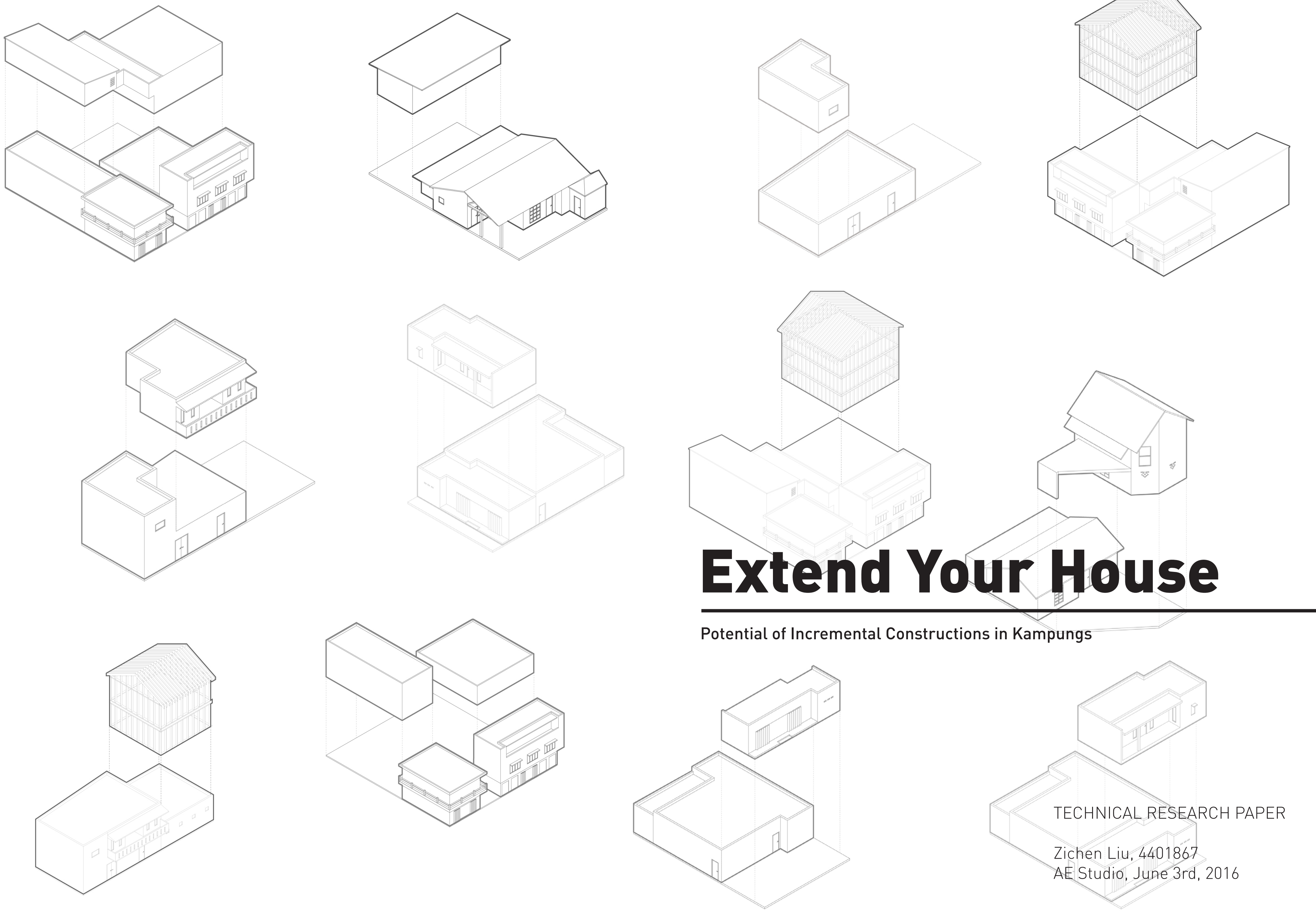

Extend Your House

Potential of Incremental Constructions in Kampungs

TECHNICAL RESEARCH PAPER

Zichen Liu, 4401867
AE Studio, June 3rd, 2016

ABSTRACT

How to develop incremental strategies for kampung dwellings with a suitable construction method based on existing kampung context?

This research paper answers the questions in two aspects, the existing kampung context is about self-construction and the trend to extend vertically from or above the roof of existing houses. This is a process of requalification of existing situation by local people spontaneously. From field research, the needs and problems of on-going incremental constructions are formulated. In order to find the suitable construction method, prerequisite for the selection is firstly decided. On this basis, light wood framed construction is proposed to help the incremental constructions from the roofs for its light weight, ease of construction and local availability. Moreover, the light wood framed constructions are researched in different systems of component: foundations, floor frames, wall frames and roof frames. The joints of making certain component are listed and compared with each other under prerequisite and some other criteria. In the end, the research question becomes: how to build incremental constructions on the existing house roofs with light wood framed constructions? And all the alternatives of different components constitute a suitable solution of light wood framed constructions on site with specific requirements.

Key words
Incremental construction, Kampung requalification, Light wood framed construction, Existing situation

Zichen Liu
4401867
Design Tutor: Monique Smit
Research Tutor: Pieter Stoutjesdijk

Architectural Engineering Graduation Studio
Master of Architecture, Urbanism and Building Sciences
Delft University of Technology

Date:
June 3rd, 2016

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INTRODUCTION

Housing Issues in Indonesia

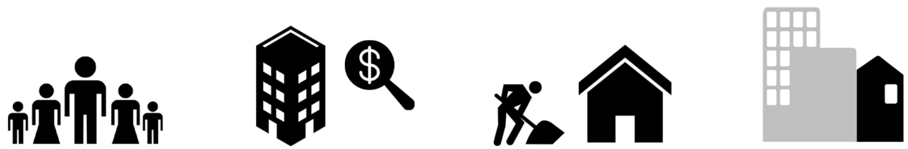
Indonesia, with a population of over 250 million, has been experiencing rapid urbanization in the last few decades. This rapid urbanization has caused many problems in Indonesian cities, urgent one of which is to provide adequate and affordable housing for millions of the urban poor. It is predicted that every year more than one million housing units should be built to meet Indonesia's housing demand (Herlianto, 1993). However, the issue of housing provision is much more complicated. On one hand, there are many supply problems in the formal housing sector, on the other hand, a majority of the urban poor cannot afford to buy housing provided by either the public or the private sectors due to their low and unstable income. This condition forces them to various individual solutions including self-built inappropriate houses and squatting in slums and squatter settlements (Sudarmo, 1997; Tunas and Peresthu, 2010).

In Indonesian cities, most poor residents live in spontaneous informal settlements referred to as kampung. Kampungs are scattered throughout the city and have substandard infrastructure, small plots of land for each dwelling and low quality of building structure and materials. Most of the dwellings in kampungs are constructed gradually by the residents from permanent and non-permanent materials depending largely on what the residents can afford (Tunas and Peresthu, 2010). It is true that many kampungs face pervasive problems of high density, poor living conditions, and poor infrastructure and public facilities. However, in general, kampong have met the basic needs of millions of urban dwellers with the flexibility and the variety of housing arrangements, furthermore, the social environment of the kampong has also enabled new incoming migrants to adapt incrementally to urban lifestyles (Setiawan, 1998). In order to solve the housing problems in Indonesia, besides providing more newly-built affordable housing, interventions and upgrades of existing kampungs will surely play important roles in Indonesian cities.

Incremental Housing Strategy

Interventions in informal settlements are a subject of debate throughout the world seeking how to integrate these areas in the cities that surround them. The interventions arise from many types of possible approaches, identifying two distinct groups by their initial nature. One based on total demolition and complete replacement of the area and the other in the transformation and requalification of these clusters through qualification strategies of the pre-existing. Following this last strategy emerges the Incremental Housing as a solution to a flexible intervention to the real needs of these areas. (Neves and Amado, 2014)

As Neves and Amado cited from Portas and Silva Dias in the study "Incremental Housing", the main quality of incremental housing is the capacity to build a system based on simple rules of design and execution, able to define the first phase of installation, promoting qualitative evolution of the home environment and others areas, essential to next inhabitant's sociocultural evolution (Neves and Amado, 2014). Based on the concept of kampung requalification, the overall design question is "How to develop incremental strategies for kampong dwellings but also set rules to promote a well-organized community in the future?" Correspondingly, the technical research question is naturally formulated, "How to build incremental constructions based on existing Kampung context?"



