

Design Issues in Expansion and Modification Process of Detached Houses in Bangkok



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Abstract

Purpose / Context - This research was conducted to find better solutions of expansion and modification process of detached houses in Bangkok, alongside with the improvement of existing structures, in order to provide design possibilities which can accommodate future modifications.

Methodology / Approach - This paper categorised existing detached house structures into 3 different categories: 1. Interlocking and joint; 2. Masonry and concrete casting; and 3. Prefabricated load bearing wall and modular unit. This paper analysed 30 randomly selected expansion projects to detached house units in Bangkok. It used questionnaire surveys involving parties in the expansion process in order to investigate pros and cons of existing structure toward expansion projects.

Results – The study reveals the prefabrication system has the most difficulties with the future modification due to the fact that there is inflexibility of the structure itself. On the other hand conventional systems such as 1. interlocking and joint and 2. Masonry and concrete, provide more flexibility in modification. However, house owners still need to consult with engineers because the quality of long-term expansive construction requires expertise.

Key Findings / Implications – The research focuses on the advantages and disadvantages of various existing structures of detached houses towards modification processes.

Originality - The research contributes to improve current expansion and modification of detached houses in Bangkok. This study also states the potential status of structure, expanding material and modification construction process.

Keywords - house expansion, modification, prefabrication, customisation



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1. Introduction

Bangkok is the capital city of Thailand. There are 5,692,284 city occupants and 2,746,944 housing units (Bangkok Official Statistics Registration Systems, 2015) with incessantly residential growth rate. Rural citizen from other provinces and foreigners moved here for better life opportunities and better living condition, this phenomenon affects density of Bangkok. It testifies by elevating of land price around 3 - 4% for 2 consecutive years in 2013 to 2014 (Pornchokchai, 2014) with supplemented by excessive condominium, apartment, town home and developed housing projects that emerged around mass transit stations (BTS and MRT) and suburban areas. Limiting space and expansive habitants forced expansion and modification to the detached house.

Another factor derived from customisation of tenants that intended to redesign the space from existing developed housing project and modified a house to conform user's lifestyle and satisfaction. To understand the diversity of house structures, this research conducts an analysis of existing detached house structure into 3 different categories. Under the aspect of construction methods, Figure 1 shows various materials and technique of construction.

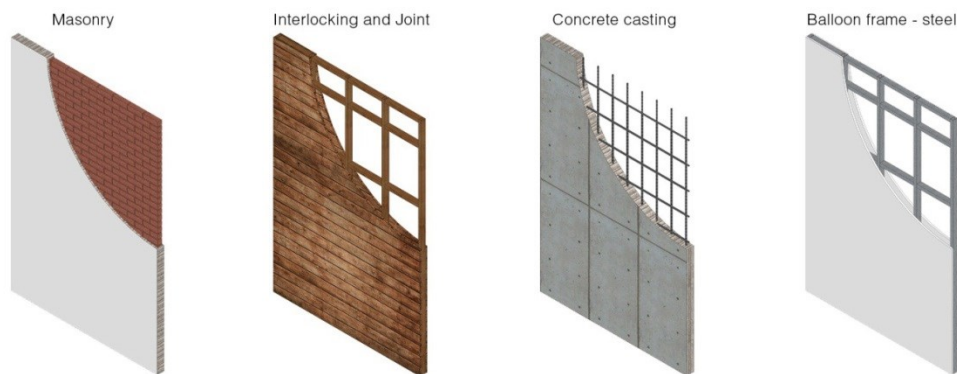


Figure 1 Various materials and techniques of construction

1.1 Interlocking and Joint

The origin of detached house in Bangkok using natural wood as main materials that can harvest around site area as local material, surprisingly semi-prefabricating system have been used extensively by applied to house's structure and wood panels (Translated in Thai as ฟาก or Fa eg. Fa Pakon, Fa Saibua) using interlocking and joint to form a house which can disassemble for purpose of relocation.

