COMPARATIVE STUDY OF THE STRUCTURE OF TRADITIONAL TIMBER HOUSING IN TURKEY AND JAPAN

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ABSTRACT

COMPARATIVE STUDY OF THE STRUCTURE OF TRADITIONAL TIMBER HOUSING IN TURKEY AND JAPAN

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The objective of this thesis was to examine the structural order of traditional timber houses in Turkey and Japan. A comparative analysis, based on literature and a case study was made to establish differences of traditional timber structures in the two countries by examining their spatial organization, spans and pitches of the timber components. Four Houses were chosen for survey from Safranbolu, Turkey and Gokayama, Japan. Following two points were appeared as a conclusion: in Turkey, the structural order was orientated to the room size while the room size was dictated by the structural order in Japan, and the second conclusion is that the space size was dictated by the human body proportion in Turkey and by the module based on the *ken* measurement in Japan. Consequently the number of the structural components required for the room was discussed as a third conclusion.

Keywords: Traditional Timber House, Turkey and Japan, Structural Order, Timber Skeleton, Room Size, Timber Components

ÖZET

TÜRKİYE VE JAPONYA'DAKİ GELENEKSEL AHŞAP EVLERİN STRÜKTÜRÜ ÜZERİNE KARŞILAŞTIRMALI BİR ÇALIŞMA

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Bu tezin başlıca amacı Türkiye ve Japonya'daki geleneksel ahşap evlerin sütrüktürel düzenlerini incelemektir. İki ülkedeki geleneksel ahşap yapıların farklılıklarını ortaya koymak için; ilgili yapılardaki ahşap elemanların mekan içi düzenleri, açıklıkları ve aralıkları incelenerek literatür ve özel bir durum çalışmasına dayanan karşılaştırmalı bir analiz yapılmıştır. Bu çalışma için Türkiye'nin Safranbolu ilçesinden ve Japonya'nın Gokayama köyün'den toplam 4 tane ev seçilmiştir. Yapılan çalışmanın ışığında aşağıda belirtilmiş olan 2 önemli sonuç ortaya çıkmıştır: İlk olarak, Türkiye'deki örneklerde sütrüktürel düzen odanın boyutuna yönlendirilirken, Japonya'da oda boyutu sütrüktürel düzen tarafından belirlenmektedir. İkinci önemli sonuç; Türkiyedeki geleneksel evlerde mekan boyutu insan vücudu oranlarıyla belirlenirken, Japonya'da bu boyut "ken" ölçü birimi ile şekillenmiştir. Bahsedilen noktaların değerlendirmesi olarak, odalar için gerekli sütrüktürel elemanların sayısı üçüncü bir sonuç olarak tartışılmıştır.

Anahtar sözcükler: Geleneksel Ahşap Ev, Türkiye ve Japonya, Stürüktürel Düzen, Ahşap İskelet, Oda Boyutu, Ahşap Elemanlar

To My Parents

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CHAPTER 1
INTRODUCTION

1.1. Argument

The reason for studying traditional housing culture in general is that they provide us ideas about how people have tried to create structures with limited means and materials under the influence of physical conditions and natural disasters generated by wind and water.

Timber was preferred to use as a building material for housing construction in Turkey and Japan. Timber has lots of advantages including lightness, flexibility, and resistant to tensile stress. Thus timber framed structure was the most ideal construction system in two countries, which are located in the seismic zone. Though timber structure houses were developed in both Turkey and Japan carrying the common issues to come over, the ideas which form the timber structure was not compared before. Thus the comparative study of the structural order was established as a main topic of this study.

1.2. Objectives of the Research: The Structural Organization of the Traditional Timber Housing.

In this study, the timber skeleton structures of traditional houses were studied especially by examining the order of the structural components including posts and beams. In order to investigate the structure of traditional timber structure, this study concentrated on:

1. A general description of the spatial organization of traditional timber houses in Turkey and Japan. The aim here was to clarify the general aspects of the traditional timber houses.
2. An evaluation of the structural order of traditional timber houses based on case studies. Selected houses from Safranbolu, Turkey and Gokayama, Japan were studied on as representative of traditional timber houses in the two countries.

A comparative analysis of building components, a checklist, and measured drawings were used to establish the differences of Turkish and Japanese timber structures. Safranbolu and Gokayama were chosen to carry on the fieldwork, as neither settlements has been a spoiled by introduction of new materials and technologies. Thus their structures have not been altered much and keep the best examples of the traditional timber skeleton houses. Furthermore, Both towns are representative settlements of traditional timber housing which is something difficult to find elsewhere in either country in recent times. Mostly we encounter traditional timber houses which remain singly among new settlements.

1.3. Scope and Method of the Study

In chapter 2 is presented a survey of literature on the architectural characteristics of traditional timber housing in Turkey and Japan. The traditional timber house focused on in this study is defined in this chapter. The period covered is from the 18th to the 20th centuries.

In chapter 3, general overview of the city and timber house in Safranbolu and Gokayama were reviewed by means of literature survey.

Then the methods of case study and the construction systems were introduced in chapter 4. The outline and characteristics of the surveyed houses, which was based on the data collected by fieldwork and bibliography, were described. Then the evaluation of the construction system and structural organization of the surveyed houses in Safranbolu and in Gokayama were studied. The main sources were the literature material, drawings, photos and the data of the checklist based on the work of Kaya (1996: 107-109), Şahin (1995: 173-202) and Toyama Prefecture (1979). The checklist is given in Appendix A.

The conclusion is presented in chapter 5. Since they are difficult to translate into English, the Japanese terms which designate the space, style and building components are defined in a glossary given in Appendix B.

1.4. Disposition of the Thesis

As explained in argument, timber framed structure was the most common methods for housing construction in Turkey and Japan. Though they were developed carrying the common issues to come over, there is no research about comparing the ideas which form the timber structure of traditional timber houses in the two countries. Thus this study concentrated on the comparative study of the structural organization of the timber houses in two countries. This is the basic research for the structural order. The study is intended to be made use of further researches including evaluation of the structure in terms of earthquake resistance.

CHAPTER 2
OVERVIEW OF TRADITIONAL TIMBER HOUSES IN TURKEY AND JAPAN WITH RESPECT TO ARCHITECTURAL CHARACTERISTICS

Regional characteristics and the spatial organization of the traditional timber houses were described in this chapter.

2.1. Regional Characteristics

Building materials influenced the regional characteristics of the Turkish house. Other than building materials, the climate, topography, and the household occupations were the main factors which formed the regional characteristics of the Japanese house.

2.1.1. Regional Characteristics of the Turkish House

People had built their houses with building materials that were available in the region until international modernism of the twentieth century. The regional climate was reflected in the building materials and formed the regional differences of the Turkish houses. Küçükerman (1978: 37) divided the traditional architecture in Turkey into four groups according to the building materials used in traditional dwellings. In Northern Anatolia, timber was the main material for housing construction while stone was commonly used in Eastern Anatolia. In central Anatolia, houses were of mixed construction of timber, adobe and stone. Stone and timber were easily obtained in South and South-West Anatolia.

Half-timber construction technique was widely used in northern Anatolia especially in the Black Sea region where the warm and rainy climate made it possible to obtain the timber. For example, completely wooden structure system (log system) was observed in the highlands while squared wood framed structure filled with stone called 'eye filling' system (*göz dolma*), was applied in the coastal region of Artvin (Fig.2-1A). In Eastern Anatolia, the Aegean and the Mediterranean area the houses were of mixed construction of timber and stone with flat roof, and cubical bright colored form (Fig.2-1C). In Marmara region especially in Istanbul, complete wooden houses were developed (Fig.2-1D). As we can understand from the residences in Erzurum and Mardin, thick stone construction and flat roof styles which were reminiscences of the Late Roman and Early Islamic styles were commonly applied in Southern Anatolia (Fig.2-1E). Whatever the differences in the use of building material were, these regional characteristics were peripheral to the more general type of Anatolian dwelling: foundation and ground floor walls built with stone whereas the wooden upper floor structure filled with adobe, brick or stone was the most common structure. In Safranbolu, which belongs to Central Anatolia, dominant type of the traditional Turkish timber houses can be seen. That is to say, the house is consisted of the masonry built ground floor and the timber skeleton upper floors. Timber skeleton projection projected to the streets. Stone and adobe were main materials for the wall infill (Fig.2-1B).

2.1.2. Regional Characteristics of the Japanese House

The basic structure of the Japanese housing was also richly valid from region to region. The various local characteristics of the Japanese traditional dwellings were entirely oriented according to the four factors including the climate, the topography, household occupation and the specific building materials. The regional differences were clearly expressed in the plan types, style, the form of the village and the structure (Fig.2-2).

The houses which were located in snowy region, usually had developed garret roof for silkworm culture. The window was opened on the roof in order to obtain the light and air. In order to construct the wide space the slope of the roof was steep. Thus the thatch was preferred as roofing because of its lightness. The methods of the roof construction differs from region to region (Fig. 2-2B,D, F, H, K, L, N). Rooms tended to be built in one housing unit in north region (Fig. 2-2A, B, C, E, G) in order to keep the warm. On the other hand they were constructed separately, then connected to each other in south part of Japan (Fig. 2-2 Q, U, V).

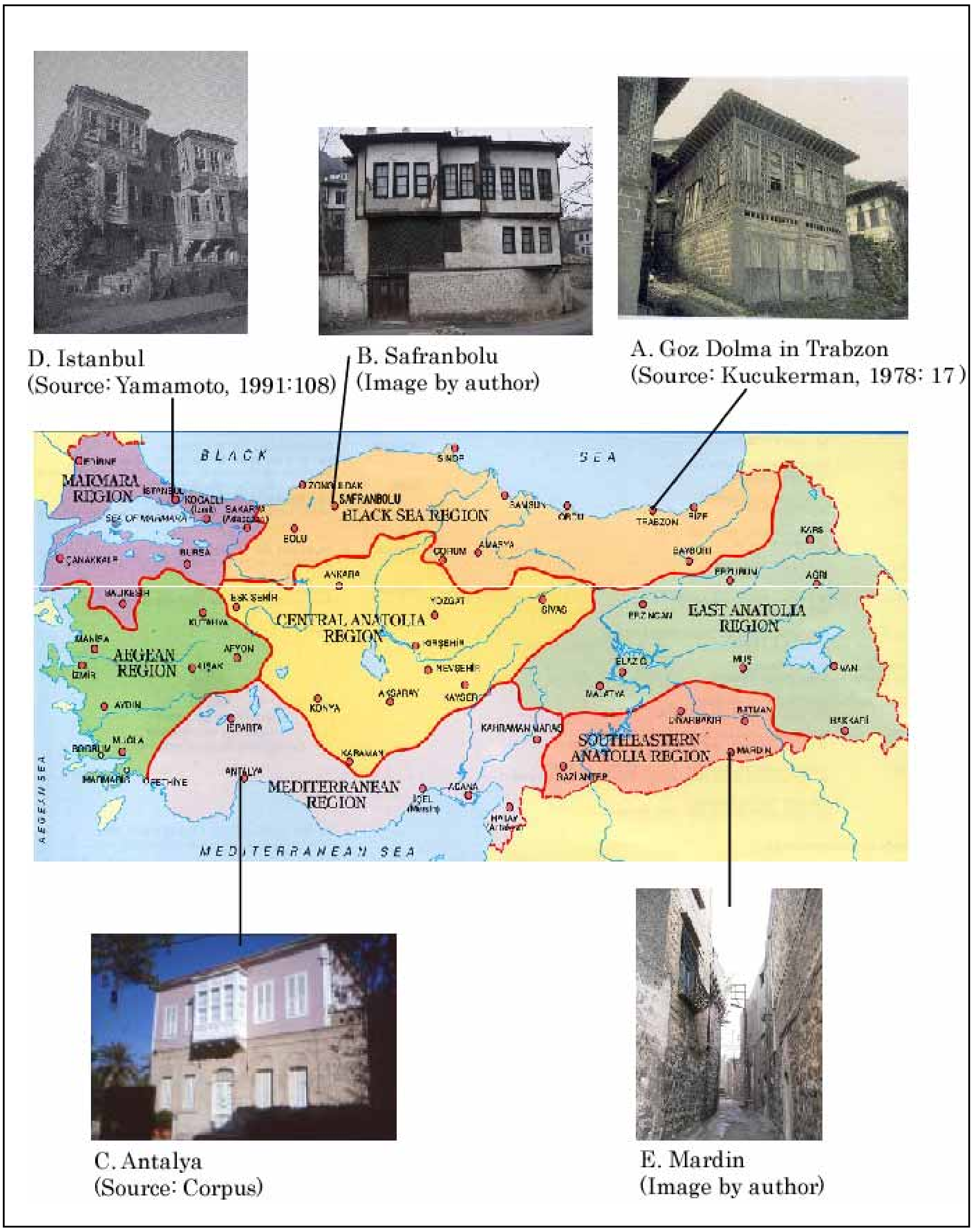


Figure 2-1. Regional differences of the Turkish house
(Source: Yamamoto, 1991:108, Küçükerman, 1978: 17, Corpus)

a. Influence of the Climate

In South part the working place called *doma* and the living place were built separately with independent structure so that they could provide cool wind inside in every corner of the house during hot summer. Between the buildings a gutter was installed to collect the raindrops which fell from both sides of the roof (Fig.2-3, 4). On the other hand, the whole structure of the dwelling was built as a single unit in the North in order to heat up the interior efficiently during the cold winter. Thus the size of a single building tended to be larger in the North.

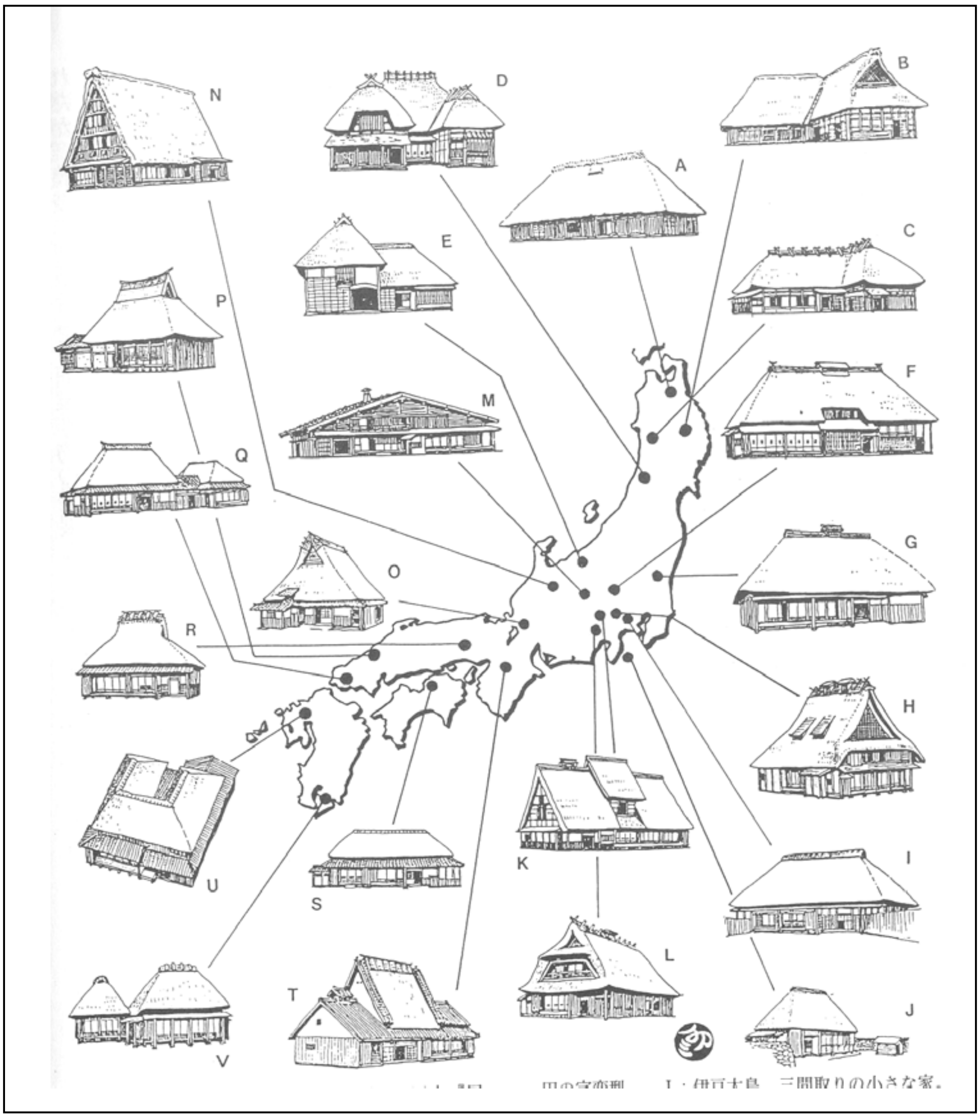


Figure 2-2 Regional differences of the Japanese house
(Source: Nishiyama, 1989: 118)

Figure 2-3 Separate building types
(Image by author)

Figure 2-4 Gutter
(Image by the author)

b. Influence of the Topography

Topography also determined the regional characteristics: whether the house existed in plain, mountains, coasts or town effected not only the plan types but also the village form. In plain area, village was developed in two types: the first one was dispersed type, which could be found in Kanto, Sanin, and Hokuriku. The houses were built distant from each other in order to surround the house with groves to protect the building from the strong wind, which was peculiar to the region (Fig. 2-5A). Roof slope tended to be gentle in this type of the housing. In contrast, the houses were gathered in one place, stood close and were surrounded by a moat so that they could protect the village from the enemy outside (Fig.2-5B). This type of village was common especially in Nara. In order to build houses in inclined plain in mountainous regions, usually the ground was scraped to obtained flat land, thus it was difficult to obtain wide spaces. Owing to this fact, the narrow and linear plan types were preferred (Fig. 2-5C). In the coasts, fishing villages had been developed close to harbors. In Tango Peninsula, the houses contained hanger and storage which were built on the shore very close to each other (Fig.2-5D).

A. House in Kantou Plain (Image by author)

B. Village surrounded by a moat in Nara
(Source: Kawasaki City, 2001: 47)

C. House in mountain region
(Image by author)

E. House in Tango Peninsula (Image by author)

Figure 2-5 Influence of topography on the houses
(Source: Kawasaki City, 2001: 47)

c. Influence of the Occupation

Other than agriculture, sericulture, animal husbandry and fishing were popular side jobs in the modern times. Regarding the style of the house, floor plan and structure were largely influenced by the occupation. In the house of the farmer who engaged in the silkworm culture, garret was developed in order to enlarge the space to keep the silkworm. As a result, the roof was cut to obtain the window for ventilation and lighting. Various types of the roof and window types were observed in the country (Fig.2-6).

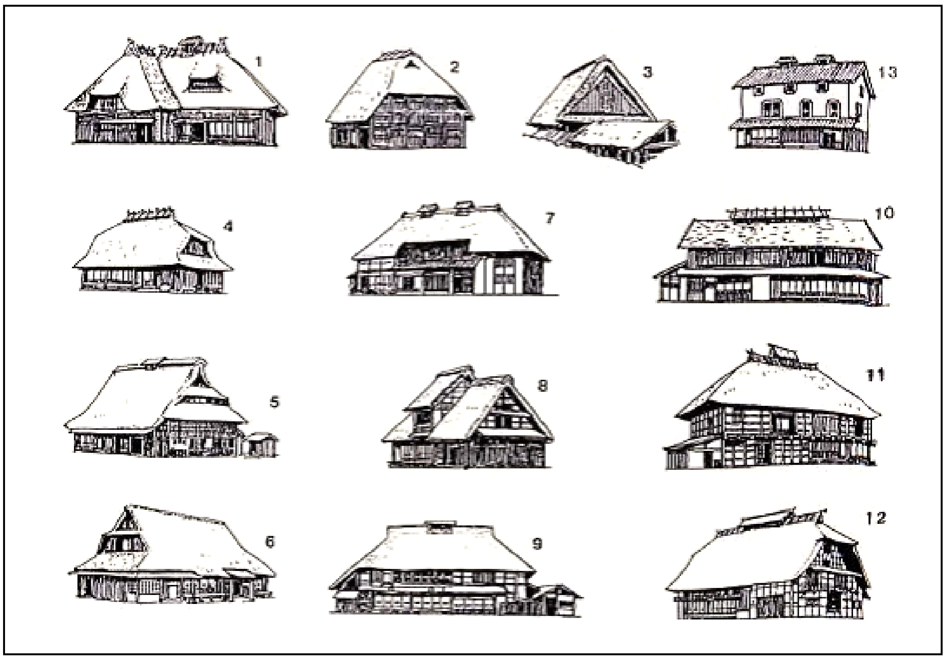


Figure 2-6 Various types of roof structure
(Source: Nishiyama, 1989: 118)

In stockbreeders house, the dwelling unit with the stable was relized in two manners: *magariya* and *chumon-zukuri* (Fig.2-7). Although both styles had L-shaped plan, they were developed with different backgrounds. In *magariya,* the stable was added perpendicular to the main space so that it could avoid the restriction of the span of the beams of the main space and set the size freely. The *magariya* was built around the central part while *cyumon-zukuri* was preferred in the snowy area. The stable was connected to the main space with a passage and together with them. The whole structure was covered by a single roof so that they did not have to go out for stock breeding during the winter.

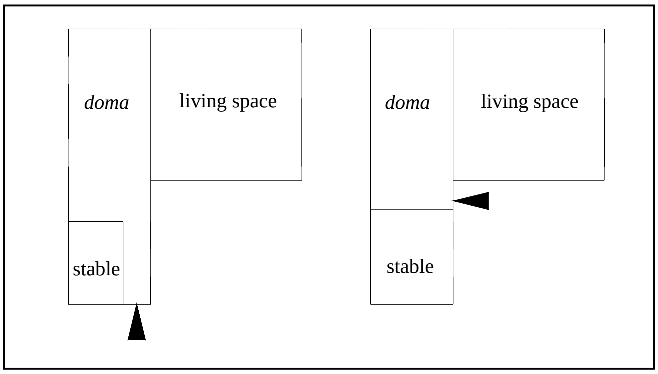


Figure 2-7 The *Chumon-zukuri* (left) and *Magariya* (right)
(modified from Ono, 1993: 23,15)

e. Influence of the Building Material

Like the Turkish house, local climate influenced the building materials and the form of the housing. For example, the bamboo roofs and doors were typical of the dwellings in the southern Kyusyu, while houses were covered with thatch in order to protect the house from the cold weather in Northern Japan. In regions where thatch was difficult to obtain, shingles were used as roofing. However, these regional characteristics were secondary to the more common type of Japanese dwelling; the houses had timber-framed structure that was separated in two parts called *jyo-ya* and *ge-ya* (Fig.2-8). *Jyo-ya* was main space of the dwelling, which was supported by the tall timber post and beams. In order to widen the space toward the direction of the beam, the additional space, *ge-ya*, was appended to *jyo-ya.*

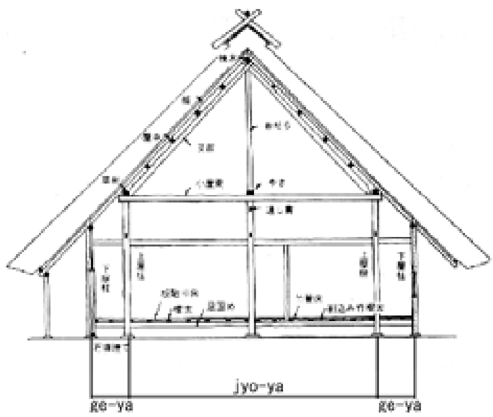


Figure 2-8 The *Jyo-ya* and *ge-ya* (modified from Kawashima, 1976: 111)

2.2. Spatial Organization

The typical plan types, rooms and its elements, secondary spaces and service spaces were studied in order to clarify both the Turkish and Japanese house.

2.2.1. Plan Types

In this section, the representative plan schemes of the Turkish and Japanese house were introduced.

i) Turkish Plan Types

The plan layout of the Turkish house has been surveyed by various researchers. In his book '*Türk Evi Plan Tipleri*', Eldem investigated the typological development of the Turkish house according to the location of *sofa* in the space and the change of the relation between the *sofa* and the rooms. Same as Eldem, Küçükerman (1985) too, regarded that the sofa and the rooms were the fundamental elements forming the structure of the Turkish house. However, he concentrated more on the rooms and examined the characteristics, arrangement, and the concept of the Turkish room. Finally he theorized that the room and sofa relationship was a continuation of the tent tradition. Kuban (1995:104-106) adopted a different approach by stating that the Turkish house consisted of the room and secondary spaces such as *hayat, eyvan* and cupboard, and the Turkish house type were obtained by the multiplication of the single unit according to the orthogonal, longitudinal, or parallel axis. In this study, the location of the *sofa* in relation to the rooms is examined as the typological study.

The Turkish house consisted of rooms, secondary spaces such as *hayat* (open *sofa*), *eyvan,* and service spaces. The rooms were connected to each other by means of the *hayat* and *eyvan* and thus kept independent. There were several plan types according to the sofa position in the house: the outer *sofa*, the inner *sofa*, and the central *sofa* plan (Fig. 2-9).

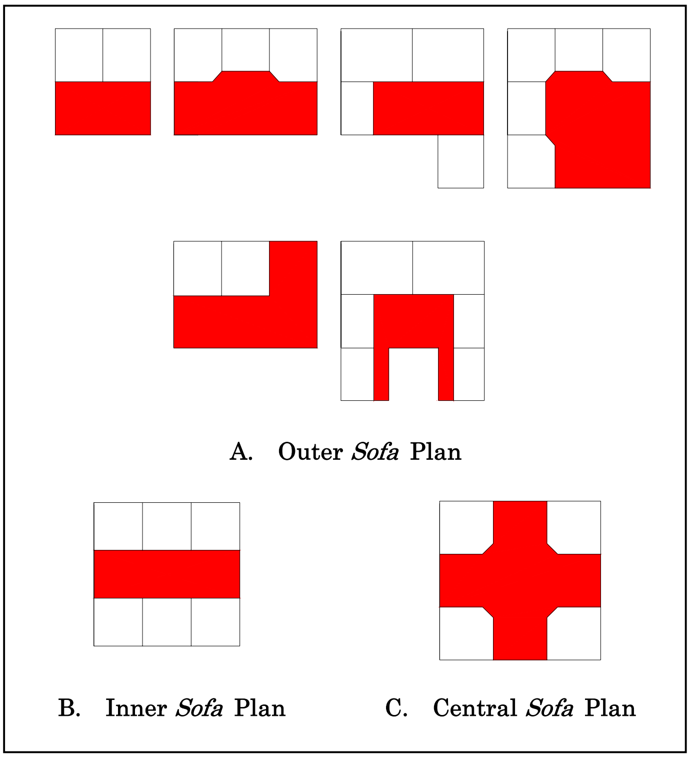


Figure 2-9 The typical plan layout of the Turkish house (modified from Günay, 1998: 17)

a. The Open *Sofa*

The open sofa was the earliest type of the plan scheme which appeared and settled into Anatolia. Early type of housing from fifteenth and sixteenth centuries had the double storey *sofa* that opened only to the courtyard and the rooms lined along the *sofa* (Kuban, 1995: 50,51). Between the two rooms was an alcove called *eyvan*. By the seventeenth century, the simple cubical house with single façade changed into a more complicated form. The either end of the sofa was raised as a sitting place, which started to be cantilevered over the ground floor in later period. As stonewalls of the upper floor were replaced with timber framed structure with mud and brick infill, the rooms could have large windows and were projected toward the streets. In the eighteenth century, the size of the *sofa* decreased in order to built extra rooms. Thus the U-shaped floor with a more articulated *sofa* arose (Kuban, 1995: 58, 59).

b. The Inner and Central *Sofa*

Being influenced by the Western architectural models and the palace tradition, the *sofa* was gradually surrounded by the rooms to form the symmetrical plan scheme. The inner and central *sofa* was the main plan type of the houses of late eighteenth and nineteenth centuries especially in the urban areas. Here the *eyvan* was replaced with the staircase. Kuban (1995: 23) stated that it was when the elimination and interiorization of *hayat* was completed that the classical phase of the Turkish house ended.