Large population | Formal housing problem | Self-construction | Incrementality

RESEARCH METHODS

The research is mainly about two parts, the first part focuses on local incremental constructions. Before going to the site, case studies of incremental housing projects are collected. Questionnaires are prepared for interview with local people. During the field trip, five houses in representative locations are mapped in group research and three aspects of the incremental constructions are studied: Social-economical aspect, about why people extend their houses; Spatial-typological aspect, about what function are extended for; Material-technical aspect, about what kinds of building materials and constructions are used. All the cases are illustrated to mark the timeline of evolution. Based on these input, the real needs and hidden problems of incremental constructions are generated, which will serve as the prerequisites for the second part.

The second part started from field research and mainly based on literature study, especially focuses on reproducing the drawings. Through careful analysis of field trip results and literature references, the logic line is formulated to find a suitable solution. Then, detailed drawing research illustrates alternatives for each aspect of the solution, this accounts for a large proportion of the results, three books are mainly referenced for the drawing: Details for conventional wood frame construction" (2001) and "Wood frame construction manual for one- and two-family dwellings" (2015) by American Wood Council, "Building construction illustrated" (2014) by Francis D.K. Ching. Moreover, criteria are set based on special context. Finally, the criteria will help to find a better solution from all the alternatives from each aspects.

Literature study
Incremental construction as a method

Field trip - questionnaire and mapping
Needs and problems of local incremental constructions

Analysis
Prerequisite for additions on rooftop: weight

Literature study
Light wood framed constructions

Drawing study
Different types of joints

Analysis and Comparison
Based on prerequisite and other criteria

Decision and evaluation
Suitable or improved light wood frame

PART 1: Current Situation of Incremental Constructions on Site

1.1 Context

Bandung as one of the biggest cities in West Java has a lot of economic potential, with seven regional centers of industry and trade that could potentially be a business center as well as tourist attractions of world-class industry in the future. One of them is Textile Industry Center of Cigondewah in Bandung Kulon Sub-district, Cigondewah Kaler Village, Cigondewah Kidul Village, and Cigondewah Rahayu Village. The industry centers focus on producing various kinds of materials such as fabrics for garments, bags, hats, dolls and so on. (Baso and Astuti, 2015) In a word, the Textile Industry Center of Cigondewah has the potential to improve the economy in Bandung, thus provide massive job opportunities that attracts a lot of people from other parts of Indonesia to work here in the textile factories.

1.2 Why Cigondewah?

The upsurge of affordable housing demand is a common case all over Indonesia. While, to be more specific in Cigondewah, the urgent issue is to provide housing units that can meet the diverse and varied needs of mixed functions and mixed group of people. The houses will not only accommodate the local villagers, but also allow them to rent spare rooms to factory workers. Moreover, the close connections with the surrounding textile factories generate the small-medium economic potentials for the house owners. They can recycle the leftover fabrics from the factories and develop their own home-based textile business. Or they can run other business such as restaurants, entertainments and small shops that selling life necessities, which serve for factories workers. These social and economic dynamics already exist on site in formal or informal ways with the practice on self-help built constructions to accommodate more functions.

Factories behind Fields
(Group research, photo by Plink)

Kampung View from Fields
(Group research, photo by Plink)

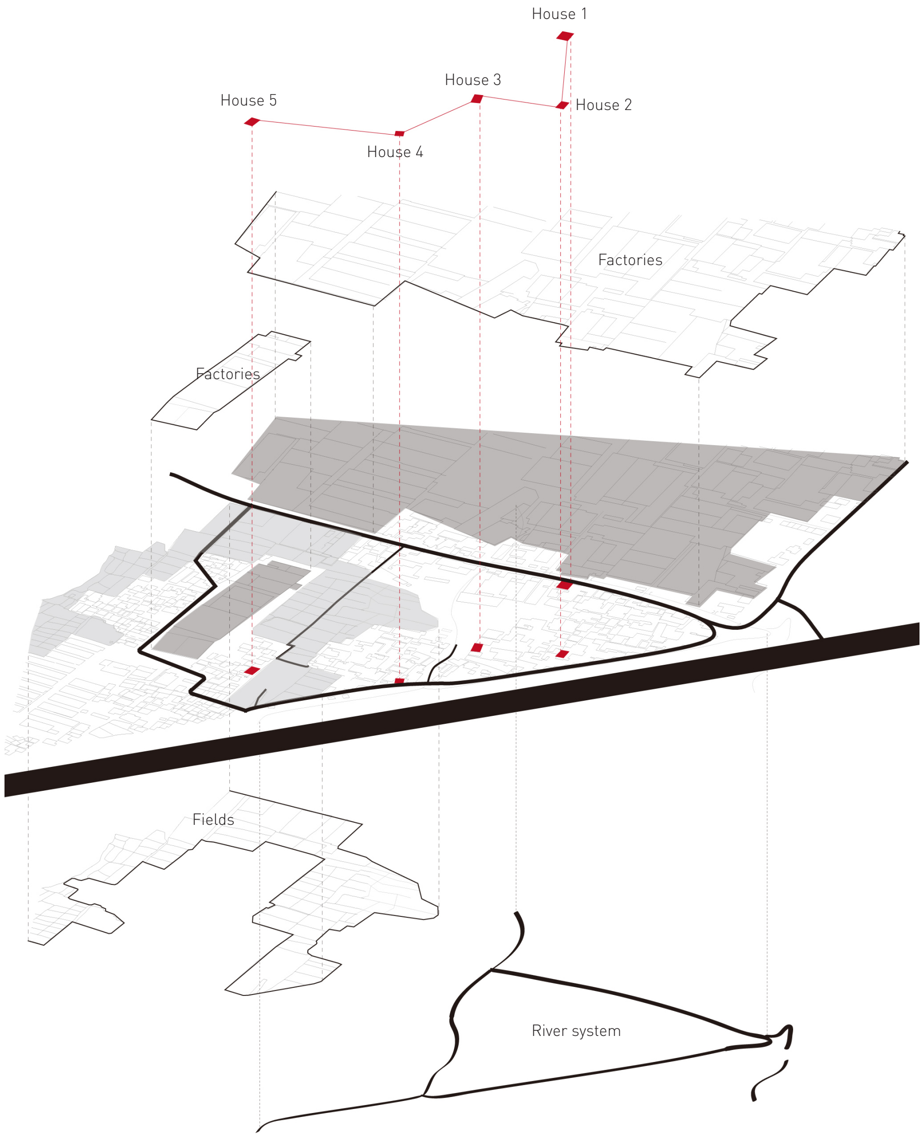


Figure 1.1 Kampung structure, drawn by author

1.3 Site

The chosen kampung is in Cigondewah region, which is known for its surrounding textile industry. It is located approximately six kilometers southwest from the city center of Bandung. The site is triangularly shaped, with the main road going east-west direction in the north. To the other side of the main road situates the big textile factory. A highway goes along the south-east border. In the west part there are some rice fields and small factories. Further to the west locates other kampung houses. A polluted river runs through the kampung in north-south direction that separates the kampung into two parts. Generally speaking, the road system of this area is quite informal, except the roads around can be accessible by car, the inner roads are so narrow that only scooters and bikes can go through. But the network of walking system naturally formulated here and works very well.

1.4 Five Case Studies of Incremental Houses on Site

In order to have a better understanding of the housing situation in this area, as a group, we conducted a detailed research into five case studies of incremental houses after an overall investment and assessment of the kampung. Based on the kampung structure, the houses were chosen from five representative locations: one along the main road, opposite to the factory; one in the kampung fabric; one near the river; one along the road with textile warehouses; one faced the open green space - football field. All the five houses were extended at least once since the house owner bought the land. The aim of the research is to know for what reasons and what functions that people extended their houses, then understand how people continued to build based on existing conditions.

