DEFINITION OF LOCALLY FOUNDED BUILDING PRINCIPLES FOR THE FUTURE SHOPHOUSE IN BANDUNG

Nanne Knijff
Faculty of Architecture & the Built Environment, Delft University of Technology
Julianalaan 134, 2628BL Delft
J.N.Knijff@student.tudelft.nl

ABSTRACT

The course of globalisation, the universalization of Indonesian cities, overpopulation, pollution and the need to change global warming provoke a search for local identity and for solutions in traditions and vernacular architecture. This paper aims to contribute to this debate, by conducting historical research into the construction and cultural building principles of (West-)Javanese residential architecture in four cases, being the Sundanese Vernacular Architecture, the Colonial architecture for European and for Native Indonesian citizens in Bandung and the Contemporary shophouse architecture in Bandung. Through an understanding of the motivations of the cultural, material and construction principles of the architecture an encyclopaedia for methods of building houses on West-Java is created. Based on the foundations for the principles categorized in this encyclopaedia, cultural, material and constructive building principles will be derived to define the principles for a future locally based residential architecture on the West of Java.

KEYWORDS: *Sundanese Vernacular Architecture, Dutch Colonial Architecture, Shophouse Architecture, principles for future residential architecture, Housing, Bandung, Indonesia*

I. INTRODUCTION

1.1. Problem Statement

From the moment Sukarno became the first president of the Republic of Indonesia in the 1950s, after the independence of Dutch colonialization, the question of a new architectural style for the newly born republic became prevalent. Sukarno was especially interested in a modern architecture suitable for the new era. Therefore he was closely involved in defining a unified architectural style for the entire Indonesian archipelago (Hasan, 2009, P.217-243). Sukarno was not the first one to raise the issue of national identity in relation to architecture, as in the Colonial era the search for an architecture specified for the Dutch-Indies (colonial Indonesia) was subject to multiple conferences. Architects like Wolff Shoemaker, McLain Pont and Thomas Karsten would debate on a suitable architecture for the Europeans, the native Indonesians and other Asian immigrants living in the Indonesian cities (Van Roosmalen, 2009, P.65-95). Nowadays the debate on Indonesian architecture is fueled by the gradual universalization of Indonesian architecture, the lack of local identity and the densification and expansion of the Indonesian cities, especially focused on the need for housing. In response some architects call to use the vernacular architecture as a source of inspiration (Hidayatun, et al., 2016, P.2). A similar call is heard by architects concerned with global warming, who believe that the adaptation to vernacular principles will lead to a more sustainable architecture. However, vernacular architecture is not sustainable per se (Alsayyad & Arboleda, 2011, P.150-151). Furthermore the focus on tradition will create a false opposition between the east and the west, where the west is modern and the east should focus on their 'otherness', and be defined as the non-west (Hasan, 2009, P.329). However, the call for local recognition in architecture is true, as tradition creates a sense of community (Rapoport, 1969, P.6) and the glass skyscraper is (usually) less sustainable than the vernacular house (Alsayyad & Arboleda, 2011, P.135). Therefore there is a need to define principles for a locally defined, contemporary residential architecture for the cities of Indonesia, that does not disregard contemporary technological innovations and societal progression, but takes the local context, climate and traditions into account.

1.2. Objective & Research question

The call for a locally defined residential architecture is not a new one, as it has been addressed by many Indonesian architects and presidents before. An understanding of historical developments can, therefore, help to define principles for a contemporary locally defined residential architecture. These principles will be used as a source of reference for a housing project in Bandung, as this is the personal interest of the author. Hence, the objective of this research is to establish an encyclopaedia of principles of building-culture and building construction methods from different techniques and styles of residential architecture over time on the Island of Java, specifically focused on West-Java. The encyclopaedia will clarify the principles that have changed and the principles that are constant (Rapoport, 1969, P.11). This knowledge will then be used to define the principles for a locally defined and contemporary residential architecture in Bandung. Therefore the research question of this paper is:

Which underlying cultural, material and technological building principles can be derived from a historical understanding of the residential building-culture on West-Java and how can an understanding of those contribute to the establishment of principles for a contemporary locally founded residential architecture in Bandung?

In order to answer the main research question, the following sub questions will be answered first. Sub question one and two are addressed in chapter 2, 3 and 4, sub question three is addressed in chapter 5 and sub question four in chapter 6.

1. What are the underlying cultural, material and technological building principles of residential architecture in this specific time and context?
2. Why are these principles applied in this specific time and context?
3. What are the differences and the similarities of these cultural, material and technological building principles for housing and how can they be classified?
4. What are the cultural, material and technological building principles that can be of value for the future of residential architecture in Bandung?

1.4. Methodology

The research approach is a historical one, since an understanding is required of a historical development. The inquiry is based on three historical and one contemporary case study. Each consisting of a dwelling of a specific time and context. All are examined on their construction and cultural principles of building methods based on the context, the form and spatial organization and the materialization and construction of the house. Furthermore, the reason why these principles are applied will be addressed. The chosen case studies are 'The pre-colonial house in Kampung Naga', 'The colonial house for the native Indonesian in Gempol', 'The colonial house for the European citizen in Gempol' and 'The contemporary shophouse'. The case-study of Kampung Naga is chosen, because the villagers live in the traditional Sundanese way, therefore it provides an understanding of the vernacular architecture on West-Java. The case study of Gempol is chosen, because it is part of a large extension of Bandung in the colonial time. Since the Dutch came from a completely different continent with a different climate and different traditions, this case study will give an understanding of how a foreign regime deals with this local context architecturally, which might provide out-of-the-box insights. The last case study of the shophouse is chosen because it is a frequently built type of house in the city centre of Bandung and other cities on Java, therefore it is a significant contemporary type of dwelling. A relevant source of information for each case study is derived from site visits by the author and interviews conducted with inhabitants. These sources are especially relevant in the case of the Kampung Naga case study. The gathered information is complemented with studies into literature, dissertations and research papers. Furthermore colonial archives are relevant for the colonial case studies in particular. A detailed description of the case studies can be found in Appendix number 1. A summary of the case studies will be provided in chapters 2, 3 and 4. Chapter 5 will then address the differences and the similarities between the construction and cultural principles of building methods between all the case studies and will qualify them by using the research of Amos Rapoport into the foundations of form of the vernacular house and finally chapter six will provide an answer on which principles have a value for a contemporary residential architecture in Bandung.

II. BUILDING PRINCIPLES OF SUNDANESE VERNACULAR ARCHITECTURE

2.1. Kampung Naga

Kampung Naga is a village in the West of Java, about one hundred kilometres away from the city of Bandung. Mister Ucuk, one of the village elders who introduced the author elaborately to the village culture, explained that the people living in Kampung Naga live their lives as much as possible like their ancestors did, because they believe it is the best way to live for them. Consequently, they maintain the traditional Sundanese lifestyle and building-culture (Interview Pak Ucuk, 2018). The Sundanese culture origins from the Kingdom of Sunda that covered the West of Java and Southern Sumatra in the 15th century. Although the difference nowadays is not as strong as it used to be, there has been a strong rivalry with the Javanese culture, which originates from East and Central Java, with its cultural heart in Yogyakarta (Sulara, 2025, P.50-64). The climate on Java is hot and humid, characterized by a predominant temperature of 25 to 30 degrees Celsius throughout the year, and two seasons, a wet and the dry one. Especially the dry season is problematic, because of the intensive solar radiation (Coch, 1998, P. 67-87). The Kampung itself is situated on a mountain slope in the curve of a river in between the mountains and volcanos of Mid-West-Java, profiting from the fertile volcanic soil for their agriculture and from the supply of fresh water from the river for their circular water system, which they use for the fish ponds, bathing, cooking and management of human waste (Interview Pak Ucuk, 2018).

Figure 1: Aerial view of the Village (Image by Author)

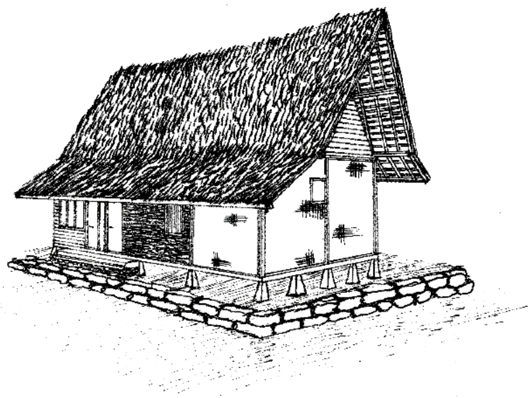


Figure 2: Exterior view of a Sundanese house (Image by Author)

2.2. Formal Principles of the Sundanese House

Observations conducted during the site visit have revealed that the Sundanese vernacular house is a single, detached house placed on a 400 mm tall platform to prevent rainwater from reaching underneath the building. On this platform it is lifted another 400 mm, by placing river stone columns underneath the timber columns of the house. Mister Ucuk explained that the need for ventilation, the keeping of livestock and the provision of storage underneath the floor are the main purposes for lifting the house. The house has only one floor, which is gradually organized from a public to a more private side. Since social interaction between the villagers in and outside of the house is highly valued in the Kampung, the kitchen, the veranda and the guestroom are situated on the street side, whereas the private living room and the bedrooms are situated in the back, see appendix 1 page number 4. Interviews with inhabitants of a typical house revealed that the spaces are approximately 3 meters high, for climatic reasons, that the roof is another 3 meters tall and is characterized by its steep angle and the node where the slope changes, allowing for a veranda to be built and for an overhang that protects the facade from sun radiation and heavy rainfall (Interview Pak Ucuk). The steep slope and the height of the roof are necessary to direct the rainwater quickly from the roof during the monsoon and to provide a heat buffer, separated by the ceiling from the house, underneath the roof during the dry season (De Bruijn, 1927, P. 31-35). A more cultural based explanation for the form of the house is the subdivision of its section in the Upper world related to the sacred and God, The Middle world related to Earth and human life and the Under World related to death, represented respectively by the attic, the room and the foundation, as is further explained in the appendix on page number 3 (Darmayanti, 2016, P.5).

2.3. Building Construction Principles of the Sundanese House

Observations have made clear that the villagers use light-weight natural building materials, which they can find or cultivate in their surroundings, to construct their houses. The main materials used are wood, bamboo, river stones, palm leaves and palm fibres, as the pictures in the appendix show on page 5 to 7. All have their own purpose climatically, constructively or functionally and are harvested and processed carefully by the villagers under de direction of the master builder. The drawings in appendix 1 on page 5 to 7 explain the building construction methods in detail based on interviews with the master builder and mister Ucuk. He explained that the main construction of the house is made of Albasiah wood, simply because it is available, although Albasiah is specifically chosen for its properties. The infill of the timber post and lintel system is of bamboo mats, woven in patterns of different densities according to the function of the room behind the façade. Likewise the material of the floor is either made of unrolled bamboo or timber planks according to the function of the room. The river stone foundation provides a strong and solid base for the house, makes it able to lift the house, but is also important to protect the timber post and lintel structure from moisture permeating from the soil. The roof construction is made from the very lightweight Balsa wood, covered with bamboo roof boarding and a water resistant layer of palm leaves and palm fibres. The material is chosen for its availability, but also because the natural material does not radiate the heat to the attic underneath it as much as ceramic tiles would do (Interview Pak Ucuk, 2017). Important to note is the fact that the lightweight timber construction with a woven bamboo mat infill and the lightweight roof construction also has advantage of its flexibility, which makes it less vulnerable to earthquakes (Maknun, et al., 2018, P. 2-3).

III. BUILDING PRINCIPLES IN THE COLONIAL ERA

3.1. Gempol – Housing for Native and European Citizens

The Gempol neighbourhood is part of the Bandung North extension planned by the Dutch government in the beginning of the twentieth century. The initiative for this extension was taken after Bandung gained the status of municipality by the colonial regime, which was followed by large investments in public facilities, which again lead to a major influx of mainly European citizens. The influx was further stimulated by the intention to move the government institutes from Batavia to Bandung. The urgent shortage of housing for these new citizens and the need to improve the living conditions for the Native Indonesians and Asian immigrants living in Bandung raised the need for an extension of the city to the north. According to modern standards and because Bandung was considered to have a healthy, more moderate climate than Jakarta, the extension was planned as a garden city. This resulted in the design of an urban tissue with a strict hierarchy in more and lesser important streets designed with vista's to the surrounding countryside. This pattern formed the structure for a low-density residential area designed with more or less detached houses with large front- and backyards regulated set-backs and building heights all placed along a street according to their social hierarchy (Ignasia, 2008, P. 91-110). There was a strict separation between European and local citizens, the European citizens resided along the bigger streets and the native citizens where housed in the inner compounds of the urban tissue, behind the houses of the Europeans both houses facing each other back-to-back (Siregar, 1990, P. 178-184).

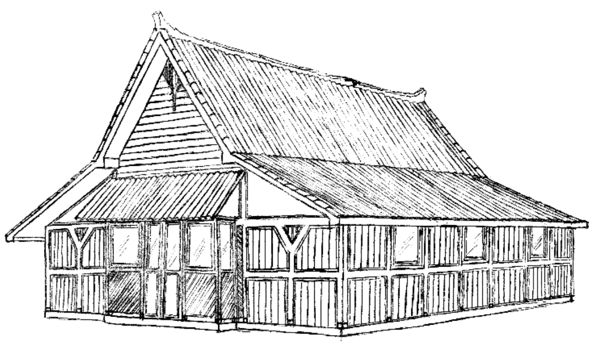


Figure 3: Exterior view single house (Image by Author)

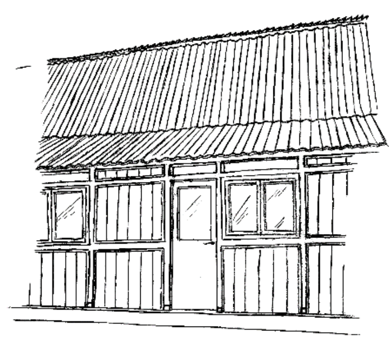


Figure 4: Exterior view rowhouse (Image by Author)

3.2. Formal Principles of the Native Housing

Several types of houses were designed for the native citizens, so all of them would be able to afford a house in the new residential area, resulting in the construction of single houses, coupled houses, quadrupled houses and row houses (Siregar, 1990, P. 188). Figure 3 & 4 give an impression of a single house and a rowhouse, which have been examined during a site visit. The lay-out of all houses contained a veranda, a small sitting room in the front, a larger living- or bedroom in the middle and a kitchen in the back, complemented with one or more bedrooms and sanitary facilities according to the size of the house, as the floor plans on page number 10 of appendix 1 shows. This gradient from public to private was implemented in the design of every house. If the house was too small, cooking and sanitary facilities were provided communally (De Bruijn, 1927, P. 245). Whereas the floor plan doesn't recall vernacular traditions, the shape of the roof is clearly inspired by the Sundanese architecture, purposely designed by the Dutch, to give a notion of locality (Siregar, 1990, P. 187). This reference is nothing more than a formal one, since the ceramic roof tiles do not require such a steep slope to speed up the rainwater when flowing down the roof and therefore the node is not required too. However, the overhang of 1200 to 1500 mm is still essential to protect the facade from solar radiation and heavy rainfall, as is the attic to serve as a heat buffer, which is again separated by a ceiling from the rooms of the house (De Bruijn, 1927, P. 37). A regular Dutch saddle roof would therefore have been sufficient.

