

MODULATE THE KAMPONG

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ABSTRACT

In the informal settlements of Indonesia, the housing quality is of poor condition but has a strong community. By analyzing modular system and implementing them into the existing way of building, there lies opportunities to increase the strength and overall quality of the building of these informal settlements. Modularity follows the existing mindset of the way of building in these settlements. Combining this with prefabrication to reduce the cost, results into a hybrid system. To achieve this goal, the methodology of product design was used and adjusted. The context generated criteria influenced the design aspect and modular systems. This eventually results in a design matrix showing and weighing solutions for certain design aspects, by combining these based on a certain theme. Combining all these solutions will give output which is input for a design.

KEYWORDS: *Modular system, Adaptable, Kampong, Informal settlement, Construction, Materials, Methodology, DIY, Housing, Prefab*

I. INTRODUCTION

Rapid economic growth in big cities and fast urbanisation has triggered the increase of residential areas. There is limited land available in these areas, which results in urban sprawl turning more and more greenery into urban fabric. The growth in population causes a high demand of housing, especially for lower income social class housing. What is also the case in Indonesia which has the fifth largest population in the world (Moochtar, 1979). The lack of housing in cities results in an unregulated area with narrow access roads and irregular, tight self-built buildings. These circumstances cause a high chance of fire spreading and others dangers like flooding's. The existing housing, especially in dense urban areas, are often of poor quality. All this results into a crowded area, poorly built housing, the use of low-grade materials, lack of space in housing, and low quality, small urban spaces. A lot of kampongs in Indonesia cannot be densified in a vertical way because of the weak construction of the buildings. These can only hold up to two levels and the second level is most of the times made of scrap materials.

This paper is about improving the strength of the construction with modular interventions for the informal settlements of Indonesia. The Kampong Braga of Bandung will be taken as a case study to represent the problems in the informal urban settlements of Kampongs in Indonesia.

How can (hybrid) modular systems improve the existing buildings to increase the strength, quality, height and adaptability of self-built housing in an informal settlement?

II. METHODOLOGY

For this study, interviews are conducted for a better understanding of the existing methods of building construction in Indonesia. The person interviewed was the "Tukang" of the Kampong Braga, which is the master builder of the area. All residents ask this person for advice if they need an "expert" on building construction. Also, literature research will give more insight about the context of building in Indonesia and modular solutions.

To implement modularity into the existing building system, a methodology was developed that can be used for all informal settlements in Indonesia. The methodology is based on the methodology used in

the product design industry. The idea is to approach the problems from an analytical point of view to create a building (product) which suits the context.

Methodology of product design

The most influential methodologies of the product design industry for this paper are the ‘Lean’, ‘Six sigma’ and the decision-matrix methods. (Ullman, 1992) These methods gained influence over the past 25 years. The Lean concepts were based on the car-manufacturing system from Toyota and seeks to eliminate waste in all parts of the system. This resulted in eliminating design/products nobody wants, unneeded steps in the process, excess materials and people. “In design and manufacturing, the term “lean” has become synonymous with minimizing the time to do a task and minimize materials needed to make a product.

Lean focuses on efficiency and time, where the six sigma method is more focused on quality. Six sigma finds its origin from Motorola in the eighties and became influential in the late nineties because of the high standards of quality. The methodology involves statistical and analytical methods to account and manage uncertainty and variation. The key to the six sigma methodology is the five-step DMAIC process which stands for define, measure, analyze, improve and control. This eventually resulted in improved processes and products. However, real quality starts with a good design. Recognizing this, the methodology emphasizes quality earlier in the cycle. Therefore, the six sigma method was renamed in DFSS design, in which the best practices and ideas from multiple methods are combined. DFSS is still an emerging discipline and still gaining influence nowadays.

Understanding the design problem is an essential foundation for designing a quality product. (Ullman, 1992) In this research, the design problem is constituted by the context problems.

