THESIS

COMPRESSED EARTH BLOCK (CEB) CONSTRUCTION:

A VIABLE BUILDING ALTERNATIVE FOR OLANCHO, HONDURAS

Submitted by

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ABSTRACT

COMPRESSED EARTH BLOCK (CEB):

A VIABLE BUILDING ALTERNATIVE FOR OLANCHO, HONDURAS

The second deadliest Atlantic hurricane on record, a category 5 Cape Verde tropical wave storm with sustained winds of 180 mph, named Hurricane Mitch, swept through the small country of Honduras in October of 1998. Across the country, the storm destroyed 33,000 houses, damaged 50,000 others, and destroyed 70-80% of the road infrastructure. Many countries and organizations responded to the immediate housing crisis to rebuild these homes in the more populated and accessible regions of Honduras. Survivors in the mountain regions, however, were left to rebuild on their own with limited resources and technology.

This study investigated 30 residents of the region of La Union de Capapan to explore their acceptance of compressed earth block as an alternative building material to more conventional building methods utilized. The researcher collected participant responses through a convenience-sample questionnaire to determine attitudes, perceptions and knowledge of earth building techniques. Through this qualitative study it was expected that a theory about material selection, preferred building methods and attitudes towards them would emerge.

The results indicated the majority of the survey population was receptive to CEB as an alternative method to current building practices and further expressed interest in learning more about this technology. A valid point has been made that earth construction done properly would be a viable building method in any culture for any economic class (Zumi, 2010).

ACKNOWLEDGEMENTS

This thesis was made possible by the permission of the Predisan Medical Mission Organization and community leaders of Capapan, Honduras. Its contents are solely the responsibility of the author and do not necessarily represent the views of the Predisan organization.

DEDICATION

This thesis is dedicated to the staff of Predisan and their tireless efforts to provide health care and a better quality of life for the residents in the region of Capapan.

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DEFINITION OF TERMS

ATTITUDE: Manner, disposition, feeling, position, etc. with regard to a thing, tendency or orientation especially of the mind towards a thing. (Webster, ISBN 1-56619-147-5, Random House Value Publishing Inc. 1994).

COMPRESSED EARTH BLOCK (CEB): One of three types of earth building (mud or adobe, rammed earth, and earth block) created by pressing earth into steel, wood or aluminum forms by hand or mechanical compaction. Various agents such as concrete, pot ash, or native site materials can be added to these earth mixes to increase strength and durability. The process involves working dirt through a screen to remove rocks and break up existing clay. Block size and shape are determined by the form. The cured blocks are lain much like brick. (Snell, 2012) (Appendix D and E).

SOCIAL CONSTRUCTIVISM: A sociological theory of knowledge that applies the general philosophical constructivism into social settings, wherein groups construct knowledge for one another, collaboratively creating a small culture of shared artifacts with shared meanings. When one is immersed within a culture of this sort, one is learning all the time about how to be a part of that culture on many levels. Its origins are largely attributed to Lev Vygotski. en.m.wikipedia.org.

KNOWLEDGE: Acquaintance with facts, truths, or principles, familiarity or conversance, as with a particular subject, i.e. compressed earth block. (Webster, ISBN 1-56619-147-5, Random House Value Publishing, Inc. 1994).

PERCEPTION: The act or faculty of apprehending by means of the senses or of the mind, cognitive understanding. (Webster, ISBN 1-56619-147-5, Random House Value Publishing, Inc. 1994

CHAPTER 1 – INTRODUCTION

The second deadliest Atlantic hurricane on record, a Category 5 Cape Verde tropical wave storm with sustained winds of 180mph, named Hurricane Mitch, swept through the small country of Honduras in October 1998, killing an estimated 7,000 people. The infrastructure of the entire country suffered enormously with 70-80% of the transportation system destroyed, including nearly all bridges and secondary roads; the road damage was so great that existing maps of the road system were rendered obsolete (National Climate Data Center, 2004). Across the country, the storm destroyed 33,000 houses and damaged 50,000 others (Stormcarib, 2006). Flooding and mudslides left 1.5 million people homeless, 20% of the country's population (Thompson, 2008). Many homeless conditions still exist in the remote mountain regions of the country as this research effort gets underway. Many countries and organizations responded to the immediate housing crisis with financial support and preassembled housing components to meet these needs in the more populated and accessible regions of Honduras. Survivors in the mountain regions throughout the country were left to rebuild on their own, with limited resources, and limited access due to the decimated road systems.

The predominant reconstruction technology utilized conventional concrete CMU block construction materials typical in more densely populated regions throughout Honduras. Though these materials were readily available, they presented insurmountable financial hurdles to the country's poorer classes with limited incomes. Transportation challenges further compounded the difficulty of individuals to acquire building materials. While the use of CMU's effectively addressed housing needs quickly in the plains regions which were more accessible, many mountain communities still suffer homeless conditions and inadequate housing now 16 years after the storm event (Stormcarib, 2006). Many of these mountain communities are extremely remote making delivery of outside materials virtually impossible. Entry points into these regions consist of destroyed or unmaintained roads, often

limiting transportation options to foot or horse travel. When this becomes the only means of access, transportation of building materials becomes a labor-intensive, time- consuming effort, with economic challenges that can only be met by a limited few. Recent drug and territorial violence further complicates safety of residents and material transport into the mountains.

An alternative building material proposed for this region for house construction that may significantly lessen the transportation challenges and financial hardships is compressed earth block (CEB). It is the goal of this study to explore the acceptance CEB in these mountain regions as a viable building material incorporating local resources to reduce material and transportation costs for reconstruction of homes. A supporting objective is to identify the attitudes, perceptions, and knowledge of the La Capapan de Union residents of CEB technology. The community selected is representative of many mountain communities within the district of Olancho, Honduras in need of home reconstruction. In these communities, residents have limited resources to purchase outside materials. By gaining a greater understanding of acceptance toward this technology and identifying attitudes, perceptions, and knowledge toward its use, recommendations can be made regarding the suitability of this technology for Capapan, similar regions throughout Honduras, and possibly other parts of the world. Once general acceptance and favorable attitudes are determined, ongoing research should be conducted to identify educational and training strategies for local residents. Analysis of regional soils is an anticipated need in future studies to determine its suitability for use in this approach, as well as available stabilizing materials that may be necessary to construct durable block.

Research Context

Earth has been used in the construction of shelters for thousands of years and approximately 30% of the world's population still lives in earth structures (Cofferman, 1990). Data from the U.S. Geological Survey show that 65-70% of the soil present on the earth's surface can be used to make

compressed earth block (CEB). Previous trips to Honduras over the past 16 years by the researcher have identified evidence of earth construction techniques. Adobe brick construction is common in many parts of the country where abundant clay and water resources are present. Although this is a viable method, it requires the bricks to be fired or dried and then transported to their final destination. In contrast, one of the advantages of CEB technology is the use of indigenous materials and cheap local labor, which translates into reduced construction costs (Benge, 1999).

Another significant benefit for this region is the high fire-resistant characteristics of CEB construction. Forests have been removed through slash and burn agricultural practices to create planting fields for corn, beans and yucca crops. Fires are often left to burn out on their own, creating fire hazards to any structures in the region. Honduras is also a wet, tropical climate and CEB technology offers the ability to moderate humidity within the structure and provide a cool, quiet interior (Hodson, 2006). Housing design is also a very personal choice (Tibbets 1998) and offers the observation that block construction can be deployed in many types of curves and shapes, thus allowing a more artistic element than its rammed earth counterpart. CEB construction is one of three types of earth building (mud or adobe, rammed, and earth block) created by pressing earth into steel, wood, or aluminum forms by hand or mechanical compaction (Snell, 2012). CEB is a simple technology that can be taught to local residents allowing them the opportunity to build their own homes, in a convenient time frame utilizing materials from the existing site, eliminating the need for expensive imported materials.

In a 2010 visit, community leaders in La Capapan de Union expressed interest in learning more about CEB technology and its use for the construction of homes in their community. Health care providers to this region are interested in solutions for home construction that address the Chagas disease caused by the triatomine insect which dwells in the wall cavity of living environments constructed of thatch, wad and dab, adobe or rustic lath. Accessible construction units made from local materials, which are more densely compacted and incorporated with a methodology to provide

permanent dwellings, are one of the methods offering solutions to eradicate this disease and provide a healthier environment for this community and individual families in the region (See Appendix A).

Statement of the Problem

Many homes in the community of La Capapan de Union were damaged or destroyed by Hurricane Mitch in 1998 and remain in disrepair due to the lack of economic resources and undeveloped or damaged road access into this region. Some residents have resorted to temporary structures made of wad and dab, wood lath, banana branches and various types of vegetation. Adobe structures are also common in the region. In some cases cement block is being made manually block by block with a steel block form and stockpiled for future use; it takes approximately eight hours to produce 30 blocks in this manner. Can on-site earth materials be used to rebuild these homes in a timelier manner, providing a more permanent shelter, with potential to eliminate material transportation issues? It will be important to determine whether this community will accept the CEB technology as a viable alternative building practice, and what barriers may need to be overcome to allow its implementation.

