

MIX AND MATCH TRADITIONAL AND MODERN TECHNOLOGY, TOWARD SUSTAINABLE ARCHITECTURAL HOUSING IN THE TROPICS

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ABSTRACT

Nowadays environmental concerns have become more important at the local, regional, and global level. The facts have shown that our planet is facing problems regarding the degradation of environment and it has a tendency to grow. Looking cost and environmental factors, more attention need to be drawn on the development of sustainable buildings material and technologies. Traditional housing culture building conserved resources, environment and natural ecosystem. The geographical condition gave birth to the housing forms that fit to the condition of regions. Modern trend in building construction is to provide durability and comfort at the cost of natural degradation. The development of new building technologies often push us to ignore the balance of nature which resulted in environmental degradation, global warming, ozone depletion and rapid growth in greenhouse gases. This paper will analyze the principles of green architecture housing in the tropics like Indonesia which not only promote sustainability in building construction but also comfort to the occupant. Innovated mix and match techniques of traditional culture and modern technology of construction has discussed here to provide more safer, economical, sustainable and comfortable solution.

KEY WORDS

mix, match, traditional, sustainability, modern technology, housing, tropics, building construction

INTRODUCTION

Sustainable Architecture is architecture that meets the needs of the present without compromising the ability of the future generations to meet their own needs. Those needs differ from society to society and region to region and are the best defined by the people involved. (*Brundland Commision 1987*)

Architectural housing in Indonesia, especially after Indonesian independence, shows that the building for residential purpose are not based on regional and social needs. Studies indicate that some new development housing was left by inhabitant because floods, no match façade orientation with livelihood, type of house and/or different habit of new housing space. It is tending towards modern construction and architecture due to that the old and historical architecture is being replaced by modern building. The consequences of centralization regulation urban development housing shows that the houses were build with the nearest available material, and often tradition and/or culture govern construction-materials. So that whole towns, areas, countries or even states/countries built up of one main

type of material. In the tropics area like Indonesia, it is particular different settlement. Traditionally wood has been used as major element of building construction. The type, shape, structure, ventilation and waste disposal depends upon many factors, depending upon the culture, regional area, religion, topography, geographical conditions. The development of new building material, methodologies and technologies not only costly but also some times doesn't match the tropic. Looking cost and environmental factors, more attention need to be drawn to develop some optimization of use of combination traditional and modern construction technology so that, not only sustainability may be attained in building construction but traditional architecture can also be maintained. But optimization of mixing traditional and modern construction should be done based upon the natural disaster like earthquake, flood, volcano and fires which frequently occur in the wide spread region of the country.

Traditional buildings are not costly and environmental friendly but sometimes they are not able to resist the natural disasters occurring in this region. The extensive uses of natural resources are unbalancing the natural ecosystem equilibrium, which result in environmental degradation, global warming, ozone depletion and rapid growth in greenhouse gases.



Figure 1. Flood in Jakarta, Pebruari 2007



Figure 2. Destruction under Earthquake in Bantul Yogyakarta (May-2006)

History shows that in Indonesia natural disasters such as earthquake, volcanic eruption, floods, land slides, dryness, or the forest fire has been periodically occurring in the region. The example of one of the worst natural disasters in the last 10 years was the flood which came in Jakarta, in February 2007. About 60% land and building in Jakarta were affected. Residential and other buildings were also badly effected from partially to fully damage. In some regions likes Ciledug Indah Village water reached up to the height of 4 meter from the ground.

Another example of natural disaster is Earthquake occurred in Bantul, Yogyakarta (May-2006). Even though the intensity of earthquake is not too high but death toll counted nearly 6000 casualties. Most of the people were buried under collapsed building. The building collapsed during earth quake was brick made with low strength (quality) cement-sand mortar. These structures were absolutely not resistant to earthquake. In many of the regions the buildings too dense, this multiplies the impact of earthquake. This also shows the ill planning in housing sector with ignorable regulation of building department. There is also need of restructuring of building code.^{1]} According to the Chief of public housing of Indonesian Cares (MP3I), Dr. Eng. Aca Sugandi, to save this country from natural disasters we have to maintain the environmental and ecosystem at its natural balance. On the other hand, it is also required to revive the countryside and urban area housing planning.^{2]} Prof. Dr. Ing. Uras Siahaan lic.rer.reg (2006), said that the traditional housing settlement culture conserved resources, environment and natural ecosystem. The geographical condition gave birth to the housing forms that fit to the condition of regions. The natural condition of Indonesia is often threatened by the earthquake, volcano eruption, floods and floods waves on the strand, so that construction form and development system of the building have to able to handle them.^{3]} The concept of "sustainability" in its modern sense emerged in the early 1970s in response to a dramatic growth in understanding that modern development practices were leading to worldwide environmental and social crises. Sustainability represents a balance that accommodates human needs without diminishing the health and productivity of natural systems (Mendler, Sandra F and William Odell, 2000). According to AIA (American Institute of Architecture) sustainability is the ability of society through exhaustion or overloading of the key resources on which that system depends.^{4]}

