

The Effect of Building Form for Post-Disaster Housing Design Success

Case Study: *Rumah Dome* Desa Nglepen , Yogyakarta

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Abstract: During the process of post-disaster reconstruction, the housing provided has to facilitate the dwellers. The design of the housing itself should accommodate the growing needs of the dwellers during the reconstruction process of their area. The problem of the dwellers being unable to adapt to the building itself or the building being unable to facilitate the dwellers is an indicator of how the design has failed to provide those means. The shape of the building, materials chosen, and the layout of the building itself has to not only accommodate physical needs of the dwellers, but also their behavior, culture, and how their society has lived their lives throughout the years in that certain environment. The purpose of this research is to examine the pattern on how the housings provided develop and adapt to keep up with the dwellers' needs, as a mean to evaluate whether the dome house design is suitable as post-disaster emergency housings in Yogyakarta or not.

Keywords: Housing, Post-Disasters, Reconstruction, Building form, local

1. INTRODUCTION

1.1 Reconstruction Process in Desa Nglepen for the Victims of 2006 Yogyakarta earthquake

One of the villages affected by the 2006 earthquake in Yogyakarta was Desa Sengir in Sumberharjo, Yogyakarta. Due to the unstable state of the soil, the destroyed village was unable to be reconstructed. On September 2006, the villagers were relocated to a new set of land in Desa Nglepen and received aids from LSM WANGO which were emergency housings in the shape of dome houses. These dome houses were resulted from researches conducted by DFTW for buildings that are earthquake resistant, light in structure, and easy to be built and completed.

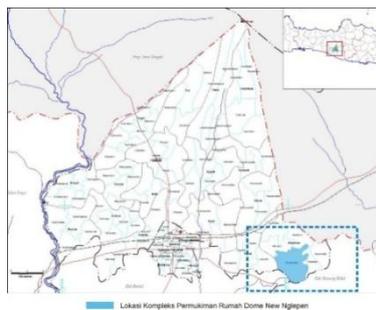


Figure 1 : Research object location in Nglepen, Yogyakarta Region, Indonesia

These dome houses in Desa Nglepen were the only dome houses in Indonesia and the first of its own in Asia. It was a foreign and new kind of structure and building shape for the villagers as they were used to living in traditional houses. Consisted of 6 clusters and 71 houses, this dome house housing complex was done in only three months. Every dome house is 38 square meters large, with a circular shaped plan, and the whole dome shaped building was constructed from reinforced concrete.

During the reconstruction process of the village and its environment, the needs from the dwellers in the dome house housing complex also grow to a certain extent. However, the design of the houses itself could no longer provide spaces that could accommodate the multiple activities each family had. In 2016, much of the design of the houses were no longer in its initial dome shape, as most of the dwellers had made multiple changes to not only the façade of the building, but also the spaces inside the dome house itself.

The purpose of this research is to examine the pattern on how the housings provided develop and adapt to keep up with the dwellers’ needs, as a mean to evaluate whether the dome house design is suitable as post-disaster emergency housings in Yogyakarta or not.

1.2 Javanese Traditional House, The Local House of the Villagers in Nglepen

Rumah or “omah”, means ‘home’, has a significant meaning for Javanese people, especially in the villages in Yogyakarta. The Javanese has three sayings in their lives: *sandang, pangan, papan*, which means: food, clothes, and housing. Typology of Javanese houses consists of four rectangular or square-shaped plans, with *Tajug, Joglo, Limasan, kampong* or *panggangPe* shaped roof.

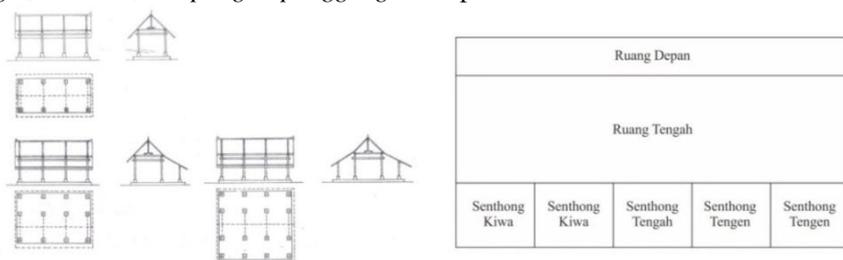


Figure 2 : Javanese tradisional House Form and Plan

The traditional housing of Yogyakarta has long been a place to accommodate the social behaviour and culture of the villagers in Yogyakarta for over generations. Therefore, the house and the shape itself is related to the habits of the dwellers.