3.3. Building Construction Principles of the Native Housing

The houses in Gempol are not lifted from the ground, which requires other materials and construction methods of the foundation and the ground floor (De Bruijn, 1927, P.36-41). The designs of the Dutch were focused on efficiency, costs reduction and a healthy indoor climate (Poldervaart, 1932, P. 13-16). Therefore the ground floor is lifted 300 mm above ground level to prevent rainwater from entering the building and the floor is made from Portland cement tiles placed in a Portland cement mortar founded on a 300 mm base layer of sand to provide a stable base for the floor and to prevent moisture from permeating into the house. The foundation is made from stacking river stones of which the depth depends on the cracks in the soil during the dry season. A Portland cement mortar is applied in the first 300 mm above and below ground level to prevent water from permeating into the wall. The wall itself is constructed of a post and lintel timber construction of the durable Teak wood with an infill of 1000x240x40 mm concrete panels. These building construction principles are further elaborated on in appendix 1 page 11 and 12. Although the construction method of the wall is highly efficient, it influences the indoor climate negatively, since the concrete does not allow for ventilation through the wall and it conducts a lot of heat from the outside to the indoor environment. Ventilation openings between the wall and the roof are, therefore, essential. The timber roof construction is made from Rasamala wood, which is less durable, but more lightweight and cheaper than Teak, which is sufficient for a roof construction, since the wood is not exposed to heavy weather conditions (De Bruijn, 1927, P.6-58). Furthermore an earthquake resistant house requires a lightweight roof construction (Maknun, et al., 2018, P. 2-3). The roof is covered with ceramic tiles, which require a minimum roof angle of 30º, although the tiles direct rainwater from the roof easier, they conduct more heat to the indoor environment (De Bruijn, 1927, P.6-58). Furthermore bamboo was prohibited to be used as building material, because of plague prevention (Gmelig Meijling, 1953, P. 64-69).

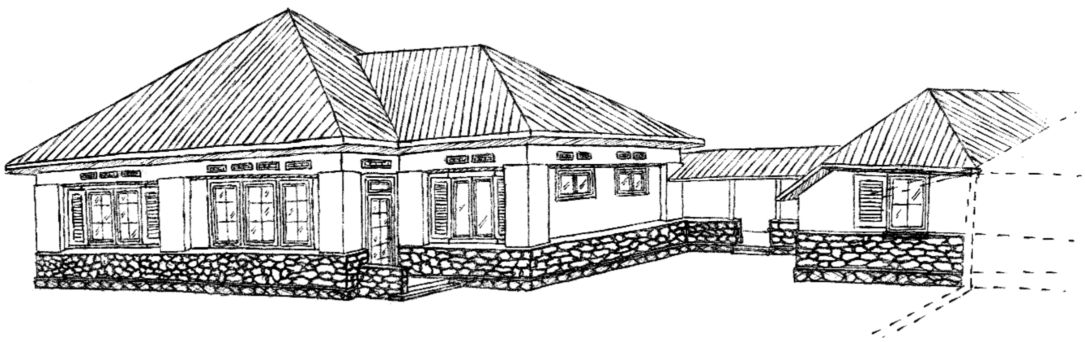


Figure 5: Exdterior view of European Villa class 5 (Image by Author)

3.4. Formal Principles of the European Housing

Similar to the design of the types for the housing of native citizens, the houses for the European citizens were designed in several types too, ranging in size from a large colonial estate to a modest 32 m2 house of three rooms, respectively a first and an eight class house. The house analysed in this paper is one of the fifth class, since it is a moderate type, containing all aspects present in each of the other types, See figure number 5. The design of all houses is separated in the main house and the outbuildings. From the first until the sixth class the houses are detached, for some of them the outbuildings are coupled. The seventh and the eight class houses are coupled. The drawings in the appendix on page 13 show that the floor plan of the houses is designed with a sitting room in the front and in the back, complemented with one or more bedrooms and other rooms with a specifically assigned function whenever allowed by its size. The quarters for the servants, cooking, sanitary and storage facilities are situated in the outbuildings for ventilation and hygienic purposes. The outbuildings are always connected to the main volume by a covered passage. No formal reference to Sundanese vernacular architecture is made in the design, however the overhang of the roof of 1200 to 1500 mm is still necessary to protect the facade from sun radiation and heavy rainfall and the attic serves as a heat buffer, as it is separated from the house by the ceiling. Considering the floor plan, the stimulation of cross-ventilation is important to create a healthy indoor environment (De Bruijn, 1927, P. 83-95).

3.5. Building Construction Principles of the European Housing

Since the house is not lifted from the ground level, the floor is raised approximately 300 mm to prevent rainwater from entering the building. Furthermore the soil adjacent to the building underneath the overhang is covered by ceramic or Portland cement tiles to direct the rainwater away from the building. These and the building construction principles described hereafter can be found on page 14 and 15 of the appendix 1. The foundation is made from the stacking of river stones as deep as necessary to provide a stable base for the house in the dry season, when the deep cracks destabilize the soil. In the first 300 mm above and below ground level of the foundation a Portland cement mortar is applied to prevent water for permeating into the wall. In order to enhance this property, the first 1000 mm of the wall is made of Riverstone masonry, plastered on the inside. Above this river stone masonry the wall is made from a double stone brick masonry, plastered on the inside and rendered on the exterior, since the aesthetic quality of the brick is very bad and the brick has to be protected from weather conditions (Gmelig Meijling, 1953, P. 7-17). As the plastered/rendered brick wall is impermeable to air circulation and causes an accumulation of moisture indoors, ventilation openings are necessary. These openings are provided above the windows, less than 1000 mm underneath the ceiling, moreover 1/12 of the surface of a room should be provided as window opening in the facade (De Bruijn, 1927, P.84). Since the bricks are very brittle and cannot withstand seismic forces very well, a single brick masonry bond is usually not applied, unless it is strengthened by a concrete structure. The roof construction is made from Rasamala wood covered with ceramic tiles, as for the natives (Gmelig Meijling, 1953, P. 10-34).

IV. BUILDING PRINCIPLES OF THE CONTEMPORARY SHOPHOUSE

4.1. The Shophouse in the Pasar Baru Area

The Pasar Baru, translated in Indonesian as New Market, is a market in the city centre of Bandung, located there by the colonial regime in the middle of the nineteenth century after the original market burned down (Siregar, 1990, P. 140-141). At first a native Kampung neighbourhood, the construction of the market was followed by the layout of a grid pattern of roads to provide access to the new market. Jalan Otto Iskandar Dinata, is one of the important north-south axes in the city and connects the Pasar Baru to the (former) Groote Postweg, which was the main road from the east to the west of Java in the colonial era, see appendix 1 page 16. The settlement of merchants along these roads, at first immigrants from other parts of Indonesia and later Chinese immigrants, forced to live in this area by the Dutch, gradually created an urban tissue of city blocks of which the periphery was inhabited by the foreign merchants and the interior by native Sundanese citizens, establishing the characteristic 'Urban Pockets' (Nurtati et al., 2017, 1017). The merchants developed a type of building that contained their house as well as their shop, resulting in the shophouse type analysed in this paper (Siregar, 1990, P. 140-141).

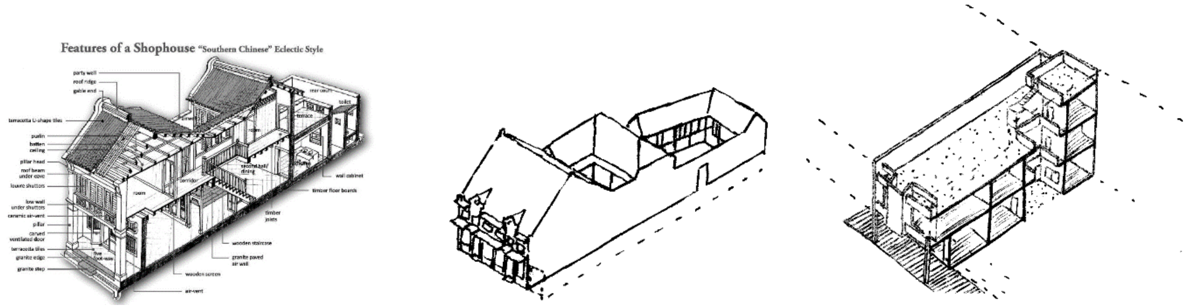


Figure 6: Traditional Chinese Shophouse (Han, et al., 2014, P. 240), Europeanized Cirebonese Shophouse (Siregar, 1990, P. 78) & Contemporary Pasar Baru Shophouse (Siregar, 1990, P. 82)

4.2. Formal Principles of the Shophouse

The original shophouse was a traditional Sundanese type with an extra room situated at the street side of the house for selling goods (Nurtati et al., 2017, 1019). After merchants from Cirebon settled in the area, importing their own architecture which adapted European innovations, the type evolved to the Europeanized Cirebonese shophouse, shown in figure 6. This type is characterized by its horizontality and gradual extension to the back with rooms situated around courtyards, as an extension sideways is impossible in the densely built city centre. The shop is situated on the street side and the house in the back. The courtyards provide natural ventilation and allow daylight to enter into the residential quarters of the building (Siregar, 1990, P.158-159). Although both types have probably been developed individually, the traditional Chinese shophouse of south-east China has a similar layout, although a more densely built urban context lead to the construction of storeys in this type already (Kubota, 2017, P.56). When the Chinese settled in the area at the beginning of the twentieth century the type slowly evolved to the contemporary shophouse, which is characterized by its verticality and its narrow width. This transformation is stimulated by the growth of the population, leading to the subdivision of the old and wider shophouses into several narrow ones. As space is required to house the merchants and the shop, a vertical extension is the only option. Unlike the other types analysed in the paper, the shophouse is located in the middle of the city centre, therefore it is an attached type of building of which nowadays only the front facade is not connected to adjacent buildings (Siregar, 1990, P.158-159). Therefore the courtyard in the middle of the building is even more essential in this contemporary type for daylight to enter into the building and to provide the essential ventilation air flow. In order for an air flow to be stimulated, but to prevent the warm outdoor air from getting into the building, the courtyard should be rather small, approximately 3x3 m^2 (Kubota, 2017, P.56). The street side of the ground floor is usually occupied by the shop, whereas the back of it and the upper floors are reserved for the dwelling. The roof is flat, since it is used as a garden space of service area (Siregar, 1990, P.158-159).

4.3. Building Construction Principles of the Shophouse

The foundation of the contemporary shophouse is made from reinforced concrete, likewise the main structure of the building is made from a reinforced concrete frame. The facade is constructed by a brick masonry infill of the concrete frame, plastered on the inside and rendered with cement on the exterior. The floors are made from reinforced concrete slabs or from a corrugated steel sheet with concrete poured on top of it, as is the flat roof (Benjamin, et al., 1985, P. 106-107). For a detailed description of these construction methods see the appendix 1 on page 18 and 19. As in the colonial era, the choice of concrete and brick as main building materials is based upon the higher social status gained from using these materials opposed to less permanent materials as bamboo and wood which are considered to be materials for a poor man (Mugica, 2018, P.4), however a causal link remains unproven. Furthermore the concrete structure is used for the need of vertical extension too (Benjamin, et al., 1985, P. 106-107). For these reasons the negative influences of a concrete and brick facade are disregarded and additional ventilation is necessary. Similar and functional motivations apply to the use of a flat roof without any overhang, because of which the facade is exposed to heavy rainfall and solar radiation and the heat buffer is absent, since there is no attic (Gmelig Meijling, 1953, P.59).

V. Summary and Qualification of the Foundations for the Building-culture and Building Constructive Principles

5.1. Summarizing Matrix of Building Principles

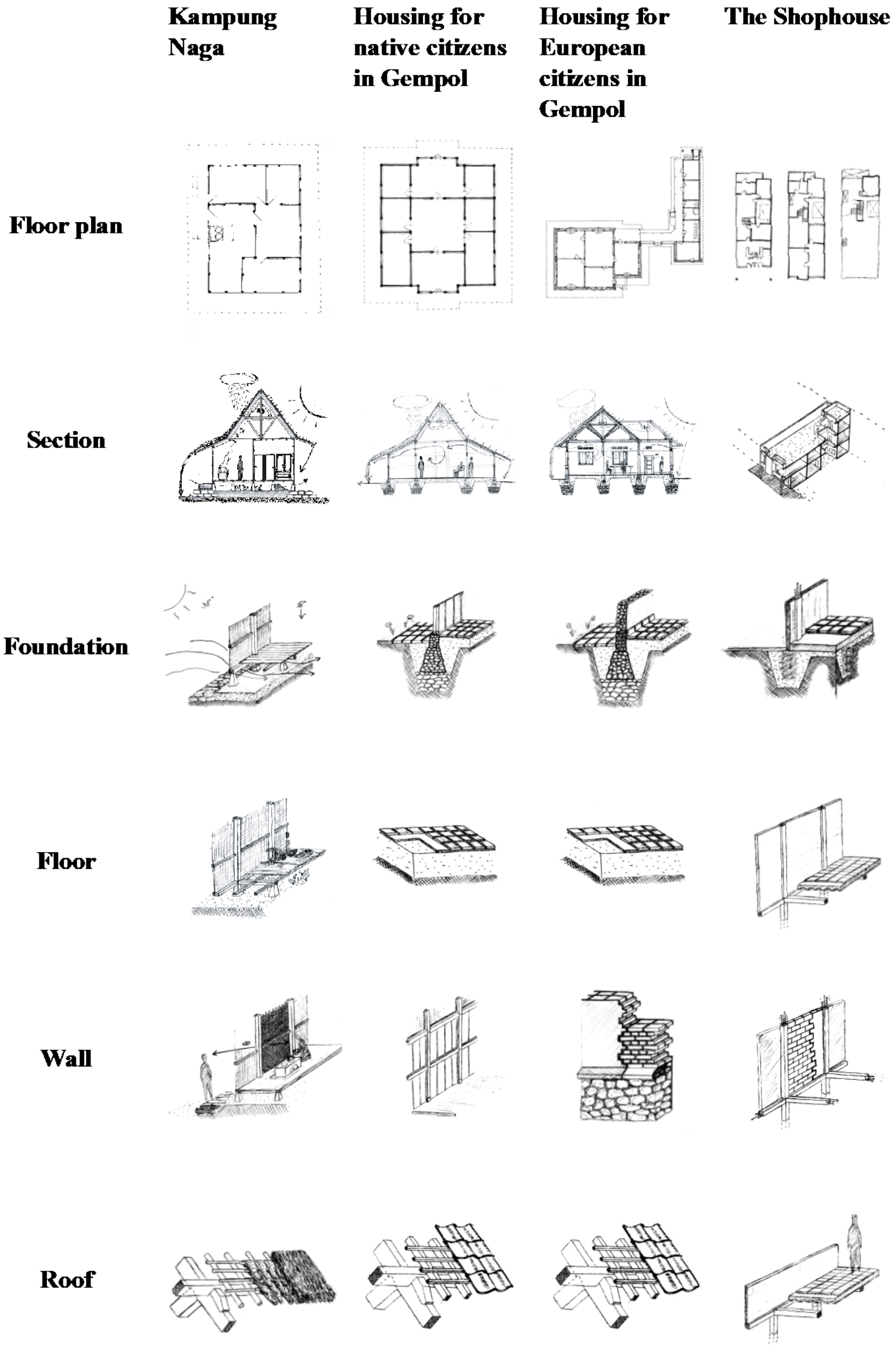


Figure 7: Summarizing Matrix of Building Principles, see appendix 2 (Images by Author)