RESEARCH OBJECTIVE

- To discuss the matching concept of traditional housing in Indonesia with sustainable architecture concept.
- To generate a relationship between traditional and modern housing (architecture) so that a balance can be obtained in terms of ecosystem, natural resources used, environment friendly construction.
 - To discuss the acceptability of innovated mix and match techniques of traditional culture and modern technology of construction to provide more safer, economical, sustainable and comfortable solution.

RESEARCH METHODOLOGY

Formulation of problem used Formal Analog.. Formal Analog is a problems invention taken from dissimilar science and applies it to research area. Pursuant to research operational system, research type used by The Descriptive Survey Method, the research hit data obtained from observation. Pursuant to procedure of research step, method of research usage is qualitative, with Deductive Empirical method. Deductive Empirical method is method of knowledge analyzing theory with existing fact, so that can be formulation a new theory. This Research aspect is sustainable traditional housing settlement in the tropics area concerning in Indonesia. Population used is going concerns about traditional housing in Indonesia. The variables are concern in sustainable construction, material, structure, form of building and comfort, on traditional and modern technology. Analysis method is for knowing standard of Sustainable Housing for Tropics area by innovated mix and match techniques of traditional culture and modern technology.

HISTORY OF INDONESIAN ARCHITECTURE

Indonesia consists of 17,508 islands, about 6,000 of which are inhabited.^[5] These are scattered over both sides of the equator. The five largest islands are Java, Sumatra, Kalimantan (the Indonesian part of Borneo), New Guinea (shared with Papua New Guinea), and Sulawesi. Indonesia shares land borders with Malaysia on the island of Borneo, Papua New Guinea on the island of New Guinea, and East Timor on the island of Timor it is the world's largest archipelagic state. Indonesia's size, tropical climate, and archipelagic geography, support the world's second highest level of biodiversity after Brazil.^[6] Forests cover approximately 60% of the country.^[7] Indonesia has around 300 ethnic groups and 742 different languages and dialects, each with cultural differences developed over centuries, and influenced by Arabic, Chinese, Malay, and European sources.^[8] Indonesian Architecture reflects the same diversity of cultural, historical, and geographic influences that have shaped Indonesia as a whole. Invaders, colonizers, missionaries, merchants and traders brought cultural changes that had a pronounced effect on building styles and techniques. Traditionally, the most significant influence has been Indian, but Chinese, Arab, and more recently. European influences which have been important.

There are three vital impacts seen on the Indonesian architecture; **1. Religion 2. Regional 3. Colonial**
 The most influential impact was religion in traditional architecture For example the during 8th to 14th century the construction was more inclined towards Hindus style and myth. because of Hindu-Buddhism kingdom at that time. By the fifteenth century, Islam had become the dominant religion in Java and Sumatra, Indonesia's two most populous islands. The foreign influences that its were absorbed and reinterpreted, with mosques given a unique Indonesian/Javanese interpretation. At the time, Javanese mosques took many design cues from Hindu, Buddhist, and even Chinese architectural influences. Particularly during the decades since Indonesian independence, mosques have tended to be built in styles more consistent with global Islamic styles, which mirrors and tombs. Climate condition is Humid-Tropics Climate. Against heavy Rainfall the Building has steep roof and long overhang. The high humidity will be reduces through good air circulation and houses stand on poles and stones (1 to 4 m). Against the high temperature all over the year the houses were built with long overhang on the roof.

