SUSTAINABLE HOUSING MATERIALS IN SHIRAZ

NARGES SAMAVATI

A thesis submitted in fulfillment of the

requirements for the award of the degree of

Master of Science (Planning Housing)

Faculty of Built Environment

University Technology Malaysia

Jan 2012

ABSTRACT

Sustainable, or "green building," design and construction provide an opportunity to use resources more efficiently, while creating healthier and more energy-efficient homes. Successful green buildings leave a lighter footprint on the environment through conservation of resources, while at the same time balancing energy-efficient, cost-effective, low-maintenance products for construction needs. A similar concept of green building is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally

In this thesis, sustainable housing materials for Shiraz houses are identified. In the first step the concept of sustainable materials are revealed and then, the characteristics of sustainable hosing materials are explained based on previous works and researches. Forward these works, same thesis for sustainable building materials in Sri Lanka is modified and its methodology is analyzed. Total characteristics and modifications of Shiraz and Shiraz houses are explained in next step, and then the analysis based on the sustainable material characteristics is started. Each objective is analyzed based on each house condition and the results are determined.

The results show that, gathering the following materials would lead us to have a sustainable house in Shiraz: insulated cement block due to its low embodied energy and carbon emission for using in inside walls, the low amount of carbon emission and embodied energy of travertine stone in faced walls, steep clay roof as roofing system because it has the least carbon emission, and UPVC window for windows materials. In case of widows materials iron windows has the least amount of embodied amount of carbon emission and embodied energy but because they do not have many characteristics of sustainability, UPVC windows are preferred instead of these windows.

ABSTRACT

Sustainable, or "green building," design and construction provide an opportunity to use resources more efficiently, while creating healthier and more energy-efficient homes. Successful green buildings leave a lighter footprint on the environment through conservation of resources, while at the same time balancing energy-efficient, cost-effective, low-maintenance products for construction needs. A similar concept of green building is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally

In this thesis, sustainable housing materials for Shiraz houses are identified. In the first step the concept of sustainable materials are revealed and then, the characteristics of sustainable hosing materials are explained based on previous works and researches. Forward these works, same thesis for sustainable building materials in Sri Lanka is modified and its methodology is analyzed. Total characteristics and modifications of Shiraz and Shiraz houses are explained in next step, and then the analysis based on the sustainable material characteristics is started. Each objective is analyzed based on each house condition and the results are determined.

The results show that, gathering the following materials would lead us to have a sustainable house in Shiraz: insulated cement block due to its low embodied energy and carbon emission for using in inside walls, the low amount of carbon emission and embodied energy of travertine stone in faced walls, steep clay roof as roofing system because it has the least carbon emission, and UPVC window for windows materials. In case of widows materials iron windows has the least amount of embodied amount of carbon emission and embodied energy but because they do not have many characteristics of sustainability, UPVC windows are preferred instead of these windows.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

WCED	-	World Commission on Environment and Development
MSDS	-	Material Safety Data Sheet
IAQ	-	Indoor Air Quality
SC	-	Securities Commission
HVAC	-	Heating Ventilation and Air conditioning
LCA	-	Life Cycle Assessment

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

According to the World Commission on the Environment and Development (WCED), sustainability is “a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” Sustainability should be viewed as a process and not just a goal. That allows a broader evaluation over time, of the environmental, economical and societal impacts of building products.

Sustainable, or "green building," design and construction provide an opportunity to use resources more efficiently, while creating healthier and more energy-efficient homes. Successful green buildings leave a lighter footprint on the environment through conservation of resources, while at the same time balancing energy-efficient, cost-effective, low-maintenance products for construction needs. In other words, green-building design involves finding the delicate balance between homebuilding and sustainable environment. Viewing sustainability as a process is essential for “green designers” as specifies are challenged to evaluate the full life-cycle of products.

Green Building, also known as the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from sitting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort (U.S. Environmental Protection Agency, 2009).

A similar concept of green building is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally (Hopkins, R. 2002).Green building practices aim to reduce the environmental impact of buildings. Buildings account for a large amount of land use, energy and water consumption, and air and atmosphere alteration (Frej, Anne B, 2005).

There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy. Recycled content paving materials, furnishings, and mulches help recycling Energy Efficiency.

Select sustainable construction materials and products by evaluating several characteristics such as reused and recycled content, zero or low off gassing of harmful air emissions, zero or low toxicity, sustainably harvested materials, high recyclability, durability, longevity, and local production. Such products promote resource conservation and efficiency. Using recycled-content products also helps develop markets for recycled materials.