"The house is an institution, not just a structure, created for a complex set of purposes"

Amos Rapoport (Rapoport, 1969, P.46)

5.2. General foundation for the principles of the Sundanese vernacular house

A surplus of reasons form the well-developed foundation for all building principles, whether related to form or construction, for the house in Kampung Naga, which is a representative of Sundanese vernacular architecture. The foundations related to heavy rainfall, the hot temperature and the high humidity of the air when considering the lifting of the house, the lightweight materials used in the facade and the shape of the roof are related to the climatic conditions on the Island of Java. However the choice for lightweight materials is also beneficial in the case of an earthquake and the shape of the roof is related to the availability of material too. Moreover the cosmic believe in the upper, the middle and the underworld form the foundation for a religious and more emotional background, rather than a purely climatic one. Furthermore the argument of social status, seen in the materialization in the facade of the guestroom, where a timber paneling is applied instead of the climatically more convenient bamboo mat, has to be considered as well. Conclusively the motivations of the choices made in the building-culture of the Sundanese vernacular architecture are based upon climatic and cultural reasons and the availability of materials. None of the choices made is motivated by only one of these aspects, since usually all three are interrelated. This conclusion is supported by research conducted into the form of the vernacular house in general and the motivations behind the established form by Amos Rapoport (Rapoport, 1969, P.18-49). His claim is that the form of the house is primary derived from socio-cultural factors and secondary by climatic conditions and constructions, materials and technology. This claim is supported by his research, in which he proves that the variety of forms in vernacular architecture in similar climates must be derived from cultural differences and can even be counterproductive to the indoor climate, because of choices based on socio-cultural motivations. This does not imply that climate, the availability of materials and technology are not important, but it is subordinate to social and cultural motivations. Since only one example of vernacular architecture has been researched in this paper, the predominance of the socio-cultural motivations cannot be proved right now, but the importance of all three foundations together is clear.

5.3. General foundation for the principles of the Gempol native house

The main foundations for the building principles of the houses for native Indonesian people and other Asian immigrants in Gempol are clearly based upon socio-cultural, climatic and technological foundations as well, since the examined case studies prove the importance of efficiency, the reduction of building costs, hygiene, the stimulation of ventilation and the formal reference to the Sundanese vernacular architecture in the shape of the roof. The predominance of the socio-cultural motivations is obvious in this case, since the Dutch had a strong preference for hygiene, which is also motivated by climatic conditions, the characteristic shape of the Sundanese vernacular roof is climatically and technologically unnecessary and efficiency and the reduction of building costs was highly valued by the Dutch. This argument is further strengthened by an article in the Dutch magazine on Indonesian building construction methods 'Locale Techniek' which explains the technological development from the timber post and lintel frame with a bamboo mat infill to a timber post and lintel frame with a concrete panel infill, followed by a concrete post and lintel frame with a concrete panel infill and finally the development of a concrete composite block (Abikoesno, 1935, P. 9-19). These innovations are driven by technological, but also by economic and thus cultural motivations.

5.4. General foundation for the principles of the Gempol European house

Socio-cultural motivations, represented in the wish for social and economic status, are the main motivations for the choice for natural stone and brick masonry. Most of the other material and formal choices result from this decision, since they try to improve the indoor climate, which is negatively influenced by the natural stone and brick masonry facade. However, considering the durability of these stone and ceramic materials, they have much better properties than the traditional bamboo facade, therefore this choice reduces the costs of maintenance and is economically more interesting to invest in. Of course aesthetics play a role in this decisions process as well. Cross-ventilation and the construction of window openings in the facade that have at least the surface of 1/12th of the surface of a room are required because of climatic reasons and are necessary to account for a healthy indoor climate. Furthermore the shape of the roof and the overhang are motivated by the design of the urban environment, but is also related to heavy rainfall, the required roof angle for ceramic tiles and the protection of the facade from sun radiation and rainfall. Last but not least the construction of the floor is motivated by hygiene and the wish for a healthy indoor climate, since the Portland cement tiles are easy to clean and the layer of sand underneath the floor prevents moisture from the soil to permeate into the house. Conclusively the motivation of Social and economic status is important, as are aesthetics and the urban design, but a healthy indoor climate, hygiene and the availability of materials are important motivations too.

5.4. General foundation for the principles the contemporary Shophouse

The context of the shophouse is completely different from Kampung Naga or Gempol, since it is located in a densely built city centre where it is economically impossible for a merchant to build a detached house. The shophouse is therefore an attached type of building, characterized by its verticality, the depth of the building, gradually expanding its area to the back, and its narrow front facade, all motivated by the cultural context of the ever densifying city centre. The choice for a concrete structure with a brick masonry infill is, like in the Dutch colonial European house, based upon social and economic status. Likewise the flat reinforced concrete floor slab of the roof is motivated by the functionality of the roof area as a garden or service terrace. Both motivations disregard the climatic context completely, since there is no overhang to protect the facade, no heat buffer underneath the roof and no lightweight facade to prevent the building from overheating, and increase the need for ventilation. Furthermore the only facade available for ventilation openings is the front facade, as all the others are blocked by adjacent buildings. Fortunately in some of the shophouses the traditional courtyards are still in function, providing the necessary ventilation and daylight to enter into the building. For the same climatic reason, the brick facade is rendered with a cement plaster to protect it from weather conditions. Conclusively the economic and socio-cultural context of the urban tissue and the social status of the building owner are the main motivations for the building-culture of the contemporary shophouse, disregarding the climate almost completely.

VI. PRINCIPLES FOR THE FUTURE RESIDENTIAL ARCHITECTURE

6.1. Principles for the floorplan

Whether the organization of the floorplan is related to the shophouse, the Sundanese vernacular house or the colonial houses, all of them are organized with the more public functions at the street side and the more private functions in the back. Since the shophouse is situated in a densely built urban context, it is difficult to separate the kitchen and the sanitary facilities from the other rooms in the house, but it has to be taken into account that these rooms are well ventilated. Furthermore all rooms should be situated at the facade, which allows for natural ventilation and daylight to enter into the building and windows should be placed in a way that support cross-ventilation. The design of courtyards in the floorplan of a building in an urban context like the shophouse would already meet many of these principles.

6.2. Principles for the section

In the Sundanese vernacular house and the colonial houses, if not regarding the formal references to cultural traditions, the motivations of the building principles are in general to protect the facade from sun radiation and rainfall and to create a healthy indoor climate by the stimulation of ventilation and the prevention of overheating and moisture accumulation. Unfortunately these principles are disregarded in the contemporary shophouse, because of economic motivations and restrictions in the urban context. The desired building principles for the section, without disregarding the urban context, should be a floor height of three to four meters, the provision of a heat buffer underneath the roof, the possibility to ventilate the rooms and the protection of the facade from rainfall and sun radiation, preferably by an overhang of min. 1200 to max. 1500 mm per floor. The heat buffer can be created by the construction of a closed volume underneath the roof that is allowed to heat up, for instance a suspended ceiling.

6.3. Principles for the foundation

The foundation provides a stable base for the building and protects the building from permeating moisture from the soil in all case studies, therefore these principles are important to adapt to in any new building as well. The foundation depth depends on the weight/height of the house, the depth of the loadbearing soil and the stability of the ground during the dry season. The influences of these factors have to be researched in every individual case. Next to the depth of the foundation, the use of a Portland cement mortar in the first 300 mm above and below ground level prevents moisture from permeating into the wall, however any measure that prevents moisture from permeating into the wall can be applied.

6.4. Principles for the floor

In the urban context the motivation of sound insulation and the construction of multiple storeys is important in the choice of a floor type, therefore the concrete floor slab used in the contemporary shophouse is a good choice. However heat accumulation underneath the floor should be prevented, since concrete does not allow for ventilation through the floor, ventilation openings under the floor have to be applied

6.5. Principles for the wall

There have been major developments in the building principles of the wall. In the Sundanese vernacular house the wall is made of natural, lightweight materials, flexible and lightweight enough to resist seismic forces, to allow for some ventilation, to reduce the accumulation of heat in the house and to meet functional requirements. Economic motivations, a changing context and the social status of materials lead to the development of a concrete frame with an infill of rendered brick masonry over time. Like in the colonial era, these materials can be used in the facade, however the negative influences on the indoor climate have to be compensated with natural ventilation, which results in the ratio of window openings that should be 1/12th of the surface of the room and 1/5th of this surface should be placed within 1000 mm from the floor or the ceiling. Furthermore a brick masonry facade has to be rendered to protect it from the weather conditions, moisture et cetera and the masonry should be confined in a concrete frame to be able to resist seismic forces, see appendix 1 page 19.

6.6. Principles for the roof

Only recently the construction of the roof has changed drastically from a saddle roof with an overhang of 1200 to 1500 mm to a flat concrete slab roof without any overhang. The saddle roof eases the drainage of rainwater, however the use of the roof in the contemporary shophouse should be considered as well. The major advantage of using palm leaves or ceramic tiles as roof cover in contrast to a reinforced concrete floor slab is the reduction of heat accumulation underneath the roof, therefore a heat buffer should be provided when using a flat concrete floor slab as roof material. Additionally the lightweight timber construction covered with palm leaves or ceramic tiles is much better resistant to seismic forces, therefore the roof has to be well secured to a confined masonry construction. In general the weight of the construction should decrease if the height of the building increases, to create an earth quake resistant building.

VII. Conclusion

Whether considering the vernacular architecture, the architecture of the Dutch colonial era or the architecture after the independence of Indonesia, the citizens of Java have always been concerned with choices in their building-culture considering form, materials and constructions. Contemporary global and national changes, especially the housing shortage in the densifying cities of Indonesia, ask for a reconsideration of the contemporary residential building-culture. In order to contribute to this debate, a historical research has been conducted to provide knowledge of cultural, material and technological building principles applied in residential architecture throughout time on West-Java and of the motivations behind those principles. The main research question of this inquiry is:

Which underlying cultural, material and technological building principles can be derived from a historical understanding of the residential building-culture on West-Java and how can an understanding of those contribute to the establishment of principles for a contemporary locally founded residential architecture in Bandung?

The research is focused on three timeframes, the vernacular, the colonial and the contemporary, represented by the architecture of Kampung Naga, the Houses for Native Indonesian and those for European citizens in Gempol and the shophouse in the Pasar Baru area in Bandung. The house in Kampung Naga is characterized by a lightweight construction of natural materials, the fact that the house is lifted from the ground and the typical steep roof and its overhang. These principles are motivated by climatic and functional reasons, the availability of materials, the exposure to seismic forces and the cultural beliefs. The roof shape of the houses for the native Indonesian citizens in Gempol is inspired by the vernacular Sundanese roof, to provide a feeling of locality. The construction of a timber frame with a concrete panel infill is mainly motivated by efficiency, cost reduction and hygiene. Because of heat and moisture accumulation in the house, additional ventilation has to be provided. The houses for European citizens in Gempol had to represent the social status of the Dutch, which motivated the choice for a rendered brick masonry facade. In order to prevent water from permeating into the bricks, a base and a foundation of river stones are constructed. Since the facade materials do not allow for ventilation and stimulate heat and moisture accumulation, cross-ventilation is required and windows of a sufficient size have to be provided. Furthermore, the kitchen and sanitary facilities are situated outside of the main house for hygienic and ventilation purposes. The cultural, material and technological building principles of the contemporary shophouse in the Pasar Baru area are mainly motivated by its location in a densely built city centre. The narrow width, long depth and verticality of the building are characteristic and motivate, as does social status, the use of concrete in the structure and the infill of cement-rendered brick masonry. The flat roof without any overhang is problematic for the indoor climate and the facade, but conceivable in a functional sense. The application of a courtyard and the creation of a thermal buffer underneath the roof will improve the indoor climate. This knowledge lead to the definition of these principles for a contemporary locally defined residential architecture in Bandung:

1. *The floor plan should be gradually organized from the more public functions in the front of the house, to the more private in the back. Visual/sound interaction between those more public functions in the house and the public environment outdoors is a valuable contribution to the social cohesion of the neighbourhood*
2. *The kitchen and sanitary facilities should be separated from the living- and bedrooms and should be well ventilated, to enhance the hygiene and indoor climate of the house*
3. *Every room should be located at a facade, to ensure for ventilation and daylight to enter in every room, if necessary design a courtyard*
4. *The floor height should be at least 3 meters, to ensure a healthy indoor climate*
5. *The roof should be a saddle roof where possible, to ease the drainage of rainwater. The attic underneath the saddle roof serves as a heat buffer too*

6. *Although the use of a saddle roof is positive for climatic reasons, the shape has a cultural value too, since an expressive roof shape is present in many Indonesian houses. Therefore the expressivity of the roof can enhance the locality of the architecture, when this is related to climatic conditions as well*

7. *There should be a heat buffer underneath the roof, i.e. by a suspended ceiling or attic, to prevent the house from overheating*

8. *There should be an overhang of 1200 mm to 1500 mm protect the facade from sun radiation and rain fall. An overhang more than 1500 mm will obstruct the natural ventilation in the house*

9. *The foundation should provide stability to the house in the case of an earthquake and should protect the house from permeating moisture from the soil*

10. *The ground floor should be raised 300 mm form the ground, to prevent water from entering the house. The construction of the first/second etc. floor should meet the requirements for the construction and sound insulation, but heat accumulation underneath should be prevented, by ensuring natural ventilation*

11. *Lightweight, natural materials are the best to use for a facade, regarding the indoor climate and the resistance of seismic forces. A well-constructed confined masonry wall provides protection for earthquakes as well. However, this façade has to be rendered on the exterior to protect it from weather conditions. Moreover, to prevent moisture and heat accumulation indoors, cross ventilation should be possible and the window openings should be 1/12th of the surface of the room and 1/5th of this surface should be placed within 1 m from the floor or the ceiling*

12. *The roof construction should be as light-weight as possible, to resist seismic forces and to prevent the space underneath the roof from overheating*

