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Ancient vernacular architecture: characteristics categorization and energy performance evaluation

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ABSTRACT

Building has significant impacts on the environment and natural resources. The emerging world energy and environment challenges demand a substantial revolution of building design philosophies, strategies, technologies, and construction methods. Vernacular architectures, built by people whose design decisions are influenced by traditions in their culture, have been gleaned through a long period of trial and error and the ingenuity of local builders who possess specific knowledge about their place on the planet, and thus are valuable in promoting climate-specific passive building technologies to modern buildings. This study introduced an approach to categorizing distinct vernacular regions and evaluating energy performance of ancient vernacular homes as well as identifying optimal constructions using vernacular building techniques. The research conducted an extensive computer energy modeling for a number of representative ancient vernacular architectural characteristics observed for different climatic regions. The vernacular test subjects were compared against those established according to the International Energy Conservation Code and those generated by the optimization software. The simulation results of the energy models suggest that considering traditions seen in ancient vernacular architecture as an approach to improving building energy performance is a worthwhile endeavor and a scientific guidance can help enhance the performance. The study indicates that, although many vernacular dwells exist in the world, it is challenging (but desired) to package vernacular architecture traditions and quantitative design knowledge to modern building designers. This project is the first part of a much larger project that intends to create a knowledge base of vernacular building traditions that will include information about not only the energy performance of traditional building techniques, but also address areas of cost, material availability and cultural traditions.

1. Introduction

Buildings account for 45% of worldwide energy use, 80% of potable water use, and 50% of the timber harvest in North America. They also account for about 40% of municipal solid waste and 30% of U.S. greenhouse gas emissions that contribute to global warming and acid rain [1]. The emerging world energy and environment crises demand a substantial revolution of building design philosophies, strategies, technologies, and construction and management methods. In most developed countries, architects design the majority of new buildings. However, when one looks collectively at the world's buildings both now and throughout history, it becomes clear that professional architects designed a very small percentage of structures. In fact, Oliver [2] of the Oxford Institute for Sustainable Development estimated that over 90% of all structures in existence today were designed by the people who use them, not architects. The number of dwellings associated with this estimate includes approximately 800 million dwellings.

Vernacular architecture is used to describe structures built by people whose design decisions are influenced by traditions in their culture. Vernacular architecture varies widely with the world's vast spectrum of climate, terrain and culture. It contains inherent, unwritten information about how to optimize the energy performance of buildings at low cost using local materials. Over the course of time, vernacular dwellings have evolved to respond to challenges of climate, building materials and cultural expectations in a given place. Vernacular traditions have been gleaned through a long period of trial and error and the ingenuity of local builders who possess specific knowledge about their place on the planet, a commodity that is becoming increasingly scarce in our era of remote communication and outsourcing. As such, there is value in understanding and applying attributes seen in ancient vernacular architecture to new buildings.

A great deal of literature was found on the topic of vernacular building traditions. The most extensive document by far is the *Encyclopedia of Vernacular Architecture*, a 4000 page collection of

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research by over 750 authors from 80 countries compiled by Professor Paul Oliver of Oxford University and published in 1997 [3]. With two volumes categorized by climate and the "vernacular responses" of a plethora of cultures and another volume focused on materials, resources and production, it is the world's foremost source for research in the area. Another noteworthy text is *A Pattern Language*: *Towns*, *Buildings*, *Construction* [4], which draws conclusions about a basic language of architecture (similar to Carl Jung's archetypal patterns) that has evolved out of vernacular building traditions over the course of human history.

This study is particularly interested in the energy-saving implications of vernacular architectural traditions. The *Encyclopedia of Vernacular Architecture*, a subset of its essays called *Dwellings* [2], and several academic papers were used in conjunction with photographs found online to help identify vernacular test subjects and define constructions. The book *Anthropological Linguistics*: *An Introduction* by the renown, and some say controversial, linguist and African anthropologist Greenberg [5] was also used in research related to the task of mapping cultural heritage. This project develops a method for categorizing distinct vernacular regions, a process by which energy performance of vernacular homes can be measured relative to base-case dwellings designed using the International Energy Conservation Code (IECC), and a manner to identify optimal constructions using ancient vernacular building techniques. The study investigates a number of representative ancient vernacular dwellings collected at 22 locations in 11 major climate zones, with an effort to identify vernacular trends, test technology effectiveness, and shed light upon ancient building technologies at risk of being forgotten by the building industry. The impetus behind the project is to apply the developed approach to create a comprehensive body of knowledge about vernacular architecture that can be leveraged by architects and engineers at the beginning of the building design process so energy-saving vernacular technologies can be integrated into new construction and cultural vernacular traditions can be preserved. Another goal is to demonstrate a methodology that can be used by future researchers to quickly distinguish between vernacular traditions precipitated by climate and those carried on by cultural traditions.

