a corridor in front, rule 33, 34 or 35, or it may be a semi-open space, rule 36, 37 or 38.

One would need to insert openings in each room: at least one room had doors to the outside, rule 39, 40 or 41, a window,

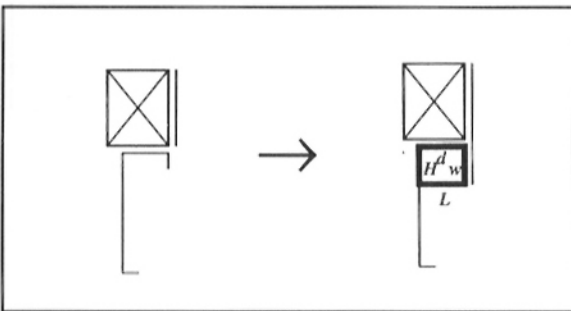
DOU-KOU: Literally, block mouth. In an intercolumnar eaves brackets or bracket set, *dou-gong*, *dou-kou* is the opening in the principal bearing block and lowest in a *dou-gong*, the *lu-dou*, to receive the bracket arm, the *gong*, a bow-shaped timber set in a bearing block that supports smaller blocks at each upraised end and at its center. Its width was the basic module in the Qing dynasty. A *dou-kou* equals the width of the *gong*. In the Song dynasty, the width of the opening equals the thickness of the timber and equals 10 *fen*.

FEN: unit of measure, 15 *fen* equal the depth of a *cái*

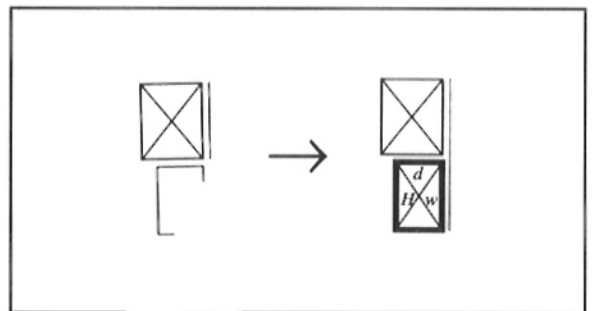
FENG-SHUI: Chinese geomancy, literally wind and water

FU-LUAN: spirit writing in Taiwanese (or Chinese) popular religion

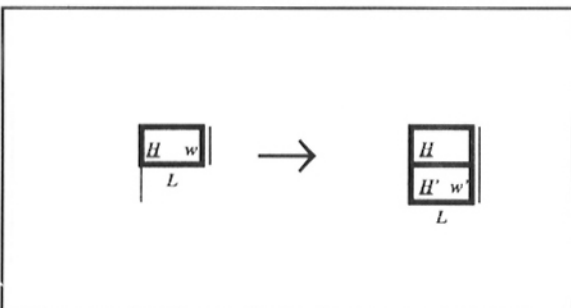
Gǎo-CHI(ZHÀNG-GÁO): construction ruler



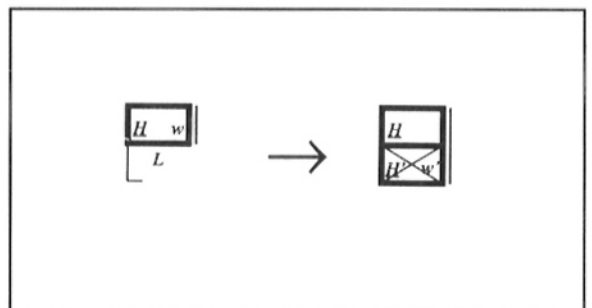
Rule 29. Starting secondary building



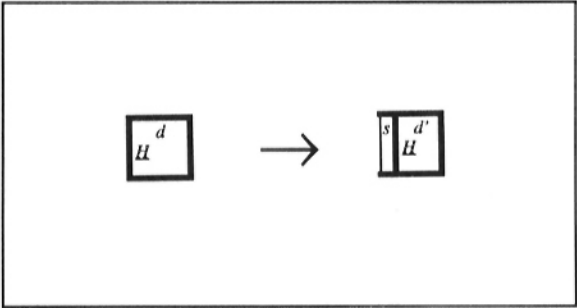
Rule 30. Alternative start for secondary building