ⅱ) Japanese Plan Types

The Japanese house was consisted of the two functionally separated spaces; residence spaces and the work place called *doma.* Furthermore, residence spaces were separated into rooms for daily use and those for special occasions. The bedroom (*nema*) and living room (*hiroma* or *katte*) belong to the former and the guest room (*dei* or *zasiki*) to the latter. However, these rooms were usually formed as an undifferentiated space, being placed next to each other without any intermediary spaces. Compared to the Turkish room, it had less independency.

Doma was un-boarded ground floor while the residence spaces were raised higher than the *doma* and boarded or covered with mattress. *Doma* was usually used as a workplace, service place, a passageway and stable.

The checkered type and the hall type we the most popular form of the Japanese house (Fig. 2-10). The checkered type had four rooms divided like checkerboard by the partitions. On the other hand, the floor plan with a hall surrounded by rooms was called the hall type dwelling. The hall, which was equipped with the hearth, had multi purpose use including eating, talking, working, ritual ceremony and sleeping. The hall type floor plan was preferred in Northern part of Japan since the heat from the hearth could warm every room efficiently. Both the checkered and the hall types were common plan scheme of the middle class farmers' residence. The poorer ones lived in more modest houses, which consisted of even only one room and the *doma,* while that of the rich contained many rooms which formed complicate plan schemes.

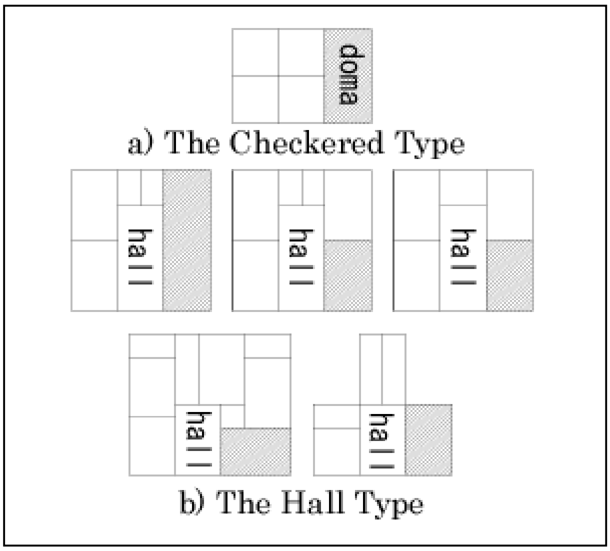


Figure 2-10 The typical floor plan of the Japanese house
(modified from Ishihara, 1931:8)

The *doma* had its origin in the earth-floored dwellings in the Stone Age. Although the boarded floor was introduced to a part of the dwellings in order to avoid moisture, in later period the *doma* had been the central space of the commoner's life for a long time. Under the strict control of the ruler class, the Japanese house developed very slowly and its architectural characteristics hardly changed until the late nineteenth century when the feudal society finally collapsed. Then the *doma* was gradually transformed into the entrance, which only the warriors had been allowed to have in the house in the era of the feudal society. The kitchen was raised from the earth floor to the separated earth floor of the entrance. They tried to imitate the elements of the entrance of the warrior's house. For example, a door case called *koen* and a lattice door was imitated and applied to the entrance door of the farmhouse. Those components were forbidden for the commoners in the modern times. In the twentieth century, the *doma* was completely changed into the entrance hall.

2.2.2. Room and its Elements

Both Turkish and Japanese room served for the multipurpose use; sleeping, eating, entertaining the guests, and other activities of life. There was no room with special functions. In order to use the room in various ways, the removal of furniture was fully used. Those include a low stool (*sofa islemlesi*) and large metal tray (*sini tepsi*) for eating, braziers (mangal) and table with brazier filled with charcoal fire called *tandır* for heating in the Turkish room. For Japanese house, a low timber table and brazier were also commonly used.

The *sekialtı* and *sekiüstü, sedir, harem, seramlık,*door, windows, the storage and the fireplace were explained in this section as the main characteristics of the Turkish room. Features of the Japanese room were described as doors, windows, storage, fireplace, zashiki and its elements.

a. *Sekialtı* and *Sekiüstü*

Especially in Turkish houses dating back to 17th century, room was consisted of two functional parts: *sekialtı* and *sekiüstü* (Fig. 2-11). In general, the room was not entered directly. In order to enter the room one must past the anteroom called *sekialtı*, change the direction at least once or twice to reach the main unit called *sekiüstü.* Consequently one could not see the inside the main room from the hall.

Instead of square plan, the Turkish room generally had a rectangular form. In the rectangular plan, when separated into two spaces, *sekiüstü* was often reduced to a square (Kuban, 1995: 107). *Sekialtı*, a space for entrance and service, was usually placed on the side where the cupboards and sometimes fireplace were located. The sitting place called *sekiiüstü* was enclosed by low built-in sitting platform, *sedir* (*divan*). *Sedir* occupied the most lighted place under the window. *Sekialtı* and *sekiüstü* were visually divided by a triple arcade called *direklik* and balustrades. The difference could be observed from their respective furniture and decoration of their ceiling; those of *sekiüstü* were more elaborate. This spatial separation of two functional areas was emphasized by raising the floor of *sekiiüstü* one step higher than that of *sekialtı*. The level of *sekialtı* was the lowest which corresponded to the level of the *hayat.* The terracotta tile paved *sekialtı* was covered by a straw mat or left uncovered, while the raised sitting section of the room was covered by soft carpets. Then the surrounding *sedir* represented the highest level (Fig. 2-12). This subtle difference in floor level, which expressed the hierarchy of the family, was one of the characteristics of the Turkish house.

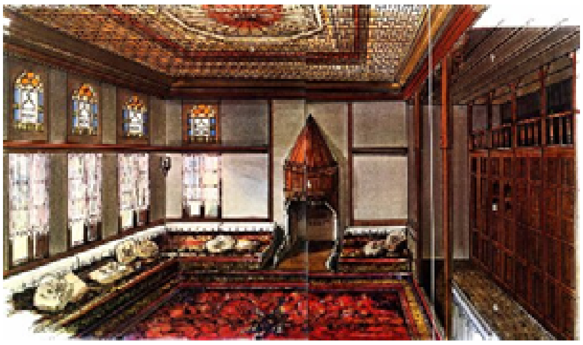


Figure 2-11 *Sekialtı* and *sekiüstü.*
(Source: Küçükerman, 1978: 71)

Figure 2-12 *Sedir*
(Image by author)

b. *Sedir*

The sitting section in the Turkish room, *sedir* (*divan*), usually occupied two or three sides of the room with windows all around and thus best-lighted part in the room. The best window seat at the corner was prepared for the father or elders while the younger sit on the floor near the entrance. The servants stayed in *sekialtı.* The *sedir* had dimensions of 70 to 80 cm in depth and 30 to 40 cm in height. They were built by wooden planks as box constructions on the main beams on the floor, the raiser being partly covered by the floor rafters and wooden revetment (Kuban, 1995: 117). The *sedirs* were slightly raised from the floor and this manifested the continuing custom of nomads sitting on the floor.

c. *Harem* and *Seramlık* (Women's Space and Men's Space)

In the house dating back to earlier periods and belonging to richer families, women were not expected to be seen by other men from outside because of religion. Thus in some houses there were separate spaces for women called as "*harem*" and men as "*seramlık*" respectively. Yet this was for families wealthy enough to afford these quarters in the house. In such houses men and women were served in their own quarters by means of a cylindrical cupboard called *dönme dolabı* (Fig. 2-13). The food prepared in the *harem* was put on this cupboard which revolved around its central axis and opened to the *selamlık* side. In this way, women served foods to the men's quarter without being seen.


Figure 2-13 Cylindrical cupboard
(Image by author)

d. Door

· **The Turkish Door**

The door of the Turkish room had a threshold which separated the hall from the room (Fig. 2-14). Kuban (1995: 125) stated that "when the interiorization of the sofa was completed, and the sofa was transformed into the interior hall, the threshold which rose from the floor was eliminated." In general the door opened toward the room.

Doors of important rooms such as *baş oda* were elaborately decorated while those of ordinary rooms left undecorated. Thus one could understand the importance of the room by standing in front of the door.

· **The Japanese Door**

In the Japanese house, wooden sliding doors were widely used mainly for utilitarian rooms, the storage, and main entrance. People entered the living rooms removing a partition panel *shouj* or *fusuma*.
The *shoji* was consisted of a timber panel with timber skeleton arranged

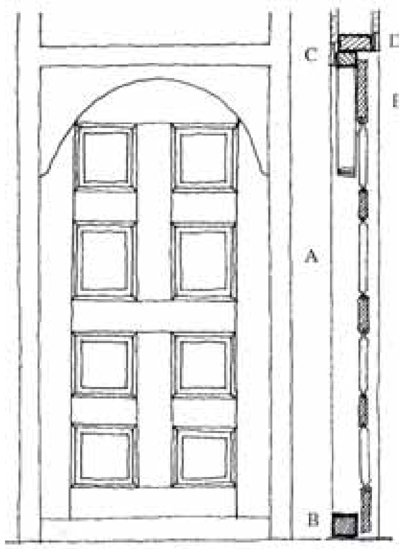


Figure 2-14 The Turkish door
(Source: Küçükerman, 1978: 144)

in a square pattern and translucent paper which was pasted to one side of the timber panel (Fig. 2-15). The grid of the timber skeleton of *shoji* was formulated according to the standard measurement. The intervals between the timber posts determined its width whereas the length of the posts determined its height. Thus, we can say that the size of the *shoji* grid was subjected to the horizontal and vertical modular order of the house (Engel, 1964: 146). The *shoji* was utilized not only for door but also for partition walls, which faced directly to the outside, and even for windows. Through translucent paper, the light came inside the room.

Fusuma (Fig. 2-15) owned a similar structural skeleton as *shoji*, however, thick and opaque paper covered both side of the panels. Timber frames enclosed its four sides. *Fusuma* constituted the room partition, room door and door for the closets. Above mentioned sliding doors and windows in the Japanese house were held in place by fittings called *shikii* and *kamoi* (Fig.2-16). The *shikii* was the wooden tracks which were placed on the floor and hold the lower frame of the panels, whereas the upper frame was held by another track, *kamoi*, which was fixed to the braces called *nageshi*. *Nageshi* existed since eighth century as a structural element which tied columns in order to resist lateral force of earthquakes. However, in later period *nuki* (horizontal beam which pierces the columns) replaced *nageshi,* and as a result, *nageshi* were no longer needed as a structural element. Instead it became the component which supported the *kamoi*.

Figure 2-15 *Shoji* (left) and *fusuma* (right) (Image by author)

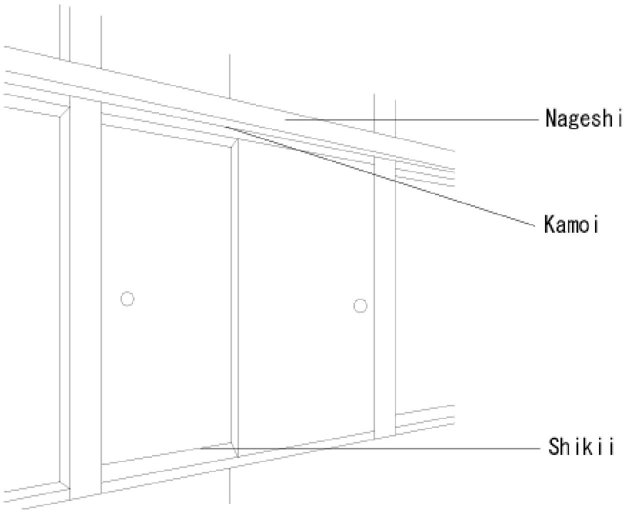


Figure. 2-16 *Shikii* and *kamoi*
(modified from Kawasaki City, 2001: 31)

e. Windows

· The Turkish Windows

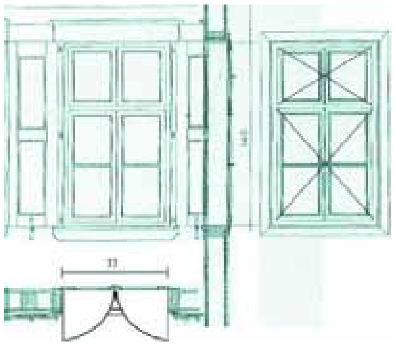
The rooms of the Turkish house usually had two different types of windows, those include, large lower windows which were placed just above the *sedirs* and smaller upper lights called *tepe penceresi* (Fig.

2-17). They were used for different purposes and thus provided different qualities of light into the room. The lower windows had functions of a normal window; to provide the outside air, light and outside view into the rooms. Especially women, who spent most of their lives inside the house, observed the outside world through the windows without being seen by the passengers. In order to solve this complicated interior and exterior relationship, the wooden lattice called *kafes* was fixed on the outside of the windows. Küçükerman (1978: 125) suggested three main window types of the traditional Turkish house including perpendicular sliding sash, vertical hinged sashes and combination sash (Fig. 2-18). The methods to deal with the relationship between inside and outside can be observed in various window types.

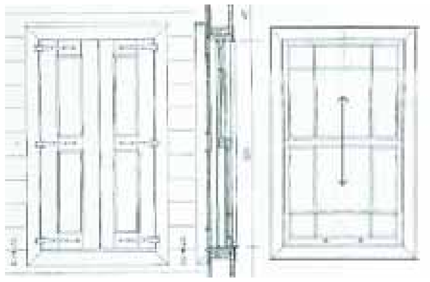
Upper light was one of the characteristic elements in traditional Turkish house. They were built between ceilings and lintels fixed on the top of the windows. Prior to the introduction of plate glass to house tradition in Anatolia, openings were closed with wooden shutters and curtains used to protect the space from cold and dust. Upper lights were created in order to provide light into rooms. Glasses were used in upper lights. Generally they were elaborately decorated with colored glass and plaster providing colorful lights into the room while the windows were designed in quite simple way.

Figure 2-17 Double row window
(Image by author)

A. Combination Sash
House of Hayri Reis, 1820, Büyükdere
(Source: Eldem 1908; 235)



B. Vertical Hinged Sashes
Old College doorkeeper’s house, 1840,Bebek
(Source: Eldem, 1908; 235)



C. Perpendicular Sliding Sashes
An example of Ankara house
(Source: Kömürcüoglu 1950; 91)

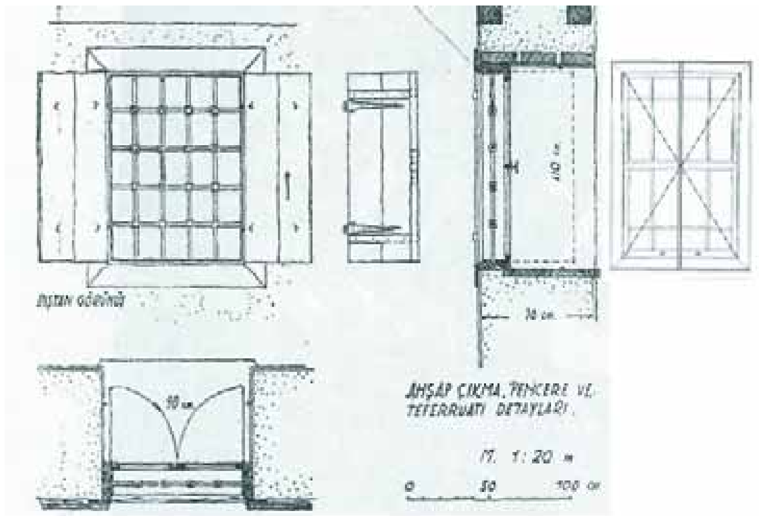


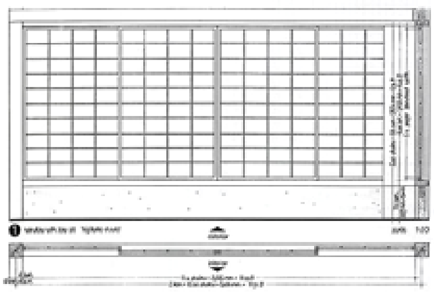
Figure. 2-18 Three types of window of the Turkish house
(Source: Kömürcüoglu, 1950: 91, Eldem, 1908: 235)

· The Japanese Window

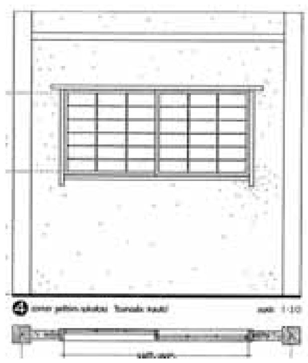
While windows played essential role in the Turkish house, the application of windows in the Japanese house was limited compared to the other elements. This was because *shoji* (translucent paper panel) performed the functions of openings. However, there were various standard types of windows which differed in shape, size and opening and shutting methods according to the purpose and location. The windows which were frequently encountered in the Japanese house are described as follows (Fig.2-19).

The *hikae-mado* (the window with low sill) was preferred for the exterior walls of living rooms. The main functions of this window were to provide light, air, and view into the interior spaces.

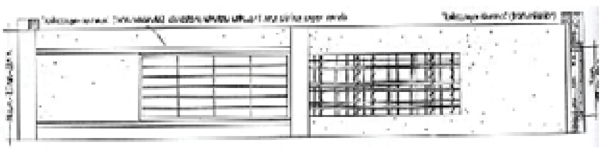
On the other hand, the functions of the *taka-mado* (the window with high sill) were more limited to illumination and ventilation. Thus it was commonly used in kitchen, bath and toilets.
Ranma was fixed on above the partition panels, *shoji* and *fusuma*, between living room and the *engawa*, or between two rooms in order to provide the light and air into the farer side of the room. Usually wooden grills, sliding paper panel, or elaborately decorated openwork were applied for the *ranma*.



A. *Hikae-mado*



B. *Taka-mado*



C. *Ranma*

Figure 2-19 Japanese windows
(Source: Engel, 1964:151,152, 154)

f. The Storage and the Fireplace

· **The Turkish Storage Spaces and the Fireplace (*Ocak*)**

The Turkish room, in principle, contained cupboards and a fireplace (*ocak*) placed on the windowless side of the room, usually perpendicular to the entrance wall (Fig. 2-20). They were built during the construction together with *sedir*. The fireplace (*ocak*) was usually built in the most important room (*başoda*) and a winter room in the house. It was placed at the center of the wall. The most common type was the half-circular niche. It was built within the timber framed floor as a wall in which the fireplace located, precaution was built-in masonry stone and mudbrick. taken against fire. The cupboards of the Turkish house which were usd to keep the bed mattress during the daytime called as "*yüklük*". They were 75-90 cm deep and 130-150 wide (Günay, 1998:240). The closet had double winged and mostly one of the closets contained a secret place for bathing called *gusulhane* (Fig.2-21) so that an Islamic couple can take a bath after sexual intercourse following the ritual. Besides the cupboards, there were small niches for storage keeping small utensils such as water jugs. They were usually built next to the fireplace; depth and width were less than those of "*yüklük*". They started about 60 to 80 cm from the floor (Günay, 1998:240) and reached up to the level of the *sergen*. The open single shelves called *sergen* were arranged around the room above the first row of the windows. These shelves were used as storage for kitchen utensils, fruits and other small things.

Figure 2-20 Fireplace(*Ocak*)
(Image by author)

Figure 2-21 *Gusulhane*
(Image by author)

Just above the cupboards, a storage space called as a *musandıra* in some localities was placed. Sometimes they were left open like a gallery and sometimes they were closed with doors. Less frequently used articles were stored here.

· **The Japanese Storage Space and the Fireplace (*Irori*)**

In Japanese house, wall cupboards were built in living rooms in order to store bed linen and other commodities. The wooden sliding door covered the storage rigidly. The lower track which supports the door (*shikii*) was set higher than the floor. This style of carpentry was called *nando-gamae* (Fig.2-22) and was frequently encountered in the Japanese house built in the eighteenth century.

The *irori* which was installed in the hall played a role of a fireplace in Japanese house. Since the hall had function of a common space, family always gathered around the fire for eating, working and chatting. Thus the *irori* was used for multiple purposes such as cooking, lighting, warming the house, and drying the wet clothes. Above the fire, a wooden nail was hung in order to fix the pots and kettles (Fig. 2-23). In general Japanese houses did not have ceiling, thus the smoke rose up and accumulated in the high attic space.

Figure. 2-22 *Nando-gamae*
(Source: Kawashima, 1973: 184)

Fig. 2-23 *Irori*
(Source: Kawashima, 1973: 152)

g. *Zashiki* and its Elements

The family hierarchy was also expressed in the reception room called *zashiki* (*dei*) in the Japanese house. The *zashiki* was used as a room for special guest and decorated with elements including *tokonoma, tana*, and *syoin* (Fig. 2-24). These elements were built according to the modular organization. Few families who were rich enough to afford them had the *zashiki* in their house and it was not popular among ordinary people. A picture recess called *tokonoma* was not only the main feature of the *zashiki* but also the spiritual center of the Japanese house. It was usually recessed 0.5 *ken*, which corresponded to 90 cm, with width of 1 ken (180 cm). The floor of *tokonoma* was sometimes slightly higher than the rest of the floor. The *tokonoma* was decorated with flowers, pictures or the picture scroll called *kakejiku*. Definitely the *tokonoma* was the main decoration of the room and in all ages, it had played the formal role in the residence. The position in front of the *tokonoma* was the honored place for the guest or the head of the family. Usually *tana* (cupboards and shelves) was fixed to the space next to the *tokonoma* called *tokowaki*. Small cupboards with sliding doors were placed above and below the wall niche. In the space between the upper and lower cupboards, two boards at different heights were joined to form the shelves. Together with *tokonoma*, these shelves were used as an ornament in the *zashiki*. Another feature of the *zashiki* was a bay window called *shoin*, which was used as a studying desk. The wall above the bay was equipped with the window and the space underneath the window seat was used as a cupboard.

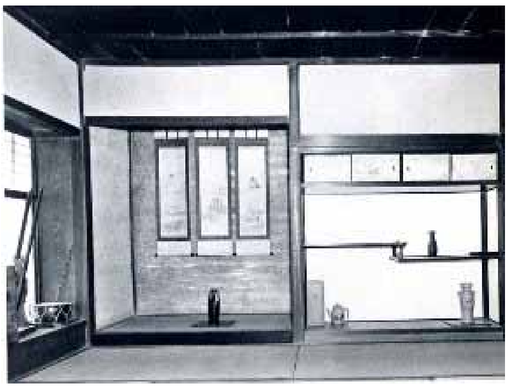


Figure 2-24 *Zashiki* (Source: Kawashima, 1973: 196)

2.2.3. Secondary Spaces

The main function and the physical characteristics of the *sofa*, *eyvan,* balcony, entrance hall and staircases of the Turkish house are compared to *doma*, *engawa*, and staircases of the Japanese house.

a. The Hall

· The *Sofa*

The *sofa,* the semi-open area which faced the courtyard, was the most dominant element in the design of the Turkish house. Sofa was the element which discriminate the Turkish timber house and timber houses in other countries. One cannot enter the rooms without passing the *sofa,* thus the room units were connected by the *sofa* (Fig.2-25). Sofa functioned not only as a hall but also as common space: people used this space in multi purposes including eating, chatting, sleeping; they even brought a small washbasin to the *sofa* for ablution. People spent most time in *sofa*. As explained before, three plan types of sofa were observed according to the era. Those include open, corner and central sofa. Among them, central sofa was the most common type.

Figure 2-25 *Sofa* (Image by author)

· The *Hiroma*

The *hiroma* played the role of a hall in Japanese house (Fig.2-26). The *hiroma* contains the fireplace, *irori*. As explained in the section of the fireplace, the family came together in the hall, sit around the fire for multiple purpose including cooking, eating, and working. Also close friends of the family were invited to the *hall.* In the case the special guests came, the place called *dei* was prepared by partitioning the corner of the *hiroma*. The *dei* contained the fireplace (*irori*), a Buddist altar (*butsudan*), and a recessed wall for picture and flowers (*ouin*) (Fig.2-27).

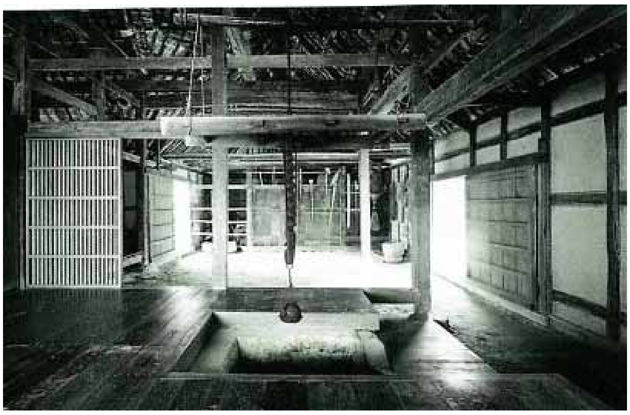


Figure 2-26 *Hiroma*
(Source: Kawashima, 1973: 191)

Figure. 2-27 *Dei*
(Kawasaki City, 2001: 57)

b. The *Eyvan*

In its development, the *sofa* was extended along the wall and created extra secondary spaces for more specified functions. The semi-opened space between rooms called *eyvan* (Fig. 2-28) and the projecting corner called *köşk* were developed from the *sofa*. They were used for more private purpose. Sometimes a balustrade was fixed between the *sofa* and the *eyvan*. The façade was usually covered with wooden lattice. During the transformation of the Turkish house to a centrally planned house, the *eyvan* was used as a space for staircases.

