Bridge and Box: A Typological Study on the Construction Systems of Malay Houses in the Malay Peninsula

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Abstract
Malay houses have a great variation in construction systems despite their consistencies. With the coding method shown in this study, construction elements and their relations are presented in both words and symbols. In this study there are 95 house cases that have been coded and studied according to their construction processes. The study shows that the construction systems of Malay houses are composed of the house and its encroachment, and each house is composed of supports and a roof. The two major systems of support are the "bridge" and "box". Their roof variation generates five sub-systems of house construction. Encroachments can be divided into encroached semi-house (Es), encroached house (Eh), and encroached selang (Esg). There are 15 Es, 3 Eh, and 2 Esg in the 95 cases studied. The completion of house construction coding facilitates the description of the house construction, comprehension of uniqueness and limitation of house forms, along with the establishment of Malay house construction systems. The evolution and adaptability of the Malay house construction system can thus be understood more precisely.

Keywords: Malay house; Malay Peninsula; coding system; house construction; encroachment

1. Introduction
Southeast Asia covers a broad geographical range that contains a variety of ethnic groups, languages, and house types with common yet diverse features. Traditional Southeast Asian houses are mostly stilt houses, be they of log wood or light wood construction (Ismail, 2005), single or multiple houses, or comprised of a patrilineal or matrilineal family system. Some single houses accommodate several families, while some multiple houses accommodate only one family. The houses in the Malay Peninsula, also known as peninsular Malaysia, tend to be constructed from light wood, with house grouping common for a single patrilineal family (Nasir & Teh, 1995). Despite the rich design variation, Malay houses have the same spatial content. The serambi (reception area), rumah ibu (main space), and dapur (kitchen) are arranged from front to back with different house grouping arrangements (Syed, 2001). Malay house construction systems have their consistencies, but a rich diversity is also to be found. The purpose of this paper is to explore the completion, from "consistence" to "variation", of Malay house construction systems.

On a small scale, a Malay house is just a single house. The original house, named rumah tiang enam (a six-column house), would be comprised of three columns on each of its two sides. In case of the need for extension, two rows of columns, parallel to the house ridge, are added to extend two spans, which form a rumah tiang dua delas (a 12-column house) (Hilton, 1992). Rumah tiang dua delas, in the style of a gable roof with double-slope, are mostly used as the Rumah

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Ibu (main house) and have long been considered as the image of identity for Malay-built structures. In general, a Malay main house (Rumah tiang dua delas) is composed of one original house (rumah tiang enam) and two encroachments. (Chen, 2008).

As the scale grows, the length of the main house expands along the roof ridge, and sub-houses or other encroachments are added mostly in the back, seldom at the side. Therefore, Malay house features also reflect the image of house grouping (Lim, 1987).

After investigating more than 200 house cases in peninsular Malaysia, this paper selects 95 cases (Fig.1.), exclusive of Chinese immigrant or Western colonial influences, and tries to develop a method to study the construction of Malay houses. The method possesses three methodical requirements. Firstly, it is a descriptive method that is simple, effective, and general. Secondly, it can reveal features taken from drawings and literature regarding construction. Thirdly, it is well organized to assist further studies.

2. Method

A typological study on houses focuses on the discussion between their compositional elements and their relations. The study naturally encompasses a great number of case drawings. The analysis may rely on a large quantity of descriptive words, as it is difficult to convey concisely. The coding system used in this study names the compositional elements and relations by using simple words and symbols, and turns them into a prudent descriptive language for generative and inferable calculations. Describing the construction systems of house cases from a coding system makes specific details and small differences easier to observe. LISP programming language serves as a reference for the coding system.

Construction coding aims at defining construction elements and their relations. Parsing is done throughout the process of construction, establishing a fully comprehensive construction coding procedure.