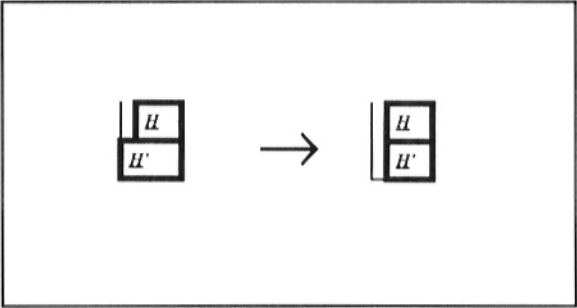
Rule 31. Continuation of secondary building



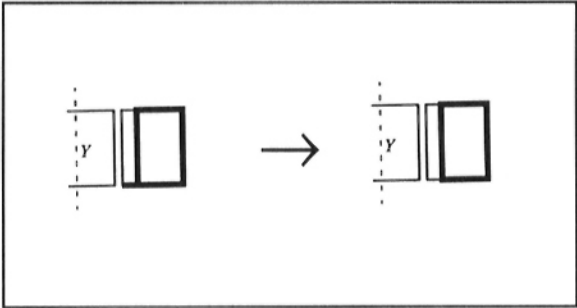
Rule 32. Alternative continuation



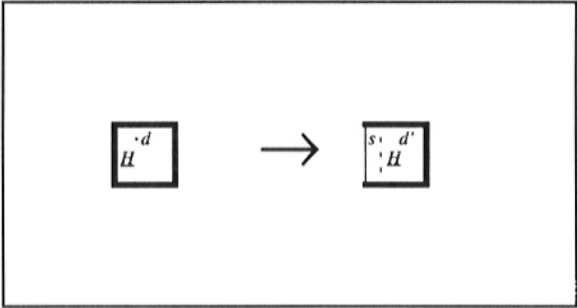
Rule 33. Adding corridor



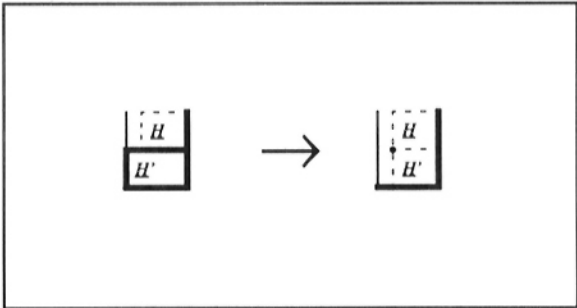
Rule 34. Alternative corridor



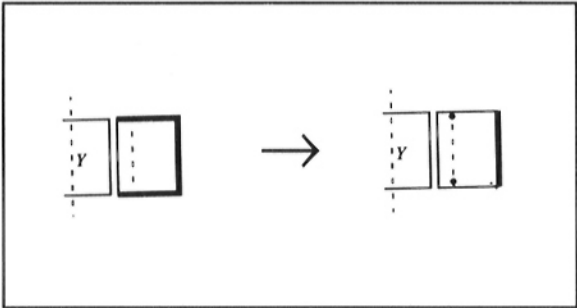
Rule 35. Alternative corridor



Rule 36. Adding an open space



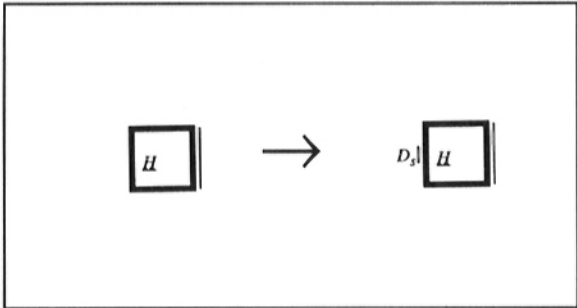
Rule 37. Alternative open space



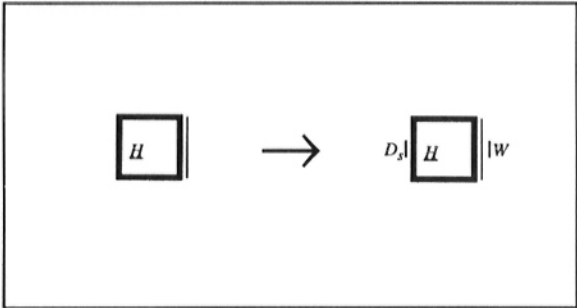
Rule 38. Alternative open space

rule 40 or 42, two windows in the rear or front wall, rule 41 or 42, or an interior door to connect two rooms, rule 42.

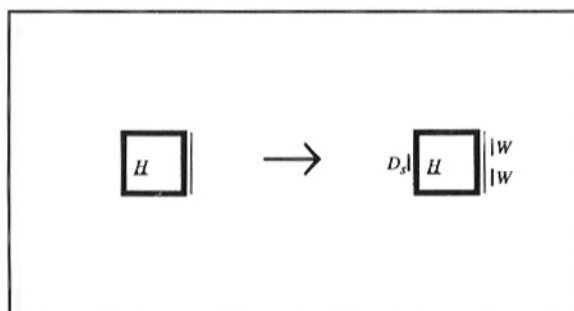
If more main buildings are needed, these are added to the front with width and *jiāns* not exceeding those of the principal



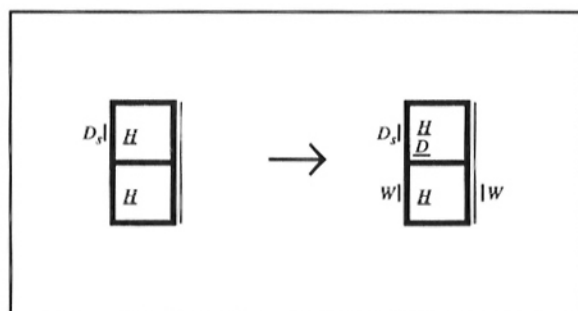
Rule 39. Inserting opening for secondary space