The 16th and 17th centuries saw the arrival of European powers in Indonesia who used stone and masonry for much of their construction. Previously timber and its by-products had been almost exclusively used in Indonesia, with the exception of some major religious and palace architecture. One of the first major Dutch settlements was Batavia (later to become Jakarta) which in the 17th and 18th centuries was a fortified brick and masonry. For almost two centuries, the colonialists did little to adapt their European architectural habits to the tropical climate. In Batavia, for example, they constructed canals through its low-lying terrain which were fronted by small-windowed and poorly

ventilated row houses, mostly a Chinese-Dutch hybrid in style. Although, row houses, canals and enclosed solid walls were first thought as protection against tropical diseases coming from tropical air, years later the Dutch learnt to adapt their architectural style with local building features (long eaves, verandahs, porticos, large windows and ventilation openings).^[9] The Indo-European hybrid villas of the 19th century would be among the first colonial buildings to incorporate Indonesian architectural elements and attempt adapting to the climate. The basic form, such as the longitudinal organisation of spaces and use of joglo and limasan roof structures, was Javanese, but it incorporated European decorative elements such as neo-classical columns around deep verandahs. Whereas the Indo-European homes were essentially Indonesian houses with European trim, by the early 20th century, the trend was for modernist influences such as art-deco—being expressed in essentially European buildings with Indonesian trim (such as the pictured home's high-pitched roofs with Javan ridge details). Practical measures carried over from the earlier Indo-European hybrids, which responded to the Indonesian climate, included overhanging eaves, larger windows and ventilation in the walls.

MATCHING CONCEPTS OF GREEN ARCHITECTURE TRADITIONAL HOUSING IN INDONESIA WITH SUSTAINABLE ARCHITECTURE

Sustainable architecture applies techniques of sustainable design to architecture. It is related to the concept of green building (or green architecture). Green Architecture can describe as the architecture development and environment that have any typology of architecture which could conserve resources, environment and natural ecosystem.^[4] Characteristics and classifications of Traditional housing in humid tropic climate like Indonesia, have matching concept with sustainable architectural concept, among others:

1. Use Natural Material and Local material
2. Keep cool the house with raised-floor construction, Steep Roof and long over hang
3. Lay out plan increasing a sun lighting
4. Small is beautiful and Energy efficient

Use Natural Material and Local material

Traditionally in Indonesia, wooden buildings have been constructing. The type and use of wood are lies in wide range from hard wood to bamboos. The use of extensive wood in housing sector is the main cause of deforestation in



Figure 9(a).Sulawesi Tenggara House, Figure 9(b). Aceh house, Figure 9(c). H - Frame

the country which caused frequent floods and erosion of top soil in to river system. The traditional construction was fit for earth quake resistance, because of their resistance to horizontal loading (earthquake waves). Example of a five meter high traditional warehouses and barns made of bamboo and sugarcane leaves in the badly hit Bantul district in Yogyakarta has put here, which still stands in its original position after the earthquake (May,2006) while modern buildings in the same region were ruined.^[1] However, bamboo is not only strong and flexible material, it aesthetically appealing. The material was easy to obtain and easily replaced when aged or damaged by weather condition.



Figure 8 (a). Traditional warehouse in Bantul which is highly resistant to the earthquakes Figure 8 (b). 35 year old roof in Surabaya

Traditionally, Iron wood shingles or sirap are one of the most commonly used roofing materials of Indonesia. Ironwood is known locally as Kayu Besi or Ulin. It is one of the world's most durable timbers. Originating from Kalimantan (Borneo) these shingles have been used for hundreds of years by the locals there for traditional housing. The Dutch colonials introduced them to the rest of the archipelago and they are now found on many large government buildings as well as high class houses. It has a serviceable lifespan of at least thirty years. Alang alang thatching has been used in Indonesia for hundreds of years on the islands of Bali, Lombok, Sumbawa, Timor and Sumba as a traditional system of roofing. There are slight variations in the application of the material throughout these different places but by far the neatest and strongest form is found in Bali.