Use dimensional planning and other material efficiency strategies reduce the amount of building materials needed and cut construction costs. For example, design rooms on 4-foot multiples to conform to standard-sized wallboard and plywood sheets.

By using more efficient building methods and materials, it is also estimated that we could reduce the energy, resource consumption and / or waste production by 50-60% without decreasing value, aesthetics or function. With the understanding of the Earth's finite resources and the knowledge that manufactured products, including all building materials, have an effect on our resources, it is becoming increasingly important to make wise decisions regarding the use of these limited resources to protect our environment and our ability to sustain ourselves. The design and construction industry is in a position to effect change in building practices through the use of resource efficient construction materials and methods.

Green building materials offer specific benefits to the building owner and building occupants such as:

- Reduced maintenance/replacement costs over the life of the building;
- Energy conservation;
- Improved occupant health and productivity;
- Lower costs associated with changing space configurations;
- Greater design flexibility;

1.2 Problem Statement

In the case study of Shiraz, there are many types of houses especially big ones which are the main sources of wasting energy in Iran; whilst there is almost no usage of sustainable materials. This study analyzes the Shiraz local materials to investigate their sustainability and finally choose the most sustainable ones to use in Shiraz Houses.

1.3 Objectives

The objective of this thesis is analyzing sustainability in Shiraz local materials to find out which one is better in sustainability to use in Shiraz houses. To reach this, the project will investigate theses aspects:

1. To study the concept of Sustainable Housing Materials and in particular in Shiraz Housing Materials.
2. To analyze the materials used in 5 houses in different geography directions in Shiraz.
3. To find out the percentage of carbon emission in different materials used in the Shiraz Houses.
4. To come up with the most sustainable materials for future Shiraz houses.

1.4 Research Questions

1. What is the concept of Sustainable Housing Materials and what is the level of sustainability in Shiraz Housing Materials?
2. What are the characteristics of Shiraz Housing Materials?
3. What is the percentage of carbon emission in different Shiraz Housing Materials?
4. What are the most sustainable materials for future Shiraz houses?

1.5 Project Outline

This thesis is divided into five chapters. The chapters Outline is as follows:

1.5.1 Chapter 1- Introduction

This chapter provides readers a first look at the basic aspects of the research undertaken, such as an overview of Sustainability and Sustainable Materials, the Sustainable Materials Advantages, problem statements, objectives and outlines.

1.5.2 Chapter 2 – Review of literature studies

This chapter reviews the previous works on Sustainability and Sustainable Housing Materials. It contains the definitions of building envelope and natural materials and the criteria of Sustainable Housing Materials and also other reviews related to this project.

1.5.3 Chapter 3 – Research Methodology

This chapter presents the overall systems methodology and steps that must be taken into consideration for sustainable housing materials analysis. In this chapter the sustainability in five houses materials in Shiraz will be discussed to find out whether these materials which are samples are sustainable or not.

1.5.4 Chapter 4 – Results

This chapter reveals the final results for sustainability of the samples materials. All results that have been achieved will be presented here.

1.5.5 Chapter 5 – Conclusion and Recommendation

This chapter will complete the results gained and make conclusions then it will be some recommendations for future sustainable materials in Shiraz houses.

REFERENCES

Akbari, H., P. Berdahl, R. Levinson, R. Wiel, A.O. Desjarlais, W.A. Miller, N. Jenkins, A. Rosenfeld, and C. Scruton. 2004. Energy Efficiency in Buildings, proceedings of American Council for an Energy Efficient Economy, Pacific Grove, CA, August.

Alison Lindburg, DR. Jeff Howe, Kathryn Fernholz, DR. Jim Bowyer, Green Building Materials: Made in Minnesota, May 29, 2008.

Asif, M.; Muneer, T.; Kelly, R. Life cycle assessment: A case study of a dwelling home in Scotland. Build. Environ. 2007, 42, 1391-1394.

Anderton, Frances. "When Shelter Is Made Out of the Earth's Own Dust" The New York Times 15 Apr 1999: Design Notebook

Prof. Adinarayana, M. Building Materials, Jana Vignana Vedika (A.P), Hyderabad.

Babel, S.; Gheewala, S. A & Abeysundara, U.G.; matrix in life cycle perspective for selecting sustainable materials for buildings in Sri Lanka, Build, Environ, 2009, 44, 997-1004;

Calkins, M. Materials for Sustainable Sites: A Complete Guide to the Evaluation, Selection, and Use of Sustainable Construction Materials; John Wiley & Sons: Hoboken, NJ, USA, 2009.