Rule 40. Adding a window to secondary space



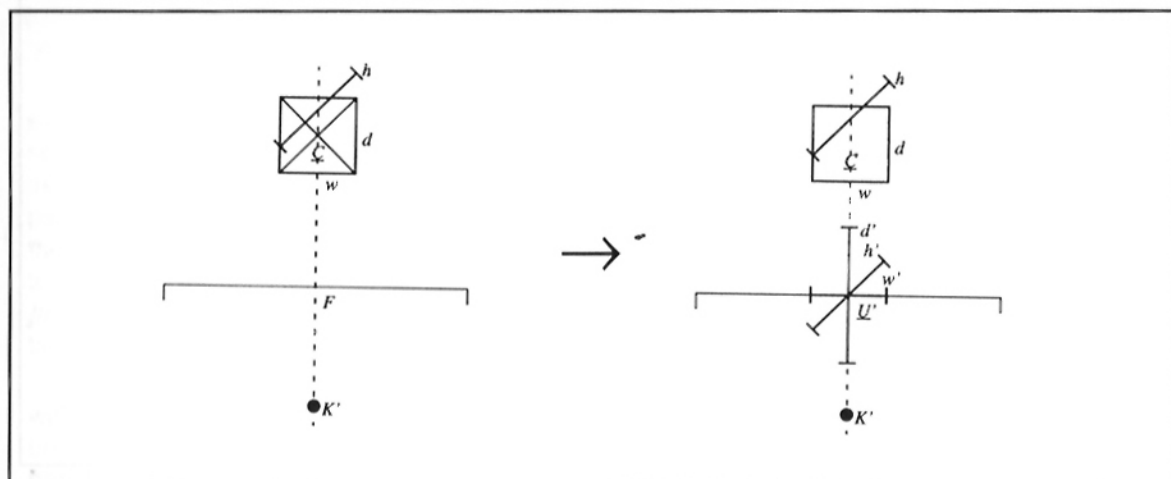
Rule 41. Adding two windows



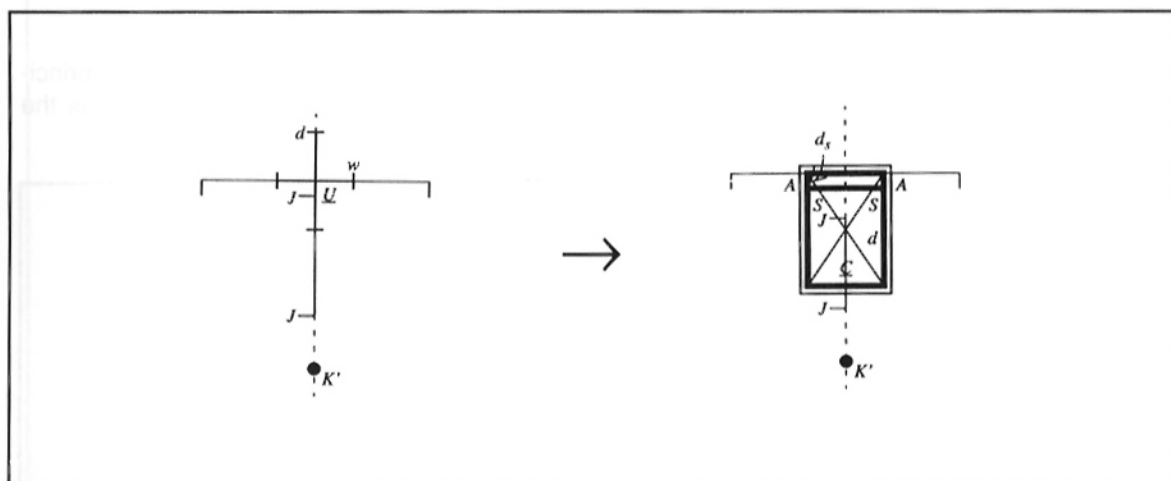
Rule 42. Adding interior door

building. The measurements of the central room for this main building are determined by the same method as were the dimensions