THE PRELIMINARY STUDY OF RESPONSIVE WALL TECHNOLOGY FOR INDONESIA'S TRADITIONAL HOUSE; LEARNING FROM WOGO HOUSE, FLORES, INDONESIA

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ABSTRACT

Indonesia's traditional house have been imposed to steadily extend their functionality at comfortable living. The expanding application of basic in this context has lead to the emergence of the terms responsive technology to describe a building envelope form that can meet such demands, be it to a varying degree of success. Within the scope of this paper, intelligent behaviour for a building envelope by means of psychical process defined as adaptiveness or responsive to the environment which enables the envelope to solve conflicts and deal with new situations that occur in its interaction with the environment. This definition is used as a basis for an analysis of the functions a local technology can be expected to perform in the context of incident solar radiation and indoor temperature to the requirements of the traditional building occupant. Among the characteristics discussed in this paper, are the traditional wall's ability to adapt the indoor climate and preferences, to choose the most appropriate response in each situation, to anticipate the development of environmental conditions, and to evaluate its own performance. Several stage are discussed: Wogo House's responsive environment, wall technology, thermal environment and and contemporary context. The result of study in Flores Island illustrated that the traditional house achieved good thermal environment performance by responsive wall technology in Wogo traditional house.

Keywords: *Indonesian traditional house, responsive, wall technology*

ABSTRAK

Rumah tradisional Indonesia dipaksakan agar secara stabil menambah fungsionalitasnya pada kenyamanan hunian. Aplikasi yang dasar yang meluas pada konteks ini telah berpengaruh terhadap munculnya istilah teknologi responsive untuk menggambarkan bentuk amplop bangunan yang dapat memenuhi permintaan tersebut, apakah hal tersebut adalah bagian tingkat kesuksesan. Didalam skup artikel ini, perilaku cerdas untuk amplop bangunan yang bermakna proses fisik didefinisikan sebagai adaptasi atau respons terhadap lingkungan yang menjadikan amplop bangunan sebagai solusi konflik dan berurusan dengan situasi-situasi baru

yang terjadi didalam interaksinya dengan lingkungan. Definisi ini digunakan sebagai dasar untuk analisis fungsi dari teknologi lokal yang dapat diharapkan untuk dilakukan didalam konteks peristiwa radiasi matahari dan temperatur ruangan terhadap persyaratan-persyaratan dari penghuni bangunan tradisional. Diantara karakteristik yang didiskusikan dalam artikel ini, adalah kemampuan dinding bangunan tradisional untuk beradaptasi dengan suhu ruangan dan kecenderungan penghuni untuk memilih respons yang paling cocok dalam setiap situasi, untuk mengantisipasi perkembangan kondisi lingkungan dan evaluasi terhadap kinerjanya. Makalah ini berdiskusi beberapa tahapan: respons rumah Wogo terhadap lingkungan, teknologi dinding, suhu lingkungan dan konteks kontemporer. Hasil penelitian di Pulau Flores mengilustrasikan tentang rumah tradisional yang memiliki kinerja baik terhadap suhu lingkungan menggunakan teknologi dinding pada rumah tradisional Wogo.

Kata kunci : *rumah tradisional Indonesia, responsif, teknologi dinding*

INTRODUCTION

The main challenge confronting indigenous peoples today is that of being dispossessed of their native customary land. Land is their source of livelihood and its dispossession has invariably trapped indigenous peoples into a cycle of poverty. Equally important is the fact that land embodies their cultural identity and thus its loss strikes at the very core of their identity. The irony is that it is the "modern" development strategies that have resulted in the present environmental crisis. There is international level agreement that development has to be sustainable, i.e. consideration has to be given to the environment in planning. Research has found that the traditional lifestyles of indigenous peoples are environmentally sound. It appears that architecture has been losing its ability to coexist with nature. Contemporary architecture seems to have lost the capacity to control the architectural environment itself. It is essential that architecture recovers its close connection with nature and retains its capacity to control its own environment. Architecture needs to be harmonized with nature. Methods to improve coexistence between nature, architecture, and human beings need to be determined (Kim, 2006). Indonesia traditional architecture has a diverse capacity to control the architectural environment in harmony with nature. This capacity of Indonesia traditional architecture can be called a ''natural environment responsive''. This implies that we may in fact have a great deal to learn from them.