Keep Cool The House with Raised-floor Construction, Steep Roof and Long Over Hang

Climate condition is Humid Tropical Climatic which the high temperature all over the year. A house with raised-floor construction can control the room temperature to keeps cool by natural ventilation system. The raised-floor construction, make add space behind the floor. The air circulation flow and influence a house temperature to keep cool. The more advantage could be find if using wood material floor. So that, wind will acquire the sixth side of house and reduce high temperature that influence from around the village. Almost all of Architecture Traditional housing in Indonesia especially Sumatra, sulawesi, aceh, Kalimantan, Riau and Betawi use raised-floor construction. The first floor is functions especially for breeding animals, wild animal, climate condition and disaster. The construction of living space there are again two alternatives; either the beams of the raised floor are mortised through posts reaching up to the roof – H frame- or alternatively, the foundation elements do not reach above floor level and carry a box frame/ construction (ex :Toraja House, Sulawesi house, aceh House). (Figure 9)^[11] On the other hand, traditional house roof in Indonesia also varies by form. All varies also construction by wood. Varies roof from Java are Kampong Trajumas roof, Kampong Doro gepak roof, Limasan roof and Joglo roof. Against heavy Rainfall, it has steep roof and long overhang. The high humidity will be reduces through good air circulation. Kampong Trajumas roof, have open air circulation for ventilation in front to back the house. Kampong Doro gepak roof have steep roof and open air circulation also in front to the back house, but less than trajumas. Limasan roofs, has closely roof and no open air circulation. Joglo roofs have steep roof and open air circulation from inclination of steep and sloping roof.

Lay out plan increasing the sunlight

The main ordering principles of the Javanese houses are centrality and linearity. Centrality dominates the open pavilion, which has its focus in the middle, and the house as a whole where the duality of the pavilion and the living quarters are synthesized by the passageway. Linearity is dominant with respect to the most sacred place in the house, which is situated at the middle at the back of the living quarters. A further differentiation between private and public opposes the living quarters to the open pavilion where guests are received in a formal way. Around this basic structure of the house other rooms, such as the kitchen, bathroom, guest room, and dining hall, may be found. The whole compound is encircled by a fence. (Prijetomo ;1984) Building orientation of Javanese houses is to fit in with point of the compass, North and South or West and East. North and South are upstream towards the sea. West and East are upstream towards the mountain. In the East there are Semeru and Merbabu mountains, whereas in the West is Merapi mountain. Orientation direction to East and West is influenced by the people in habitant livelihood as a

farmer. They use in front and the back of the house to dry their rice-plant. North and East orientation are influenced by their traditional beliefs with the goddess, especially Nyi Roro Kidul from East.

The Balinese dwelling is likewise a form of open space architecture. The orientation upstream of the house towards the holy mountain Gunung Agung plays an important role. This direction is considered sacred, while its opposite is profane. The territory of the house is divided, on the one hand, into mountain (head), land (body), and sea (legs), and, on the other hand, into the rising (head), zenith (body), and setting (legs) of the sun. The combination of these two divisions results in nine cells of which the mountain/sunrise (head/head) combination is the most sacred and oriented towards the holy mountain. The sea/sunset (legs/legs) combination is the most profane. This means that the Balinese house is dominated by anthropomorphic and cosmic principles combined in gradation from sacred to profane (Nas 1995).



Figure. 10. *Pawongan* from the Panglipuran village house, one of traditional housing in Bali

Figure 11. Bali traditional house in Tenganan village basically formed of open wall architecture, which consists of a wall compound and court yard

Figure 12. Bali traditional house in Panglipuran village basically which consists of a wall compound and open space in court yard.

Figure 13. Toraja house is compound system., have several building with different function.

Small is beautiful and Efficiency energy

Indonesian housing generally have compound (pavilion) system which consist of several units with different function. Every rooms like the living room, main bed room, kitchen, bath room and dining hall represent in constructed by own building. The several building is integrated by inner court. Examples houses are, Toraja, Bali, Sulawesi and Javanese house. The functional room like the living room, main bed room, kitchen, bath room and dining hall in constructed of small building. The benefit of small building for a humid tropical climatic area is possible in use crosses ventilation. The sun light can be source from the four sides of walls. So the building has energy efficient for lighting and ventilation. The small building means less material for construction which may have less to own environmental consequences. The general advantage to this is efficiency in use of space, good organization, and keeping possessions to a manageable level.

MIX AND MATCH TRADITIONAL AND MODERN TECHNOLOGY TOWARDS SUSTAINABLE ARCHITECTURE HOUSING IN INDONESIA

Traditional architecture are disappearing and being replaced by modern civilization. Following Indonesian independence, a number of government-funded major projects were undertaken in the modernist style, particularly in the capital Jakarta. Figure-14 shows the modern view of Indonesian architecture. Reflecting President Sukarno's political views, which is openly nationalistic, consequently the architecture strives to show the new nation's pride in itself. President Sukarno who is civil engineering himself influence the Indonesian architecture. *"Let us prove that we can also build the country like the Europeans and Americans do because we are equal"* Sukarno. ^[12]

It was arguably that native architecture more influenced by the new European ideas than colonial architecture that was influenced by Indonesian styles; and these Western elements continue to be a dominant influence on Indonesia's built environment today. Economic stability and growth in the 1970s, 1980s and 1990s saw large construction booms and major changes to Indonesian architecture.