Figure 2-28 *Eyvan*
(Image by author)

c. The Entrance Hall and the Entrance Door

· The *Hayat* (*Taşlık*) and the Entrance Door

The entrance to the house was usually earth floor. Sometimes it was paved with stone. The masonry wall, which was a basis for the structural columns, reached to the height of about 60 to 80 cm. In general, the entrance hall named *hayat* (*taşlık*) opened to one, two or three sides and especially in Safranbolu, the space between the ground and ceiling was covered with the wooden lattices (Fig. 2-29).

A double winged large door was fixed at the entrance and the courtyard in most Turkish houses. A metal door knocking and grip were nailed on the exterior surface.

Figure 2-29 Entrance hall of the Turkish house
(Image by author)

c. The *Engawa* and the Entrance Door

In Japanese house, usually the wooden sliding door was fixed to the earth floor space (*doma*). The guests entered to the house from the *engawa* (intermediary space between interior and exterior), which was installed around the outer edges of the *zashiki* and went directly to the *zashiki* (Fig. 2-30). The width of *engawa* was 0.5 to 1 ken (about 90-180 cm) and usually it was covered with timber. Originally it was semi-open space; however, after the glass was introduced to Japanese housing, it was covered by glass doors to be interiorized. The *engawa* was used in various ways: it was a light-subduing anteroom during the summer time while in winter it became sunbathing place. It was used as corridor and passage to the garden since the *engawa* was connected to the garden with stone stepping. When the special guests visited the family, the *engawa* was used for the official entrance which leaded the guest to the special guest room (*zashiki*).

Figure 2-30 *Engawa*
(Source: Kawashima, 1973: 206)

d. The Balcony

The balcony was not a common element in the earlier examples of the Turkish house. It became popular on 19th century. It was used for sitting, chatting, and drinking tea, like *sofa* and *eyvan,* but the main function of the balcony was to sundry fruits and vegetables. In order to protect the food from the dust, pets, insects and animals, usually the balcony was built on the middle or the top story (Günay, 1998:144)

e. The *Doma*

The space first entered from the outside was *doma*. Generally, the *doma* had dirt floor which extended from entrance to the backside (Fig. 2-31). The main functions of the *doma* were clearly separated from those of rooms for the *doma* was mainly used for a place for farm works: threshing and selecting vegetables, storage rooms, entrance and passage, and barns and stable. It was openly connected to the kitchen so that together they were used for preparing meals. Like the *sofa*, a portable bathtub was brought in *doma* for bathing.

Figure 2-31*Doma* (Image by author)

f. The Staircases

· The Turkish Staircases

The staircases played a principal role in the Turkish house (Fig. 2-32). In order to promise the visual privacy from the outside, the greatest care was paid to the relationship between the staircases and the main entrance, the *sofa*, the *eyvan*, and the main room door

Figure 2-32 Staircases of houses in Safranbolu (Image by author)

· The Japanese Staircases

In general Japanese house was a one-storied house. The staircases of the Japanese house were found in the snowy regions or the house of the farmer who engaged in silkworm culture for the former required the second floor in order to enter the house during the winter when the ground floor was buried under the thick snow. The latter utilized the second floor mainly for keeping silkworms and workplace. The staircase in the farmhouse was so simple that it was rather closer to a ladder (Fig. 2-33).

Figure 2-33 Typical Staircases of the Japanese House
(Source: Kawashima, 1973: 206)

2.2.4. Service Spaces

The location and the facilities of the kitchen, bathroom, and the courtyard are studied both for the Turkish and house in this section.

a. The Kitchen

· The Turkish Kitchen

The kitchen was either a semi-open or closed space built on the ground floor as a part of the courtyard in the Turkish house. In order to prevent a fire, a masonry wall and stone paved floor were applied. As the Turkish house developed into central or symmetric plan being influenced by the Western culture, the kitchen was also integrated into the houses and stated to be located at one side of the sofa or even in the first floor.

· The Japanese Kitchen

The location of the kitchen differed according to the floor plan in the Japanese house. In the checkered type, the kitchen space called *daidokoro* was adjoined to the cooking stove which was built in the *doma*

(Fig. 2-34). The Japanese kitchen contained the hearth (*irori*) (Fig. 2-23). People used both the cooking stove in *doma* and hearth in the hall for preparing meals.

On the other hand, in the hall type house, the hall with the hearth was the central space for cooking. The *doma* was not used as a kitchen in order to avoid the coldness. Therefore this type of the dwelling was found mostly in the northern part of Japan.

Figure 2-34 Japanese kitchen
(Source: Kawashima, 1973: 232)

b. The Bathroom and Lavatory

· The Turkish Bathroom and Lvatory

The bathroom was equipped in one of the closets of the built in cupboards usually in each room in the Turkish house. This was termed as "*gusulhane*". At the same time, in Anatolian houses the bath, the kitchen, and the fireplace were usually erected in a single independent building in a garden called as "*müştemilat.*" However, in Safranbolu the lavatory and landry were built in the projected space in the middle and top floors, and the exterior was enclosed with timber panels. At the same time people used public bath, *hamam*.

· **The Japanese Bathroom and Lavatory**

In the Japanese house, the bathtub may be brought into the *doma* once a week. Since a few villagers owed the bathroom, the people in the community made use of it together. Like the Turkish house, the lavatory was built outside separately or at the corner of the house. Since people spent most of the times at farms outside, a hut for toilet was built outside separated from the housing unit. In some houses the simple toilet was placed at the corner of the *doma*.

CHAPTER 3
GENERAL OVERVIEW OF THE SETTLEMENTS OF SAFRANBOLU AND GOKAYAMA

There were three reasons behind choosing houses in Safranbolu and Gokayama.

1. The original configuration of traditional timber houses remained intact in both cities. Since the timber houses in both Safranbolu and Gokayama are registered with the UNESCO World Cultural Heritage, it is forbidden to make any alteration to the houses without permission.

2. Nowadays it is difficult to find representative settlements of traditional timber housing in either country. Usually we encounter traditional timber houses which remain singly among new settlements.

3. In general the Japanese house was single story while the Turkish house was multi storied. However, the houses in Gokayama consisted of at least second stories, the size of the house was quite similar to the house in Safranbolu.

Gokayama consisted of two villages including Ainokura and Hagimachi. In this thesis, Ainokura village is presented as Gokayama. Four houses were chosen from each settlement for the survey. General aspects of the villages are described in the following sections. The method of survey is explained in chapter 4.

3.1. Climatic Conditions

3.1.1. Safranbolu

Geographically Safranbolu belongs to the Black Sea region, however, the climate of Safranbolu is on a transitional belt between the climates of the Black Sea and inland Anatolia. Winter and summer are not as harsh as inland climate. It rains constantly through the four seasons. At the same time, snowfall, which is not common in the Black Sea region, is noticed every year. (Günay, 1998: 92).

3.1.2. Gokayama

Since Gokayama settled on the inland surrounded by steep mountains, winter is quite severe. Gokayama is one of the heavy snowfall areas in Japan. During wintertime, ground floor was buried under the snow, in consequence the garret of the dwellings developed to be high and large in order to provide light to interior spaces (Fig.3-1).

Figure 3-1 The houses in Gokawama in winter time
(Source: Eda, 1996: 31)

3.2. Topography

3.2.1. Topography of Safranbolu

Safranbolu places in the north-western Black Sea region, located at the cross section of the 41 ° 16' northern latitude and 32 ° 41' eastern longitude (Fig.3-2). Mountains on the northern and western sides surround Safranbolu. Due to these mountains, it was difficult to access to inland Anatolia and to the sea. The city is at an altitude of 400 to 600m (Günay, 1998: 92).

Figure 3-2 Location of Safranbolu
(Source: Turkey Tourist Map)

The city of Safranbolu consists of the plateau which inclines from north to south and valley which was formed by three rivers including Akçasu, Gümüş, and Tabakhane. On the delta where Akçasu and Gümüş River flowed together, the commercial center of the town named Çarşı developed.

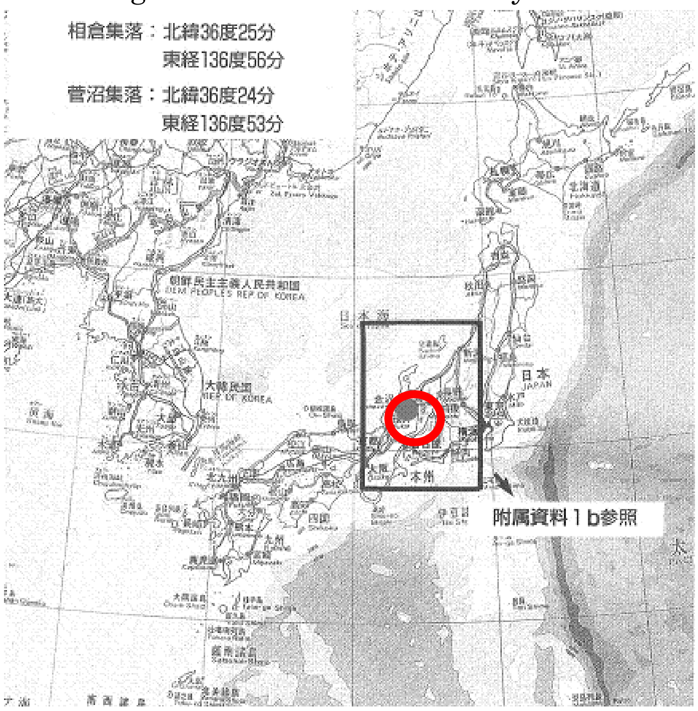
All the geographic areas where the traditional timber houses spread are within seismic zone. According to general directorate of disaster affairs earthquake department, Safranbolu belongs to first-degree earthquake zone where the strongest gravity (0.4g) was expected to cause in earthquake. It may be due to this fact that the timber frame construction system was applied and widely used. This method is thought to be resistant to the horizontal loads and is also safer because of its lightness.

3.2.2. Topography of Gokayama

Gokayama is located in the Chubu region , at the cross section of the 36 ° 25’ northern latitude and 136 ° 56’ eastern longitude (Eda, 1996: 42) (Fig.3-3). Since Gokayama is settled on a in hilly district, the mountains made difficult the access to other cities. The Shou River runs from north to south forming a deep valley . After crossing the center of Gokayama, the river finally reaches to the Sea of Japan. The village was developed on the narrow terrace of the valley.

Same as Turkey, most part of Japan including Gokayama is settled on the earthquake zone. Gokayama is sited on the first-degree seismic zone, which is the heaviest, according to the building regulation.

Figure 3-3 Location of Gokayama



(Source: Eda, 1996: 82)

3.3. Settlement Pattern and Design Methods of the Houses

a. Safranbolu

Once people differentiated the summer and winter way of life house which served two separated settlements in Safranbolu. The summer settlement called Bağlar was set up on the plateau while the winter settlement called Şehir was formed inside the valley where the commercial district Çarşı is located. Between Çarşı and Bağlar, is situated the Greek village called Kıranköy (Fig.3-4).

According to the 1965 Census, a total of 2301 houses were registered in Safranbolu: 1140 in Şehir, 249 in Kıranköy, and 912 in Bağlar (Günay, 1998: 92).

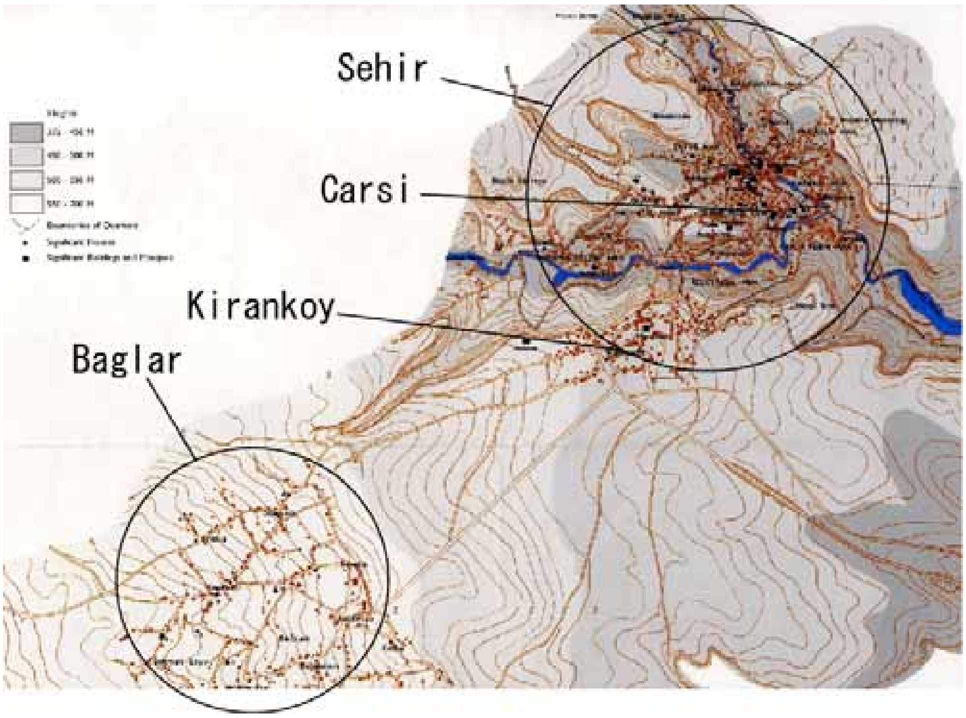


Figure 3-4 City of Safranbolu
(Source: Günay, 1998)

3.3.1.1. Şehir (Winter Town including the Commercial Center)

In order to protect the houses from cold winds, people built their houses along the steep slope or bottom of the valley. Houses were densely built especially in the center of Şehir. It was difficult to obtain the wide and flat land in winter town; most of the building sites was small and had irregular shape. In this type of the building plots, foundation and ground floor walls were formed according to the topography and form.

The upper floors were projected over the streets in order to acquire wider space (Fig.3-5, 6,7). In the case the houses were built on a steep slope, masonry foundation walls became thicker and higher, sometimes it continued until the second floor. The houses located on the slope were oriented paying attention not to conceal other's view. Thus one can see every house from facing hill (Fig. 3-8).

The morphology of the streets of Şehir was determined by the curve and undulation of the topography. Width, slope, and pavement system of the streets were determined by the needs of the users. For example, places where markets were opened, streets were widened to set the market.

In Çarşı the administration, schools, workshops, mosques, a public bath, and market places were located to form a central commercial district. People in Safranbolu worked here all year round even during summer when they moved to summer town. The workshops, which were operated between 13th to 15th century by guild system, were gathered according to the occupation including shoemaker, saddler, leatherworker, and craftsman of metal fittings and steel (Günay, 1998:342).

Figure 3-5,6,7 Houses and streets in Şehir
(Image by author)

Figure 3-8 The winter quarter, Şehir
(Image by author)

3.3.1.2. Bağlar (Summer Town)

Among several summer towns in Safranbolu, Bağlar which was located on northwest of Şehir was the largest. Compared to Şehir, the topography of Bağlar was flat. The houses for summer residence were built with less density. Each building plots had large and regular shape (Fig.3-9, 10). The plan scheme of the ground floor was mostly square, which was repeated at the upper floors quite often. In general, summer houses had balcony on the top floor at the south side. Its main role was to dry foods under the sunlight. The street in Bağlar was wide and its slope was gentle.

Figure 3-9,10 Houses and streets in Bağlar
(Source: Günay,1998: 124)

3.3.2. Gokayama

The size of the village of Gokayama was smaller than that of Safranbolu. According to the record of 1887, 47 houses existed in Gokayama. In 1994, 27 houses presented and among them 20 were timber houses (Eda, 1996: 49). The settlement was developed on the narrow terrace of the left bank of the Shor River. The terrace is enclosed by forests and is about 400m over the sea level. The terrace spreads 500m from northeast to southwest and 200~300m southeast to northwest. Within this flat land, the residence district and cultivated lands were developed (Fig.3-11).

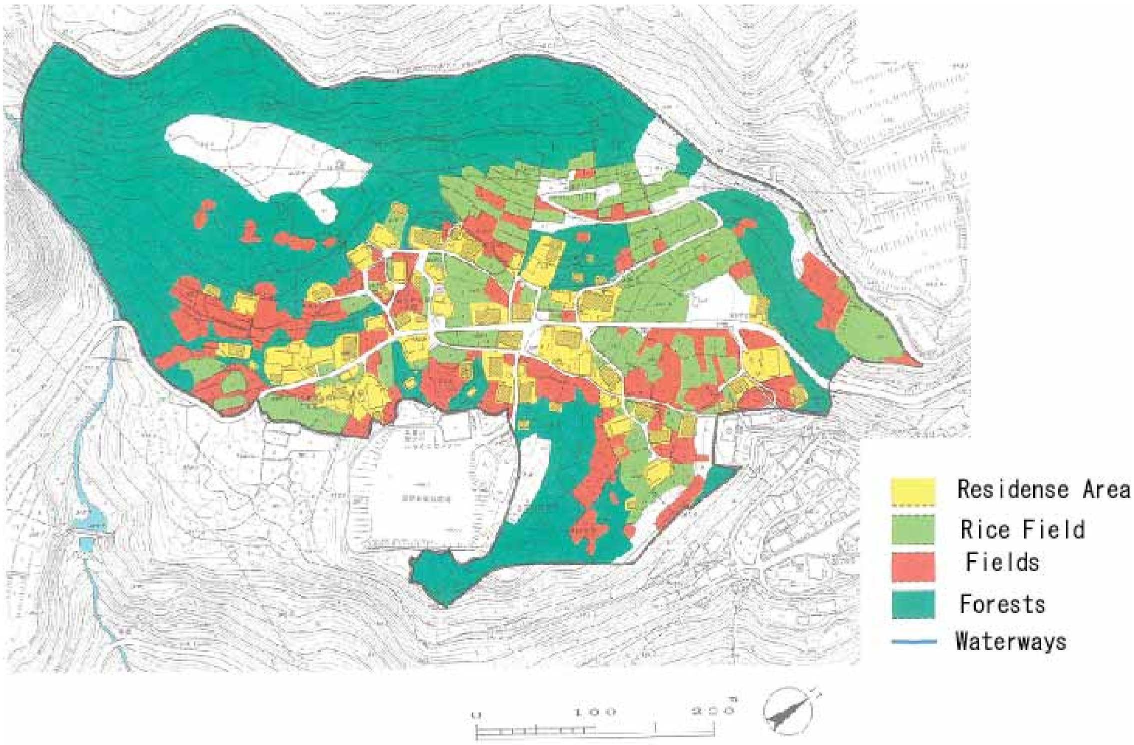


Figure.3-11 The village of Gokayama
(Source: Eda, 1996: 96)

The structure of the village consisted of the main road which crossed the terrace straight from northeast to southwest and narrow winding paths which connected the main road and dwelling units. Most houses were built on small irregularly shaped lots without any garden (Fig.3-12, 13).

The flat ground was prepared by constructing stone masonry base. Since there was no hedge or wall around the house, the house was opened to the exterior. The cultivated land enclosed the residence district. Most of them were used for rice cropping.

No commercial center existed in Gokayama, only five religious buildings including temples and a Shinto shrine. The administration of the village was operated by the community called *kumi.*

Figure 3-12,13 Houses and Streets in Gokayama
(Source: Eda, 1996: 20-22)

3.4. Industry

3.4.1. Safranbolu

People in Safranbolu engaged in agriculture to lead self-sufficient life. Most people owned farmland around the city, which they used as orchards or field for rice, wheat, and vegetables. Other than this, trade and production of export goods were the main income. Since Safranbolu was located on the route between Asia and Europe, and between the Black Sea and inland Anatolia, the city was developed as a trading spot. At the same time, Safranbolu was famous for commerce. Farm surpluses, shoes, leather products, furs, timber, and saffron were the main exports. Among them shoemaking was the most active production. The shoemaker workshops were gathered at one of the districts in Çarşı, which was called Arasta (Fig.3-13). For each workshop, 3 to 5 craftsmen were employed. Shoes were sold all over Turkey by caravans. Leather for shoe production was made at the tanneries, which were established at Tabakhane quarter situated besides Akçasu river facing Çarşı (Fig.3-14). At the beginning of the twentieth century, among 415 people were employed in a hundred tanning factories and 430 people engaged in shoe production. As rubber boots and synthesis leather replaced with the leather boots in late period, both leather and shoe making were abandoned (Günay, 1998: 100~104, 342).

Figure. 3-13 Arasta
(Source: Günay, 1998: 345)

Figure 3-14 Tannery (Tabakhane)
(Image by author)

3.4.2. Gokayama

In Gokayama agriculture was not active compared to most villages in Japan. The farm production was just enough for self-sufficient life. Instead the products including Japanese papers and silk supported people's earnings. Since it took time and energy to process Japanese papers, it was a reasonable industry for regions with heavy snowfalls for they could not work outside during winter times. It was popular industry until the machine-made paper was introduced from the west in the nineteenth century. Consequently production of Japanese paper declined.

Silkworm culture was started from the end of the seventeenth century in this Gokayama. Due to the opening of trade with foreign countries in the nineteenth century, the import of raw silk and silk fabrics increased. As a result, the silkworm culture in Gokayama developed rapidly and became the most important industry. Silkworm culture continued until about 1970, however, nowadays it was completely abandoned. Same as Japanese paper making, time and energy were inevitable for taking care of silkworms. Furthermore, in order to keep silkworms and to pile up mulberry leaves, which were feed for silkworms, wide indoor spaces were required. This need for wide spaces resulted in the structure of the houses; the garret was composed of multi layers to promote active use of garret (Fig.3-15).

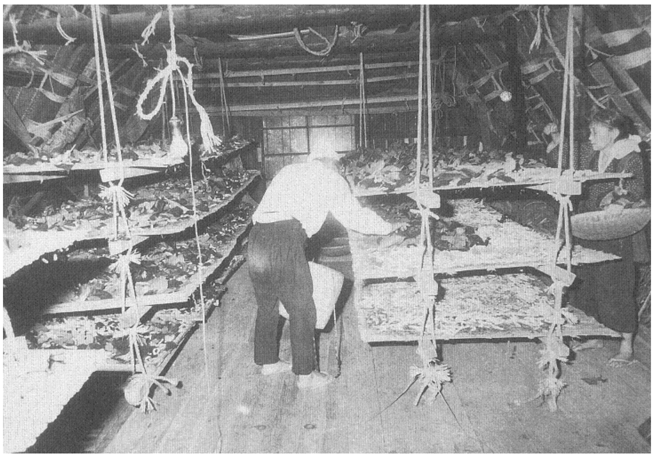


Figure. 3-15 Silkworm culture in Gokayama
(Source: Eda, 1996: 75)

CHAPTER 4
CONSTRUCTION SYSTEMS OF TRADITIONAL TIMBER HOUSES

In order to discover the structural order of traditional timber housing, four houses were chosen to collect the scale the pitch, span, and length of timber components. In this chapter, the concrete methods of survey is presented. Then the construction system and structural organization of the timber components are studied based on the data collected.

4.1. Survey Methods

Since the construction methods of the houses in Safranbolu and in Gokayama were different from each other, different survey methods were taken for investigation. Thus in this section, the methods of the survey for each settlements are explained.

a. Safranbolu

Three houses were chosen from the winter town, Şehir, and one was chosen from the summer town, Bağlar for carrying out the inquiry (Fig.4-1). The sample houses in Şehir were built on the steep slope of the valley while the one in Bağlar was located on the flat land. The object of the survey was to research the construction system and order of the timber components which formed the structure of the traditional timber houses. Two methods were applied for this purpose; the checklist which was prepared beforehand and the drawings. Based on the data collected by the checklist, the drawings, and reading materials the construction system and structural order are studied in chapter 5.

· **The Checklist**

Measurement of the timber components and consulting of the construction systems were preceded according to the checklist. The items of the survey were divided into two classes; structural parts including masonry structure and timber structure and non-structural parts including finishing and furniture. Timber structure was divided into two groups; timber framed structure and roof structure. Wall, floor and projection were categorized to the timber structure (Fig. 4-2). The cross section and length of timber components, span and pitch of columns and beams of the *baş oda*, the joint type of each component were surveyed based on the checklist which was prepared referring to the thesis of Kaya (1996), Şahin (1995), and Köysüren (2002). For the collected data refers to the Appendix A.

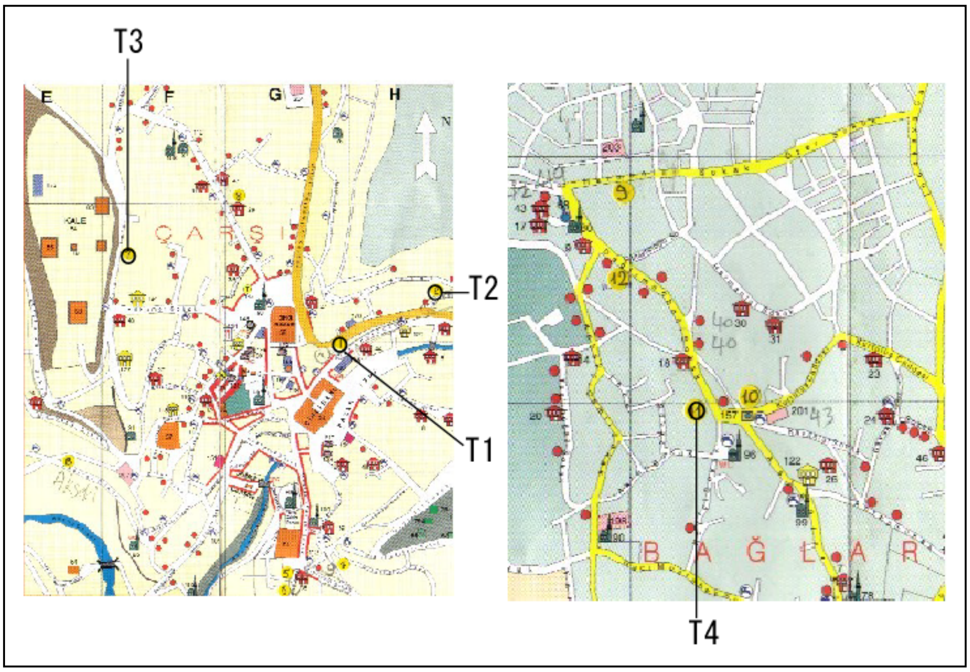


Figure 4-1 The location of the samples; Şehir (left) and Bağlar (right)
(Source: Tourist Information of Safranbolu City)

· Drawings

Before starting the measurement of the houses, the drawings including plans, elevations, and sections were collected. The students of Zonguldak Karaelmas Üniversitesi Safranbolu Meslek Yüksekokulu prepared these original drawings. Among 20 houses, 4 were chosen. The timber houses with exposed timber skeleton were chosen since its structural order was easier to understand when compared to the houses which were entirely covered by stucco. Consequently, the survey was carried on drawings; checking whether the numbers, pitches, spans, lengths, and cross sections of timber components which were re-drawn in the drawings were correct or not. Then the plans, elevations and plan detail were modified, which was prepared as Appendix C.