of the principal building, rule 43. In general, the height of the central room would decrease from the rear-most to the front-most *jìn*.

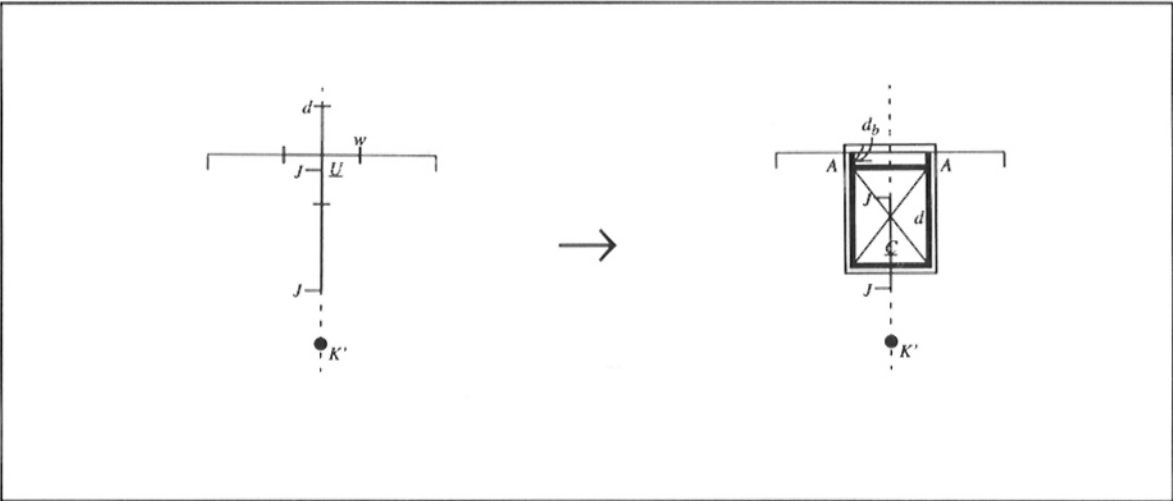
This central room, *jiān*, may have rear storage space, rule 44, a back porch, rule 45, or no additions or extensions, rule 46.