Table 1. Construction Elements and Their Code Names

<table>
<thead>
<tr>
<th>Parts</th>
<th>Code</th>
<th>Name of Element</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ho: Original House</td>
<td>c</td>
<td>Column</td>
<td>Vertical, square section.</td>
</tr>
<tr>
<td></td>
<td>cb</td>
<td>End cross beam</td>
<td>Flat beam, parallel to rg.</td>
</tr>
<tr>
<td></td>
<td>tb</td>
<td>Tie beam</td>
<td>Flat beam, perpendicular to cb.</td>
</tr>
<tr>
<td></td>
<td>p</td>
<td>King post</td>
<td>Vertical, on the middle point of tb.</td>
</tr>
<tr>
<td></td>
<td>ob</td>
<td>Oblique beam</td>
<td>Oblique, connecting tb and p.</td>
</tr>
<tr>
<td></td>
<td>rg</td>
<td>Ridge piece</td>
<td>Horizontal, perpendicular to p.</td>
</tr>
<tr>
<td></td>
<td>rg’</td>
<td>Ridge-parallel beam</td>
<td>Lower, horizontal, perpendicular to p.</td>
</tr>
<tr>
<td>E: Encroachment</td>
<td>e</td>
<td>Column 2</td>
<td>Vertical, square section.</td>
</tr>
<tr>
<td></td>
<td>eb</td>
<td>End cross beam 2</td>
<td>Flat beam, parallel to cb.</td>
</tr>
<tr>
<td></td>
<td>ob</td>
<td>Oblique beam 2</td>
<td>Oblique, various connecting ways.</td>
</tr>
<tr>
<td></td>
<td>pl</td>
<td>Purlin</td>
<td>Horizontal, parallel to cb.</td>
</tr>
<tr>
<td></td>
<td>rf</td>
<td>Rafter</td>
<td>Oblique, perpendicular to pl.</td>
</tr>
</tbody>
</table>

2.1 Construction Elements

Construction elements are listed in Table 1., identifying the parts of the construction, element codes, element names, and relevant characteristics.

2.2 Relations among Construction Elements

The relations between construction element A and B can be:

\[
\begin{align*}
\downarrow (A, B): & \text{ B abuts on A.} \\
\times (A, B): & \text{ B crosses A.} \\
\square (A, B): & \text{ B penetrates A.} \\
\wedge (A, B): & \text{ B converges on A.} \\
\rightarrow (A, B): & \text{ B connects to A.} 
\end{align*}
\]

All the symbols (\(\downarrow\), \(\times\), \(\square\), \(\wedge\), \(\rightarrow\)) signify at least one connection form (Fig.2.). Most of them are tenon jointed. Fig.3. shows "Rumah Encik Hussein Be, Melaka, built in 1900" (Juminan et al., 1980) serving as an example for demonstrating the construction process and for construction coding. (Rumah is the word for "house" in Malay).

| Fig.2. Relations between Construction Element A and B |
| \(\downarrow (A, B)\) | \(\times (A, B)\) | \(\square (A, B)\) | \(\wedge (A, B)\) | \(\rightarrow (A, B)\) |

2.3 Construction Coding Parsing

Ho (original house) follows the construction procedure from bottom-up, coding as follows:

Coding step 1: Four columns (c) abut on (\(\downarrow\)) one cross beam (cb.), four columns become a three-span unit. (span distance = 220cm). The distance between two units is 247 cm. The coding is:

\[
2\downarrow (c, cb, /220)/247
\]

Coding step 2: Two units of "\(\downarrow (cb, 4c, /220)\)" are crossed by four tie beams (tb). The coding is:

\[
\times (2\downarrow (cb, 4c, /220))/247, 4tb\]

Coding step 3: Four posts (p) abut on four tb. The coding is:

\[
\rightarrow (\times (2\downarrow (cb, 4c, /220))/247, 4tb), 4p\]

Coding step 4: Two oblique beams (ob) at every set of "\(\downarrow (tb, p)\)" abut on the tie beam (tb.) and post (p). Eight oblique beams, angle = 40°. The coding is:

\[
\rightarrow (\times (2\downarrow (cb, 4c, /220))/247, 4tb), 4p, 8ob, (40°)\]

Coding step 5: A ridge piece (rg) is abutted on by four posts. The coding is:

\[
\rightarrow (\times (2\downarrow (cb, 4c, /220))/247, 4tb), 4p, 8ob, (40°), rg\]

This coding is rather complicated. If the element number, span distance, and the angle were omitted, a simpler coding would be as follows:

\[
\rightarrow (\downarrow (cb, c, /220), tb, p, ob, rg)
\]
Construction coding, as given above, tries to make full and detailed descriptions, yet some information is lost, for example, the size of the construction element. It is impossible to encode all the information of a house into just one sentence of coding. Thus, the messages such as quantity, distance, angle, size, etc., may be particularly recorded as "specifiers".