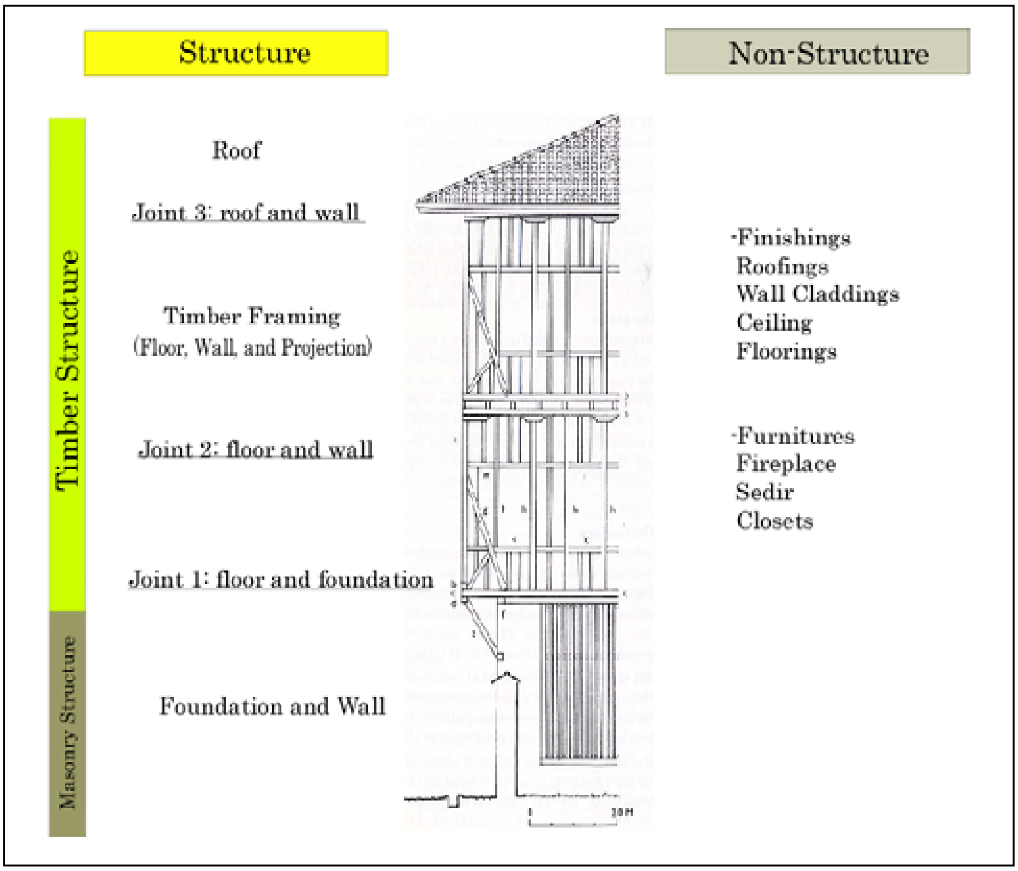


Figure 4-2. The methods of survey of houses in Safranbolu

(Source: Günay, 1998: 302)

4.1.2. The Methods of Survey in Gokayama

Four houses were chosen from Ainokura village in Gokayama (Fig.4-3, 4, 5). All of them were placed on the flat and narrow terrace. In order to survey the structural organization of those houses, a literature survey was applied. The books used for the survey were the reports of reconstruction of the traditional timber houses which were readied by Toyama Prefecture (1979) and the committee of repairing of the traditional timber house (1963). These reports contained precise drawings and measurements of timber components, which were fully used for the study. The whole house was of timber structure separated into two according to the structural character; timber framed part including wall and floor, and roof (Fig. 4-6). Same as the Turkish samples, the numbers, pitches, spans, lengths, and cross sections of timber components and three joints were studied in order to discover the structural order and the construction system of the timber houses.

Figure 4-3 The location of the Samples

(Source: Yahoo. Maps)

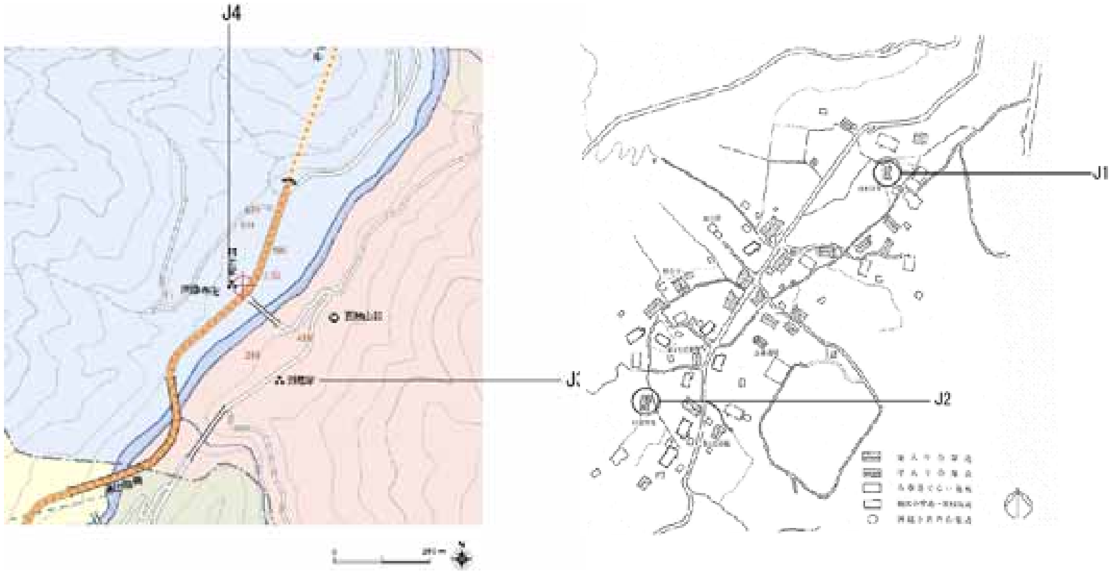


Figure 4-3, 5 Location of samples of Gokayama

(Source: Yahoo Maps, Toyama Prefecture, 1979: 8)

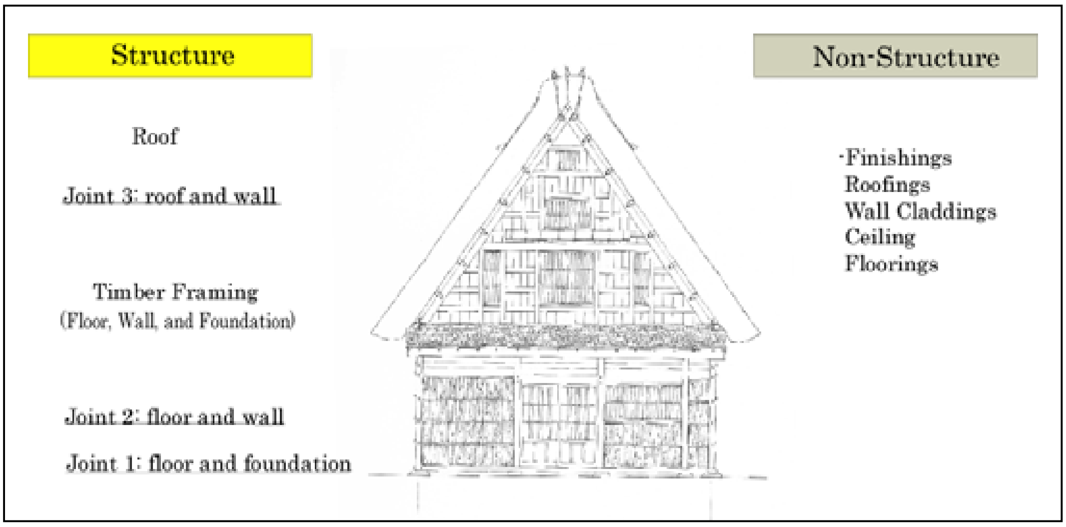


Figure 4-6 The methods of survey of houses in Gokayama

(Source: Toyama Prefecture, 1979: 47)

4.2. Summary of the Samples

The outline of the samples in Safranbolu and Gokayama was described from four items including age of the construction, the size of the house, the plan scheme, and the level of the alteration, which are summarized in Table 4-1,2.

i) Age of the Construction

a. Safranbolu

Though the precise date was unknown, every house chosen from Safranbolu was built in the early twentieth century.

b. Gokayama

The age of the construction of the houses in Gokayama were dispersed from the middle of the seventeenth century to 1922 (Table4-2). However, four of them were once dismantled and reconstructed after the twentieth century because of serious decay of the timber structure.

ii) The Size of the House

a. Safranbolu

As explained in chapter 2, in general, the Turkish house consisted of several floors. Among the four samples, three had three floors including masonry built ground floor and timber framed upper floors. One sample was two stories and the ground floor was also timber-framed structure. The minimum size of the total area of the house was 162 ㎡ (sample T4), on the other hand, the largest one had 324 ㎡ (sample T2). As for the number of the family, sample 1 and 4 were vacant, while 5 persons lived in sample 2, 4 lived in sample 3.

b. Gokayama

The houses in Gokayama are larger than the average Japanese traditional timber houses. The houses were built with multi stories because the space for keeping silkworm required large spaces, and consequently the attic developed. Among four samples, sample J1 and J2 had two stories, J3 had three and J4 had four. Families in Gokayama usually lived on the ground floor. The upper floors were used for silkworm culture. As for the total area of the houses, the smallest house had 141.8 ㎡ and the largest one had 533.7 ㎡. Usually the size of the family occupying a house unit was of 6 to7 members.

iii) The Plan Scheme

a. Safranbolu

Two types of plan schemes were observed; the inner *sofa* and the central *sofa* plan (Table 4-1). The rooms lined along each side of the *sofa* in the inner *sofa* plan of sample 1,3 and 4. In sample 2, sofa was located on the center of the house surrounded by rooms. Two *eyvan*s were connected to the *sofa* facing to the streets.

b. Gokayama

The main plan type of this region is the hall type; the room was planned next to the hall which was fixed next to the *doma*. The living space usually consisted of four rooms including hall, *zashiki*, and two rooms. Sample J3 had the typical plan type in this region. In smaller houses, hall and zashiki were united as one room. This plan type was observed on the plan of sample J1 and J2. Sample J4 had large plan which included 5 rooms with a hall. Since it was difficult to obtain large flat land in this hilly district, a long and narrow plan scheme developed. The *doma* part contained a stable and kitchen.

iv) The Level of the Alterations

a. Safranbolu

In Safranbolu, it was forbidden to alter the structure of the houses without permission of the Regional Conservation Council. Consequently most houses remained in their original form. However, in some examples small changes were found. A portion of the stone masonry exterior walls was replaced with concrete blocks in sample 3. The partition wall of the ground floor of sample 4 was completely replaced by concrete block. Despite these changes in structure, the structural order of timber components and construction system were understandable.

b. Gokayama

Most traditional timber houses in the settlement were rebuilt in the twentieth century. According to the record of reconstruction of the houses in Gokayama (Toyama Prefecture, 1979: 5,6), the original figure of the houses was preserved as far as possible. Few timber components which were not reusable were removed, thus big changes in structure were not seen. The study is based on the data of the original structure of the samples. As for the scale, the traditional measurement *ken* was applied. One *ken* varied from region to region: in Gokayama one *ken* corresponded to 1.82 m in sample J1, 2, and 3 and 1.99 m in sample J4. The structure of the Japanese house was separated into two: *jyo-ya* and *ge-ya* (Fig. 2-8). Sample J1 and 2 does not contain *ge-ya*, while in J3 *ge-ya* was connected to the left side of *jyo-ya* and J4 had on both side. Usually the width of the *jyo-ya* ranged from 3 to 4 *ken*s for the ordinary house and the larger house had 6 *ken*s In general, the width of the *ge-ya* was 0.5 to 1 *ken* (Table 4-2).

Table 4-1 Summaries of the samples in Safranbolu

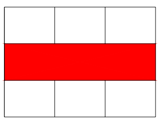
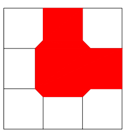
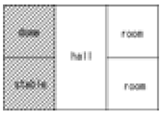
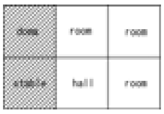
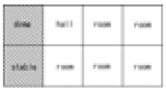
Plan Type	Stories	Sample Number	Address	Number of Rooms	Floor Area(㎡) (Timber Structure Part)	Households
	2F	T4	Bağlar Mah. Değirmenbaşı Sok.1	2	162(88)	0
	3F	T1	Çavuş Mah. Hamamönü Sok.11	5	297(199)	0
		T3	Çeşme Mah. Kalealtı Geçidi Sok.9 (Aygırlar Evi)	4	270(163)	4
	3F	T2	Çavuş Mah. Altığ Sok. 9 (Mehmet Özdemir Evi)	5	324(218)	6

Table 4-2 Summaries of the samples in Gokayama
(Source: Toyama Prefecture, 1979)

Plan Types	Stories	Sample Number	Address	Number of Rooms	Floor Areas(㎡) (Ground Floor)	The Age of Construction (Reconstruction Age)	The Area Beam×Girder (*ken*)
	2F	J1	Toyama-ken Higashi Tonami-gun Tairamura (The Mizuguchi)	3	141.8 (70.9)	1878? (1981)	jyo-ya: 3.5×6
		J2	Toyama-ken Higashi Tonami-gun Tairamura (The Kubota)	3	162.3 (81.15)	1922 (1981)	jyo-ya: 3.5×6
	3F	J3	Toyama-ken Higashi Tonami-gun Tamukai (The Haba)	5	209.9 (93.12)	17c? (1963)	jyo-ya: 3.5×6 ge-ya: 0.5×6 total: 4.5×6
	4F	J4	Toyama-ken Higashi Tonami-gun Tamukai (The Murakami)	8	533.7 (217)	18c.	jyo-ya: 4.5×6 ge-ya: 0.5×6 total: 5.5×6

4.2. Structural Systems of the Traditional Timber Housing

This chapter is separated into three parts according to the structure of the traditional timber dwellings in Turkey and Japan, that is to say, the foundation, the timber framed structure, the roof structure, and the building enclosure. The detail data of the timber components including, span, pitch, cross section and number refers the Appendix C.

4.2.1. Foundation and the Ground Floor Walls

Main types of the Turkish and Japanese foundation are introduced in this section.

a. The Turkish Foundation

In general, the foundation of the Turkish house was categorized into three types according to the structural characteristics (Şahin, 1995: 175). Those include single foundation, continuous foundation, and composite foundation (Fig.4-7). The characteristics of each foundation are as the follows.

· **Single Foundation**

Timber posts rested on the single stone bases which were raised 25 to 40 cm from the ground. The load of the upper floor was conveyed to the post and to the foundation stone. Specific joints were observed between foundation stones and posts. A timber beam connected these posts and formed a frame. Space between the posts was filled with stone, brick or timber boards to constitute the non load-bearing wall. Single foundation was popular in the northeast Black Sea region and was not found in the Safranbolu houses.

· **Continuous Foundation**

The foundation stones formed a frame under the external edges and through the axis of the building. This type of the foundation was commonly used in central Anatolia including Safranbolu houses. Especially in the winter district, because of small building plot the foundation wall was formed according the building cite, then in order to obtain wider space the upper floor was projected toward the street. In order to lay foundation stone, the ground was dug until the layer of the firm soil appeared. This was usually 100-150cm. The width of the foundation was 80 to 100 cm and its height was 100 cm or continued until the ground floor level.

· **Composite Foundation**

Both single and continuous foundation systems were combined in this system; the foundation built with rubble stone formed the peripheral edges of the building and the inner axis or partition walls made of timber framing were supported by single post in the foundation. After the foundation was settled, the stones of the ground floor were placed with mud mortar. The width was about 80 cm. For the corners, the larger and smoother stones were selected. The herringbone pattern was preferred in many houses. Adobe was another alternative for the ground floor wall which reached until 60 to 70cm above the ground. Timber lintels were inserted in every 80 to 150 cm to reinforce the wall and to avoid the usual damp from the mud bricks. In general, the ground floor of the Turkish house was built in masonry structure while the upper floor was built with timber skeleton. Stone and mud brick were the most preferred material for the masonry built ground floor construction.

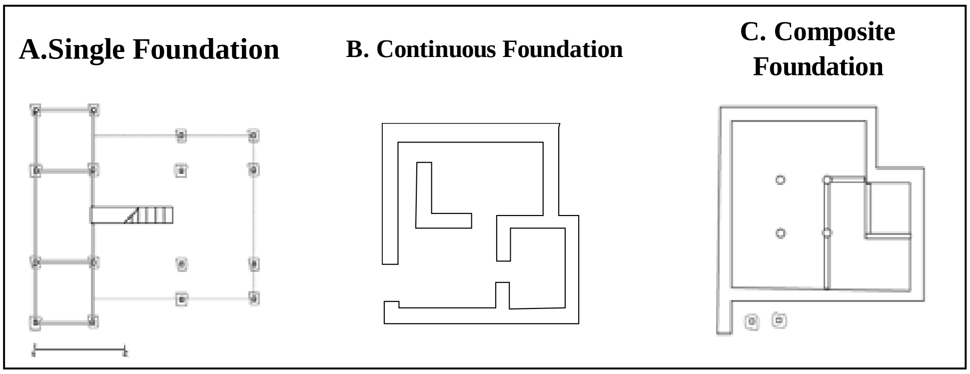


Figure 4-7 Turkish foundation
(modified from Özgener,1970: 60, and Şahin, 1995: 176)

b. The Japanese Foundations

The single foundation was general type of the foundation in the Japanese house. The purpose of this foundation was to elevate the floor to keep the wood parts from the rising damp and to tie building solidly to the ground. The floor was usually elevated about 50 to 80 cm above the ground. The structural columns were provided together with the foundation. Three types of single foundations were observed according to the organization of foundation and columns. Those include: *hottate-basira* (column without stone), *ishiba-date* (column on the foundation stone), and *dodai-date* (column on the sleeper) (Fig.4-8).

· *Hottate-Bashira*

The timber columns were inserted directly into the ground. Since the columns were imbedded to the earth, they were easily to be deteriorated. However, the *hottate-bashira* was widely used among ordinary houses until eighteenth century.

· *Ishiba-Date*

The *hottate-bashira* was gradually replaced with this type of the foundation. The ground was dug in order to arrange the rubble stone called *wariguri-ishi*, which had diameter of 15 to 25 cm. The size and depth of this hole varied according to the size of the foundation stone; however the depth was usually more than 1.2 *shaku* (31.4 cm). The hole filled with *wariguri-ishi* was rammed down until the ground became firm. After the half of the foundation stone was imbedded in the ground, the stone and the ground were again rammed. This type of the foundation was widely applied to the houses in Gokayama.

· *Dodai-Jiki*

Foundation timber was placed continuously on the foundation stone to support the post. This treatment brought the regularity to the length of the timber posts. It is said that the *dodai-jiki* was applied after the 18th centuries especially for the *doma.* Together with the *ishiba-date*, the *dodai-jiki* was applied to the houses in Gokayama.

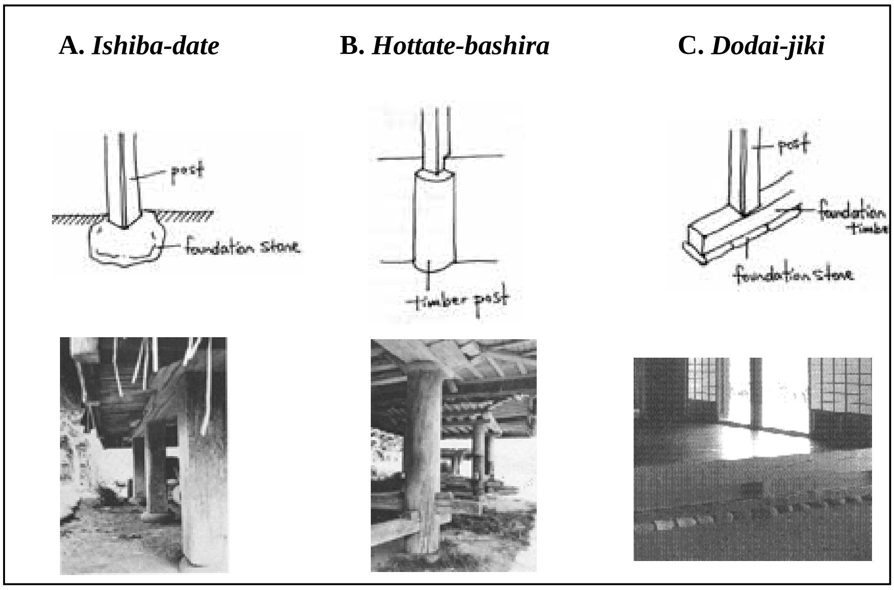


Figure 4-8 Japanese foundations

(Source: Kawashima, 1973: 125, 270)

4.2.2. Timber Framed Structure

Construction system and structural order of the timber framed structure of the Turkish and Japanese house are presented in this section. Timber framed structure was categorized into two parts including floor framing and wall framing. The intervals and span of the components were studied. Consequently the idea which formed the structural organization was clarified.

a. Timber Framed Structure of the Turkish House

Timber frame was applied in three different techniques including the log house, timber skeleton, and the combination of the two (Kuban, 1995: 240). In this thesis, the most common timber skeleton structure is focused as a typical Turkish house.

On the other hand, the Japanese house was built in universal timber framed structure which is separated into two parts; *jyo-ya* and *ge-ya*. In this section, the floor framing and wall framing, which organize the timber-framed structure, are examined especially focusing on the structural order of the *baş oda*.

The components which formed the structure are depicted in Fig.4-9, 10. The details of each component of the four sample houses including the cross-section, span and pitch were showed on the Appendix C. Since it was difficult to find a long and straight timber in Anatolia, the timber components were set up to form the respective floor.

The Turkish house was composed with posts, studs, wall plates, joists, ledger, brace, knee brace, window sill, and lintel. Here the posts were defined as columns which were located on the corner. The columns which divided the space between posts were defined as studs.

On the other hand, the Japanese house consisted of posts including *jyo-ya bashira* and *ge-ya bashira*, beams, girder, *uchinori-nuki*, *sashi-kamoi* and *ashigatame-nuki*.

