Investigations of New Construction Systems for Habitat for Humanity

Prefabricated Systems for the 21ST Century

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Mr. James Dolan
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Mr. Dolan:

Enclosed is our report entitled, "Investigation of New Construction Systems For Habitat for Humanity: Prefabricated Systems for the 21st Century." The report was written during the period of May 16 through July 4, 2000. Copies of the report are being submitted simultaneously to Professors Arthur Gerstenfeld and Susan Vernon-Gerstenfeld for evaluation. Upon faculty review, the original copy of the report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time you have devoted to us for this project.

Sincerely,

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INVESTIGATION OF NEW CONSTRUCTION SYSTEMS FOR HABITAT FOR HUMANITY:
PREFABRICATED SYSTEMS FOR THE 21ST CENTURY

An Interactive Qualifying Project
Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

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This project is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of Habitat for Humanity or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The reader should not construe the report as a working document.

Abstract

This report, prepared for the Costa Rican affiliate of Habitat for Humanity, is intended to present a conclusive study that examines cost, time, quality, and social and environmental implications of six low-cost construction systems. If the recommendations that this project concludes upon are put into practice by Habitat for Humanity the cost and time that is necessary to construct a house will decrease, while quality will increase, and social and environmental factors will not be disturbed.

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David Emery was also responsible for attending interviews, the collection of data, obtaining information for the Literature Review, and translations.

Victoria Steward was also responsible for attending several interviews and the collection of data.

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Executive Summary

Habitat for Humanity, a non-profit organization, commissioned a project from Worcester Polytechnic Institute that hopes to improve the standard living conditions in Costa Rica. Costa Rica is a developing nation located in Central America between Nicaragua and Panama. Because of Costa Rica's location, the country undergoes severe rains and seismic activity, which include earthquakes and volcanic eruptions. These harsh conditions have a serious impact on all structures in Costa Rica, especially those located in underdeveloped areas.

The project's objective was to compare five alternative building technologies to the building method that Habitat is currently employing. The purpose of this comparison was to determine if using any of these alternate technologies would reduce the cost and time of construction and improve the quality of the Habitat houses without upsetting societal balances or the environment. In theory, if one or more of these technologies can decrease the time and cost needed for the construction of a house, Habitat will be able to reach out to more families in need in a smaller amount of time.

The six systems that were studied were: cement block, PBC, Zitro, Concrepal, Habicon, and Covintec. Fernando Chavarria, the head Habitat architect for Latin America, James Dolan, the project liaison, and the project group chose these systems for analysis.

The methodology used to obtain all the data needed to complete the project proposal was divided into two main sections. In the first section of the methodology we interviewed employees of Habitat for Humanity. We then interviewed the CIVCO professors that developed the Habicon system, Hopsa, PBC, Concrepal, and Zitro

representatives, University of Costa Rica engineers, and other experts in the field of prefabricated systems. In the second section we observed different building system sites around Costa Rica. Through site observation, we were able to gain practical information about the construction of a house. This also allowed our project to move from a two dimensional view into a reality.

Based on the research done on Habitat's system and the five other prefabricated systems, cost, time, and quality estimations were conducted, along with environmental and social implication studies. Using the afore mentioned estimations and studies we compared the costs, time for construction, strengths, and the weaknesses of each of the systems in the following report that answered the questions that Habitat proposed.

A current concrete blockhouse built by Habitat takes thirty to thirty-five days to construct, and costs $4,760. All of the prefabricated systems that were analyzed took longer to build except the Habicon and the Covintec systems. The Habicon system requires twenty-seven days for construction, while the Covintec system requires only fifteen days. Also, all of the systems analyzed were more expensive that the existing system except for Covintec, which cost $4,533.

Although on the surface it may seem that Covintec is a better system, it was still necessary to examine quality, societal, and environmental aspects of each system. To perform these examinations we used a decision matrix. We asked four Habitat employees qualified in construction management to weight the importance of each of the categories: cost, time, quality, and social and environmental implications. They were asked to rate these categories individually on a scale of 1 to 20; then the four individuals were asked to consult with each other and determine what weighting system would correctly represent Habitat's needs. Then we ranked each system on a scale from 1 to 100 on how well they represented each category. Then the weights were multiplied to the rankings, and a sum was taken of all of the categories. This gave us a mathematical foundation for our recommendations.

After careful analysis of all data, especially the data in the decision matrix, we have concluded that Covintec is the best system. We encouraged Habitat to begin implementing this technology. We realize that it might be difficult to get the community to accept the Covintec system, so we recommend that an educational program be run with Hopsa, the company that manufactures Covintec, and Habitat. If there are still questions concerning the systems that we have studied, we recommend that Habitat build a house out of each system with three purposes in mind: to allow Habitat and Costa Rican society to observe the construction process, to train the families how to construct the system, and to allow them to feel the strength of the house when finished. This would make it easier to compare each of the systems. However, if Habitat wishes to research more systems before they come to a final conclusion, we provided our methodology to make this process as quick and easy for Habitat as possible.

The research completed for this project could not only benefit Habitat for Humanity in Costa Rica, but it could also increase the quality of the Habitat houses, resulting in a higher standard of living for those Costa Ricans living in the houses. This research could also encourage Habitat for Humanity International to reexamine the work being done in the other Latin American countries and possibly implement some of the changes that this project suggested.

Chapter 1. Introduction

This report was prepared by members of Worcester Polytechnic Institute Costa Rica Project Center. The relationship of the Center to Habitat for Humanity and the relevance of the topic to Habitat for Humanity are presented in Appendix A.

Habitat for Humanity, a non-profit organization, commissioned a project from WPI that hopes to improve the standard living conditions in Costa Rica. Costa Rica is a developing nation located in Central America between Nicaragua and Panama. Because of Costa Rica's location, the country undergoes severe rains and seismic activity, which include earthquakes and volcanic eruptions. These harsh conditions have a serious impact on all structures in Costa Rica, especially those located in underdeveloped areas.

The proposed project compared alternative building technologies to the building methods that Habitat is currently employing in order to determine if using any of these alternate technologies will reduce the cost and time of construction and improve the quality of the Habitat houses. In theory, if these technologies manage to decrease the building cost of a house, Habitat for Humanity will be able to reach out to families with less money. These alternate technologies should also be able to decrease the amount of time needed to build a house; this will allow Habitat to build more houses, thus reaching out more families. Alternative technologies may also help provide the Habitat structures with increased resistance to severe conditions such as: wind gusts in excess of 120 miles per hour, torrential downpours, excessive heat, and earthquakes. One of the restrictions placed on these alternative technologies is that they need to be environmentally friendly, because the deforestation of the rainforests in Costa Rica and other pollutants are something that Habitat for Humanity and the people of Costa Rica are concerned with. One of the most important considerations that Habitat must take into account is whether the people that they are building for would accept the new building systems. The Costa Rican people are resistant to change and the alternative systems need to be readily accepted by society.

This project's objectives included researching previous Habitat building methods and techniques and using this information to determine the need for improvement in future assemblies. Along with Habitat's construction method, background, construction, and material information, this information was also obtained for the five other prefabricated systems: Habicon, Covintec, PBC, Zitro, and Concrepal.

The methodology used to obtain all the data needed to complete the project proposal was divided two main sections. In the first section of the methodology we interviewed Habitat for Humanity employees, CIVCO professors, Hopsa, PBC, Zitro, and Concrepal representatives, and other people that are experts in the field of prefabricated systems. In the second section we observed different building sites around Costa Rica that use one of the six building systems. Through site observation, we were able to gain practical information about the construction of a house.

Based on the research done on Habitat's system and the five other prefabricated systems, cost, time, and quality estimations and studies of the environmental and social implications were developed. Using these estimations and studies, we compared the costs, time for construction, strengths, and the weaknesses of each of the systems in a report that answered the questions that Habitat proposed. This formal report determined which of the six systems, the current Habitat system and the five prefabricated systems, was the most cost effective, was the quickest to construct, had the ability to control the quality of the finished product, caused the least amount of stress on the environment, and would be socially excepted by the people of Costa Rica. After all of the estimations and studies were preformed, we recommended to Habitat whether or not they should change their current system, and if they should, which system we believed would be most beneficial.

The research completed for this project will not only benefit Habitat for Humanity in Costa Rica, it could also increase the quality of the Habitat houses, resulting in a higher standard of living for those Costa Ricans living in the houses. By decreasing building time, this project will allow families to spend less time helping with the construction of their homes; therefore, allowing the family to return to the work force earlier. This and the reduction of the cost of the house will allow the families to pay off their mortgages sooner. This research could also encourage Habitat for Humanity International to reexamine the work being done in the other Latin American countries and possibly implement some of the changes that this project suggested.

If all of our methods of research are sound and carried out, thereby meeting all of the proposed objectives, the Costa Rican branch of Habitat for Humanity may take the information compiled by this project and use it as a future plan of action. The implementation process might be difficult and tedious because the locals are not always interested in change; they are happy with the current system, which is a system that they know and trust.

An IQP, Interdisciplinary Qualifying Project, is a degree requirement that all undergraduates at Worcester Polytechnic Institute must complete in order to graduate. This project is intended to show the students how technology and society relate to each other and complement each other in the outside world. The project done for Habitat for

Humanity fulfills the criteria of an IQP. The technology that makes the alternative housing system possible will be used to benefit the lower income society of Costa Rica; thus bringing together technology and society.

Chapter 2. Literature Review

2.1 Guide to the Literature Review

The following literature review contains background information concerning the geography, climate, and history of architecture in Costa Rica. This literature review includes the information on the geography and climate, because these factors influence the design and construction of houses. To thoroughly understand all of the construction systems, research must be done on all aspects of a house. This includes but is not limited to: foundations, roofing assemblies, and septic systems. This literature review focuses mainly on wall construction and roofing.

2.2 Costa Rican Background

This section covers background information on Costa Rica. The geography, climate, and architectural history of this country are included. These subjects are important to include in this literature review because when looking at a old and new systems of construction it is important to determine what the system needs to be able to withstand in terms of natural occurrences. Also when looking to introduce a new system into a culture, it is important to understand where the Costa Rican building systems come from and what the local people are used to and will accept.

2.2.1 Geography

Costa Rica is a small country half the size of Kentucky; it is situated between Nicaragua and Panama, and is located on the very active junction of the Cocos and Caribbean tectonic plates. This geographical position makes the country prone to earthquakes and volcanic eruptions. Also due to its location, the majority of the Costa

Rican land consists of volcanic mountain ranges: the Cordillera de Guanacaste in the northwest, the Cordillera de Tilaran in the southeast, and the Cordillera de Talamanca found the furthest southeast. The seismic activity of a country is very important to consider before the design of a house or a construction system can even be considered. Between these mountain ranges is the central plain that supports more than half of Costa Rica's population and four of the five major cities. The Caribbean and Pacific coastal lowlands are found on the other sides of the mountain ranges (Rachowiecki, 1997: 18-19). See figure 1.

FIGURE 1. MAP OF COSTA RICA

2.2.2 Costa Rican Climate

According to Rachowiecki (1997: 19) Costa Rica does not have four seasons like most of the temperate regions; it only has a wet and dry season. The wet season, from May to November, is considered to be winter; the dry season, from December to April, is considered to be summer. The amount of rain that Costa Rica receives varies with the country's regions. The Caribbean coast tends to be wet all year round, while the Pacific coast and the highlands receive rain for up to twenty days a month during the rainy season.

The temperatures in Costa Rica, says Rachowiecki, stay constant throughout the year, depending only on the altitude of a specific location. The coastal temperatures vary from twenty degrees Celsius (forty-three degrees Fahrenheit) at night to thirty-three degrees Celsius (fifty degrees Fahrenheit) during the day. San José, which is found in the central plain, has temperatures that range form fifteen degrees Celsius (forty degrees Fahrenheit) to twenty-six degrees Celsius (forty-six degrees Fahrenheit). The climate of a region is as important as seismic activity when a design for a house is being considered; this is important because some construction materials are not suitable or cannot withstand some climactic occurrences such as excessive rain or heat.

2.2.3 History of Architecture in Costa Rica

Costa Rica's architecture has an extensive history; it mixes much of its architecture in combination of Spanish, Indian, and Colonial styles. After the arrival of Columbus in 1502, much of the early construction was of Spanish decent. It was not until the sixteenth century that Colonial architecture began to flourish.

Cultural changes in Costa Rica began with the cultivation of coffee, this occurred because the influx of money led to increased education and travel. The influx of European ideas paved the way for structures such as San José's National Theater, which was completed in 1897. Costa Rica has a one hundred year history of promoting institutional architecture that is based on its cultural roots. Religious, governmental, and educational buildings are the main landmarks of San José. (http://www.incostarica.net/docs/history/index.shtml).

Costa Rica's architectural history is important to consider when looking at a design or the construction system for the house, because in order to introduce a change into a culture, it is important to understand where a culture is coming from and what it is accustomed to. Only after an understanding is obtained can a new design or construction system be chosen that will satisfy the aesthetic and structural requirements that the Costa Rican people consider important.

2.3 General Building Background

The following section provides the background information on general building subdivisions: foundations, walls, and roofs. The information on what general practices are used for the construction of these sections of the house will give a better understanding on how a house should be constructed properly.

2.3.1 Foundations

Foundations are utilized in construction to bear the load of a building and also to stabilize a building. There are two criteria for stability: first, the soil under the foundation should be able to receive the imposed load without more than one inch (2.5 centimeters) of settlement and, second, the settlement should be uniform under the whole building.

The foundation system used for low-rise residential buildings is appropriate for light bearing loads. Most of these low-rise buildings are supported by spread footings. There are two types of spread footings: continuous footings that support walls and isolated pad footings that support concentrated loads. The footings are normally made of concrete that is poured into a foundation trench with a minimum depth of twelve inches

(30 centimeters). The foundation walls can be built with reinforced concrete or masonry, particularly concrete block. Concrete blocks are larger than bricks, and they are also hollow. When these blocks are laid they form a vertical grid. These blocks are the least expensive form of masonry, yet they are still amazingly strong (www.members.eb.com).