Purpose of the Study

The purpose of this qualitative study is to explore the acceptance of compressed earth block as a viable building alternative to current building practices, by identifying the attitudes, perceptions, and knowledge of the residents of La Capapan de Union toward CEB technology.

Rational/Justification/Significance

The research topic is important to the construction industry, to residents of La Capapan de Union and other regions of Honduras, to housing relief workers around the world engaged in providing housing solutions for the world's poor, and to the researcher personally. The need for affordable, sustainable housing for many cultures continues to present unrelenting challenges to governments of developing countries and their people. New developments in construction materials and methods need to be shared at a global level to provide solutions that are accepted and embraced by their intended

recipients. Culturally embedded building practices need to be periodically assessed and recalibrated to improve their efficiency, viability, sustainability, and economic impact. Technological advances and methods that improve current practices should be considered and implemented when feasible. Despite a number of studies that clearly identify the technical aspects of compressed block construction (Nelson, 2006; Christensen, 2008; Keable, 1996; Norton, 1997; Saxton, 1995; Maniatidis & Walker, 2003; Minke, 2000), appropriate soil stabilization methods (Hammond, 1973; Ngowi, 1997; Kateregga, 1983; Collet, 2006; Ozkan, 1995; Binici, 2005) and durable block construction (Walker, 2000; Shihata & Baghdadi, 2001; Keable, 1994; Jones, 2000; Benge, 1999; McHenry, 1984; Easton,1996) that have successfully been implemented in various countries throughout the world, few studies exist that identify attitudes and acceptance of potential users of this technology. Graphs depicting summary recommendations for materials from various studies are shown in Figures 1and 2. The lower range limits of desirable sizes of clay, silt, sand and gravel are noted in Figure 1, (Maniatidis & Walker, 2003). The upper range limits of the same materials noted above are listed in Figure 2, (Maniatidis & Walker, 2003). These ranges are assumed to be similar for compressed earth block, and would need to be researched in future studies.

This information was of value for this study for the construction of samples for participants to comment on, touch and interact with, but this is not the focus of this study. Of particular interest to this research effort is a study done in Zambia (Baiche, 2008) that has provided foundational information identifying attitudes and perceptions that may be relevant to the research study in Honduras. This particular study summarizes barriers that need to be overcome in order to implement the use of compressed earth block in Zambia, and further details attitudes toward the use of compressed earth block. The Zambia study will be covered in detail in Chapter 2 – Literature Review.

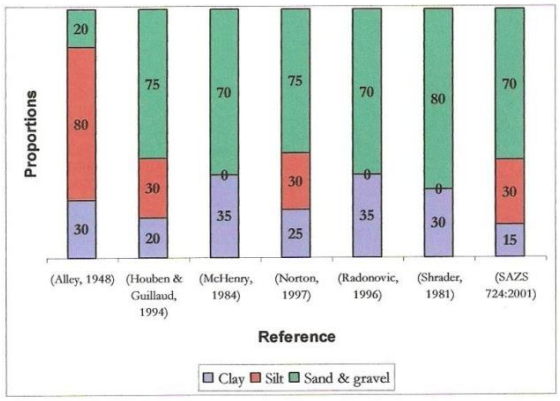

Figure 1: Lower Range Limits of Particles

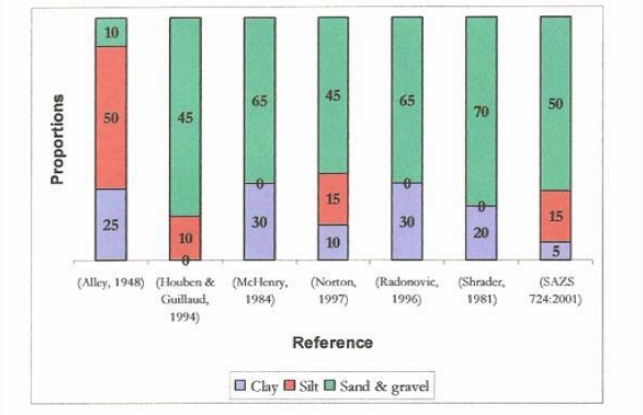

Figure 2: Upper Range Limits of Particles

The researcher is a graduate student in the Department of Construction Management at Colorado State University. A hunch driving this study is that introduction of different building practices into an existing cultural setting should be studied to determine acceptance of that technology by its intended users before it can be successfully implemented and embraced. Attitudes, perceptions, and knowledge of new practices will be fundamental elements in helping to determine the level of acceptance by the population involved in this study. This information may then be used to develop specific design criteria, training programs and building practices with an end goal of improving housing and economic circumstances for the people who would eventually occupy these structures. This study was guided by literature and research on compressed earth block technology, and its use and acceptance in various cultural settings.

Research Questions

This study will address the following central research questions:

1. What are the attitudes, perceptions, and knowledge of the residents of La Capapan de Union (LCDU) toward compressed earth block (CEB) construction?
2. Do the residents of LCDU support the use of CEB as an acceptable alternative building practice and a viable improvement to current building methods?

To answer these research questions, a convenience sample of 30 residents of the community were asked to respond to the following questions:

1. What building materials were used to construct your current home?
2. Why do you think these materials were selected?
3. How were these materials transported to your site?
4. What was the length of time it took to procure the materials for your building project?
5. What was the primary reason for choosing the materials used to build your current home?
6. What are three important factors concerning the construction of a home you would build in the region?
7. What knowledge do you have of compressed earth being used as a building material for a home?
8. Do you think compressed earth would make a durable building material for a home?
9. What is the main reason you think compressed earth would make a durable building material for your climate?
10. Do you think it would withstand a storm event like Hurricane Mitch?
11. Would you consider living in a house made of compressed earth as an alternative to other materials currently available? Why or why not?
12. Would you have an interest in learning more about compressed earth being used as a method for building a house?
13. Would you be interested in seeing or handling a sample of this product? Why or why not?

Limitations

Limitations for this study were identified as follows:

1. Participants in the study make up a convenience sample of residents of La Capapan de Union that have agreed to participate in the study and were not randomly selected.
2. The questionnaire instrument used in the study will be administered in face-to-face interviews at the homes of the participants, involving the participant, the researcher, Predisan volunteers assisting the research team and a language interpreter.
3. The success of the interviews conducted is dependent upon the interviewing skills of the researcher (IDRC, 2007), pre interview training of the Predisan volunteers, and those of the language interpreter assisting in the interviews.

Delimitations

Delimitations for the study are identified as follows:

1. Participants in the study are current residents of La Capapan de Union that agreed to participate in the study. All participants live in the selected community located in the Olancho district of Honduras, Central America.
2. This study will not seek to identify whether the soils in this selected area are appropriate for compressed earth block construction.
3. This study will not seek to identify available or appropriate stabilizing methods necessary for construction of durable earth blocks in this climate.
4. This study will not seek to identify design criteria, training programs, or educational opportunities for implementation or construction.

Assumptions

Exploring the acceptance of alternative building practices and attitudes towards this technology is a necessary step in successfully implementing it as a building alternative by the people of this region. Other identified assumptions for the study are as follows:

1. The review of the literature pertaining to the subject matter and research effort will be accurate and complete.
2. The participants in the study will be effective in addressing the research questions because they live in the community selected for the study.
3. The responses to the questionnaire by the participants will be accurate and honest.
4. The qualitative sample taken is a representative sample of the population.
5. Through contacts developed on previous trips, permission to interview residents within the site selected will be granted to the researcher, volunteer members of the research team, and interpreters conducting the interview portion of this study.

Summary

The research questions attempt to clarify the selected community's acceptance of this technology compared to current means and methods employed. By gaining understanding of the general acceptance and identifying attitudes, perceptions, and knowledge of this method, future recommendations may be made for possible implementation of CEB technology as a viable building alternative to existing cultural practices in this region. Chapter 2 will provide the literature review that supports the rationale and basis for the study. Figures 3-6 are included in this introduction for reference and provide a general illustration and clarification of how the process of manufacturing and construction of CEB may be considered in the future. Additional photos of CEB buildings are located in Appendix C. A proposed manual block press for use in future studies for block production is shown in Figure 3. This type of machine would lend itself to portability in the mountainous region of Capapan.

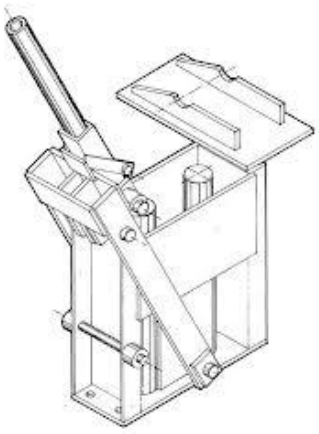

Figure 3: CETA Ram Manual Block Machine

Figure 4 illustrates the use of a CETA RAM manual block machine during field production of a compressed earth block, utilizing on-site materials with approximately six per cent Portland cement and water added. Consistency of the soil mixes will need to be determined in future studies to identify appropriate mixes for Capapan.