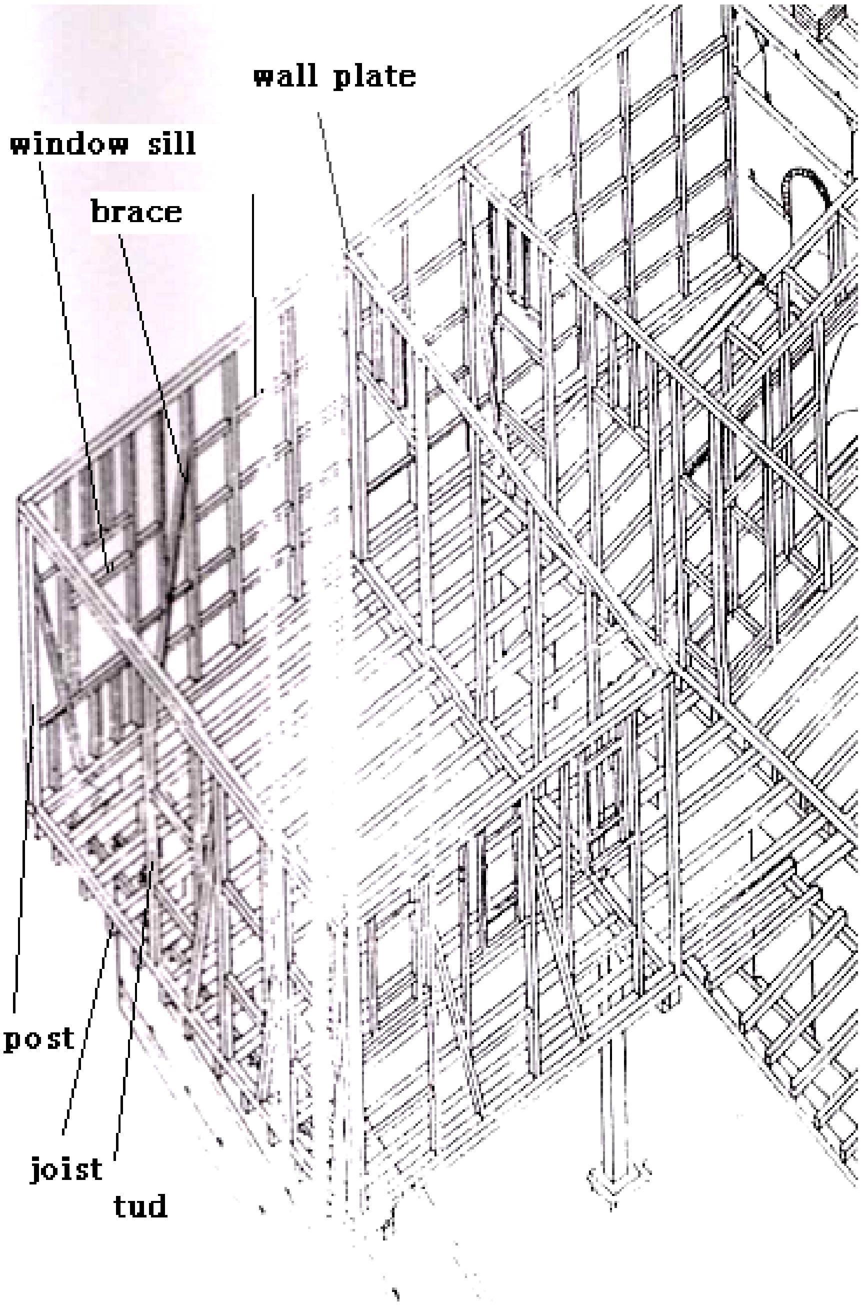


Figure 4-9 Timber Structure and Components of the Turkish House
(Source: Şahin, 1995: 213)

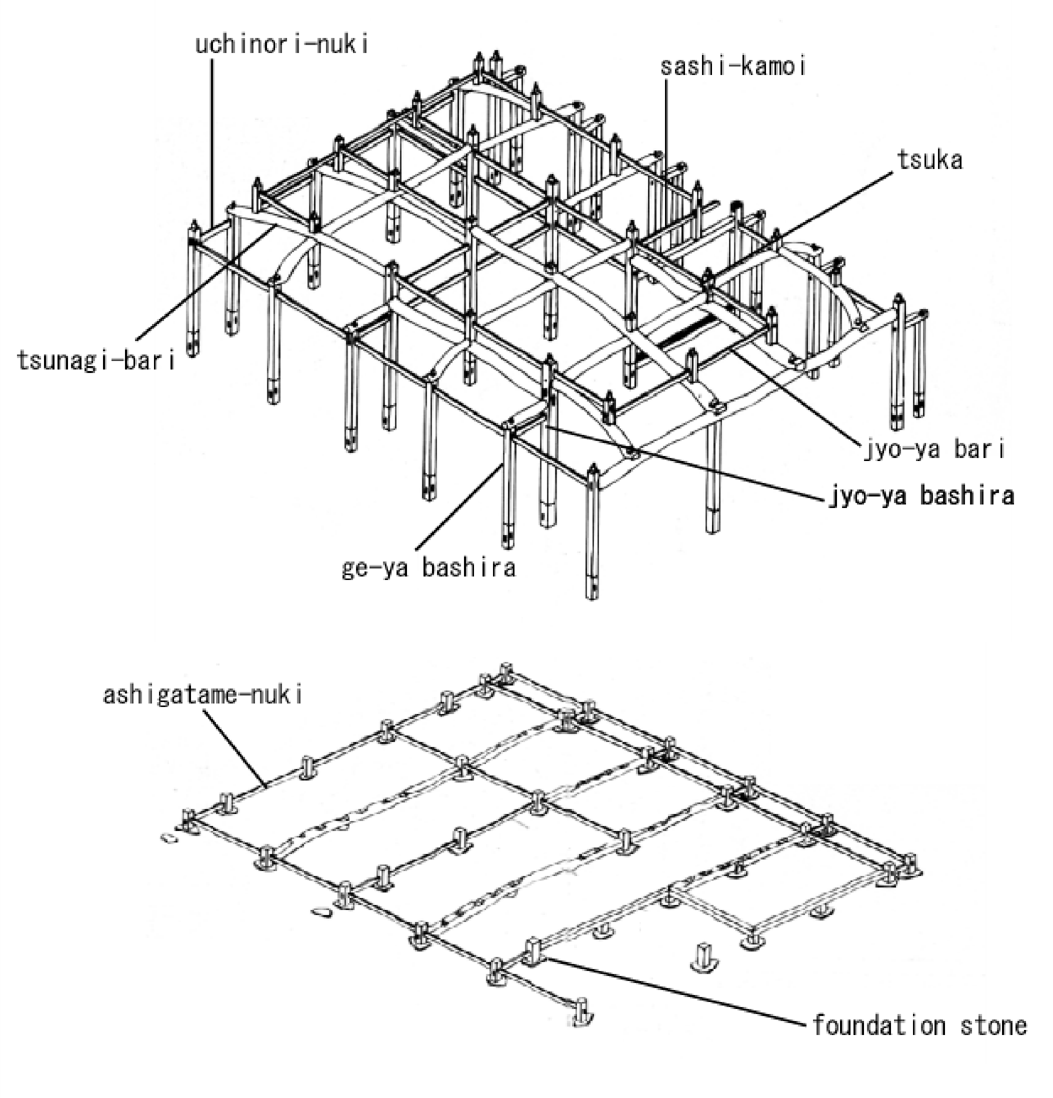


Figure 4-10 Timber structure and components of the Japanese House
(Source: Kawasaki City, 2001: 38)

a -1. Floor Framing

i) Floor Framing System

The floor framing of the Turkish house consisted of the horizontal elements including sill plate, sole plate, top plate, and joists. After the ground floor wall of the Turkish house was erected, the timber frame was constructed. At the end of the masonry base, the wall plates were placed on the inner and outer edges of the masonry walls. Then the floor joists were laid on the wall plate (Fig.4-11). Wall plates were connected to each other at the corner. They were overlapped and simply nailed or a special joint was applied. The edges of the wall plates were half cut off and these surfaces were overlapped and nailed. The wall plates and joist application had been developed in a variety of ways as the followings (Table 4-3)

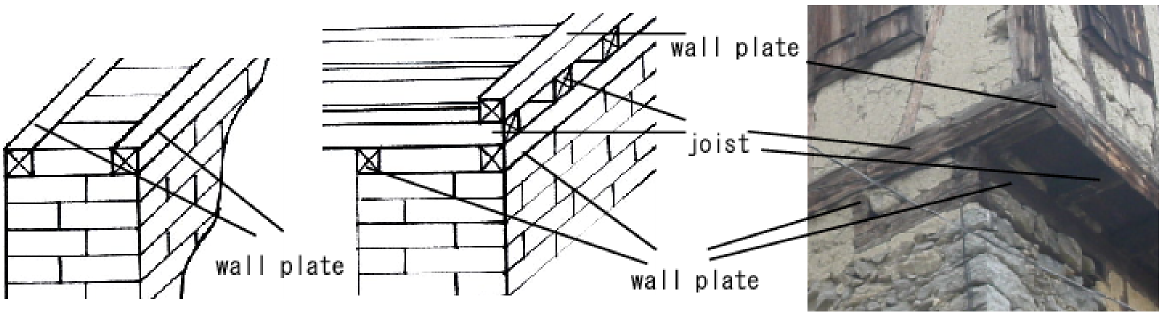


Figure. 4-11 Construction of the floor framing
(Image by author)

· *Tek Yönde Çift Tabanlı* (Double Plates in Single Direction)

On top of the joists, which was constructed on the wall plate, another wall plate was installed. Then posts and studs were erected on the wall plates. This type of the wall plates structure was commonly used in traditional timber skeleton.

· *Iki Yönde Çift Tabanlı* (Double Plates with Double Joist Directions)

In case the corner of the room was projected, double plates with double joist direction type was applied. The floor joists could be built as single floor or double floor. In former type of the floor, joists were placed in two directions on the top plate. Each joist was extended to form the floor of the projection. As seen from Table 4-3, three types of the joist application were commonly used in the single floor.

On the other hand, the second layer of joists was installed perpendicular to the first layer of joists to form the double floor. The first layer of joists was covered with timber and thus occasionally the hollow space between the joist and floor was filled with earth with the purpose of insulation. Finally the second layer of joists was covered with tiles or timber boards. This type of floor was called *bulgurlama* (Fig. 4-13) (Şahin, 1995: 195).

The floor framing system differs from room unit to room unit, thus the combination of the different floor system can be observed in the same floor (Fig.5-5).

ⅱ) The Pitch and Span of The Floor Joists

In general, the floor joists were laid on the shorter direction of the room. The span of the floor joists of three sample houses in Safranbolu were between 410 and 436 cm (sample T1, 2, and 4) while sample T3 was about one meter longer than them. In Turkey, 410 to 420 cm was an economical length of joists (Kaya, 1996: 76). The joists were laid with the intervals of 61.5 cm (sample T4) to 76.5 cm (sample T2). In Safranbolu, the joists were settled on wall plates with intervals of 45 to 75 cm (Kaya, 1996,76). The cross sections of floor joist were about 10×15 cm. The area of the *baş oda* ranges from 370cm×520cm (T4) to 400cm×520cm (T2). In order to build the *baş oda,* 5 or 6 joists were used.

Table 4-3 Wall plates and floor joists application
(Source: Köysüren, 2002: 52)

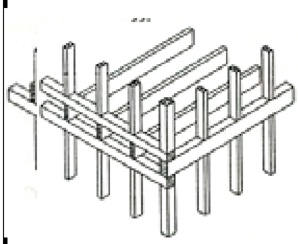
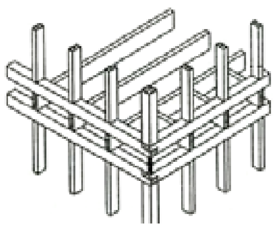
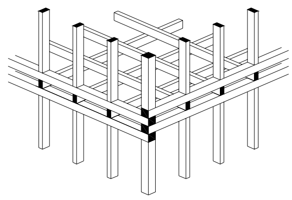
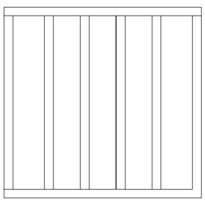
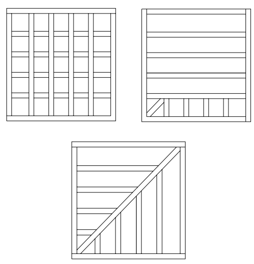
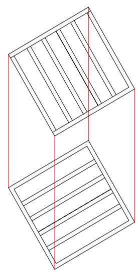
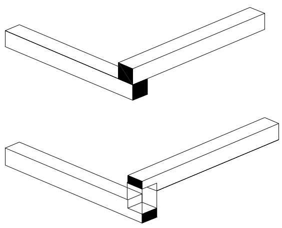
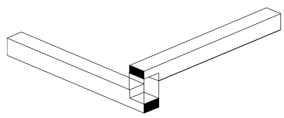
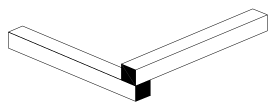
	Double Plate with Single Direction *(Tek Yönde Çift Tabanlı)*	Double Plate with Double Direction *(Iki Yönde Çift Tabanlı)*	
		Single Floor	Double Floor
Axometric			
Floor Joists			
Corner Joints			

Figure 4-12 Application of the different floor system
(Image by author)

ⅲ) The Floorings and Ceilings

" For the flooring of the service spaces like stable and storage on the ground floor, usually earth or stone were chosen. In the living spaces such as kitchen and rooms, the floor was covered with timber boards. In order to construct the timber-boarded floor on the ground floor, two ways were commonly used in the Turkish house." (Şahin, 1995: 190, 191) (Fig. 4-13)

Being slightly raised from the ground, the timber beam was set on the ground floor in order to support the floor joists. The width of the ground floor was narrower so that they could install these two components. Finally timber boards covered the floor joists by means of nailing. In another type, both beams and joists were embedded to the ground floor walls. Both systems were constructed together with the ground floor. Although it was difficult to change the flooring, this later type of floor construction was quite popular. As a third alternative, the beams which carried the floor joists were supported by the short vertical member at the side of the ground floor wall.

The upper floor was usually covered with timber or tiles. Sometimes timber boards were nailed on both sides of the floor joists however, usually ground floor ceiling was left without any covering so the upper floor structures were exposed. As mentioned before construction of the floor which had double plates with double joist directions, the void between the floor joists were filled with pressed earth, sand or mortar, which worked as a heat insulator. This is called *bulgurlama* (Fig. 4-14). The sitting place in the room (*sedir*) and platform in *sofa* was built together with the floor (Fig. 4-15). It was generally constructed in direct relation to the structure of the building and in the conjunction with the supporting floor (Küçükerman, 1978: 148,149). At the end it was covered with soft material.

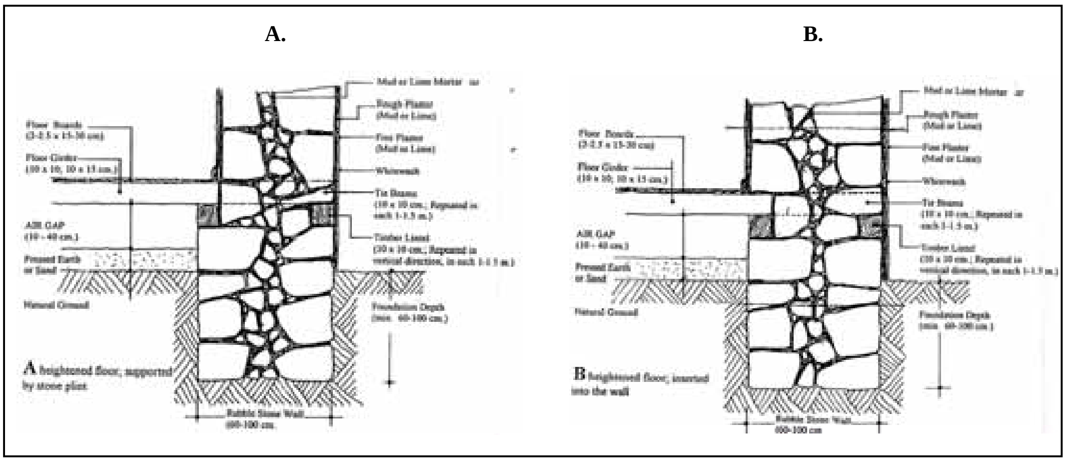


Figure 4-13 Two types of timber boarded ground floor of the Turkish house (Source: Şahin, 1996: 191)

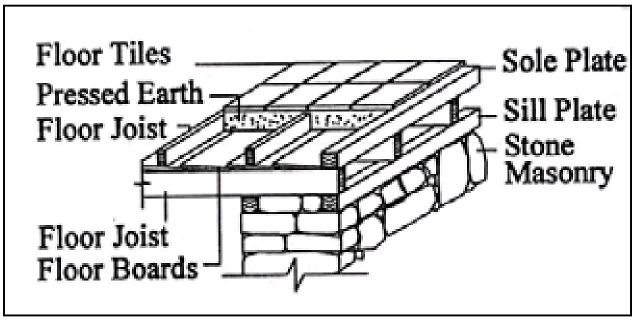


Figure 4-14 *Bulgurlama*
(Source: Şahin, 1995: 194)

Figure. 4-15 *Sedir*
(Image by author)

The ceiling of the important rooms such as *sofa* and *baş oda* was elaborately decorated with timber laths, borders, stucco, central buss (*göbek*) and painted decoration (Fig. 4-15). On the other hand, the simple timber boarded ceiling was applied to the other rooms and the ceilings of the service space on the ground floor were usually uncovered. The ceiling system can be classified in three types. The most common one was the flat ceiling. The raised ceiling in the form of a vault was preferred after eighteenth century being influenced by the Western Baroque design. The domical form, which required more complicated construction, was preferably used in the rich mansions in Istanbul.

Figure 4-16 *Göbek*
(Image by author)

a-2. The Construction of The Projection

The projection was one of the peculiar characteristics of the Turkish house. The structural elements of the projection were constructed together with the upper floor as the extension of the joists. Thus the construction of the projection differed according to the type of floor framing, that is to say, the direction of the joists. Three structural types of projections were observed in the traditional Turkish house. Those include *bindirmeli çıkma* (the projection with overlapping components), *payandalı çıkma* (the projection with bracing), and *konsol çıkma* (cantilever projection) (Fig.4-17) (Kaya, 1996: 84-86).

· *Bindirmeli Çıkma* (the Projection with Overlapping Components)

In this type, several joists were overlapped to form the layers which supported the projection. The projected span was about 70 to 80 cm (Kaya, 1996: 85) Since it required more timbers compared to the other two projection types, it was not frequently used in Safranbolu houses.

· *Payandalı Çıkma* (the Projection with Bracing)

The projected joists were supported by several bracings so that it could be widely projected toward the street. The bracings were connected to the timber lintel, which was embedded in the masonry walls, by means of simple joint and nail. Sample T7 had this type of projection, and the room was projected 140cm toward the street. Compared to the cantilever projection, which is described next, the projected length was quite longer in the projection with bracing.

· *Konsol Çıkma* (the Cantilever Projection)

The joists were extended to form the floor of the projection in the cantilever projection. This type was the most frequently found in Safranbolu, samples T1, 2, and 4 applied this with its projected length being 50 to 60 cm. According to Kaya (1996: 89), the projected length of the cantilever projection ranged from 40 to 70 cm.

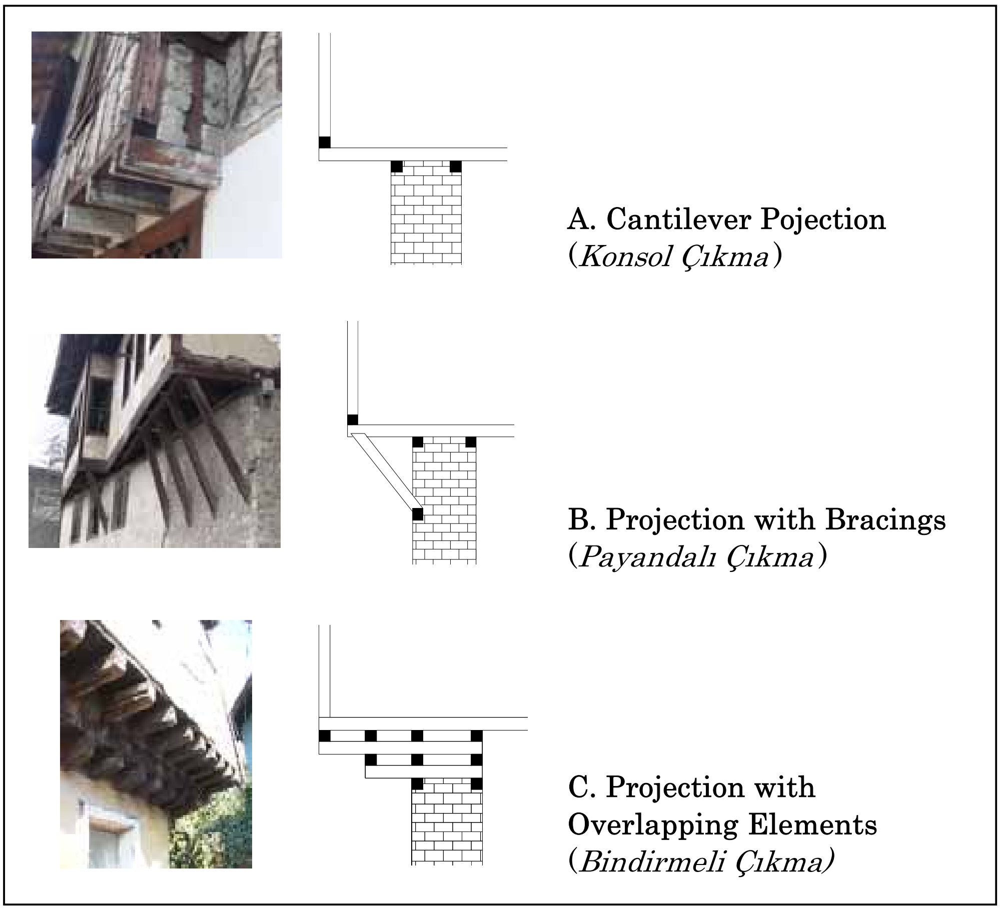


Figure 4-17 Three types of the projection
(Image by author)

Since the projection was built as extension of the floor joists, the projections was orientated according to the direction of the joists. In case the projection was constructed on one side of the room, two ways to install the floor joists were employed. The first way was to construct the projection as an extension of the floor joists (Fig. 4-18A). The second method was to set the projected joists perpendicular to the floor joists (Fig. 4-18B). However, if the floor was constructed with double plates with double joist directions, it was possible to construct the projection in both parallel and perpendicular to the floor joists.

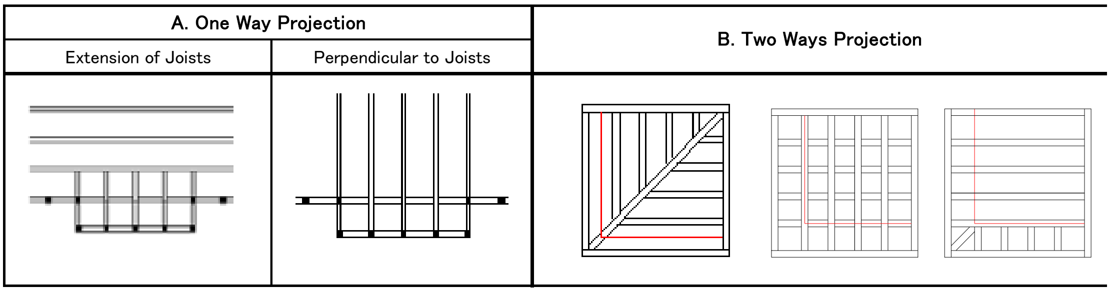


Figure. 4-18 Floor joists arrangement of the projection.
(Source: Kaya, 1996: 86, 87)

a-3. The Wall Framing of the Turkish House

i) The Wall Framing System

Wall frame was consisted of vertical members including corner posts, studs, window posts, brace, knee-brace and horizontal members; sill plate, top and sole plates, tie beams, and windowsills. First the main posts were set on the top plate. The cross section of the wall plate was about 10×10 (Şahin, 1995:185). The studs and window studs divided the space between the main posts with constant intervals. The cross section of the studs was about 5×10 cm smaller than that of the main posts. The intervals and number of stud were determined according to the number of windows and infill material. Braces were placed between studs where there was no window to support the timber frame structure. Cross sections varied from 5 to 7cm ×10 to 15 cm.

Secondary structural elements including tie beam, windowsill, and knee braces were inserted between the studs in order to support the timber frame and to keep the infill material in place. They were not installed with regular distances like studs. "The knee brace was connected to the top plate, however, it did not reach to the sole plate. Instead they were connected to half, 2/3, or 1/3 of the floor height." (Şahin, 1995: 188) They support the studs, doorposts, and windowsills.

After constructing the first floor walls, again the floor and wall of the second floor were installed in same way.

One of the most prevailing features of the timber-framed construction in Anatolia is the lack of complicated processed joints. Even in the regions where the timber framed construction were frequently used such as north west and central Anatolia including Safranbolu, the structural timber elements except few samples were connected by means of overlapping each other or by nailing.

ii) The Post Placement

The order of the posts differed by the wall type: the walls with windows, the walls without a window, and the partition walls. Consequently the placement of the timber post in each wall is evaluated in this section.

· The Walls with Windows

This type of walls was observed in the front façade of the house. Usually the *baş oda* occupied the place with a view on the top floor. The wall which faced to the street and the another exterior wall which connected perpendicular to the front façade contained windows in order to provide light and view to the *baş oda.* The number of windows installed to one wall was three in the sample houses. In general, the *baş oda* had rectangular plan separated into two part: the living area and the service space. The living area formed into a square plan, consequently the exterior walls had the same length with the same posts arrangement which is depicted in Fig 4-19. Each value is explained in the Appendix E. The studs were installed in both sides of the windows while the main posts were located at the corners of the space. Both the size of the window and the intervals between the windows (a) were equal. Furthermore, the studs placed closest to the corner posts were usually cut diagonally by the brace (Fig.4-20, 21). For this reason in this type of wall, three types of pitch of the posts and studs were observed, that is to say, the interval between the windows (value a), the width of the window (value b), and the span from the corner post to the next stud (value a+b). Sample houses applied different post intervals: the value (a) ranged from 32.5~44cm, value (b) ranged from 75~80cm, value (a+b) ranged from 112.5~120cm, and value (c), which corresponds to the length of the wall, was from 370~410 cm (Appendix E). Standards for the post arrangement were found in the houses in Safranbolu.

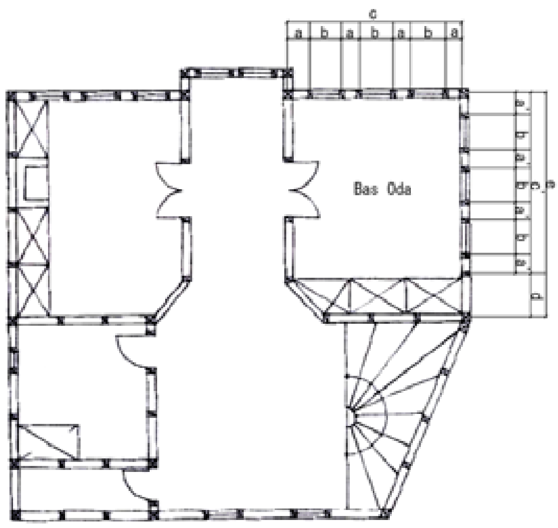


Figure 4-19 The Post arrangement of the *baş cda.*

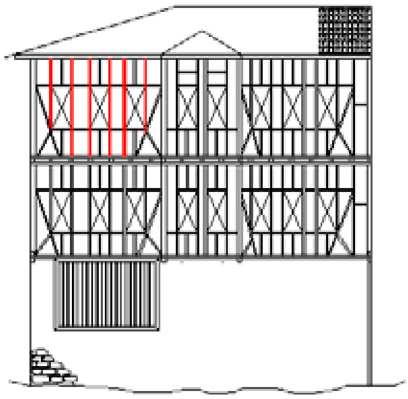



Figure 4-20, 21 The façade of the *baş oda* (sample T1)
(Image by author)

· **The Wall without a Window and The Partition Wall**

The posts were set up every 100 to 140 cm in the exterior wall. As for the partition wall, the intervals of the posts and studs depended on the infill material: stone, adobe or timber. In general, adobe was popular in construction of the partition wall though in Safranbolu stone was the most common material. The intervals of the partition walls was not discovered for they were completely plastered.

· **The Stud Arrangement**

In traditional constructions of the Turkish houses the space of wall framing was filled with various materials which was obtained at the region. Especially brick, adobe, stone and timber were the preferred material for the wall infill (Table 4-4).

· **Stone Infilled Wall**

In this system, the number of studs was increased compared to other type of walls in order to hold the rubble stones. The interval of the vertical components were about 20 to 25 cm (Kaya, Uysal and Sümerkan, 2001: 62) Secondary bracings were frequently used. Stones were usually settled with lime mortar. Mostly stone infilled wall was left bared without any wall cladding.

In the East Black Sea Region, the peculiar stone infill system called *göz doluma* was employed. In this system the horizontal and vertical timber elements formed a grid pattern and flat rectangle stones were embedded to the square space of the timber lattice.

- **Adobe Infilled Wall**

Adobe was common in almost every region of Turkey. The intervals between the posts were 70 to 75 cm and cross-sections of the studs increased when the stud interval increased. In order to produce adobe, straw is added to the mud and thoroughly kneaded by food. In Safranbolu the size of adobe was determined as 27×22×10, 27×13×10, and 27×13×10 (Kaya, 1996: 64).

- **Timber Filled Wall**

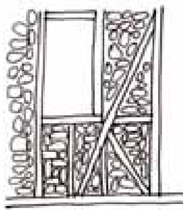
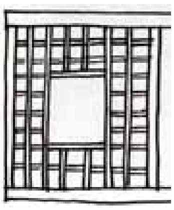
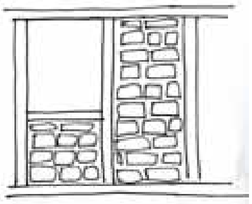
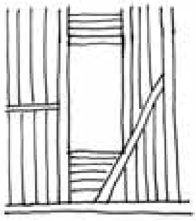
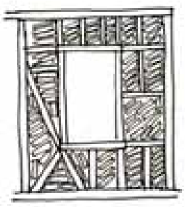
Timber pieces connected to each other vertically and horizontally filled space between the studs. These elements were designed to be demounted and light enough to carry. Since it consumed many timbers, this type of wall was not economical. In the Black Sea region, timber filled wall was frequently found because the region was rich in timber resources. In Safranbolu, a few summerhouses used timber as infill material with different studs intervals.