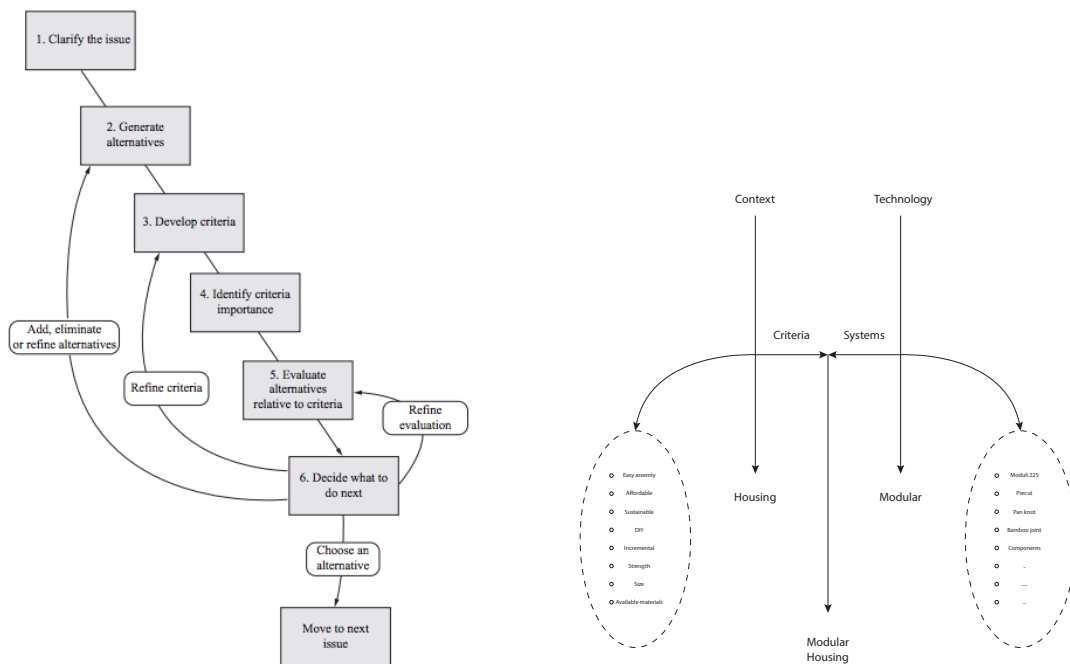


Figure 1 and 2. Product design methodology (Ullman, 1929) and Research scheme

The methodological approach provides designers with a framework to develop their products based on modular principles. [2]

The design matrix

This matrix is used for analysing the pro and cons when a choice between design aspects is need to be

made. Then options are eliminated to eventually decide the directions to follow. The same methodology can be used to evaluate multiple concepts at a time by having a set of criteria developed in the start of the process.

The matrix is an effective way to compare alternative concepts. The matrix is shown in figure 5. The matrix provides a means of scoring each concept to each other in its ability to meet the criteria. Comparing the scores and concepts in this way gives insight in which will be the best alternative and gives useful information for the design. The matrix method is evaluating concepts by checking the criteria, quickly showing the strongest concept, and helping to improve alternatives. The comparing nature of the method helps to improve the concept on different levels by evaluating the outcomes.

Adjusted methodology developed for this research

The methodology starts with a context. In the study case, the Kampong of Braga in Bandung forms the context. However, in fact every informal settlement of Indonesia can be taken. These settlements have the same problems and these will form, together with my fascination, goals and ambitions the criteria for the modular systems implemented and chosen. Also, from the criteria-list, design aspect or sub-themes will be formed. The modular systems and ideas will influence the sub-themes or design aspects and will be combined in the matrix. This results into sub-solutions per theme, causing other problems or criteria. Then the sub-solutions will be weighted according to cost, adaptability and quality. The sub-solutions together will form the framework of the start of a design. See figure 3.