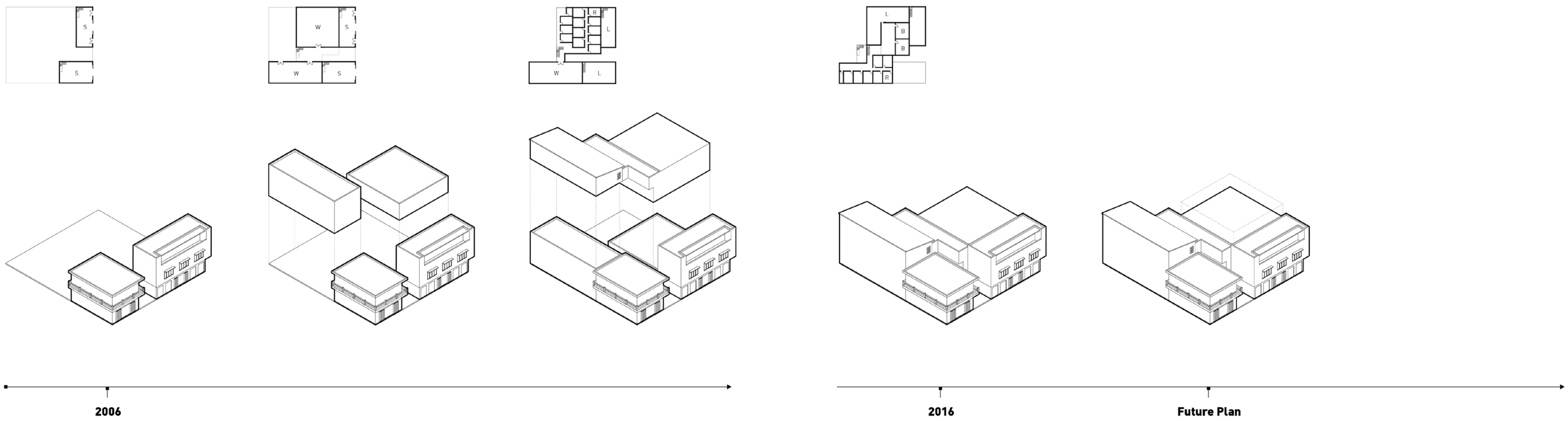


Figure 1.2 Incremental timeline of house 1, drawn by author

1.4.1 House one - along the main road

Family: five people, parents and three children
Initial House: 2006, two floors with shops on the ground level.
Extension: big Warehouses on the ground and first floor, 24 rooms for rent on the first and second floor.
Future Plan: rooftop additions for more rental rooms. Since the land has not been fully occupied, there is still possibility to add horizontal extensions for warehouses.
Structure & Materials: concrete frame system, brick wall infill, concrete floor slab with corrugated steel sheets at the bottom
Potential: vertical extension on the rooftop and horizontal extension on the ground level

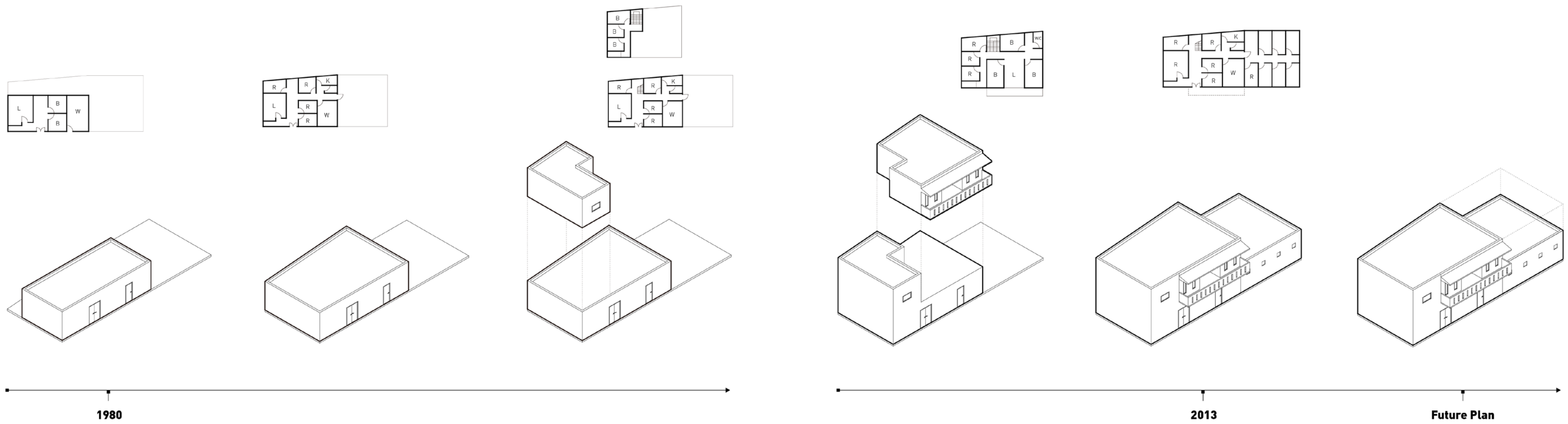


Figure 1.3 Incremental timeline of house 3, drawn by author

1.4.2 House three - along the riverside

Family: eight people, mother, father, two children, two children in laws, two grandchildren.
Initial House: 1980, one floor house with two bedrooms and a workshop.
Extension: In 6 times, rooms for additional families on the first floor and rent rooms on the ground level
Future Plan: rooftop additions for more rental rooms and a bigger space for homemade food business, if possible, more green space around the house.
Structure & Materials: concrete frame and slabs, brick walls, wooden roof.
Potential: vertical extension on the rooftop.

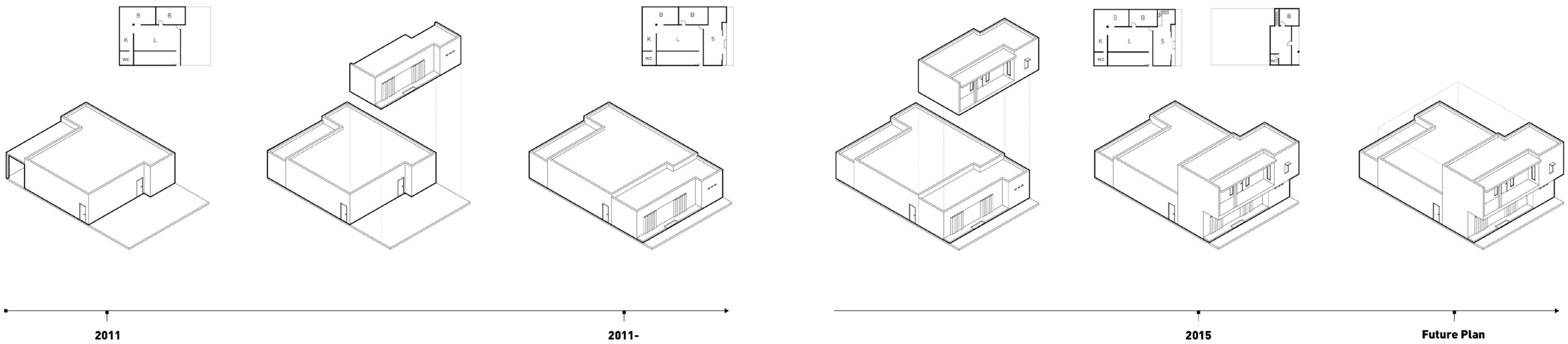


Figure 1.4 Incremental timeline of house 5, drawn by author

1.4.3 House five – faced open green space

Family: two people, mother and son.
Initial House: 2011, one floor house with two bedrooms and temporary kitchen and toilet.
Extension: the front was extended to become a shop and bedrooms above
Future Plan: extension of the first floor to cover the terrace.
Structure & Materials: brick walls, concrete column.
Potential: vertical extension on the rooftop and horizontal extension in front of the house.