1.3 Dome House, The Post-Disaster Housing Houses in Desa Nglepen

Due to the condition of the unstable soil that is prone to collapse, the villages were unable to be reconstructed at the aftermath of 2006 Yogyakarta earthquake. The dome houses in Desa Nglepen were a part of a project to relocate the villagers, aided by WANGO and DFTW. The dome houses were unique and strikingly in contrast with the other traditional houses in the area.

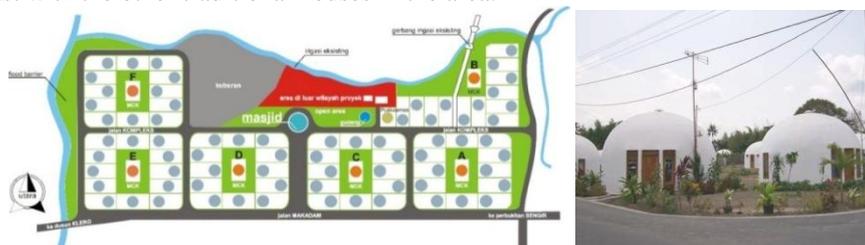


Figure 3 : Siteplan and Form of Dome House in Nglepen village

From structural researches done by DFTW, the dome shape of the building is considered the best shape to resist earthquake. The monolithic eco shell structure has a shape similar to eggshell made out of 5-8 centimetres thick reinforced concrete. It’s light in structural weight and able to resist the lateral force of earthquakes. Other than its resistance to earthquake, it’s also efficient in material usage (about 50% less than the usual dome shape) and fast construction process. 1 unit of dome house can be done in just 1 day. As of those benefits, the dome house was considered to be the right choice for post-disaster housings in Desa Nglepen.

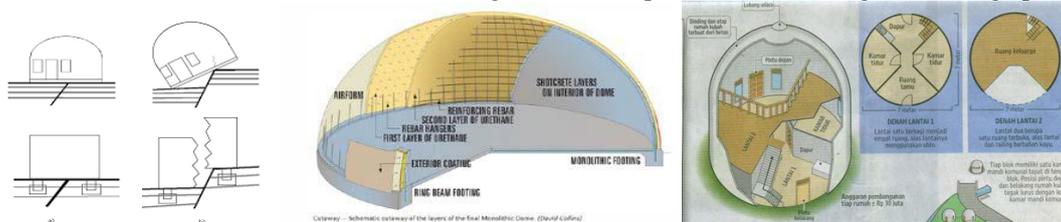


Figure 4 : Dome House structure

1.4 Testimonials from Dome House Dwellers of 10 years

As of today, not all of the dome houses are occupied. Some of it were inherited to the dwellers’ next of kin or relatives, and some changed its ownership. They complained about how uncomfortable it was to live in

the houses. From interviews done with the dwellers of the dome houses, some of the complaints raised by the dwellers were:

- The house was too small, and it was hard to arrange the furniture to fit the space due to the fact that the plan itself was not the usual rectangular/square-shaped that the villagers were accustomed to
- The house was too small and difficult to develop. It was difficult to add more space into the building due to its dome shape made out of concrete.
- The difficulty to repair the damages occurred due to leakage. Adding eaves to the existing windows and doors were also difficult as it was prone to leakage in its joints.
- The thermal condition of the interior was too high in temperature and made it uncomfortable to live in.
- The kitchen had no separate location, therefore the gas and smoke from the cooking process circulated inside the confined space of the house, raising the internal temperature of the building