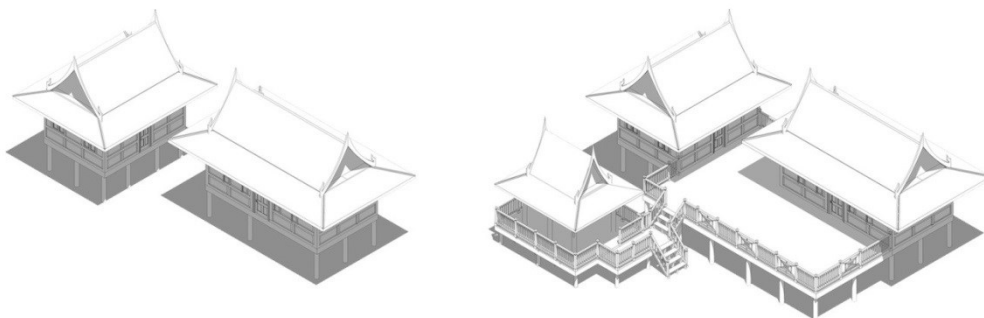


Figure 2 Traditional Thai house - terrace expansion (original 3D model by John)

The traditional Thai house is normally built with three notable characteristics: 1. Elevated floor; 2. Steep pinch roof with long overhangs; and 3. Large open terrace (Chalermwat, 2001). The characteristic and materials of traditional Thai house benefits the modification process with flexibility in expanding function and utilise space. For example, Figure 2 shows a terrace to connect house units together. However traditional Thai house is not the only significant example of interlock and joint category but it shows clear evidences of combination between materials and construction technique that support further modification.

1.2 Masonry and Concrete casting

With development of construction materials, masonry and concrete casting have been broadly used to construct every scale of architecture projects including house and housing projects in Bangkok. The masonry technique uses bricks or stone units laid and bound together by mortar: it is generally a highly durable form of construction (Almansa, 2010). On the other hand, the casting technique is performed by pouring concrete into formwork which is reinforced with steel bars to strengthen a structure.

In terms of modification, this category is still questionable on adaptive ability and flexibility for modification process, due to materials and structural aspects.

1.3 Prefabricated (Load bearing wall) and modular unit

Prefabrication has been around in architectural industry for a long period of time. This system has been used by Great Britain's colonisation in India, Middle East, Africa, Australia, New Zealand, Canada, and America. Since the British were not familiar with local materials, components were manufactured in England and shipped to the various locations worldwide (Smith, 2009). Manning cottage in 1624 was one of the earliest evidence of prefabricated housing, sent to a fishing village of Cape Anne (Massachusetts) (Areiff, 2002), shown in Figure 3.

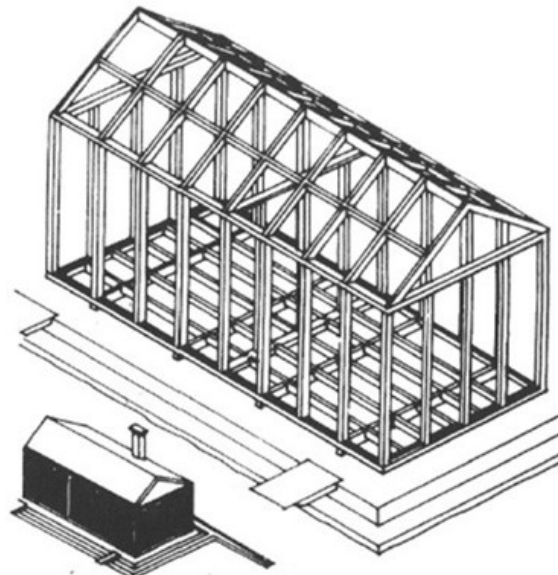


Figure 3 Portable Colonial Cottage (Manning) manufactured in Great Britain and shipped to colonies throughout the world. Credit: Ryan E. Smith

On the other hand, prefabrication in the east was adopted by post-war era especially in Japan to compensate for devastated housing in World War 2 (Oshima, 2008). In Thailand, the prefabricated system has been selected prominently by housing development due to advantages of the system: save construction time, maximise profit, minimum construction waste, and for safety procedure. A majority of prefab systems for housing units are pre-cast load bearing walls and pre-stressed concrete slab. This type of system does not require a beam to support vertical load but on the other hand pre-cast units face some difficulties, from tailor-made design and flexibility to adaptability for any future development.