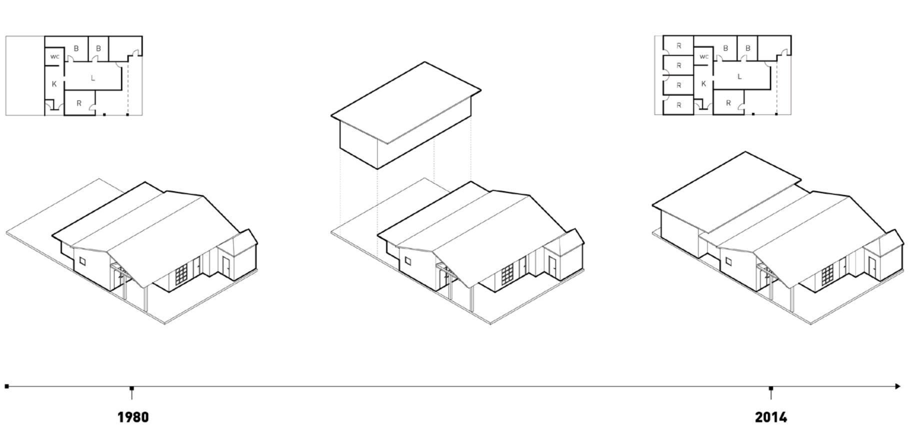


Figure 1.5 Incremental timeline of house 2, drawn by author

1.4.4 House two - in kampung fabric

Family: two people, couple.
Initial House: 1980, one floor house with two bedrooms and a back yard.
Extension: 4 rooms rent for factory workers on the ground floor, renovation of kitchen and toilet shared by family members and workers.
Future Plan: no, because there is no space left.
Structure & Materials: concrete column, brick walls, wooden pitched roof with tiles
Potential: vertical extension above the pitched roof

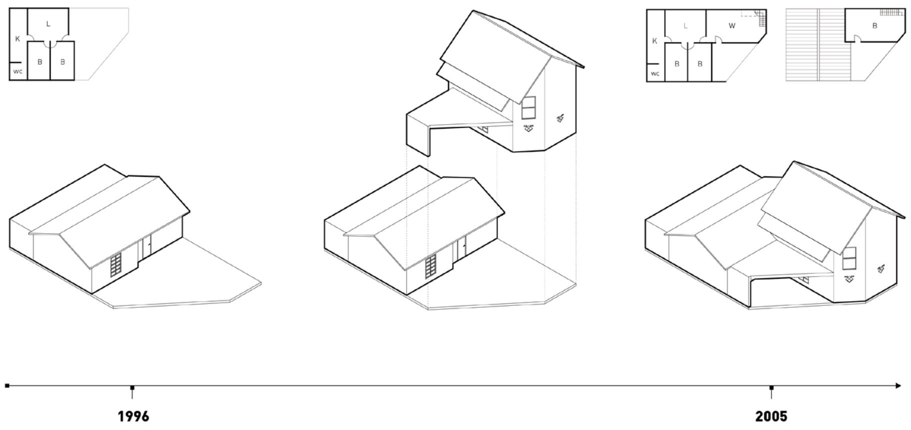


Figure 1.6 Incremental timeline of house 4, drawn by author

1.4.5 House four - near the textile warehouse

Family: six people, parents and four children.
Initial House: 1996, one floor house with two bedrooms and a front yard.
Extension: the front yard was extended to be a two-story unit, with working spaces on the ground floor and bedrooms above.
Future Plan: extension of the available front yard for bigger working spaces.
Structure & Materials: brick walls, concrete foundation, wood for stairs and upper floor slab.
Potential: vertical extension on the rooftop.

1.5 Conclusion

1.5.1 Needs of incremental constructions

In general, people extended their houses mainly based on economic factors, however it differs according to different locations:

a. In the inner parts of kampung, e.g. house 2 & 3, house owners make money mainly by renting rooms to factory workers, they care more about the living conditions such as a larger house or green space around.

b. In the open space surroundings of kampung, e.g. house 5, house owner runs a small store in front of his house, he does not want to expand the business scale but plan to extend spaces for rent.

c. On the border of kampung, e.g. house 1 & 4, house owners have close business relationship with factories around, they intend to expand the business scale with larger warehouse or workshop, more rent rooms for workers, restaurants and so on.

1.5.2 Problems of incremental constructions

As people built incremental constructions without a pre-plan, there exists the problems in two aspects:

a. In terms of design level, as house owners always want to occupy the whole ground area, then build upper floors, which means the potential of incremental construction will be in vertical direction. However, if the incremental constructions continue like this, it results in some houses which are too close to each other, lighting and ventilation conditions of houses will become worse and worse.

b. In terms of technical level, the common building method on site for multi-story houses is concrete frame with brick wall infill, concrete foundation, concrete or wooden slab and roof. According to the field research, self-help built incremental constructions with local building methods are capable to produce houses with no more than 3 stories due to substandard building materials and limited knowledge of construction. However, incremental constructions are still happening on site even with substandard constructions, which will result in serious security problems later if the houses build higher. Even the current status is not optimistic.

PART 2: Improvement Strategies of Incremental Constructions on Site

According to the existing situation, ground area of housing plots is almost fully-occupied. So the potential of incremental constructions inclines to extend vertically, either directly from the rooftop of existing houses or self-supported raising above. Based on this premise, the prerequisite that should be taken into account is the weight of new constructions.

2.1 Prerequisite for incremental constructions on site

2.1.1 Prerequisite: weight of construction
In order to make sure the additions on the roof of existing houses safe, with the consideration of the quality of original structure, under the same premise, the weight of the new constructions should be the lighter the better. As known, weight of construction mainly talks about two parts: the weight of structural system and the weight of building envelope. In terms of structural system, buildings are made up of two basic types of structures to resist vertical and horizontal loading: Mass structures and frame structures. Mass structures can be solid load-bearing to transfer load not through distinct elements, but through surfaces and solids. Mass structures can be built of stacked wood, laminated wood, concrete, or stressed skin panel in metal or wood. Frame structures act as skeletal systems in post and beam, space frame, and diagrid. These are primarily made of wood, steel/aluminum, and/or reinforced concrete – materials that are strong enough to resist both tension and compression stresses and support multistory buildings. Frames are the most common structural system due to their flexibility for non-load-bearing infill and ease of erection. Based on the differences of the above two categories of structure systems, frame system has more flexibilities to provide a light weight construction for its non-load-bearing infills.

Currently, the common building method for multi-story houses is concrete frame with brick wall infill. However, it is not a good idea to continue this method when the house built higher. The newly built part should reduce the structural weight with the consideration of the original constructions. Heavy material like concrete or brick will not fit into this specific situation anymore. Frame and infill that made from lighter materials should be adopted. Moreover , lighter materials are much easier to erect by hands, which is a simple but good way that people can invest on building their own houses. Thus, the light-frame construction is quite promising for the housing additions.

2.1.2 Light-frame construction
Light-frame construction is a type of construction whose vertical and horizontal structural elements are primarily formed by a system of repetitive wood or light gage steel framing members. The structural members, or studs, form a frame of exterior walls. Diagonal bracing members provided lateral stability in the past, but this arrangement has been superseded by carefully nailed grid panels for higher shear strength. Cladding is added to the exterior to protect against weathering, and the voids between the studs are filled with soft insulation or rigid insulation boards attached to the studs. There are two popular types of light-frame constructions: light wood frame and light gauge steel frame.

Light wood framed construction
This type of construction has the following advantages:
1. It is light, and allows quick construction with no heavy tools or equipment. Framing could be easily packaged. Every component can easily be carried by hand.
2. The houses can be built without skilled labor. The main tool is a handheld nail gun.
3. It is able to adapt itself to any geometric shape, and can be clad with a variety of materials.
4. There are a huge variety of products and systems tailored to this type of construction.