2.3.3 Roofing Assemblies

The protocol for design and installation of roofing systems always tends to be experiencing change. The National Roofing Contractors Association (NCRA) (1996: 1019) recommends that when deciding upon a roofing system research on the geographical area where the system is going to be installed is necessary. The NCRA also recommends that a roof assembly should be designed only after a certain number of criteria have been looked at carefully. These criteria include, but are not restricted to: climate, exterior and interior temperature, humidity, building and roof life expectancy, type of roof deck, building code requirements, drainage and slope, thermal requirements, and fire, wind, and impact resistance. These criteria play important roles in the success or failure of a roof assembly, and the NCRA believes that these criteria must be considered by the roof designer to determine the appropriate components of the roof assembly.

2.3.3.1 Tile Roofing

Tile has been a common roofing material for centuries. Sun-baked slabs of beaten clay were used for roofs in early Egyptian, Asian, and Babylonian times. The hand made clay tiles were dried, and then fired in brick kilns, making the tiles durable for many years. Currently, tile roofing is used on a worldwide basis.

There are very many different variations of tiles, which can be categorized many different ways. As of 1996, tiles are separated into two general categories by the shape of the tiles and their composition. These categories are then subdivided by breaking strength, porosity, resistance to freezing and thawing, and how the tile is joined and secured. The general shapes of tiles are the flat tile and the profile tile.

The tiles that are currently manufactured are made of clay, cement, or stone. The mineral composition of all of these tiles is responsible for the hardness, durability, and color of the finished tile.

2.3.3.2 Synthetic Roofing Systems

After reviewing common types of roofing assemblies used throughout the world, it can be observed that roofing systems have mainly consisted of natural materials. These materials are generally indigenous to the geographic area or region that they are used in. These natural materials began a tradition of having roof coverings made of clay tile, cement, aluminum, slate, and wood shingles and shakes.

The NCRA (1996: 1231) states that research and development efforts have improved in the 20th century, which has led to the introduction of synthetic materials for roofing. Most of these synthetic materials have been engineered to resemble the appearance of traditional roofing materials. Many of the synthetic products that are being introduced into the roofing world are evolving and changing according to various climate and weather experiences.

2.3.3.3 Micro Fiber Cement Roof Tiles

The NCRA (1996: 1232) states that a majority of the micro fiber cement roof tiles are manufactured to simulate wood shakes and shingles, slate, or tile. These fibrous cement tiles are normally a blend of cement, synthetic or natural fibers, and occasionally an aggregate that help to imitate the look of natural slate, wood shakes or shingles, and tile. The resulting fibrous cement product can then be cut or sawn and used in many different roofing assemblies.

Architect, Peter Blaisdell (personal communication, 04/04/00), in agreement with the NCRA, tells why fibrous reinforcement is beneficial for roofing tiles in Costa Rica and other similar climates. The typical, non-synthetic tiles are decided upon because of many reasons, including rain fall, humidity, the incidence of rot and rust, bug infestation, and many other criteria. The synthetic tiles are also chosen because of these criteria, but on a stricter scale. These tiles are fiber-reinforced, creating a stronger breaking point in the tiles and increasing elasticity, not rigidity, in the tiles, which is critical for roofing assemblies in areas where hurricanes and earthquakes are common.

2.4 Costa Rican Building Codes

This section is taken from the Código Sísmico de Costa Rica (2000). In Costa Rica, as in every other country in the world, there are many laws and requirements for the design and construction of a house. The functions of these laws are to ensure the durability of the houses and the safety of the families that live in the houses. Since earthquakes and large amounts of rain are common occurrences in Costa Rica, many of the regulations are written to make sure that the houses will stay structurally sound, even in the worst conditions.

When building a house, the quality of the materials that are being used is one of the most important aspects to examine. Even if all the structural laws are closely followed but the materials are of poor quality, the structural integrity of the house can be severely compromised.

One of the main materials used in building a house in Costa Rica is cement. When building beams, columns, and crowns, the concrete used must be able to support 210 kilograms per square centimeter. The concrete that is used for the building blocks that are utilized in foundations and load bearing walls is required to support 175 kilograms per square centimeter. The requirement for the reinforcing steel placed in the concrete foundations and walls is a minimum strength of 2,320 kilograms per square centimeter.

It is important to reinforce the concrete used in construction. Without reinforcement, concrete does not have a great deal of tensile strength, and it is likely to shift under large weights and during earthquakes.

The foundation supports the weight of the entire house, therefore it is doubly important to reinforce. Each foundation must have a minimum width of 30 centimeters and have a minimum of three rods running horizontally through the poured concrete along with U shaped vertical rods. If a traditional foundation system is being used, a seismic beam, of same width as the walls, must be poured on top of the foundation.

The walls like the foundations, also need to be reinforced. The minimum thickness of interior walls is 10 centimeters, and the minimum thickness of the load bearing walls is 12 centimeters. The walls also need to be reinforced in the horizontal direction in order to ensure that the wall does not bow. The maximum height of a wall without any tensile support is 2.6 meters. Walls are built directly on top of the foundation that is reinforced with a concrete beam that has a minimum width of 30 centimeters. If columns are used to horizontally stabilize the walls, it is not necessary to make crown beams that stabilize the flexible walls near the roof.

For all of the frames around doors, windows, and other openings, there must be a minimum of one steel rod placed into the concrete to reinforce the rest of the wall. The first reinforcing bar must extend at least 60 centimeters past the frame, and have a minimum area of horizontal and vertical reinforcement that is 0.0013 times the area of the wall. The area of reinforcement in any direction cannot be less than 0.0005 times the total area. The maximum separation between the reinforcing rods cannot be greater than three times the thickness of the wall, but at most 45 centimeters.

The walls must also have horizontal reinforcing beams at intervals of 20 centimeters; the maximum vertical separation must not exceed 25 centimeters. This beam consists of a minimum of four rods tied together every 20 centimeters. The cells of blocks adjacent to the doors and windows must also be reinforced with two-rod beams.

All the walls must be connected at reinforced concrete corners. The walls must be either in direct contact with the ground, or in contact with a concrete seismic beam. The reinforced concrete must be designed to have a height not greater than 2.5 meters and a length not greater than 3.0 meters. The ideal locations for reinforced cement are at intersections, corners, boarders of free walls, and around the frames of doors and windows. For columns, walls, beams, and crowns, the reinforced concrete needs to be 20 centimeters in width, and for other intermediate beams the reinforced concrete needs to be 15 centimeters in width. When building multilevel houses the floor thickness has to be 20 centimeters; however, the minimum thickness for the ground floor is 40 centimeters.

2.5 Polystyrene

Polystyrene is the technical name for Styrofoam, which was coined by Dow Chemical. The chemical formula for polystyrene is $C_6H_5CHCH_2$–n. Polystyrene is a polymerized styrene, therefore placing it in the styrene family that is further defined by being in a class of synthetic organic polymers (Weissermel, 1996: 363-372).

In 1996 the world production capacity for styrene was close to 19.2 million metric tons per year. To date, Dow Chemical is the world's largest producer of styrene, with a total production capacity of 1.8 million metric tons per year in the USA, Canada, and Europe. Currently 65 percent of all styrene is used to produce polystyrene (http://www.polystyrene.com). Styrene is also well known as phenyl ethylene, $CH_2{=}CHC_6H_5$. The most common production method for styrene is direct catalytic dehydrogenation of ethyl benzene. In this process ethylene enters a catalytic reaction with benzene by using aluminum chloride as a medium to yield ethyl benzene. This yield of ethyl benzene then undergoes a process of dehydrogenation to produce pure styrene in aqueous form. When the aqueous styrene is polymerized, crystallization occurs; the crystallization process occurs through dehydration, thereby creating polystyrene (Weissermel, 1996: 363-372).

2.5.1 History of Polystyrene

According to Encyclopedia Britannica (http://www.encyclopediabritannica.com) in 1839, the German physicist Eduard Simon discovered how to polymerize styrene; it was not until the late 1930's that large-scale manufacturing of polystyrene began. Before the 1930's there was little use for polystyrene because it was very brittle and cracked easily due to many impurities that were found in the cross-links of the polymer chains. In 1937, the Dow Chemical Company was able to remove those impurities in the polymer chains and they established a chemical plant to process the polystyrene. By the mid-1960s, more than half the polystyrene in the United States was produced by using a rubber latex additive to increase durability and resistance to impact. Currently, more than half of the polystyrene produced throughout the world is combined with a polybutadiene solution (5 to 10 percent) to reduce brittleness and improve impact resistance.

2.5.2 Polystyrene Production

According to Weissermel (1995: 562-564), polystyrene is made in a reaction vat using 50 percent of the end product weight of styrene, 100 parts per million of water, 2,000 parts per million of boron tri-fluoride, and an organic solvent that makes up the difference in the weight. 1,2-dichloroethane is most commonly used as the solvent for the polymerization of styrene, but carbon tetrachloride, ethyl chloride, methylene dichloride, benzene, toluene, ethyl benzene, or chlorobenzene can also be used. In this reaction, temperature control is very important; the temperatures of the reactants should not vary more than 15 degrees Celsius throughout the entire reaction. If the temperature varies more than 15 degrees, the molecular properties of polystyrene do not stay constant throughout, and as the reaction temperature increases the average molecular weight of the polystyrene decreases.

DeVito (1995: 820-831) points out that in the past, chlorofluorocarbons (CFCs) were used for blowing gas into polystyrene. But after several bans on CFCs throughout the world for the destruction of the ozone, hydro-chlorofluorocarbons (HCFCs) replaced the CFCs; however, HCFCs were still harmful to the ozone. Carbon dioxide and pentane are now being used as the blowing agents, but these chemicals still contribute to smog.

2.5.3 Polystyrene Disposal

Since the inception of polystyrene, disposal has always been a problem. Polystyrene products do not biodegrade well and, if incinerated, they produce toxic ash. However it is a large misconception that anything biodegrades readily in landfills: not polystyrene, not paper, not even food wastes (http://www.polstyrene.com).

There are several running arguments on the harmfulness of burning polystyrene. The Amoco and Dart Corporations both claim that if polystyrene is incinerated, it produces only carbon dioxide and water because it burns at a high temperature. However Mirsha (1995: 219-244) brings about the point that carbon dioxide severely contributes to global warming thus making it harmful to the environment. Most modern incinerators are not able to burn polystyrene at the proper temperature to just produce carbon dioxide and water. When polystyrene is burned at a typical incinerator temperature of 800-900 degrees Celsius several byproducts are produced. The byproducts consist of a complex mixture of polycyclic aromatic hydrocarbons, and over 90 different compounds. Inevitably chlorine donors will be added to the combustion gas of polystyrene in municipal solid waste incinerators; this in turn leads to the formation of highly chlorinated polycyclic compounds like dioxins, furans, hexachlorobenzene, and chlorophenols. All of the above are part of the family of compounds that are some of the most biologically active toxins known to humans (DeVito, 1995: 820-831).

2.5.4 Dioxin Information

The Encyclopedia Britannica (http://www.encyclopediabritannica.com) states that a dioxin is formed as a by-product of industrial processes using chlorine in waste incineration. A dioxin is one of the most toxic chemicals currently known. Burning chlorine-based chemical compounds with hydrocarbons forms a dioxin. Mirsha (1995: 219-244) defines a dioxin as a chemical that is highly persistent in the environment in which there is no safe level of exposure for animals. The most toxic dioxin has been found to be 2,3,7,8 tetrachlorodibenzo-p-dioxin or TCDD.

In the Encyclopedia Britannica (http://www.encyclopediabritannica.com) it is reported that the Environmental Protection Agency (EPA) stated that a dioxin is a cancerous agent, and exposure to a dioxin can also cause severe reproductive and developmental problems. A dioxin can also cause immune system damage and interfere with regulatory hormones. Dioxin exposure has already had several adverse effects on our society at large. In men, the average sperm count has dropped 50 percent in 50 years, the incidence of testicular cancer has tripled in the last 50 years, and prostate cancer has doubled. In women, the incidence of breast cancer has more than doubled since 1960. Endometriosis is a condition in women where there is abnormal growth of the cells that line the uterus; this condition was formerly rare, but increased dioxin production has led to more than 5 million American women being affected. Men have no biological ways to rid dioxins from their systems. Women are able to shed dioxins in two ways, both concerning childbirth: one way is when the female is pregnant and the dioxins move through the placenta and into the growing infant, and in the second way the dioxins are shed from the body through breast milk (Costner, 1995: 202).

Dioxins began accumulating in the environment around 1900 when the founder of Dow Chemical invented a way to split table salt into sodium atoms and chlorine atoms, creating a large amount of chemically unattached chlorine (DeVito, 1995: 820-831). This led to many of today's pesticides, solvents, and plastics. Unfortunately, when chlorinated hydrocarbons are processed in a chemical plant, or are burned in an incinerator, they release the unwanted dioxin byproduct. According to Greenpeace chemist Pat Costner (1995: 202), the largest producers of dioxins currently are factories that make popular plastics.

People are exposed to dioxins through their diet because dioxins are fat-soluble; 97.5 percent of dioxins in food are found in meat and dairy products. The average U.S. citizen has little or no exposure to dioxins besides what is found in food. The EPA estimates that roughly 5 percent of Americans, or about 12.5 million people, have dioxin levels that are extremely elevated (DeVito, 1995: 820-831).

If someone is exposed to too many dioxins they will acquire a disease known as chlorance. This disease was first discovered in 1897, however it was not until 1930 that it started to occur with some regularity among pesticide workers and workers who manufactured industrial grade polychlorinated biphenyls (http://www.polystyrene.com).

According to Costner (1995: 202) dioxins have been proven to have many adverse on humans. Some of these adverse effects are cancer, behavioral effects, learning disorders, diabetes and immune system toxicity. Since 1996, it has been believed that the National Research Council (NRC) had found polystyrene and other kinds of plastics to be an endocrine disrupter leading to cancer, infertility, and personality disorders. It had been believed that endocrine disrupters were so malignant that they even rendered plastic plates and baby bottles as potential killers. However, in mid-August of 1996 there were reports that the NRC had found no proof that synthetic chemicals act as human endocrine disrupters. It is still believed that this could be true, however the evidence supporting this is inconclusive.

