

DEVELOPMENT OF WIND-RESISTANT CONSTRUCTION SYSTEMS IN SOUTHEAST

Takashi Ohno

Department of Architecture, Faculty of Engineering
Tokyo Polytechnic University, Kanagawa, Japan

ABSTRACT

The production and construction conditions are composed of various elements, including building materials usable for construction and type of labor. The actual situations of them are clearly indicated by conventional construction systems. Under the COE program, we chose the theme of “Development of wind-resistant construction systems based on their respective situations in APEC countries.” Many teaching materials for building construction systems, being used at each university and vocational school in Southeast and East Asia are collected and compared to find similarities and differences. To position developed wind-resistant construction systems as conventional construction systems, I think it is important to clarify their functions as well as use familiar shapes and techniques.

Keywords: Conventional building construction, Teaching material, Asia,
Wind-resistant system, Development of roofing system.

Introduction

Development of construction systems requires grasping legal constraints, weather and other environmental conditions, estimated conditions of use,

related policies and cultural aspects as well as production and construction conditions. The production and construction conditions are composed of various elements, including building materials usable for construction and type of labor. The actual situations of them are clearly indicated by conventional construction systems. Under the COE program, we chose the theme of “Development of wind-resistant construction systems based on their respective situations in APEC countries,” and I determined to grasp conventional construction systems in their countries as the first step of the study.

System of Study

To grasp conventional construction systems, I collected various kinds of related materials including production and construction conditions in each country and in each area, and conducted hearings with intellectuals who are well versed in their local situations. In parallel with these activities, I visited some construction sites and housing estates to confirm the construction systems actually implemented as well as to hear opinions and collect related materials. I visited only limited places in the centers of cities for a short period of time, and I have not collected sufficient materials yet. I give you advance notice that this paper describes only one part of the actual situation.

Results of Study

Consideration to Dwelling Houses as Conventional Construction Systems

As might be expected, the construction systems for large buildings that are expected to have new functions, for example, office buildings and commercial facilities, are almost the same as those used in Japan. These kinds of buildings use the global standard construction systems that are almost the same anywhere in the world. The conventional construction systems are suitable for buildings that serve functions that will not change for a certain period of time. Dwelling houses are the typical representative of such buildings. In many countries, production of dwelling houses accounts for the major part of building construction, and are likely to reflect the actual situations of the conventional construction systems, or the production and construction conditions, in each country and in each area.

Many people may imagine high-floored wooden houses as the residential construction system in Southeast Asia. However, at least in cities and suburbs, most houses are constructed on the ground and have frames of columns and beams, and masonry walls as shown in Figure .1.

The former is the so-called traditional construction system as used for private folk houses in Japan. This type of construction system is still used in many

countries, but in most cases, it is not covered by national policies. Some materials indicate that the latter construction system that uses columns, beams and masonry walls is due to influence from China. However, this construction system is not limited to Southeast Asia. We can find similar construction systems all over the world, though there are some differences in building materials for columns, beams and masonry walls. It's no exaggeration to say that this is the world's conventional construction system. Figure ure 1 shows the walls made of bricks. Concrete blocks and autoclaved lightweight concretes (ALC) are used in Europe and the United States, while sun-dried bricks are used in the Middle East and Africa. These are the building materials easily available in each area. Columns and beams are made of reinforced concrete (RC), steel, wood, bamboo and other materials. This fact makes me to recognize again that the frames, columns and beams, serve not only as the building structure but as the leveling rule during the erection.

The Focus of Roof Construction System

For earthquake resistance, some breakage in non-structural members in various parts of building is acceptable. However, for wind resistance, breakage in non-structural members is critical, because it may cause complete collapse of the building. In Southeast Asia, most dwelling houses generally have masonry walls on all external perimeters, and only the roofs become the object of study about wind resistance.

On the assumption that collapse-resistant measures are fully taken for buildings, major damage by wind is caused by the negative pressure, wind blowing up. When the construction of a roof is considered as three groups of surface construction from roofing to purlin, roof frame and corner such as eaves, rake, ridge and others (Figure .2), joints between surface construction and roof frame on eaves, rake, ridge and others are critical points. The wind power factor of the roof surface is determined by the inclination. Generally, it decreases in the order of the joints between ridge and rake, the joints between rake and eaves, the ridge, the rake, the eaves and the general part. Long eaves that have wind blowing up are one of the most important parts. Most Southeast Asian countries are located in the potential paths of typhoons. Some wind resistant measures are taken and design standards are available in those countries.

Figure 3 shows the structure I happened to see in a temple in Vietnam. The fascia boards and inner horizontal members are connected to reinforce the eaves. I'm not sure if it is for wind resistance. I have never seen such a structure in Japan. On eaves, "Hanegi", holding rafter, in Japan is the countermeasures against vertical load of eaves themselves (Figure 4). In most cases, wind blowing up is prevented by the weight of building materials.