Two major light-frame building techniques are the balloon frame and the platform frame, with the latter continuing to be the predominant method of light wood construction today, while the former already outmoded and no longer used today. (Figure 2.1)

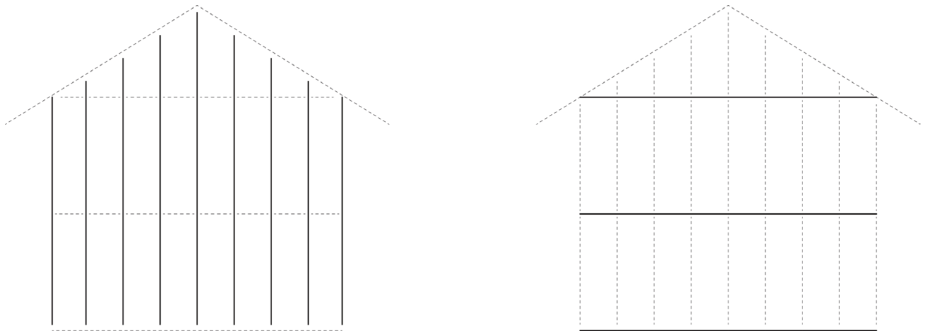


Figure 2.1 Balloon frame and platform frame
(redrawn by author on the basis of Knaack's book, 2012)

The diagrams show the differences between the basic principle of the two frame types. In the balloon frame, studs reach from the base sill past the intermediate floors up to the top plate, which results in two problems: If you had a two-story house that was twenty feet high, you would use a single 20 feet long vertical stud for both stories. This made the studs heavy and difficult to handle. The second problem is the gap between the two studs, which acted passageways for the spread of fire from the lower to the upper story. In the platform frame, the studs are connected from sole plates to top plates to form story-high planar forms, or platforms. Compared with balloon frame, this system uses shorter, lighter studs that are easy to handle. It is much easier to build walls flat and then tilt them into place. Since each floor is a separate horizontal platform, this makes it convenient for construction workers to move around, so it will also help future incremental constructions. These platforms also break the vertical spread of fire. However, it still has one problem: Each floor constitutes of a thick layer of wood, which leads to relatively large amount of vertical shrinkage in the frame, as moisture dries from the wood.

Light gauge steel construction
Light gauge steel construction is very similar to wood framed construction in principle - the wooden framing members are replaced with thin steel sections. The steel sections used here are called cold formed sections, meaning that the sections are formed, or given shape at room temperature. This is in contrast to thicker hot rolled sections, that are shaped while the steel is molten hot. Cold formed steel is shaped by guiding thin sheets of steel through a series of rollers, each roller changing the shape very slightly, with the net result of converting a flat sheet of steel into a C or S-shaped section. Like in wooden framed construction, a frame of steel members is first constructed, and then clad with dry sheeting on both sides to form a load bearing wall. Construction with steel follows the platform frame system of house building. Connections between members are made with self-tapping and self-drilling screws.

Compared with light wood frame construction, it has many advantages:
1. They are light, and allow quick building without heavy tools or equipment. Every component can easily be carried by hand. Since steel is strong, LGS structures are lighter than wood framed structures of equivalent strength.
2. Their higher strength allows greater spacing between members when compared to wood frame construction: about 24" (600mm) for LGS vs. about 16" or 20" (400 or 500mm) for wood. Fewer members translate to quicker construction times.
3. It is able to shape itself to any form, and can be clad and insulated with a wide range of materials.
4. It is easy to change or modify this construction at any point in its lifespan.
5. There are a great range of systems and products catering to this type of construction.
6. Light gauge steel structures do not rot, shrink, warp, or decompose like wood structures.

2.1.3 Conclusion:
Even though light gauged steel construction is an upgraded version of light wood framed construction, with the consideration of the source and cost of building materials in Indonesia, light wood framed structure is a better choice and capable enough to meet the requirements of incremental constructions on site.

2.2 Feasibility of light wood framed constructions in Indonesia

2.2.1 Wood source

In order to test if light wood framed construction is feasible in Indonesia context, the first thing to research is about the wood source.

In general, Light structural lumber is mainly used in residential construction. It is milled from softwood trees, SPF (spruce, pine and fir) that are sawn and machine-planed to standard dimensions (2x4", 2x6", 2x8", etc.). SPF wood as a material is advantageous in light framing, as it doesn't undergo much transformation during processing, it has a low embodied energy, it's a renewable resource and it stores carbon. Coincidentally, according to the statistics from PT Perhutani, the national forestry corporation in charge of the management of state owned forests on Java Island, traditional plantation species, such as Teak and Pine, account for most of the plantation forests in Java. For instance, of the approximately 3 million hectares of national forest estate managed by PT Perhutani in Java, production forests accounts for 1.92 million hectares (0.64per cent), among which 0.57 million are pine trees. (Table 2.1)

Thus, wood source for light wood frame construction is quite abundant in Java island. Besides, as the processing of wood is simple for light frame, rich timber resources of Indonesia will make this way of construction much more adoptable.

Total Area: 3.01 Million hectares

Production Forests:	**1.92Million ha**
Teakwood:	1.09 Million ha
Pine tree:	0.57 Million ha
Damar:	0.08 Million ha
Mahoni:	0.07 Million ha
Meranti:	0.02 Million ha
Snokeling:	0.02 Million ha
Acacia Mangium	0.02 Million ha

Table 2.1 National forest estate managed by PT Perhutani in Java (Nemoto, 2002)

2.2.2 Nails

Besides wood, nails are the other important component for light wood frame construction. Nails, used alone or in combination with metal framing anchors and construction adhesives, are the most common method of fastening framing lumber and sheathing panels. Ring or spiral shank nails provide higher load-carrying capacities than common nails of the same diameter, and are particularly useful where greater withdrawal resistance is required.

Nailed joints provide best performance where the load acts at right angles to the nails. Nailed joints with the load applied parallel to the nail should be avoided wherever possible. Where tile-up wall framing is not practical, or where stronger stud-to-plate attachment is required, toe-nailing, which nails are driven at a 30-degree angle to the stud, is the most practical method of framing studs and plates. (Figure 2.2)

Even though architects may not like using nails to fix a node, however, it cannot be denied that it is a feasible and simple way for people building their own houses. Since nails are so cheap nowadays and commonly used in kampung already, light wood framed construction will smoothly fit into this building context.

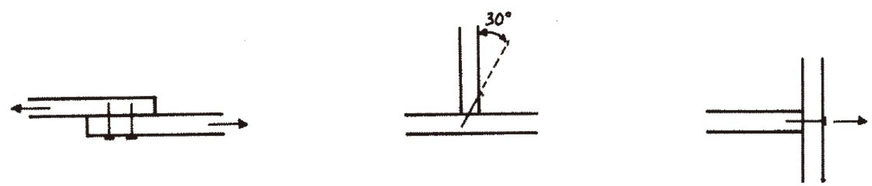


Figure 2.2 Methods of loading nails (American wood council, 2001)

2.3 Details of light wood framed constructions

In terms of incremental constructions, the platform frame is a potential system to apply. (Figure 2.3) As an upgraded version of the balloon frame, it reduced the fire risk but increased installation workability. The floors act as the platform for workers to move around and continue to build. In the ensuing discussion, the details of making platform frame will be illustrated. After an overall understanding of the system, the final goal will try to find a suitable platform frame application reference, furthermore, to improve the existing platform frame according to local conditions.