Figure 4: Preparation of typical earth block mix

Figure 5 provides an illustration of a compressed earth block wall. Blocks may be connected with a layer of mortar between the blocks, which consists of Portland cement and/or clay, or they can simply be dry-stacked.

Figure 5: Compressed earth block wall under construction

Figure 6 illustrates a completed structure built with compressed earth block, including clay exterior finishes and metal roof system. In this photograph, the building was constructed on a shallow concrete foundation. Many adobe structures in the Capapan area of study use a rubble foundation overlain with Portland cement. Some version of this may be utilized for construction of homes in Capapan.

Figure 6: Compressed earth block structure

CHAPTER 2 - REVIEW OF RELATED LITERATURE AND RESEARCH

Speaking from personal building experience, some of the motivating factors for change in building practices and methodology may center on issues as simple as availability of materials, their affordability, personal likes or dislikes of available materials, and maybe even aesthetics. Recent considerations by US homebuyers have included a desire to decrease the environmental impact of the building footprint or a particular material's useful life over time. Would any of these factors be applicable to the study population engaged in this research effort? What factors might impact the decision making process if you are poor and have limited choices due to circumstances or resources? Answers to these questions and others like them are yet to be determined. This study explores the acceptance of CEB as an alternative building practice to take advantage of on-site materials that could eliminate material transport issues over inaccessible terrain and relieve dependence on outside support in remote regions that have hampered the rebuilding efforts in the community of La Capapan de Union caused by Hurricane Mitch in 1998.

Relevant Case Studies

One component of the building process is a proactive consideration of how different building methods or techniques may be received by the intended users. Identifying current knowledge of the proposed methods and assessing acceptance of these methods seems crucial to successful implementation and long term use. For this study literature and research findings that examined the viability of earth construction as a building material and technique for urban housing in Zambia (Baiche, 2008), were reviewed. In that study specific attitudes and barriers towards the use of CEB construction were identified that had to be addressed and overcome for successful implementation. Details of this study will be discussed later in this chapter.

Another key study identified a widespread social-cultural perception that modern building techniques and materials are substantially better than older or traditional methods (Sojkowski, 2002), and that earth materials and techniques are perceived as temporary, "substandard" and "second class". Modern materials were seen as civilized or a symbol of affluence. Sojkowski asked why this perception prevailed and determined that missionaries and colonists who came to this region built in a style that reflected wealth and power. He states, "The Zambian people may have become convinced that having expensive imported materials were a status symbol and that vernacular styles using native materials were substandard." Research among the rural population selected in Honduras is necessary to determine if this perception is shared by this culture and if CEB would be considered a viable alternative in this region of Honduras by these homeowners. A similar study in Nigeria (Olotuah, 2002) explored the affordability of earth construction using on-site materials as a solution to low-cost housing. Specific attitudes and acceptance were not addressed in this study, although on-site materials were determined to be a viable material solution that was economical. Another review of CEB as an alternative building material reported stabilized earth blocks successfully being used in low income housing in Sudan (Adam & Agib, 2001) but user's attitudes and perceptions were not recorded.

The potential for earth building in Botswana has also been studied, with the aim of developing suitable soil mixes, block mixes, mixing methods, stabilization, strengthening, and transport methods. The study encouraged earth block use for housing in Botswana, Nambia, and Zimbabwe given the similarity of their soils (Longfoot, 2003). Acceptance and attitudes toward its use were not explored. A pilot project on earth architecture (CRA Terre, 2005) was undertaken in Uganda to promote traditional earth building. The study identified several barriers to earth building and suggested some of these barriers could be overcome by promoting earth building for low cost housing in Zambian urban areas. Barriers cited in this study included the need for new legislation addressing earth construction, the lack of building standards to govern the quality of work, the need of public awareness of the sustainability of

earth construction, maintenance issues, poor aesthetics caused by the lack of proper care and protection from the elements, and need for more knowledge sharing among practitioners.

For Honduras to benefit from these research studies there is a need to investigate and assess acceptance, attitudes, perceptions, and knowledge of end users towards earth building as it pertains to their culture. Earth as a building material and technique has the potential to offer a viable alternative that may effectively provide affordable, sustainable housing for remote communities in Honduras. Acceptance needs to be determined before earth buildings may be embraced by the people of this region. Perceptions and barriers may be similar to those encountered by earth constructors in the African countries of Botswana, Nambia, Zimbabwe, Uganda, and Zambia (Baiche, 2008).

In the study involving these African countries, Baiche (2008) utilized surveys and interviewed ten residents living in rural earth-constructed dwellings regarding five key issues using earth technology which included: (1) affordability, (2) durability, (3) living conditions, (4) aesthetics, and (5) general performance between living in an earth dwelling or a home constructed with more modern materials. He also interviewed ten residents living in an urban setting in homes built with more modern materials regarding the same key issues. He then randomly distributed sixty questionnaires to contractors and designers identifying the same key issues to determine their attitudes toward earth construction and whether they would support and promote the use of earth in their design and building practices.

Findings revealed all resident interviewees confided that earth dwellings were very comfortable compared to houses built with conventional materials. A total of 50% stated their houses were durable lasting more than 20 years, and 50% reported a dwelling life span of less than ten years, requiring regular maintenance exacerbated by two major problems: (1) rain water washing away walls and foundations of the house, and (2) termite damage. Eight out of ten interviewees confided that their earth dwellings were very comfortable and provided a very good thermal environment. These eight added that when a house was roofed with thatch it was even more comfortable, and provided a well-

humidified and thermally-regulated interior. The two negative responses cited hot temperatures in the summer and cold temperatures in the winter. The researcher determined these conditions were caused by the use of corrugated iron sheet roofs and the absence of interior ceilings in these dwellings. Heat transmission in these cases was excessive, creating an uncomfortable environment in winter and summer. The researcher found no consensus on aesthetics with four out of ten disliking the appearance, two indifferent, and four liking the different color effects of the clay as a façade finish. The researcher also reported if given enough financial resources, seven out of the ten interviewees would choose to live in something other than an earth house. Perceptions cited that their culture associated these dwellings with poverty and low social class. This study noted that a third of the residents agreed that they would live in earth houses provided construction methods and exterior finishes were improved. In addition to the rural interviewees, ten people living in urban conventional medium to high cost houses were asked if they would buy or rent an earth dwelling. All urban interviewees gave negative responses citing these types of homes being a symbol of low social status, unattractive in appearance, a lack of durability due to poor design and lack of construction standards.

The questionnaire utilized in the same study identified nine factors influencing potential specification of earth construction and thirteen barriers that impeded the use of earth in the Zambia construction industry. Respondents were asked to rate a range of criteria for potential specification and selection of earth as building material in their projects against a five-point Likert scale. The nine factors influencing potential specification shown in Figure 7 indicate material cost ranked highest (4.58), followed by availability (4.37) and workability (4.11) as factors supporting the use of earth in housing construction. Respondents were also asked to rate a number of limiting factors that impede the use of earth as a building material. According to Figure 8, the majority (69%) strongly believed that structural weakness (mean value of 4.50) was the key constraint in specifying earth in their projects, followed closely by lack of interest by clients with a mean value of 4.31. Lack of technical knowledge (mean value

of 3.50) and perception of earth as not suitable in up-market developments are also critical barriers. Poor water resistance and unattractive appearance were cited as additional impediments to its wider use.

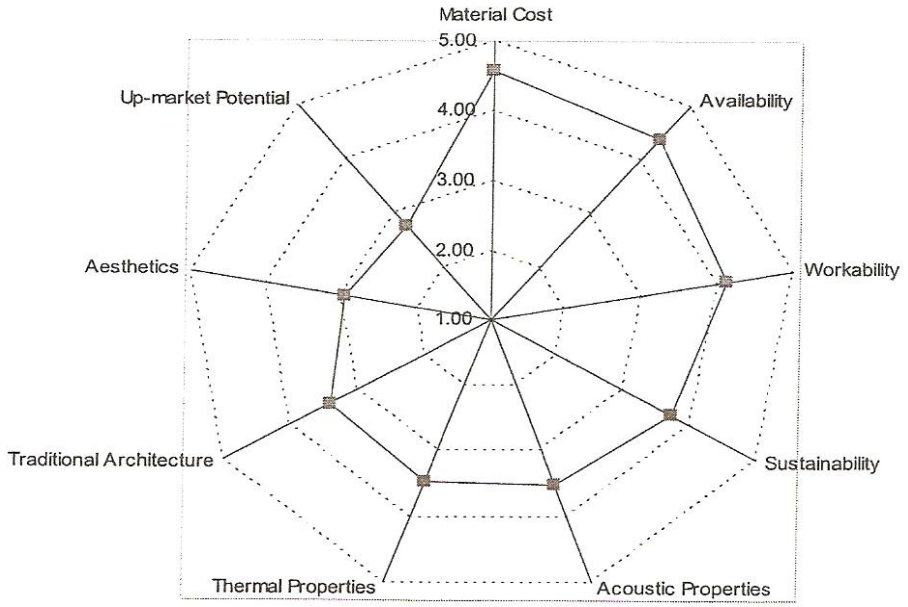

Figure 7: Factors influencing potential specifications of earth in the Zambian construction industry