Sustainable development and sustainable construction have been increasingly concern throughout the world (Kibert, 1994). Prefabricated systems can minimise time and materials for construction process by using off site factory but in contrast the system seems to be inflexible usability in terms of adaptation and modification.

The following section evaluated satisfaction and opinions of involving parties in modification process with expectation to develop sustainable and optimise house modification technique along with improve existed structural system adaptive ability to support future expansion and modification.

2. Research method

This paper categorised existing detached house structures into 3 different categories: 1. Interlocking and joint; 2. Masonry and concrete casting; and 3. Prefabricated load bearing wall and modular unit. The purpose is to contemplate future development with suitable construction techniques. Data was collected from 30 house expansion projects from detached house units in Bangkok. These study subjects are selected alongside with the questionnaire survey from people who are involved with the construction process. The questionnaire surveys are administered with 1. Detached house owners; 2. Architects/Engineers; and 3. Contractors, in order to figure out the pros and cons of the existing structure toward the expansion process. Empirical evidence has been gathered to support this argument, by giving advantages and disadvantages of existing structures toward expansion process. Figure 4 shows the overall research method in diagrammatic form

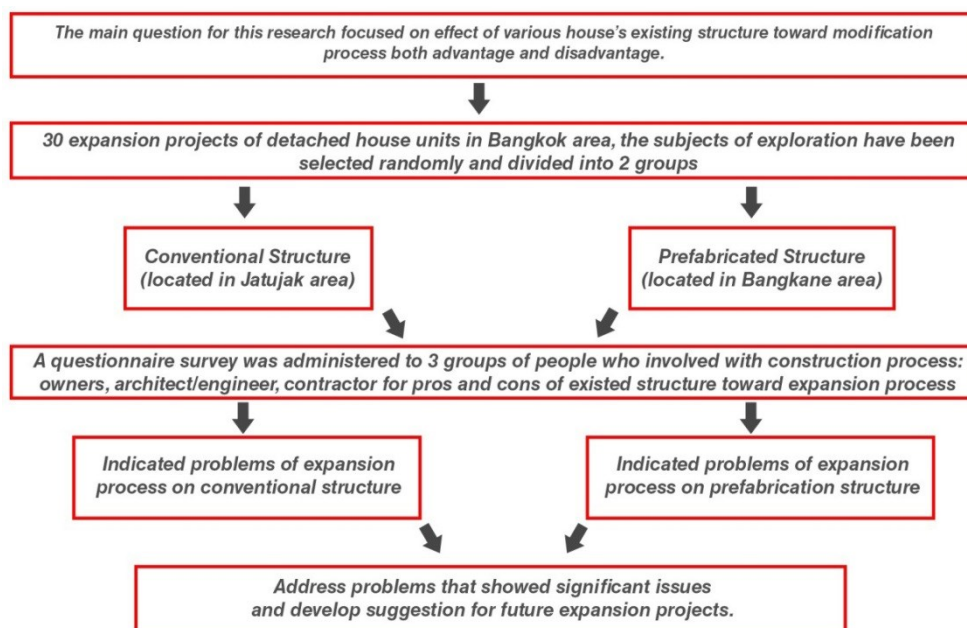


Figure 4 Method of research process

The main topics of questionnaire survey focused on function of expansion area, construction material of expansion area, cost, timing, and opinion on existing structure toward expansion process (limitation, difficulty, advantages, and disadvantages). The subjects of investigation have been selected randomly from Jatujak district and Bang-kane district which considers as periphery areas of Bangkok that develop through suburbanisation, these locations consist copiously with detached house and housing units that developed by private owners and developers.