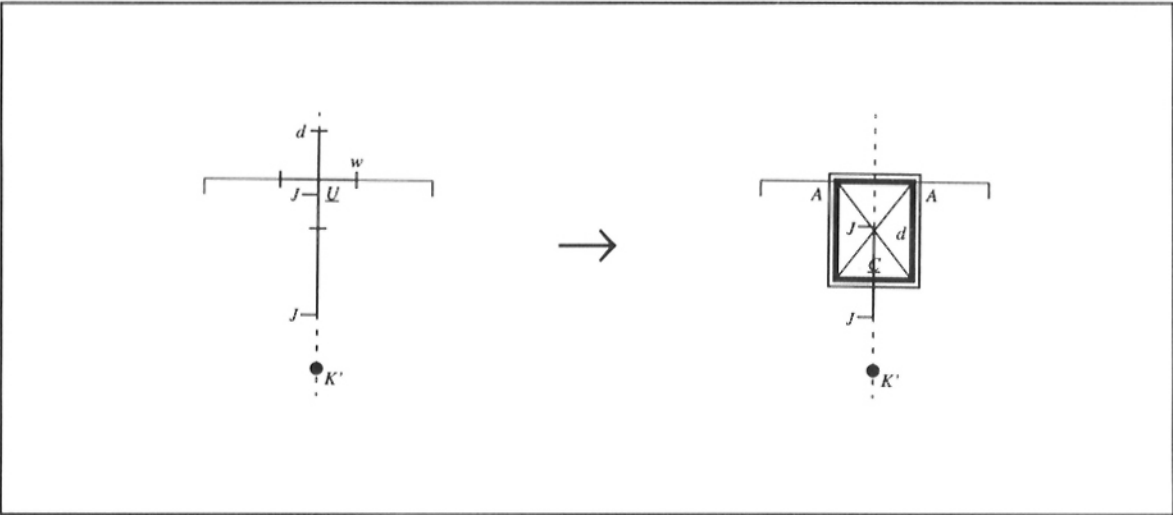
Rule 43. Establishing the measurements for the central room



Rule 44. Adding a rear storage space



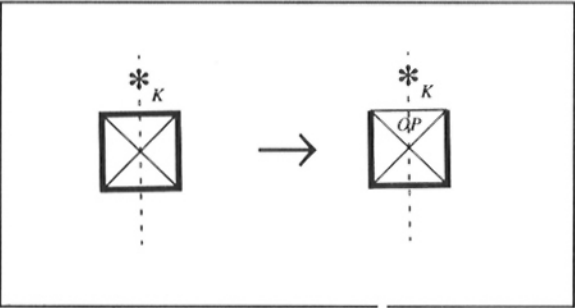
Rule 45. Adding a back porch



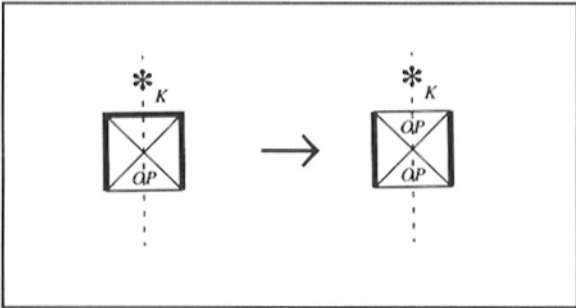
Rule 46. Central room with no additions

A front porch can be created by rule 5.