Figure 5 shows an example of close connection of bargeboard and purlin on rake. This also is very rare case.

Research of Teaching Materials for Building Construction

Many teaching materials for building construction systems, being used at each university and vocational school in Southeast and East Asia are collected and compared to find similarities and differences. Table 1, 2, 3 show the comparisons by the countries and the areas. It is evident that China has very large land areas, and covers most kinds of the roof construction systems in Southeast and East Asia. In Malaysia and Singapore, teaching materials of Western countries are used as their textbooks and it has significant effect on their construction system.

Figures 6 to 11 show outlines of roof frames and Figure 12 to 26 show detail examples of eaves and rake that tend to have trouble by wind blowing up. Figures 27 to 32 introduce roof elements that have distinctive shapes and functions to each other.

A few of teaching materials indicate the selection of the construction system by the length of eaves and Figure 19 and Figure 20 are detail examples with long eaves that are reinforced firmly.

Conclusions

The temple shown in Figure 3 was made in the traditional construction system. Similar construction systems are found in teaching materials for building construction that are commercially available (Figure 19). Therefore, it can be said that this type of construction has become a conventional system to some degree.

Figure 33 shows a similar measure that is often seen in Indonesia, which we have never collected enough teaching materials, and other areas. We think this is a countermeasure mainly against vertical load, but it can also be applied as a wind-resistant construction system to reinforce eaves.

To position developed wind-resistant construction systems as conventional construction systems, I think it is important to clarify their functions as well as use familiar shapes and techniques. Now, we are planning development of new wind-resistant construction systems and remodeling systems for existing building in consideration of conventional construction systems.

Table 1: Type of pitched roof frame

	M	P	R	T	F	M+P	M+R	M+F	P+R
	Masonry	Principle rafter (Couple roof)	Roof truss	Trussed rafter	Post frame				
Japan		0	0		0				0
China	0	0	0		0		0		0
Korea			0	0	0			0	
Taiwan	0				0				
Thailand		0							0
Vietnam	0	0	0		0			0	
Philippine			0		0		0		
Malaysia		0		0		0			0
Singapore		0		0		0			0
(Figure)	3	7	8	9	10		11		

0 : exist

: unknown

Table 2: Suppot type of eaves and rake

	Eaves							Rake		
	Parapet/ Fascia	Roof sheathing	Common rafter	Support beam	Principle rafter/ Roof truss	Other member	Combina- tion	Purlin	Other member	Parapet/ Verge- board
Japan			0	*				0		
China	0	0	0	0				0	0	0
Korea					0					
Taiwan	?	0	0			0				0
Thailand	0				0					
Vietnam	0	0	0	0	0	0				0
Philippine	0				0					
Malaysia	0				0				0	?
Singapore	?				0				0	0
(Figure)	12,13	14	15	16	17	18	19,20	21,22	23	24,25,26

0 : use

? : case by case

* : traditional

: unknown

Table 3: Elements of surface construction

	Horizontal batten	Vertical batten	Mortar	Roofing paper	Roof sheathing	Metal sheet	Roofing felt	Common rafter	Purlin
Japan	0	×	?	?	0	×	×	0	0
China	?	?	?	?	?	×	×	?	0
Korea	?	×	?	?	0	×	×	0	0
Taiwan	?	×		?	0	×	×	0	0
Thailand	0	×		×	×	×	×	×	×
Vietnam	?	?		?	?	×	×	?	?
Philippine	0	?		?	0	0	×	×	?
Malaysia	0	×			0	×	0	?	?
Singapore	0	×		×	0	×	0	×	?
(Figure)	27	28	29	28	28,29	30,31	32	30	28

0 : use

? : case by case

×: no use

: unknown



Figure 1: Conventional construction system at a site in a suburb of Jakarta (RC frames and brick walls)

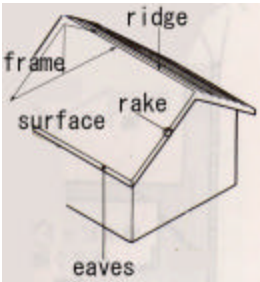


Figure 2: Roof elements

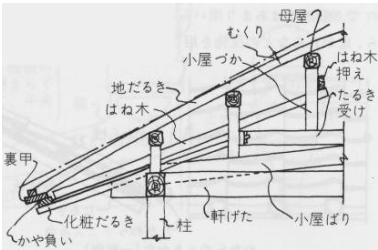


Figure 4: “Hanegi” for reinforcement of eaves (Rikogakusha Publishing Co., Ltd.)