REFERENCES

1. Abikoesno, R. (1935). Aanleg van Stedelijke Bevolkingskampoengs. *I.B.T. Locale Techniek,* (4), pp. 9-18.
2. Alsayyad, N. and Arboleda, G. (2011) The Sustainable Indigenous Vernacular: Interrogating a Myth. In: S. Land, ed., *Aesthetics of Sustainable Architecture*, 1st ed. Rotterdam: 010 Publishers, pp. 134-151
3. Benjamin, S., Arifin, M.A. and Sarjana, F.P. (1985). The Housing Costs of Low-Income Kampung Dweller. *Habitat International,* (9), pp. 91-110.
4. Coch, H. (1998). Bioclimatism in vernacular architecture. In: *Renewable and Sustainable Energy Reviews,* 1st ed. Pergamon.. Elsevier Science Ltd, pp. 67-87
5. Darmayanti, T.E. (2016). *The Ancestral Heritage: Sundanese Traditional Houses of Kampung Naga, West Java, Indonesia.* MATEC Web of Conferences 66, 00108. EDP Science
6. De Bruijn, C.J. (1927). *Indische Bouwhygiëne Deel 2.* Weltevreden: Landsdrukkerij
7. Frick, H. (1995). *Strukturformen Indoesischer Bautechnik.* Eindhoven: Universiteitsdrukkerij
8. Gmelic Meijling, J.P.B. (1953). *Bouwen in Indonesië.* Haarlem: N.V. De Technische Uitgeverij H. Stam.
9. Han, W. and Beisi, J. (2015). A morphological study of traditional shophouse in China and Southeast Asia. *Procedia – Social and Behavioral sciences*, (179), pp. 237-249
10. Hasan, I. (2009). *Architecture and the Politics of Identity in Indonesia: A study of the Cultural History of Aceh.* Msc. University of Adelaide.
11. Hidayatun, M., Prijotomo, J. and Rachmawati, M. (2016). Vernacular architecture as an alternative design approach with interpretation of Paul Ricoeur's critical theory. *A|Z ITU Journal of the Faculty of Architecture*, (13), pp. 107-114
12. Ignasia, H. (2008). *Transformations and Conservation of the Ex-colonial Dwelling Settlements in North Bandung – Indonesia.* Msc. University of Stuttgart.
13. Knijff, J.N. and Pak Ucuk. (2018) *Interview with Pak Ucuk about building culture in Kampung Naga*
14. Kubota, T. (2017). *Lecture 2: Vernacular Architecture*
15. Maknun, J., Busono, T., Nuryanto. (2016). *Disaster-friendly Sundanese Traditional Building Constriction.* IOP Conference series: Materials Science and Engineering
16. Mugica, C., (2018). *Application of Javanese Self-Build & Vernacular Principles to Urban Kampung of Bandung.* Bsc. Technical University of Delft.
17. Nurtati, S., Taufan, H. and Eka, V. (2017). *Building transformation in Bandung city centre: Expansion of land lot at Pasar Baru area*. ISUF International Conference series: City and territory in the Globalization Age
18. Poldervaart, A. (1932). De Woningvoorziening in de Steden. *I.B.T. Locale Techniek,* (1), pp. 13-16.
19. Van Roosmalen, P.K.M. (2009). *Ontwerpen aan de stad: Stedenbouw in Nederlands-Indië en Indonesië (1905-1950).* Msc. Technical University of Delft.
20. Rapoport, A. (1969). *House, form and culture.* Englewood cliffs, NJ: Prentice-Hall
21. Siregar, S.A. (1990). *Bandung – the Architecture of a City in Development: Volume 1.* Msc. Catholic university Leiden.
22. Sulara, P. (2015). *Sundanese Architecture.* Bandung: PT Remaja Rosdakarya

APPENDIX 1: CASE STUDIES

Case Study 1: Pre-Colonial Housing – Kampung Naga

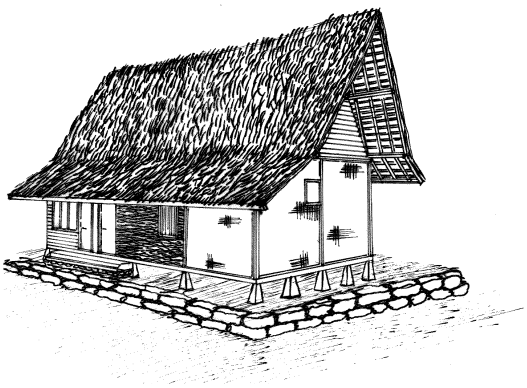
Case Study 2: Colonial Housing - Housing for native citizens in Gempol

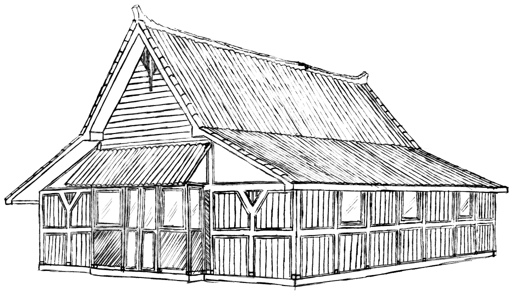
Case Study 3: Colonial Housing - Housing for European citizens in Gempol

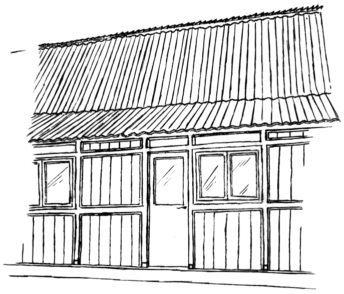
Case Study 4: Contemporary Housing – The Shophouse

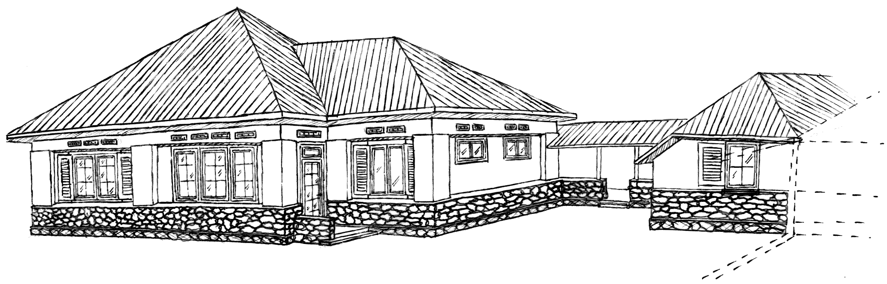
APPENDIX 2: SUMMARIZING MATRIX

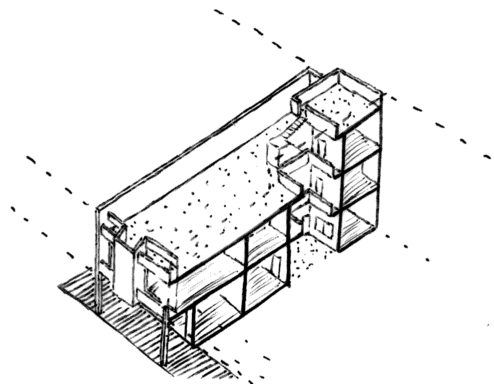
Appendix 1: The Case Studies











Case Study 1: Pre-colonial housing - Kampung Naga

I. Kamung Naga

1.1 Village Context

The village of Kampung Naga (Kampung means village in Javanese language and Naga means Dragon) is situated on the Island of Java, in the province of West-Java, close to the city of Tasikmalaya and about 100 kilometres away from Bandung. The area around the Kampung is very mountainous, as the middle of Java in general is, and covered with volcanoes, caused by the subduction of the Indian Oceanic plate under the Eurasian plate (Rajendran, 2018, P.339). The vulcanic soil and the huge amount of small rivers flowing down from the mountains make the island very fertile, hence the entire area is covered with rice terraces. The Kampung itself is also situated on a mountain slope, in the curve of a river.

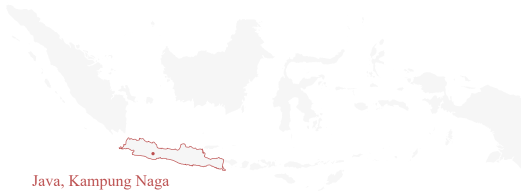


Figure 1: Island of Java, Kampung Naga (Image by Author)

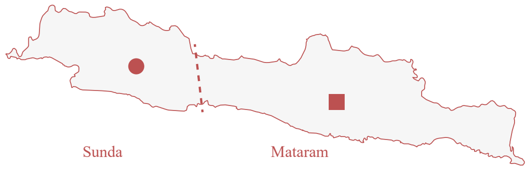


Figure 2: Sunda & Mataram (Image by Author)

1.2 The Climate

The climate on Java is characterized by its hot air temperature and humidity, a predominant temperature of 25 to 30 degrees Celsius throughout the year, and two seasons, a wet and the dry one. The dry season is problematic, because of the intensive solar radiation and the destabilization of the soil and in the wet season the huge amount of rainwater has to be dealt with. (Coch, 1998, P. 67-87).

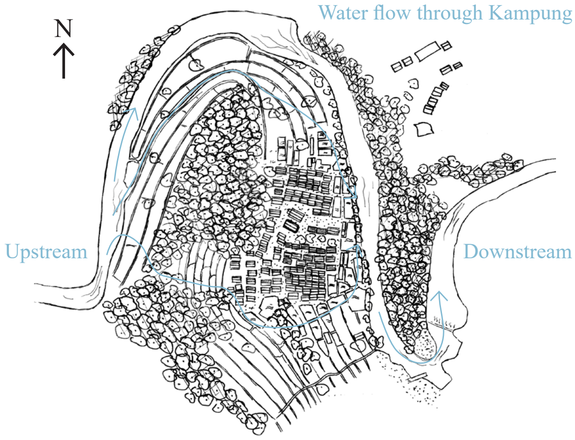


Figure 3: Aerial Map (Image by Author)

1.2 The Sundanese

The Sundanese culture origins in the Kingdom of Sunda that covered the West of Java and Southern Sumatra, therefore controlling the Street of Sunda, in the 15th century, although references to the King of Sunda on the West of Java were already made in the 5th century A.D.. Later on the Kingdom of Mataram from the East of Java took control over West-Java and in the 18th Century the V.O.C. that was based in Batavia, nowadays the city of Jakarta, united almost all of Java under its rule, which founded the base for the Dutch


Figure 4:Aerial view (Image by Author)

Colony. When referring to Javanese culture and its vernacular architecture, people refer to the Mataram region in the East of Java, with its cultural heart in Yogyakarta. The Sundanese culture is characterized as more egalitarian and democratic, whereas the Javanese society was a feudal one, which had a major influence on the development and the spread of their knowledge and culture. The Javanese culture is therefore more expressive and more widespread. One of the reasons is the conquest of the Javanese over the Sundanese. Most of the Sundanese are followers of the Islam, however the religion is influenced by the old animistic believe in spirits and mystic forces (Sulara, 2025, P.50-64). These animistic believes become visible in the explanation of the shape of the house, which is subdivided in the Upper world related to the sacred and God, The Middle world related to Earth and human life and the Under World related to death, represented respectively by the attic, the room and the foundation (Darmayanti, 2016, P.5).

1.2 Village Culture

The villagers live like their ancestors did as much as possible. Therefore they maintain their vernacular housing culture, festivals, cuisine, traditional food production, (human-)waste management and collection and production of building materials. The village is led by a leader, who is supported by several men, among them are the Imam and the master builder. Every family has a house, built collectively, under the direction of the master builder. The most prominent houses are grouped along a central square, which is used for festivities, for drying rice and other communal activities. The Mosque and the communal building are also located around this square. In order to do maintain their traditional lifestyle, they constructed an elaborated water system, taking water from the river upstream, directing it through a system of fish ponds and rice fields to release the water downstream again. The water is used for food production in the rice fields, cultivation of fish, washing and managing human waste (Interview Pak Ucuk, 2018).

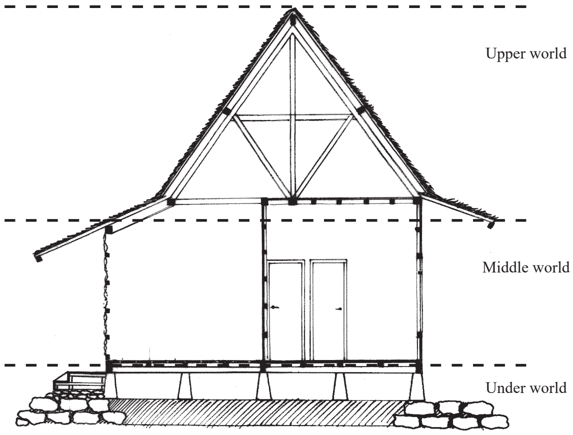


Figure 5: The three worlds
(Image by Author)

Figure 6: Fishponds at Kampung Naga
(Image by Author)

Figure 7: The square of Kampung Naga
(Image by Author)

Figure 8: House in a fish pond
(Image by Author)

1.3 Form & Spatial configuration

1.3.1 The elevated house

The building is built on an elevated plot, making sure that rainwater won't be able to come under the building (Interview Pak Ucuk, 2018).

The house is elevated about 400 mm above the building plot, allowing for ventilation underneath the house, storage and chickens and small cattle to live (Interview Pak Ucuk, 2018). The ventilation underneath is important to lower the temperature in the house, as ventilation is the best mean to cool down the indoor air temperature. Next to temperature reduction, ventilation underneath the floor is important for moisture evaporation, since the timber construction and the timber floor are vulnerable to moisture contained by the air and permeable from the soil (De Bruijn, 1927, 23).

1.3.2 Shape of the roof

The roof angle of 70% is very steep. Since the natural roof material is quite permeable to water, this angle is necessary to quickly direct the water away from the roof. The change in angle from 70% to 35%, made to direct the water further away from the building, allows for the construction of a veranda and protect the facade from solar radiation and rainwater (Interview Pak Ucuk, 2018). The people only live on the ground floor of the house. The volume of the attic mainly serves as a heath buffer, separated from the house by the ceiling (De Bruijn, 1927, 31).

1.3.3 Spatial configuration

The veranda and the kitchen are the most important spaces in the house, since the veranda allows for social interaction with the neighbours and the kitchen is the heart of the house, where food is cooked and heath is produced for the colder nights. Therefore they are situated along the public street. The living room is only for receiving guests officially and the bedrooms are used only for sleeping (Interview Pak Ucuk, 2018).