Christian Meyer, "Concrete for the New Century", Association of New York City Concrete Producers, 2002

C. Thormark, The Effect of Material Choice on the Total Energy Need & Recycling Potential of a Building, April 2005.

D, J. Gielen, Building Materials and CO2, Western European Emission Reduction Strategies, October 1997.

Embodied Carbon in Natural Building Stone in Scotland Prepared for Historic Scotland, Purpose of Issue1 Final Report; Authors: Naeeda Crishna, Dr. Suzy Goodsir, Professor Phil Banfill, Dr. Keith Baker; 10.03.10.

Frej, Anne B., editor. Green Office Buildings: A Practical Guide to Development. Washington, D.C.: ULI--The Urban Land Institute, 2005.

Dr. Gupta Y. P. Need for Developing Green Building Concept in the Country, January 2010.

Gorgolewski, Mark. "The Implications of reuse and recycling for the design of steel buildings" Canadian Journal of Civil Engineering April 2006: 33-. Engineering Village.

Gustavsson, L.; Sathre, R. Variability in energy and carbon dioxide balances of wood and concrete building materials. Build. Environ. 2006, 41, 940-951.

G. Weir and T. Muneer, Energy &Environmental Impact Analysis of Double-Glazed Windows, May 1996.

Hopkins, R. 2002. A Natural Way of Building, Transition Culture, Retrieved: 2007.

Hadley, S.W., J.M. MacDonald, M. Ally, J. Tomlinson, M. Simpson, and W. Miller. 2004. Emerging Energy- Efficient Technologies in Buildings: Technology Characterizations for Energy Modeling.

Halliday, S. Sustainable Construction, 1st ed.; Butterworth-Heinemann: Oxford, UK, 2008.

Husain, Yasha. "Space-Friendly Architecture: Meet Nader Khalili." SPACE.com 17 Nov 2000.

Ignacio Zabalza Bribian, Antonio Valero Capilla, Alfonso Aranda Uson, Life Cycle Assessment of Building Materials: Comparative Analysis of Energy & Environmental Impacts & Evaluation of the Eco-Efficiency Improvement Potential, 2011.

John, G.; Clements-Croome, D.; Jeronimidis, G. Sustainable building solutions: A review of lessons from natural world. Build. Environ. 2005, 40, 319-328.

Jong-Jin Kim, Sustainable Architecture Module: Qualities, Use, and Examples of Sustainable Building Materials, December 1998.

Kunzel, Hartwig, and Achilles Karagiozis. 2004. "Vapor Control in Cold and Coastal Climates Zones.

Lynn Froeschle, Environmental Assessment and Specification of Green Building Materials, October 1999.

Marilyn A. Brown, Frank Southworth, Therese K. Stovall, Towards a Climate Friendly Built Environment, July 2005.

Michael Lyons, A Comparative Analysis Between Steel, Masonry and Timber Frame Construction in Residential Housing, October 2009.

Mohan Yellishetty, P. G. Ranjith, A. Tharumarajah, Iron Ore & Steel Production Trends & Material Flows in the World: Is this really Sustainable?, 2010.

Nina Nurdiani and Religiana H. Aziz, The Changes of Building Configuration and Material Use in Traditional Balinese House.

Norfatiha Hamzani, The Eco Labeling on Sustainable Roof Materials, 2008.

Roodman, D. M. and Lenssen, N. (1995), A Building Revolution: How Ecology and Health Concerns are Transforming Construction, March, 1995.

Spiegel, R. & Meadows, D. (1999), Green Building Materials: A Guide to Product Selection and Specification.

Sun, M.; Rydh, C.J.; Kaebernick, H. Material grouping for simplified product life cycle assessment. J. Sustain. Product Des, 2003, 3, 45-58.

Sustainable Architecture Module: Qualities, Use, and Examples of Sustainable Building Materials, Jong-Jin Kim, Assistant Professor of Architecture, and Brenda Rigdon, Project Intern.

Thormark, C. The effect of material choice on the total energy need and recycling potential of a building, Build. Environ. 2006, 41, 1019-1026.

U.S. Environmental Protection Agency. (October 28, 2009). Green Building Basic Information, Retrieved December 10, 2009.

U. G. Yasantha Abeysundara, Sandhya Babel, Shabbir Gheewala, A Matrix in Life Cycle Perspective for Selecting Sustainable Materials for Building in Sri Lanka, 2009.

Venkatarama-Reddy, B.V.; Jagadish, K.S. Embodied energy of common and alternative building materials and technologies. Energ. Bldg. 2003, 35, 129-137.

Waitakere City Council's Sustainable Home Guidelines, January 2000.

Willmott Dixon, Embodied Energy, November 2010.

Zhu Song and Davorin Kralj, Greenovation, Makes Green Future, 2011.