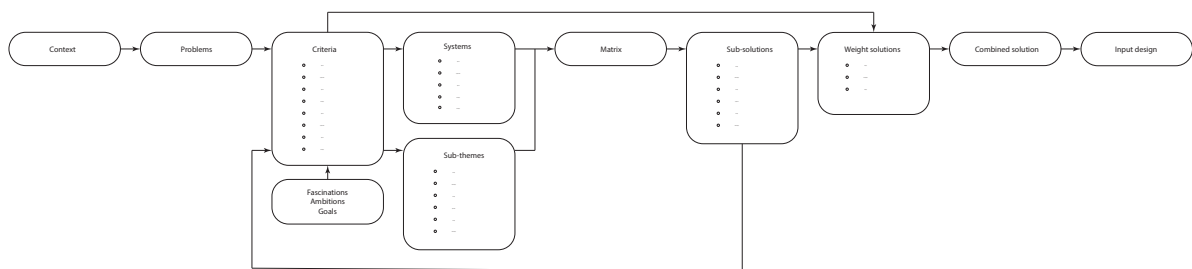


Figure 3. Adopted from product design methodology for this research

How were the modular systems chosen.

The systems are based on the criteria given by informal settlements of Indonesia. The criteria list is made for a specific location in Bandung. However, some of these criteria are not applicable to general informal settlements. Therefore, these were eventually not used for this research. Some of the criteria are weighed heavier on the choice of the suggested modular system than others. One of the criteria weighed heavier from the context, is the focus on the joints. The chosen modular system had to be mainly focused on the connection points of the different components. The reason for this was to focus on improving this specific problem to increase the overall strength of the construction.

Due the fact that layout can vary enormously in informal settlements, this paper is focusing on the joints of construction and not looking at a set module.

III. RESULTS

How do they build in informal settlements.

The initial build house is only the beginning of a larger housing commitment, to which improvements and additions can be made when resources allow and/or are required by the users. The residents of the kampong build over time if they can afford to expand. The kampong of Braga consists of mixed income households and a social economic support system. The kampong house represents more than a simple shelter against the environment, it can be a shop, restaurant or an enterprise. Building costs can be reduced by the community working together, called "Gotong Royong". The idea behind this

concept is that people do not pay for the help they get, but help each other without payment (Benjamin et al, 1985). All buildings are self-built under guidance of a “Tukang”, which is the master builder of a certain area (RW). Layouts of the houses can vary a lot because of different size of land. Types of housing in informal settlements of Indonesia are permanent, semi-permanent and temporary. (Benjamin et al, 1985)

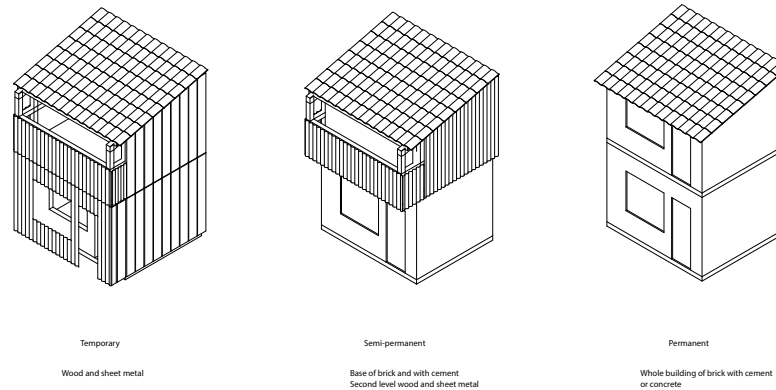


Figure. 4 types of buildings.

One of the differences between housing in Indonesia and the western world, is that in the informal settlements in Indonesia, houses are never completely done. Western countries and the formal building sector of Indonesia desire a finished product. Yet, in the informal settlements they build in small increments over different periods of time if the community can help and money is available. (Angel et al, 1976)

As mentioned before a house starts small and grows over time in size and material. They begin with a temporary, one-room building, constructed out of wood and scrap metal. The wooden frame is built by themselves and then the metal plates are nailed to it. The roof is made of a timber frame and finished with tiles or also scrap metal. The next step is to replace the metal with bricks or concrete and remove the wooden structure behind it. A finishing layer of plasters are put on top of the bricks to give it a finish. The one-roomed house is finished for now. When the need arises to have more space, once again a wooden structure is added on top or next to the current brick walls. Next, it is finished with scrap metal and a roofing of tiles or metal. Before, this was done making use of the free space surrounding the building. Due to lack of space, nowadays the buildings are most of the time topped up.