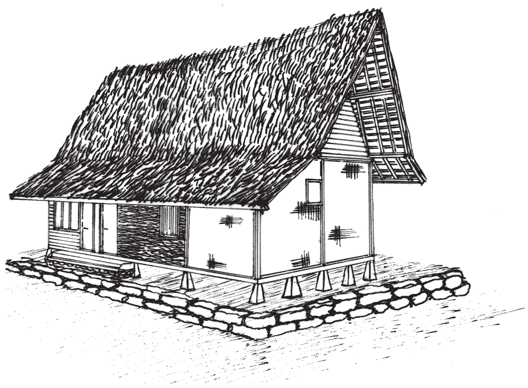


Figure 9: Exterior view (Image by Author)

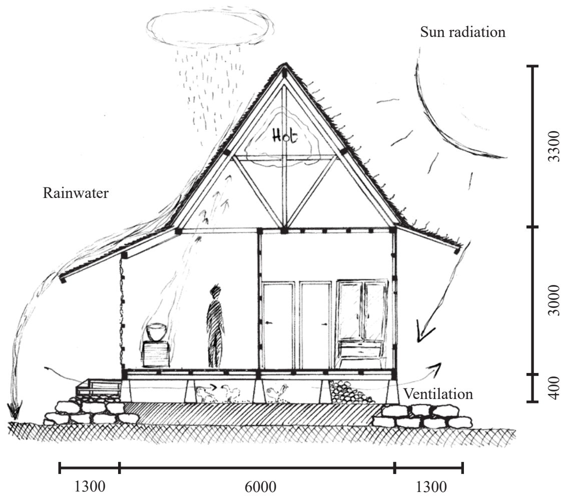


Figure 10: Section (Image by Author)

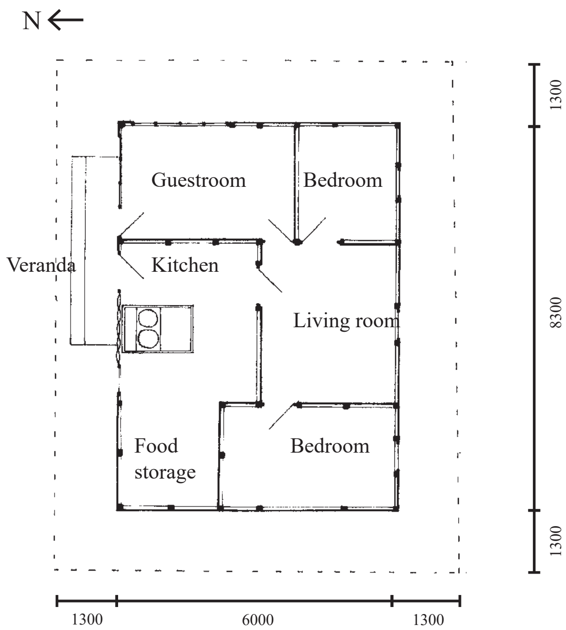


Figure 11: Floor plan (Image by Author)

1.4 Materials & Connections

1.4.1 Natural building materials

Most of the building materials are collected in the surroundings like wood, bamboo and leaves, however some, like nails and other iron products, are bought in the next city. Figure 12 shows some of the building elements that are made only from bamboo (Interview Pak Ucuk, 2018).

Figure 12: Collection of building elements made from bamboo (Image by Author)

1.4.2 Foundation

The foundation is made from a rammed earth base, surrounded by untreated river stones, that make sure the rammed earth will not be washed away. The height of the rammed earth is about 400 mm, creating a solid base for the building and protecting it from rainwater. The building itself is placed on pyramid-shaped river stones, elevated the building up to 400 mm. The river stones do not transfer the moisture from the soil to the wooden construction and therefore prevent it from rotting easily (Interview Pak Ucuk, 2018).

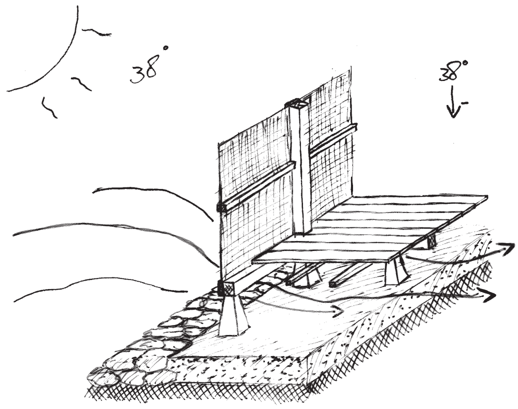


Figure 13: Foundation (Image by Author)

1.4.3 Regular floor

The regular floor, used in all rooms except for the kitchen, is made from Manglid wood, which is strong, durable and the villagers like its aesthetics. In order to lengthen the lifespan of the material, the wood is placed in the fish ponds for several weeks after the tree has been chopped down. The mud in the pond treats the wood in a way that hardens the material (Interview Pak Ucuk, 2018).

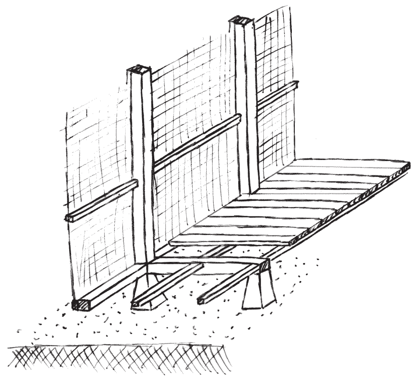


Figure 14: Regular floor type (Image by Author)

1.4.4 Kitchen floor

The Kitchen floor is made from unrolled bamboo tubes, which are cut longitudinally to be able to unroll them. After unrolling, the bamboo is treated in the fish ponds for several weeks as well and dried in the sun for another few weeks to create a durable and strong, but flexible floor. This floor is different than in the other rooms, because of the need for flexibility, to be able to lift the floor and throw waste food under the floor to feed the cattle (Interview Pak Ucuk, 2018).

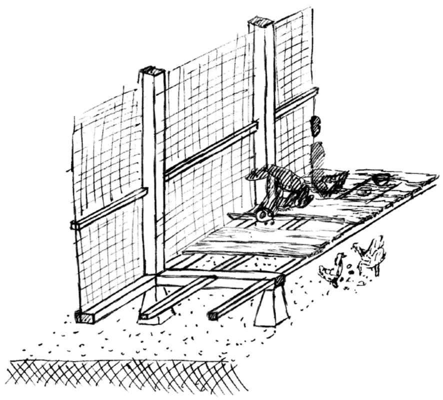


Figure 15: Kitchen floor type (Image by Author)

1.4.5 Timber construction

The floor and the facade are supported by a post and lintel construction of Albasiah wood. It is a light coloured and strong wood, treated by placing it in the fish ponds for several weeks as well, similarly as the timber floor, to enhance its durability. The connections are mostly made in wood only, as the notch in the posts shows in figure 16. However, wherever necessary nails and screws are used (Interview Pak Ucuk, 2018).

An important advantage of using timber as the main construction material, in combination with the other light-weight natural construction materials, is the fact that these materials and the connections between them are flexible enough to resist earthquakes. In general the weight of the construction should decrease as the height of the building increases (Maknun, et al, 2018, P. 128).

Figure 16: Workshop in Kampung Naga
(Image by Author)

Figure 17: Facade Kampung Naga house
(Image by Author)

1.4.6 Bamboo used as facade material

Figure 12 shows that bamboo can be used in many ways, accordingly it is used for the facade too. The bamboo is sliced into slim, long slats, that are used to weave bamboo mats. These mats can be woven in several patterns, which can be categorized as open or closed, see figure 18. The open pattern allows for three times more light to come through and air ventilation than the closed one (Frick, 1995, P. 124). As for the floor, the bamboo used for the facade is the green bamboo, which is the biggest, strongest and most durable (Interview Pak Ucuk, 2018).

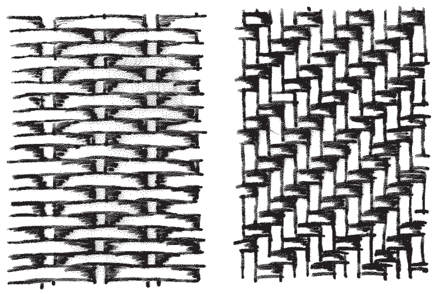


Figure 18: Open en closed weaving pattern
(Frick, 1995, P. 124)

1.4.7 Open pattern

The open pattern is used only in the kitchen, allowing for light to enter the kitchen, for ventilation, establishing an airflow empowered by the heat of the stove and most importantly it is applied to establish social interaction between the kitchen, the veranda and the public space (Interview Pak Ucuk, 2018).

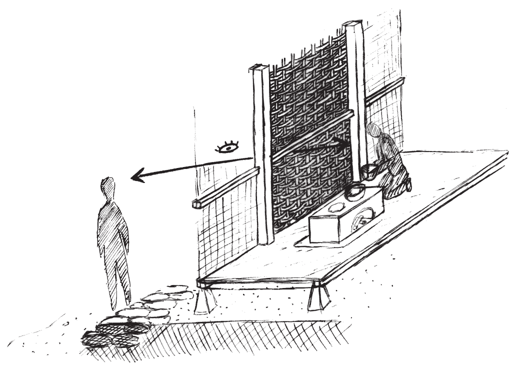


Figure 19: Wall, open weaving pattern
(Image by Author)

1.4.8 Closed pattern

All the other facades in the house are made with the closed pattern, allowing for shelter. The room behind lightweight material doesn't heat up much, tiny holes in the pattern allow for some ventilation and the bamboo mat is plastered with a lime plaster, to reflect sun radiation (Interview Pak Ucuk, 2018). Sometimes the closed facade is made from Maglid timber planks, to show the status and the wealth of the owner, since the wood is less available and requires more effort to produce (Interview Pak Ucuk, 2018). However, climatically the timber facade is less profitable, since the space behind the facade warms up more easily (De Bruijn, 1927, 26).

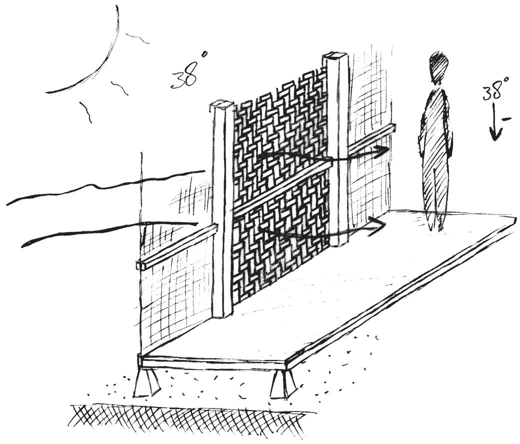


Figure 20: Wall, closed weaving pattern (Image by Author)

1.4.9 Roof construction

The construction of the roof is made from balsa wood, which is a very lightweight material and therefore easy to use. Although it is not that well resistant to moisture, it will not affect the durability of the construction much since the material is used indoors (Interview Pak Ucuk, 2018).

The roof boarding is made from the green bamboo, which is easy to treat and available in abundance. On top of the bamboo boarding, bamboo slats are placed that hold palm leaves attached to it. These palm leaves are the first water-resistant layer of the roof, forming a base for the second layer. This second layer consists of the tree trunk fibres of the palm tree. These fibres are applied on top of the palm leaves. Because of its higher density, the fibres increase the water impermeability of the roof (Interview Pak Ucuk, 2018). The lightweight roof materials prevent the attic from heating up as much as possible and allow for ventilation, when warm air is stored underneath the roof.

The durability of this roof seems questionable, however the villagers say that it can last at least a decade and the part of the roof above the kitchen lasts even longer, since the smoke from the kitchen stove is permeated through the roof itself, protecting it from dampness (Interview Pak Ucuk, 2018).

Figure 21: Roof material, palm leaf (Image by Author)

Figure 22: Roof material, palm Tree truck fibre (Image by Author)

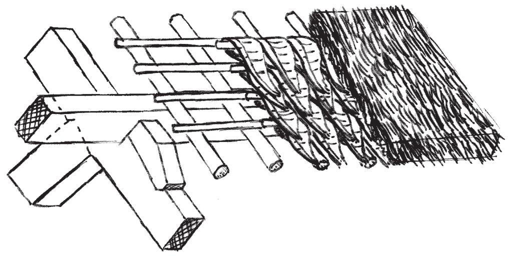


Figure 23: Roof construction (Image by Author)

Case Study 2 & 3: Colonial housing - Gempol

II. Case Study 2 & 3: Gempol Housing Area

2.1 Gempol Context - Bandung North

In 1906 Bandung gained the status of municipality by the Dutch Government. This triggered the development of many public functions for European citizens, which caused a major influx of Europeans, who wanted to enjoy the new facilities and the moderate climate of Bandung. This population growth and the intentions of the colonial regime to move the government offices to Bandung, raised the need for an extension of the city to the north. Bandung had to be the example of a European city in a tropical climate, by implementing the garden city concept. This concept was manifested in a strict hierarchy of roads designed with vista's to the countryside, a green belt surrounding the urban neighbourhoods and the maintenance of a strict ratio between green open space and buildings, by obligatory set-backs, front- and backyards, regulated building heights and roof slopes. The whole concept was focussed on improving the quality of life and creating a healthy environment (Ignasia, 2008, P. 91-110). The housing area of Gempol is part of this design.

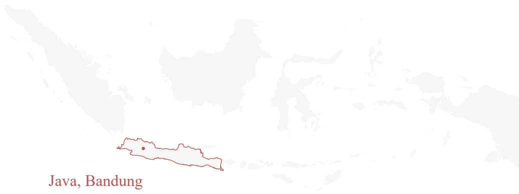


Figure 24: Island of Java, Bandung (Image by Author)

Figure 25: Bandung, Location of Gempol (Image by Author)

Figure 26: Bandung North Extension (Siregar, 1990, P. 88)

2.2 European and native housing - Spatial segregation

The hierarchy of the roads, nodes, parks and rivers can also be seen in the urban design for the residential areas. The bigger, more prominent and more expensive European villas are situated along the main roads, whereas the houses for the regular European labourer are situated along the smaller roads and the residential areas for the native people are situated in enclosed compounds with the backs of their houses faced to the back of the European ones and usually only accessible by a few entrances. Gempol is a typical example of this design hierarchy, which also reflected the social and economic hierarchy in the city (Siregar, 1990, P. 178-184).

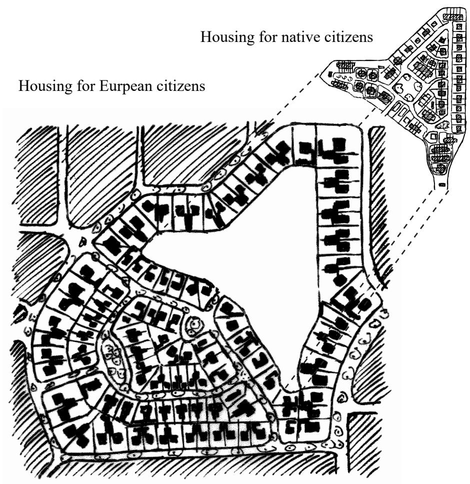


Figure 27: Gempol Housing Complex (Siregar, 1990, P. 93)

2.3 Case Study 2: Social housing for the native Indonesian people

2.3.1 Form & Spatial configuration

2.3.1.1 Types of houses

In the colonial time the inner compound of Gempol housed native Indonesian, or Asian Immigrants, who worked in the government offices and in the households of European citizens. For all inhabitants, the more wealthy and the very poor, a type of house is designed, resulting in the design of a single house, the coupled house, the quadrupled house and the rowhouses of various amounts, see figure 28 (Siregar, 1990, P. 185). The houses examined here are the single house and the rowhouse.