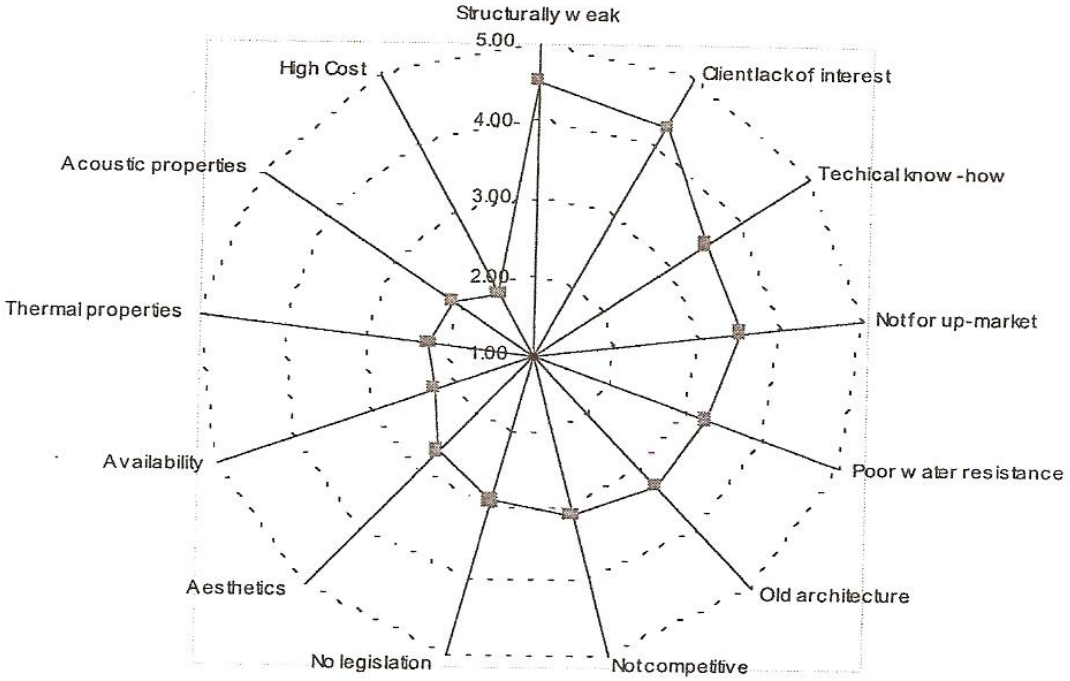

Figure 8: Barriers to earth construction in Zambia

Literature review findings concluded that earth buildings offer good interior conditions, maintained pleasant thermal comfort, and would be affordable by the majority of the poor in both a rural and urban setting. Building professionals saw it as cost effective, available, having a positive impact on the environment and an efficient use of available resources. The major barriers included a lack of codes and standards or government initiatives to utilize the technology, a need to correct the technical and performance limitations of the technology, and poor aesthetics due to poor maintenance on the part of the homeowner. Related studies done in Zambia noted that current building codes and regulations favor conventional building methods over earth building (Mususa and Wood, 2004), and that vernacular construction methods and materials are not promoted or supported (Tyrell, 1996) due to perceived inferior quality of materials. An expert in a related study argued that earthen architecture and construction should be taken more seriously with the technology not just considered as a low cost alternative for the urban poor but as an alternative for both the rich and the poor to consider (Zumi, 2010).

Summary

It is interesting to note that the African studies deal with a population that is transitioning from rural living to a more urban setting. This raises yet another question to ponder. To what extent were their attitudes and perceptions influenced by the conditions of their previous environment now framed in a new urban context? The population in La Capapan de Union lives in a very remote area with many residents traveling less than 10 miles from where they were born in their lifetime. Many will remain in this rural context for their entire lifespan. Will this isolation have an impact on their perception and acceptance of a new building technology like compressed earth block? If they don't have anything to compare their current living conditions to, will that impact their attitudes and acceptance of anything new as a viable alternative to their current building practices?

When the Cave of the Skulls National Park was established in Honduras in 2002, an area within 20 miles of the research site, many of the park's buildings were constructed with vernacular construction technology that included compressed earth block and native stone. Although not widely used, why was this method chosen over the more common cement block technology? A similar observation was made regarding Zambian vernacular structures being constructed in game parks as lodging for tourists instead of using more modern materials (Sojkowski, 2002). Sojkowski (2002) further notes the irony of these structures being built for the benefit of tourists and not the native people. He concludes that if people can be reassured about the beauty and quality of their vernacular styles, he believes a positive shift can take place toward more traditional building practices. A valid point has been made that earth construction done properly would be a viable building method in any culture for any economic class (Zumi, 2010). With these thoughts and supporting research in mind, this study proceeds with the intent to add to this body of available knowledge concerning attitudes and perceptions impacting building practices within the region of La Capapan de Union.

CHAPTER 3 – METHODOLOGY

The purpose of this qualitative study is to explore the acceptance of compressed earth block (CEB) as an alternative building material to the more conventional building method of using concrete block in the mountainous region of Olancho, Honduras. The research questions guiding this research are:

(1) What are the attitudes, perceptions and knowledge of the residents of La Capapan de Union (LCDU) toward compressed earth block construction (CEB) and

(2) Do the residents of LCDU support the use of CEB as an alternative building practice and a viable improvement to current building methods?

Support in the form of assistance with access to the research population, translation of the survey instrument, and conducting the interviews was provided by Predisan, a health care provider and coordinator for community development activities in this region of Honduras. A request for waiver of consent from individual participants was granted by community leaders in Capapan, supported by Predisan, and approved by the Research Integrity and Compliance Review Office (RICRO). A letter of support from Martha Rivera, Predisan Executive Director of the organization's health care services and Community Development Support in the LCDU community since 1987, is provided in Appendix A.

The study was approached from a social constructivist worldview to better understand current LCDU building practices and how CEB technology might be applicable in this cultural setting.

Research Design

Qualitative research was the chosen method of research for this study. Qualitative research is a term used to identify several forms of inquiry that help researchers gain greater understanding and to explain the meaning of social phenomenon (Merrian, 1998). It began as one of the first forms of social studies conducted by Bronislaw Malinowski & Elton Mayo and now crosscuts many disciplines and

subject matters (Denzin, Norman, & Lincoln, 2005). The intent of qualitative research is to understand a particular social situation, event, role, group, or interaction (Locke, Spirduso, & Silverman, 1987). Qualitative research allows the researcher to come to know the reality of a situation by being there (i.e. by becoming part of the phenomenon of study, and by documenting the understanding of the situation by those engaged in it (Hathaway, 1995). Qualitative research strategies were used due to the exploratory nature of this study with respect to the attitudes of La Capapan residents towards CEB. The research team conducted the interviews during the 30-day research period. Preliminary observations and information gained from the interviews and site visits will guide future research efforts. Assessing the historical, cultural, and social elements that impact housing decisions and potential attitudes related to acceptance of CEB within this community were critical elements to be understood.

Through this qualitative study it was expected that a theory about material selection, preferred building methods and attitudes towards them would emerge as the study unfolded. The study was conducted simply to discover and understand the perspectives of the people involved. It was formulated on concepts and models from a case study conducted in Zambia (Baiche, 2008) that sought to identify attitudes and barriers to earth construction in that region. In that study residents living in rural earth-constructed dwellings were asked to rate five key construction components which were: (1) affordability, (2) durability, (3) living conditions within the structure, (4) aesthetics, and (5) general performance. Baiche (2008) also surveyed building contractors and building designers regarding the same components and nine barriers identified in the survey that may impact the use of earth construction technology. The study currently being undertaken explored what LCDU residents' attitudes and perceptions were towards earth construction, specifically CEB. It sought to identify barriers that residents have that may impede the use of CEB technology as a viable building method for their region of La Capapan de Union. Builders and designers were not interviewed as homes in this region are designed and constructed by the residents themselves. It is believed that determining the attitudes,

perceptions and barriers are the first steps in successfully implementing this new technology in this culture and thus clarifying acceptance of this building practice for this population.

Information gained primarily through interviews and personal field observation regarding attitudes, perceptions, and knowledge of CEB technology was explored to understand the level of acceptance of this alternative building material in LCDU. The questionnaire outlined in Chapter 1 was used to guide the interviews. Residents were asked to verbally respond to each question, with their responses recorded by hand. This information was transcribed verbatim. Data collected from participants was recorded in the presence of two interviewers who then compared notes. These semi-structured interviews were conducted with the selected population, first utilizing the predetermined questions mentioned in Chapter 1, followed by open-ended questions to obtain a deeper understanding of the participant's responses (Merriam, 1998). This allows the researcher and the participants to be more interactive, both influencing the other (Mertens, 1998). The structured questions were developed based on the researcher's previous experience and observations with similar populations within Honduras. These questions sought to (1) identify current building materials used, (2) why they were selected, (3) how long residents have lived in the community, (4) what their opinion was of earth being used as a building material, and (5) if they felt earth would be a viable building material in their culture and climate. Additional questions utilizing a simple "yes" or "no" response format, supplemented these questions to establish the current knowledge of CEB technology and participants' desire to learn more about its applicability and use in this environment and culture.

