

Extended summary

Housing development situation and climate-adapted design solutions for Hue city

Curriculum: Analysis and design of the architecture and landscape

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Abstract. In the climate change situation, the energy source is exhausted gradually. With the development speed of many fields in Vietnam nowadays, energy is a problem that Vietnam has to face in the near future. Therefore, proposal solution of mitigation and adaptation towards climate change is particularly pressing and urgent. Thus, in Vietnam building, industry and transport are the most energy consuming sectors and the biggest producers of greenhouse gasses. After a long time of war and economy change, currently, people are experiencing a significant improvement of their living standards with many new values are formed. However, when making the decisions for the target of development, most of the metropolitans face with many problem of sustainability developments because they need a research investment and easily overlooked due to economic benefits.

This study introduces some kind of housing in Vietnam and the situation of building development in Hue city. There are many shortcomings and errors both in old and new construction which need to repair and change. Responsive climate housing has chosen for low cost energy during construction process as well as operation process. It can be seen that, this issue is warning with the power shortage, frequent blackout in recent years. From this research, the building strategies bring out sustainable living environment with the adaptive climate solutions. The strategies develop base on the local climate, local material, traditional construction methods



and some scientific approaches. This study will be the evident for many solutions which use the advantage of local climate to reduce the cost of energy and support a comfort living for inhabitants. Besides that, the further study also proposal some oriented measures for storm and flooding area in Hue.

The result of this research adds the specialized knowledge for architecture, designer in sustainable architecture, climate responsive, and low cost housing. It also support for other people who reflect about building to help understand the role of climate responsive for more energy efficient as well as sustainable environment.

Keywords. Climate-adapted design, low cost housing, responsive climate housing, sustainable environment.

1 Overview of hot-humid climate architecture and status of housing in Hue

1.1 Climate responsive architecture-architecture in hot humid climate

Nowadays, under the pressure of population increase, the amount of land is limited due to the speed of urbanization; this is also parallel to the risk of energy depletion, the global warming and ecosystem pollution. Therefore, it can be recognized recently the construction industry are working in a tendency to conservation and ecological balance. A variety of research fields of architecture was born such as ecological architecture, environment architecture, green architecture, sustainable architecture, energy-efficient architecture, and climate responsive architecture. All these fields of architecture aim to reduce the cost of energy using, reduce environmental pollution, and protect the Earth's ecosystems and creating a comfortable living environment for people.

Climate architecture or climate responsive architecture is the architecture which considers the climatic conditions of the location, so that the design and construction in accordance with local climatic conditions, take advantage of natural energy reduce the artificial energy using.

Climate architecture can be said that it appears for a long time with the evident of traditional design of building; it is the usual basis for examining the relation between building and climate. The building exists thousands illustrate the relationship between building and climate and represent more holistic models for the development of a climate responsive architecture.

In the world, from 1948, James Marston Fitch is one of the first people who show the interest in climate architectural design. This problem was continued by Victor and Aladar Olgyay who make climate architecture into a science field which bioclimatic architecture is a subject. This was also followed by Barush Givoni and Donald Watson. They got the research results contribute to the development of climate architecture and adaptive design.

There are four kind of climate in the world, it is divided depend on the location and some features such as temperate, precipitation, humid and radiation. In the scope of this thesis, it concentrates research the architecture in hot humid climate, the specific climate of case study. The hot humid climate is found close to Equator and extends to 15 degrees latitude, north, and south. This climate is the complete antithesis to the moderate climate. The dominant feature is lack of seasonal variations in temperature. This climate is characterized by high humidity and relatively high temperature although it does not have the extremes of temperature and humidity as are found in the moderate climate, which are the lower winter temperatures and high peak summer temperatures . The architecture of this area copes with excessive solar radiation and moisture then housing structure creates condition for free air movement and shading surrounding. Most of the solution is large roofs with steep angle and extensive overhang to protect form sun and also rainfall; the floor is elevated and separate with ground to avoid humid and allow air circulation underneath.



