

DEVELOPMENT OF PASSIVE DESIGN AND COOLING TECHNOLOGY IN TROPICAL CLIMATE

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RESEARCH PROJECT LIST

Research Project:

Title: Passive and hybrid design of building for sustainable society in tropical climate with special emphasis on human comfort through efficient building construction, ventilation, lighting and cooling strategies, by adopting renewable or zero energy concepts and recycling of building products

Abstract

The project covers a number of sub-projects consisting of either fundamental or applied research, which aims at producing a sustainable home in tropical climate. The research will be applied on three units of double storey terrace or link house covering two end units and one middle unit. In Malaysia, terrace or link house is presently the most common type housing typology for the low and middle class groups. The sub-projects include the study on the human factor (cultural and social behaviours of the end users), ecological and climatic design principles (sun, wind, rain and noise), renewable and zero energy technology, sustainable materials and construction, and external environmental factors which include landscaping and physical planning.

Public acceptance on a specific housing concept, human perception and judgment on the actual building performance need to be evaluated based on the cultural, social and religious background of the occupants. Therefore, a study on the physical and non physical factors which influenced the design and construction as well as the post-construction evaluation is necessary to be carried out to the prototype house/houses. The daily activities of the residents need to be studied in determining the actual climatic and energy performance of any retrofitting or technology applied to the house.

Ecological and climatic design inputs which are based on topographical character of the site, solar geometry, wind speed and direction, driving rain and noise privacy specifically for terrace houses need to be studied and analyzed. The passive techniques of providing day lighting with less indoor solar heat gain, encouraging wind induced and stacks ventilation with less water penetration problems, and reducing noise from neighbouring units to increase privacy will help to reduce dependency on active technique which consumes more energy. Balanced concepts and approaches of passive, active and the interference from any limiting factors such

as local by laws, building regulations and guidelines which require to be complied with in terrace house design demand a thorough study to be carried out before any logical compromised solutions to be adopted.

Achieving zero energy consumption at the minimum or least construction cost is the ultimate aim for zero energy housing. Energy systems of the future will have to be cleaner and much more efficient, flexible, and reliable than they are today in order to ensure Malaysia's energy security and environmental viability. Hence, renewable energy resources such as daylight and solar energy can be utilized for the development of zero energy housing. The next challenge is to incorporate solar energy technologies into sustainable buildings in hot and humid climates such as Malaysia. In this project several solar energy technologies that been developed by the Solar Energy Research Institute, in UKM will be studied and its appropriateness as well as cost competitiveness for Malaysian homes will be evaluated. Solar energy technologies that are considered appropriate for achieving low energy homes are (a) day lighting technology (b) solar thermal technology (c) photovoltaic thermal solar collector and (d) solar hydrogen eco house with grid connected building integrated photovoltaic system.

Research on sustainable materials and construction require a deep study on the concepts of reuse and recycling of local materials and building products to be carried out. Building debris from construction sites and demolition of old houses require specific studies on the reusability as new materials or by-products to be used in a new construction sites. Waste materials from rubber trees, oil palm trees and vegetable wastes can be recycled and reproduced as building products. Research on Cedar tree in Kyoto University, Palm oil tree in UKM and Foam and earth concrete in USM could be used as the basis for further research. Composite materials which are light, tough and having good thermal insulative properties might be used in the construction of the proposed houses. However, a detail study (LCA analysis) on the performance, reliability and acceptability is still necessary to be carried out in order for the products to penetrate the future building market in the tropical region and elsewhere.

The external factors directly influence the indoor climate in a totally passive building design. Therefore, outdoor space treatment including landscaping and overall planning require to be studied in order to reduce the formation of hot air pocket including heat island and encourage the formation of an acceptable outdoor temperature with cooler, faster and cleaner air flow into the building. Creation of hot and contaminated air with unwanted odour should be prevented. A study on the best strategies and selection of alternative planting, paving materials, outdoor furniture and the layout is necessary especially in the construction of terrace houses with a very limited and restricted site for such green spaces.

SOCIAL AND STATE OF THE ART AND FUTURE ISSUES

Social State of the Art

Proceeding and collection of papers on research findings from previous research carried out by members of group 10 and other researchers in this area covering a range of topics in passive design retrofitting and energy efficient features including:

- Building envelope
- Natural ventilation

- Space planning
- Innovative lighting design
- Energy efficient building
- Thermal comfort
- Sustainable design features

The area that is still not covered is the research on human factors, especially the post-occupancy evaluation and the reuse or recycling of building products. However most of the research carried out by members varies in the scope and is not targeted to a specific housing typology. Therefore, a concerted effort which can integrate all the research with a similar objective of developing a comfortable homes in tropical climate is very much welcome.

Future issues on the sustainable building and environmental design are the developments of a better house with good architectural features, ecologically sustainable, humanly planned, reasonably built and maintained, consume less energy or zero energy by using reusable source of energy.

RESEARCH PROJECT PLAN

Sub-project 1:

Title

Human Factors and Post-occupancy Evaluation Study of Terrace Houses in Hot-humid Climate

Objectives

The main objective of the research is to study the public acceptance on a specific housing concept, the human perception and the judgment on the actual building performance based on the cultural, social and religious background of the residents. The study will also cover the physical and non-physical factors which influence the design and construction as well as the post-construction occupation based on daily activities of the residents.