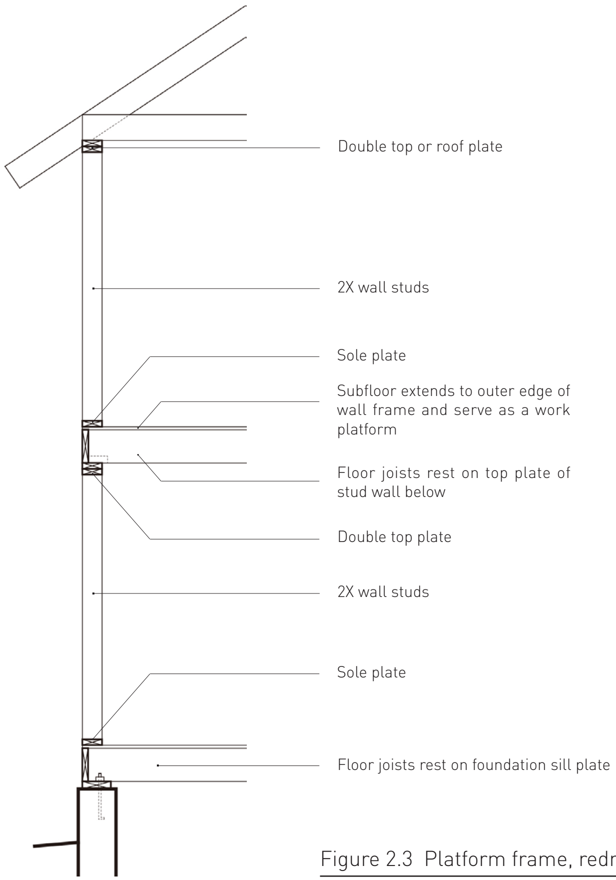


Figure 2.3 Platform frame, redrawn by author (Ching, 2014)

2.3.1 Foundations

A firm foundation, consisting of properly installed footings of adequate size to support the structure, is essential to the satisfactory performance of all buildings.

Two principal foundation types are commonly used: concrete and pressure preservative treated wood. Concrete footing with poured concrete or masonry block foundation walls are most common. Other foundation types include free standing piers, piers with curtain walls, or piers supporting grade beams. (American wood council, 2001) Below listed 5 types of foundation that wall assembly to it or sill plate to it.

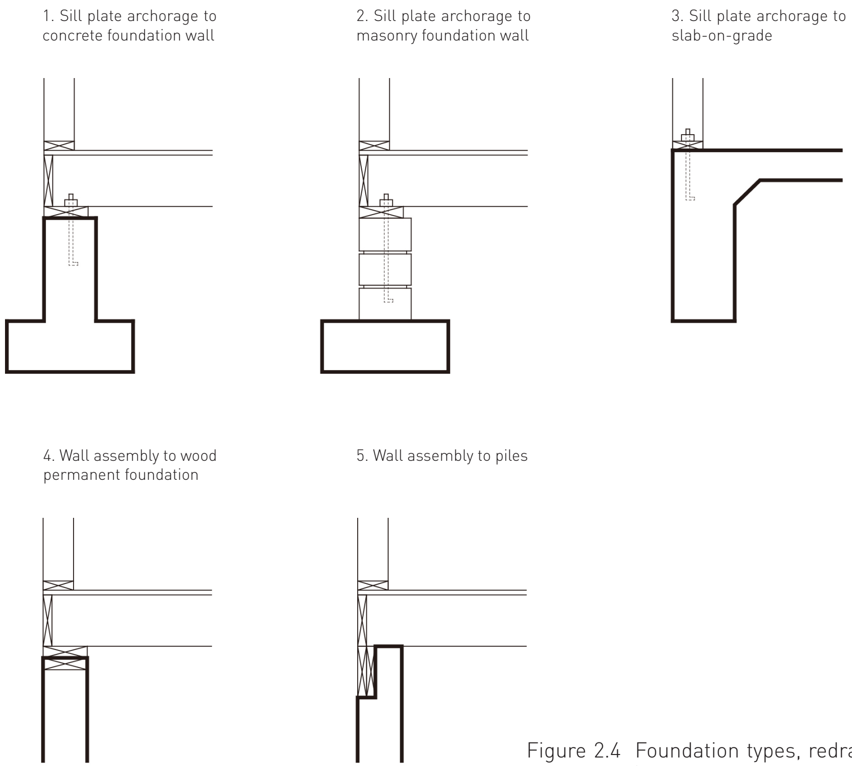


Figure 2.4 Foundation types, redrawn by author (American wood council, 2015)

2.3.2 Floor frames

There are three types of floor systems: wood joist systems, wood I-joist systems, wood floor truss systems. The latter two are pre-engineered frame systems which are generally lighter and more dimensionally stable than sawn lumber, they are manufactured in greater depths and lengths and can span longer distances. (Ching, 2014) However, as the principles of construction are similar to wood joist systems, the simple but conventional one is chosen to illustrate.

Wood joist floors are an essential subsystem of wood light-frame construction. The dimension lumber used for joists is easily worked and can be quickly assembled on site with simple tools. Together with wood panel sheathing or subflooring, the word joists form a level working platform for construction. If properly engineered, the resulting floor structure can serve as a structural diaphragm to transfer lateral loads to shear walls. (Ching, 2014)

Space and span (Figure 2.5)

Joists are spaced 12", 16", or 24" (305, 405, or 610) o.c., depending on the magnitude of applied loads and spanning capability of the subflooring.

Joist span is related to the:

• magnitude of applied loads
• joist size and spacing
• species and grade of lumber used
• deflection allowable for the intended use. (Ching, 2014)

Connections

Left listed 5 types of placing joists to girders. (Figure 2.6) Girders are built-up construction in which multiple pieces of nominal 2-inch thick lumber are nailed together with the wide faces vertical. Preferably, joists will be placed into the sides of girders to reduce the cumulative effect of seasoning shrinkage. (American wood council, 2001) For light framed construction, girders are mostly used on the ground floor to support joists and studs frame, but also seperate floor frame with ground.

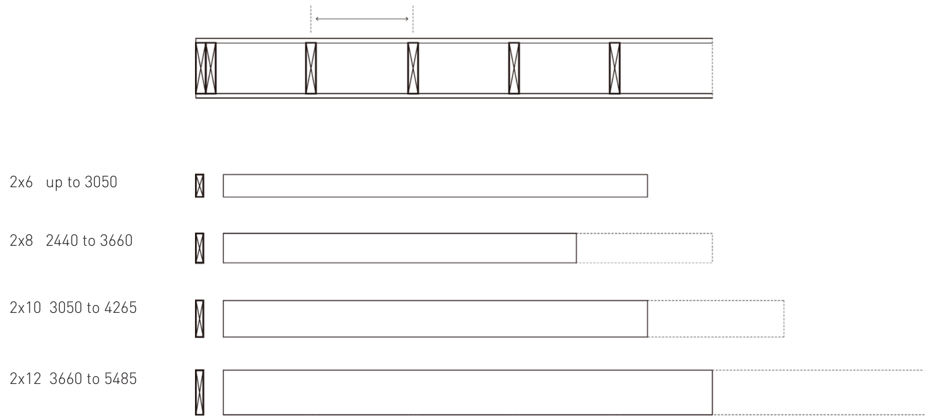


Figure 2.5 Wood joists cross section & Span ranges, redrawn by author (Ching, 2014)

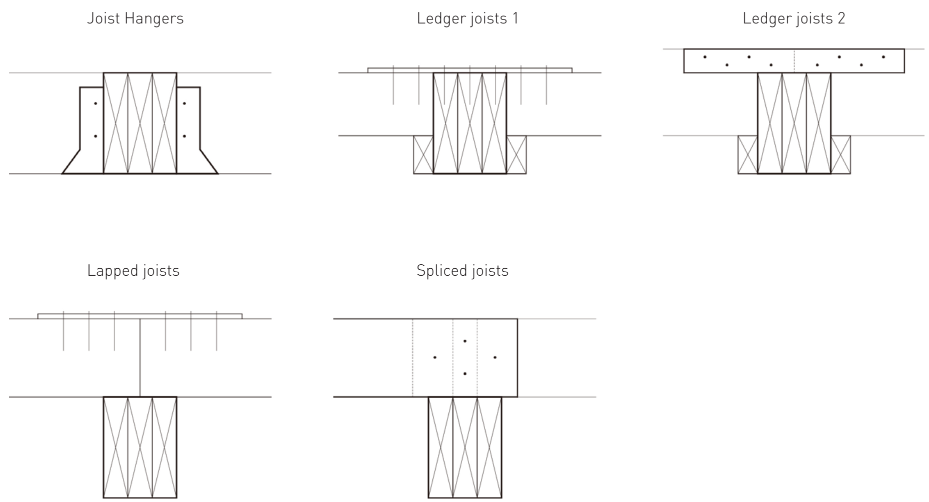


Figure 2.6 Cross section of placing joists, drawn by author (Ching, 2014)