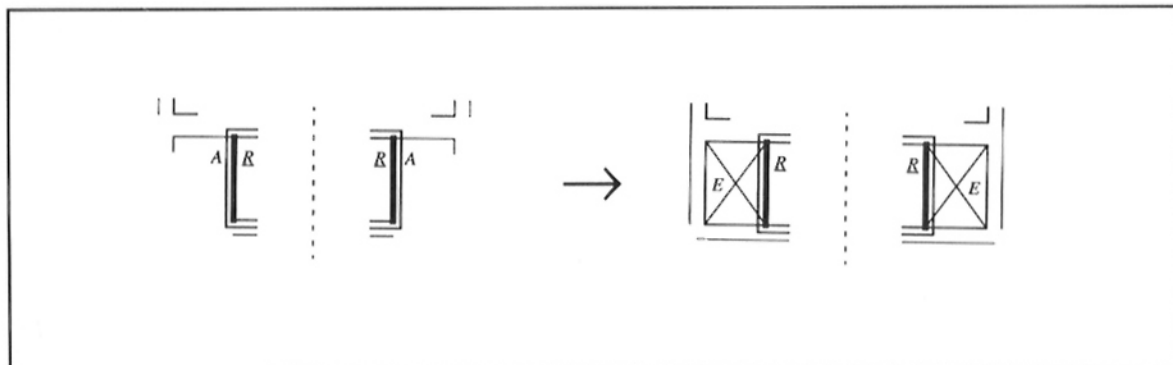
This main building is designed in the same way as the principal building; the back porch extended in the same way as the



Rule 47. Forming a semi-open space



Rule 48. Opening front and rear walls



Rule 49. Opening side rooms

front porch, rules 17 and 18. Here, one needs a back door, rule 10 or two back doors, rule 11 placed in the rear wall of the room. The rear wall may be removed to form a semi-open space, rule 47. It is usual for the rear wall to be semi-open if the front is, rule 48. If the main building is the first, front-most *jīn*, it may have just one enclosed room as the entrance hall; the other spaces become open, rule 49.

Once all the main buildings have been designed, one may extend laterally by adding secondary buildings. In connecting the secondary buildings to the main buildings, one may add a passing room that connects to the principal building, rule 50, or two passing rooms, one that connects to the principal building and the other to the first *jīn*, rule 51. A passing room may be added to any main building between the principal building and the first *jīn*, rule 52. The length of the secondary building equals the distance from the principal building to the first *jīn*.

In a similar manner one can create outer secondary buildings with rooms and openings likewise generated. Outer secondary buildings are connected to inner secondary buildings through passing rooms. The heights of secondary buildings increase

GUO-SHUI: passing room, a space(room) which connects a main and secondary building