2. Categorization of vernacular architecture regions

To create a comprehensive knowledge base about vernacular architecture using analysis, one must start by creating a list of test subjects derived from influences that make the test subjects unique. Since vernacular traditions are shaped strongly by culture, weather and geographic location, it makes sense to divide the world into distinct regions each with a unique combination of these three traits. Building materials also strongly influence vernacular building traditions, but introducing maps of materials would make a list of vernacular regions untenably large. And, although a map of timber resources and a map of soil conditions (which could be used to denote the availability of clays and stone) are available from the United Nations Food and Agriculture Organization, no world-wide mapping of indigenous building materials was identified. Thus, this study focuses on a regionalization of vernacular architecture based on climate, cultural heritage and continent, with a goal of creating a manageable number of vernacular regions (e.g., 100) that can be explored by a limited number of researchers over a limited time-frame.

2.1. Mapping climate zones

Mapping climate zones is no trivial exercise. Much work continues to be put into classifying the earth's locations based on weather. German climatologist Wladimir Köppen (1846–1940) developed a classification system that is generally accepted as the most accurate method of mapping world climates. It includes 14 zones separated by temperature and humidity. However, the Köppen climate zone map was found to be considerably complex for the purpose of this research and a simplified map based on the Köppen climate classification system developed by de Dear [6] was chosen (Fig. 1). The de Dear map combines tundra and ice cap regions, as well as some arid and semi-arid, and some tropical and sub-tropical locations. The de Dear map was thought to be an acceptable compromise, especially considering its use was accepted in a 1997 ASHRAE (The American Society of Heating, Refrigerating and Air-conditioning Engineers) study entitled *Developing an Adaptive Model of Thermal Comfort and Preference* [6]. It would be ideal to utilize a simplified world map with ASHRAE climate zone definitions, upon which the IECC was developed. Unfortunately, none was found to exist.

2.2. Mapping cultural heritages

Given the migration of peoples and the temporal nature of national borders, the question arises of how to map cultural heritages. A relatively accurate method generally accepted by anthropologists is the tracing of language families. A language family is a grouping of languages based on linguistic similarities. While religions, geographic locations, regional languages and even skin color change within a related people, basic language traits

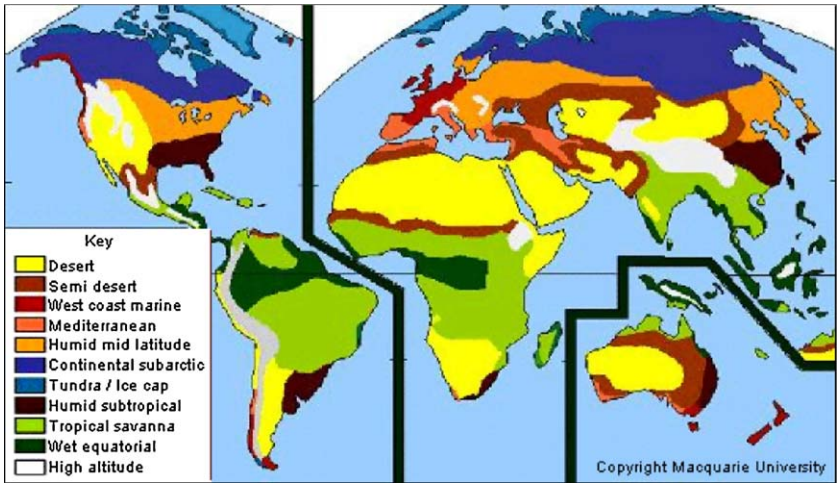

Fig. 1. A simplified map of world climates [6].