2.5.5 Dow Chemical and Habitat for Humanity

This section is taken from the Dow homepage unless otherwise noted (www.dow.com). The Dow Chemical Company has supported Habitat for Humanity since the early 1980′s through house sponsorships, product donations, and volunteers. Since 1994, Dow has donated over $2 million to Habitat for Humanity. Dow supplies all of the Styrofoam brand polystyrene used for construction in the United States.

2.6 Pressure Treated Pinewood

The majority of this section is taken from the Southern Pine Council (www.awpa.southernpine.org) unless otherwise noted. Southern pine is a generalized group of four species of trees: loblolly, slash, longleaf, and short leaf. This group of tree species is one of the strongest and most versatile in the world, and also the easiest to treat. Southern Pine makes up over 85 percent of all the treated wood in the world. Southern Pine is very easy to treat because of its cellular structure, therefore creating thorough and unvaried penetration of the preserving chemicals. This makes the wood virtually untouchable by fungi, termites, and microorganisms.

There is some general concern when building with wood in certain areas where the wood is exposed to the elements, is in contact with the ground, or is used in areas of high humidity. All three of these characteristics make the wood prone to insect infestation and decay. Chemically preserving wood will help shed water and render the wood uneatable for insects.

2.6.1 Benefits of using pressure treated wood

There have been many scientific studies performed by the American Wood Preservatives Association (AWPA) to prove the benefits of using treated wood. Chemically treated wood has a longer life than many alternative materials, therefore saving natural resources. The preservatives used on wood do not contentiously work into the ground water. If the materials used to treat the wood are handled correctly, there is no increased risk of cancer for mammal, avian, and marine life. Also, treated wood products have been proven to be more dependable and durable than alternative products that are less energy-efficient in production.

There is some difference in opinion concerning the life of pressure treated wood. It is believed that the treating will double the life of the wood, depending on the area in which it is used. There are several ongoing tests that are sponsored by the USDA Forest Service Product Laboratory where they bury pieces of pressure treated wood in various locations, from the swamps of Mississippi to the Canadian border. The Chromated Copper Arsenate (CCA)-treated Southern Pine that has been buried since 1938 has shown no failures at chemical retention levels of .29 pounds of preservative per cubic foot of wood or higher (Forest Service Products Laboratory; 1995).

2.6.2 Types of Preservatives

There are three categories of preservatives used for the pressure treating of wood. The first category is commonly referred to as waterborne preservatives. Waterborne preservatives are used for residential, commercial, marine, agricultural, recreational, and industrial applications. The second is the creosote and creosote/coal-tar mixtures category that is used for the preservation of railroad ties and utility poles. The third is the pentachlorophenol category that is used for industrial applications and utility poles.

Waterborne preservatives are clean, odorless, and able to be painted; they are also registered by the Environmental Protection Agency (EPA) for both indoor and outdoor use without a sealer. The most commonly used waterborne preservative is CCA.

2.6.3 Quality and Grade Requirements

In the United States it is highly recommended that all treated wood being used for building is grade-marked by the American Lumber Standard Committee (ALSC). Southern pine that passes inspection by the ALSC attests that the wood in question has met structural and appearance requirements, along with being properly aged before being chemically treated. Also, all treated Southern Pine should meet the standards of the AWPA; wood that has been treated correctly will receive an AWPA quality mark.

All species of wood are not naturally conducive to being chemically treated, some wood must be incised or perforated with a number of small slits along the grain of the wood to allow for sufficient penetration of the preservative. There are very few species of wood that do not need perforation before treatment, Southern Pine is in this category.

2.6.4 Health and Safety Issues

The following section consists of tips provided by the AWPA for the handling of CCA-treated pinewood. Whenever treated wood is being sawed or manipulated by machines, eye protection and facemasks should always be worn. Inhalation of sawdust from treated wood should always be avoided. Treated wood should never be used in an area where the preservative may be able to become a part of food or animal feed; an example would be a structure such as a silage or a barn. Treated wood should never be used for counter tops or cutting boards. Treated wood should never be used in an area where it may come into direct or indirect contact with public drinking water. After working with treated wood, any area of skin in contact with the wood should be washed before eating or drinking. Clothing that accrues sawdust should be washed separately from normal-use clothing.

Treated wood should be disposed of by ordinary trash collection or burial. The AWPA strongly states that treated wood should never be burned under any circumstance. When treated wood is burned, toxic chemicals are released in both the smoke and ashes.

2.6.5 CCA-Treated Wood and Habitat for Humanity

According to Dave Mason, an employee of the AWPA (personal communitcation, 06/19/2000), Habitat for Humanity in New Orleans, LA, is currently constructing their first 100 percent CCA treated pinewood-frame house. CCA treated wood was chosen by Habitat because the area they are building in has a severe problem with Formosan Termites. The state of Lousianna is currently trying to incorporate a mandate requiring that all wood being used in new construction and remodeling be pressure-treated wood.

2.7 Cost Estimation

This section on cost estimation is taken primarily from Stewart (1982: 4-30) unless otherwise noted. The definition of an estimate is a determination, opinion, or prediction. From this, a cost estimate can be defined as a determination, opinion, or prediction of the cost of a process, product, service, or project. Further defined, a cost estimate can be seen as an appraisal, assessment, or an evaluation.

There are four kinds of productive work output previously mentioned: processes, products, services, and projects. Processes involve the conversion of raw materials into useful materials through physical or chemical alterations. Industries that specialize in processes tend to need large amounts of energy for the alterations, a large amount of money for equipment, and a good knowledge of how to control pollution. Examples of processes include: Aluminum production, oil refining, raw material extraction, waste treatment, water treatment, plastic and rubber production, etc.

Commercial items that are sold in large quantities to both private and industrial consumers are categorized as products. Industries that specialize in products deal with large-scale marketing, advertising, and distribution costs. Examples of products include beverages, jewelry, military products, paints, clothing, etc.

Work performed, either labor-intensive or non-labor-intensive, that provides assistance to any type of consumer is categorized as a service. The service industry primarily deals with price, cost, and competition. Some typical services include car repair, entertainment, photography, landscaping, and health care.

The project category has the most relevance to this project. Projects are defined as "multidisciplinary activities that frequently advance the state of the art of technological knowledge" (Stewart, 11; 1992). Projects are very difficult to estimate because there can be many unknowns involved that are overlooked or not present during the planning stages. Projects include all construction; especially pertinent to this project is the construction of homes.

There are two different methods of cost estimation for projects. The first method is referred to as the "industrial engineering approach." This requires the estimation of both the man-hours and materials needed for every direct and indirect element of work. This is information is used to compute all the prices for all elements of the work to compile the cost estimate. The second is known at the "parametric approach" that uses historical data from a previous project and determines the new costs of all services necessary for the completion of a new project. The parametric approach will be used for the cost estimations in this project.

There are nine major components that must be assessed to correctly perform a cost estimate: man-hours, labor rates, materials, subcontracts, transportation costs, direct services, indirect costs, administrative costs, and profit. Because Habitat for Humanity is a non-profit organization, the profit component of cost estimation is negated.

There are five tools that are needed to combine the previously mentioned components of the cost estimate, these include: A team of estimators, a methodology, a knowledge of the project (process, product, or service in other circumstances) at hand, calculation ability, and publication ability. In relation to the project at hand, the student research group will serve as the team of estimators who will research all aspects of current construction by Habitat for Humanity and five prefabricated systems, develop a methodology, perform all calculations for the completion of the cost estimate, and then present all findings to Habitat.

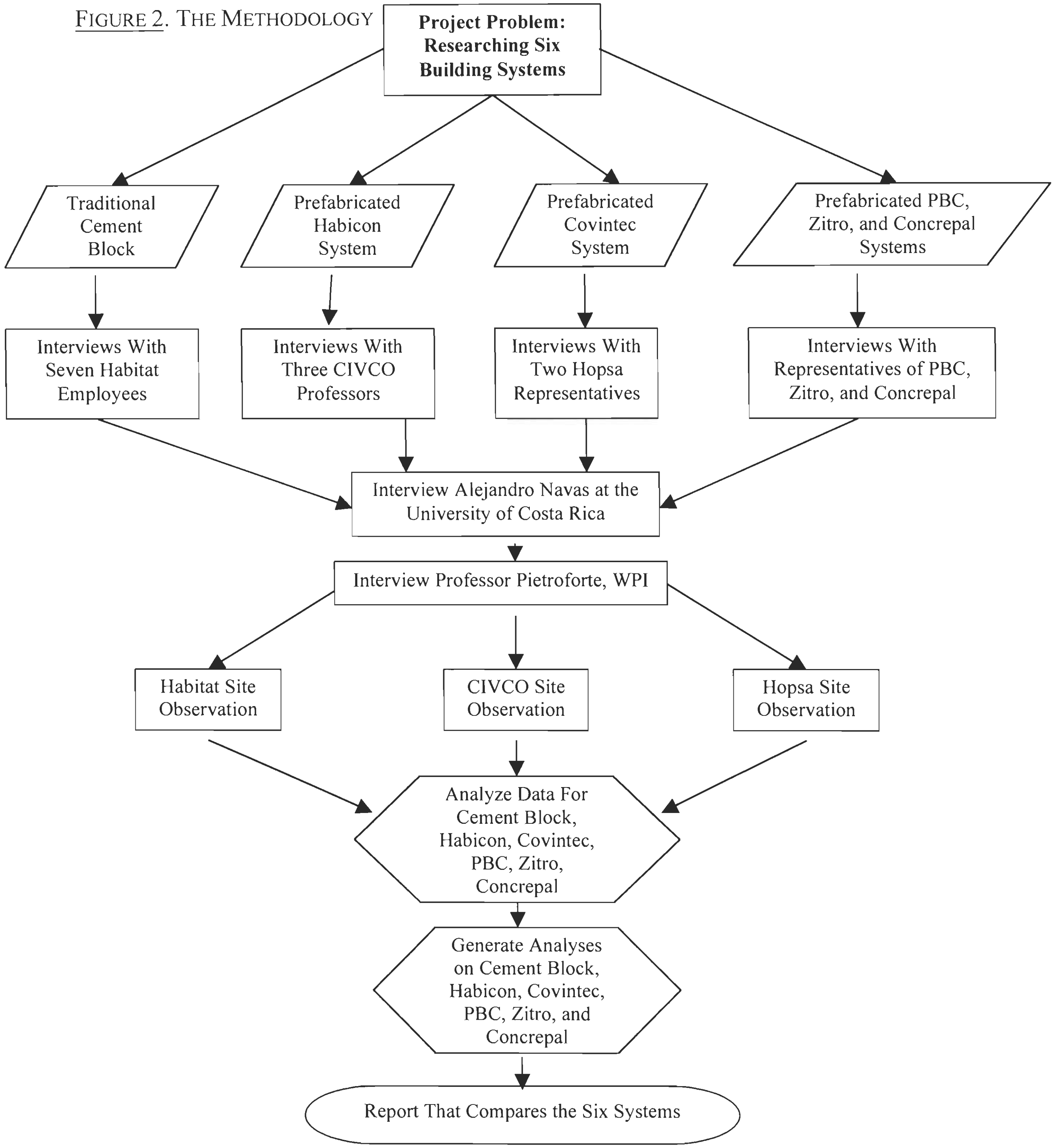
Chapter 3. Methodology

This project encompassed cost, time, quality, environmental, and social estimations of the current building methods of Habitat for Humanity and the five possible alternative building technologies for the Habitat houses. The estimations determined how the cost, time, quality, and environmental and social implications of each of the six methods compared to each other. Although quality was the primary concern for Habitat, time, cost, durability, and social and environmental implications were also seriously considered. Due to the number of systems and lack of time, we did not go into as much detail as we would have liked for the quality, environmental, and social estimations.

This methodology consisted of two major steps. The first step for this project involved performing interviews with experts and laborers in order to obtain background information on the construction of low-cost housing. Habitat for Humanity's current concrete block building system, the five alternatives, Habicon and Covintec, PBC, Zitro, and Concrepal were all examined. Site observation of the cement block, Habicon, Covintec, PBC, Zitro, and Concrepal building systems was the second step of this methodology. This step provided information on how the systems are actually built, and provided the opportunity to talk to the people who actually build with the six systems in question.

After both of the steps of the methodology were completed, the information gathered was compiled to generate the cost, time, quality, environmental, and social estimations for the six building systems. The last step was to develop a report that provided Habitat for Humanity with our conclusions and recommendations. The following figure visually shows the flow of this methodology.

FIGURE 2. THE METHODOLOGY



If the report shows that the capital and time needed for the construction of the alternative technologies was less than or equal to that of the currently used method, the quality was better, and the environmental and social implications were less than that of the current system, then the Costa Rican affiliates of Habitat for Humanity will consider adopting the technology.

The first step of this methodology, the interviewing stage, began with interviews of seven Habitat for Humanity employees. They provided background information on current Habitat methods and the alternative technologies that Habitat for Humanity was interested in pursuing.

The first Habitat interviewee, and probably the most important, was the liaison for this project, James Dolan. He was able to provide background information on Habitat for Humanity in Costa Rica, the methods that are currently used for the building of the Habitat houses, the material breakdown of a Habitat house, and the costs of the materials used in the construction. Mr. Dolan also supplied the names of other Habitat employees and other organizations that needed to be contacted in order to get important background information on Habitat building techniques and the two alternative technologies.

Fernando Chavarria, the Habitat architect in charge of all Latin American construction, was the second Habitat interviewee, and also very important. His interview helped determine what alternative technologies Habitat for Humanity has information on and which systems the organization would seriously consider. Mr. Chavarria was also able to describe which alternative technologies have been attempted or implemented by Habitat affiliates in other Latin American countries, which of these systems have been successful, and those that have not. Since Mr. Chavarria is in charge of approving all the housing designs for Latin America, he was able to provide the Costa Rican building codes. He also discussed the government Bono system, particularly how it applies to Habitat construction.

Another Habitat interview done was Wayne Nelson, the expert on alternative technologies for all of Habitat for Humanity International. This interview explained what alternative technologies are being applied by Habitat around the world, and why they are being used. Mr. Nelson also explained why some of the building technologies have failed while others have succeeded.