3. Coding of the Original House Constructions

An artisan’s understanding of house construction is not only from element to element, but elements combined into several modules, then module by module. The construction of Ho can be considered as a complete unit, encompassing the house from foundation to roof. It can also be divided into several parts. Construction coding can be drafted all at one time or in several phases with coordination at the end.

Consider a house with three parts: body (under roof truss), head (roof truss), and tie (connection between roof trusses). In some cases, head and tie cannot be separated and thus are considered as one. Fig.4. shows five different types of Malay house construction systems, coded with body, head and tie respectively, and then integrated into one.

(Fig.4.a) Truss is formed with a tie beam (tb), post (p), and oblique beam (ob). The code is trs.

(Fig.4.b) Two ridge pieces (rg, rg') connect each truss and form the head. The code is 2rg.

With one Es, as Fig.3.b shows, construction coding from c₂ to c₁ is:

Coding step 6: Four columns (c₂) abut on a cross beam (cb₂). The coding is:

\( \perp (cb₂, 4c₂) \)

Coding step 7: Four oblique beams (ob₂) penetrate four columns (c₂). The coding is:

\( \bowtie (\perp (cb₂, 4c₂), 4ob₂) \)

Coding step 8: Four oblique beams (ob₂) abut on four tie beams (tb₁) of Ho. The coding is:

\( \perp (4tb₁, \bowtie (\perp (cb₂, 4c₂), 4ob₂)) \)

If the element number were omitted, Es coding would be as follows:

\( \perp (tb₁, \bowtie (\perp (cb₂, c₂), ob₂)) \)

To enable the construction details to be more concise and easier to comprehend, the coding focuses on three elements (ob₂, tb₁, c₂), which clarify that ob₂ connects tb₁ (Ho) and c₂ (Es). Ob₂ abuts on \( \perp \) tb₁, ob₂ penetrates c₂(\( \bowtie \)), the coding is:

\( ob₂ \perp tb₁, \bowtie c₂ \)

Body  | Head  | Tie  |
-----|-------|------|
\( \perp (cb, c) \) | \( \perp (tb, \bowtie (p, ob)) \) | \( \perp (rg, p) \) |
\( \times (\perp (cb, c), \perp (rg, \perp (tb, \bowtie (p, ob)))) \)

Fig.4.a Eo Construction Coding "trs(bdg)"

Fig.4.b Eo Construction Coding "2rg(bdg)"
(Fig.4.c) Post (p) (penetrated by ridge piece (rg)), sitting on tie beam (tb), with two oblique beams (ob) on top, combining head and tie. Ridge piece (rg) move from top end to near the middle of the post. The code is mrg. \(\downarrow (\perp (tb, p), rg, ob) = mrg\)

(Fig.4.d) Ridge piece (rg) is placed on the top of post (p); rafters on the top of ridge piece directly, without oblique beam (ob). The coding is rfp by using rafter (rf) and post (p). \(\times (\perp (tb, p), rg, rf) = rfp\)

(Fig.4.e) Head is without post, oblique beam and ridge piece, with only a rafter (rf). The coding is rf. \(^{\wedge} (rf, rf) = rf\)

The body coding "\(\downarrow (cb, c)\)" in Fig.4.a, 4.b and 4.c, is analogised as the "bridge"; and another body coding "\(\downarrow (cb, c), tb)\)", in Fig.4.d and 4.e, is as the "box". They can be respectively coded as:

\(\downarrow (cb, c) = bdg\)
\(\downarrow (cb, c), tb) = box\)

In Fig.4.a, considering the feature of "trs" crossing "bdg", Ho can be edited as \(\times (bdg, trs)\), which can be further edited to \(trs (bdg)\). "Trs" is a construction coding module, as well as a symbol of relation. Five Ho construction codings can be simplified as shown in Table 2.:

**Table 2. Construction Coding Modules of Ho**

<table>
<thead>
<tr>
<th>Body</th>
<th>Head+Tie</th>
<th>Two kinds of coding 'Body+Head+Tie'</th>
</tr>
</thead>
<tbody>
<tr>
<td>bdg</td>
<td>trs</td>
<td>(\times (bdg, trs)) trs (bdg)</td>
</tr>
<tr>
<td>bdg</td>
<td>2rg</td>
<td>(\times (bdg, 2rg)) 2rg (bdg)</td>
</tr>
<tr>
<td>bdg</td>
<td>mrg</td>
<td>(\times (bdg, mrg)) mrg (bdg)</td>
</tr>
<tr>
<td>box</td>
<td>rfp</td>
<td>(\times (box, rfp)) rfp (box)</td>
</tr>
<tr>
<td>box</td>
<td>rf</td>
<td>(\times (box, rf)) rf (box)</td>
</tr>
</tbody>
</table>

4. Coding of the Encroachment Constructions

4.1 Es: Encroached Semi-house

Es serves mainly to establish an oblique roof between the original house (Ho) and additional columns (c₂). Connecting elements are the oblique beam (ob₂) or rafter (rf₂). In the case of an oblique beam, the construction process will be columns \(c₁\) \(\rightarrow\) oblique beam \(ob₂\) \(\rightarrow\) purlin \(pl₂\) \(\rightarrow\) rafter \(rf₂\) \(\rightarrow\) roofing.

The coding of Es is explained in the first diagram in Fig.5. Ob₂ abuts on \(c₁\) and crosses \(c₂\). Ob₂ is connected with \(\downarrow (c₁, ob₂)\) and \(\times (c₂, ob₂)\) on \(c₁\) and \(c₂\) sides respectively. It can be coded as \(ob₂ (\downarrow c₁ / \times c₂)\).

In this study, 15 types of Es in Malay house cases are shown in Fig.5. If Ho has a "bdg" construction, Es is usually included in the construction system to form the main house. With a "box" construction, however, a house without Es is often seen. The most common Es construction is \(ob₂ (\downarrow tb / \times cb₂)\).
4.2 Esg: Encroached selang

Esg (encroached selang) includes the gable roof between Ho and sub-house (H_1), forming a selang (corridor). In Fig.6.-a, the connecting beam (cb') connects Ho and H_1. Underneath the cb', columns can be settled. The corridor can be lengthened, which is the conceptual expansion of box. If the columns are not in alignment, another free column (c_2) is settled to connect with cb'. (Fig.6.-b)

4.3 Eh: Encroached House

The construction of an encroached house (Eh) includes the gable roof, with a small volume attached on Ho. Three Eh types are collected in this study. In Fig.7.-a, Es is ob_2 (-tb/×c_2). Eh extends from the Es. Cb_2 and c_2 extends to form bdg_2 (┴(cb_2, c_2)). By placing trs' on the top of bdg', Eh is formed.

Fig.7.-b shows a smaller box connected to the original box. The coding is rf'(box'), only the connecting tb' can be shorter. In Fig.7.-c, purlins (pl') extend to the side and connect with the gate (gte) frame. The coding of Eh is pl'(gte).

5. Analysis of Malay House Grouping with Construction Coding

Starting with five construction systems of original houses (Ho), one case for each original house type is chosen to demonstrate construction coding. Each chosen case is composed of a house grouping, and the analysis is thus conducted with the construction coding of the original house (Ho), encroached semi-house (Es), encroached house (Eh), encroached selang (Esg), and sub-house (H_1, H_2). The connection of a house grouping and its construction system is interpreted clearly from the analysis as follows:

a) trs(bdg): Rumah Dato'muda Haji Omar Bin Lajim, Negeri Sembilan, built in 1747 (Ahmad, et al., 1997)

Located in Negeri Sembilan in the mid-west part of peninsular Malaysia, and with a trs(bdg) construction system, this original house (Ho) forms the main house by adding an encroached semi-house (Es) in the front and back, serving as the main living space. Two additional encroached houses (Eh_1, Eh_2) are attached to the main house. The back sub-house, coded as H_2, serves as the kitchen. The overall house construction analysis and coding are illustrated in Fig.8.
b) 2rg(bdg): Rumah Itam Bahak, Perak, built in 1819 (Mohamad, et al., 1978)

Located in Perak in the mid-northern region and with 2rg(bdg) as its construction system, this original house (Ho) forms the main house by adding Es, to both its sides, with the back house coded as H₁. Encroached selang (Esg) connects Ho and H₁. The overall house construction analysis and coding are shown in Fig.9.