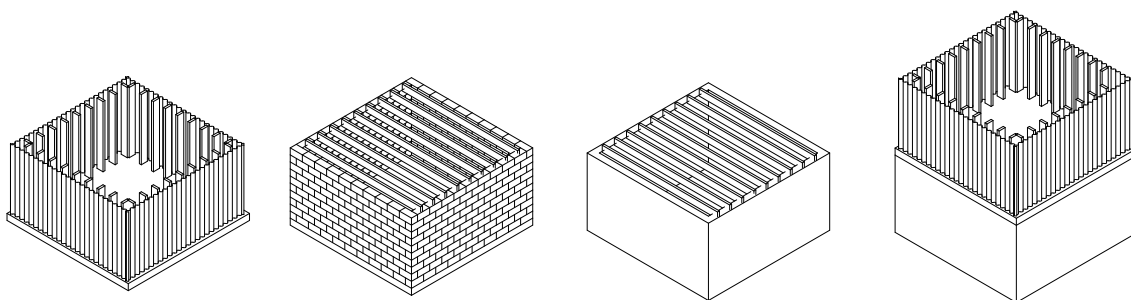


Figure. 5 way of building.

What is Modularity.

Modularity makes it possible to change elements without redoing the whole building (Baldwin et al, 2000). So, modularity in architecture can be seen as a system composed of different elements which can be changed without affecting the building. Even though full modularity in architecture is difficult to accomplish, implementing modularity in certain aspects of the building is realistic. The most

important aspect of modularity for this research, is the opportunity to upgrade buildings in an incremental way, which is something modularity can offer. (Smith, 2010)

What is Prefab.

The idea behind prefabrication was created a long time ago. It was already used in Indonesia's vernacular architecture. Also, on each island of the Pacific Islands, parts of buildings were made by a community who were experts in that certain part. The first western prefabrication started in the early 20th century with the low-cost packaged house by the E.F Hodgson Company. They sold prefabricated wood panel houses. The trend continued throughout the 20th century. (Cherner, 1957)

For informal settlements, prefabrication of a whole building unit is not possible. Instead, the potential lies in a hybrid system of integrating it into the existing way of building. The idea of hybrid prefabrication is combining a prefabrication method with another method. In this case, this is the self-built method (DIY) combined with off-site method, which is production in factory and assembly on site by the user them self.

Hybrid prefabrication is a method that can be used in combination with another prefabrication method or traditional construction. It involves onsite construction and assembly of prefabricated components (Dykman, 2018). "Prefabrication can combine traditional materials with contemporary aesthetics to create innovative solutions and still be affordable." (Armstrong, 2008)

Chosen systems for implementing modularity:

Moduli 225 (Bergdoll et al, 2008)

Moduli is a modular wooden system introduced in 1974 by two architects, Kristian Gullichsen and Juhani Pallasmaa. They made use of prefabricated standard elements with the size of 225 centimeters. These elements are connected with metal profiles added to the wood and metal rods to the ground.

Pan-knot (Kahlert, 2017)

The pan-knot system is the only system which is a space frame. However, it can offer some great ideas for design aspects and overall output. The system allows to connect different elements -which can consist of several materials- with each other by a joint ball. This allows for fast assembly and expansion.

Bamboo joint by CLC (Inhabitat, 2018)

The bamboo joint is designed by CLC (Chiangmai life construction) with the idea to explore new ways of building using bamboo. The end result is an industrial looking modular aluminum connection which allows for easy expansion and assembly.