Other Habitat interviews were done at the San Ramon national office with the head of Habitat for Humanity in Costa Rica and a structural engineer that works for Habitat. Both of these interviews provided information on how we could get the people that are in charge of deciding if a change is going to be implemented to take us seriously. The engineer was also able to provide us with some of the information on the structural strengths of the systems.

The final Habitat interview was done with the paid construction worker that actually does the building of the Habitat houses. This interview provided information on the actual time it takes for the houses to be constructed, the ease of construction, and his general opinions on the concrete block system as a whole.

The second group of interviewees was from the CIVCO division of the Costa Rican Institute of Technology. All three of the CIVCO professors interviewed provided background information on their prefabricated system, Habicon. These interviews also helped to determine the cost of the Habicon system based on the breakdown of the raw materials used for the walls, roof, and septic system.

One of the interviewees from this group created an alternative wall assembly system for low-cost housing. The information that was provided allowed for an introductory understanding of how the wall system works. Also provided was a detailed description of Habicon and how the wall design is incorporated into the system as a whole. Another interviewee from CIVCO was a specialist in the field of the micro fiber roof tiles. Although the main objective for this project was to find an alternative for the wall system currently being used by Habitat, roof tiles were an interesting and possibly viable substitute for the zinc sheeting that is presently being used for Habitat roofs. The final interviewee from CIVCO has approached Habitat and other low-income housing organizations with alternative options to the currently used septic systems in Costa Rica. The problem of human waste is a major environmental issue in Costa Rica; and even though this also was not a major focus of this project, it was worth investigating with the hopes of curbing the problem in the near future.

The third group that was interviewed was the Hopsa representatives that are experts on the Covintec system. The Hopsa representative stationed in Costa Rica was interviewed; he provided the general background information on Hopsa and the Covintec system, locations where Covintec is being used, the names of other experts and representatives of Hopsa who can provide more useful information, and the costs of the Covintec panels and machinery needed for the construction of this system. The second Hopsa interview was done with a civil engineer working for Hopsa. This engineer supplied the information on the materials needed for a Habitat house built using Covintec. He was also able to provide an estimated price for the Covintec-Habitat house.

Interviews were also done with representatives from PBC, Zitro, and Concrepal. These interviews provided background information and the cost breakdowns on these three systems. This information was used to develop the estimations of these systems.

The interview done at the University of Costa Rica with an engineer that works with the testing of prefabricated wall systems provided background information on the prefabricated systems and their structural integrity, how the systems hold up in earthquakes and hostile weather, any problems that they might have, and any environmental implications that the systems create. The engineer also provided a report that was done ten years ago on prefabricated systems; even though the report is older, the information still applies to the systems that are currently available. Also, the engineer gave us names of other experts that we could to talk to get more information on prefabricated systems.

Professor Roberto Pietroforte was also interviewed in order go obtain more background information on prefabricated systems in general. Pietroforte is a professor at WPI, an architect, and an expert on different building systems; therefore, he was able to point out what information we would need to obtain in order to sufficiently prove that the prefabricated systems that we are examining are of good quality. He also stressed the importance of using systems that are appropriate to the areas where the building is being done.

As part of this methodology, we observed the sites where the three building systems are being implemented in Costa Rica. The specific sites visited were San Ramon for Habitat, Cartago for CIVCO's Habicon system, and Puntarenas for Hopsa's Covintec system. The purpose of visiting these locations was to visit the local offices of the corresponding organizations to get background information on how each system is being applied at the specific sites and to actually observe the construction processes done at these localities. During the observation process, we conducted some of the interviews previously mentioned. While at one current block site, the interview with the paid Habitat construction worker was accomplished.

Chapter 4. Results

The results section of this report contains the information that was gathered throughout the project on the six building systems. The information in this chapter is divided into six sections; these sections correspond to the six different building systems that are the focus of this project: concrete block, Habicon, Covintec, PBC, Zitro, and Concrepal.

Through the interviews we conducted, we gained the background information on the organizations: Habitat, CIVCO, Hopsa, PBC, Zitro, and Casas Prefabicadas Concrepal and the six systems, concrete block, Habicon, Covintec, PBC, Zitro, and Concrepal, respectively; we also obtained a cost breakdown for all six systems. We also interviewed experts who confirmed or refuted the information that we received from interviews with individuals that could have been biased toward one system. The observation of sites where the six systems are currently in use provided information on how the systems actually compare to one another.

Our results show that a Habitat house built with the Covintec system can be fully constructed in fifteen to twenty days and costs $4,533.00. The Covintec system does have some disadvantages to the current concrete block system. The first major disadvantage of this system is that it might have problems being culturally accepted, because some people may not want to have their houses built from polystyrene panels. The second problem is the polystyrene itself; polystyrene is not bio-degradeable and this causes serious environmental concern. The Covintec system has many advantages over the concrete block system. The flexibility and reduced weight let the Covintec walls move and bend with the forces of an earthquake, making them more resistant to damage during an earthquake. Another advantage of the Covintec system is its construction time. Covintec houses are constructed in half the time in takes to build a house using the concrete block system. When construction time is reduced the price of the house is also diminished.

Our results further show that the concrete blockhouse can be constructed in thirty to thirty-five days and costs $4,760.00 to construct, and it also has many disadvantages and advantages. A disadvantages of using concrete block is that it is very difficult to control the quality of all of the materials being put into the house; the concrete and the mortar used are the hardest to control. Another disadvantage is that building with concrete block is a long and difficult process; someone skilled in laying concrete block is needed in order for the house to be constructed properly. One of the main advantages of this system is this is a proven system; concrete block has been prevalent for decades, and if built correctly, these houses stay standing for a long time. This leads into the next advantage, this system is already socially accepted; the people of Costa Rica know this system well, trust it, and build with it.

A Habitat house constructed using Habicon takes twenty-two to twenty seven days to build; this is about ten days less than construction with concrete block. The Habicon house costs $4,803.00 to construct. One of the disadvantages of building with Habicon is social acceptance; the Habicon system uses pinewood as the frame for its construction. In Costa Rica, wood is something that is avoided because in the tropical weather it either rots or is eaten by the multitude of insects that live in the climate. Another problem with Habicon is the chemical that is used to pressure treat the wood, chromated copper arsenate is a poison and harmful to people and the environment. Habicon has many advantages over the concrete block system; the first and most important is that the panels that are the walls of this system can be prepared on site by the individuals who are constructing the house. For Habitat, this reduces the cost of the panels to just the cost of the raw materials. Another benefit of Habicon is that it uses much less cement than the concrete blockhouses. This should also reduce the cost of the house since concrete is one of the more expensive materials that goes into a Habitat house.

A Habitat house built using the last three systems, PBC, Zitro, and Concrepal, takes up to forty-five days to construct because Habitat only makes use of only one skilled and three unskilled laborers. A house of Habitat design built using the three systems costs: $5,320 using a PBC wall system, $6,200.00 for Zitro, and $5,316.00 using the Concrepal system. Our results show that these three systems are very similar and have many of the same advantages and disadvantages. One of the major disadvantages to Concrepal that does not apply to the other two systems is that this system is fairly experimental; it has only been available for one year; therefore, it could have problems being socially accepted. A major disadvantage for the other two systems that does not apply to Concrepal is that PBC and Zitro are older systems. Even though this makes them proven systems, these systems have not been improved upon to fix the problems that they have. Houses that are constructed using these three systems remain standing during seismic activity and earthquakes; however the walls tend to shift. As the walls shift, the panels also shift, and this causes the concrete and mortar between the panels fracture. This can cause the strength of the structure to be compromised. Another disadvantage of these systems is that each panel weighs a great deal more than the concrete blocks, this makes transporting and erecting the panels time consuming, costly, and difficult. This also this also increases the time necessary to construct one of these houses over the traditional concrete blockhouse. These systems do have their advantages thought, one advantage that applies to all three systems is that they all employ a foundation that uses less concrete than the current foundation used by Habitat. This reduces some of the time and costs for the house. Another benefit to all three systems is that the electrical installation is simplified. This occurs because the electrical conduits are already installed into the PBC columns and the Zitro and Concrepal panels. The following table compares the information on all three systems.

TABLE 1. COMPARISON OF THE SIX SYSTEMS

	Covintec	Concrete Block	Habicon
Wall/Panel Composition	Galvanized Steel Wire Matrix Polystyrene Reinforcing Steel Bars	Concrete Block Reinforcing Steel Bars Mortar	Non-Galvanized Steel Wire Grid Micro Fiber Concrete Pressure-Treated Pinewood
Unit Weight	11.33 kilograms	11.33 kilograms	60 kilograms
Foundation	20 X 20 centimeter Trench	65 X 40 centimeter Trench	6 centimeter Diameter X 80 centimeter Pillars
Roof Options	Covintec Roof Galvanized Zinc Sheeting	Galvanized Zinc Sheeting	Micro Fiber Concrete Tiles Galvanized Zinc Sheeting
Construction Time	15 to 20 Days	30 to 35 Days	22 to 27 Days
Total Cost	$4,533.00	$4,760.00	$4,803.00
Savings	$227.00	$0.00	-$43.00

	PBC	Zitro	Concrepal
Wall/Panel Composition	Non-Galvanized Steel Wire Grid Micro Fiber Concrete Reinforced Steel Columns	Non-Galvanized Steel Wire Grid Micro Fiber Concrete	Non-Galvanized Steel Wire Grid Micro Fiber Concrete
Unit Weight	20 to 93 kilograms	32 to 180 kilograms	32 to 190 kilograms
Foundation	30 X 30 X 80 centimeter Holes	20 X 30 centimeter Trench	30 X 30 centimeter Trench
Roof Options	Galvanized Zinc Sheeting	Galvanized Zinc Sheeting	Galvanized Zinc Sheeting
Construction Time	Up to 45 days	Up to 45 days	Up to 45 days
Total Cost	$4982.00	$6,156.00	$5,316.00
Savings	-$222.00	-$1,396.00	-$556.00

4.1 Covintec

Unless otherwise noted, the following sections are taken primarily from an interview with Diego Estrada, a Hopsa representative (personal communication, 05/23/2000). According to James Dolan (personal communication, 06/02/2000), the Covintec system is a proven technique because it has been used in construction for the past fifteen years, and is still being used for construction today. Covintec is based on a simple structure that incorporates a three-dimensional galvanized wire matrix with a polystyrene (Styrofoam) core into a panel that is 122 by 244 centimeters. This system provides an economical, durable, insulated, and structurally resistant system.

4.1.1 Description

The first step in constructing a Covintec house is the digging of the foundation. According to Ricardo Lincano (personal communication, 06/06/2000), the foundation for a Covintec house needs to be 20 centimeters in height by 20 centimeters in width. After this foundation is completely dug and level, steel, L-shaped mooring rods are inserted into the foundation ditch. These rods are three-eighths of an inch in diameter and 80 centimeters long. They are placed at equal distances throughout the foundation, and a forty centimeter portion of the rod is located above the foundation. When the concrete foundation is poured over these rods they support, reinforce, and ground the panels.

The Covintec panels are then slid down on top of the foundation, thereby positioning the mooring rods parallel to and in-between the polystyrene and the galvanized wire in order to hold the panel in place. Hopsa recommends that the polystyrene be heated behind the mooring rods so they adhere to each other. Before the panels are connected to each other, metal or wood beams are positioned against the panels and the ground in a forty-five degree angle to keep the panels flush with each other.

The panels are then tied together with galvanized wire braces by hand or with a wire gun. The small wire braces wrap around the outer mesh of two panels, thereby connecting them. The connections are made every four inches, or at every other horizontal intersection of the panels mesh wiring. In the corners the panels are connected the same way, but an addition a piece of metal or wood is placed in the corner and connected to the panels by U-nails for additional reinforcement.

The construction of doors, windows, and vents is a straightforward procedure. The shape of the door, window, or vent is cut from the preexisting walls. The wire is cut out with wire cutters and the polystyrene can be removed with a knife or it can be burned out. Once the desired cutout is achieved, the contour is reinforced with extra pieces of the panels and connected in the same manner as the walls.

The installation of the electrical wiring involves burning the polystyrene with a blowpipe or a burner and then feeding the wires underneath the wire mesh. Then the electrical boxes can be positioned inside the panels by cutting out a portion of the mesh that is the same size as the electrical box.

The covering of the walls with the mortar is divided into two steps. The first step consists of applying a thick layer of mortar with a mortar gun that is attached to an air compressor or by throwing the mortar up with a shovel. This covering must be sufficient to cover the mesh with a one centimeter thick layer. Sometimes another thick layer needs to be applied to make sure that all of the wire mesh is covered. After the thick layers are finished, the thin coat is applied for aesthetics. In order to prevent cracks in the finish, any imperfections in the mortaring must be fixed within forty-eight hours.

The roofing structure of a house constructed with Covintec can be made of the Covintec panels themselves or with the zinc sheeting that Habitat for Humanity currently employs. The frame of the roof can be constructed with either wood or metal purlings which are horizontal supporting beams for the roof. If the roof is constructed of Covintec, the panels are connected to the purlings with U-nails, and then the panels are connected in the same manner as the walls. They are also sealed with the mortar in the same fashion as the walls, but colored clay can be added to the mortar for appearance purposes. If the roof is made of the zinc sheeting with metal purlings, then the sheeting is welded on. If the sheeting is applied over wood, then the zinc sheeting is just nailed to the purlings.

4.1.2 Disadvantages to the Covintec System

Although there are many advantages to the prefabricated Covintec system, there are also several disadvantages. Sr. Chavarria (05/18/2000) addressed many of these disadvantages during an interview. One major problem is technology dependence. Sr. Chavarria believes that the "ultimate system" is one that can be totally manufactured in Costa Rica. The materials needed for this system would have to be shipped from Panama and this fact creates some concern for Sr. Chavarria. Although in an interview with Diego Estrada (05/23/2000), the representative from Hopsa, he stated that his company would be opening up a plant in Costa Rica within one year.

Another large problem with the system is cultural acceptance. While Oscar Arias was President of Costa Rica from 1986 to 1990 (http://members.eb.com), he initiated the

Bono program that donated land and built houses for underprivileged families. Although Arias was greatly appreciated for all of his efforts to combat poverty, the houses he had built were made of Styrofoam. Because the walls had no internal reinforcement and the wood that supported the walls rotted away, all the houses got infested with rats and they were eventually eaten away. According to James Dolan (05/30/2000), all of the Costa Ricans remember the Styrofoam disaster and he believes that it will cause problems in getting the Covintec system to be accepted.