2.3.3 Wall frames
Studs in exterior walls of one and two-story buildings are at least nominal 2x4 inches with the 4-inch dimension forming the basic wall thickness. Stud spacing is normally 16 inches in exterior walls, although 24-inch spacing of 2x4 studs is acceptable in one-story building if wall sheathing or siding is of adequate thickness to bridge across studs. In three-story buildings studs in the bottom story are at least nominal 3x4 or 2x6 inches and may not exceed 16-inch spacing. (American wood council, 2001)

Studs are arranged in multiples at corners and partition intersections to provide for rigid attachment of sheathing, siding and interior wall finish materials. Followings are different arrangements of studs at corners or partition intersections. (Figure 2.7 & 2.8)

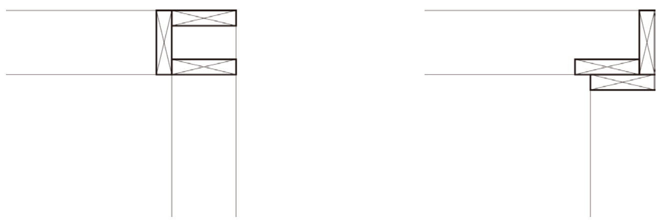


Figure 2.7 Plan of corner studs, drawn by author (Ching, 2014)

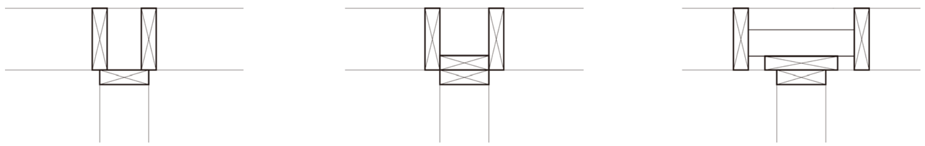


Figure 2.8 Plan of intersection studs, drawn by author (Ching, 2014)

Wall openings
A header of adequate size is required at window and door openings to carry vertical loads across the opening. Headers may be supported by doubled studs or, where the span does not exceed 3 feet, framing anchors may be used with single supporting studs, as illustrated below. Where the opening width exceeds 6 feet, triple studs are used with each end of the header bearing on two studs. (American wood council, 2001)

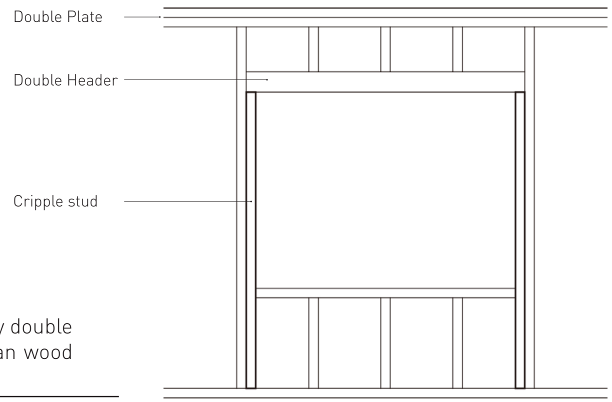


Figure 2.9 Openings supported by double studs, drawn by author (American wood council, 2001)

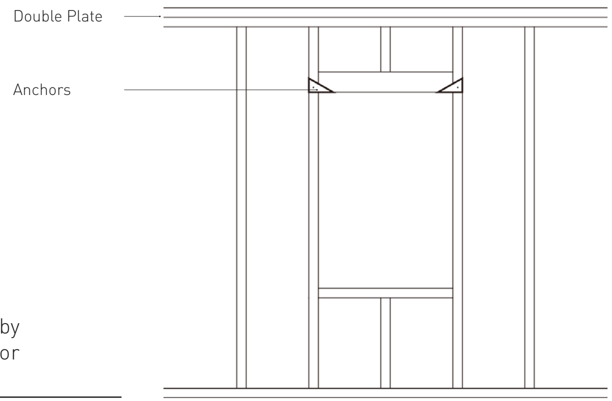


Figure 2.10 Openings supported by frame anchors, drawn by author (American wood council, 2001)

2.3.4 Roof frames

Like floor systems, correspondingly, there are three types of roof systems: wood rafter systems, wood I-joist systems and wood roof truss systems. The first type is chosen to study on the basic principles. Roof structures framed with wood rafters are an essential subsystem of wood light-frame construction. The dimension lumber used for roof joists and rafters is easily worked and can be quickly assembles on site with simple tools. The space and span range can be similar to floor systems. Below listed two types of eave attachment and ridge connection.

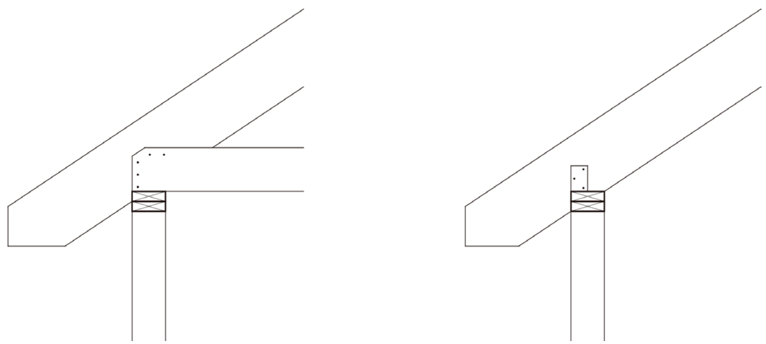


Figure 2.11 Cross section of eave attachment, drawn by author (Ching, 2014)

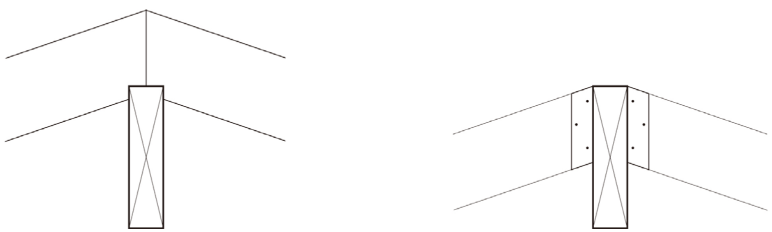


Figure 2.12 Cross section of ridge connection, drawn by author (American wood council, 2015)

2.3.5 Supplement

2.3.5.1 Explanation

All the drawings of details are produced by the author of the paper, mainly referring to three books: "Details for conventional wood frame construction" (2001) and "Wood frame construction manual for one- and two-family dwellings" (2015) by American Wood Council, "Building construction illustrated" (2014) by Francis D.K. Ching. The aim of this research is to gain a basic knowledge of light wood framed constructions, especially the platform frame system. However, the drawings illustrated above are through careful selections. They mainly focus on the joints in different systems of component (foundation, floor, wall and roof) that have more than one alternatives, which requires predeterminations to choose one from all possibilities. For the reasons of different types of joints, most are related to the load-bearing requirements, others may differ based on different scenarios.

2.3.5.2 Criteria

Based on former research, light wood framed constructions are chosen because of the prerequisite of light weight and the comparatively cheap cost. To continue this logic line, it goes to the stage to choose a lighter solution in all kinds of light wood framed constructions. In terms of joints, the prerequisite is also about the weight, however, it is more about the interaction and balance between weight and structural stability. There are also some special criteria that needed to be considered for different systems of components:

1. The position of incremental constructions

For foundations, in the scenario that set up at the beginning of this chapter, the constructions will probably happen on the rooftop of existing houses. According to the field research, the roofs are mainly built with wood frame or concrete slab and the walls are mainly built with bricks.