Research Participants

Study participants were a convenience sample of 30 families living in the community of La Capapan de Union located in the Olancho district of the country of Honduras, Central America. The study group was made up of individuals willing to participate. This is a community of 53 family units as recorded in an unofficial community health census taken by Predisan in 2008. A map indicating the

location of this community and area of study is located in Appendix B. Due to the small population in the area being studied and the uniqueness of this area, the researcher's goal was to collect responses from at least 30% of the 53 family units comprising this community.

Method of Data Collection

The primary method of data collection for this study was face-to-face interview sessions using semi-structured and open-ended questions engaging residents of LCDU. Data was collected using journal notes of interview sessions, photographs of existing building techniques, and personal observation. Demographic information collected during the interview session included: (1) length of time the resident had been in the community, (2) whether they were head of household or adult member of family, (3) male or female, (4) age, (5) how long they had lived in their current home, (6) whether they own or rent it, (7) and number of people living in the home.

Predisan employees notified residents of the opportunity to participate in advance of the interviews being conducted and only those who indicated a willingness to participate in this study were contacted for an interview. In order to facilitate the interview process, the survey forms were sent from the researcher via electronic mail to the Predisan Director, who then delivered them by vehicle or foot to their health care workers in the field for distribution and collection. The researcher arrived several days after these forms had been collected to meet with volunteers who conducted the interviews. A post-interview session was conducted with the Predisan staff to review the interview questions, interpret the results and discuss the research data collected.

Volunteers who conducted the interviews included the nurse practitioner of the community, the director of international community development, two support staff traveling with the research team, and the research assistant. The interviews were conducted in the homes of the interviewees over a 30-day period. Interviewers utilized hard-copy questionnaires and wrote responses down by hand during the interview sessions. A physical sample of the proposed building material was provided for the

interviewee to see, feel, touch, smell, and then comment on after questions were administered. Assistance of a language interpreter was available during the interview process.

Method of Data Analysis

The research team's impressions and observations during the interview played a key role in examining the data collected, as these individuals were engaged in the collection of the data. Journal notes and responses to the questions from the interviews were brought back to the States to be transcribed, reviewed and analyzed to identify the attitudes, perceptions, and knowledge of the participants towards CEB. Validating the data employed an analytical procedure to organize data collected; generate categories, themes and patterns; identify emergent hypotheses and understandings; and write a summary report of the field activities. The following procedures were utilized during the research effort:

1. *Organize the data collected*. Notes were transcribed verbatim from the participants interviewed by the research team following the interviews. Journal notes of the researcher and volunteer support that captured nonverbal communications, notable pauses, and voice inflections were included in the transcription.
2. *Generate categories, themes and patterns*. The researcher sorted the data into evident categories, attitudes, perceptions, themes and patterns. These categories, attitudes, perceptions, themes and patterns were identified by a thorough investigation of the transcribed interviews.
3. *Identify emergent hypotheses and understandings*. The researcher interpreted the data based on impressions and understanding of the responses to the interview questions and the interviewer's observations made during the interview sessions. Emergent ideas, themes, and patterns were noted when possible during the interview process and field observations. The

data was reanalyzed once it was organized to determine if new coding or alterations were necessary to clearly identify emerging hypotheses and understandings.

4. *Write a summary report*. A summary report of the organized data, the categories, themes and patterns, emerging hypotheses and understandings reflected on and captured the attitudes, perceptions and knowledge identified during the field investigation phase of this research.

Ethical Issues

In an effort to anticipate ethical concerns, the overall strategy and intent of the interview process relevant to the study was disclosed to community leaders who granted their permission to conduct interviews with the participants. This consent was established to ensure that the interviews would be carried out without harming individuals involved in the study (Marshall & Rosmann, 1999).

Validity Issues

Documentation of the time, data, location and interviewees was logged in the journal and made available with the transcribed data for review by authorized individuals engaged in the study and the participant sample. The study design and decisions concerning what information would and would not be collected or measured were determined prior to the interview process.

Research Limitations

The success of the interview process was dependent upon the interviewing skills of the interviewer, the interpreter employed to assist in the process, and Predisan volunteers. Journal entries were the primary backup for data recording and collection. Tape recordings and videos were not utilized or available in this preliminary study. Previous trips to the region provided foundational understanding of the housing needs, knowledge of the cultural setting, and level of understanding of the current building practices. Information gained through this interaction is not exhaustive.

Research Timeline

The timeline for this study began with previous trips to the region that identified the need for the research, the development of the research questions, and the request for permission from community leaders and Predisan staff to perform the research study. Interviews were conducted over a 30-day period in the community of LCDU. Results of the study, significant findings, emergent themes, recommendations for use of CEB technology in this region, and additional research opportunities were analyzed after completion of the interviews.

Summary

The methodology employed in this study was intended to gather data to help determine the attitude, perception and knowledge of the residents of LCDU. This qualitative study was formulated to explore the acceptance of CEB technology as an alternative building practice for the residents of LCDU in the Olancho region of Honduras. Attitudes, perceptions, and knowledge of the residents of La Capapan de Union may identify possible patterns, themes, and generalizations that could apply to other cultural settings. A greater understanding of current building practices, why they were adopted, and a better understanding of the potential acceptance of CEB as an alternative building practice by the participants involved in the study was gained. It was anticipated that when participants were given the opportunity to interact with CEB samples (e.g. touch, smell, and see this material), their initial attitudes and perceptions could be measured as positive or negative, providing a baseline for additional research in this community in the future. Information gained from interviews and personal observations in LCDU helped establish impressions and emergent ideas that may impact future implementation of CEB technology as a suitable building alternative for the entire Olancho region of Honduras.

CHAPTER 4 - RESULTS AND DISCUSSION

The final sample population for the study totaled 30 survey respondents consisting of 11 males and 19 females from the geographic region of Capapan, Olancho, Honduras. They were permanent residents within the region and were head of the household or an adult member of the family. Health care workers employed by Predisan conducted the surveys during their routine visits within the region through convenience sampling in the homes of the respondents.

Survey Questions Results

Each of the 30 survey respondents were asked to provide their age with responses divided into 5 categories noted: between 20 and 30, between 31 and 40, between 41 and 50, between 51 and 60, and between 61 and 90. The age of the participants was requested to determine if attitudes and perceptions toward compressed earth block would vary depending on their age. The results are shown in Table 1.

Table 1 - Age of Participants

Age	Number of Participants	Male	Female	Percentage (%)
20-30	12	3	9	40%
31-40	7	3	4	23.5%
41-50	3	0	3	10%
51-60	1	1	0	3%
61-90	7	4	4	23.5%

Participants provided the number of people living in the home, which helped to determine the population density of the participants in the survey. A total of 167 people live in the homes of the 30 survey participants. This equates to 5.56 per household. The fewest number of people living in a home

was one; the most was 10. The size of the homes occupied by participants was approximately 500 square feet, with all homes being similar in size.

Participants were asked to provide the number of years they had lived in the region of Capapan so that it might be determined if that played any role in acceptance of an alternative building method. Responses ranged from six months to 40 years. Responses were placed in four categories: between 0-10 years, 11-20 years, 21-29 years, and 30 or more years. A total of 14 respondents had moved to the Capapan after Hurricane Mitch and had lived in the region 0-10 years. Three had lived in the region between 11-20 years, six between 21-29 years, and seven had been in the region for more than 30 years. Six of the participants (20%) had lived their entire life in Capapan and all six were between the ages of 20-30 years. Of the participants in the 61-90 age group, 20% of these had lived 30 years or more of their life in Capapan. The majority of the individuals in this age group had come to the region of Capapan to escape the Contra War conflict in Nicaragua in the late 1970's (Klerlein, 2006). Fourteen participants (46.5%) had lived in the region between six months and 10 years with the largest number between the ages of 20-30 (16.5%) and 31-40 (20%). The Honduran government has provided an opportunity for individuals to homestead land east of Capapan and some of these individuals had come to the region to pursue that opportunity.

Question #1 asked what building materials were used to construct the home in which they lived. Four categories were mentioned by the participants, which included adobe, wood, brick, and cement block. The number of responses for each category included 22 stating adobe, three wood, two fired brick, and three stating cement block.

Table 2 summarizes question #2 requesting why participants thought these materials were selected. The number of responses supporting a particular material and quality of that material are also noted. Economy was identified as the primary reason for selection, amounting to 46.5%.