Basically, the 3 type of structures have been categorised by specified criteria of characteristic, material and technique of construction. However, the study methodology was changed a little due to the absence of Interlocking and joint subject these days. This survey will focus on Masonry /concrete casting (Conventional) and Prefabricated load bearing wall /modular unit (Prefabricated) only. Most of the prefabricated sites were designed and constructed by a developer company by using a load bearing wall system that has been custom-made according to architectural designs, prefabricated from the factory and assembled on the site. Some subjects were built from steel modular structure. Refer to the appendix for site locations.

3. Data Analysis

The analysis section will have dedicated on 5 main categories: 1. functions of expansion area; 2. construction material of expansion area; 3. Cost; 4. Timing; and 5. Opinion on existing structure toward expansion process (limitation, difficulty, advantages, and disadvantages). A data in each category will divide into 2 groups; existing conventional and prefabricated structure systems to demonstrate similarity and dissimilarity by converting raw data into numerical (percentage) with supportive arguments and empirical evidences to compare and magnify an outcome.

3.1 Function of expansion of area

Table 1 shows majority in trend of expansion for conventional construction which owners tend to expanded storage space (30%) far beyond other functions. On the other hand, house owners who chose to use prefabricated construction, expanded living room area (40%) following by storage space (33.3%). Due to the fact that developer and architect provided inadequate space for following function to reach owners' satisfaction level but the outcome cannot be summarised as a whole, for future trend of future expansion projects. With the needs of the owner were diverse and dissimilar from each other. This show some significant problems from and early stage of design in prefabricated category that architect cannot provide enough living room and storage spaces for the users.

Table 1: Functions of expansion area

Functions	Conventional Structure	%	Prefabricated Structure	%
Garage	3	15%	0	0%
Storage	6	30%	5	33.3%
Kitchen	3	15%	2	13.3%
Maid Room	2	10%	0	0%
Bedroom	2	10%	2	13.3%
Living room	3	15%	5	40%
Wash area	1	5%	0	0%

3.2 Construction material of expansion area

From Table 2, steel played a dominant role for expansion material in conventional category since it's required less time to construct compare to reinforce-concrete that required setting period (28 days), good quality of wood become expensive due to abbreviated and insufficient

supply. Most of the time expansion process with existing conventional structure allows new expansion part to attach directly on existing structure and form simultaneously effect to the houses.

On the other side, majority of expansion process on prefabricated structure used load bearing wall to construct expansion area along with project construction period (construction by developer) due to limitation of load bearing wall structure which cannot be penetrate and demolish selected area because all of above process will decrease structure performance. Another technique that been used by house owners was to build detached expansion steel structure (33.3%) from existing to avoid association with load bearing wall

Table 2: Construction materials of expansion area

Materials	Conventional Structure	%	Prefabricated Structure	%
Reinforced Concrete	4	26.6%	0	0%
Brick & Mortar	3	20%	3	20%
Wood	2	13.3%	0	0
Steel	6	40%	5	33.3%
Concrete (LBW)	0	0%	7	46.6%

3.3 Cost

Table 3 shows average cost of expansion process. Conventional and prefabricated categories cost average around 200,000 - 300,000 THB, however there are 5 cases in prefabricated category that cost less than 100,000 THB. It indicated the adaptability of existing prefabricated structure in term of scale and adaptive ability compare to expansion on conventional structure.

Table 3: Cost for expansion process

Budget	Conventional Structure	%	Prefabricated Structure	%
500,000 THB	2	13.3%	1	6.6%
400,000 THB	2	13.3%	1	6.6%
300,000 THB	2	13.3%	4	26.6%
200,000 THB	5	33.3%	4	6.6%
100,000 THB	4	26.6%	0	0%
90,000 THB	0	0%	2	13.3%
60,000 THB	0	0%	2	13.3%
40,000 THB	0	0%	1	6.6%

3.4 Timing

Time is one of the most crucial factors for expansion process because delay construction period can affect addition cost for owners and contractors. From the Table 4, average timing for conventional category used 3 months (33.3%) for expansion process and maximum period was 6 months (6.6%). In contrast, prefabricated house owners tend to expand their space along with developer (53.3%) to avoid and minimise chances of future expansion due to limitation of load bearing wall. Average of detached structure on prefabricated category used 2 months (33.3%) for expansion process.