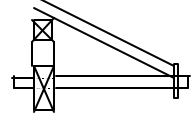


Figure 3: Details of fascia boards and eaves in Chua But Thap temple in the suburb of Hanoi

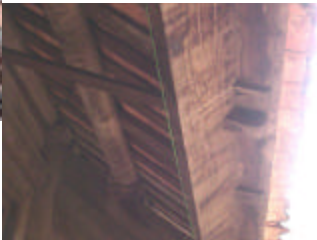


Figure 5: Tight connection of verge with bargeboards and purlin at Maekawa House (Edo-Tokyo Open Air Architectural Museum)

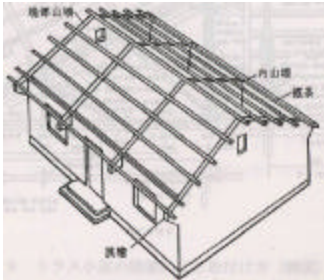


Figure 6: Masonry wall

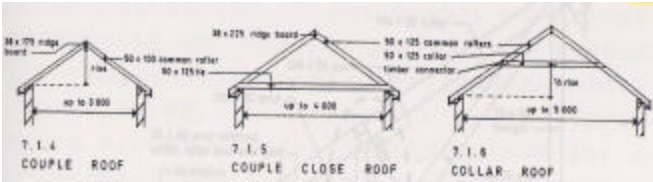


Figure 7: Couple roof and others

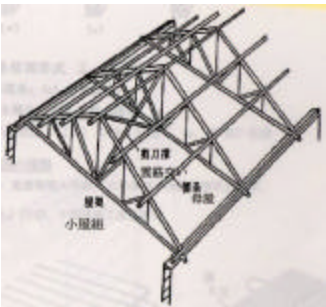


Figure 8: Roof truss

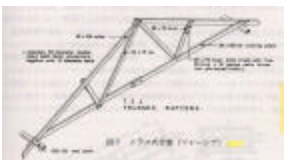


Figure 9: Trussed rafter

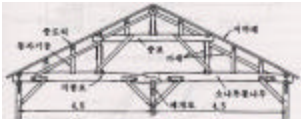


Figure 10: Post frame

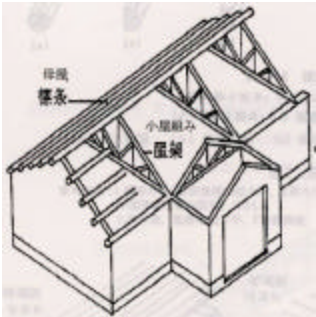


Figure 11: Masonry wall and roof truss

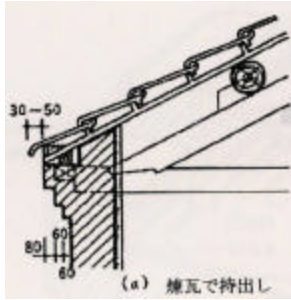


Figure 12: no overhang at eaves

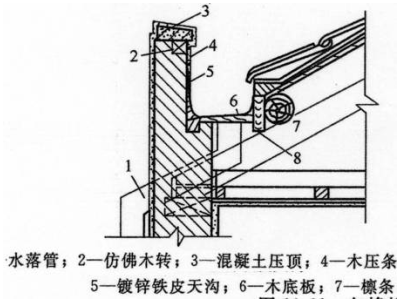


Figure 13: eaves by parapet

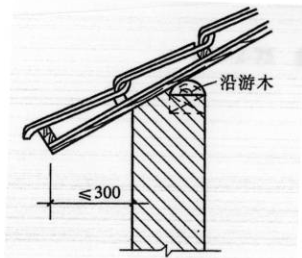


Figure 14: eaves by roof sheathing

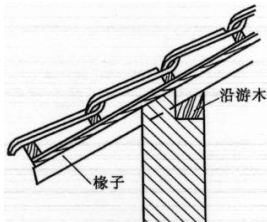


Figure 15: overhang by common rafter

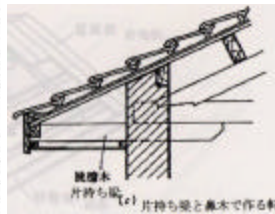


Figure 16: overhang by support beam

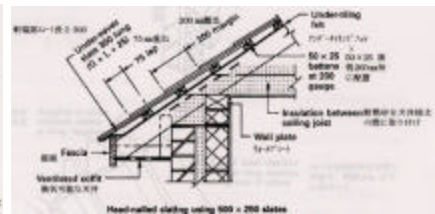


Figure 17: overhang by principle rafter

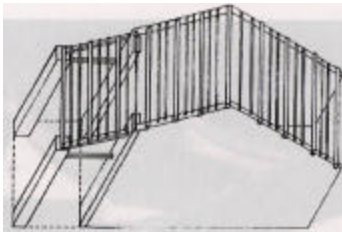


Figure 18: lean-to by other member

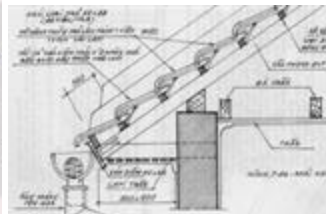


Figure 19: common rafter and support beam (1)