Table 2 - Reason for Selecting Existing Home Materials

Type of Material	Quality of Material Mentioned	Number of Responses	Percentage (%)
Adobe	Economical	14	46.5%
Adobe	Aesthetic appeal	5	16.5%
Adobe	Easy to acquire	5	16.5%
Wood	Easy to acquire	1	3 .5%
Cement block	Strong	5	16.5%

Question #3 asked participants how building materials were transported to their site. The primary means of material transportation to the site was by foot or on horseback. Fifteen of the participants (50%) stated that their selected material that was obtained locally to build their houses was adobe. One participant personally harvested wood to build his house. Eight of the participants (26.5%) obtained cement blocks and fired adobe bricks from the community of Catacamas, a four-hour drive into the Capapan region, placing a significant hardship on residents. Six participants were renting a house or had bought a home previously built and were uncertain about the transportation of materials.

Table 3 - How Materials Were Transported

Origin of Material	Transportation Method	Number of Responses	Percentage
Made locally	Foot or horseback	15	50%
Harvested locally	Foot or horseback	1	3.5%
Outside region	Trucked from outside of region	8	26.5%
Did not know	Did not know	6	20%

Question #4 asked participants the length of time it took to procure the materials for their building project. Table 4 summarizes the four categories identified by participants and the number of

responses for each time period given. Six participants did not know the length of time required to procure the materials; these participants were renting the house or had bought the house pre-built.

Table 4 - Length of Time to Procure Materials

Time To Procure Materials	Number of Responses	Percentage
Less than a month	4	13%
1 month	10	33%
2 months	8	27%
3 months or more	2	7%
Did not know	6	20%

Question #5 explored the primary reason participants chose the material selected to build their current home. Answers given were placed in five categories noted in Table 5. The number of respondents in each category and percentage responding to a specific category are summarized in Table 5. Six respondents did not know why the materials were chosen because they were renting the house or had purchased the home already built. The ease of acquiring a material (n=10, 33.5%) and its economic value (n=9, 30%) surfaced as the top two reasons for material selection.

Table 5 - Primary Reason for Material Selection

Primary Reason	Number of Responses	Percentage (%)
Easy to Acquire	10	33.5%
Economical	9	30%
Strong	4	13.5%
Durable	1	3.5%
Not involved in Construction	6	20%

Question #6 requested the three most important factors to the participant for building a home in the region and they are summarized in Table 6. The top three factors identified by the participants for building a home in the area were to be close to a school (n=27, 90%), close to work (n=23, 76.5%), and close to the health center (n=8, 26.5%).

Table 6 - Three Most Important Factors for Building a Home

Factors for Building a Home	Number of responses	Percentage (%)
Close to School	27	90%
Close to Work	23	76.5%
Close to Health Center	8	26.5%
Safe place to live	4	13%
Close to clean water	2	6%
Close to community	2	6%
Close to Family	2	6%

Question #7 asked if the participants had any previous knowledge of compressed earth being used as a building material. Table 7 summarizes responses that all of the participants had some knowledge or experience of earth being used as a building material. Half of the participants viewed it as a strong building material, 13.5% more adding that it was durable, and 36.5% said easy to work with.

Table 7 - Previous Knowledge of Using Compressed Earth as a Building Material

Response	Number of Responses	Percentage
Strong Material	15	50%
Easy to work with	11	36.5%
Durable	4	13.5%

Question #8 asked participants if they thought compressed earth would make a durable building material for a home. The majority of the respondents (n=29, 95.5%) answered in the affirmative. One of these responders further added that earth as a building material was bullet proof. There was one negative response stating it would not be durable because it would not withstand an earthquake.

Question #9 requested the main reason participants thought compressed earth block would make a durable building material in their climate. Table 8 summaries these responses with 60% of the participants indicating that earth would provide comfort in their climate. Four participants (13.5%) thought that earth blocks would be damaged by the amount of rain received in this climate.

Table 8 - Main Reason Given for Compressed Earth Durability in Honduran Climate

Response	Reason	Number of Responses	Percentage
Good for a hot climate	Comfort	18	60%
Good material	Keeps a fresh look	8	26.5%
Not good	Broken down by rain	4	13.5%

Question #10 asked if participants thought compressed earth would withstand a storm event like Hurricane Mitch. A majority of the respondents (86.5%) answered in the affirmative. Two participants added that the houses in which they were living had been well constructed and survived the storm. One of these homes was constructed with adobe, the other with cement block. Four individuals stated that it would not be durable because their houses had been broken down or damaged by the storm. These four homes were constructed with adobe.

Question #11 asked participants if they would consider living in a home constructed of compressed earth as an alternative to other materials currently available and their reason why. Table 9 provides a summary of these responses. The main reason stated for this consideration, 63.5% of the participants, was that they viewed earth as an economical building material compared to other material

choices. Almost one-fourth (n=7, 23.5%) of the survey population preferred the aesthetics of earth compared to other materials, and 13% of the responses said earth was stronger and more durable than other materials they had used, which included wood and wad and dabble.

Table 9 - Reason for Considering Compressed Earth as an Alternative Building Method

Response	Number of Responses	Percentage (%)
Economical	19	63.5%
Aesthetics	7	23.5%
Strong/durable	4	13 %

Question #12 asked participants if they would be interested in learning more about using earth blocks as a method for building a house. A majority of the participants (n=29, 96%) indicated interest. An 85- year old participant responded that he would not be interested because of his age, further stating that the work was too hard for him now and you need to be young.

Question # 13 asked if participants would be interested in seeing or handling compressed earth block material. There were 15 participants (50%) that indicated they would like to learn more about it so that they could teach others and build their own houses better. Nine participants (30 %) stated they would like to learn how to select the correct building material and to teach their children. A majority of the survey population (80%) expressed an interest in learning more so they could teach someone else. Three participants (10%) stated they would like to learn more about it so they could start a business, either building a house for someone else or selling the material to others. Other participants stated they would like to learn more so they could build a rental house to use it as a source of income and that it would provide work. The 85-year old participant said he was not interested because of his age. Many of the reasons expressed regarding interest were unexpected such as to start a business or build a house

as a source of income. The responses stating a desire to teach the method to someone else were also unexpected.

Discussion of Results

The purpose of this study was to explore the acceptance of compressed earth block (CEB) as an alternative building material to more conventional building methods utilized in the region of Capapan. To analyze the findings the central research questions are revisited here for discussion which are:

1. What are the attitudes, perceptions and knowledge of the residents of La Capapan de Union (LCDU) of CEB construction and,
2. Do the residents of LCDU support the use of CEB as an alternative building practice and a viable improvement to current building methods?

Indicators of Attitudes, Perceptions, and Knowledge

Comments from participants identified several areas indicating an attitude, perception, or knowledge toward earth being used as a building material. Data provided in Table 2 indicates that 76.5% of the survey population had used earth materials in their building projects. Attitudes participants expressed indicated that they knew it was affordable compared to cement block and wood, and their perception was that earth buildings were more aesthetically appealing than the other two materials.

Another area noted by some participants in Table 8 in response to Question # 9 was they believed earth walls would be damaged by the amount of rain received in this climate. Question # 10 further investigated whether participants thought earth would withstand a storm event like Hurricane Mitch. The question is whether these responses were based on knowledge they had from prior experience or on perception. What did the data collected indicate? Some participants (6.5%) are living in a home that had weathered this storm without being damaged, because they perceived it to be well

constructed. Another 13.5% said their home was damaged in that event. Because these participants had personally experienced water damage to their home from Hurricane Mitch, their perception was that an earth structure would be damaged by water. Their attitude indicated the storm event had caused the damage, without commenting about how they viewed the quality of the construction of their home. The remaining 80% of the participants believed or perceived that an earth building would not be damaged. Their homes had not experienced any damage because of the storm. It is interesting to note that 50% of the participants had moved to Capapan after the storm event. These participants perceived an earth building would withstand this event even though they had not personally experienced it, at least in the region of Capapan. All the participants had some knowledge of earth being used as a building material and most (86.5%) perceived it to be a durable material that would not be damaged by water.

The concern about water damage specifically relates to the research findings identified by Baiche (2008) where poor resistance to water was cited as a barrier for implementation of this technology in Africa. Baiche's study further indicated that establishment of construction standards for builders would assist in overcoming this barrier. Participant responses in the Capapan study seem to indicate an awareness or perception of both good and bad construction techniques. There are currently no construction standards governing CEB construction this region of Honduras for homeowners or builders. The need to govern quality of work (CRA Terre, 2005) has been documented further indicating implementation of some type of construction standard may assist in overcoming this barrier in this region of Honduras.

Additional indications offered by participants of attitude or perception to earth being a durable building material for a home was that it would not be strong enough in an earthquake. This negative observation was given by one person in the sample population. It was not determined whether this individual had experienced an earthquake, or whether the home they were currently living in had

suffered damage from such an event. The majority of participants responded positively and saw earth as a durable building material for their climate. The negative perception, however, is not unfounded as Reuters (2009, May 28) and USGS (2009, May 29) sited 67 earthquakes in 2013 in Honduras. One of the largest earthquakes that may have influenced this negative perception occurred on May 28, 2009. A magnitude 7.3 earthquake, killed 5 people and destroyed 60 homes in the capital city of Tegucigalpa, located 160 miles southwest from the research site.