1.2 The current status of the residential housing and residential quarter in Hue city

Hue city has a long history of construction, when Nguyen Lord use Hue as capital, beside the construction of citadel, pagodas, temples, the mandarins began to build their own house far from citadel, called surrounding villages with the large garden of fruit trees like Kim Long, Nguyet Bieu, Luong Xuan, Xuan Duong or some shop house combines commercial and living like Bao Vinh port. Following the development of technique, build-ing material, and wishing to replace the traditional homes which are very difficult to preserve in extreme weather of hot and humid, along with the increase of population, people started building permanent houses by masonry. When the Vietnam's design standards and urban planning is at the first stage of beginning with the chaos situation, many residential have built everywhere with many kind of performance, style, color, material and construction ways, without density distribution. Recently, many urban planning projects have been renovated and upgraded with new indicators; new buildings are positive change with low significant and still low effect (figure 1).



Figure 1. The development of building density in Hue city (Source: drawing by Dr.G.Casagrande)

Previously, when Hue city has not been renovated and unplanned, spontaneous construction with many model leads to a complicated urban, poor quality. In addition the errors in design lead to the low using efficiency and high cost of much energy. Besides, so far, many areas have planned with new indicators which create a healthier and more quality with energy saving, advantaged microclimate and the improvements of surrounding environment such as green space and open space. This study bring out a general comparison especially the organization of residential area layout among a number of traditional residential areas as well as new area to find out the advantages and benefits of new and old design. It also points out the negative and unsuitable as a prerequisite for the study of the



more profitable strategies which used Hue's climate for a good quality of life, comforts and maximum energy savings.

2 Methodology

The methodology of the research is based on analyzing and comparing documentations, going in field survey collecting data and photography. The architecture design approach was used in studying and analyzing supported by computer programs. The software used in the process are dedicated to simulate the local climate, considering all the environment factors which contribute to the analysis resulting in data that come as close as it can be to reality.

Besides the particular design strategies, it is necessary to study the technologies from some samples, which they are sustainable house in the world. The survey focus on the kind of houses, which is adaptive local climate bring out the best solution, they have the similar climate and similar situation of society with Vietnam. Most of them concentrate in developing countries with hot-humid climate or called tropical countries.

3 Housing design strategies

The presentation of the results is focused on those aspects that characterized mainly the original contributions of the thesis. They are as following distribution:

3.1 The traditional approach

The features of traditional house can be show as the strategies following:

- Site selection has a great influence to the house's characters. The best orientation for hot humid climate housing is north south. The main façade face south to catch the breeze from south in summer and avoid north wind in winter.
- Trees plant around the house with different height in order to create different pressure control flow and wind velocity. Besides that, the vegetation improves microclimate by reducing heat radiation and support shade. It also depends on kind of tree choice, direction, and altitude of sun.
- Water body should locate at the advantage wind direction such as south due to cool by evaporation
- House in hot humid climate usually has elongated, extending along east west. The wall in west and east is usually solid to avoid radiation. Main house of HTGH is an evident to see it can extend the length easily.
- Thick roof with thermal insulation material like clay and slope 30 degrees would be easy for reduction heat radiation and rainwater drainage.
- Space underneath roof should have vents for wind transferring to avoid termite wood with high moisture condition.
- Veranda is a very important factor for house in hot humid zone. Effective shade depends on the wide of veranda. It is also reduce the thermal mass into the house.



- Wide eaves keep the sun from attacking wall or window directly; also avoid the precipitation fall in wall
- A solution for the house with timber structure in flooding area is putting the columns on the rock mass. The columns raised way protects the timber away ground moisture and subterranean termites.
- Yin-yang door design creates semi-closed space; it is a good condition for ventilation. Air is always clean and flow to avoid pollution and humidity.
- Courtyard is one of the important elements in vernacular house, it is not only Vietnam but also another areas. This should be applied in modern house.

3.2 Research and apply the solution of climate architecture base on the analysis of local climate

This study concentrates in four important fundamentals for good housing design in the tropic area with many effect factors concurently. In addition, these following strategies focus on the row house/ town house and independent house with garden typologies, as these types is the most widespread building type in Hue City. All above can be illustrated and explain in the same diagram of the following figure (figure 2).