Flores as one of the largest islands of the Nusa Tenggara Timur is distinguished with her unique traditional architecture from the rest of the surrounding environments. Parallel to the recent changes in socio-cultural, economical and political conditions of the Island; a rich system of traditions and customs as well as beliefs and values are struggling for validity. These years coincided with the importation of foreign values and understandings as well as building materials and techniques into Flores. Since then, the traditional built environment was neglected and the tradition-

nal houses were mainly left to deteriorate over the time. The early years that modern materials and techniques were imported to Flores architecture witnessed many successful modern building forms. The main objective of this paper is to assess the responsive wall technology for comfortable traditional house in Wogo Traditional House and to learn from traditional built environment by re interpretation of the contextual value.

Fundamental Theory

Architecture is formed under the influence of many elements. These elements are largely divided into the human environment and the physical environment. In addition, elements that complement each other influence the architecture. Indonesian traditional architecture was formed under the influence of various environmental factors. These will be mentioned to assist in understanding the natural environment responsive of traditional architecture. From these thoughts, traditional architecture was developed to be one with nature that have recognized architecture as coexisting and maintaining harmony with nature. Architecture has had to cope with respon of climates and has reflected the regional change in the climate (Kim, 2006). Indonesian traditional architecture has coped well. In contrast, because modern architecture ignores the natural environment, many problems such as excessive energy consumption can occur.

The Indonesian traditional rural forms were developed according to the response of the agrarian lifestyle, available local building materials and climatic conditions. In spite of religious, ethnical and regional differences, an agrarian way of life and economical production have been the primary determinants of shared rural traditions and consequent traditional rural architecture of the island (Dincyurek & Turker, 2007). Throughout the ages, the right architecture was developed in the rural landscape according to the needs of local peasants (Ateshin HM,et.al, 2005). In order to understand the logic behind the traditional rural architecture, the series of spatial qualities in the form of closed, semi-closed and open spaces have to be identified. The formations of the rural houses are based on the modular combination of the structure in the buildings. The modules are evaluated by their spatial features, structural types, constructional techniques and materials (Dincyurek O, et.al, 2003). The linear modular combination of spaces expresses the main development features of the rural house form. The modularity of the rural house ensures the flexibility as an answer to possible functional changes such as the family growth. This flexible understanding was reflected to the rural houses in the forms of removal or addition of spaces as well.

Traditional building techniques utilized the environmental challenges and responds to achieve comfortable indoor environments. Thermal performance of housing has been a matter of concern in many countries. Some research have been performed by Givoni (1993), Kru¨ger and Givoni (2004) and Cheng et al. (2005) to evaluate the influence of thermal mass, night ventilation and the effect of envelope colour on thermal performance. A comparative study between traditional house and modern low cost house by Jones P. J., et al., (1993) indicated that both house types had 2.5°C higher internal temperatures than the external temperatures during the

day time. Further, at night the traditional house cooled rapidly near to external temperatures compared to the modern low cost house, which retained the temperature 2.5°C higher than the external temperature throughout the night. Studies on building tropical design in order to improve thermal performance have also been reported by Nugroho et al. (2007), to quote just a few.

Research Methods

The field study is a Bena and Wogo traditional house in Flores Island, Nusa Tenggara Timur, Indonesia. The wogo traditional architecture is usually located at the foot of mountains (Figure 1). Mountains have a great effect on the local climate. Through a suitable relation with mountains, architecture has been able to control the effect of climate. Wogo traditional architecture has utilized the effects of mountains and responded to the seasonal climate changes. Selecting the envelope material of buildings to utilize solar energy has been one of the most important elements in controlling the architectural environment.