Further, one individual stated that an earth structure was bullet proof. It was not determined if this individual had experienced a situation that led to this response, or that their home had been fired upon. It is possible, given the current violence in the region (Taylor, 2006) that an incident involving gunfire on their home could have occurred. A bullet-proof test on a compressed earth block wall has been performed and substantiates this perception. A video documenting the test procedures is available and may be accessed as noted in Appendix D.

A final point made indicating an attitude or perception was recorded in response to question #12. This question sought to determine the desire or interest of participants to learn more about earth being used as a method for building a house. One participant, an 85-year old man, stated that he would not be interested. He perceived that he was too old for this type of work, further stating that this type of work was for the young and the strong because of the hot climate and amount of labor involved.

Table 10 provides a summary of the indicators of the attitudes, perceptions, and knowledge identified. From the interview sessions, there were five key statements of attitudes, six of perception and five indicating knowledge or experience using earth as a building material.

Table 10 - Summary of Attitudes, Perceptions and Knowledge Indicators

ATTITUDES	PERCEPTIONS	KNOWLEDGE
Economical	Bulletproof	Familiar with material
Aesthetically pleasing	Vulnerable to earthquake	Vulnerable to water damage
Easy to acquire	Durable for climate	Withstand a hurricane
Comfortable environment	Too old to learn	Locally obtainable
Strong material	Business opportunity	Easy to work with
	Provide a better home	

Participants' Desire to Learn about CEB

Responses given to question #13 was analyzed to determine whether participants were open to learning more about CEB and using it as an alternative building method to current practices. Participant responses offered some interesting reasons and some unexpected answers. An initial assumption was that Capapan residents would be interested in CEB technology to improve their current living conditions. Data collected supported this assumption, indicating that 50% of the participants wanted to learn how to build a better home for themselves. There are no building codes governing this region of Capapan so residents build what they want with resources available, learning by trial and error what works and what does not. This same group of participants also wanted to learn so they could teach others how to build more effectively. This teaching component sought by the participants was unexpected. An additional 30% of the participants stated they wanted to learn so they could teach their children how to build a better house and select the appropriate materials. This emerging theme about learning to teach others indicates a perception that knowledge is important to a majority of participants in this study, specifically

to learning about CEB technology. An interesting but unanticipated perception offered by some of the participants was that this new technology would provide a business opportunity and means of generating income.

Age as a Factor in Acceptance

The age of the participants showed no difference of attitude toward the use of compressed earth block as a building material. When asked if it would be durable for their climate 91.5% of the 20-30 age group said it would. Of the seven participants in the 31-40 age group, 86% answered affirmatively. All participants in the 41-90 age groups believed it would. When asked if it would be strong enough to withstand a storm event like Hurricane Mitch, 86% of the sample population responded positively. Of the survey population 97% said they would consider living in a home constructed of compressed earth block as an alternative to wood, adobe or cement block. Only one person had no interest in learning more about this material with age being the reason stated.

Number of Years in Community

The sample population had been in the region of Capapan from six months to 40 years. The research data collected indicated a willingness to use compressed earth block as a building material regardless of the length of time the participant had been in the community.

Perceived Durability

When participants were asked if they thought earth would make a durable building material for a home, 97% believed that it would. Of the participants, 50% stated they found it to be a strong material, 36.5% said it was easy to work with, and 13.5% considered earth as a durable material. Data collected indicated no significant difference of opinion or perception among participants as to whether earth blocks would hold up during a storm like Hurricane Mitch. The majority of the sample population lives in structures made of adobe and either had knowledge from personal experience or perceived that

that it would hold up in a hurricane. The length of time they had lived in current structures appeared to validate the positive perceptions about earth being a durable material for construction in their climate.

CHAPTER 5 – CONCLUSION

Knowledge Gained

The convenience sample of the 30 participants involved in this study were residents of the community of La Capapan de Union and their responses were viewed as representative of the community at large. A majority of the participants viewed earth blocks as a favorable alternative to other materials because of its economics or affordability (Table 9). Responses from participants indicated a preference for earth block because of its aesthetic appearance (Table 8 & Table 9), and strength and durability in their climate (Table 7). A large majority said earth blocks provided a comfortable building for their climate (Table 8). A majority obtained their building materials within the community (Table 3). It was not determined if making earth blocks as compared to buying wood or cement blocks provided an economic savings to the participant, simply that participants viewed earth blocks as an economic choice preferable to other materials such as wood or cement block. According to Table 2, the majority of responses from participants in this study showed that being able to acquire materials easily and affordably are key factors in the selection of building materials. The affordability of earth block as an alternative material identified in this study aligns with the findings in Nigeria (Olotuah, 1999) and Sudan (Adam & Agib, 2001). One of the reasons for pursuing this research study was the assumption that the material to make compressed earth block is readily available, easily accessible, affordable, and does not have to be transported to the site.

The age of the participants showed no difference of attitude toward the use of compressed earth block as a building material. There appeared to be no difference of opinion among participants regarding the durability of earth as a building material or its ability to withstand a major storm event like Hurricane Mitch. The majority of the participants said they would consider living in a home constructed of compressed earth block as an alternative to other building materials. Number of years the participant

had been in the community indicated no difference in willingness to use earth blocks as a building material.

All 30 participants in the study had some knowledge of earth being used as a building material and had utilized adobe or earth block in some type of construction project, and further viewed it as strong, durable, and easy to work with (Table 7). A 97% majority affirmed earth would make a durable building material for a home. Participants also communicated that earth would make a durable material for their climate, stating it maintained a fresh look and they liked its aesthetic appearance. A small percentage of the participants shared concerns about damage to their structure caused by water (Table 8), even though the majority of the respondents indicated that an earth building would withstand a major storm event like Hurricane Mitch. The majority of the study sample currently live in an adobe block structure (Table 2) which may be a reason for their positive response to compressed earth block as an alternative building material due to their similar characteristics (Figures 1 and 2). The majority of the participants are interested in learning more about CEB for various reasons which included teaching others, building a better home and possible business opportunities.

One of the surprises discovered in this research effort was the relative short length of time participants had taken to procure their building materials (Table 4). It was assumed that homes were not being rebuilt in Capapan because of the difficulty of material transport due to poor roads and the general poor economic situation of the region. Even though roads are still in a state of disrepair, residents in this region are figuring out other means of getting materials to their site (Table 3). Damaged homes were still visible by the researcher on a trip to the region in 2012. In post interview conversations with Predisan, volunteers communicated that some homes damaged in the 1997 hurricane were never rebuilt. Former residents moved out of the region or rebuilt somewhere else. There appear to be other factors unaware to the researcher or the volunteers who collected data from the participants regarding the repair or rebuilding of some homes. The current violence in the region is

something that was not anticipated when this research project was undertaken, and its impact on residents desire to build or stay in the region was not determined.

Summary of Research Questions

The research questions for this study were: (1) What are the attitudes, perceptions, and knowledge of the residents of La Capapan de Union toward CEB construction, and (2) Do the residents in LCDU support using CEB as an alternative building practice and a viable building method to current building methods? The purpose of this study was to explore the acceptance of compressed earth block (CEB) as an alternative building practice in the region of La Capapan de Union. It was determined that 97% of the sample population expressed favorable attitudes towards CEB, and were receptive to its introduction as an alternative building method. This study is intended to establish a baseline for future research projects that would explore attitudes toward CEB in other communities and potential prototype housing projects incorporating CEB material.

Comparison to the Literature

The collected data from the participants interviewed indicated some similarities to the findings in the published literature. One of the highest ranked factors in the Africa study (Baiche, 2008) for choosing compressed earth block as a building material is its economics and affordability. The affordability of compressed earth block was also cited in the housing study for Nigeria (Olotuah, 1999) and Sudan (Adam & Agib, 2001). This Capapan study supported those findings with 63.5% of the participants stating affordability would be the primary reason for selecting earth block for construction of their home (Table 9). A second factor noted in the Africa study (Baiche, 2008) for selecting compressed earth block was its durability. The Capapan study supported this finding with 86.5% of the participants stating they believed earth blocks would be a durable building material for their climate. A third factor provided by Baiche (2008) for selection of earth blocks was aesthetics noting 40% of the survey population liked the color effects of the clay finishes. This Capapan study supported this data

with 23.5% of the participants stating they would choose earth block as a building material because of its aesthetics (Table 9). A fourth factor influencing potential use of earth in the Zambian construction was availability of the material (Baiche, 2008). The Capapan study supported this finding with 33.5% of the participants stating this was the reason they had selected earth blocks to build the home in which they were living (Table 5). A fifth factor in Baiche's study listed workability of the building material as an influencing factor for use. The Capapan study supported this factor for use of earth as a building material with 36.5% of the participants stating they had used earth and found it to be easy to work with (Table 7). A sixth factor cited by Baiche influencing the use of earth as a building material was its thermal properties. Of the survey population in the Capapan study, 60% mentioned earth providing a comfortable structure in which to live (Table 8). Of the nine factors identified by Baiche (2008, Figure 3) found to influence compressed earth block utilization as a building material, six of these factors were specifically supported by the findings of the Capapan study and included affordability, durability, workability, aesthetics, thermal properties and availability. The three remaining factors, acoustic properties, up-market potential, and traditional architecture, were not commented on by participants in the Capapan study.