Fig.2. The diagram to illustrate working process (Source: author's elaboration)

3.3 The impact of surrounding landscape

- High elevation on the windward side is always an advantage, choosing the house located in high places and water body if possible.
- Hue is a special city with the landscapes include both of mountain and river. Especially, Huong river is as can be seen a lung of the city to convect the air for the city. However, it cannot choose the house near the river or mountain as the wishing of the owner. Therefore, the creation of artificial topography should be proposed. For an independent house with garden, should create a create a land size



is higher than the ground in the construction site to get the ventilation crow in ground floor. This thing is difficult with row house because of limite area but raised floor is also a solution for ventilation

- Using ponds and water fountains as an artificial water body in front of the windward to reduce ambient outdoor air temperature around buildings, however, it is necessary to consider their impact of water conservation and maintenance because they can be a mosquito and bacteria breeding sites.
- Plan the high tree and thin in front of the house suppose the shading when the sun with high attitude in the morning. The back of the house plan the tree with a big canopy to support a large shadow and reduce the high temperature in the afternoon. Planting coniferous trees for sun shading in summer and windbreak in winter.
- Bush, grass reduces temperature on the ground. Therefore, around the house, especially near the window, plan the grass to reduce the reflection of radiation to the house.
- Planting shrubs or other vegetation between the building perimeter and sidewalk to reduce heat build up and also for decoration.
- In humid condition, it is difficult to plan the tree on the wall because the moisture can destroy the wall in winter. Therefore, planting trees between walls can help to reduce the temperature. However, should pay attention about the tree's root because big root can attack to the basement.
- According the above idea, the block of plan can be seen a concrete wall but it need to be against the absorption of moisture because planning shade walls and paved areas adjacent to the building to reduce solar radiation striking the building during the summer.
- Grass roof is seems like a difficult solution in Hue city because of the heavy rainy season and humidity. It damages, spread fungus into the roof and even building. Therefore, the reinforcing of waterproofing and installing drainage system are the most rigorous way to avoid accumulation of water on the roof.
- Plants can control wind direction or reduce the velocity of the wind by the tree wall). Therefore, to reduce the wind pressure of wind impact to the house (storm) should plan the tree or block of tree to resist high winds, or control the direction of the wind.
- Plants in a tropic country shed their leaves in winter, therefore, it should be planed the shrubs to prevent wind storm in winter.
- The more tree plant, the more shading we have to protect house from the radiation and strong wind.
- Plan trees in front and back of the house, with town houses, should spend some for garden even inside the house.
- All of that above strategies, it can be easy to apply in an independent house with large area and free space around. However, for a town house, it is nescessary for the offset for small garden, even inside the building.



• It is not only the garden belongs to the house, it also needs to plant the tree on the sidewalk, paverment to provide shade on the streets which help reducing temperature.



1. Green facade

- 2. Grass in front of the house
- 3. Vegetation of pavement (bush, grass)
- 4. Green vertical install
- 5. High and thin tree in front of the house
- 6. Treen in public space

Fig.3. Illustrate tree and vegetation installing strategies (Source: Author's elaboration)

3.4 Insulation

- Always create an inlet and an outlet underneath the roof for ventilation, reducing heat by many support device even a gable site vent need to set up two items.
- The best system for installing ventilation method is: the outlet is near the ridge and the inlets are in the soffit area. The hip roof is best suited to this system, since there is soffit area on all sides of the house. Outlet vents can be provided by roof louvers, gable end louvers, turbine ventilators or continuous ridge vents.
- Using foil under the roof and bulk above ceiling for insulation effect.
- Using cool metal roof at the first time of the building to reduce the fee for upgrade housing
- Metal roof is a good option beacase of the rapidly cooling at night, in this case, it should use a sheet with a reflective coating on its underside, to reduce daytime heat gains.
- The resistance to heat flow is measured by the R-value the higher the insulation's R-value, the longer it takes heat to transfer through and the more effective it is. It is necessary to compare and choose among the material which has the different R-value.
- Combine grass roof for insulation and garden terrain.