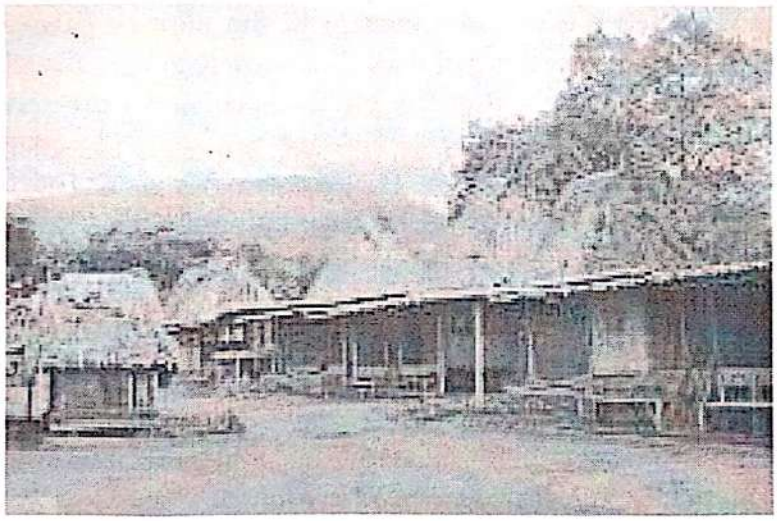

Figure 1. The Wogo housing at the foot of Mountains

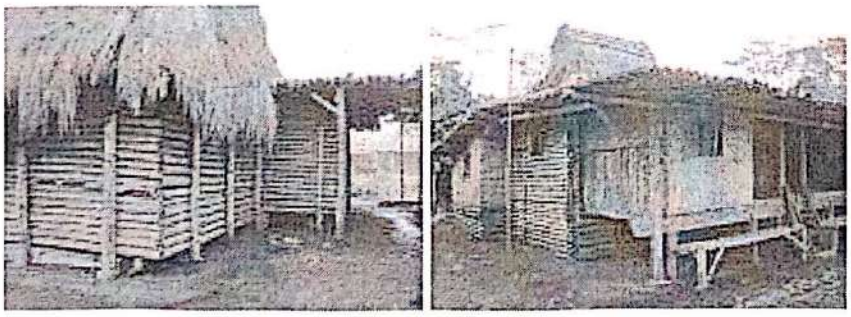

Figure 2. Bamboo Wall of a Wogo Traditional House

The wall of Wogo traditional architecture have had a variable and complex function so that the architectural space might have variability and adaptability. The

spaces room to room, room to outside, could be easily divided as well as combined into one. This characteristic has made Wogo traditional architecture responsive of climate. As the wall of house are composed of double facade, on the outside made from bamboo trees and on the inside made from wood pairs. In Wogo's traditional architecture, a room accommodates everyday life, including sleep (Figure 2).

The Wogo traditional house is surrounded by lush landscaping and the longitudinal axis of the house is oriented east-west. The roof component providing shelter from external climatic forces, such as solar radiation, rain and wind. The leave of the roof extends about 1 m from the external wall thus controls the solar penetration even at low solar angles. The middle zone is enclosed with 80 mm bamboo horizontal louvered panels and 12 mm thick solid timber walls. The wooden horizontal panels cover 80% of the wall area and positioned in all two cardinal orientations.

The design intentions of these horizontal bamboo louver panels are to provide secondary skin for passive heating. The floor is constructed with 25 mm and 150 mm wide bamboo stripes. The height between the natural ground and the raised floor of the building differed from 1 m and 0.8 m. The authors carried out a survey to determine the thermal parameters of a Wogo traditional timber house in Flores island. The measurements were collected starting from 1 July to 2 July 2010. The instrumentation consisted of sensors with a data logger system. The sensors were setup to monitor outdoor and indoor climatic conditions. Figure 3 shows the positions of the instrument installation within and outside the investigated house.