- **Brick Infilled Wall**

Brick was employed between studs and posts; in this type of wall horizontal tie beams were not common. The span between the studs varied from 60 to 80 cm to 20 to 25 cm according to the timber frame construction (Köysüren, 2002: 128). The bricks were arranged with different pattern. Among them the herringbone pattern was the frequently used.

In Safranbolu houses, adobe, stone, timber, and mixed use of adobe and stone were found as wall infill material. Among them stone and adobe were the most popular.

Table 4-4. Wall Infill of the Turkish house (Image by author)

Infill Material	Photo	Sketch	Pitch of the Posts
A1. Stone (Safranbolu)			40～45
A2. Göz Dolma (Trabzon)			20～45
B. Adobe (Safranbolu)			70～75
C. Timber (Safranbolu)			30～75
D. Brick (Bursa)			60～80

iii) **Method of The Measurement and The Scale of The Space**

According to the researcher following two points became clear about the scale of the Turkish house. First, the scale of the space was determined according to the human body in the Turkish house (Günay, 1998: 228). Secondly, the ratio of length and breadth of the window was usually 2 to 1 (Yamamoto, 1991: 68). This was confirmed by examining the windows of the sample houses (Table 4-5). The scale of the Turkish house expressed in Fig.4-22 is examined in this section.

Table 4-5 The Ratio of Length and Breadth of the Window

	h/b
T1	2
T2	2.2
T3	1.9
T4	2

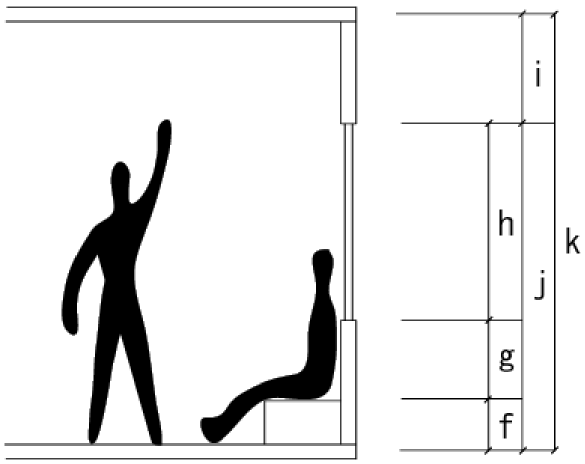


Figure 4-22 The sectional scale of the Turkish room

According to Şahin (1995: 168), the height of the *sedir* (chair): value f was fixed between 25 to 40 cm. Value k corresponded to the maximum height which a grown up could reach (Küçükerman, 1996: 75). Among the samples,value k ranged from 295 to 310 cm. The length between the *sedir* and the windowsill (value g) was also determined by the human body proportions. It would be set so that the person who sits on the *sedir* could spread his arms. The value f+g of the samples were between 60 and 70 cm.

The window height, value h, was oscillated from 145 to 170cm. When compared to the value f+g, it ranged in wider scope. Therefore, it can be said that in order to decide the sectional scale of the Turkish room, value j, f and g were determined beforehand, then value h (window height) was regulated to adapt to them. The ceiling height of the samples, value k, fluctuated between 295 to 310 cm. This height was determined according to the available timber components. Thus the distance between the windowsill and the ceiling (value i) was adjusted to value k and j.

The window height, value h, was 145 to 170 cm. Since the ratio of length and breadth of the window was 2 to 1, the width of the window, value b must be 72.5 to 85 cm. Value b of the samples ranged from 75 to 80 cm. A minimum space between the windows (value a) was 32.5 cm (sample T4), thus the minimum length of the wall of the *baş oda*, value c, must be 340 cm. The minimum area required for the living area of *baş oda* was 340×340 cm. The minimum value of the sample was 370×370 cm (T4) which fits this extent. Value d, the length of the service space, ranged from 50 to 130 cm. Therefore the minimum space for the *baş oda* was 340×390 cm.

ⅳ) The Wall Claddings and The Furniture

After the timber framing and roof structure were set up, and the wall infill materials were filled, the wall was covered with wall cladding materials. Generally, wooden lath and timber boards were used as a wall cladding system in the Turkish house (Fig.4-23).

· Wooden Lath (*Bağdadi*)

Wooden lath was widely used in the Turkish house. Timber lath was nailed on both exterior and interior sides of the posts and studs providing a base for plastering. The cross section of the timber laths was approximately 2××2 cm and 2×3 cm was nailed onto timber posts at close intervals of 3 to 5 cm (Köysüren, 2001: 79). Mostly mud plaster was applied onto the timber laths.

· Timber Cladding (*Hartama* or *Bedavra*)

Especially in Marmara region including Istanbul, timber cladding was preferred. The timber skeleton did not contain the infill materials and was covered with timber boards either horizontally or vertically. Nailing was the easiest way of connecting cladding materials.

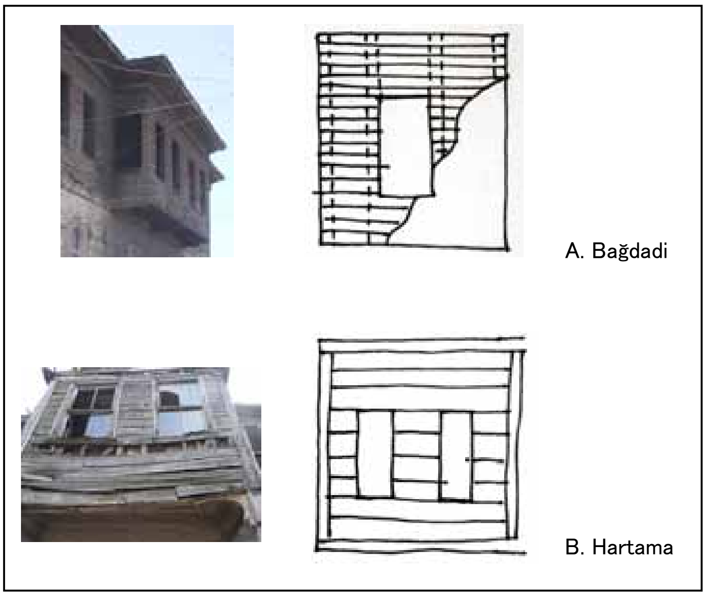


Figure 4-23 Wall cladding of the Turkish house
(Image by author)

b. The Timber Framed Structure of the Japanese House

After the foundation stone was laid, timber skeleton was constructed. The components used for the timber structure were depicted in Fig.4-11. The details of each component are showed on the appendix D. The diagonal bracings were not found in the Japanese timber skeleton.

b-1. Floor Framing

ⅰ) Floor Framing System

Floor framing of the Japanese house consisted of the vertical elements, *jyo-ya bashira* (the column for the *jyo-ya*), *geya-bashira* (the column for the *ge-ya*), and horizontal members including battens (*ashiko-nuki*), sleeper, floor joists and sill (Fig. 4-11).

After the foundation stones were placed, the posts were set up. The positioning of the foundation and the posts were dictated by the roof structure; they were installed in order to support the weight of the roof. The posts were installed with intervals of 1 *ken*, which corresponded to 1.82 m for sample J1, 2, and 3 and 1.99 m for sample J4. The order of the columns was a priority matter of the planning in the Japanese house.

The foot of the timber posts was connected firmly below the floor level with the horizontal elements called *ashiko-nuki.* These horizontal components provided firmness to the structure however they did not contribute to the earthquake resistance so much. The sleeper was installed with the same direction of the beams; the shorter side of the plan in order to support the joists. Finally, the joists were placed perpendicular to the sleeper.

ⅱ) The Pitch and The Span of The Joists

The floor joists were placed between posts to posts to divide the space into 4. Since the posts were placed with the intervals of 1 *ken*, the joists were placed every 0.25 *ken*, which corresponded to 455 cm (sample J1 to 3). The ground floor joists were installed according to the longer side of the plan (Fig.4-24). The span of the joists ranged from 8.29 m (J1) to 20.43 m (J4), which was connected on the sleeper every 1 or 2 *ken*s. The commonly used joint methods of the joists were *tsuki-tuke, sogi*, and *aikaki* (Fig. 4-25).

The sleeper was located perpendicular to the joists to support them. The length of the sleeper matched with the width of the house; 3.5 *ken*s (6.37 m) for sample J1 and 2, 4.5 *ken*s (8.19 m) for sample J3 and 5 *ken*s (10.64 m) for sample J4. The sleeper was also jointed every 1 or 2 ken*s* by means of *ari* or *kama* (Fig.4-25). The upper floor joists were installed in the shorter direction of the house (Fig. 4-24). The joists were set as they divided the space between the beams into 3: the pitch of the joists was about 606 cm.

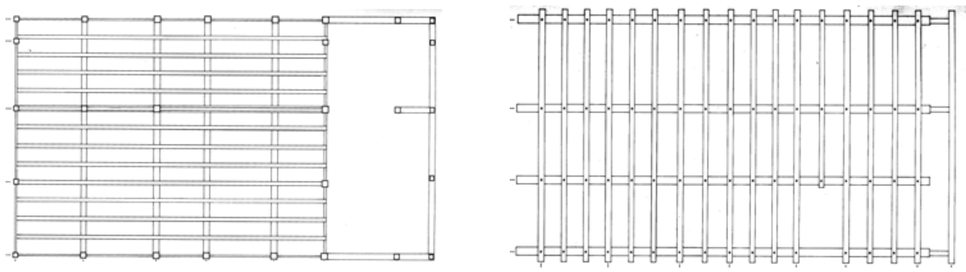


Figure 4-24 The floor joists of the ground floor (right) and the upper floor (left) (Source: Toyama Prefecture, 1979: 22)

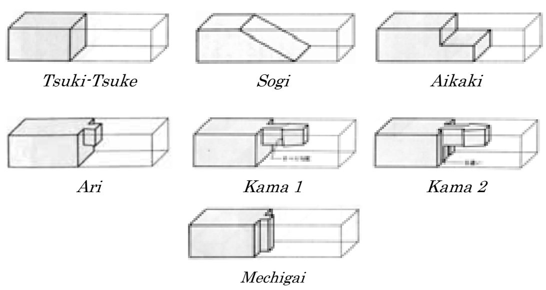


Figure 4-25 Typical extension joints for joists, sleepers, girders and beams (Source: Hamashima, 1984: 36)

iii) The Floorings and The Ceiling

The flooring of the Japanese house was simpler and not so elaborated in its construction when compared to the Turkish floors. Different systems were used for the flooring of the living place and working place, *doma*. The bare earth ground was compressed to form the flat floor surface for the *doma,* and other than this, no specific precaution was taken. For the living space floor, three types of flooring system including *sunoko-yuka* (bamboo flooring), *doza* (earth floor covered with straw mat), and timber boarded floor were commonly used (Fig. 4-26).

a) *Sunoko-Yuka* (Bamboo Flooring)

The rough bamboo lattice (*sunoko*) simply consisted of the frame called *mawatashi-dake,* and strips called *komai-take* which was fastened perpendicular to the frame. They were installed on the timber floor structure. Each *mawashi-take* was arranged between the floor joists, which were supported by horizontal elements penetrating the columns (*nuki*). The bamboo lattice was covered with straw mats. This rough construction was built to protect from the raising damp from the ground. The *sunoko-yuka* was also applied to the upper floorings of the houses in Gokayama.

b) *Doza* (Earth Floor Covered with Straw Mat)

The thatches were spread to form the living space floor. The floor level was slightly higher than the earth floor. The gap between the *doma* and the living space was slight and just a timber strip divide the *doma* and living space floor. Therefore it can be said that the living floor was continuously built from the *doma*. The straw mats covered the thatches. This type of floor was widely used all over the country in the old times and even in later periods it was continuously used especially in the northern part of Japan.

c) Timber Boarded Floor

Floor joists which laid on sleepers were covered with timber boards. This was the most popular flooring in Gokayama. The living space of sample J1 to J3 was covered with the timber boards.

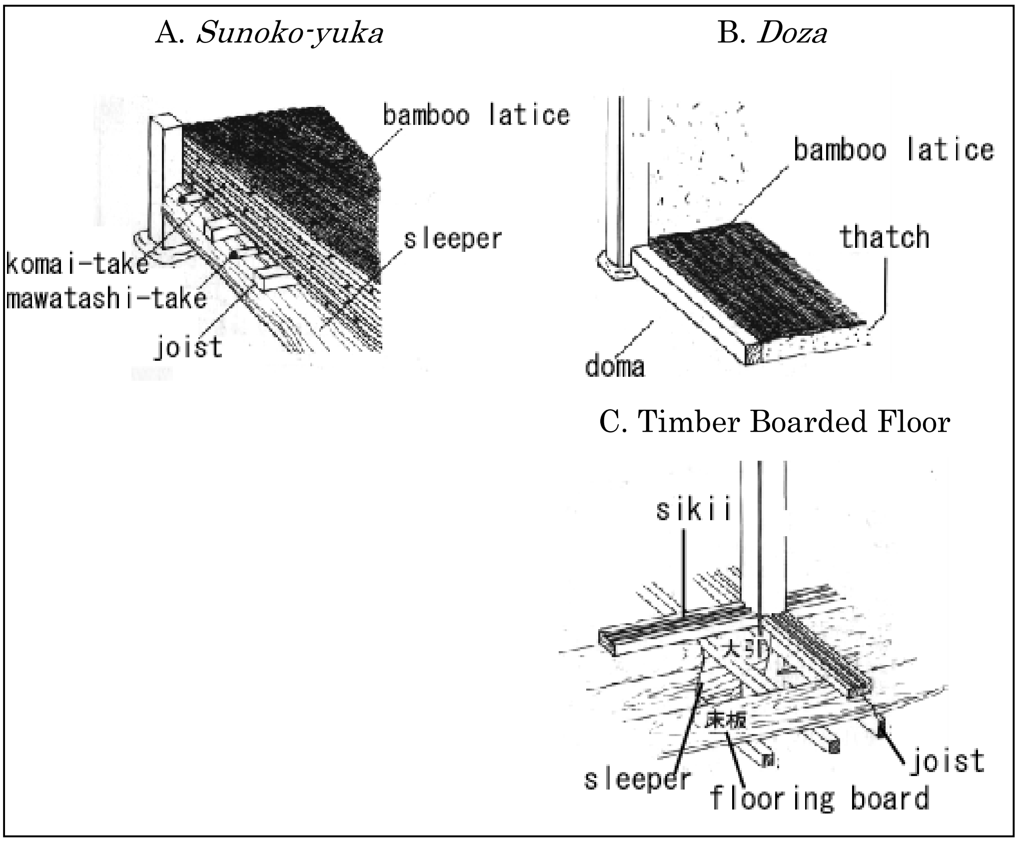


Figure 4-26 Japanese flooring
(Source: Kawasaki City, 2001: 30)

Other than the above-mentioned floorings, the *tatami* (straw mattress) was also common. In this case timber board was used in the service spaces including kitchen, hall, circulation space, and utilities. The size of the *tatami* was 1×0.5 *ken*, which corresponded to 1.82×0.91m. Originally this number was derived from the size of human body corresponding to the necessary area to accommodate one man sleeping. The *tatami* was subjected to the structural system of the room enclosure. Being closely related to structure, *tatami* distinctly reflects the structural order. The mats were renewed from time to time. Though tatami was not popular for the ordinary people, it was used among a few rich families. As for the houses in Gokayama, *tatami* was observed at sample J4, which was originally the house of an influential family in the village.

In general, the Japanese house did not have ceilings; the roof structure was left uncovered. Anyhow the following three types of ceilings were commonly used in the living space as follows (Fig. 4-27).

· *Neda-Tenjyo* (Joist Ceiling)
Timber boards were supported perpendicularly by the ceiling joists. In this type of ceiling the joist arrangement was exposed to the interior but the other roof structure was concealed.

· *Sunoko-Tenjyo* (Bamboo Lattice Ceiling)
In this type of ceiling, bamboo or timber strips were just simply located on the beams. This type of ceiling was widely used in the houses in Gokayama.

· *Saoen-Tenjyo* (The Hanged Ceiling)
Horizontal timber battens (*tenjyomawari-en*) were placed on the inner edges of the wall. Smaller battens called *saoen* with regular intervals divided the space between the battens. Sao-en was fastened to the vertical timber elements jointed to the roof beams. The structure of the ceiling was hanged from the roof. The timber boards were arranged perpendicular to the *saoen*s. Since the *saoen-tenjyo* required materials, techniques, and time, it was found only in the house of the rich. Sample J4 applied this ceiling to the *zashiki*.

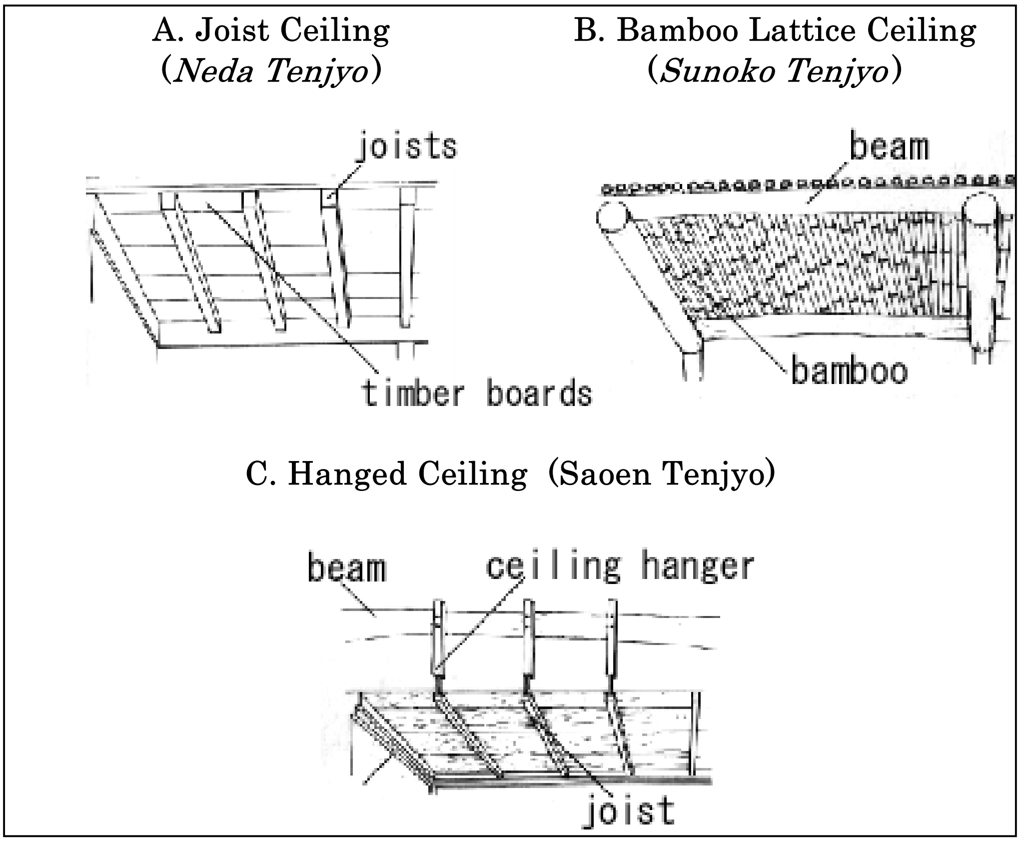


Fig. 4-27 Typical ceilings of the Japanese house

(Source: Kawasaki City, 2002: 29)

b-2. Wall Framing

i) The Wall Framing System

The structural elements which formed the wall framing were the posts and the horizontal elements including *nuki*s (*kabe-nuki, uchinori nuki*), girders, beams, and *sashi-kamoi* (Fig.4-11). The *kamoi* and *shikii* were non structural elements which hold the partition panels.

The space of the Japanese house was separated into two by structure system called *jyo-ya* and *ge-ya* (Fig.2-8). The limited span of the beam resulted in the limited depth of the space. Therefore, the short columns called *geya-bashira* was connected to the columns (*jyoya-bashra*) with beam on both or either direction in order to expand the space. This appended space was called *ge-ya* while the main space was called *jyo-ya*. Generally the columns of the *jyo-ya* (*jyo-ya bashira*) were taller than those of the *ge-ya*.

Because there was no diagonal element in the timber structure of the Japanese house, various horizontal elements were frequently used. The upper part of the posts was fastened by the several kinds of *nuki* as follows. The beams called *uchinori nuki* penetrate the *ge-ya bashira*, which enclosed the outset part of the frame. *Hi-nuki* jointed to the short columns called *tsuka* which hold the roof structure. The *kabe-nuki* was inserted in between the columns at the middle height of the post to sustain the wall. The jyoya-bashira was connected with *jyoya-bari*. The *sashi-gamoi* and the *tsunagi-bari* connected the *jyoya-bashira* and *geya-bashira*. Each component was connected to each other with complicated and elaborate mortise and tenon joints without nail or metal fittings (Fig.4-28). The function of these horizontal elements was to keep the columns straight and to keep the durability of the solid wall.

The beams and girders were used to connect the columns firmly to provide strength to the timber frame. Since the Japanese house did not contain so many walls, they provided an effective way to protect the frame from twist and distortion. The beams and girders connected the posts so it was installed every 1 to 1.5 *ken*s. The beams were set on the shorter side of the house while the girder was installed perpendicular to the beam. The length of the beam ranged from 3 to 5 ken*s,* which was connected by means of *mechigai*, *ari*, and *kama* (Fig. 4-25). The span of the girders ranged from 6 (J1, 2, and 3) to 10 kens (J4). The connection types of the girders were same to those of the beams.

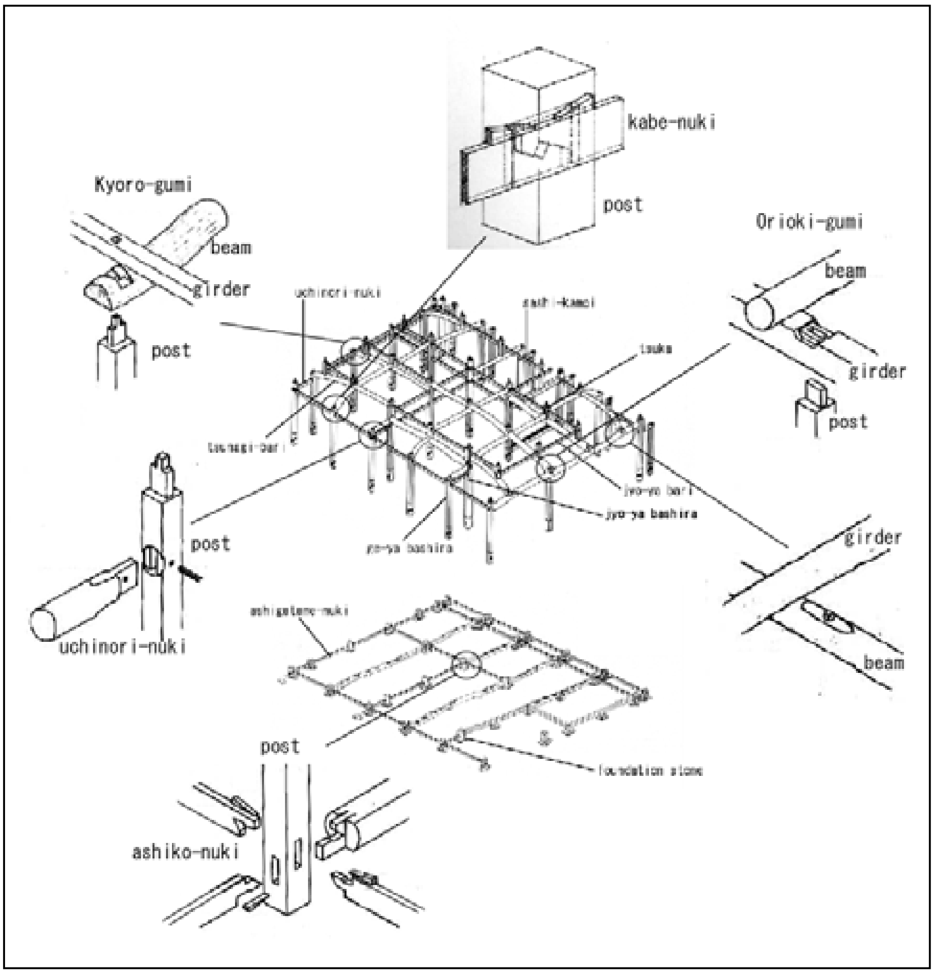


Figure 4-28 Joint of the Japanese timber framing
(Source: Kawasaki City, 2001: 38)

Two ways to set the beam were commonly applied, that is to say, *kyoro-gumi* and *orioki-gumi* (Fig.4-29). The beam was put on the girder in the *kyoro-gumi* while the beam penetrated the head of the columns in *orioki-gumi*. In case the size of the girder was large, it was possible to omit the middle columns in the *kyoro-gumi.* Since the length of the girder was fixed at the *kyo-ro gumi*, the length of the space was also fixed. On the other hand, because the timber frame of post and beam was connected by girder in the orioki-gumi, the space was easily enlarged in the direction of the girder. The *kyoro-gumi* was a newer construction than the *orioki-gumi*. In Gokayama, we frequently encountered to the *kyo-ro gumi*.

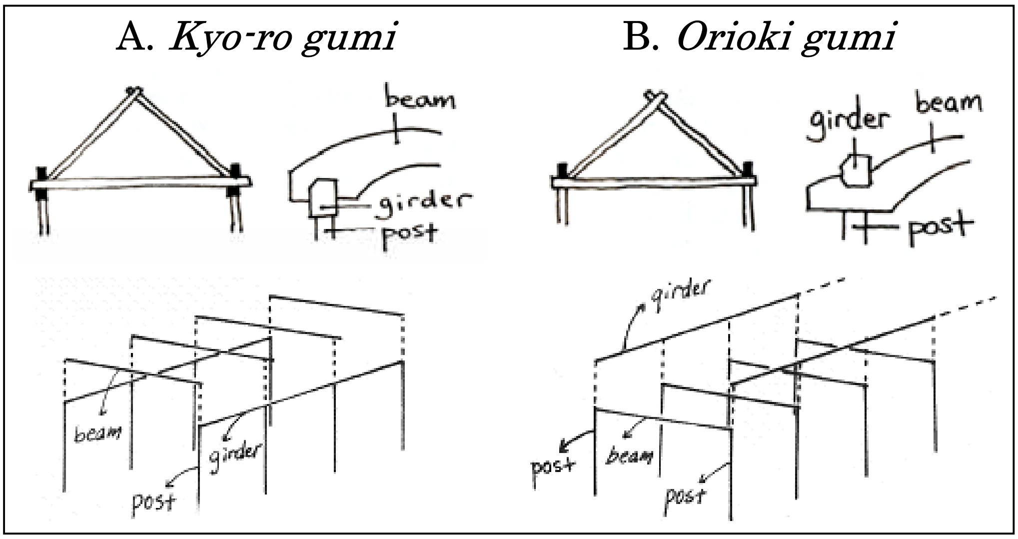


Figure 4-29 Beam construction of the Japanese house

ⅱ) The Post Placement

The design of the Japanese house was determined by a module called *ken*, which was based on the human body. One *ken* derived from the space which was enough for one person to lay. In the design and construction of buildings, the carpenter in each region played a decisive part. Thus the measurement of ken was standardized in each village, though differed from region to region. For the houses in Gokayama one *ken* equaled to 1.82 m (sample J1 to3) or 1.99 m (sample J4). The posts were set according to this module. In general, the width of the *jyo-ya* part was determined either 3, 3.5, or 4.5*ken*s in Gokayama. The posts were placed every 1 or 1.5 kens, that is to say, 1.82 or 2.73 m.