2. THEORY AND METHOD

2.1 Development and Adaptation of The Building

Buildings are one of the most important needs for humans. As the development goes, there's also an increase of demands for housing and infrastructure. Therefore, it is quite likely for developers to neglect the need of functional purposes and the process occurred in the background. As society grows in its cultural, economic, and social needs, the buildings provided have to adapt. Many aspects of the building could be changed during its development, especially the usage of material that no longer use disaster prone materials that could endanger the dwellers of the building. The process ranges from small scale renovations such as reinforcing or repainting the walls, to the extent of bulldozing the entire building to be reconstructed with newer and stronger materials. The building itself becomes the subject and it needs to adapt according to its context. Graham (2006) in Schmidt (2009) stated that a building that is easy to adapt with changes is not a building that stands forever, but a building that is sustainable.

To maintain the sustainability of the building to a much longer period, the building has to adapt to its dwellers' needs. Douglas (2006) stated that the adaptation process of the building is a process to change its capacity, function, and performance; an intervention meant to repurpose and enhance the building's capability to sustain life. There are three concept of adaptation stated by Arge (2005):

1. Generality. The ability of the building to not change as a mean to fulfil the needs of the building user.
2. Flexibility. The ability of the building to adapt in small scales to fulfil the needs of the building user.
3. Elasticity. The ability of the building to be extended or parted in sections to adapt with the user's needs.

2.2 RumahIntiTumbuh

According to *KepmenKimpraswil No. 403/KPTS/M/2002 tentang Pedoman Teknis Pembangunan Rumah Sederhana Sehat (2002)*, the definition of *rumahintitumbuh* (roughly translated as 'Developing House') is a dwelling that has the minimum standard of liveability and affordability to low-waged society. The building's floor area has to be 21 m² large, with overall area of 72-90 m² large to provide spaces for the building to be extended as a mean to fulfil the dwellers physical, social, and cultural needs.

RumahIntiTumbuh has a couple criteria:

1. Consisted of basic spaces, including an open space protected with roof, a closed space, and a space for sanitary necessities.
2. The shape of the roof itself has to anticipate the changes ought to be made in the future.
3. The shape of the roof itself, other than gable roof, can be of other shapes according to the area.
4. Natural lighting and ventilation requires opening that allows cross circulation of air and sunlight.

The development process of *RumahIntiTumbuh* has to provide spaces for the dwellers to express themselves to a certain extent. Therefore, it is more unlikely for the building to be reconstructed heavily in near future.

2.3 Architecture Form of the Houses and the Aspect of Local Culture

Architecture of the locals was resulted from the pattern of how local society behaved and responded towards the environment on where the building was made. Important aspects such as climate, topography, and the land itself become the defining role, although not that significant as some were found with different varieties in the same environment.

Other defining factor such as social and cultural aspects of the locals: beliefs, social structure, and local habits, create differences between each local architecture, even though most of them are still located in the same environment not far from one another.

In this case, to find the relation between architecture and the dwellers' behaviour, it is needed to observe their social and cultural habits, and how they relate to their environment.

2.4 Method

The research of the effect of building form for post-disaster housing design success in Prambanan, Sleman, Yogyakarta is conducted using qualitative research method. The method uses descriptive analysis approach (exposure towards conditions) and evaluative method. Qualitative analysis method will be conducted through field observations and surveys, while descriptive analysis method will be conducted through historical approach and will be explained furthermore through the condition of the dome houses in correlation with the local architecture before disaster occurred. This study will be achieved by gathering the results from the observation field, photos, private and legal documents which are both related and relevant towards the objects that are being observed.

3. ANALYSIS RESULTS AND DISCUSSION

3.1 Dome Houses and Local Houses

In comparison to the rectangular shaped plans and traditional roof of the local architecture, the dome structure is considered new and foreign to the villagers of Nglepen. The overall structure created spaces that are strange for the locals, as the circular shape of the plan created strange segments and angles that made the locals unable to adapt and arrange the spaces inside the house.

Furthermore, the spaces inside the dome houses were different from the local houses. The local houses and the spaces inside were created as a synthesis from the local culture and habit that has gone for over generations. With the lack of terraces or open space on the front side of the house, the locals were unable to practice their social activities that require such spaces.

