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How Historical Solutions to Thermal Comfort Influenced Modern Construction Efforts

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Abstract

This paper explores the history behind the international movement for greater climate control and how this progression has influenced modern green building technology. From Greek Hypocaust systems to Mexican pueblos, many cultures have succeeded in manipulating their built environment. How have these seemingly simple concepts transformed modern society and the building industry as a whole? What lessons in geographical adaptive architecture have been overlooked in our desire to control our environment? How can these concepts be applied to modern technology to create a more sustainable construction infrastructure? These questions are explored to provide a greater understanding of how trends toward isolated control are exponential in relative cost and energy use. The future of climate manipulation is hypothesized to be in a mélange of historical precedents and modern technology, interwoven to create comfortable but innovative solutions that require less work, money, and energy.

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Introduction

Seeking shelter is an attempt to control the influence of factors such as dynamic weather conditions or danger from other animals. Shelter is also more peripheral and includes rational such as creating a community bond and storing precious goods. Wolves, bears, and early man dwelled in caves. Then fire was invented and the smoke caused man to build a cave that would vent the smoke but retain the heat. This is the first and instance where man manipulated his environment and attempted to regulate his comfort. Following this seminal moment in our species history, man has attempted, with varying degrees of success, to improve upon his surroundings. Traditionally, environmental comfort in the sense discussed here is defined on two axes: humidity and temperature. They have a complicated relationship and as shown later are difficult to manage simultaneously. Our history is riddled with failed attempts at stabilizing both factors but this paper will mainly highlight the successful attempts and draw the conclusion that as technology advances we create more variables that need consideration. Thus, instead of creating habitable spaces, we create new problems and new issues arise. These factors increase cost, energy, and construction time. Through our desire to sustain our planets resources, we have taken a closer look at the building construction and maintenance process. Indoor environmental quality is a strain on modern energy resources and when we transpose historical techniques for temperature and humidity control onto modern building and material technology, we find improved efficiency.

Background of Historical Thermal Comfort Solutions

The story behind the advent of the modern HVAC system is an evaded but interesting topic that must be explored further in order to draw a conclusion between energy use and thermal comfort. Below is a simple review of the most influential inventions and adaptive solutions for climate control through human history. Looking back across these discoveries, one can easily see the patterns that have shaped the systems predominantly used today. The term HVAC is an acronym for heating, ventilation and air conditioning, which is a composite of the main functions, which contribute to our thermal comfort. Today, there are a few types of HVAC composite systems that have dominated the market and they are divided into commercial or residential use. Both applications typically use mechanical systems that are designed to isolate and control the thermal and humidity qualities of a space. How did these systems develop? How did the Greeks, Egyptians, and early American Settlers tackle the thermal comfort issue? What events in history helped define HVAC and what are the other methods prevailed?

Human civilization is known as originating in the Indus Valley which is located between North East Africa and South West Asia. The climate here is hot and dry making a relatively comfortable climate at which humanity can survive. However, as one travels North or South, the cold becomes a mortal barrier. Thus, for nomadic reasons, fire prevailed as the impetus for heating. The inventions that

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follow all surround the efficiency, control, and malleability of fire as a heat source. Subsequently, as mortality became less of a critical issue, comfort reigned. History tells of a civilization that began to seek a stable humidity and temperature to create thermal comfort. From this desire stemmed chilled air and then progressively conditioned air.

Brazier

One of the devices to control fire for heating is known as a Brazier, a Hebrew word originating from the Egyptian word 'Ach. Braziers have been discovered in archeological excavations like the Nimrud brazier which is now housed at the Iraqi National Museum that dates back to 824 BCE [1]. A brazier was merely a fire box, first made from dense wood and later from porcelains and metals. The box kept hot coals from a fire pit and holes on all sides to maximize heat while minimizing smoke. They typically had a handle to hang on doors or legs to sit on the floor. People would carry them from room to room, taking the heat with them as they moved.

The Qin Dynasty was the ruling dynasty from 221 BC through 206 BC and is most well-known for starting construction on the Northern Border (Great Wall). They are lesser known for their infiltration of Bizhao, a type of wall furnace that was the prominent heating device used by common village people in their homes. The Bizhao is essentially a brazier; the knowledge was thought to be distributed through the great trade route through Siberia. The connection shows how important a role heating was to early civilizations. Ancient China was advanced in the manufacturing of iron and developed several types of braziers: the Huotang 火塘 (fire pool), Huoqiang 火墙 (fire wall), Bizhao 壁炉 (wall brazier) and Luzhao 炉灶 (standard brazier) [2]. They generally used woods and charcoals for heating. In Japan, the Hibachi was similar to a brazier. They were predominant in Japan from 798-1185 AD as they were made of either carved out wood or porcelain as metal was scarce in the region.

Rammed Earth

"Evidence of the early use of rammed earth as been seen in Neolithic archaeological sites of the Yangshao culture and the Longshan culture in China along the Yellow River dating back to 5000 BCE. By 2000 BCE, the use of rammed earth architectural techniques was commonly used for walls and foundations in Chin" [3]. Rammed earth is a building technique for the construction of walls using the raw materials of earth, chalk, lime and gravel. It is an ancient building method that has seen a revival in recent years (in America mainly due to Department of Agriculture sponsored studies) as tenants seek more efficiency from buildings and lean toward environmental stewardship. Because of the nature of the materials used it is incombustible, thermally massive and very strong and durable. It also has the added advantage of being a simple way to construct walls. Traditionally, rammed earth buildings are common in regions where wood is in scarce supply.

Figure 1 shows the construction of a rammed earth wall. Formwork is set up creating the desired shape of the section of wall. The material is then compacted either by hand or machine to at least half of its original height. Further layers of material are added and the process is repeated until the wall has reached the desired height. Once complete, the wall is able to stand alone. The wall will start to cure within one hour but may take up to two years to fully harden.

Figure 1: Rammed earth construction [4]