There were thirteen barriers noted in the Zambia study (Baiche, 2008, Figure 4) found to influence successful implementation of compressed earth block as a building material into that culture. Both the Africa study and the Capapan study determined that the cost of earth materials was a low barrier because participants viewed earth as economical. Both studies agreed that the thermal properties and availability was a low barrier to overcome for the implementation of earth construction. Participants in the Baiche study moderately approved of the aesthetics of earth construction, while the majority of the Capapan residents preferred the aesthetics of earth buildings over other choices. Participants in the Baiche study ranked water resistance as a large barrier, while a small percentage of the Capapan participants mentioned it as an issue to overcome. The Baiche study stated that technical

know-how was a high barrier. Participants of the Capapan study simply wanted to learn more about the technique. The two studies differed significantly on two barriers. Baiche identified client lack of interest as a high barrier, while the Capapan study indicated a majority of the participants were interested in learning more about it. The highest ranking barrier in the Baiche study was structural weakness of earth materials. The opposite was true of the Capapan study; most considered earth a strong and durable building material (Table 7). The barrier of no legislation or lack of code mentioned in Baiche's study would not be a barrier in Capapan because there are no governing codes for construction in this region. Not for up market, old architecture, not competitive, and acoustic properties, the remaining barriers mentioned in Baiche's study, appear to be nonfactors to the participants of Capapan, as they were not mentioned. Table 11 provides a summary of the contrast of thought regarding identified barriers between the African and Capapan studies.

Table 11 - Contrast of Thought in African and Capapan Studies

AFRICAN STUDY	BARRIER IDENTIFIED	CAPAPAN STUDY
5th highest	POOR WATER RESISTANCE	Only 13.5% said vulnerable to water
3rd highest	TECHNICAL KNOW HOW	All had some knowledge of earth building
2nd highest	CLIENT LACK OF INTEREST	80% had interest in learning
Highest	STRUCTURAL WEAKNESS	86.5% said earth would withstand hurricane
	DURABILITY	95.5% said durable for home
8th highest	NO LEGISLATION	Non-factor – no building codes
6th highest	CONSIDERED 2ND CLASS	80% live in earth structures

A key study of the widespread social-cultural perceptions that modern building techniques and materials are substantially better than older or traditional methods (Sojkowski, 2002) and that earth materials and techniques are perceived as temporary, "substandard" and "second class" was cited in the

literature. The findings of the Capapan study did not support this perception. When participants were asked if they would consider living in a house constructed of earth blocks, a majority responded affirmatively (Table 9) citing the economics of earth block as the primary reason. Additionally, 60% of the participants stated earth blocks would make a durable material for their climate, and 26.5% preferred the aesthetic appearance of earth block, stating "it keeps a fresh look". Of the participants involved in this study, 80% currently live in an adobe structure with 97% of all participants stating they were interested in learning more about compressed earth block technology. Many of the respondents (44%) had lived in their house twenty years or more. This compares to the Africa study (Baiche, 2008) where 50% of the respondents in that study had lived in their home more than 20 years, which may confirm the durability of earth buildings in both climates.

Limitations

This study had a number of limitations. The most difficult being limited access to the research site due to an on-going drug war in the region. The region of Capapan has been severely impacted by this conflict, suffering the loss of ten of its community members to this violence in 2012 (Taylor, 2013). For safety reasons native health care volunteers of the Predisan organization conducted the face-to face interviews in the homes of the participants after a briefing with the researcher in the community of Catacamas.

Another limitation identified was that volunteers chose not to use recorders or video cameras. This may have impacted the depth or clarity of information gathered from participants.

A third limitation was that the depth of information collected may have been influenced by the limited interaction and influence of the researcher and the participants on each other (Mertens, 1998). Elements of this particular social situation and group setting could not be explored because of the limited interaction with the participants (Locke, Spirduso, & Silverman, 1987). A level of understanding and connection with those who participated in the study may have been missed (Hathaway, 1995).

Future Studies

Future studies should be directed toward neighboring communities to see if they share the same attitudes towards compressed earth block as an alternative building material to current practices relative to the participants in this study. The depth of knowledge gained through this research should be expanded by building a prototype house of compressed earth block and then collecting further data regarding reaction of the participants after they have opportunity to interact with this material over a period of time. Soil types and appropriate stabilizing mixes were not a part of this study but these should be considered in future research efforts. Effective roof systems and their connection to the earth block structures should considered in future research studies. The effects of climate and forces of nature on a prototype model constructed of compressed earth block should be analyzed to determine durability over time. Effective building methods and techniques should be perfected specific to this climate and then shared with participants in a learning environment. The majority of the survey population (97%) expressed interest in learning more about this product. Appropriate teaching methods should be studied along with effective ways of implementing training for those interested in utilizing CEB technology.

Application of the three most important factors (Table 6) for building a home in the region should be further studied. These factors could be used to develop a prototype community utilizing CEB as a building material. A fourth factor mentioned by 13.5% of the participants was living in a safe place. The impact of the current violence in the region should be analyzed to determine the effect it is having on desire of participants to stay in the region. The safety and economic climate of this region are being influenced by this violence (Taylor, 2012) producing uncertainties no one could have anticipated.

The impact of utilizing compressed earth block in the place of adobe materials to eliminate the Chagas disease causing severe health problems to inhabitants of adobe dwellings in Capapan is a potential long-term study and research effort, warranting possible CEB construction projects.

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APPENDIX A

Predisan Letter of Support

PREDISAN, USA, Inc.
1625 Cooledge Rd.
Tucker, GA 30084
Tel. (770) 414-8717
Fax. (770) 414-8722

PREDISAN
Asociación Hondureña Predicar y Sanar

PREDISAN
Apdo. No. 47
Catacamas, Olancho, Honduras
Tel. 799-4027, 799-4662
Fax: 799-5564
E-mail: predisan@predisan.org

Colorado State University
Construction Management Department
Attention Dr. Mary Nobe

The Honduran Association To Preach and To Heal (PREDISAN) is a registered non-profit organization working in coordination with the Honduran Ministry of Health to deliver primary health care services to marginal and remote populations in the department of Olancho in Eastern Honduras.

Based in the city of Catacamas, PREDISAN expects over 50,000 patient encounters in the year 2010 through three acute programs that reach out to those in need and with limited access to resources. With a focus in community based primary health care, many organizational activities are focused in prevention and education leading families to develop habits and living environments that maximize their potential to live healthy lives and prevent prevalent sicknesses.

Working directly with a population of just over 13,000, the organization has more than 24 years of participation with the communities, families, and civic institutions. This relationship has allowed the organization to accompany community leaders in obtaining basic necesities such as potable water, sanitation systems, and the improvement of education centers. Facilitating outside resources to come alongside and help community leaders in their desire to develop their community is one of the goals of the organization's intervention in the population we serve.

PREDISAN is very interested in integrating the research study of Milton Brown in representation of Colorado State University as a way to research better solutions for home construction and address the disease "Chagas," caused by the **triatomine** insect which dwell in the wall cavity of living environments constructed of thatch, wad and dab, or rustic wood lath. Accessible construction units made from local materials which are more compact and incorporated with a methodology to provide permanent dwellings are one of the methods to eradicating this disease and assisting in the development of the community and the individual families that receive health services.

As executive director, I express the desire of the organization to collaborate and facilitate the work of Milton Brown and participants representing Colorado State University.

Thank you for your interest in bettering the lives of others through research and product development.

Sincerely,

[redacted]

Martha Rivera
Executive Director
PREDISAN

ASOCIACION HONDUREÑA PREDICAR Y SANAR
PREDISAN
CATACAMAS OLANCHO, HONDURAS C.A.

Lucas 9:2 "Y los envió a predicar el reino de Dios y a sanar a los enfermos"

APPENDIX B

Map of Honduras Research Area

APPENDIX C

Photographs of Compressed Earth Block

APPENDIX D

Internet Sites

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APPENDIX E

Comparison of CEB and Adobe Properties

Table 12 - Comparison of CEB and Adobe Properties

CEB	TECHNICAL CHARACTERISTICS AND PROPERTIES	ADOBE
	Oven fired/ sun dried	✓
✓	Unfired/dry mix	
✓	Uniform	
	Hand pressed	✓
✓	Mechanically pressed	
	Porous	✓
✓	Densely compacted	
✓	Use of stabilizers	
	150-300 pounds per square inch (psi) typical	✓
✓	1,200-1,400 psi typical	
	Heavy clay base	✓
	Brittle	✓
	Water absorbing	✓
	Use of top soils	✓
✓	Use of sub soils	
✓	Dry stacked	
✓	Use of local materials	✓
✓	Economical	✓
✓	Minimal cure time before use	
✓	Water resistant	