The idea of the Japanese structure was to construct a heavy roof which was believed provided the stability of the timber skeleton by compression. Consequently the main function of the posts became to support the roof structure (Kawasaki City, 2001: 25). After the posts were installed the space was divided by partition panels to form the room. Since the post arrangement was determined by the roof structure, sometimes the post were set in the middle of the room. In later periods, thick beams were installed to support the roof. This enabled wide spaces by excluding the posts. In Gokayama house, the bow shaped beam called *cyona-bari* was used. The undulation of the beam was fully utilized to the construction of *ge-ya*: *jyo-ya* and *ge-ya* were built as a whole structural unit under the same roof (Fig.4-30).

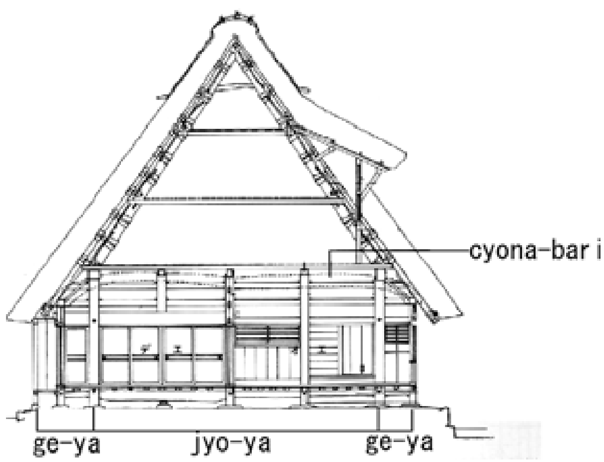


Figure 4-30 The *cyona-bari* (Source: Toyama Prefecture, 1979, 12)

ⅲ) The Method of Measurement and The Scale of The Space

Two methods of the post placement were mainly taken in Japanese house design: *edo-ma* and *kyo-ma*. The basic units of the traditional measure system, *ken*, indicated the interval between posts. In *kyo-ma* method the ken was measured from face to face of two posts. Contrary in *edo-ma* method related to center-to-center distance between columns. As a result the plan which was designed according to *kyo-ma* method became larger than that of *edo-ma* method (Fig.4-31). *Kyo-ma* method was preferred in west Japan while *edo-ma* spread at east Japan. In Gokayama, the houses were built according to the *edo-ma* system.

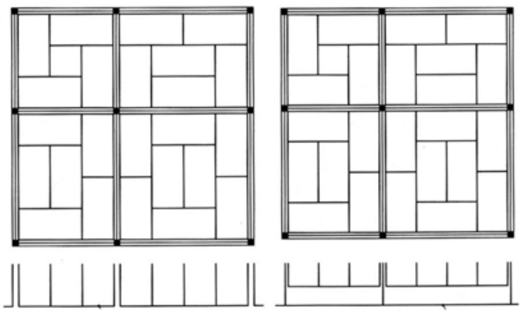


Figure 4-31 *Kyo-ma* (left) and *edo-ma* (right)
(Source: Committee of the Architecture Dictionary, 2001: 55)

The traditional drawing called *bantsuke-hyo* was commonly used among the carpenters to determine the placement of the posts. The *bantsuke-hyo* was a table of 0.5 *ken* square grid (Fig.4-32). First the posts were placed on the grid every 1 or 1.5 kens. Other than the posts, beams and girder, foundation elements, *nuki* (horizontal elements which connected the posts), roof components were placed on this grid respectively coordinating the structural order of the timber framing. Then finally the planned space was divided by partition panels to form the rooms. Therefore the location, span, pitch, and the number of components required were determined beforehand. The basic rules of the arrangement of the structural elements were as follows.

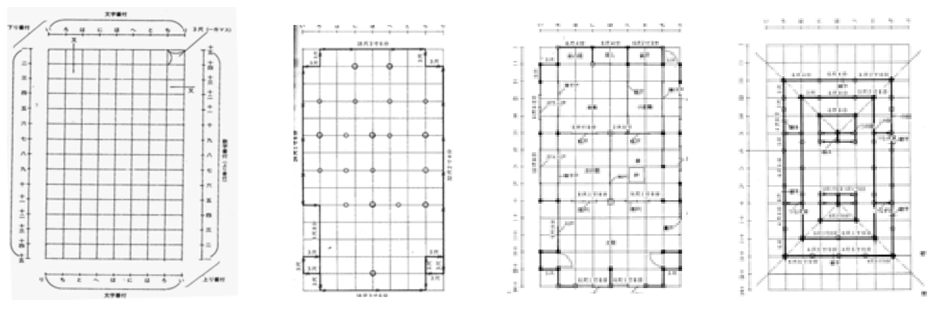


Figure 4-32 *Bantsuke-hyo* and arrangement of the structural components (Source: Fukaya, 2001: Mokuzou Kenchiku Dentou Gihou Jiten: 568-571)

Since the beams and girders were placed on the posts, the interval of the posts influenced to that of the beams and girders; they were set every 1 or 1.5 *ken*s. In case thick beams were installed some posts were eliminated. The sleepers were placed perpendicular to the joists with interval of 1 or 1.5 *ken*s for they also connected to the posts. The floor joists were placed to divide the space between columns into 3 or 4. Foot of the posts was penetrated by the *ashiko-nuki*, which connected the posts to each other. The *kabe-nuki* was installed between the posts to construct solid exterior wall. In general 4 *kabe-nuki*s were inserted between the posts in houses in Gokayama. The kamoi and shikii which holds the panels and windows were located at the border of the rooms and the exterior wall. Considering these rules, the construction of the room with its area 2×2 *ken*s, which was common size for the *zashiki* in Gokayama, required the following number of timber components.Minimum 7 posts, 3 beams and girders, 9 floor joists for the ground floor and 4 joists for the ceiling, 2 sleepers, a minimum of 12 horizontal elements including nuki and sashi-kamoi, and a minimum of 5 *ashiko-nuki*.

Sectional proportion of the Japanese room was also determined by the *ken* measurement. The height of the ceiling was dictated by the number of floor mats (tatami), in other words, the room size. For example, the span between two rails (*shikii* and *kamoi*) which hold the partition panels was usually measured as number of floor mats × 1/6 *ken*. Therefore, for 6 mats rooms the ceiling height was 1 *ken*.

ⅳ) The Wall Infill and Claddings

Bamboo latticework was the general infill material for the Japanese house. It consisted of vertical members called *mawatashi-dake* and horizontal bamboo strips called *komai-dake* (Fig. 4-33). The edge of the *mawatashi-dake* was slightly inserted to a slit in the stud. Then vertical members were fastened to *kamoi-dake* with rope to form a delicate grid.

This bamboo skeleton was covered with clay. Since bamboo is a material with flexibility and durability compared to timber, it hardly expands and changes form. Therefore it might be appropriate to use together with clay wall, which absorbed and emitted the moisture very easily.

After the bamboo lattice infill was complete, both interior and exterior side of the structure was daubed with several layers of clay. The base coat was called *arakabe* and usually its thickness was 6 to 9 cm. Then *naka-nuri,* the second coat was laid on it. Finally colored mortar called *uwa-nuri* covered the wall and completed the wall construction. However three layers of wall coat application were only for the privileged classes who could afford it and only the base layer, *arakabe* was used in most Japanese houses. The timber structures were neither covered with clay nor painted and its natural colored surface was exposed to the outside. Timber board was an alternatives for the wall infill. Timber board was filled horizontally or vertically in the space between the posts. In Gokayama, instead of the combination of bamboo latticework and clay, timber boards were preferred. Exterior walls were covered with thatch (Fig. 4-34), while interior walls were left bared.

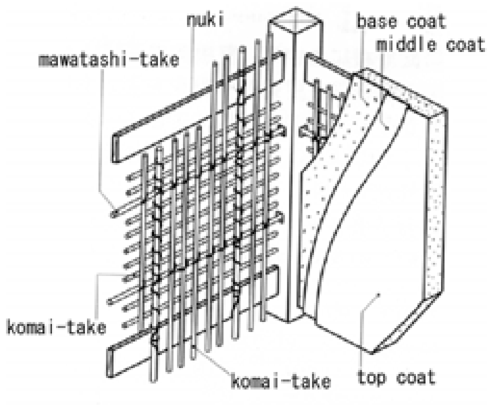


Fig.4-33 Japanese Wall Infill
(Source: Committee of the Architecture Dictionary, 2001: 94)

Figure 4-34 Typical exterior wall cladding of the houses in Gokayama

(Source: Toyama Prefecture, 1979: 53)

4.2.3. Roof Structure

Roof structure of the Turkish and Japanese house is presented as follows.

a. The Turkish Roof

i) The Roof Structure

After the whole timber skeleton was completed, the roof structure was constructed according to the shape of the timber frame. Four-hipped roof was preferred in the Turkish house including houses in Safranbolu. The components used were depicted in Fig. 4-35A. In this type of roof, rafters inclined in four directions being settled on a shorter ridge of the roof structure. The roof structure was set on top of the ceiling girder to be supported by the timber skeleton structure. First, the roof girders were placed on the ceiling girders and king post and corner post were set on the ceiling joists to support the ridge purlin and the angle rafter. Rafter was rested with regular intervals on the space between ridge purlin or angle rafter and roof girder. The rafter was extended 60 to 70 cm toward exterior to form the eaves. Occasionally the purlin and rafter was connected by means of the bird’s mouth joint. In case the rafter was too long to support by itself, the purlin was installed under the rafter for supporting. The purlin was supported by shorter posts.

A. The Turkish Roof Structure

B. The Japanese Roof Structure

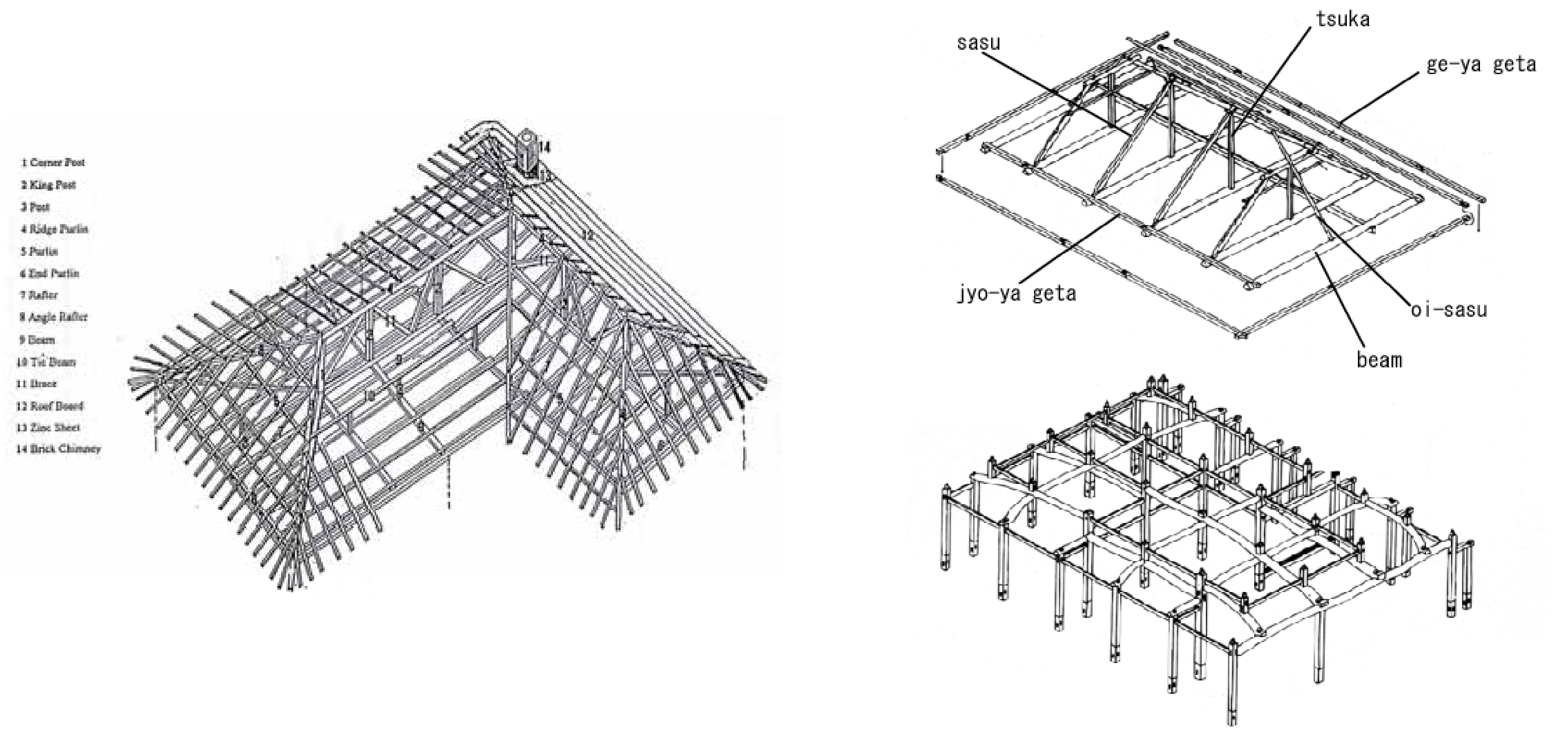


Fig.4-35 The Turkish (left) and Japanese (right) roof structure

(Source: Şahin, 1996: 201, and Kawasaki City, 2001: 39)

ⅱ) The Roofing

After the rafters and purlins were covered with the timber boards with thickness of 2 cm, the tiles were arranged on top of the roof structure. Timber singles once had been widely used as a roofing material in Turkey. However, they were later replaced by the burned clay tiles. Each tiles was laid overlapping to two others (Fig.4-36).

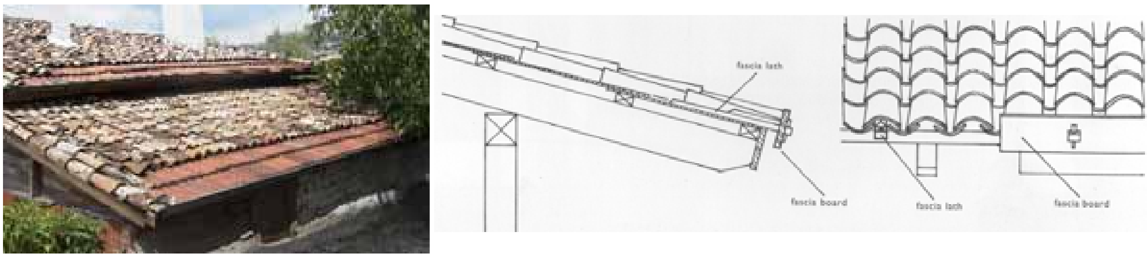


Figure 4-36 Roofing of the Turkish house
(Image by author, Source: Günay, 1998: 298)

b. The Japanese Roof

The roof structure of a Japanese house consisted of horizontal and vertical elements without diagonal bracings (Fig.4-35B). Each component was connected by means of mortise and tenon joints. It was placed straight on the main frame of the house. The main types of roof were the gable roof, the hip roof and a peculiar kind of dwarf hip roof called *irimoya-yane*, a span roof in which shorter hips were placed against the gables (Fig.4-37). Far beyond the walls the roof projected to provide the eaves to protect the wall from rain. The projected length was generally about 45 to 90 cm. The roof framing was classified in three types according to the structure: *odachi-gumi*, *wagoya,* and *sasu-gumi*. (Fig.4-38). These roof systems were chosen according to the roofing material.

· *Odachi-gumi*

Rafters were laid on the purline which was supported by the post (*shin-zuka*) in this system. The post was hold by a combination of horizontal elements and shorter posts (*koya-duka*). *Odachi-gumi* was used to the roof covered with thatch or timber boards.

· *Wagoya*
In order to cover a roof with clay tiles or timber boards, this type of the roof structure was applied. Roofing was supported by organization of several vertical and horizontal components including purline (*munaki*), *moya, koya,-duka, and koya-nuki*.

· *Sasu-gumi*
This type of roof was widely used in thatch-covered roof. The rafters called *sasu* was inclined and joined to each other at the ridge with vines of plants. The foot of the *sasu* was connected to beams which was placed with the intervals of one *ken* (1.82 m). Thus, in order to construct the house with its depth of 6 *ken*s, 6 sets of *sasu* were required. The edge of the sasu was shaved to stacked into the beam. This joint was supported by a log and stopper (Fig.4-40). On the intersection of the *sasu* the purline was located to reinforce the roof framing.

The sasu-gumi realized the steeply pitched roof, which was necessary for the area of heavy snowfall including Gokayama. In general, the inclination degree of Japanese roof was 45°, while that of the sasu-gumi in Gokayama was 60°.

In Gokayama, the special roof structure in the region called *gassyo-zukuri* was developed. *Gasyyo-zukuri* was a gable roof which applied sasu-gumi (Fig.4-39) and it means joining the hands in prayer. The shape of the roof which resembled in that of the joined hands, thus it was named *gassyo-zukuri*. The brace was used exceptionally in gassyo-zukuri in order to support the roof framing.

Other than snow solution, the main purpose of applying sasu-gumi in Gokayama was to obtain a wide space in the attic. Other roof systems including *odachi-gumi* and *wagoya* required posts and horizontal elements which occupied the attic. The attic was used for the silkworm culture. The window were opened to bring light and air inside.

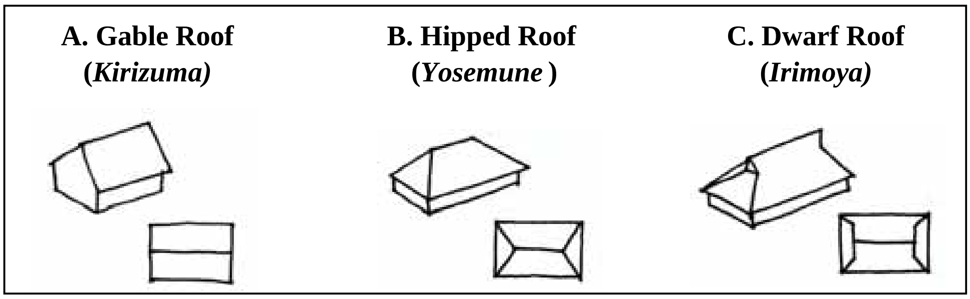


Figure 4-37 Three types of typical Japanese roof

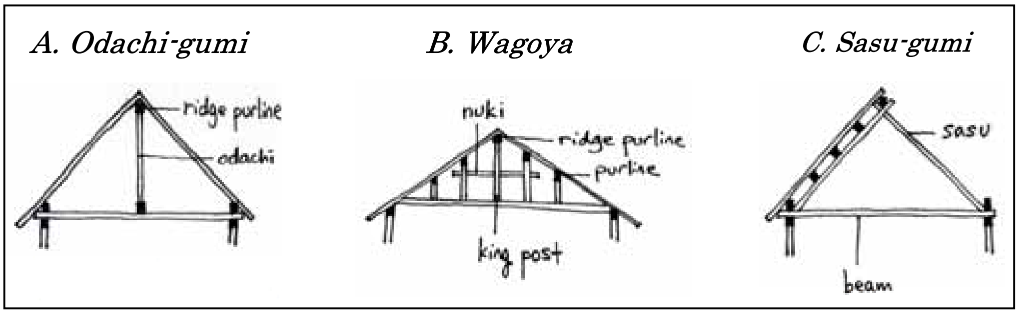


Figure 4-38 Three types of typical roof structure of the Japanese house

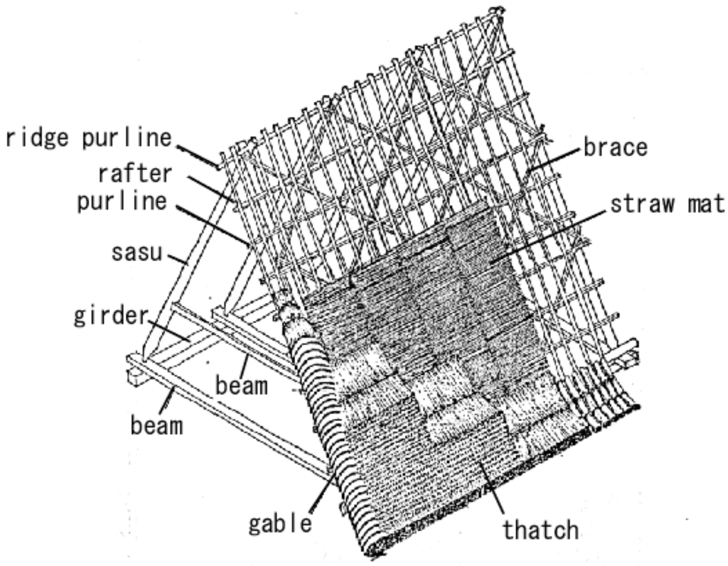


Figure 4-39 The strtucture of the gassyo-zukuri
(Source: Toyama Prefecture, 1979: 5)

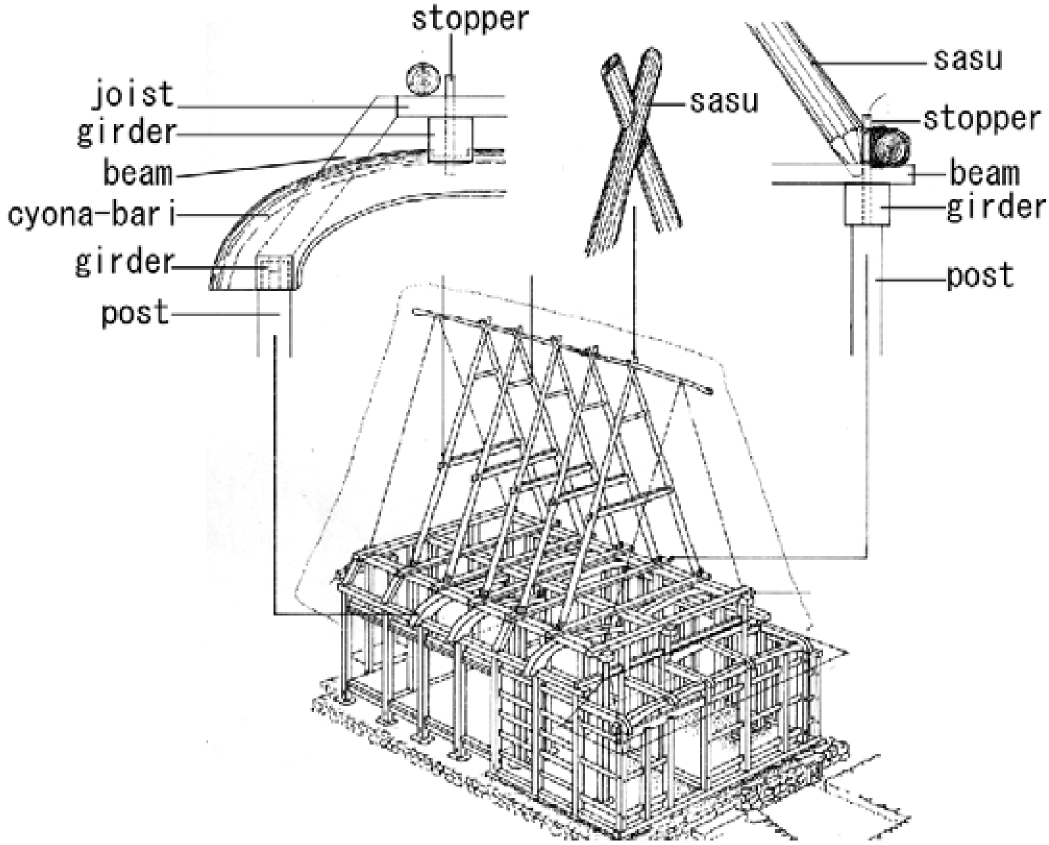


Figure 4-40 The joints used in the roof structure
(Source: Toyama Prefecture, 1979: 13)

ii) The Japanese Roofing

Thatch, timber singles, and burned tiles were main roofing materials of the Japanese house. Though tile was not common material since its use was restricted among warrior status and rich farmers. Each material was chosen according to the roof structure.

As for the *gassyo-zukuri*, thatch was applied. Straw mats covered the roof structure as a base, and then the bundled thatches were sewed on to the rafters, which was installed with intervals of 40 cm, with a rope. This work started from the eaves and ended at the ridge purlin (Fig.4-41). Once the roofing of the house in Gokayama was done by the community called *kumi*. The villagers replaced the roofing of each others house in turn cooperating with each other every year. The roofing of the house was renewed every 20 years.

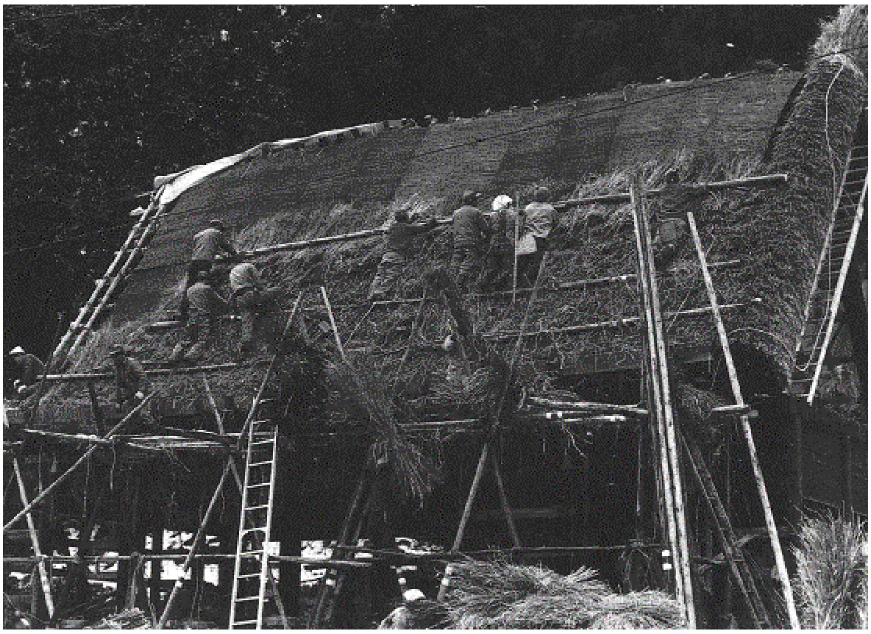


Figure 4-41 The roofing of Gassyo-zukuri
(Source: Toyama Prefecture, 1979: 43)

CHAPTER 5
CONCLUSION

Following three points were conclusions of this study.