Pre-built house for 6000\$ (Cherner, 1957)

The idea from this system is to create an affordable house for around 53000\$ nowadays. Besides on the price, the main focus lies on small, compact, efficient and expandable building. This is done by creating components which could be assembled by average builders with minimum effort because of the simple connections.

Japanese prefabricated pre-cut system (Matsumara, 2018)

This method 'pre-cut' is has been used a lot in Japan. The system uses computer-aided machinery to pre-cut joint connections, which allows almost perfect fits and less work assembling the structure. Secondly, it reduces the costs and waste materials.

In the appendix 1-5 more information on these systems can be found, including drawings and a list of pros and cons per system. The systems were chosen due the criteria list derived from the context. All the systems have easy connectable joints, which is important for my research. Now I will shortly

describe the reason why the systems are chosen. The moduli 225 offers a simple connection between elements and a connection to the existing structure. The pan-knot has the ability to connect different materials what can be of different size as well. The bamboo joint gives insight in how another material can be added to the joint to make it stronger and adaptable. Pre-built housing offers insight in the simple connection between components. Precut systems to reduce the work done on site and easily assembly on site. More systems could have been chosen, however the chosen systems for this research is covering important aspects which supports the research. Also, the chosen modular systems are using available materials and technique's used in Indonesia.

What are criteria extracted from the kampong.

Based on the created methodology, the context results in criteria that influence the chosen modular system to be analyzed and tested to the criteria. The criteria are based on the problems of the informal settlements, in this case the Kampong Braga.

The first criteria would be affordability. When interviews were conducted, the inhabitants of the kampong said they are willing to improve if it is affordable. Of course this has to be seen over a certain time, because beforehand its hard to make something cheaper then a piece of sheet metal. Therefore, if the quality is improved and in the long run it is cheaper then it is more affordable. The second criteria is that the modular system has to be self-buildable (DIY). Because nowadays most of the building are self-built. Therefore, it is important to maintain this aspect of the building process. The third criteria is that the system has to be incremental upgradable/adjustable. Currently, the users only change their house when they have the means for it. The next criteria is transportable size, because the alleys of the kampong are mostly around 1,20-meter-wide and therefore cannot transport every size through these alleys. Another criteria is available materials; the system has to consist mostly of material which can be obtained locally. Another criteria is that is has to be strong enough to let the building grow in a vertical way. The system has to be de- and re-mountable, so it can be changed and improved if needed. The eventual system for the context has to keep the possibility of making it personal. Every house in the kampong is different and you see the hand of the creator. Therefore, the option to make it more personal is taken into account. The most important problem in the construction of houses lies in the joints of connecting materials and elements. Therefore, the last but not least criteria, is that the chosen systems have to be focused on the connection. Short overview of all the criteria: Affordable, DIY (easy assembly), Incremental upgradable, Transportable size (alley), Available materials mostly (shop), Strength for construction, De- and re-mountable, Possibility of making is personal and Focused on the connection

The design matrix

For the design matrix (see appendix 8) five modular systems are chosen based on the criteria. The chosen system is: Moduli 225, Pan-knot, a bamboo joint system designed by Chiangmai life construction, Pre built house for 6000\$ and Japanese prefabricated pre-cut system. These are located in the top row of the matrix. These systems are mentioned above, where more information about every system can be found.

In the matrix these systems are analyzed and distilled for certain design aspects: Material joint connection, connection to the existing, incremental upgradability, connection with the infill, connection size and expression. These aspects are located on the left column of the matrix.

The design aspects where chosen after analyzing the context where the main problems of the contemporary building structures lie, like material joint, connection with the infill connection size. Also some aspects were chosen with an eye on potential design problems arising in the process, like connection to the existing. Another third reason for the chosen design aspects was the current way of building, like upgrading incrementally and the consequence of using a certain system for the expression of a building.

The center squares of the matrix are filled in with drawings of the design solutions influenced by the systems. These drawings of the design solutions are an abstract visualization of the system. They represent the essence of what the system can offer for each design aspect. The row of a design aspect gives five solutions for that aspect.