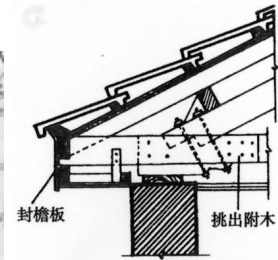


Figure 20: common rafter and support beam (2)

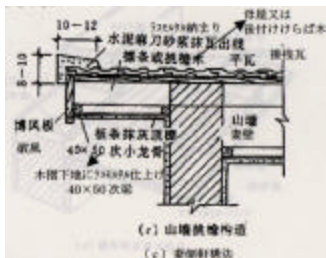


Figure 21: rake by purlin (1)

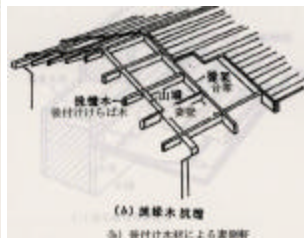


Figure 22: rake by purlin (2)

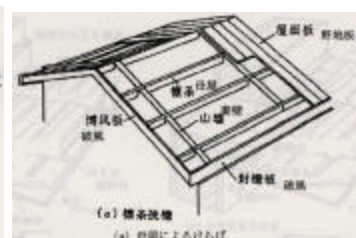


Figure 23: rake by other member

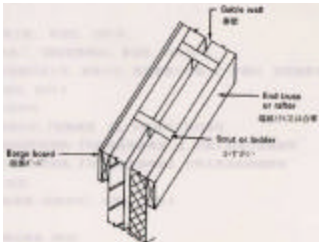


Figure 24: rake by verge board

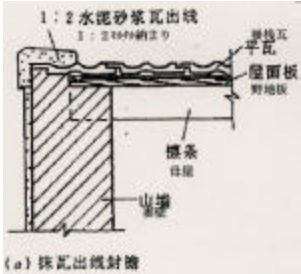


Figure 25: no overhang at rake

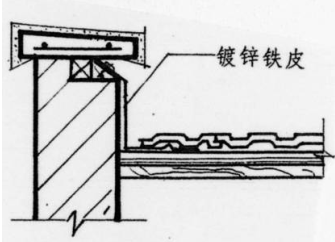


Figure 26: rake by parapet

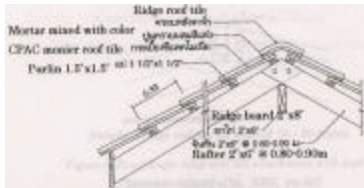


Figure 27: only horizontal batten common rafter

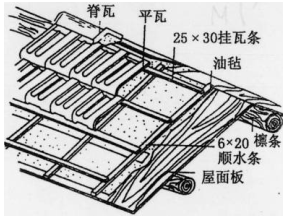


Figure 28: surface construction without common batten

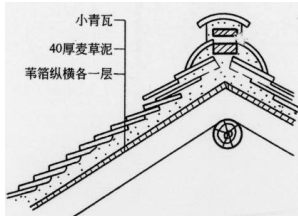


Figure 29: no horizontal and vertical batten

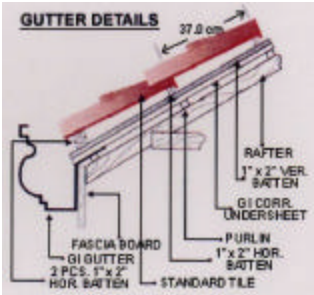


Figure 30: metal sheet for waterproof (1)

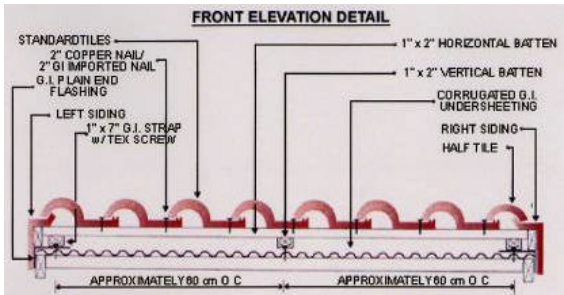


Figure 31: metal sheet for waterproof (2)

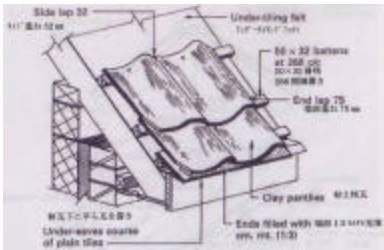


Figure 32: roofing (under-tiling) felt



Figure 33: Details of Eaves of the Eco House in Surabaya Institute of Technology

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