Another disadvantage also lies within the polystyrene. Polystyrene is not biodegradable and this causes great environmental concern. If the house is torn down, it will be difficult to deposit or reuse the material. Also, polystyrene emits noxious gas when burned. This may not be a problem because the Covintec polystyrene burns at 300 degrees Celsius, but it could still be a major concern.

4.1.3 Advantages to the Covintec System

According to the head Latin American architect for Habitat for Humanity, Fernando Chavarria (personal communication, 05/17/2000) and Diego Estrada (05/23/2000), the Hopsa representative in San José, there are many advantages to using the Covintec system. One main advantage concerns the weight and flexibility of the panels; because the panels are made of a polystyrene and wire matrix covered in mortar, they are much lighter and more flexible than the concrete block walls that Habitat is using. The panels' flexibility and reduced weight let the Covintec walls move and bend with the forces of an earthquake, making them more resistant to damage than concrete blocks. According to Sr. Chavarria (05/18/2000), concrete block walls move in a serpentine motion during an earthquake, this causes a high probability for the walls to collapse; a Covintec wall cannot fall unless all the walls fall. Because of the way that the panels are connected to each other and reinforced to the foundation, this is virtually impossible. Sr. Chavarria (06/26/2000) also stated that even though there is not much documented seismic information on this system, or any of the other proven systems that we examined for this project: concrete block, PBC, and Zitro, all of these systems have been proven to be seismically sound by the fact that the buildings that have been constructed using these systems are still standing.

Another advantage to the Covintec system is construction time. Sr. Chavarria (05/17/2000) and Diego Estrada (05/23/2000) stated that the panels are easy and quick to erect, and there is less room for error in construction with the Covintec system than with the current concrete block system. When construction time is reduced, the price of the house automatically drops. In addition, many things are required for a typical Habitat house that Covintec does not need. One example is a crown beam that is placed on the top of the wall structure before the roof is constructed. The Covintec system does not require a crown beam and therefore, cost and labor are cut.

Another benefit to this system are the materials that the panels are made of and how they are constructed. The wire is galvanized to prevent rust, which is extremely important because of all the rainfall in Costa Rica. Also, the Styrofoam is very durable and it will not break down; in addition to that the Styrofoam is very fire resistant, it will only burn at temperatures at or above 300 degrees Celsius. The way that the panels are constructed makes them very resistant to break in. In the typical concrete blockhouse someone who wishes to break in can pop out individual blocks with a sledgehammer. To get through the Covintec panels one must break through a layer of mortar, cut through a galvanized wire grid with wire cutters, cut through the Styrofoam, cut through another galvanized wire grid, and then break through another layer of mortar. This is not a simple and quick break in, therefore making the Covintec system safer than the traditional Habitat house.

The following three paragraphs show how well a system similar to Covintec withstood harsh conditions; we are using this as a positive comparison to how Covintec would perform under similar conditions. This section is taken primarily from an article by Nancy Ross found in the Washington Post (09/02/1992). After Hurricane Andrew swept through Dade County, FL, in 1992, there was severe concern over why so many houses were lost despite strict building codes requiring structures to withstand winds over 120 miles per hour. A group of houses that survived the hurricane were built in 1991 by Habitat for Humanity. These houses were built with prefabricated polystyrene and wire panels encased in concrete. All fourteen houses built by Habitat in Liberty City, Miami, were all structurally intact, along with a house in Homestead, FL that was the site of the worst destruction.

The houses in Florida were made of panels from the Insteel Construction Systems; these panels are almost exactly the same as the Covintec panels. In June of 1992, the vice president of Insteel, Gerald B. West, told a trade publication: "When the panel system is used for a total building, its potential for fire safety, hurricane and seismic resistance is superior to virtually any other standard building system."

In April of 1990 the Concrete Construction Magazine reported that 200 houses in Puerto Rico that were built of a polystyrene and wire panel system experienced no structural damage during Hurricane Hugo, where winds exceeded 195 miles per hour.

4.1.3.1 Covintec Societal Implementation

Klaus Stadthagen (personal communication, 06/23/2000), the Hopsa representative in Matagalpa, Nicaragua provided information on the societal aspects of implementing Covintec into a third world country. There was a great deal of skepticism in Matagalpa when Habitat decided to use Covintec instead of concrete block. One area of great concern was the polystyrene panel that gave the impression of a light, low-resistance wall. To overcome the skepticism, Hopsa and Habitat had to decide upon a way to prove to the people that there were additional benefits to the Covintec system: faster to construct, stronger, and better thermal and acoustic insulation.

Hopsa and Habitat ran an educational program for all of the families about the Covintec system. This program included seminars, construction videos, and pictures of all the steps in the construction process. Hopsa also donated all of the Covintec materials necessary to build a model house in Matagalpa, this was done with three purposes in mind: to allow the families to see the construction process and how quick it is, to train the locals how to construct the system, and to let them feel the strength of the system once it was finished. Once this education program was finished, along with the construction of the model house, all sixty-five families who were waiting for the initiation of construction of their houses opted for the Covintec system over the traditional system.

4.1.4 Covintec Costs

Based on the material and cost breakdown that Diego Estrada (05/23/2000) provided on what is needed for a house built with Covintec, and the quantities of the materials that Ricardo Lincano (06/06/2000) stated that a house of Habitat design would need, the cost breakdown of a Habitat house built out of Covintec was determined. The foundation and walls were changed, and the crown beam was taken out entirely. The floor, pluming, electric, windows and doors, roof, and fixed costs stayed the same. The total cost of the Habitat house built with Covintec walls came to $4,568. The following table shows the cost breakdown of the house.

TABLE 2. A HABITAT HOUSE BUILT WITH COVINTEC

Section	Section	Quantity	Cost in Colones	Cost in Dollars
Cement	*Cimiento*	*1*	*¢54,214.68*	*$178.34*
Walls	*Paredes*	*1*	*¢440,687.00*	*$1,449.63*
Roof	*Techos*	*1*	*¢141,867.00*	*$466.67*
Floors	*Pisos*	*1*	*¢61,026.00*	*$200.74*
Pluming	*Plomeria*	*1*	*¢97,916.76*	*$322.09*
Septic Tank	*Tanque Sectico*	*1*	*¢66,494.00*	*$218.73*
Windows and Doors	*Ventanas y Puertas*	*1*	*¢93,083.23*	*$306.19*
Electric Installation	*Instalacion Electrica*	*1*	*¢86,152.48*	*$283.40*
Roofer	*Thechos*	*1*	*¢12,000.00*	*$39.47*
Doors	*Puertas*	*1*	*¢18,000.00*	*$59.21*
Glass	*Virdios*	*1*	*¢28,000.00*	*$92.11*
Construction Supervisor	*Maestro de Obra*	*1*	*¢40,000.00*	*$131.58*
Legal Fees	*Costas Legal*	*1*	*¢74,250.00*	*$244.24*
Transportation	*Transporte*	*1*	*¢12,334.00*	*$40.57*
Mason	*Albanil*	*1*	*¢89,255.00*	*$293.60*
Maintenance	*Costas Mantentimiento*	*1*	*¢4,560.00*	*$15.00*
Administration Fees	*Costas De Administracion*	*1*	*¢68,736.98*	*$226.11*
		Total Cost	*¢1,388,577.13*	*$4,567.69*

4.2 Concrete Block

Manuel Granados (personal communication, 05/20/2000), the paid construction worker for one of the housing groups in San Ramon, Costa Rica, gave us his estimation on the time of construction of a Habitat house out of concrete block. Later James Dolan (05/30/2000) confirmed, with other construction workers at other building locations, that the typical Habitat house takes thirty to thirty-five, ten hour days to construct.

4.2.1 Description

This section is based on the information that was gathered from James Dolan (05/16/2000, 05/20/2000) and Fernando Chavarria (05/17/2000, 05/18/2000). Habitat for Humanity builds a forty-eight square meter house using concrete block. The construction of the house begins with the foundation; a 65 centimeter by 40 centimeter trench is dug around the perimeter of the house and under the bathroom walls. Four reinforcing steel bars are placed into the foundation, and the trench is filled with 25 centimeters of concrete. After the concrete solidifies, two rows of concrete block are laid below the level of the ground, this way the walls are grounded to the foundation.

The walls are constructed using 12 by 20 by 40 centimeter concrete blocks; every 20 centimeters reinforcing steel bars are run vertically through the concrete blocks to provide added strength to the walls. Every two rows, reinforcing bars also run horizontally through the entire wall structure; the bars are also used to reinforce the frames of the windows and doors. As the walls are being constructed the pipes for electrical wiring and pluming must be installed. In order to install the pipes, holes must be made in the concrete block to let the pipes run through.

Once the walls are fully constructed a crown beam is poured. This beam connects the four walls into one solid structure, adding strength to the structure of the house. Depending on the design of the house, either on the 6 meter walls or the 8 meter walls, a tapichel is constructed on top of the crown beam. The tapichel portion of the wall forms the triangle that meets the sloped part of the roof. The construction of the crown beam and tapichel are very time consuming. After all the walls and tapichels are completed, the walls are covered with mortar; once the mortar is in place, the owners of the house can paint it.

On top of the walls and on the tapichels, either wooden or metal purlings are attached; these serve as the support structure for the roof. When the purlings are in place, galvanized zinc sheets are welded on to produce the roof of a Habitat house.

Once the exterior of the house is completed, a concrete floor is poured. If the soil contains a great deal of clay, a wire grid is put down to keep the ground in place; otherwise, the concrete is just poured right onto the ground and leveled. Once the structure of the house is complete, the windows, doors, and interior fixtures are installed, and a septic tank is installed. Once all of these portions of the house are done, Habitat is finished with construction of the house, and it is up to the families to put the finishing touches onto their house.

4.2.2 Disadvantages of Concrete Block

One of the major disadvantages of using concrete block is that it is very difficult to control the quality of the mortar and concrete that is used for the foundations. Each construction site mixes its concrete with different amounts of water; this makes it very difficult to control the quality or viscosity of the concrete. If concrete is too watered down it will not be as structurally stable as required by Costa Rican law.

Another disadvantage of building with concrete block is the long and difficult process of construction. A skilled laborer is necessary when laying concrete block, otherwise the structural integrity of the house is compromised. According to James Dolan (05/20/2000) and Fernando Chavarria (06/09/2000), the long building time prevents continuity in construction. The concrete mixed one day may not be the same as the next day; therefore, the blocks are not held together with the same strength mortar. This can causes weak spots in the structure of the house that can be compromised during seismic activity and natural disasters.

4.2.3 Advantages of Concrete Block

Fernando Chavarria (06/09/2000) states that an advantage of using concrete block is that it is a proven system; in Costa Rica concrete block is used for most of the low cost housing. If properly constructed, a house built with concrete block should be able to withstand all natural occurrences including earthquakes. Because most Costa Rican people have everyday exposure to concrete block, this system is considered socially acceptable. In addition to concrete block being very reliable, it is has also been proven over time to be fireproof.

Professor Pietroforte (personal communication, 06/14/2000) noted that the concrete block that is currently used by Habitat for Humanity is appropriate for the low income society of Costa Rica. This system is appropriate for several reasons: low cost, relatively low skill involved in construction, and there is no necessity for special equipment. This system is also advantageous because the construction of a concrete block house is very labor intensive; in theory, the more labor intensive a construction process is, the more beneficial the process is to society because it creates work for low income citizens.

4.2.4 Concrete Block Costs

Based on the costs of the materials needed to build a Habitat house that were obtained from James Dolan (05/16/2000) and Fernando Chavarria (05/18/2000), the current cost of a Habitat house was determined. This information was the basis for the cost estimations of a Habitat house built with all five alternative sysems. The total cost of a Habitat house includes all of the materials, the septic tank, electrical and pluming installation, windows and doors, the roof, and all of the administrative costs; this comes to be $4,760. The following table is the cost breakdown of the current Habitat house.

TABLE 3. A HABITAT HOUSE BUILT WITH CONCRETE BLOCK

Section	*Section*	*Quantity*	*Cost in Colones*	*Cost in Dollars*
Cement	*Cimiento*	*1*	*¢74,757.68*	*$245.91*
Walls	*Paredes*	*1*	*¢294,912.70*	*$970.11*
Beams, Rafters, and Crown	*Viga Corona y Tapichel*	*1*	*¢99,094.70*	*$325.97*
Roof	*Techos*	*1*	*¢141,867.00*	*$466.67*
Floors	*Pisos*	*1*	*¢163,826.73*	*$200.74*
Pluming	*Plomeria*	*1*	*¢97,916.76*	*$322.09*
Septic Tank	*Tanque Sectico*	*1*	*¢66,494.00*	*$218.73*
Windows and Doors	*Ventanas y Puertas*	*1*	*¢93,083.23*	*$306.19*
Electric Installation	*Instalacion Electrica*	*1*	*¢86,152.48*	*$283.40*
Roofer	*Thechos*	*1*	*¢12,000.00*	*$39.47*
Doors	*Puertas*	*1*	*¢18,000.00*	*$59.21*
Glass	*Virdios*	*1*	*¢28,000.00*	*$92.11*
Construction Supervisor	*Maestro de Obra*	*1*	*¢40,000.00*	*$131.58*
Legal Fees	*Costos Legales*	*1*	*¢74,250.00*	*$244.24*
Transportation	*Transporte*	*1*	*¢12,334.00*	*$40.57*
Mason	*Albanil*	*1*	*¢178,510.00*	*$587.20*
Administration Fees	*Gastos De Administracion*	*1*	*¢68,736.98*	*$226.11*
		Total Cost	*¢1,549,936.26*	*$4,760.31*

4.3 Habicon

The following four sections are based on the information that was gathered in an interview with Professors Rolando Fournier Zepeda and José Francisco Pacheco (personal communication, 05/26/2000) unless otherwise noted. CIVCO has developed several new housing systems that range from new septic systems to new wall structures and new roofing tiles. Habicon is a prefabricated system that incorporates both micro fiber concrete wall structures and roofing tiles. CIVCO's Habicon system is an innovative technology that aims use only materials that can be produced in Costa Rica.