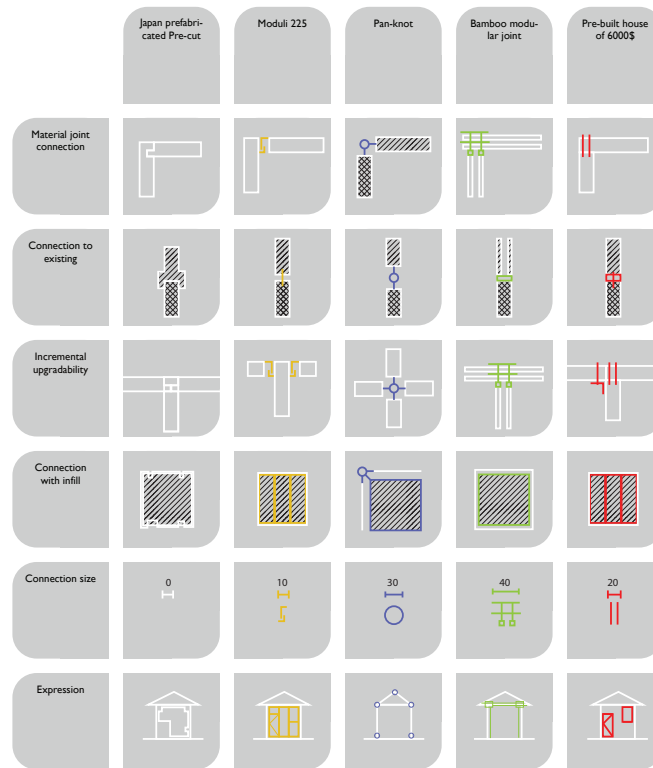


Figure 5. The design matrix

Weighting system

The weighting system allows to show the best options for a certain theme, like cost, adaptability and quality. For example, in the sense of fitting to the context. However, more themes can be formulated and tested based on the matrix, depending on the context and personal design direction. The weighting system shows the best option in green, second best option in yellow and the “worst” option for every aspect per theme in red. The idea is to combine all the best options per design aspect to create input for a design, which designer for example offers the lowest costs. The second best solution can be chosen due other more personal requirements. The worst is added to give insight what potentially should be avoided.

IV. CONCLUSION

The output of the design tool is a good start for everyone who wants to implement modularity in informal settlements of Indonesia. And additionally, for designers who want to improve the overall quality of a building in these settlements. Just like modularity, the design matrix can be adapted to the needs of the designer by implementing more systems and design aspects.

To answer the research question (How can (hybrid) modular systems improve the existing buildings to increase the strength, quality, height and adaptability of self-built housing in an informal settlement?) a combination of the design sub-solutions has to be combined and the result would be the start of the answer. It will give the base to further develop and design the real answer to the question. This matrix is a tool to give options and value them accordingly. Even though the matrix will not answer the question directly, the combination of design sub-solutions based on the chosen theme, will give the right direction.

Reflecting on the product design methodology used for this research, the implementation of modularity in building methods of the kampong of Braga works well by giving alternative options for certain design aspects. The methodology gives a more solid background for the chosen systems and sub-solutions, because it is based on pros and cons. However, the methodology lacks the ability to implement more intuitive design solutions based on intuition of the designer.

To give the design matrix more body, more systems and design aspects could be added. Also, in this paper the matrix was focused on the joints and connections. Therefore, a logical next step would be to look into other components of the buildings.

Limitations of this research are the technical workouts of the systems. Integrating the system into the existing, needs more technical workout. The exact way certain elements will connect for example. This research gives the opportunity to make fast design solution, but the research question is not fully answered. Subsequent research is needed.

Recommendations for further research are that the context or existing building needs more technical background research. For example, the strength of the existing structure. Furthermore, integrating the chosen systems into the existing produces some new technical issue's. These issues, like tolerances of connection to the existing, loadbearing capacity, detailing of connection components and available tools in the area, need further research to fully integrate these solutions into the existing building of the informal settlements of Indonesia.

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