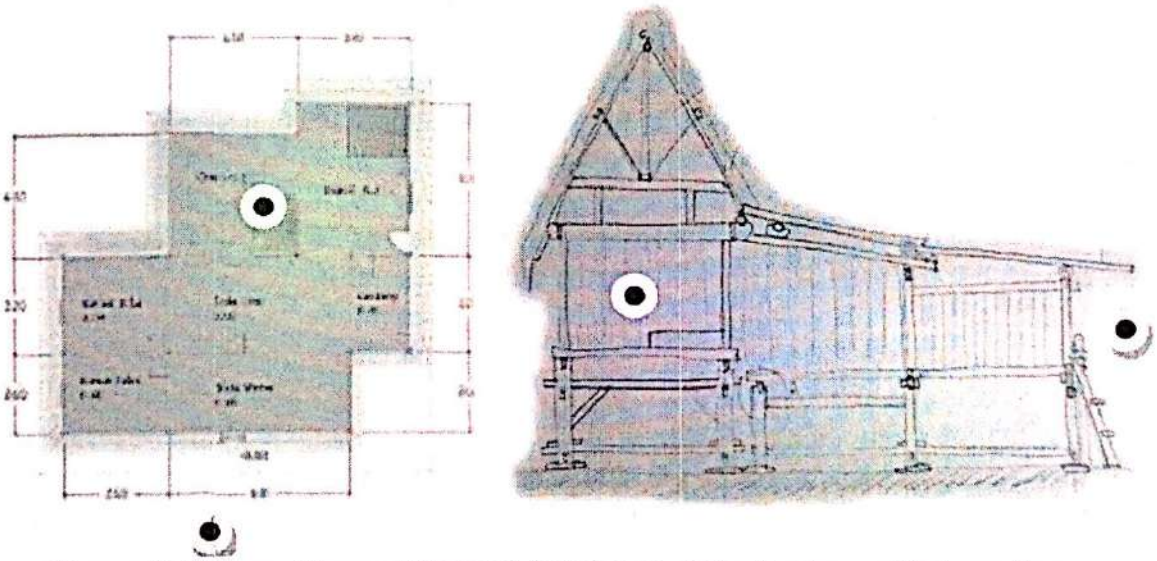

Figure 3. The positions of thermal data logger (○) a is plan and b is section

The physical measurements were carried out using air temperature and humidity data loggers. The temperatures for both internal and external were recorded at every 60 minutes interval. The data were averaged for every hour to obtain the hourly values. The temperature accuracy of the loggers ranged between 0.2°C to 0.5°C. The positions and the measured variables of the data loggers are described in Table 1. The building was occupied during this period.

Table 1. The Measurement Items and Method

Position	Data Type	Equipment	Height
Middle of the space	Air temperature, humidity and air velocity	Lutron data logger	900 mm above the floor
Outdoor	Air temperature, humidity and air velocity	Lutron data logger	900 mm above the floor

Indonesian modern architecture ignores the natural material of building envelope. Therefore, modern architecture has a lower capacity to control its architectural environment arising from change in climate. However, all contemporary walls are differrent from the traditional wall, which consist of both bamboo and wood wall. A bamboo wall is not used. Therefore, there is less variability and adaptability than in traditional architecture.

RESULTS AND DISCUSSION

Wogo Traditional as a Representative Responsive Environment

The existence of the transitional space dominated the development of the spatial organization of the Wogo house. Beyond the circulation activities, the transitional space is utilized for leisure and domestic uses; moreover it is a regulator of privacy, climate, indoor and outdoor interactions. The verandah as transitional space between indoor and outdoor spaces provides shade to the wall as well as creating a cool and shadowy area.

Additionally, the use of the traditional materials such as bamboo and wood in the construction of the load bearing walls provided appropriate micro climate for the human comfort inside the closed spaces. In principle, the traditional thick walls acted as natural heat barriers. The adaptability to the changing topographical conditions by using available local building materials has to be pointed out as another positive feature of the Wogo house. While, the developments of rural houses on the flat topography are observed as particular prototypes and their variations without any topographical constraint; those on the steep topography are logically developed in relation to the topographical conditions. Thus, the fundamental types of the traditional rural house can be suitably adapted to different topographies. In Wogo's traditional architecture, a room known as an "ONE" is the main space for living. Constant natural ventilation can purify the inner air as well as maintain proper humidity. This is because the Wogo's heating system known as fireplace generates a convection current which is used for bamboo walls, ceiling, windows and doors, is a material that can breathe. In the room, the nearest side to a fireplace is warmer compared with the opposite side. The difference in temperature causes a convection current in the inner air. Incidentally, according to traditional oriental medicine, it is

very healthy to keep the head cool but the feet warm. Both the walls and floors are made of bamboo and wood pairs. Bamboo, as a natural material, capacity for insulation is comparatively high and. The roof which is made of a grass material has a very high insulating effect in comparison to other materials and has many minute gaps that allow air circulation. Despite the wall being closed, the inner air can be ventilated continuously through the roof. Therefore, the room's environment is controlled according to the change in the surrounding environment. Therefore, Wogo's traditional rooms can purify their air and retain an agreeable level of humidity with the fireplace and the wall. In Indonesian modern architecture, the inner air is excluded from the outer air and materials such as concrete and brick. These problems arise because of controlling the environment with energy consuming equipment.