Because of CIVCO's goal of using only resources that can be produced in Costa Rica, Habicon is constructed using pressure-treated pinewood for the frame, and micro fiber concrete panels for the walls and floors of the house. This is very unique for Costa Rica, because according to James Dolan (personal communication 05/16/2000), untreated wood rots very easily and quickly in Costa Rica because of the large amount of rain and insects that can destroy the wood.

4.3.1 Description

The Habicon system is very unique because it does not require a foundation. Instead of the traditional foundation trench, 80 centimeter deep holes are drilled into the soil; the holes are then filled with concrete to make the pillars that the house sits on. The main and the load bearing wooden beams are then attached to these pillars. Using the solid beams as a base, a pressure-treated pinewood frame is constructed to serve as an outline for the house; metal connectors are used to hold the wooden frame together.

Concrete panels are then slid into the furrows found in the supporting wooden beams; these panels serve as both the wall and floor systems. These panels consist of an internal non-galvanized wire grid encased by a mixture of concrete and micro fiber. After the panels are in place, mortar is used to caulk the separations between the panels. The finishing touch involves applying a layer of plaster over the entire surface of the structure, both inside and out. The finished panels are only one inch in thickness and weight up to 60 kilograms, but they can withstand a bullet fired from a thirty-eight-caliber pistol, the force of a fifty kilogram weight swung into the panels, and fire.

The Habicon roofing assembly is also very unique. A wooden frame, separate from the house frame, is constructed and mounted on the existing wall structure. The tiles used for the roof are made of the same micro fiber and concrete material as the wall panels. These tiles are attached to the wooden frame by wires that are implanted into the tiles when they are being made. The tiles weigh approximately 30 kilograms. The color of the tiles can be manipulated through adding ochre to the concrete.

4.3.2 Habicon Disadvantages

The major disadvantage of the Habicon system that Professor Zepeda (05/26/2000), James Dolan (06/07/2000), and Fernando Chavarria (06/09/2000) mentioned was social acceptance. Typically, richer citizens build with blocks, and the underprivileged want the same type of construction because they recognize concrete block as quality. Habicon makes use of pinewood as its frame; in Costa Rica wood is something that is avoided in construction because the humidity promotes wood rot, and insects thrive in the Costa Rican climate.

Another major problem with the wooden frame is the chemicals used in the pressure-treatment process. The CCA is cancer causing agent, that when used incorrectly, can cause severe adverse effects on the environment and its inhabitants (Dave Mason, personal communication, 06/19/2000).

Another disadvantage of the Habicon system is that the internal metal grid is made of non-galvanized wire; although the structure has a layer of plaster over all the panels and exposed wires; non galvanized wire has a strong incidence of rust.

Human error is also a possible disadvantage for the Habicon system. As in the concrete block system, each individual mixes concrete differently. Wayne Nelson (personal communication, 06/19/2000) is wary of all concrete panels that are produced on site without proper quality control because of a high incidence of failure in previous Habitat attempts with similar systems.

Start up costs are also an issue when considering Habicon. In order to be able to produce the panels and tiles on site, vibrating tables, cement mixers, and molds are needed. All of these supplies are very expensive and require excessive transportation. This may prove to be too expensive for Habitat for Humanity.

4.3.3 Habicon Advantages

Habicon has been designed to reduce waste, building time, cost, and environmental disturbances; because of this Habicon has many advantages over other building systems. The first advantage concerns the production of both the panels and the roofing tiles. When dissecting the cost of a tile, there are four categories that when summed together to produce the total cost. These four categories are raw material, labor, fixed costs, and utility of enterprise. Raw materials account for everything that goes into the tiles: the concrete, micro fiber, and wire. The cost of labor includes what is paid to the workers for the production of the tiles. The fixed costs and utility of enterprise costs cover the costs of marketing the product, the administrative costs, transportation, and equipment depreciation. However, people who are building the houses are trained by CIVCO to produce the panels and tiles themselves. Training people to build the tiles themselves removes the middleman. By removing the middleman, the advertising, administrative, and equipment depreciation costs are removed; thus eliminating the fixed and utility costs, thereby saving money on the panels. According Professor Zepeda (05/26/2000), this reduces the cost by 79 percent, because that having the panels and tiles produced by the families eliminates every cost except for the raw material costs.

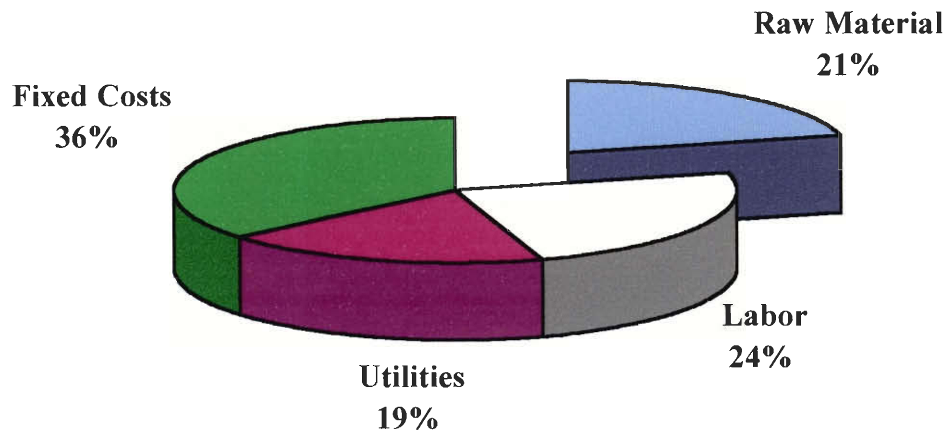


FIGURE 3. COST BREAKDOWN OF A HABICON MICRO FIBER PANEL

After the training, it takes five people two days to produce all the panels and tiles needed for one house and one roof. Another five days are needed for the panels and tiles to dry enough to be ready for use. One additional day is necessary to produce all the metal connectors needed for the frame of the house. After all the materials for the house are produced, it takes approximately fifteen days to construct the house using one skilled laborer and three unskilled laborers; therefore, complete construction time is approximately twenty-two to twenty-seven days for a Habicon house.

Another important benefit of the Habicon system is that when it is compared to the current methods used by Habitat for Humanity, Habicon uses less cement in its construction of foundations and wall structures. A problem with using cement is that over 50 percent of its cost is in the petroleum used for transportation. Because of the difficulty in transportation, concrete is not easy to make in Costa Rica. Another problem with concrete is that it requires reinforcement materials such as steel. Costa Rica itself has very little iron ore and is forced to import steel from Russia, Brazil, and several other countries. Because of the reduction in the amount of steel needed in the Habicon system, the overall cost of the house is reduced.

Using wood in the Habicon system is also beneficial because the pinewood that is used for the frame of the house is taken from a Costa Rican plantation; this means that the wood is harvested as if it were a crop instead of just logging the country's forests. Costa Rica's wood plantation has over one hundred fifty hectares of different species of trees. Using wood is also beneficial because it does not have to be imported unlike steel, therefore, creating jobs and income for Costa Ricans. After the pinewood has been harvested, it is pressure treated with a mixture called Chromated Copper Arsenate or CCA. This treatment theoretically adds at least fifty years to the life of the pinewood and decreases incidence of rot and bug infestation.

According to Professor Zepeda (05/26/2000), the Habicon system increases the interior area of the six by eight meter house by 10 percent. This is because current low cost houses are built using concrete blocks that are twelve centimeters in width; Habicon panels are only one inch thick. The floor space is further increased because the panels are attached to the outside of the wooden frame instead of the inside or middle.

Another benefit of the Habicon house is that it is more flood resistant than a traditional house because it is built on top of concrete pillars that can be elevated up to 40 centimeters above the ground. This makes finding areas to build houses easier because they can be built in swampy areas and on land with up to a 20 degree slope. According to

Fernando Chavarria (05/17/2000), traditional foundations disturb natural vegetation and compromise the strength of the soil. Because Habicon is built on a system of stilts, it avoids many of these problems.

4.3.4 Habicon Costs

Based on the cost breakdown of the materials needed to build a Habicon house that CIVCO and Professor Escalante (personal communication, 06/13/2000) provided, we were able to determine what would be needed to build a Habitat house using the Habicon wall system. The plumbing, electric, roof, septic, and all administrative costs stayed the same, but the foundation, walls, and floors changed and the tapichel was taken out completely. The total cost of the Habitat house built with Habicon comes out to $4,803. The following table is the cost breakdown of this house.

TABLE 4. A HABITAT HOUSE BUILT WITH HABICON

Section	*Section*	*Quantity*	*Cost in Colones*	*Cost in Dollars*
Tracing	*Trazado*	*1.00*	*¢9,640.00*	*$31.71*
Foundations	*Cimientos*	*1.00*	*¢31,862.85*	*$104.81*
Floor	*Entrepiso y Piso*	*1.00*	*¢205,746.00*	*$676.80*
Walls Finishing	*Afinado Pared*	*1.00*	*¢58,792.00*	*$193.39*
Walls	*Parades*	*1.00*	*¢390,228.10*	*$1,283.65*
Roof	*Techos*	*1.00*	*¢141,867.00*	*$466.67*
Pluming	*Plomeria*	*1.00*	*¢102,916.76*	*$338.54*
Septic Tank	*Tanque Sectico*	*1.00*	*¢76,494.00*	*$251.63*
Windows and Doors	*Ventanas y Puertas*	*1.00*	*¢103,083.23*	*$339.09*
Electric Installation	*Instalacion Electrica*	*1.00*	*¢86,152.48*	*$283.40*
Roofer	*Thechos*	*1.00*	*¢12,000.00*	*$39.47*
Doors	*Puertas*	*1.00*	*¢18,000.00*	*$59.21*
Glass	*Virdios*	*1.00*	*¢28,000.00*	*$92.11*
Legal Fees	*Costos Legales*	*1.00*	*¢74,250.00*	*$244.24*
Transportation	*Transporte*	*1.00*	*¢12,334.00*	*$40.57*
Construction Supervisor	*Maestro de Obra*	*1.00*	*¢40,000.00*	*$131.58*
Administration Fees	*Gastos De Administracion*	*1.00*	*¢68,736.98*	*$226.11*
		Total Cost	*¢1,460,103.40*	*$4,802.97*

4.4 PBC

PBC stands for Prefabricadora de Baldosas y Columnas S.A., or the prefabrication of tiles and columns.

4.4.1 Description

The PBC building system consists of two major parts: steel reinforced concrete columns and micro fiber concrete panels. A PBC panel is made of a non-galvanized wire grid incased in micro fiber concrete; the grid intersects every 15 centimeters. At the top of the panels, two wires from the grid protrude out of the concrete to allow roof-supporting purlings to be welded to the panels. Each PBC panel is 3.8 centimeters thick and 50 centimeters high, the panels come in eight different widths: 1.9 meters, 1.65 meters, 1.4 meters, 1.27 meters, 1.15 meters, 0.9 meters, 0.65 meters, and 0.4 meters. The normal panels range in weight from 20 kilograms to 93 kilograms.

Each reinforced concrete column has four reinforcing steel bars running vertically through the length of the column; every 20 centimeters a square piece of reinforcing steel bar connects the four vertical reinforcing steel bars within the cement. The reinforced columns are 13 centimeters by 13 centimeters, and come in two heights, 3.3 meters or 3.8 meters. The columns have grooves that allow the panels to slide into place and stay stable; they vary in shape according to the number of panels that connect to the column.

The walls are constructed by horizontally placing the micro fiber panels, one on top of the other, in between the concrete columns that rise vertically 3.3 meters from the foundation. As stated in the PBC construction manual, the PBC house does not need a foundation. Instead, 30 centimeter long by 30 centimeter wide by 80 centimeter deep holes are dug for the reinforced columns every 0.5 meters to 2.0 meters, depending upon the length of panel used.

Once the holes are dug, the reinforced columns are placed into the holes, and concrete is poured to fill the holes in order to secure the columns in the ground. Once the columns are in place, the panels are slid between the supporting columns until the space between the columns is filled with five to six panels. According to Enrique Baz (personal communication, 06/20/2000), a PBC representative, the panels can be left without any adhesive keeping them together, or they can be connected using mortar. When installing a window, a column must be placed on each vertical side of the window frame; panels are then slid between the columns to cover the area that the window does not occupy.

Once the walls are in place, PBC uses a crown that is made of fibrolit, a new formula of asbestos cement sheeting that uses natural fiber and is not harmful or cancerous, to connect the walls to the roofing assembly. Once construction is finished, PBC uses a kind of plastic paint, called revistimiaento, to cover the seams created by joining panels. Once this is done, the builder can cover the wall with mortar or cement, paint the wall, plaster the wall, or leave it untouched.

PBC has developed a column with the electrical conduits and a line that goes to the circuit breaker already installed. This makes the installation of the electrical system simple; however, in order to install the pluming, a hole needs to be made in the panel for a pipe to run from the sink, toilet, or shower into the septic tank.

4.4.2 PBC Disadvantages

The PBC system has many disadvantages; the most important to Fernando Chavarria (06/09/2000) is that PBC is an older system. Even though this makes PBC a proven system, this system has not been improved upon to fix some of the problems that it experiences.

According to Sr. Chavarria (06/09/2000), even though a house constructed using PBC remains standing during seismic activity and earthquakes, the walls tend to shift. As the walls shift, the horizontal concrete panels also shift. This causes the mortar between the panels fracture; therefore, after every earthquake or tremor the panels need to be resealed. This costs money, takes up time, and the strength of the structure is compromised.

Sr. Chavarria (06/26/2000) also stated that mistakes that compromise the strength of the house are easy to make when building with PBC. The most frequent mistakes made are not lining up the panels correctly, or digging the holes for the columns too close or too far apart so that panels do not fit between the columns. The houses built out of PBC have columns that invade the living areas of the house; many people find it uncomfortable, unattractive, and difficult to arrange furniture.

Another disadvantage with this system is that the ground that it is constructed on needs to be level so that the panels can be stacked correctly. Most of Costa Rica is not level; thus filling and leveling land must be done often and accurately for this system to work well. Also in order to slide the panels between the columns, the columns need to be perpendicular with the ground. If they are not, the panels will not fit between the columns.