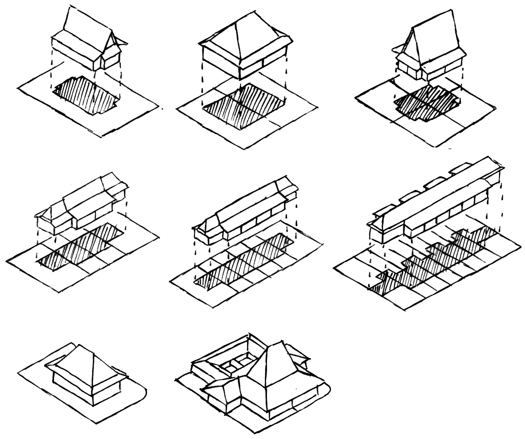


Figure 28: Types of houses for native citizens (Siregar, 1990, P. 185)

2.3.1.2 Shape of the roof

The shape of the roof is a reference to the vernacular Sundanese architecture, which is characterized by its steep angled roof and the node followed by a slight angled roof (Siregar, 1990, P. 187). Since the roof material has been changed to roof tiles, the steep angle is not necessary anymore and is therefore just a formal refenrence. However, the overhang of the roof of 1200 mm is still relevant to direct the water away from the facade and to protect the facade from direct sun radiation and falling rainwater. The overhang should not be more than 1500 mm, since it will influence the ventilation of the house negatively. (De Bruijn, 1927, P. 37) Moreover, the attic, separated from the house by the ceiling, still operates as a heath buffer.

Figure 29: Single House (Image by Author)

2.3.1.3 Spatial configuration

The floor plans do not refer to any traditional architecture (Siregar, 1990, P. 185). They are designed efficiently, always containing a veranda, usually located at the streetside for social purposes, adjacent a small sitting-room, than the larger living-/bedroom and in the back, the kitchen follows. This scheme is applied throughout all houses, complemented with one or more bedrooms. When a kitchen and sanitary facilities are missing, common facilities will be provided in the area (De Bruijn, 1927, P. 245).

Figure 30: Rowhouse (Image by Author)

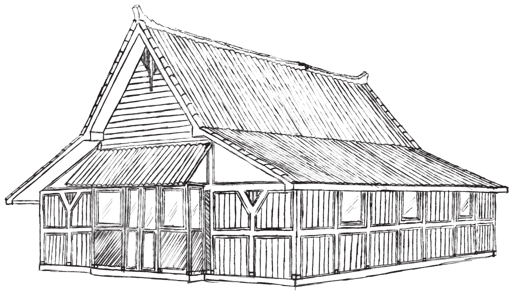


Figure 31: Exterior view single house
(Image by Author)

Figure 34: Exterior view rowhouse
(Image by Author)

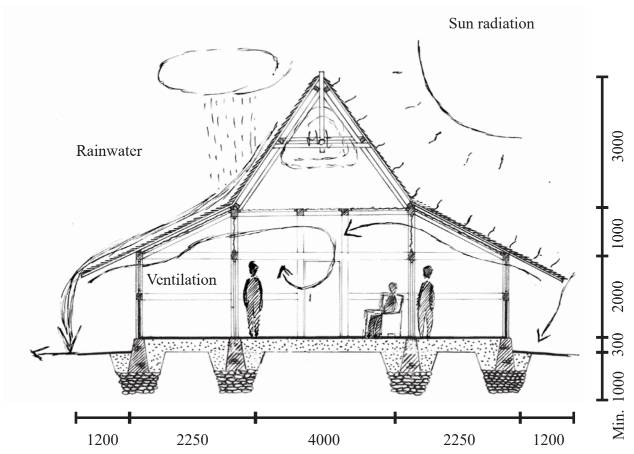


Figure 32: Section single house
(Image by Author)

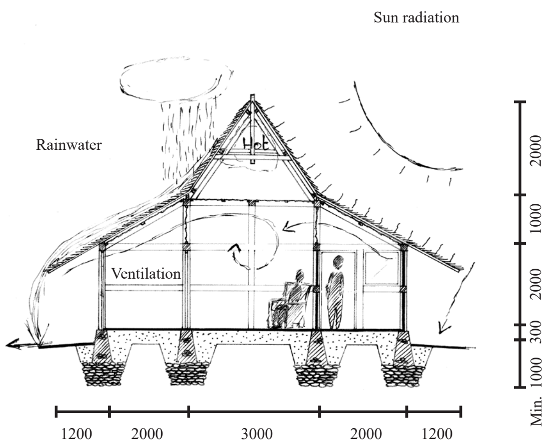


Figure 35: Section rowhouse
(Image by Author)

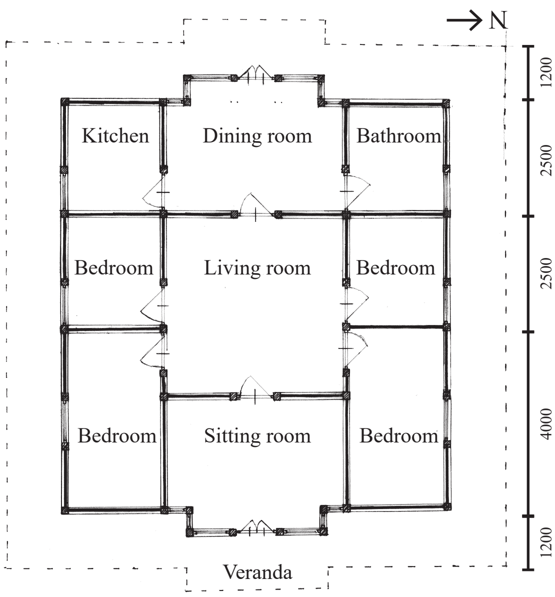


Figure 33: Floor plan single house
(De Bruijn, 1927, P. 251)

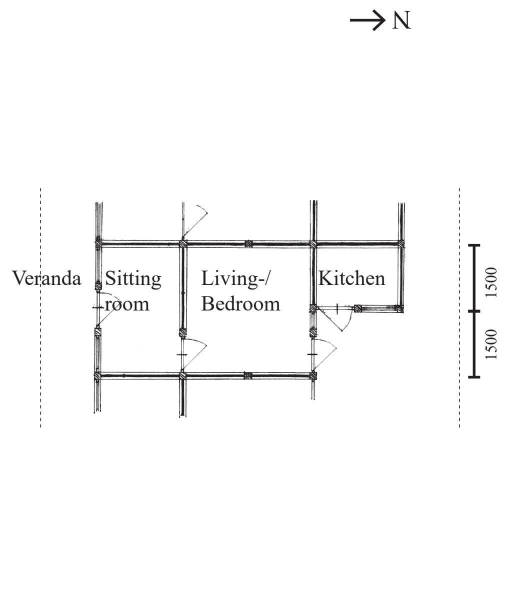


Figure 36: Floor plan rowhouse
(De Bruijn, 1927, P. 251)

2.3.2 Materials & connections

2.3.2.1 Foundation

The foundation is made of stacking of river stones of at least 1000 mm deep built on another layer of bigger river stones. Determinative factors for the foundation depth are the depth of a stable soil type and the depth of the cracks in the soil during the dry season. About 300 mm above and below ground level a Portland cement mortar is in the river stone foundation to create an impermeable layer to moisture. Next to the foundation a layer of tiles, gravel or natural stone underneath the roof overhang is placed, to provide a clean and dry passage, to direct the water away from the building and to prevent the soil close to the foundation from getting soaked. The ground floor should be at least 300 mm above ground level for hygienic purposes (De Bruijn, 1927, P.36-41).

Figure 37: Facade view of single house (Image by Author)

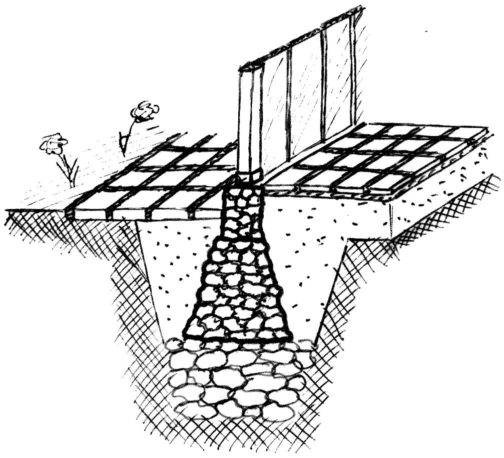


Figure 38: Foundation (Image by Author)

2.3.2.2 Floor type 1

The floor is constructed out of a 250 to 300 mm layer of sand and a finishing of Portland cement tiles of 1,5 to 3,5 mm thick with a Portland cement mortar. The layer of sand is applied to create a stable base for the floor, to prevent water from permeating and to provide a base free from organic materials. The Portland cement tiles are chosen because of their density, therefore preventing soil moisture from permeating into the house and providing an easy to clean surface, as the tiles do not take up water and waste easily (De Bruijn, 1927, P.19-20).

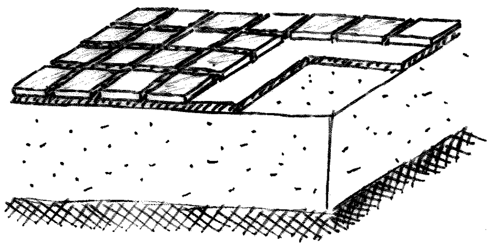


Figure 39: Floor type 1 (Image by Author)

2.3.2.3 Floor type 2

This floor type is cheaper than the first one, however, it still provides a stable and impermeable floor. It is build up out of two layers of river/natural stone strengthened and bond together by a mortar of Portland cement finished by a 8 mm mixed plaster of Portland cement and sand, providing the impermeable and solid surface that is necessary to create a clean and healthy indoor environment (De Bruijn, 1927, P.19-20).

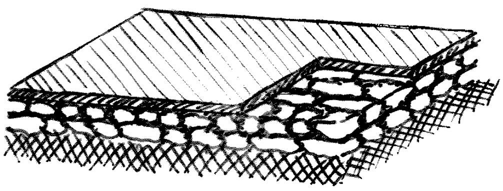


Figure 40: Floor type 2 (Image by Author)

2.3.2.4 Wall construction

The wall is constructed out of a post and lintel timber frame from teak wood with an infill of concrete panels up to 2 meters, above that a bamboo mat is applied (De Bruijn, 2917, P.251). The teak wood is used because it is the most durable and strong source of wood produced locally, resistant to weather conditions and insects. (De Bruijn, 2917, P. 13). The concrete panels have a thickness of 40 mm, a width of 240 mm and a length of 1000 mm and are reinforced with bamboo slats. The material is easy to clean and lasts longer than bamboo mats, however, the thermal conductivity and the lack of air ventilation through the wall, causing a hot indoor temperature, condensation and moisture accumulation increase the need for ventilation. Therefore ventilation openings in the top of the wall and are necessary (De Bruijn, 2917, P. 27). Despite these negative properties the Dutch wanted to replace the traditional bamboo mats in the facade by a more durable material since it would reduce the costs of the maintenance (Poldervaart, 1932, P. 13-16). Moreover bamboo is not used in the constructing for the prevention of the plague (Gmelig Meijling, 1953, P.65).

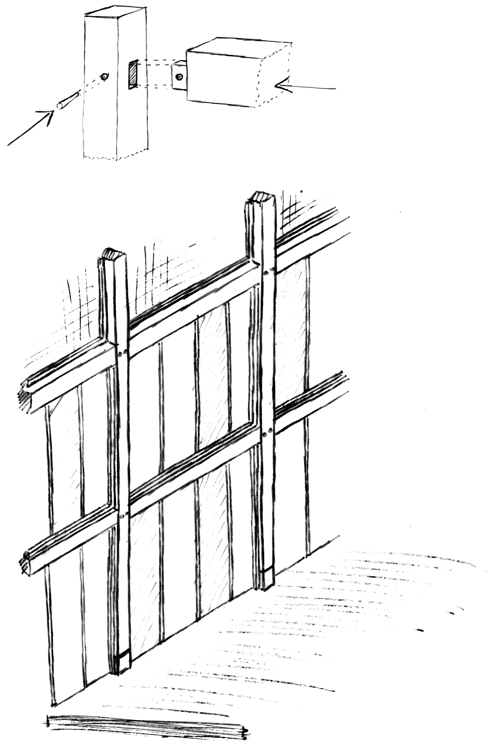


Figure 41: Wall construction (Image by Author)

2.3.2.5 Roof construction

For economic reasons and to prevent vermin from living in the roof, the material has been changed from the natural palm leaves to the mass-produced ceramic tile. This tile is placed on a Rasamala timber construction and underneath this roof a bamboo mat ceiling is applied (De Bruijn, 1927, P. 251). The ceramic tiles are locally produced from clay and relatively cheap. They require a roof angle of 30^{o}. The accumulation of heat underneath the roof is more than with the traditional roof, but not extremely worse, moreover the attic still serves as a heat buffer that is seperated from the house by the ceiling (De Bruijn, 1927, P. 33-35). The Rasamala wood is less durable than the Teak wood, however since it is not exposed to heavy weather conditions the wood is perfectly suited and strong enough for roof construction (De Bruijn, 1927, P. 13).

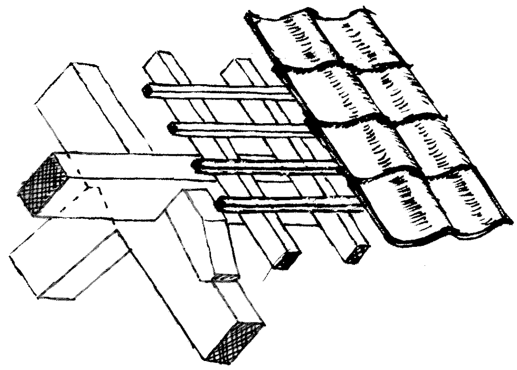


Figure 42: Roof construction
(Gmelig Meijling, 1953, P.31)

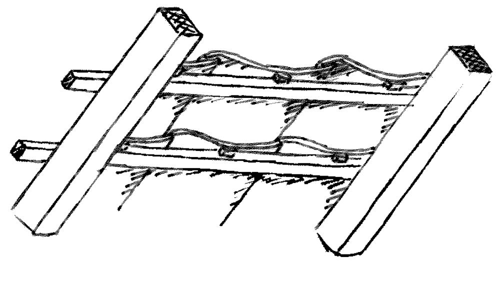


Figure 43: Roof construction
(Gmelig Meijling, 1953, P.31)

2.4 Case Study 3: Housing for the Dutch people

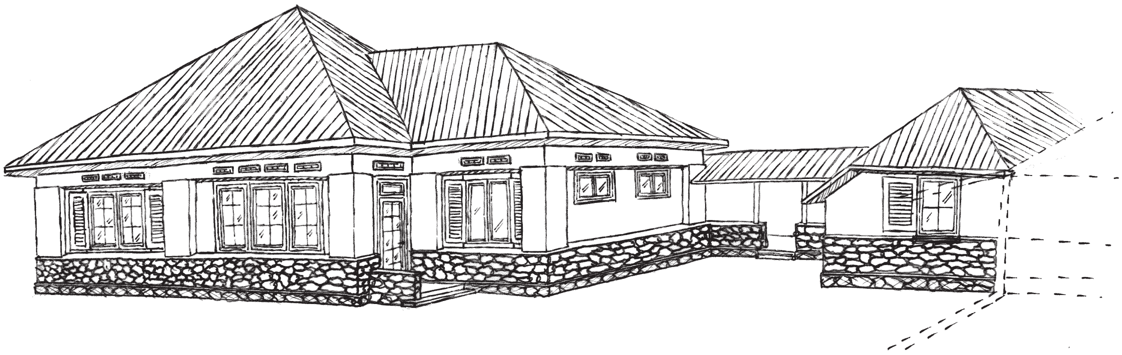


Figure 44: Exterior view European house of the fifth class (Image by Author)

2.4.1 Form & Spatial configuration

2.4.1.1 Types of houses

The houses for the European citizens are designed in several classes, ranging from 1 to 8, varying in size from a large colonial estate for an officer or plantation lord to a house of 32,5 m^2 for a low rank soldier (De Bruijn, 1927, P. 92). The house examined here is an average class 5 house.