Ho = 2rg(bdg),
Es₁ = rf₁(×pl/×cb₂),
H₁ = rf(box),
Esg = cb'(┴c₁/┴c₂),
Es₂ = rf₂(×pl/×cb₁)

Fig.9. House with 2rg(bdg) Construction

c) mrg(bdg): Rumah Bumbung Panjang Puan Rosmina, Perlis, built in 1940 (Ahmad, et al., 2002)

Located in Perlis, in the northeastern part of peninsular Malaysia, on the border between Malaysia and Thailand, this original house (Ho) has an mrg(bdg) construction system. Its main house is formed with the additional Es on three sides. An extra Eh is arranged at the front entrance, and the side house H₁ serves as the kitchen. The roof ridges of Ho and H₁ are both parallel to the direction of the entrance. The overall house construction analysis and coding are shown in Fig.10.

Ho: mrg(bdg),
Es₁: ob₂(┴cb₁/c₂),
Eh: pl'(gte)
H₁: rf(box),
Es₂: rf₂(×pl/×cb₁)

Fig.10. House with mrg(bdg) Construction

d) rfp(box): Rumah Lebei Ali, Kelantan, built in 1892 (Marzumi, et al., 1993)

Situated in Kelantan in northeastern peninsular Malaysia and with rfp(box) as the construction system, two original houses (Ho) form the main house to accommodate the main living space. Es is arranged in the front of the main house first, and then Eh is added accordingly. The back house H₁ serves as a kitchen. Overall house construction analysis and coding are shown in Fig.11.

Ho = rfp(box),
Es = rf₂(┴sr/×cb₂)
Eh = rf₃(box),
H₁ = rfp'(box)

Fig.11. House with rfp(box) Construction

e) rf(box): Rumah Haji Daeng Malasah, Johor, built in 1914 (Sarjan, et al., 1986)

Situated in Johor in the southern portion of peninsular Malaysia and with the rf(box) as its construction system, this original house (Ho) forms the main house with an additional Es on one side. H₁ and H₂ are attached at the side and back respectively. Esg connects Ho, H₁, and H₂. The overall house construction analysis and coding are illustrated in Fig.12.

Ho = H₁ = H₂ = rfg(box)
Es = ob(┴c₁/×cb₂)
Esg₁ = Esg₂ = cb'(c/c)

Fig.12. House with rf(box) Construction
The result of the coding analysis of the 95 Malay houses is recorded in Table 3. The most common construction system of the original house (Ho) is trs(bdg), while rf(box) is less seen, and 2rg(bdg) and mrg(bdg) are seldom adopted.

Table 3. Distribution of House Construction in Malay Peninsula

<table>
<thead>
<tr>
<th>Location</th>
<th>Head+Tie</th>
<th>Body</th>
<th>2rg</th>
<th>mrg</th>
<th>rfp</th>
<th>rf</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Kuala Lumpur</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Negeri Sembilan</td>
<td>14</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Melaka</td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Pahang</td>
<td>5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N Perak</td>
<td>1</td>
<td>4</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N Kedah</td>
<td>2</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N Penang</td>
<td>7</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N Perlis</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE Terengganu</td>
<td>3</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE Kelantan</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S Johor</td>
<td>2</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total 95</td>
<td>47</td>
<td>4</td>
<td>2</td>
<td>8</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

C: central region of Peninsula Malaysia, N: northern region, NE: northeastern region, S: southern region.

The result of a combined observation on the construction of five Ho and all Es is reflected in Table 4. The Ho construction coding and Es coding of each case are recorded, as well as cases without an encroached Es and with an encroached Esg. It shows that all five Ho construction systems have the possibility of having an encroached Es. A Ho without an encroached Es can only be found in an rfp(box) and rf(box). Esg is adopted by most Ho construction systems, except the mrg(bdg).