- Material for external wall should be lightweight material such as floating concrete, light brick. The most popular brick as use in building with three holes of 200x105x200cm.
- Beside the material using for insulation should be installed the shading structure such as balcony, roof overhang, double facade to reduce the thermal mass in external wall.
- Installing the water collective tank under the foundation is also another solution for thermal cooling down
- Stopping the radiation by shading through window, door, glass wall by shading device inside and outside.



Fig.4. Illustrate insulation methods (Source: Author's elaboration)

3.5 Ventilation

- Utilize pressure difference by creating the wall, opening space.
- Reducing the depth of the housing
- Increasing the opening and window for cross flow and install the air shaft depend on the depth of housing and skylight for vertical flow air
- Reduction the obstruction inside by using minimize furniture, equipment and avoid creating the walls to prevent the flow of wind
- Creating a inlet openness always lower than the outlet





- 1. Cross ventilation, inlet openness always lower than outlet
- 2. Operable window for cross ventilation
- 3. Ventilation by fan
- 4. Vertical ventilation by air shalf and skylight
- 5. Confined space for air condition

Fig.5. Some ventilation strategies in town house (Source: Author's elaboration)

3.6 Orientation and Shading

- Always close doors and windows while using air conditioning
- The space for air condition should be confined and the less area the better
- The air condition use should be moderated and on necessity
- Do not turn on the air condition at too low temperature which will cost high consumption of electricity.
- Using the riddle and shading devices is also a solution to reduce temperature
- Using fan ceiling in the common space for cooling and reducing odor from clothes, sweat and cooking.
- Planning tree surround to protect housing from heat gain
- Install heat buffer zone or veranda for housing to reduce the heat build up form solar radiation
- Constructive shading such as balconies, loggias and overhangs
- Constructive double skin facade, screen for sun protection and air ventilation
- Green wall or pergola help cooling down the wall faster at night
- Screen or skin of building allow the effect shading for all housing also create a beauty facade, however, pay attention of the ventilation, if the screen is high density, it will be block the air flow
- Constructive the shading roof for terrace for the activity oudoor and also reduce heat of roof floor.
- Using the screen, grill, louvre for sun protection but allow air movement and also taking day light.



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1. Green facade

- 2. Green and vegetation
- 3. Shading with balcony, loggia, overhang
- 4. Shading terrain
- 5. Reduction heat gain by grass roof
- 6. Overhang and fin for windows
- 7. Covering roof with solar panel

Fig.6. Shading systems in town house (Source: Author's elaboration)

4 Conclusion

In the situation of real estate market nowadays, to own a private housing property is a very difficult thing. Also, building a house has to spend amount of money to do it, after that is the spending fee for the operation process of the building. Facing with the raising of energy prices is also the time to think about how to save energy. Energy savings can be realized in several ways. For example, avoid using energy in some electric devices such as air condition, refrigerators, washing machines, microwave oven and ovens. However, beside the consuming energy depend on the equipments using, it also depend on the behavior in daily life of inhabitant and a how is the design of the building. Building housing adaptive climate is a good way to save energy with the good condition of climate in a tropic country like Vietnam. Therefore, it is necessary to bring out some strategy to design and build better housing and also to understand and to communicate, how to make buildings more climate-adapted, more energy-efficient as well as more sustainable and more valuable. Let's imagine with a good housing, besides energy saving as an economic investment in the future, it makes member in the house more independent from power shortage and network blackouts, which is a value as such, because it adds quality to your life. Respect environment thanks to building also make a contribution to solve the future problem of Vietnam and of mankind. Building or buying a house in a new place, it does not take time to research about the environment surrounding but the value we receive is more than that a secure and peaceful living environment will allow people to enjoy the achievements of progress with much more confidence and pride. In the other hand, if architecture is considered is a part of nature, then the building must achieve the harmony with the ecological



environment. That is the local climate responsive to create for people a comfortable living environment.

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