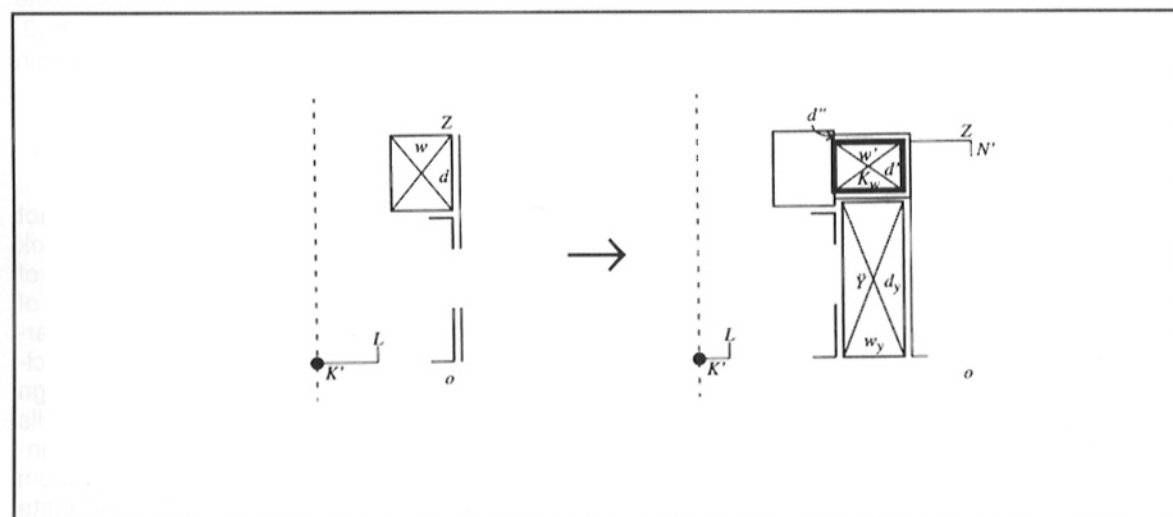
HÉ-ZHUǍN: key brick, the location of the site that the geomancer determines as fortunate for the owner

HÉ-YUǍN: enclosure-court-yard, the main spatial organization in traditional Chinese architecture

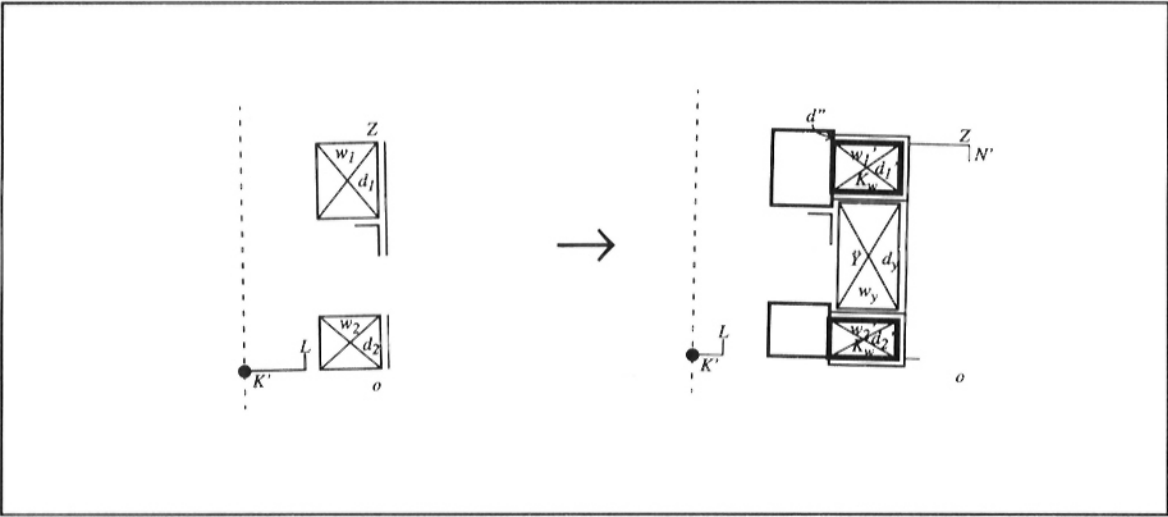
JI-TONG: wizard or witch in Taiwanese (or Chinese) popular religion