1. **In Turkey, the structural order was orientated to the room size while the room size was dictated by the structural order in Japan.**

The particular standard was not found in the arrangement of the structural components of the Turkish timber framing. Though timber components were placed according to the unique rules. Three variations of posts and studs intervals were observed in the exterior walls: a, b and a+b (Fig. 5-1). Each value ranged as follows: a= 32.5~40 cm, b= 75~80 cm, and a+b= 112.5~120 cm. The post intervals of the partition wall was not observed for they were completely plastered. The intervals of the windowless exterior wall were 120 to150 cm. Floor joists were put on the shorter side of the room with its intervals of 61.5 to 76 cm.

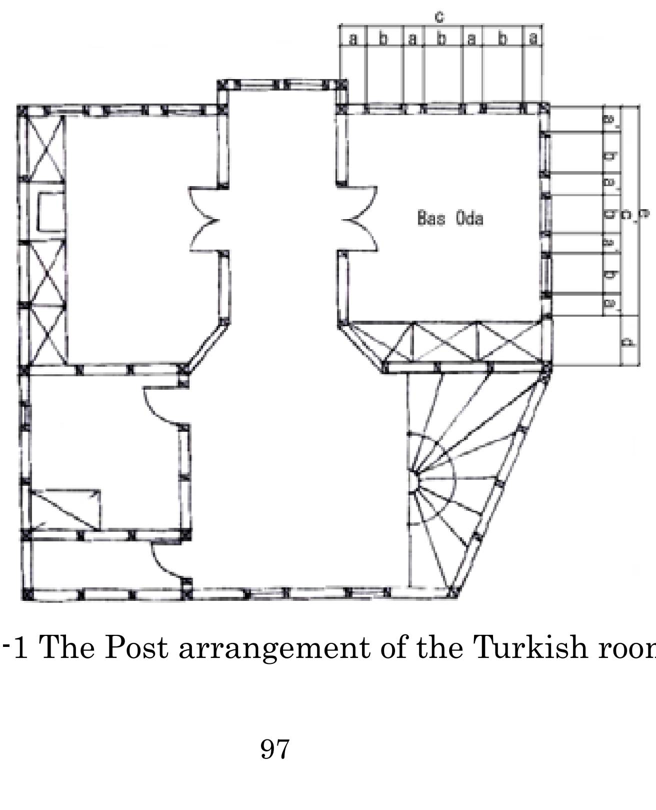


Figure 5-1 The Post arrangement of the Turkish room

On the other hand, the post arrangement was determined in order to support the weight of the roof structure in the Japanese house. The posts were placed every 1 to 1.5 *ken* following the construction manual called *bantsuke-hyo*. Other structural components including sleepers girders, beams, joists, *nuki, sashi-kamoi*, and rafters were installed according to the post placement.

2. **The space size was dictated by the human body scale in Turkey and by the module based on the *ken* measurement in Japan.**

Among the values of sectional scale of the Turkish house, value f, g, and j were determined according to the human proportion (Fig. 6-2). They oscillated as follows: f= 60~70 cm and j= 209 to 230 cm. The window height (value h) was adapted to them ranging from 140~170 cm.

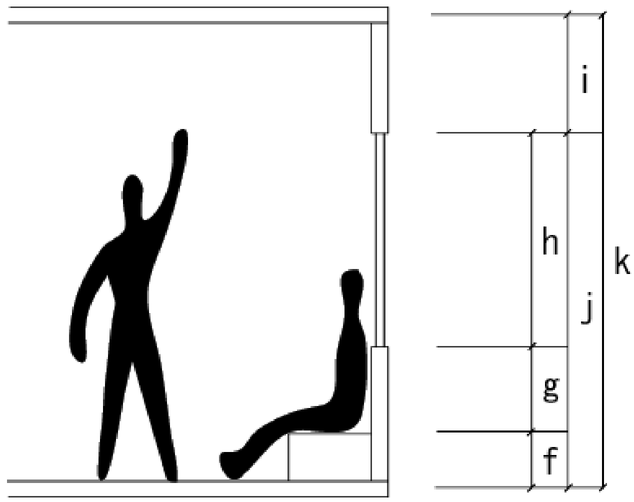


Figure 5-2. The sectional scale of the Turkish room

Since the width and breadth ratio of the window was set to 2 to1, the width (value b) corresponded to 70 to 85 cm (Fig. 5-1). The minimum span between the windows (value a) was 32.5 cm (sample T1). Thus the width of the room, value c, was 340 cm. The living space of the *baş oda* was planned square, therefore the minimum area of the living area was 340 cm×340 cm. The depth of the service place (value d) ranged from 50 to 130 cm. As a result, 340 cm×390 cm was the minimum area required

for the *baş* oda of the houses in Safranbolu.
The square grid of 0.5 ken was divided by partition panels in order to form the room. The standard size of the *zashiki* (the most important room) was 2×2 ken in Gokayama. The sectional scale was determined according to the room size.

3. **The number of the components employed to the timber framing.**
According to the rules which penetrate the room design, the number timber components can be discovered. The rules for the Turkish rooms are as follows.

- The posts were placed on the corner and side of the windows.
- One wall contained 3 windows.
- The posts which were positioned next to the corner posts were cut by the braces diagonally. Thus these posts were not counted as structural posts.
- The intervals between posts and studs were determined by the infill material.
- The joists were placed on the shorter side of the room with its intervals of 61.5 to 76 cm.

Thus the minimum number of the components required for the minimum room are, 12 posts, 5 joists, 17 studs, 12 windowsills and 8 wall plates. Number of the braces, knee braces, and tie beam were varied from house to house.

The rules of designing the Japanese room were as follows.
- The columns were placed every 1 to 1.5 *ken*s.
- The beams and girders were set on the posts with the intervals of 1 to 1.5 *ken*s.
- The sleepers were placed perpendicular to the joists with interval of 1 or 1.5 *ken*s.
- The floor joists were placed to divide the space between columns into 3 or 4.
-

Considering these rules, the construction of the room with its area 2×2 *ken*s, which was common size for the *zashiki* in Gokayama, required the following number of timber components: 7 posts, 3 beams and girders, 9 floor joists for the ground floor and 4 joists for the ceiling, 2 sleepers, a minimum of 12 horizontal elements including nuki and sashi-kamoi, and a minimum of 5 *ashiko-nuki*.

The modular coordination which was based on ken measurement penetrated the design and construction of the Japanese house. This standard was prepared by the builder. They designed the house, prepared the timbers, then constructed the house according to this standards. Thus the houses which existed in the same village employed the same scale system. On the other hand, there was no such standard in Turkish house. Though they used same design methods, the span, length and pitch of the components were different from house to house. In this thesis the process of design and construction were not studied. As a result, the production process of the traditional Turkish timber houses can be a theme for further discussion.

4. **In Turkish house the braces were used in wall framing while they were not observed in the Japanese house.**

In Turkish house, the braces were installed in order to reinforce the timber frame structure. On the other hand, no brace was observed in the Japanese house. Instead the horizontal components called *nuki* was frequently installed. Compared to braces, *nuki* did not work toward the horizontal force of the earthquake. Thus it can be induced that the Turkish house was more sustainable to the seismic power.

5. **In order to connect the timber components, nails were commonly used in the Turkish house while the mortise and tennon joints were frequently used in the Japanese house.**

Mortise and tennone joints were not common in traditional timber structure of the Turkish house. Instead the components were connected by means of nailing. On the other hand, nails were not popular in the Japanese house. Elaborately processed mortise and tennone type joints were frequently used.

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APPENDIX A
CHECK LIST

1. General Information

-The surveyed date / / 2003

-Address
…………………………………………………………………………………

-The name of the house …………………………………………………………

-Construction period
( ) before 1900 ( ) 1900-1930 ( ) 1930-1960

-The level of alteration
( ) small part ( ) change in plan ( )extended

- The topography
( ) valley ( ) the foot of the mountain ( ) slope of the mountain ( ) a ridge

-Floor heights
Ground floor…….m 1st floor………m 2nd ………..m Mezzanine …………m

2. Structural Walls

-Structure
( ) masonry wall ( ) skeletal wall

2.1. Masonry Wall

( ) stone ( ) brick ( ) timber ( ) mud brick

-The thickness of the wall …………………….cm

-The height of the wall ……………………cm

-Cross section of timber lintels ………………………cm

-The cross section of the vertical member x………….. y…………………

-The size of the brick if used x……………….. y………………………….

-Type of the foundation.
( ) discontinuous ( ) continuous ( ) mixed

2.2. Timber Skeleton Wall

a. The Wall Components

-Intervals between main posts …………………………cm

-Cross section of the main post x……………………. y……………………….

-Intervals between the studs…………………………cm

-Cross section of the stud x…………………………. y……………………….

-Cross section of the wall plate x………………………… y……………………….

-Cross section of the brace x……………………… y……………………………

-Cross section of the knee brace x………………………… y…………………………

-Cross section of the window sill x………………………… y……………………….

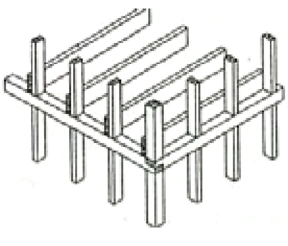
-Cross section of the tie beam x…………………… y…………………………

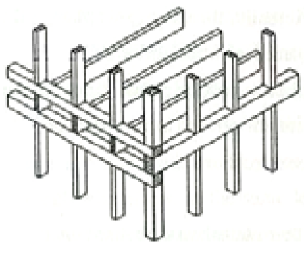
-Size of the window x…………………… y……………………………

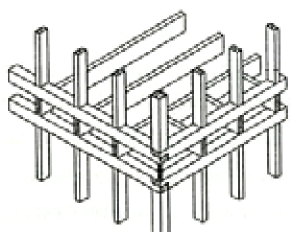
-The length between the floor and the window sill ………………………cm

-Wall plates application

a) *Tek yönde tek tabanlı b) Tek yönde çift tabanlı c) Iki yönde çift tabanlı*







b. The Joints

-Main post with the wall plates

a) Nailed b) Mortise and tennon

-Corner joint of the wall plates

a) Nailed b) c)

-Brace with wall plates and post
a) Nailed b) Un-nailed

-Brace with ribbon
a) Nailed b) Un-nailed

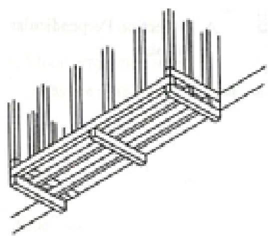
c. Timber Floor Structure

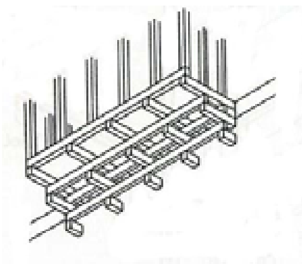
-Intervals between joists ……………………cm

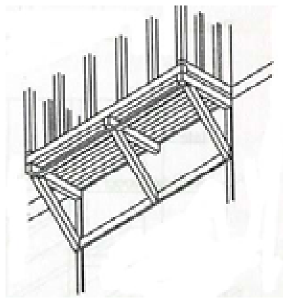
-The cross section of the joist x………………… y…………………
a) Ground floor b) 1st floor

c) 2nd floor d) 3rd floor

-Type of the projection
a) Simple projection b) Bindirmeli çıkma c) Payandalı çıkma







-The length of the projection ………………………cm

-Intervals between beams ………………………m

-The cross section of the beam x………………… y…………………

2.3. Roof Structure

-Cross section of the king post x…………………… y……………………..

-Cross section of the rafter (*mertek*) x…………………… y…………………..

-Cross section of the corner rafter (*eik mahya*) x…………….. y……………………

-Cross section of the ridge purline (*mahya*) x…………….. y……………………

-Cross section of the purline (*orta aşık*) x…………….. y……………………

-Cross section of the beam x…………….. y……………………

-The height of the king post……………………….cm

-The distance between the king post and the post……………………….cm

-The degree of inclination………………………

-Number and the direction of the rafters……………………

3. Building Enclosure

3.1. Wall Cladding

-Exterior ( ) bared ( ) wooden lath ( ) timber cladding
-Interior ( ) bared ( ) wooden lath ( ) timber cladding

3.2. Wall Infill

( ) timber board ( ) wattle and daub ( )brick ( ) mud brick ( )stone

3.3 Flooring

-Ground floor ( ) stone ( ) earth ( ) tile ( ) timber
-Upper floor ( ) stone ( ) earth ( ) tile ( ) timber

3.4. Ceiling

-Ground floor ( ) bared ( ) timber ( ) stucco
-Upper floor ( ) bared ( ) timber ( ) stucco

3.5. Roofing

( ) timber singles or boards ( )burned clay tiles ( ) tins ( )earth

APPENDIX B

GLOSSARY

BUTSUDAN: A Buddist altar

CHUMON-ZUKURI: L-shaped plan which developed in the snowy area. The stable was connected to the main space with a passage and the whole structure was covered by a single roof.

DOMA: Un-boarded ground floor which was used as a workplace, service place, a passageway and a stable.

FUSUMA: A partition panel which consists of timber skeleton and thick opaque paper.

HIKAE-MADO: The window with a low sill

HIROMA: A hall.

IRORI: A fireplace which is installed in the hall.

JYO-YA AND GE-YA: *Jyo-ya* is a main space of the dwelling, which is supported by the tall timber posts and beams. In order to widen the space toward the direction of the beam, the additional space, *ge-ya* was appended to *jyo-ya*

KAKEJIKU: The picture scroll which decorates t*okonoma*.

MAGARIYA: L-shaped plan which the stable was added perpendicular to the main space.

NAGESHI: A timber brace which supports *kamoi*.

NUKI: A Horizontal beam which pierces the columns.

OUIN: A recessed wall for a picture and flowers which is placed at the hall.

RANMA: Wooden Grills, a sliding panel, or an elaborately decorated openwork which is fixed on above the partition panels.

SHIKII AND KAMOI: *Kamoi* is wooden tracks which are placed on the floor and hold the lower frame of the panels whereas the upper frame was held by another track called *shikii*.

SHOIN: A bay window used for a studying desk.

SHOJI: A partition panel which consists with timber skeleton arranged in a square pattern and translucent paper.

TAKA-MADO: The window with a high sill

TANA: Cupboards and shelves fixed to the *zashiki.*

TOKONOMA: A picture recess installed in *zashiki*. It is usually decorated with flowers, pictures, or a picture scroll

ZASHIKI (DEI): The reception room.

APPENDIX C:
THE DATA OF THE HOUSES IN SAFRANBOLU AND GOKAYAMA

■The Floorht, The Structure, and The Finishings

Sample	Address	Floor Height (m)				Structure				Finishings						
		Basement	Ground Floor	1st Floor	2nd Floor	Foundation	Ground Floor	1st Floor	2nd Floor	Ground Floor	Upper Floor	Exterior Wall Cladding	Interior Wall Cladding	Ground Floor Ceiling	Upper Floor Ceiling	Roofing
T1	Çavuş Mah. Hamamönü Sok.11		3.16	2.91	3.1	Stone	Stone	Timber	Timber	Earth	Timber Board		Stucco		Timber Board	Tile
T2	Çavuş Mah. Altığ Sok. 9 (Mehmet Özdemir Evi)	2.5	3.25	2.45	2.8	Stone	Stone	Timber	Timber	Stone	Timber Board	Stucco	Stucco		Timber Board	Tile
T3	Çeşme Mah. Kalealtı Geçidi Sok.9 (Aygırlar Evi)		2.65	2.95	2.95	Stone	Timber	Timber	Timber	Stone	Timber Board		Stucco		Timber Board	Tile
T4	Bağlar Mah. Değirmenbaşı Sok.1		2.7	3.1	2.4	Stone	Stone	Timber		Earth	Timber Board		Stucco		Timber Board	Tile

■Cross Sections of the Timber Components (cm×cm)

Sample	Wall Framing							Floor Framing				Roof Structure					
	Post	Stud	Brace	Knee Brace	Lintel	Ledger	Tie Beam	Joist	Sill Plate	Wall Plate	Beam	King Post	Ridge Purline	Purline	Rafter	Corner Rafter	Beam
T1	13×16	8.5×13	8.5×8.5	8.5×7	8.5×7	8.5×7	8.5×7	14×17	14×20	14×20							
T2	15×18	8×16	8×10	8×8	8×10	8×8		13×18	12×17	12×17		9×14	9×14	12×18	7×11	9×12	9×14
T3	10×13	7×7	15×10	7×7	7×7	7×7	6×7	12×14	12×18	12×18		14×10	14×16	8×13	8×12	10×14	11×14
T4	10×13	6×10	7×10	7×10	7×10	7×10	7×10	12×15	10×15	10×15	10.5×15	9×12	9×12	9×13	7×12	8×12	8×12

■The Summary of the Construction System

Sample	Foundation			Floor Framing				Projection				Wall Framing				Roof Structure					
	Material	Thickness (cm)	Type	Direction and Number of the Wall Plates	Pitch of the Joists (cm)	Span of the Joists (cm)	Direction of the Joists	Type	Projected Length (cm)	Projected Direction	Direction of the Joists	Pitch of the Posts (cm)	Infill Material	Size of the Window	Height of the Ledger (cm)	Type	Pitch of the Rafters (cm)	Pitch of the Beams (cm)	Between the King Post and the Purline (cm)	Height of the King Post (cm)	Incline Degree
T1	Stone	74	Continuous	1・2	68	410	Short Side	Cantilever	50	One Way	Perpendicular	36	Stone	78×156	69	3 Hipped Roof					
T2	Stone	65	Continuous	1・2	76.5	436	Short Side	Cantilever	60	One Way	Parallel	48	Stone	80×170	60	4 Hipped Roof	84	65	106	180	44
T3	Stone	75	Continuous	1・2	66.5	520	Short Side	Braced	140	One Way	Perpendicular	58	Adobe	68×140	60	3 Hipped Roof	88	73	250	150	22
T4	Stone	67	Continuous	1・2	61.5	420	Short Side	Cantilever	60	One Way	Parallel	38	Stone	77×142	64	3 Hipped Roof	80	72	175	135	19

■The Floorht, The Structure, and The Finishings

Sample	Address	Floor Height (m)				Structure				Finishings					
		Ground Floor	1st Floor	2nd Floor	3rd Floor	Foundation	Ground Floor	1st Floor	2nd Floor	G.F. Flooring	Upper Flooring	Interior Wall Cladding	Exterior Wall Cladding	Ceiling	Roofing
J1	Toyama-ken Higashi Tonami-gun Tairamura (The Mizuguchi)	2.7	4.5			Stone	Timber	Timber		Earth, Timber Board	*Sunoko-Yuka*		Thatch	*Sao-en*	Thatch
J2	Toyama-ken Higashi Tonami-gun Tairamura (The Kubota)	3.3	4.1			Stone	Timber	Timber		Earth, Timber Board	*Sunoko-Yuka*		Thatch	*Sao-en*	Thatch
J3	Toyama-ken Higashi Tonami-gun Tamukai (The Haba)	2.92	2.05	3.3		Stone	Timber	Timber	Timber	Earth, Timber Board	*Sunoko-Yuka*		Thatch	*Sao-en*	Thatch
J4	Toyama-ken Higashi Tonami-gun Tamukai (The Murakami)	4.29	2.01	2.08	2.49	Stone	Timber	Timber	Timber	Earth, *Tatami*	*Sunoko-Yuka*, Timber Board		Thatch	*Neda, Sao-en*	Thatch

■Cross Sections of the Timber Components (cm×cm)

Sample	Timber Framing											Roof Structure							
	Sill	Joist	Sleeper	*Jyo-ya Bashira*	*Ge-ya Bashira*	*Ashiko-Nuki*	*Uchinori-Nuki*	*Kabe-Nuki*	*Sashi-Kamoi*	*Kamoi*	*Shikii*	Beam(G.F.)	Beam(1F.)	Beam(2F.)	Girder	Rafter	*Sasu*	Brace	Purline
J1	15×10	R=10	18×15	16×16	14×14	6×12	4×18	4×18	14×18			15×15	10×15	10×15	20×20		12~18		R=8
J2	15×12	R=5	15×13	15×15	12×12	4×15	4×15	4×15	15×20			15×15	10×15	10×15	18×18		12~18		R=8
J3	18×15		R=25	15×15	12×12	R=15	5×11	5×11	14×19	5.5×15	5.5×15	15×15	9×18	R=18~30	15×15	R=12	12~20		R=10
J4	16×12	15×12	15×15	18×20	18×16.5		5.7×17	5.7×17		7.5×12	7.5×12	18×24	9-18×13-21	18×24	18×18	R=10	10-		

■The Summary of the Construction System

Sample	Foundation		Floor Framing						Wall Framing		Roof Structure					
	Material	Type	Pitch of Joists (cm)		Direction of Joists		Span of Joists (cm)		Pitch of Posts (cm) (1 *ken*)	Pitch of Posts (Max) (cm)	Span of Bean (cm)	Pitch of Beam (cm)	Span of Girder (cm)	Pitch of Girder (cm)	Pitch of the Rafters (cm)	Incline Degree
			G.F.	1,2,3 F	G.F.	1,2,3 F	G.F.	1,2,3 F								
J1	Stone	Single	455, 492.5	606, 675	Prallel to girder	Prallel to beam	8,290	6,370	1,820	3,940	6,370	1,350 1820 1,950	11,150	1970, 2420	40	60
J2	Stone	Single	455	606			10,000	6,370	1,820	6,370	6,370	1,820	10,920	910, 1820	40	60
J3	Stone	Single	455	455, 567.5			11,370	6,370	1,820	5.146	6,370	1820 2,270	11,370	910, 1820	40	60
J4	Stone	Single	499.5				20,431	10,641	1,998	4995	8991		20,380	999, 2497.5	40	60

APPENDIX D:
THE SCALE OF THE HOUSES IN SAFRANBOLU

■Scale of value a to I (cm)

Sample	a	b	a+b	c	a'	a'+b	c'	d	e	f+g	h	I	j	k
T1	44	78	122	410	44	122	410	100	510	69	156	85	225	310
T2	40	80	120	400	40	120	400	130	530	60	170	50	230	280
T3	44	75	119	400	44	119	400	120	520	64	145	86	209	295
T4	32.5	80	**112.5**	**370**	32.5	**112.5**	370	50	**420**	70	160	80	230	310

■The pitch of the posts

	Windowless exterior wall	Partition wall
T1	115	135
T2	140	150
T3	130	140
T4	120	120

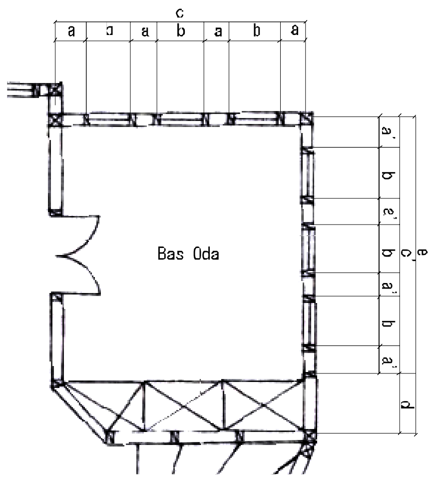
■Number of Windows

	Front Façade	Left/Right Façade	Room Shape	Plan
T1	3	3	Square	Symmetry
T2	3	3	Square	Symmetry
T3	3	3	Square	Symmetry
T4	3	3	Square	Symmetry

■The Ratio of Length and Breath

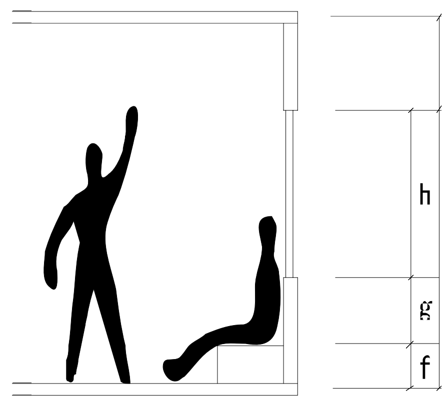
	h/b
T1	2
T2	2.2
T3	1.9
T4	2

■Pitch of the Posts of the Bas Oda



b: Width of the Window
c: Length of the Wall (Front Façade)
d: The Length of the Wall of the Service Space
e: The Length of the Wall (Left/ Right Façade)

■Scale of the Space



f: The Height of the Sedir
g: The Sedir to the Ledger
h: The Height of the Window
I: The Windowsill to the ceiilng
j: The Floor to the Windowsill
k: Ceiling Height

■The pitch, span and the cross section of the floor joists of the bas oda

	Pitch (cm)	Span (cm)	Number of Joists	Span/Pitch	Cross Section
T1	68	410	6	6.02	14×17
T2	**76**	436	6	5.73	13×18
T3	66.5	**400**	5	6.01	12×14
T4	**61.5**	420	5	6.82	12×15

■Number of Components Used for the *Bas Oda* and *Zashiki*

sample	floor framing		ceilling		exterior wall						partition wall	
	wall plate	joist	wall plate	joist	post	brace	stud	knee brace	tie beam	window sill	post	stud
T1	4	6	4	6	12	0	18	8	13	12	6	
T2	4	6	4	6	12	0	17	8	18	12	6	
T3	4	5	4	5	12	2	26	2	12	12	3	
T4	4	5	4	5	12	2	24	6	11	12	6	

sample	floor framing				ceilling	wall						
	post	*ashiko-nuki*	sleeper	joist	joists	*kabe-nuki*	*sashi-kamoi*	*uchinori-nuki*	girder	beam	*kamoi*	*shikii*
J1	7	5	2	9	4	8	2	4	3	3	4	4
J2	10	6	2	9	4	8	2	6	3	3	5	5
J3	10	7	2	9	4	4	3	5	3	3	8	8
J4	11	6	3	11	6	0	4	4	4	4	10	10