Table 4. Combined Analysis of Es, Esg and Ho Coding

<table>
<thead>
<tr>
<th>Encroachment</th>
<th>Original house construction coding</th>
<th>Ho construction coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>trs(bdg)</td>
<td>2rg(bdg)</td>
<td>mrg(bdg)</td>
</tr>
<tr>
<td>bdg</td>
<td>bdg</td>
<td>bdg</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
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<td>1</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>ob, (+c₁ / X c₂)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>rfp(box)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>rfp(box)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>rfp(box)</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>rfp(box)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Without Es</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Without Esg</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total 95</td>
<td>46</td>
<td>6</td>
</tr>
</tbody>
</table>

By scrutinising Table 3, and Table 4., it can be observed that trs(bdg) and rf(box) are widely adopted in Ho construction in peninsular Malaysia, but trs(bdg) and rf(box) have their own matching Es constructions, while rf(box) often comes without Es. Even the scarce 2rg(bdg) and mrg(bdg) constructions can have their own specific Es. A "matching" relationship seems to exist between Ho and Es. The reason should not be attributed to exclusiveness of construction, but is more likely to be due to artificial factors such as artisan habits and regional construction traditions.

6. Conclusion

6.1 "Bridge" and "Box"

The construction system of a Malay house in the Malay Peninsula is composed of the original house (Ho) and encroachment (E). The Ho construction system can be categorized into "bridge" and "box". The difference between bridge and box systems lies in the function of the tie beam. In the bridge system, three or four columns and a cross beam form the bridge. A tie beam lies across two sets of bridges, holding the post to form the roof construction, so the tie beam is a part of the roof construction. Whereas in the box system, the tie beam, cross beam and column form the box together, then rafters form the roof directly on top of the box. Instead of a part of the roof construction, the tie beam belongs to the supporting system. Bridge and box are supporting systems with subtle differences, but the roof systems on top of them vary significantly. The two main systems are derived from five sub-systems (Fig.13.).

Fig.13. Classification of a Ho Construction System

6.2 Generality and Particularity

As for marking the locations and Ho construction types of the 95 house cases on the map of the Malay Peninsula, the generality of trs(bdg) and rf(box) will be reflected. 2rg(bdg), mrg(bdg) and rfp(box) only appear in some specific areas such as Perak, Perlis, and Kelantan (see Fig.13.). These special Ho construction systems happen to be situated in the northern part of peninsular Malaysia. The possible reason for this coincidence needs to be explored further.

6.3 Relation of Construction, Form and Space

The roof forms of a bridge construction system mostly consist of a gable roof with a steep slope. The main house (Ho+Es) and sub-house (H₁, H₂,..) are all independent and with parallel roof ridges. The younger box construction system introduces the pitch and hip roof. With a hip roof, the slope tends to be gentler, having no vertical sides, and the main house and sub-house begin to combine together, or we see that the main house form begins to show variation.

The prerequisite of a bridge construction system is the formation of two bridges that support the roof.
Thus single house volume is decided by the two sets of bridges and a rectangular house body is formed. The formation of a box construction system is much more flexible, as the box can form a polygon or L-shape. Furthermore, the rafter-formed roof is much more flexible than an oblique-beam-formed roof. Therefore, the body of the house and the roof of a box construction system possess more freedom of spatial layout and more constructional variations than those of a bridge construction system. (Fig.14.)

Notes
1. KALAM Centre and Department of Architecture at Universiti Teknologi Malaysia (UTM) has undertaken the "Measured drawing programme" since 1976. The programme has collected more than 350 cases, including traditional houses, palaces, mosques, public buildings, commercial buildings, and institutes.
2. The aim of coding is to reveal the rules of compositional elements and relations of houses which can be applied in house grouping, spatial layout, and construction system. The purpose of specifiers is to "quantify" any meaningful delicateness. Relevant data of the houses have to be listed as "specifiers." Specifiers of construction could be roof slope, truss contraposition, column length, span distance, member section size, column-ground connection, etc. The coding of compositional elements and relation tend to reveal the structural significance easily. The specifiers, though details, might also disclose important information and unveil the significance of the construction, but this belongs to another study.

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