Figure 14. A view of modern architecture style of Indonesian Architecture.

Now modern housing needs technology for comfortable housing and increasing the quality of life. The concepts of traditional green architectural housing in Indonesia have also its weakness. Compounds building which consist of several units needs more space and large area. At present the land value is expensive and needs much money to pay the larger land area for houses. Using natural material can't save the forest, because it is the main cause of deforestation in the country which has caused frequent floods and erosion of top soil in to river system.

“Architecture is manifestation of material” (Paul Frank 1914). So that modern housing towards sustainable architectural housing in the tropics like Indonesia, just needs the construction and material using by modern technology that can mix and match with sustainable architecture traditional concept. According to Prof. Dr. Ir. Hasan Purbo (2006), translations and combinations of traditional architectural concepts into modern technology could be described below,

- Modern architecture technology as a mean of construction system
- Concepts of traditional architecture are applied as the meaningful and spiritual design concept.
- The decision making in the form, hierarchy, pattern, and the role of design will be taken from the traditional concepts.
- The spatial system will be reformed, adjusted with nowadays needs. But the reformation shouldn't opposite the traditional architecture concepts of space.

The following are considered in during construction of Modern house in Indonesia.

- Compatibility to tropical environment
- Durability, Safety and Comfort
- Thermal Comfort
- Resistant to Natural Disaster
- Cost factors
- Traditional and Spiritual values

The key areas to be considered have to adopt mix and match techniques for sustainable building construction. Sustainability in architecture and building construction can be obtained by improving the:

- Structure and architecture design
- Energy consumption during construction and operation phase
- Geometry and orientation of building
- Construction material
- Construction process

Looking the history of the region for earthquake and other natural disasters, building designs need to be refined and updated according to new type of loading (earthquake loading), which was considered previously negligible. But at present we have to use the horizontal loading and the factor of safety applied to these loads in the designing purpose will be dependent upon the statistical analysis of the historical earthquake data in the regions.

Geometry matters a lot in sustainability and over all construction cost of the building construction. If a housing scheme is going to be constructed and instead of rectangular plot, square plot are given then the covered area remains the same but perimeter of square is 20 percent lesser. In this case over all cost of construction may be reduced by the 30 percent shown in Figure 15 below. Building incurred by horizontal effect of earthquake have tendency to shift direction level off and rotate. So that, it is important to separate buildings being two part or more in form building lay out and constructions. In order to the times of earthquake, each share vibrates according to its time. This concept can mix with traditional green architectural concepts. The house will be safer and lesser cost. Lesser cost means the house can build part by part, according to they needs. Examples lay out shown in Figure 16 below.

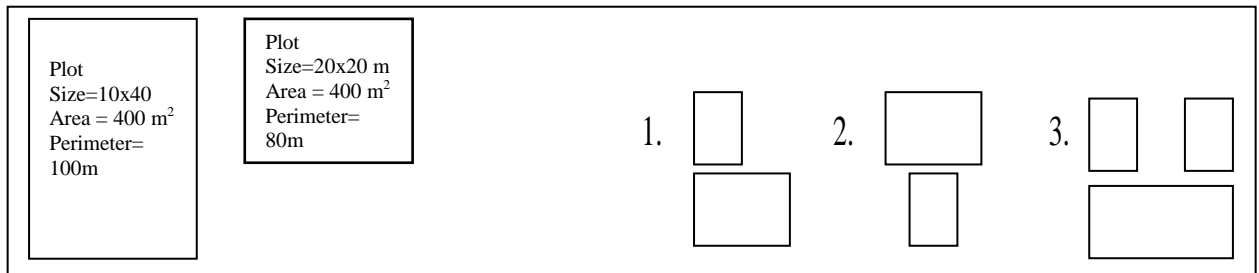


Figure 15 Shape of plot affect the cost of construction

Figure 16. Form building layout with consist of several building

Two storey houses gives the lesser cost compare to single unit. The construction cost and use of raw material can be further reduced by reducing the storey height. Perceive with floods disaster and also keep cool the house naturally, raised-floor structure and construction can use to the modern housing. Energy efficient also can reach to the house with raised-floor construction. Besides that, mixing concept raised-floor construction on single storey building is make ventilation in the bottom and up the wall. It will maximally the cross ventilation inside the house. (figure. 17)