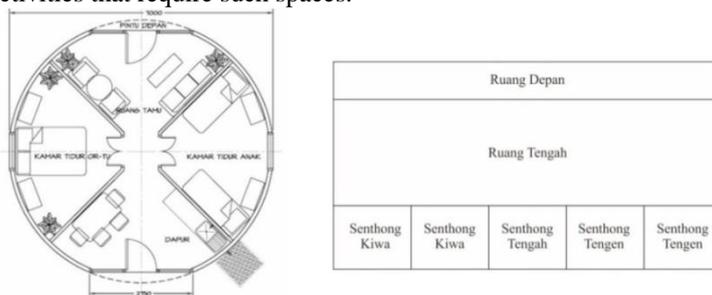


Figure 5 : Comparison of Dome Houses plan and Local Houses Plan

The interior of the building itself was also different from the ones that the locals have grown accustomed of. Made from porous walls, typically made out of wood or bamboo, with large openings, the local houses allow natural air and light to penetrate into the rooms inside. In the case of dome houses that uses shell structure, openings have to be as minimum as possible for structural integrity and stability. The solid walls and small openings could only allow small circulation of air and natural light.

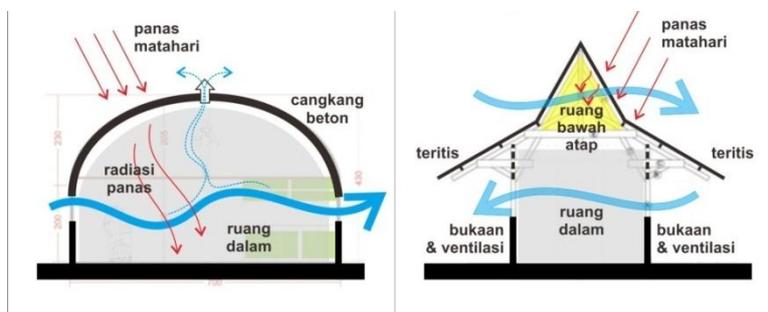


Figure 6 : Comparison of Dome Houses form and Local Houses form

3.2 Dome House as a core houses

Dome houses were built to fulfil the basic needs for the victims of 2006 Yogyakarta earthquake. The houses were 38 m² large to accommodate the basic needs of the dwellers such as spaces for bedroom, dining room, kitchen, and common room. Alongside the recovery of the victims' psychological and economic needs, the activities and spatial needs of the dwellers increases beyond their basic needs. However, the dome houses

are unable to be developed in accordance to the growing needs of the dwellers. A couple of difficulties encountered were:

- The dome shape of the house is a ‘fixed’ design, unable to be developed by adding more spaces inside and outside the house. By adding another mass unto the existing shape, it will disturb the stability of the structure and its resistance to earthquake. Furthermore, the added mass would have joint issues with the existing structure, making it prone to leakage and other structural problems.
- The building itself uses reinforced concrete as its material, therefore, it is difficult to be developed. The structural strength of shell structures lies in its solid, homogenous material, therefore by adding an entirely new mass, it will disrupt the distribution of weight throughout the structure, resulting in structural failure of the building. Moreover, concrete structure is less likely to be conjoined by other material if not constructed at the same time. Therefore, the joint between the added mass and the existing mass will be prone to leakage and other structural problem.
- The circular shape of the plan made it difficult for the interior to be altered and rearranged, as the overall dimension of the building is not too big in the first place and the existing layout of the building is already the most effective one for the dweller’s spatial needs. Rearranging the spaces inside the building would not increase the effectiveness, efficiency, nor comfort, therefore, the spaces inside the building couldn’t accommodate any future changes nor development needed by the dwellers.