Table 4: Construction period of expansion process

Month(s)	Conventional Structure	%	Prefabricated Structure	%
6	1	6.6%	0	0%
5	2	13.3%	0	0%
4	2	13.3%	0	0%
3	5	33.3%	1	6.6%
2	3	20%	5	33.3%
1	2	13.3%	1	6.6%
During Construction	0	0%	8	53.3%

3.5 Opinions on existing structure toward expansion process (limitation, difficulty, advantages and disadvantages)

One of the significant factors that affect expansion process was characteristics of existing prefabricated load bearing wall. It refuses any expansion structure to attach on. Even more, redesign and relocation of windows and doors cannot be done, there is lack of modification flexibility. Conversely, detached expansion structure avoid occurrence of fracture and crack on joint location between existing and expansion structure, on the other hand, expansion on conventional houses facing fracture and cracks on a joint due to unequally used of shorter piles system from existing piles to reduce cost and time but it resulted incongruous sunken rate between existing and expansion structure.

Table 5: Advantage and disadvantage of 2 construction methods

Structure	Advantages	Disadvantages
Conventional Structure	<ul style="list-style-type: none"> - Flexibility of existing structure support attach expansion - Acquainted system (do not require expert) 	<ul style="list-style-type: none"> - Attached expansion structure may cause crack between joint
Prefabricated Structure	<ul style="list-style-type: none"> - Detached expansion structure 	<ul style="list-style-type: none"> - Incongruity design - Redesign and relocation of windows and doors cannot be done due to limitation of load bearing wall system

Following are some comments from owners, architects, and contractors to demonstrate disadvantages from prefabricated system toward modification process.

Difficulty from existed modular structure and load bearing wall systems:

[T]his house use SCG HEIM modular housing system with expansion process; it faced some difficulty due to limitation of existing structure. Expansion unit have to detach from existing structure. - Owner of P01

[W]e cannot relocate existed door and window location due to load bearing wall system which we consider this problem as adaptive ability of the house. - Owner of P05

[I]f our customers want to redesign their property it will be much easier and convenient for owner, architect, engineer and contractor if they redesign before construction stage. It will be risky to damage existing structure for later expansion process. - Architect of P15

[I]t was very difficult when we have to dealing with prefabricated house because it has so many limitations to existing structure. On the other hand, detached system is the most suitable for this kind of expansion. - Contractor of P08

Some project facing some difficulty on timing and budget:

[L]imited time and budget also become significant problem for this project. – Contractor of P05

Law and regulation of expansion process is also one of crucial factors to avoid illegally action because it can cause demolition after project completions, which simply waste time and money. Figure 5 shows piles selection for expansion process.

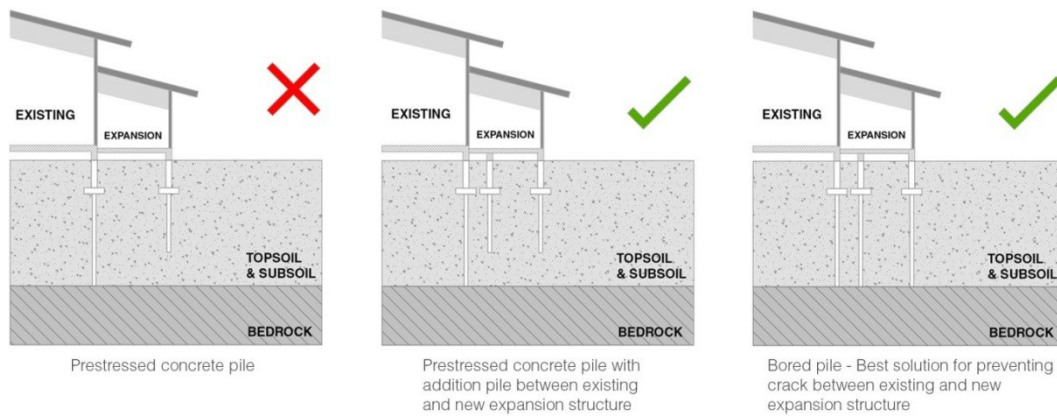


Figure 5 Piles selection for expansion process

Another factor that effect quality of expansion works come from insufficient professional knowledge on expansion process, as resulted that majority of house owners often hired only contractor to complete the job who cannot compute structure loads and stability of expansion structure which normally causing cracks between old and new structure shows in Figure 6, the worst case can affect failure collapse of a structure.