Role of Climate Factors on Responsive Wall Technology

After a close examination, it can be seen that temperature and humidity are very important in the Wogo Housing region, and that solar effects and wind factors are influential enough to be investigated. These climatic parameters are the factors that determine the structural characteristics of the region and that separate the region from other regions in Flores.

1. Temperature
   The most evident characteristics of the Wogo Housing region in terms of climate are that it gets cold temperature than any other region in Flores. The only reason for so cool temperature is that the mountains in the region are very close. The repercussion of low temperature is evident in the selection of outer wall materials in the vernacular houses. The excessive rain has hindered the use of unburnt soil as an outer wall construction material. Double facade materials are deliberately used on the facades that connect with outdoor condition and suitable materials and constructions are chosen according to the directions.
2. Relative Humidity
   The rate of humidity in the Wogo housing region is above the average of the heavy rain effects. The average relative humidity goes as high as 80%. The reason for the difference in the humidity contents is the atmospheric movements and topography. The measures taken against humidity in and around the buildings are as follows. In all Wodo house, bamboo walls and different types of wood have been preferred, which makes the flow of moisture from the inside to the outside possible. It has been observed that there is an increased use of frame walls in places where the moisture content is high, whereas bamboo walls are used in places where the moisture content is low. The excessive moisture has a decaying effect on the wood components that are connected to the soil. For this reason, the floor and wall of the Wogo house are made 1 m up from the soil.
3. Wind and Solar Radiation
   It has been observed that there are no windows on the walls facing the winds that do not create undesirable conditions in terms of heat and comfort, especially in the coldest times. There are few windows on the other walls sides. The windows of some houses have window shutters to keep out the cold and wind. The verandah or transition space in front of Wogo House blocks the sunlight

and reduces its density. The settlements on the sides facing the east do not receive direct sunlight in the afternoon, and the settlements on the sides facing the west may not receive direct sunlight in the morning. Frame wall and bamboo wall systems are used mostly as the wall construction material in the sunny. The level of daytime illumination of the living spaces in the greatest part of the vernacular houses is very low. When considering the whole house, the natural illumination is also far below the acceptable levels. Bamboo wall are used more in the bedroom sections than in other sections. The heat averages have an effect on the sizes of the bamboo wall in the vernacular houses. It was observed that the warmer sides have more bamboo wall.

Preliminary Study of Thermal Environment

The purpose of this paper is to assess the responsive wall technology for comfortable traditional house in Wogo Traditional House. The results are analyzed by comparing the internal and external temperatures by the wall element. Figures 5 illustrate the results of the internal temperatures obtained at 0.9 m height from the floor level over the period of one day. This period was taken in order to establish the preliminary study the temperature over one period a day (24 hours).

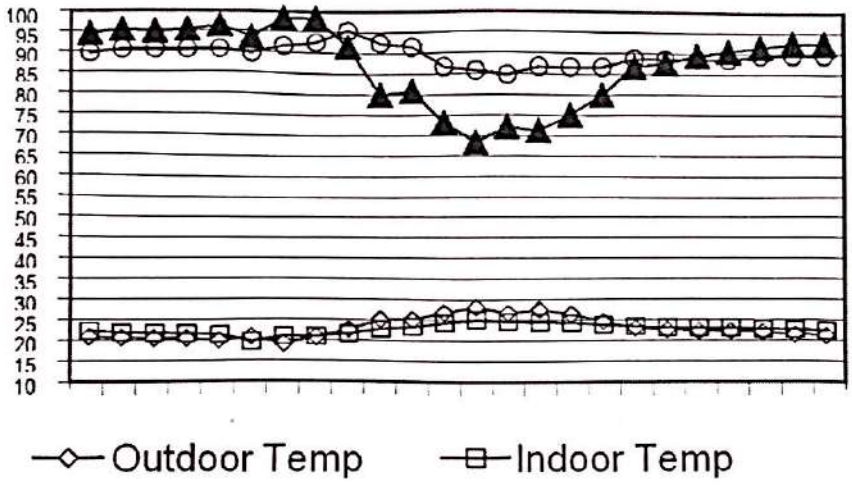

Figure 5. Comparison of internal-external temperature and relative humidity at 0.9 m height from floor level 14 to 15 April 2009 at Wogo Traditional House