2.4.1.2 Shape of the roof

The roof shape is derived from the roof angle of 35o to 40o, necessary for the ceramic tiled roof (De Bruijn, 1927, P. 38), and the experience of the urban ensemble created in the garden city. The feeling of a low density, green residential neighbourhood is strengthened by low, slight angled roofs with big roof surfaces, that are part of a continuous urban facade (Ignasia, 2008, P. 91-110) The overhang of the roof should be 1200 mm to prevent direct sun radiation on the facade and protect the facade from the rain. A too slightly angled roof and an overhang larger than 1500 mm influence the natural ventilation of the house negatively, as do additional storeys on top of the ground floor level. Moreover they were not allowed because of the urban concept. The advised storey height is at least 4 meter for a healthy indoor climate. Windows are placed opposite to each other to allow for cross-ventilation and an open ventilation shaft is made right underneath the ceiling (De Bruijn, 1927, P. 83-95).

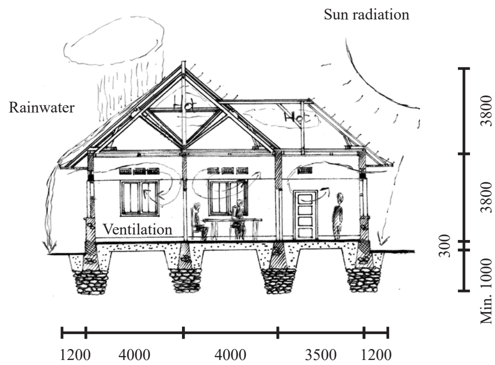


Figure 45: Section European house (De Bruijn, 1927, P.92)

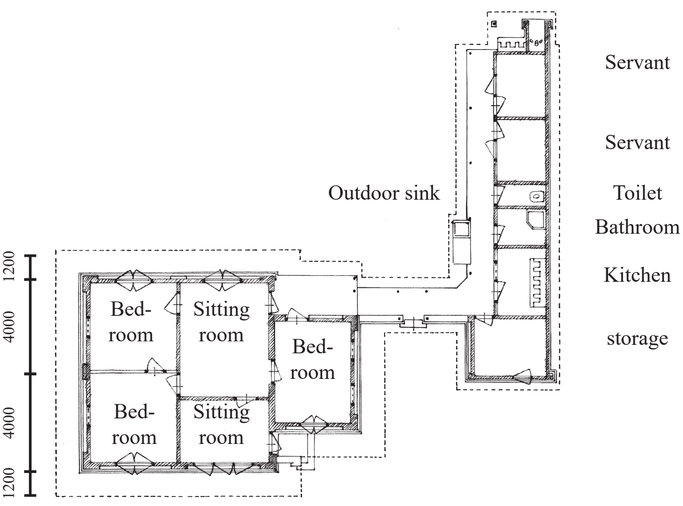


Figure 46: Floor plan European house (De Bruijn, 1927, P.92)

2.4.1.3 Spatial configuration

All houses contain a sitting room in the front and the back complemented with one or more bedrooms. The larger the house, the larger the individual rooms and the more rooms with a special function are added, like i.e. a dining room. The kitchen, the sanitary facilities and the bedrooms for the servants (if necessary) are always located outside of the main house in the outbuilding, because of ventilation and hygienic purposes. This volume is connected with the main one by a covered gallery. From the fourth class house these outbuildings are coupled with the outbuilding of the next house, whereas the main volume is detached. However seventh and eighth class houses are coupled as well. The bigger the house, the more detached is the general rule. Social status, building costs and the urban garden city ensemble were motivations to either couple or detach the houses (De Bruijn, 1927, P. 83-95).

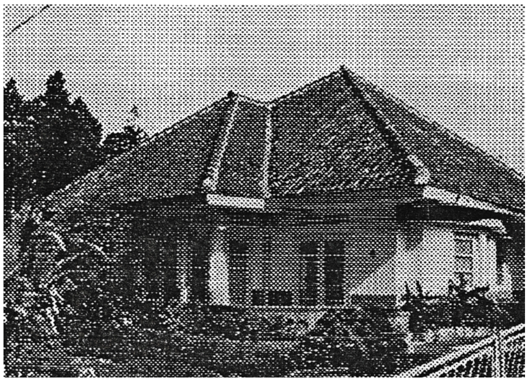


Figure 47: Colonial Villa - Fifth class (Passchier, 1989, P.33)

2.4.2 Materials & connections

2.4.2.2 Foundation type 1 & 2

Foundation type 1 is explained in the section about the native house, the only difference here is the wall that is made of a natural stone masonry. Important to note is the use of a Portland cement mortar in the first 300 mm below and above the ground to prevent moisture from permeating into the wall. Another type of foundation is illustrated in figure 49. Instead of a natural stone base to spread the weight of the building over the soil, the base is made out of sand. This sand base is about 400 mm deep and the width is defined by imagining a line under an angle of 45o from the bottom of the foundation till it reaches the 400 mm depth (Gmelig Meijling, 1953, P. 7-9).

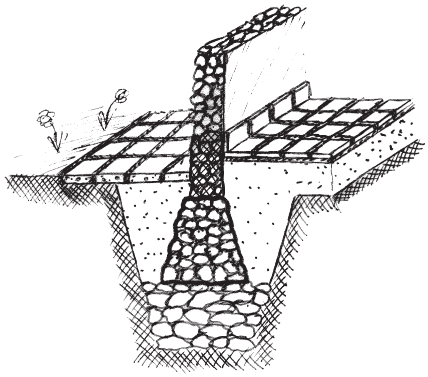


Figure 48: Foundation type 1 (Image by Author)

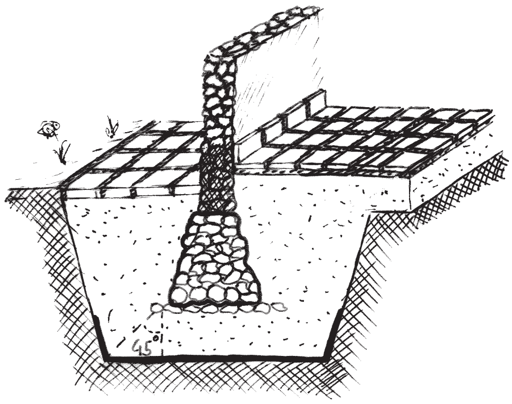


Figure 49: Foundation type 2 (Image by Author)

2.4.2.3 Floor type 1

As in the houses for the native citizens, the floor is made of a 300 mm layer of sand and finished with Portland cement tiles of 1,5 to 3,5 mm thick, secured with a Portland cement mortar (De Bruijn, 1927, P.19-20).

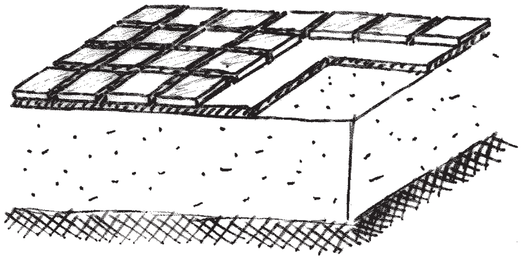


Figure 50: Floor type 1 (Image by Author)

2.4.2.4 Wall construction

Social and economic status are shown in the location, the size and the layout of the house, but very importantly also in the choice of building materials. Bamboo mats for the facade were considered socially undesirable for European citizens, as the concrete wall panels used in Gempol native housing, since they are only used for garden fences in the European properties. In general materials with a higher aesthetic quality and better climatic properties were reserved for the European houses (De Bruijn, 1927, P. 258-270).

The wall in this house is made of natural stone masonry up to 1000 mm, above which a brick masonry wall is constructed. Since the quality of the brick in Indonesia is quite bad, i.e. the bricks are brittle, absorb a lot of moisture and have a low aesthetic quality, a single masonry wall is not allowed, unless it is reinforced with a concrete frame, the bricks are not used in the first 1000 mm above the ground and the bricks are plastered. To prevent moisture from permeating into the brick wall, the base of the wall is made out of natural stone masonry, for which a Portland cement mortar is applied in the first 300 mm below and above the ground, to prevent water absorption (Gmelig Meijling, 1953, P. 10-17).

Although the heath conductivity of brick is better that that of concrete, the rooms behind a brick facade still heat up more than those behind a bamboo facade and the lack of ventilation through the wall causes moisture accumulation and condensation in the house. Therefore natural ventilation through the windows is essential. A ratio of at least 1/12 of the size of the room as the size for facade openings and at least 1/5 of that surface should be less than 1 meter above the ground and below the ceiling (De Bruijn, 1927, P. 84)

2.4.2.6 Roof construction

The roof for the European houses is usually the same as those for the houses of the native people (Gmelig Meijling, 1953, P. 34)

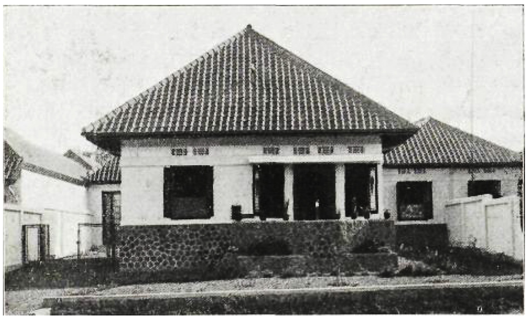


Figure 51: Colonial House - Sixth class (Poldervaart, 1932, P.2)

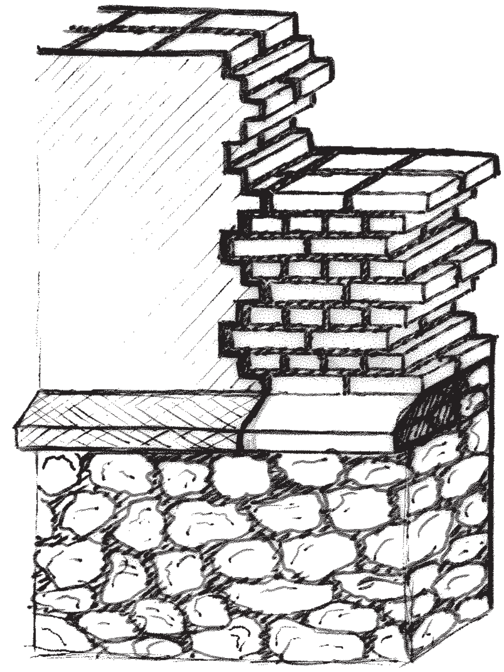


Figure 52: Wall construction (Image by Author)

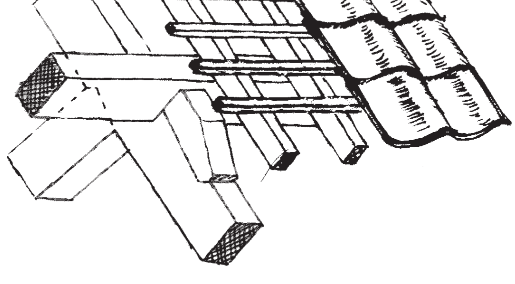


Figure 53: Roof construction (Gmelig Meijling, 1953, P.31)

Case Study 4: Contempotary Housing - The Shophouse

III. Case Study 4: Pasar Baru Shophouse

3.1 Shophouse context - Pasar Baru Area

The shophouse in this case study is located in the Pasar Baru area in Bandung. Pasar Baru is translated as 'New Market' in Indonesian. This name was given to the market after the first market burned down in the middle of the nineteenth century. The government moved the market to its current location, at that time a native Kampung area, and planned a grid structure for its urban development. The opening of the railway and the railway station of Badung close to the Pasar in 1884 stimulated the growth of the market. At first immigrants from Cirebon, Central Java and Palembang were the merchants of this Pasar, they resided along the acces roads to the market, importing their own traditions and architecture. After Chinese immigrants settled in Bandung at the beginning of the twentieth century, they became the most prominent merchants, they also resided in the area and imported their own architecture too (Siregar, 1990, P. 140-141).

3.2 Hierarchy in the urban environment

The Pasar Baru and the residential/merchant area around it are located at the Jalan Otto Iskandar Dinata, one of the main axes from the north to the south of the city. In the colonial time, this road connected the Resident of the Governor and the main horse racing track. This main road, together with the Groote Postweg, the main road from the west to the east of Java, was planned on an existing native Kampung tissue. This resulted in an 'urban pocket' structure, of which the periphery was occupied by Chinese shophouses for trade and dwelling and the interior remained the original native Kampung, illustrated in figure 57 (Nurtati et al., 2017, 1017).