In conclusion, the dome house is not a suitable option as post-disaster housing, as it doesn’t fulfil the requirement of *RumahIntiTumbuh* needed by the dwellers as they recover from the aftermath of the disaster

3.3 Development of the House

According to the three concepts of building development stated by Arge (2005), the dome house has fulfilled none of the requirement:

- **Generality.** The dome houses have no concept of generality. The initially planned dimensions and layout could only fulfil the most basic needs of the dwellers, but not able to accommodate furthermore when the dwellers’ needs increased and varied.
- **Flexibility.** The dome houses have no flexibility in terms of its interior layout. The circular shape of the plan makes it difficult for the partition to be rearranged as a mean to differentiate private and semi-private spaces. Adding more partition inside the interior would only result in the spaces inside the building to become smaller and uncomfortable to be lived in.
- **Elasticity.** The dome houses couldn’t be expanded nor reshaped to any directions on the existing land. The shape and the material itself has no room for flexibility, therefore the houses are unable to accommodate the increasing needs of the dwellers as the time goes.

3.4 Adaptations Done by Dwellers

With no generality, flexibility, nor elasticity for the building to accommodate the dwellers’ needs, the dwellers had to adapt with the knowledge they had. A couple changes were made to the buildings, from small changes to significant changes.

- **Small changes**
Small changes include adding eaves on every openings to prevent leakage on the joints between the sills and the concrete wall. Eaves were constructed using roof tiles, based on the local architecture. The material itself is not suitable with the existing material of the building, as concrete itself is quite expensive to be obtained. Other than that, the dwellers also painted the exterior of the buildings to match their personal taste. On the inside of the building, the dwellers utilized the mezzanine floor as a functioning room, although the dwellers have complained that the mezzanine floor was too short in height and too high in temperature, making the space uncomfortable to carry out any activity.



Figure 7 : Small Renovation done by the residents

- **Significant changes**

Dwellers have added new masses of building, whether it is conjoined with the existing building or completely separated, as a mean to accommodate their various needs. The new buildings were constructed with an entirely new shape and structure, as the dwellers themselves have no knowledge and ability to construct the same dome structure of the existing building. The newly constructed masses are usually in the shape of the local houses that the locals are familiar with (with *jogloroof* or *kampong* roof)

In the case of conjoined masses, the shape of the mass itself is entirely different from the existing building, making it prone to structural problems in between the joints. On a much bigger scale, the altered masses of the buildings has made irregular pattern in the housing complex.

Other than exterior problem, altering the shape of the building has created problems in the interior of the building itself. The rectangular shape of the added mass that the locals are familiarized with is joined with the circular shape of the existing building, creating an irregular space in the joints between the two masses.



Figure 8 : Major Renovation done by the residents

4. CONCLUSION

Post-disaster emergency housing has to be designed in accordance to the local's behaviour and culture that are reflected through their local architecture. Other than that, the design has to be able to develop alongside the increasing needs of the dwellers as they gained physical, economic, and psychological recovery.

The dome houses in Desa Nglepen are limited for further development. The circular-shaped plan and the dome-shaped mass constructed out of reinforced concrete hindered the building to adapt to the increasing needs of the dwellers. The building lacked flexibility to be rearranged and altered, both in its interior and exterior.

Furthermore, there's also a lack of knowledge to build dome structure, and the technology to shape concrete with casting mould requires special equipment. This specific knowledge is also required to design and construct a building that is in accordance with the existing design of the buildings.

The locals have tried to adapt to their increasing needs by adding a couple aspect and constructed it with the knowledge they have, even though in terms of aesthetics and functionality, encounters problems such as leakage in between the joints, resulting in a building that's altered in shape and not in accordance to the initial design of the building.

Advice:

1. Post-disaster emergency housing has to be built with a design that put local architecture, culture, and social behaviour as considerations.

2. Even with international aid to back up the process, the government shouldn't give a one-sided option just because the villagers' houses were destroyed from the disasters, forcing them to live in a house that is culturally and architecturally not suitable for their wellbeing. The villagers should've been asked to take part and to be involved during the whole process.
3. Knowledge to construct post-disaster housings has to be transferred to the locals, so in the future, they will able to develop them on their own.
4. Post-disaster housings should be designed and constructed with local materials that can be easily obtained from around the area

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