Diego Estrada (06/30/2000) believes that because the weight of each panel, transporting and erecting the panels will be time consuming, costly, and difficult. A truck that could hold an entire house of Covintec panels could hold only one side of a house of PBC panels. Also according to a PBC pamphlet, these houses can be constructed in less than forty-five days; according to Enrique Baz (06/22/2000) estimated that a 48 square meter house would take approximately seven weeks, or thirty-five days, to construct; however Habitat only uses four workers at a time, so a house could take up to forty-five days to construct. In relation to time, this system is not an improvement over the concrete block.

4.4.3 PBC Advantages

There are also several advantages to using the PBC system. The first and most important is that this system is a proven system. PBC has been used for construction in Costa Rica for the past three years; however a similar system, known as PC, has been used in Costa Rica for the past ten years. Therefore, the Costa Rican people are used to this system and accept it. Another advantage that comes from PBC being a proven system is that since it has been used in Costa Rica for the past three years it is common knowledge that this system can withstand seismic activity and earthquakes.

Similar to the Habicon system, PBC does not need a complete foundation trench, only the holes for each column need to be dug. This makes the construction of the foundation less labor intensive and it saves time and money on materials. Another advantage to this system is that it decreases the amount of cement needed for each house. The only cement used in the construction of the house is in the concrete that is used to fill the hole around the columns, the mortar used to connect the panels together, or the mortar or concrete that the contractor may use to cover the walls.

The simplicity of construction is another advantage to this system. In theory, a house made out of PBC should be easier to construct than one built out of concrete blocks. According to Fernando Chavarria (06/09/2000), because this is a prefabricated system, fewer mistakes should be made when constructing with PBC and quality will be easy to control. Another advantage that is provided by this system is that the installation of the electrical system is made easier and quicker due to the fact that the electrical conduits are already installed into the columns.

4.4.4 PBC Costs

Based on the cost breakdown of the materials needed to build a house that uses PBC walls that was obtained from Enrique Baz (06/22/2000), we were able to determine what would be needed to build a Habitat house using the PBC wall system. The plumbing, electric, roof, septic, floors, and all administrative costs stayed the same, but the foundation, walls, and tapichels changed. The total cost of the Habitat house built with PBC comes out to $4,982. The following table is the cost breakdown of this house.

TABLE 5. A HABITAT HOUSE BUILT WITH PBC

Section	***Section***	***Quantity***	***Cost in Colones***	***Cost in Dollars***
Foundation	*Cimiento*	*1.00*	*¢56,997.68*	*$187.49*
Walls	*Parades*	*1.00*	*¢414,221.84*	*$1,362.57*
Fibrolit Crown and Purlings	*Tapichel de Fibrolit y Perling*	*1.00*	*¢87,642.00*	*$288.30*
Roof	*Techos*	*1.00*	*¢85,761.00*	*$282.11*
Floors	*Pisos*	*1.00*	*¢61,026.00*	*$200.74*
Pluming	*Plomeria*	*1.00*	*¢97,916.76*	*$322.09*
Septic Tank	*Tanque Septico*	*1.00*	*¢66,494.00*	*$218.73*
Windows and Doors	*Ventanas y Puertas*	*1.00*	*¢93,083.23*	*$306.19*
Electric Installation	*Instalacion Electrica*	*1.00*	*¢73,039.12*	*$240.26*
Roofer	*Techos*	*1.00*	*¢12,000.00*	*$39.47*
Doors	*Puertas*	*1.00*	*¢18,000.00*	*$59.21*
Glass	*Virdios*	*1.00*	*¢28,000.00*	*$92.11*
Construction Supervisor	*Maestro de Obra*	*1.00*	*¢40,000.00*	*$131.58*
Legal Fees	*Costos Legales*	*1.00*	*¢74,250.00*	*$244.24*
Transportation	*Transporte*	*1.00*	*¢12,334.00*	*$40.57*
Mason	*Albanil*	*1.00*	*¢225,000.00*	*$740.13*
Administration Fees	*Costos De Administracion*	*1.00*	*¢68,736.98*	*$226.11*
		Total Cost	*¢1,514,502.61*	*$4,981.92*

4.5 Zitro

The Zitro system was created in 1988 and has been used to build more than 10,000 houses. (Zitro Construction Guide, 1997: 1). According to Flor Arauz (personal communication, 06/23/2000), Zitro's representative, Zitro is based in Costa Rica in Ciruelas Alajuela.

4.5.1 Description

The Zitro panel is made of the same materials as a PBC panel: a non-galvanized wire grid incased by micro fiber concrete. This grid intersects every 15 centimeters. At the top of the panel, two pieces of wire protrude out of the concrete so that roof-supporting purlings can be welded to the panels. Each panel is 6 centimeters thick and comes in two different widths: 50 centimeters and 75 centimeters. Both the 50 centimeter and the 75 centimeter panels come in five heights: 2.6 meters, 2.0 meters, 1.3

meters, 1.0 meters, and 0.7 meters. The panels range in weight from 32 kilograms to 180 kilograms. The panels connect to each other and stay stable using an indent that runs the height of the panel.

The Zitro foundation consists of a 20 centimeter by 30 centimeter trench dug around the perimeter of the house and anywhere else the Zitro panels are intended to go. In the foundation at every 50 or 75 centimeters, a 10 centimeters high cement block, the shape of a trapezoid, is placed in the foundation trench. Reinforcing steel bars are used to line the exterior and interior perimeter to provide the panels with added strength and stability.

Once the foundation is prepared, the panels placed on the blocks in the foundation; one end of each panel on top of a different block, each block supports two connected panels. The reinforcing steel bars that line the perimeter of the foundation hold the panel in place at the base. Once the panels are lined up and even, cement is poured into the hole created by the U-shaped indents of each panel; this secures each panel to the other and creates a solid wall. Once the panels are attached to one another, the remaining space of the foundation is filled in with concrete. This method creates a wall that is solid and securely connected to the foundation. Once the walls are constructed, they are covered on the interior and exterior with mortar to cover the lines between panels. Then the walls can be painted, plastered, or left untouched.

Once the walls are in place, either wood or metal purlings can be attached to the top of the wall. Three kinds of purlings can be attached to the top of the panels: an 80 centimeter piece of purling for a straight wall, a corner piece of purling 40 centimeters long, or a purling that is missing a piece from the middle to allow a T to be formed. The crown for this system is made out of fibrolit. Any type of roofing assembly can be used on a house constructed out of this system.

For electric installation Zitro has developed a panel with the electrical socket already installed. A line runs from the electrical socket to the top of the panel so that it can be attached to the circuit breaker. To install pluming, a pipe can be run from the ground through the hole created where two panels are connected to the sink, toilet, or shower.

4.5.2 Zitro Disadvantages

Fernando Chavarria (06/09/2000) believes Zitro, like PBC, is an older system that has not had its imperfections improved upon. Because Zitro is a proven system, it is common knowledge that Zitro can withstand earthquakes; however, during seismic activity Zitro's vertical panels shift due to the forces inflicted upon the system. The shifting of the panels causes the mortar between the panels to crack. This is even more of a problem than with PBC, because the concrete between the Zitro panels provides all of the strength of the walls; if the concrete is compromised so is the strength of the entire house.

A disadvantage to Zitro is that it is as difficult to transport, because the panels take up a lot of space and weigh up to 180 kilograms. Due to their weight, moving the panels into place and from place to place takes a lot of time, effort, and manpower. This can cause the cost of the house to increase due to transportation costs; the time it takes to construct the house could also increase if the labor force is limited, as it is for Habitat for Humanity.

Flor Arauz (06/23/2000) stated that the most frequent mistake made when assembling the panels is lining them up; if they are not flush, the entire strength of the wall is compromised.

An additional disadvantage to building with Zitro is increased construction time; Zitro has quoted Habitat for Humanity that they could build a 46.5 square meter house, similar in design to a Habitat house in six weeks, or thirty days, this is the same as for a Habitat house; however, since Habitat only makes use of four workers at a time, a house could take up to forty-five days to construct. This is not improvement over the concrete block system.

4.5.3 Zitro Advantages

One of the most important advantages to Zitro is the same as that for concrete block and PBC. According to Fernando Chavarria (06/09/2000), Zitro is a proven and socially accepted system in Costa Rica. This system has been used for construction in Costa Rica for twelve years, and the Costa Rican people know that this system can and will stand up to seismic activity, is a solid system, and looks similar to a cement wall. By using a smaller foundation, Zitro also saves time and money on cement costs.

Another advantage to using Zitro is that the panels already have the electrical wires installed; this makes electrical installation much easier than in concrete block. The installation of the pluming system should also be easier than in concrete block; a pipe just needs to run through the gap that is formed between the panels before the concrete is poured to connect the panels.

4.5.4 Zitro Costs

Based on the cost breakdown of the materials needed to build a house that uses Zitro walls that was obtained from Flor Arauz (06/23/2000), we were able to determine what would be needed to build a Habitat house using the Zitro system. The plumbing, electric, roof, septic, floors, and all administrative costs stayed the same, but the foundation, walls, and tapichels changed. The total cost of the Habitat house built with Zitro comes out to $6,156. The following table is the cost breakdown of this house.

TABLE 6. A HABITAT HOUSE BUILT WITH ZITRO

Section	*Section*	*Quantity*	*Cost in Colones*	*Cost in Dollars*
Foundations	*Cimiento*	*1*	*¢330,809.66*	*$1,088.19*
Walls	*Parades*	*1*	*¢493,768.30*	*$1,624.24*
Roof	*Techos*	*1*	*¢177,113.00*	*$582.61*
Floors	*Pisos*	*1*	*¢61,026.00*	*$200.74*
Pluming	*Plomeria*	*1*	*¢97,916.76*	*$322.09*
Septic Tank	*Tanque Septico*	*1*	*¢66,494.00*	*$218.73*
Windows and Doors	*Ventanas y Puertas*	*1*	*¢93,083.23*	*$306.19*
Electric Installation	*Instalacion Electrica*	*1*	*¢73,039.12*	*$240.26*
Roofer	*Techos*	*1*	*¢12,000.00*	*$39.47*
Doors	*Puertas*	*1*	*¢18,000.00*	*$59.21*
Glass	*Virdios*	*1*	*¢28,000.00*	*$92.11*
Construction Supervisor	*Maestro de Obra*	*1*	*¢40,000.00*	*$131.58*
Legal Fees	*Costos Legales*	*1*	*¢74,250.00*	*$244.24*
Transportation	*Transporte*	*1*	*¢12,334.00*	*$40.57*
Mason	*Albanil*	*1*	*¢225,000.00*	*$740.13*
Administration Fees	*Costos De Administracion*	*1*	*¢68,736.98*	*$226.11*
		Total Cost	*¢1,871,571.05*	*$6,156.48*

4.6 Concrepal

Concrepal is a new system that is very similar to Zitro. Casas Prefabicadas Concrepal took the existing Zitro system and improved on it.

4.6.1 Description

Concrepal panels are similar to Zitro panels: each Concrepal panel is a non-galvanized wire grid that is encased in micro fiber cement; this grid intersects every 15 centimeters. Concrepal panels have female and male connectors that run along the height of the panels. The male connector sticks out three centimeters, and the female connector is indented three centimeters. When the panels are put together, the male side of one panel fits into the female side of another.

The Concrepal panels are 6 centimeters in thickness and come in two widths: 40 and 60 centimeters. Both the 40 and 60 centimeter panels come in heights of 2.7 meters, 1.95 meters, 1.35 meters, and 1.05 meters. The 40 centimeter panel comes in an additional height of 0.75 meters, while the 60 centimeter panel comes in a height of 0.50 meters.

Concrepal also has two additional panel options. The first option is a corner piece, which is used for all corners that connect the normal panels. The corner panels are L-shaped, with 20 centimeter long sides. The corner panels come in five different heights: 2.7 meters, 1.95 meters, 1.35 meters, 1.05 meters, and 0.75 meters. The second optional piece is a T-panel that allows for three panels to be connected together; this allows an interior wall to join the exterior walls. The T-sections come in two different widths and lengths; the first size has a 40 centimeter section the lies flush with the exterior walls and a 20 centimeter section that is perpendicular to the first piece. The second size for the T-section is a 34 centimeter piece that lies flush with the exterior walls and a 20 centimeter perpendicular section. The T-sections come in five different heights: 2.7 meters, 1.95 meters, 1.35 meters, 1.05 meters, and 0.75 meters.

The Concrepal foundation consists of a 30 by 30 centimeter deep trench dug around the perimeter of the house, or where the Concrepal panels are intended to go. The bottom 10 centimeters of the hole is then filled with cement to stabilize the foundation. Two reinforcing steel bars then line the foundation; every 20 centimeters a U-shaped reinforcing steel bar is wrapped around the first two bars and an addition pair of reinforcing steel bars that are 8 centimeters higher than the first set.

The panels are placed into the foundation onto the top level of reinforcing steel bar. Each pair of panels fit snugly together using the male-female connections. If two panels meet at a male-male connection, then one of the male connectors is broken off, to make it a female connector; then the concrete is poured to secure the two panels together, this method is similar to Zitro's connection process. If two panels meet at a female-female connection, cement can be poured into the hole created to secure the panels.

Once all the panels are connected, the remainder of the foundation is filled with concrete; thereby, securing the panels into the foundation. Once the walls are constructed, they are covered on the interior and exterior with mortar to cover the lines between panels. Then the walls can be painted, plastered, or left untouched. In addition, a layer of plaster-bond is applied to the interior walls in order to make the plaster stick to the mortar; nylon is added to a final plaster coating to avoid cracking.

Three kinds of roof-supporting purlings can be attached to the panels: a 40 centimeter piece of straight purling, a 40 centimeter corner piece of purling, or a purling that is missing a piece from the middle to allow a T to be formed. These purlings can support any type of roof.

For electrical installation Concrepal has developed a panel with the electrical sockets already installed. A line runs from the electrical socket to the top of the panel so that it can be attached to the circuit breaker. For pluming installation, two female connections can be placed together to form a hole in the wall; then the pipes can be run from the ground through hole in the panels and into the sink, toilet, or shower.