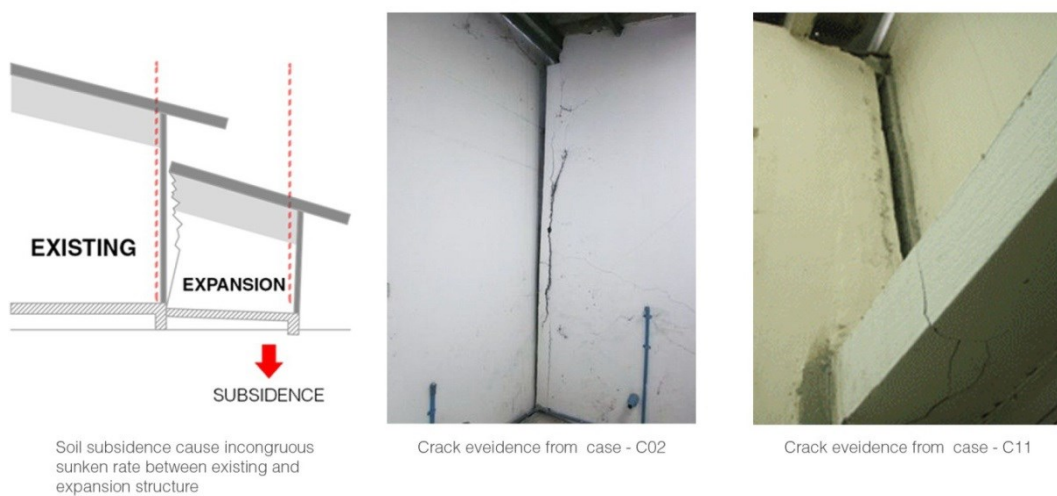


Figure 6 Empirical evidence of structure failure

4. Suggestions

There are 3 main suggestions from data analysis to improve the expansion process.

1. Develop a prefabricated system to support future expansion but allow changeable and relocation of wall panels without affecting the building structure. Figure 7 shows the potential of the redesign prefabrication system that allows some modified area on the panels.
2. Consult with experts and professionals such as architects and/or engineers not just in term of design and structure but to be legitimate to law and regulation.
3. Make sure to use appropriate piling system for expansion process to avoid imperfection incident in the future.

5. Conclusion

Structural expansion seems common for detached house to maximise habitat space to owners satisfy level. In contrast, the process requires profound attention in order to create long-term practical design and ability in modification. It needs cooperation and interaction among 3 parties; house owners, architects or engineers and contractors to maximise work performance and capability outcome.

There are some flaws to improve on existing structure methods especially prefabricated system, it can be revise in term of design stage which allow users to adapt and provide more flexibility to structure. By fixing the problem from its origin, prefabricated system can perform perfectly from construction period. While most of the previous researches have tried to indicated only advantages of prefab system. With sustainable system thinking as its priorities were to reduce cost, time and control construction quality but at the end, house owner/builder can consider dynamic matter that have to adapt and changes according to users' needs and requirements.

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7. Appendix

Figures 10 and 11 show the site locations for this research. Most of the prefabricated sites were designed and constructed by a Developer Company by using a load bearing wall system that have been custom-made according to architectural designs, prefabricated from the factory and assembled on the site. Conventional structure sites are indicated by red and coded with 'C' follow by cardinal numbers. Prefabricated existing structures are indicated by yellow and coded with 'P'.



Figure 10 Site location 1



Figure 11 Site location 2