JIA: purlin, a standard unit for the depth of a *Jian*

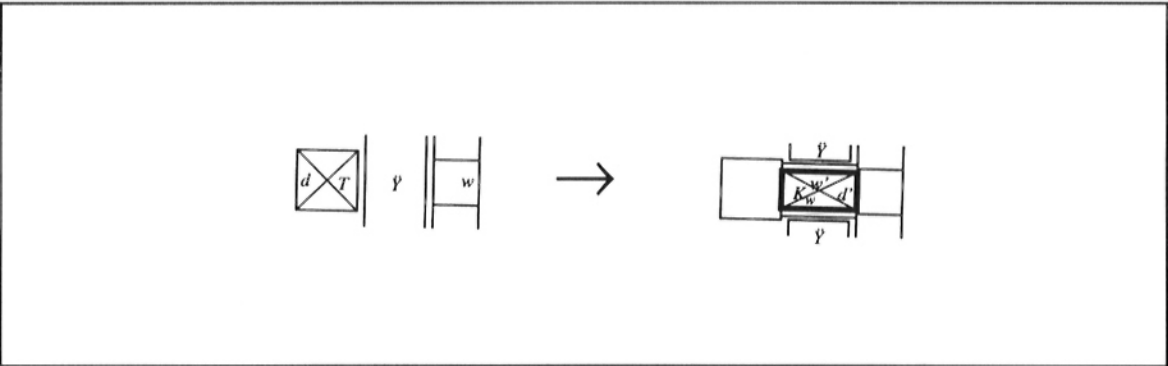
JIAǑN: bay or room, the unit of spatial organization or construction module



Rule 50. Adding a passage connecting to the principal building



Rule 51. Adding a passing room to a primary building



Rule 52. Adding a passing room to secondary buildings

- JIE-WU:** street house or merchant building
- JIN:** (1) finished, the rooms next to *Sháo*
(2) enclosure or *Luò*
- JĬNG-GÀN:** crossed log framing system
- LANG-YUÀN:** verandah or courtyard
- LING:** purlin or beam
- LU (HENG):** transverse, route
- LU-DOU:** the lowest bearing block in a set of *Dǒu-gōng*
- LUO (JIN, TÁNG):** a hall or main-building enclosure

from inner to outer. Outer secondary buildings are added lateral-ly till their total equals the required number. In this fashion one can design and generate an entire building complex. The rules shown here for purpose of illustration neither form a complete set nor are they technically precise. The reader is referred to [3, 4] for the accurate grammar and for examples of the generation of traditional dwellings of varying complexity and size.

Conclusion

The idea that the Chinese designed grammatically is not far-fetched. Traditional Chinese design and construction took place at one and the same time. Each artisan before the start of a construction, almost certainly, must have had a clear image of the entire building. The rules described above might offer a partial explanation on how such designs could have been constructed without recourse to an a priori hard description of the design details. It is known that apprentices learnt their building skills from a master artisan. Eventually, with practice these apprentices may graduate to be artisans. Only the best among them would be initiated into the secrets of computing the fortunate measurements of the central room. This was the only way for an apprentice to become a master artisan.

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- MING:** light
- MING JIǎN:** central space or room
- MI-LIANG PÍNG-DÍNG:** purlin and rafter flat roof framing system
- PIN:** the officer's hierarchy in ancient Chinese bureaucracy
- QI:** universal spiritual life breath or energy which is the focus of *Feng-Shui*
- SǎN-HÉ:** a restriction on the relationship between the main beam, light beam and main entrance
- SǎN-HÉ-YUÀN:** a horseshoe shaped building group made up of single main building and two secondary buildings
- SHǎO:** tip or end, rooms next to *Ci*
- SÌ-HÉ-YUÀN:** a square-shaped building group made up of two main buildings and two secondary buildings with all of the main openings facing the courtyard
- TÁI-LIANG:** column beam and strut framing system
- TÁNG-WU (TING-TÁNG):** hall or main building
- YIN-YANG:** the two opposing principles of nature
- XIǎNG-FANG:** secondary building or wing(side) building
- ZAN:** the collection of bearing blocks (*Dǒu*)
- ZHÀNG-GǎO (GÁO-CHǐ):** construction ruler
- ZHONG-LU:** central route