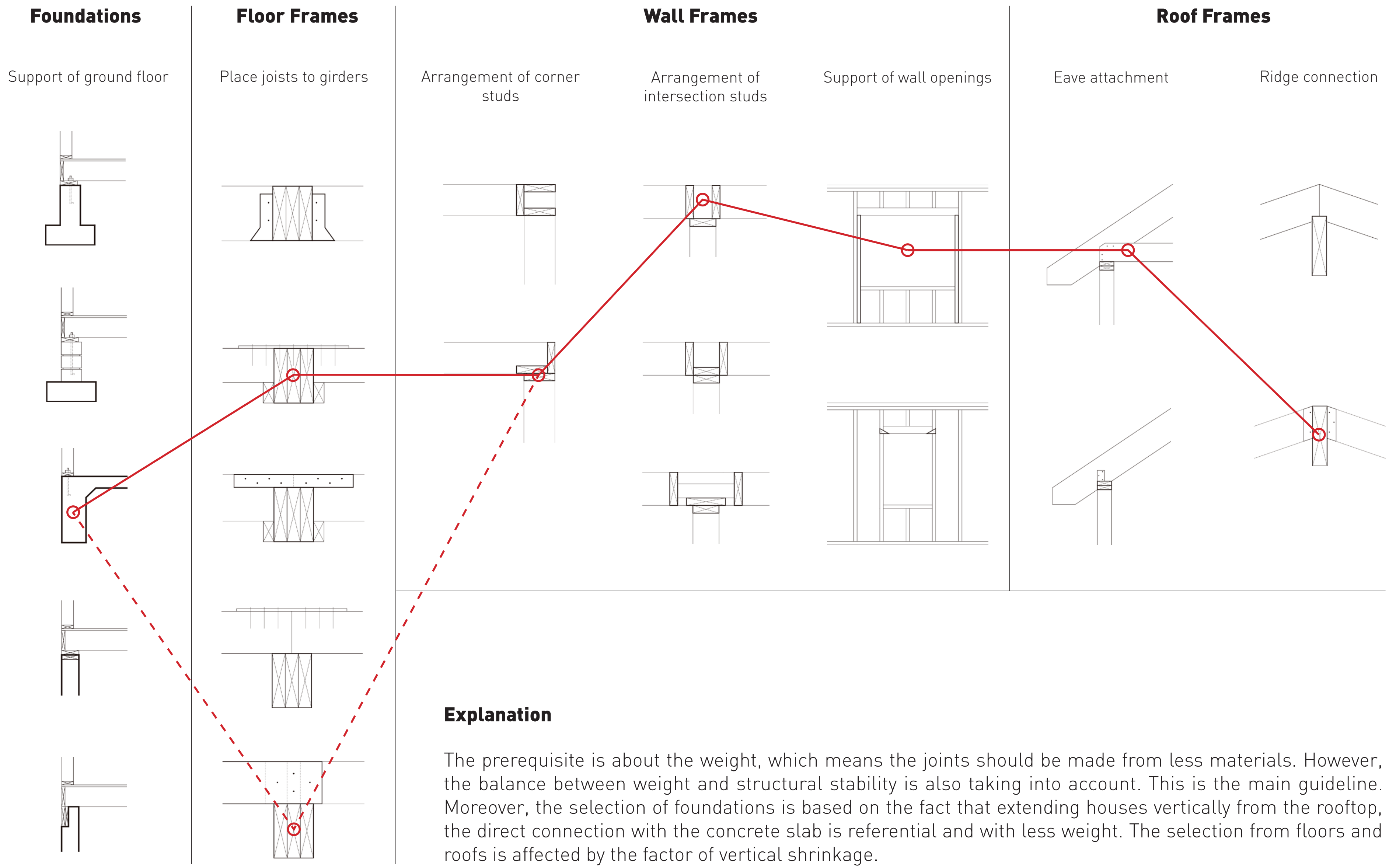
2. Vertical shrinkage

This applies to floor frames and roof frames. The ways of making intersections of wood joists or rafters differ in two basic directions: stacked position or side position, the former will have more cumulative effect on vertical shrinkage. (American wood council, 2001)

2.3.5.3 Limits

There is still a height limit for light wood framed constructions. This building method will help house owner extend their houses in an appropriate scale, but it is not applicable to large scale of incremental housing complex in vertical expansion.

2.3.6 Preselection



Explanation

The prerequisite is about the weight, which means the joints should be made from less materials. However, the balance between weight and structural stability is also taking into account. This is the main guideline. Moreover, the selection of foundations is based on the fact that extending houses vertically from the rooftop, the direct connection with the concrete slab is referential and with less weight. The selection from floors and roofs is affected by the factor of vertical shrinkage.

CONCLUSIONS

1. In general, people extended their houses mainly based on economic factors, however it differs according to different locations in kampung.

2. According to the existing situation, ground area of housing plots is almost fully-occupied. So the potential of incremental constructions inclines to extend vertically, either directly from the rooftop of existing houses or self-supported raising above.

3. Light wood framed constructions are applicable for incremental constructions from the roof top of exisiting houses within certain height.

4. For large scale of incremental housing complex, it is more efficient to set up a post-and-beam structure that self-supported above existing houses. Then build light wood framed constructions based on it.

For later research and design, more joints of light wood framed constructions need to be illustrated, the ideal result is to find a solution to improve the performance of it fitting into Indonesia context.

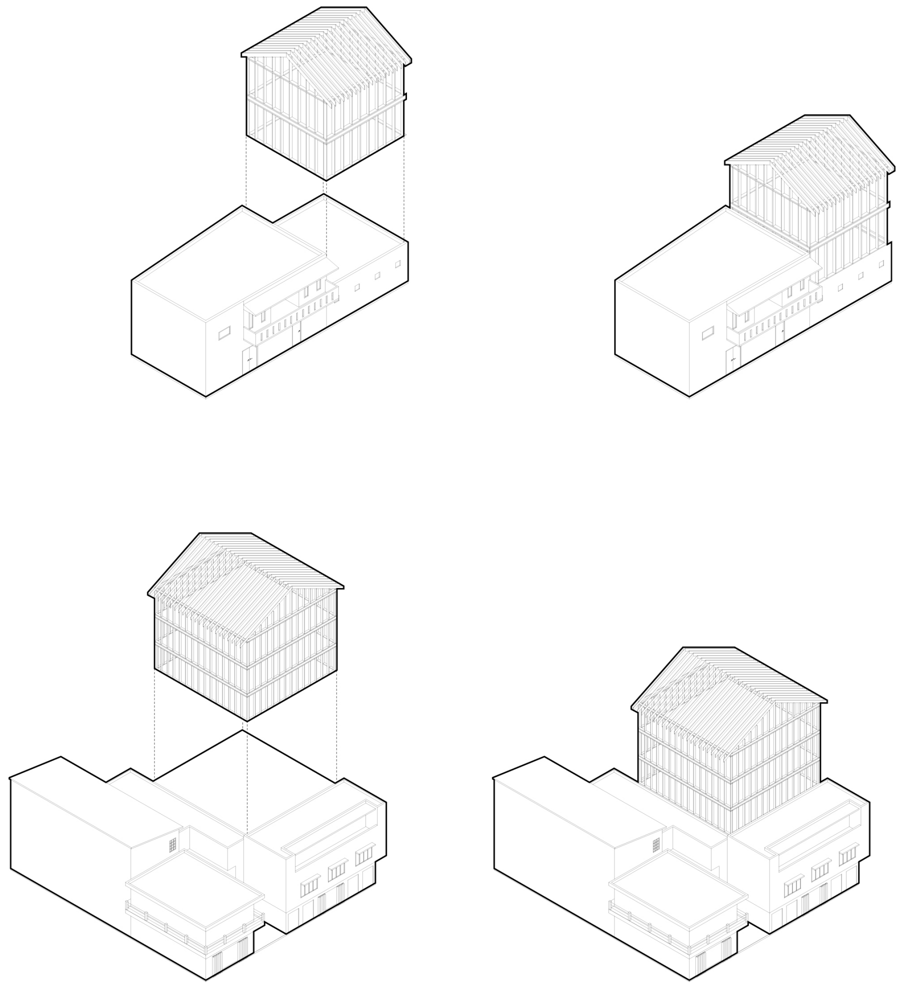


Figure 2.13 Future vision of house 1&4, drawn by author

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