Plan

| Activities | 2005 | 2006 | 2007 | 2008 | 2009 |
|--|------|------|------|------|------|
| Reestablishing research and collaborative partners in Japan | | | | | |
| Completion of the evaluation study on the human perception on a number of low and medium cost housing typologies in urban area | | | | | |
| Completion of the performance studies specifically on terrace or link house | | | | | |
| Completion of the studies on life cycle and activities to the residence of the prototype homes | | | | | |
| Joint research proposal for the human factors and post occupancy evaluation | | | | | |

Sub-Project 2:

Title

**Ecological and Climatic Design Principles (sun, wind, rain and noise):
Evaluation Study on Terrace Houses in Tropical Climate**

Objectives

To study the ecological and climatic design inputs which are based on topographical character of the site, solar geometry, wind speed and direction, driving rain and noise privacy specifically for terrace houses especially in urban settings. The research will be focussed on the passive techniques of providing efficient day lighting with limited solar heat gained, method of facilitating wind induced and stacks ventilation into the building and looking into the method of reducing water penetration problems, and developing techniques of reducing noise from neighbouring units to increase privacy. The final objective is to look into a balanced concepts and approaches of integrating passive, active ecological design elements and other constrains such as local by laws and building regulations.

Plan

| Activities | 2005 | 2006 | 2007 | 2008 | 2009 |
|--|------|------|------|------|------|
| Establishing research and collaborative partners in Japan | | | | | |
| Completion of the evaluation study on the macro and micro scale analysis on the topography, solar, wind, rain and noise factors (case studies) | | | | | |
| Completion of the design strategies and method to be adopted specifically on passive elements | | | | | |
| Completion of the studies on the design proposals (integration with active techniques) of the prototype homes | | | | | |
| Joint research proposal for the ecological and climatic design principles | | | | | |

Sub-Project 3:

Title

**Renewable Energy: Environmental Technology for Zero Energy Housing
Objectives**

The main aim is to achieve zero energy consumption at the minimum or least construction cost in housing sector with cleaner and much more efficient, flexible, and reliable systems in order to ensure Malaysia's energy security and environmental viability. The objectives of the research projects are as follows:

- (a) to evaluate environmental friendly technologies suitable for zero energy housing
- (b) to evaluate the performance characteristics of these technologies under the

Malaysian climate conditions

- (c) to develop mathematical model of the system and predict accurately the performance of the system for a given sets of parameters and conditions, and thereby optimize the designs
- (d) to develop strategies for the public acceptance of solar energy technologies for zero energy housing
- (e) to collaborate with the Japanese academics and commercial sector for the use of these system in both countries

Plan

| Activities | 2005 | 2006 | 2007 | 2008 | 2009 |
|--|------|------|------|------|------|
| Establishing research and commercial collaborative partners in Japan | | | | | |
| Completion of the evaluation of suitable solar energy technologies for zero energy homes | | | | | |
| Completion of the performance studies of solar energy technologies for zero energy homes | | | | | |
| Completion of the strategies of the acceptance of zero energy homes | | | | | |
| Joint research proposal for zero energy homes | | | | | |

Sub-Project 4:

Title

Sustainable Materials and Construction through Reuse and Recycling of Local Materials and Products

Objectives

The main objective of the research is study the concepts, principles and application of reuse and recycling of local materials and building products. The study includes the reusability building debris from construction sites to be developed as new materials or by-products to be used in a new construction sites. The study will also look into the possibility of developing waste materials from rubber trees, oil palm trees and vegetable wastes to be recycled and reproduced as building products. The possibility of using composite materials that are ecologically and climatically sustainable will also be taken into consideration in line with the (LCA analysis) on the performance, reliability and acceptability

Plan

| Activities | 2005 | 2006 | 2007 | 2008 | 2009 |
|--|------|------|------|------|------|
| Establishing research and commercial collaborative partners in Japan | | | | | |
| Completion of the evaluation of suitable concepts and principles of reuse and recycling of building products | | | | | |

| | | |
|--|--|--|
| Completion of the study on suitability of products application and comfort strategies | | |
| Completion of the (LCA analysis), study on the suitable and recycling strategies to be adopted | | |
| Joint research proposal for reuse and recycling of building | | |

Sub-Project 5:

Title

Assessment and Evaluation of Appropriate External Environmental Factors (landscaping and physical planning) for Cooling in Tropical Climate

Objectives

The objective of the research is to evaluate a number of outdoor space treatment including landscaping and overall planning which are able to reduce the formation of hot air pocket including heat island and encourage the formation of an acceptable outdoor temperature with cooler, faster and cleaner air flow into the building. This includes selection of the best strategies for alternative planting, paving materials, outdoor furniture, and the layout is especially in the construction of terrace houses with a very limited and restricted site for such green spaces.

Plan

| Activities | 2005 | 2006 | 2007 | 2008 | 2009 |
|--|------|------|------|------|------|
| Establishing research and commercial collaborative partners in Japan | | | | | |
| Completion of the evaluation of suitable concepts and principles of outdoor treatment from case studies | | | | | |
| Completion of the study on suitability of planting types and landscaping strategies for comfort | | | | | |
| Completion of the study on other limiting factors i.e. local by laws and guidelines and strategies to be adopted | | | | | |
| Joint research proposal for the appropriate external environmental factors | | | | | |

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