Raised-floor construction also can give result for humidity problem in humid tropic area like Indonesia. Humid tropic climate have much water in the air. Building always to absorb water from the air especially that was used from brick and tile brick. House that stands up directly to the earth will to penetrate water into the wall. The moistness will influence the room if the wall was satiated with water, to result in grown of mushrooms in the wall.

Construction phase is mainly dependent on design and the workmanship on site. Construction phase may be made more sustainable and efficient by improving construction methods and improving the process of construction. The design process impact on the material type of material selected for construction. During construction phase a lot of energy is wasted during transportation of materials from longer distances. Therefore a lot of energy and resources can be saved by avoiding transportation of building material from longer distances and using locally available building material, which appeared in the Use of Natural Resources.

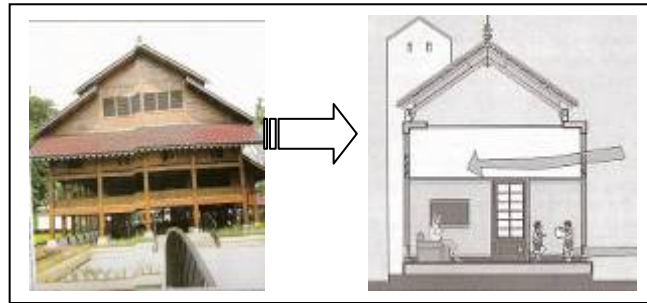


Figure 17. Mix and match concepts form from traditional to modern house single story building

The wood used in most of the traditional construction, which can be adopted in the modern construction after recycles. Wood, already used or weathered by weathering agent can be easily recycled. The ones of local / traditional material construction, beside wood which had proved tolerance with earthquake is bamboo. However now in the world, there are many buildings construction from bamboo in modern technology. Mixing construction concept between bamboos with modern engineering technology is according to sustainable architecture principle.

Substitute material is the material which it can substitution the natural materials. Use the substitute material in the right place will take an advantage of this material. Composite material is the material substitution that at presents is solution to mixing the traditional and local material with modern technology. The example material are gypsum, plywood, glass fiber reinforced cement (GRC), calboard, glass fiber reinforce plastic (GFRP), fiber reinforced polymer (FRP), etc. Composite materials are having flexibility in design, energy efficiency, easy in assembly, mass product and low cost. Introduction of composite structure members can be used to increase the strength and working capacity of material. E.g. wood beam with iron patches in the center of the beam to increase the resisting bending moment of the wood and that way cheaper wood can be utilized with improved structure characteristics. .

Indonesia comprising of the islands and most of the population are in the coast region where the speed of wind is higher than the inner part of the islands. Therefore advantage of wind energy is to convert that in electrical or other form of energy that can be used by the housing sector. As the system is costly and extensive research is needed to find the wind velocity to locate location of wind turbine stations. Therefore experimentally, it can be introduces in comparatively bigger islands like Java Sumatra and Kalimantan.

Solar energy can be used for conversion of electrical energy by using photovoltaic cells arrangements on inclined roofs. It is no doubt more costly in the start but will going to save 10 times more during its operations phase of the building. Traditional insulation techniques are more economical and efficient used in tropics therefore traditional insulation techniques can be used in modern building construction.

Orientation can be optimized depending upon site conditions and over all topography of the region.

CONCLUSION

1. Housing settlement with mix and match traditional & modern technology is not cost effective and resistant to natural hazards but will also help to maintain a concept of traditional architecture in the region. The innovation in design and construction coupled with mix and match technique will leads towards the ideology of sustainable development in the housing sector.
2. The Modern Housing Architectural which is designed with mix and match traditional and modern technology is progressively required towards sustainable architectural settlements in tropics. This also

requires the fully support from government as policy determinant, and integrated design from architect, engineer and planer.

3. Governments as policy determinant have to apply national standards for planning and construction composite material which can adapted by condition and material availability, so that the industries can give amenity and efficiency in development of houses on the area.

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