The indoor temperature showed higher value during night time, while lower value during daytime compared to the outdoor temperature. The review of maximum and minimum temperature data on each day indicated that the air temperature vary little between the day and night. The comparatively smaller temperature differrences indicate that building envelope can cool down sufficiently in the day and warm up in the night therefore the responsive wall constructions are recommended. Both relative humidities indicated a higher value compared to outdoor and indoor in the night. During the daytime the indoor relative humidity measured higher temperature than the outdoor. The maximum relative humidity was indicated at 07:00h

and 08:00h on respective days. However, the maximum indoor relative humidity was measured at 09:00h on both days. This means the indoor relative humidity measured high over 80% of hours within a day. This indicates that the iradiating temperature from the wall surface not influence on the indor humidity especially during the daytime. The use of bamboo as wall element had more effect on reducing the heat transfer from outside to inside during daytime compared to timber pairs. The elevated floor reduced the heat gains from the ground surface to the interior during daytime. However, the stored heat from the floor influenced the indoor air temperature to be higher than the outdoor air temperature during the night time.

Re-interpreting the Wogo House in Contemporary Context

One of the design problems of recent houses is embodied in the space formation which neglects the environmental conditions. In fact, the reinforced concrete structures reflect the general design approach in terms of the unawareness of material characteristics and the inappropriate solutions of materials in general. The interactions between the building materials and the climatic constraints are not properly interpreted. Together with correct precautions such as additional insulation materials and necessary constructional decisions, the climatic response of the new materials can be improved in comparison with the current ones. Additionally, the local traditional materials, such as bamboo, can be developed and adapted for today's conditions by considering their sustainable features. Today's modern building materials and techniques are being used in new architectural practices with the eclectic compositional character of past images. The consequent image conveys the ambiguity of the formal expressions. Series of reinforced concrete arches with different styles and dimensions are commonly observed in the modern built environments of Flores island. The buildings have to be designed according to the nature of the building materials for reflecting the structural honesty. At this point, the role of architecture can be emphasized in terms of providing livable and peaceful habitats. Proposing new buildings that are in harmony with the existing traditional environment is as important as the rehabilitation of the old fabric. The new buildings or contemporary additions in the historical settings should include cultural values in the new design concept. This can be achieved by using new technology and materials besides the traditional ones. The concept of cultural continuity in the traditional environments can only be realized by fulfilling current requirements by using today's tools and methods without losing the local original character and spirit.

CONCLUSIONS

Indonesian traditional architecture has been based on the vision that it should coexist with nature. Natural phenomena were accepted and used. Therefore, the architectural environment could be controlled to manage the extreme differences in climate of the seasons and mountainous ground. In contrast, Indonesian contemporary architecture ignores the natural surroundings and relies solely on contemporary techno-

logy, which consumes a great deal of energy. Consequently, contemporary architecture has lost its ability to control its environment, and its environment is not necessarily better.

Therefore, there is need for another direction for architecture. Architecture should coexist with nature. This does not mean that contemporary conveniences should be abandoned, but that they need to coexist with nature. For this purpose, there is a need to make architecture control its environment according to the natural environment. Indonesia traditional architecture and its architectural environment responsive can be applied to contemporary architecture. It is hoped that this paper will be useful to architects whose aim is to improve the architectural environment.

The aim of the study is to assess the responsive wall technology for comfortable traditional house in Wogo Traditional House with the actual data on a selected date. The Wogo Traditional House is within the comfort range during night time when the external environment is cooler. During the day time, efficiency of the wall and louvered bamboo panels are high in order to reduce the indoor air temperature in the day and to increase air temperature in the night. Louvered bamboo panels provide required night ventilation to bring the temperature within comfort range at night.

The elevated floor reduced the heat gains from the floor surface to the interior during daytime. However, the stored heat from the wall and floor influenced the indoor air temperature to be higher than the external air temperature during the night time. The heat gain from the wall surface especially bamboo material enabled to maintain the internal temperature within the comfort temperatures.

The responsibility of designers is to find the ways of analyzing and interpreting the rural Wogo housing tradition for the continuity of the tried, developed and evolved design principals in the Indonesia traditional architecture. Hence, climatically responsive and environmentally sensitive can be created. Instead of merely copying the traditional architectural elements without questioning the concept behind them, the new designs have to surpass the existing ones in the light of a new understanding. The re-interpretation and re-use of shared images and values can transfer the regular houses to Wogo house.

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