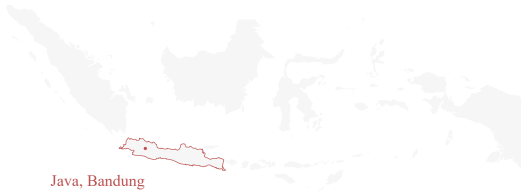


Figure 54: Island of Java, Bandung (Image by Author)

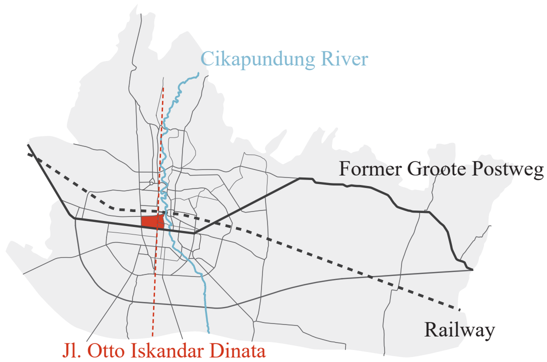


Figure 55: Bandung, Location of Pasar Baru (Image by Author)

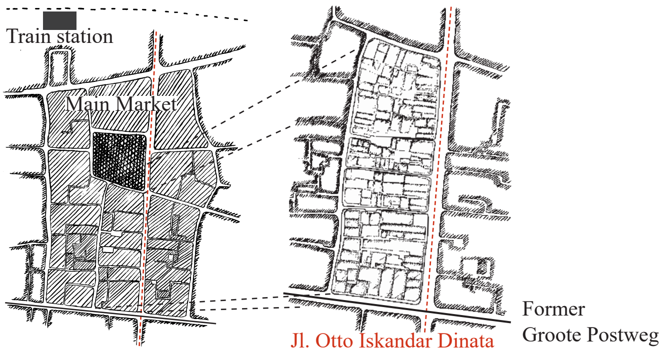


Figure 56: Pasar Baru area (Image by Author)

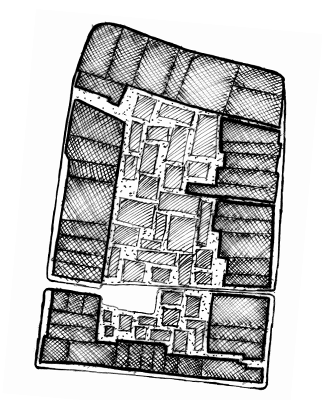


Figure 57: Analysis of city block - the 'urban pocket' (Image by Author)

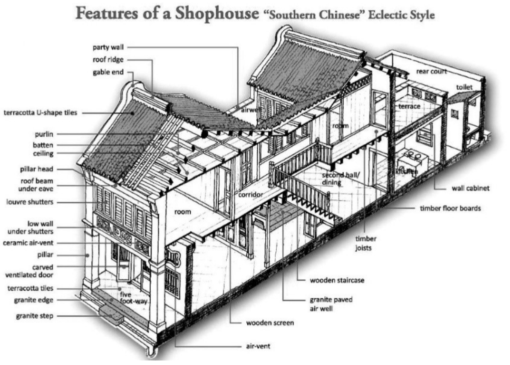


Figure 58: Exterior view Traditional Chinese Shophouse (Han, et al., 2014, P. 240)

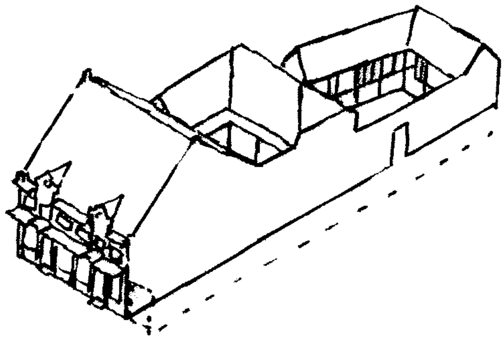


Figure 59: Exterior view Cirebonese Europeanized shophouse (Siregar, 1990, P. 78)

3.3 Form & Spatial configuration

Although Chinese immigrants live in the shophouses nowadays, the architecture of the shophouses is a mixture of the Chinese type, Sundanese, Javanese and influences from colonial architecture (Han, et al., 2014, P. 449). The earliest shophouses were similar to the vernacular Sundanese houses, where merchants would trade their goods from the house or on the street (Nurtati et al., 2017, 1019). Immigrants from other parts of Indonesia brought their own type, which quickly adapted to European innovations. However, the horizontality of the house and the formation of courtyards remained characteristic of their architecture, see figure 59 & 60. The same formation of courtyards occurs in the traditional Chinese shophouse, caused by the dense urban tissue, in which the courtyards are essential for daylight and natural ventilation in the building (Han, et al., 2014, P. 447). However, these courtyards have to be narrow, about 3x3 m2, to prevent the warm air from entering the house (Kubota, 2017, P.56). Because of the population growth, many of the old shophouses are subdivided and extended vertically, since no horizontal extension is possible anymore. Therefore, the contemporary shophouse is very narrow and consists of 2 or 3 levels. The shop is located on the street side and the house in the back. The bigger shops occupy the entire ground floor and the house is moved to the first floor. Usually, the roof is used as a garden or service area and sometimes the courtyards are maintained (Siregar, 1990, P.158-159).

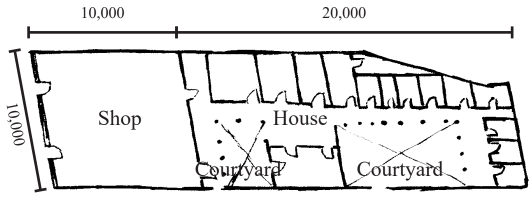


Figure 60: Floor plan Cirebonese Europeanized Shophouse (Siregar, 1990, P. 78)

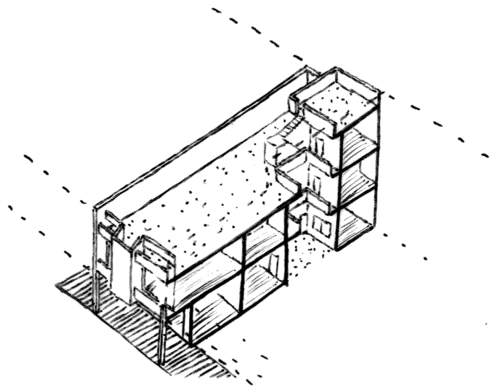


Figure 61: Exterior view contemporary shophouse (Siregar, 1990, P. 82)

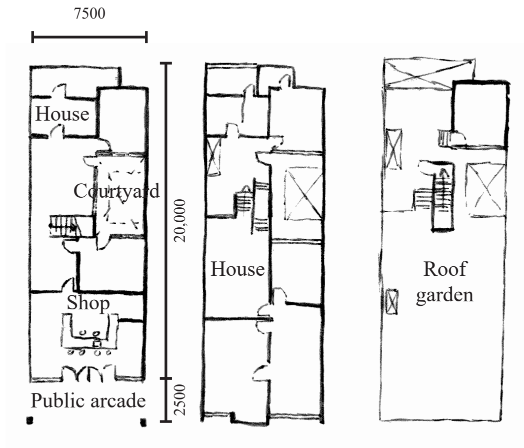


Figure 62: Floor plan contemporary shophouse (Siregar, 1990, P. 82)

3.3 Materials & Connections

3.4.1 Foundation

The foundation of the contemporary shophouse is made out of concrete(Benjamin, et al., 1985, P. 91-110). The concrete column of the main structure is cast together for a cohesive, stable and earthquake resistant building (Gmelig Meijling, 1953, P.13). The exact construction of the foundation is not scientifically defined, therefore figure 63 is an illustration of what the foundation could be like, based on the referenced knowledge.

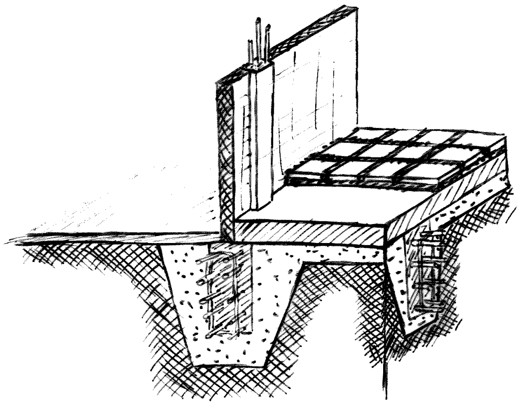


Figure 63: Foundation (Image by Author)

3.4.2 Floor

The floor is made out of concrete as well, this can either be a concrete reinforced slab or a concrete floor cast on a corrugated iron sheet (Benjamin, et al., 1985, P. 106-107). Different than previously described floor construction types, which were all ground floors, this is the floor of a storey. Therefore the sound insulation properties of the floor are more important for which the Dutch already used concrete floor slabs (De Bruijn, 1927, P.22). Since these floors do not allow for ventilation through the roof or the ceiling, extra ventilation openings should be applied in the facade (Mugica, 2018, P.4).

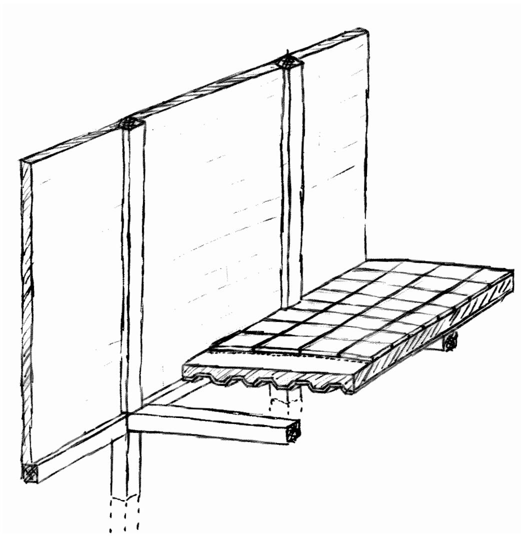


Figure 64: Floor construction (Image by Author)

3.4.3 The Wall

The main structure of the building is a reinforced concrete post and lintel frame with an infill of clay bricks plastered on the inside and rendered with cement on the exterior (Benjamin, et al., 1985, P. 106-107). The absence of a roof overhang expose the facade to heavy weather conditions and make it very vulnerable to deterioration. Therefore the render is applied to prevent rainwater from permeating the wall, furthermore it also done for aesthetic reasons (Mugica, 2018, P.4). Based on my own observations the brick masonry infill was usually of non-confined masonry, see figure 66 and 67, which is very vulnerable to seismic forces. On the contrary, a confined brick masonry infill, where the concrete column and the masonry are finger jointed, provide much

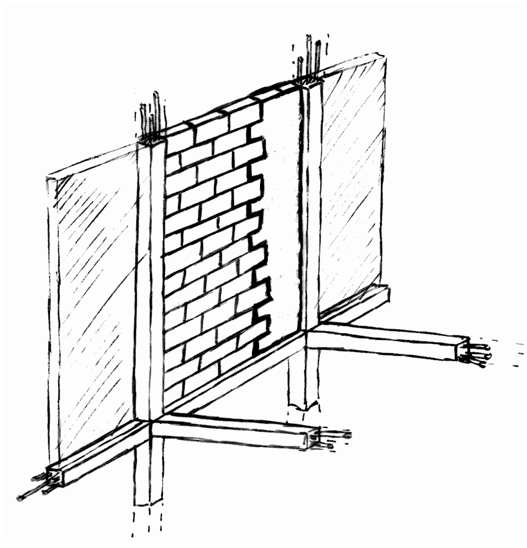


Figure 65: Wall construction (Image by Author)

more stability during an earth quake and would, therefore, be a better choice (Gmelig Meijling, 1953, P.10-14).

The choice of material is based on the social status a certain building material represents. In general, the impermanent, light-weight natural materials, i.e. the bamboo facade, are considered to be materials used by a poor man and the more solid and heavy materials, i.e. concrete, clay bricks and roof tiles, are regarded as more luxurious materials (Mugica, 2018, P.4). Whether it is directly derived from the colonial era or not, this way of thinking is at least similar to that of the Dutch colonial regime, who regarded the light-weight natural building materials undesirable to be used in houses for the European citizen, who at that time were considered to be at the top of the society (De Bruijn, 1927, P. 258-270). Because of this argument based on social status, the negative influences on the indoor climate because of using a brick masonry infill in the facade is disregarded and extra ventilation through the facade is absolutely necessary, as in the colonial villas (De Bruijn, 1927, P.84)

3.4.4 The Roof

Unlike the other roofs discussed previously, this roof type is a flat roof made from a concrete slab. The most probable reason is the fact that this roof is used as a garden or as a service area for the house and the shop beneath it since space is scarce in the inner city (Siregar, 1990, P 158). However, the use of a flat roof has some disadvantages, like the absence of a heat buffer and the need for a very good water-resistant material to cover the roof, since it will be more difficult for the rainwater to be drained from the roof. Especially the room directly underneath the roof will suffer from the heat radiation through the roof and an accumulation of hot air in their rooms if not ventilated properly. The best solution, in this case, would be the construction of a suspended ceiling, this will take over the function of the heath buffer (Gmelig Meijling, 1953, P.59).

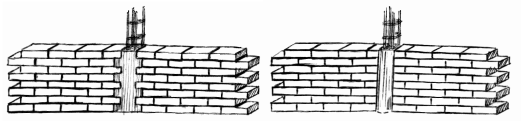


Figure 66: left: confined, right: non-confined masonry (Gmelig Meijling, 1953, P.10-14)

Figure 67: Facades and construction of contemporary shophouses (Images by Author)

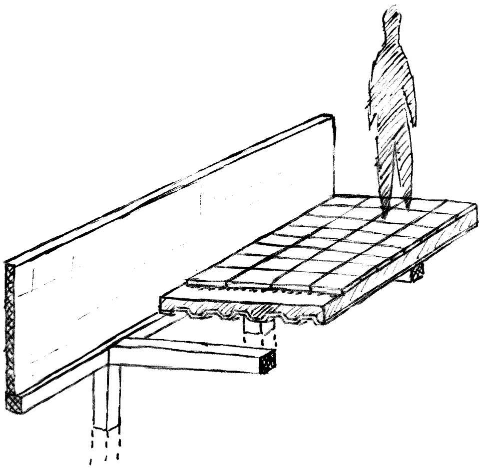
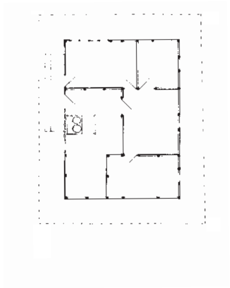
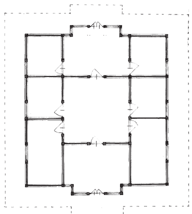
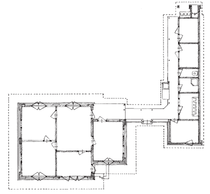
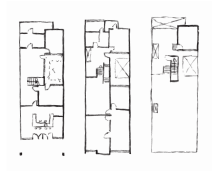
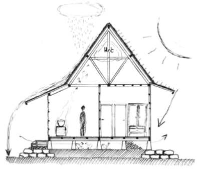
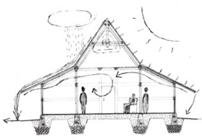
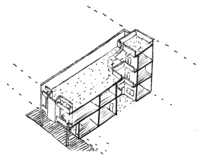
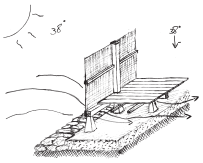
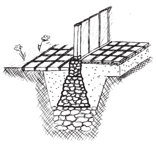
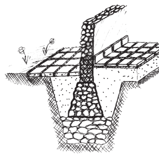
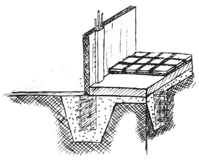
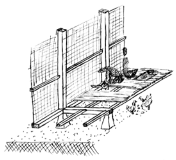
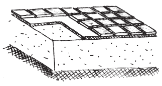
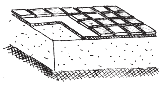
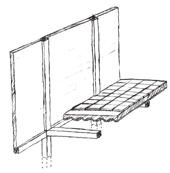
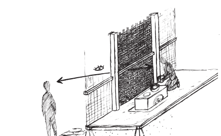
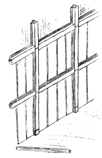
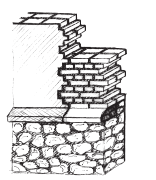
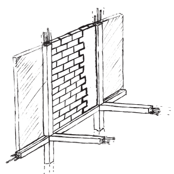


Figure 68: Roof construction (Image by Author)

Appendix 2: Summarizing Matrix

	Kampung Naga	Housing for native citizens in Gempol	Housing for European citizens in Gempol	The Shophouse
Floor plan				
Section				
Foundation				
Floor				
Wall				
Roof