4.6.2 Concrepal Disadvantages

The major disadvantage to Concrepal is, unlike concrete block, Covintec, PBC, and Zitro, this is not a proven system; Concrepal has been in existence for only one year. This means that there is no proven seismic information because the houses built with this system have yet to experience or survive prolonged seismic activity or earthquakes. Even if considerable laboratory seismic information is available, Costa Rican people will be wary of implementing a system that has not been proven over time.

Another disadvantage to Concrepal is that it weighs the most out of all of the systems examined. This makes it the most difficult to transport and to assemble, because in order to move the panels around it requires a great deal of time, energy, and manual labor. As with Zitro, this can be a problem for Habitat because the labor force is limited.

Because Concrepal is very similar in construction to Zitro, during seismic activity this system should experience the same problems such as the shifting of the panels. This will cause the seals between the panels and the mortar covering them to crack. This compromises the structure of the entire house, is not aesthetically pleasing, and costs a great deal of money to repair.

Concrepal, like the other systems that employ panels, has a disadvantage to using the panels; all of the panels need to be flush to one another in order to maintain the structural integrity of the walls. This could be very difficult to achieve with this system because of the excessive weight of the individual panels. The fact that panels only rest on reinforcing steel bars in the foundation also makes the alignment of the panels more difficult.

A final disadvantage to Concrepal is that it takes approximately thirty days to construct, but like PBC and Zitro it can take up to forty-five days to complete; therefore, this system does not improve upon construction time.

4.6.3 Concrepal Advantages

Concrepal has several advantages. Even though Concrepal is not a proven system, a wall constructed using this method still looks like a wall constructed out of concrete block. This might help the Costa Rican people accept this system.

By making use of a smaller foundation, Concrepal also saves time and money. Another advantage for using Concrepal panels lies within the installation of the electrical and pluming systems. Electrical installation is quicker and easier because all the wiring is pre-installed in the panels. In order to install the pluming all that is required is to put two female connections together to create the hole needed for the pipes; this is a great deal easier than breaking a hole of the right size in a concrete block wall.

4.6.4 Concrepal Costs

Based on the cost breakdown of the materials needed to build a house that uses Concrepal walls that was obtained from Henry Mendez Mendez (06/23/2000), we were able to determine what would be needed to build a Habitat house using the Concrepal system. The plumbing, electric, roof, septic, floors, and all administrative costs stayed the same, but the foundation, walls, and tapichels changed. The total cost of the Habitat house built with Concrepal comes out to $5316. The following table is the cost breakdown of this house.

TABLE 7. A HABITAT HOUSE BUILT WITH CONCREPAL

Section	*Section*	*Quantity*	*Cost in Colones*	*Cost in Dollars*
Wood Supports	*Arriostres*	*1.00*	*¢16,777.33*	*$55.19*
Tracing	*Trazo*	*1.00*	*¢7,750.04*	*$25.49*
Plaster	*Repello*	*1.00*	*¢47,000.67*	*$154.61*
Foundation	*Cimiento*	*1.00*	*¢61,757.42*	*$203.15*
Walls	*Parades*	*1.00*	*¢308,196.71*	*$1,013.80*
Fibrolit Crown and Purlings	*Tapichel de Fibrolit y Perling*	*1.00*	*¢87,642.00*	*$288.30*
Beam	*Solera*	*1.00*	*¢28,414.28*	*$93.47*
Roof	*Techos*	*1.00*	*¢85,761.00*	*$282.11*
Floors	*Pisos*	*1.00*	*¢163,826.73*	*$538.90*
Pluming	*Plomeria*	*1.00*	*¢97,916.76*	*$322.09*
Septic Tank	*Tanque Septico*	*1.00*	*¢66,494.00*	*$218.73*
Windows and Doors	*Ventanas y Puertas*	*1.00*	*¢93,083.23*	*$306.19*
Electric Installation	*Instalacion Electrica*	*1.00*	*¢73,039.12*	*$240.26*
Roofer	*Techos*	*1.00*	*¢12,000.00*	*$39.47*
Doors	*Puertas*	*1.00*	*¢18,000.00*	*$59.21*
Glass	*Virdios*	*1.00*	*¢28,000.00*	*$92.11*
Construction Supervisor	*Maestro de Obra*	*1.00*	*¢40,000.00*	*$131.58*
Legal Fees	*Costos Legales*	*1.00*	*¢74,250.00*	*$244.24*
Transportation	*Transporte*	*1.00*	*¢12,334.00*	*$40.57*
Mason	*Albanil*	*1.00*	*¢225,000.00*	*$740.13*
Administration Fees	*Costos De Administracion*	*1.00*	*¢68,736.98*	*$226.11*
		Total Cost	*¢1,615,980.27*	*$5,315.72*

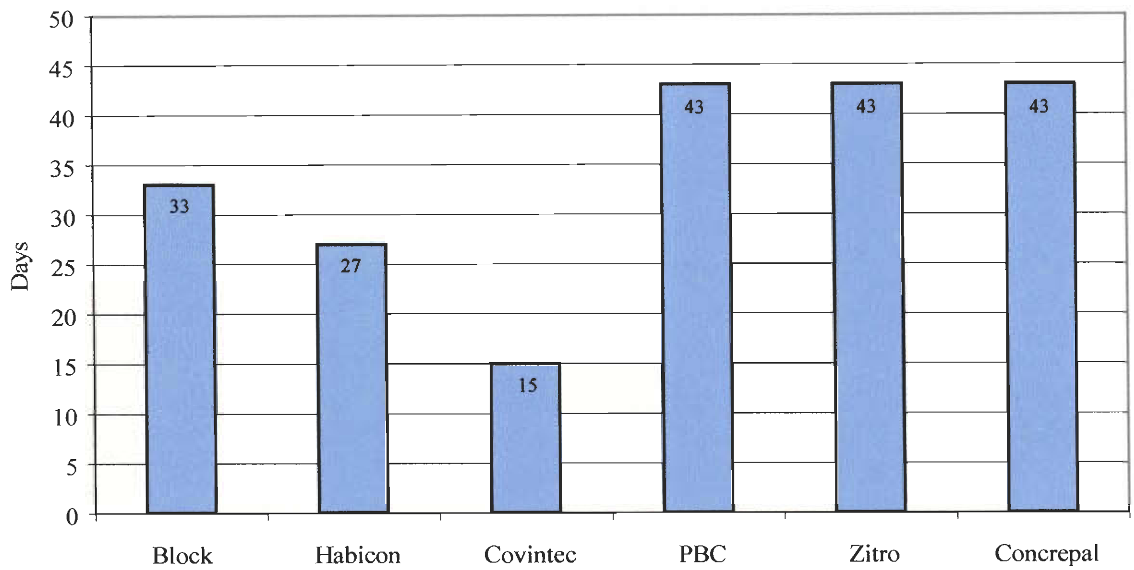
Chapter 5. Analysis

This section of this report serves to interpret the data gathered throughout the entirety of the project. In order to determine which of the six systems was superior to the others, and to see if any of the prefabricated systems are an improvement over the current concrete block system, we used a decision matrix. In order to decide how to rank each system in the decision matrix, several estimations were performed. These estimations were the main considerations that Habitat for Humanity wanted this project to investigate in order to implement a new construction system for low-cost housing in Costa Rica. These estimations were construction time, cost, quality control, environmental concerns, and social implications. The analysis section was divided into the five categories that were the focus of our examination of the systems and the decision matrix, and then each estimation was applied to the six construction systems.

5.1 Time Estimation

Before the exact cost of a house built by the six systems could be estimated, it was important to determine the number of days that it takes to construct the same size house using each of the systems. This was important because in order to accurately calculate the total cost of the house labor costs must be taken into account, to do that properly the total construction time was needed. The estimation of the construction time of each of the six systems is an important factor for Habitat to consider. If a construction system reduces the time it takes to construct a house, then Habitat can reach out to more families in less time. The following graph shows the data that was gathered on the six systems that were examined.

FIGURE 4. CONSTRUCTION TIME



This data gathered gave evidence that Covintec was the quickest system to assemble. The significant difference in construction time between concrete block and the six prefabricated systems is shown in the following table.

TABLE 8. CONSTRUCTION TIME COMPARISON

System	Time Difference
Covintec	15 Days Less
Habicon	10 Days Less
PBC	Up to 15 Days More
Zitro	Up to 15 Days More
Concrepal	Up to 15 Days More

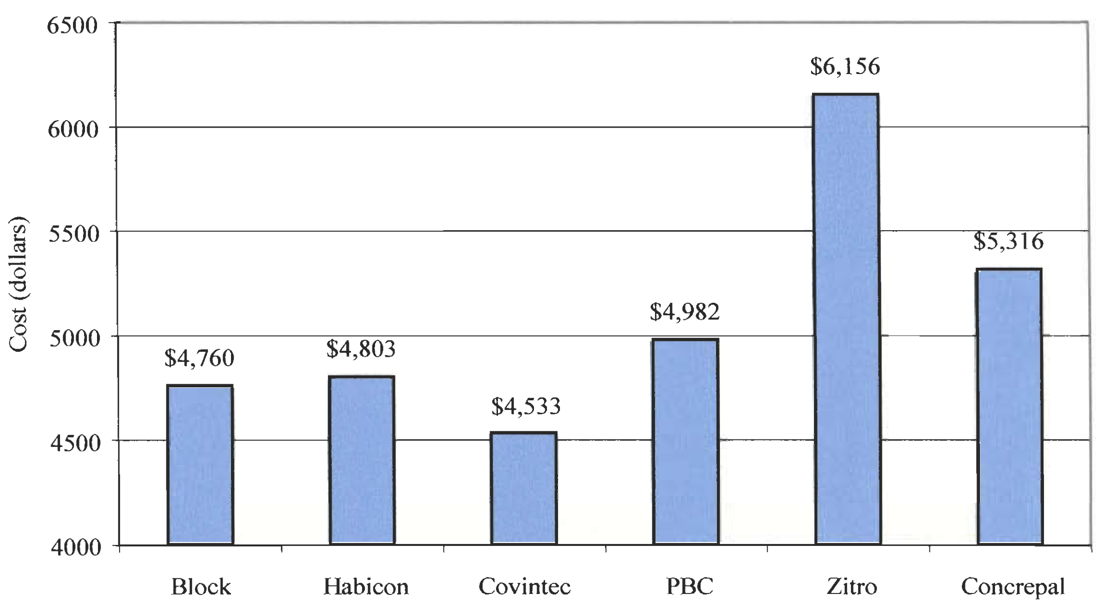
This shows how labor intensive the current building strategies employed by Habitat are compared to the Covintec and Habicon systems; however, when the block system is compared to the other three prefabricated systems, it shows that PBC, Zitro, and Concrepal are more labor intensive than the concrete block method.

5.2 Cost Estimation

Reducing the cost of the construction without reducing the quality of a Habitat house is one of the primary concerns for Habitat for Humanity in Costa Rica; the cost of concrete block construction is slowly increasing, so it was necessary to examine the five prefabricated systems to see if they could reduce the construction costs of the Habitat houses. If Habitat can lower the cost of the house, then they can help more families that have even lower levels of income. This section discusses the data gathered and computed concerning the six construction systems: concrete block, Covintec, Habicon, PBC, Zitro, and Concrepal.

The total current cost for a Habitat for Humanity house being built in Costa Rica is $4,760. The following graph shows the comparisons of the total cost of all six systems.

FIGURE 5. TOTAL COSTS



The total cost includes the administrative, legal, fixed, and labor costs along with the costs for all of the parts of the house: the septic tank, pluming and electric systems, interior divisions, floors, walls, and roof.

Any new construction system must be the same price or lower before for Habitat will even consider implementation. The Covintec house was the only system that was less expensive than the current system used by Habitat; using Covintec to construct a Habitat house reduces the price by 5 percent or $227. Table 9 shows how the cost of a Habitat house increases or decreases when it is built with each of the five alternative systems instead of using the current concrete block system.

Table 9. Cost Comparison of the Five Alternative Building Systems

System	Percentage Change	Change in Price
Covintec	5% decrease	-$227.00
Habicon	1% increase	$43.00
PBC	5% increase	$222.00
Zitro	30% increase	$1,396.00
Concrepal	15% increase	$556.00

In order to understand why each system either increased or decreased the cost of a Habitat house, a breakdown of the price was done. Table 10 shows, in dollars, how the total cost of each system broken down by material, fixed, and labor costs.

Table 10. The Cost Breakdown of Each of the Construction Systems

Costs	Block	Habicon	Covintec	PBC	Zitro	Concrepal
Material	3247	3628	3314	3267	4526	3601
Fixed	511	511	511	511	511	511
Labor	1002	664	708	1204	1119	1204
TOTAL	***4760***	***4803***	***4533***	***4982***	***6156***	***5316***

The fixed costs remained constant throughout for all of the systems. These costs include Habitat's legal and administration fees and transportation costs. The labor and material costs varied greatly from system to system. This breakdown shows why Covintec saves money on the total cost of the house. Covintec's material costs are more expensive, but they are only $67 more expensive than that of the concrete blockhouse; however, Covintec saves more money in labor costs than it adds in material costs. Covintec saves $294 in the labor costs; this is because this system takes less time to construct than the other five systems.

5.3 Quality Estimation

The quality of the materials that are used in the Habitat blockhouses is not always consistent and this can cause a problem with the structural integrity of the house. The goal for Habitat, if possible, is to not only decrease cost and construction time but to increase the quality of the materials being used for the houses.

One of the major considerations for the quality of the construction material is if the materials are made on site or if the systems are delivered to the site. The Covintec, PBC, Zitro, and Concrepal panels are completely assembled at the factory and then shipped to the construction site. This virtually removes any room for human error because precise machines assemble the panels. The Habicon system is a system where the panels are made at the construction site. This can leave room for human errors and shortcuts, similar to the concrete block system.

The inconsistent mixing of concrete is a major problem with the current Habitat construction system. All of the five other systems also use concrete for their foundations and mortar to cover the panels; however, using a thin layer of mortar for finalizing the Covintec walls would not benefit the construction workers, because if the first layer of mortar is too thin, then the workers have to keep on applying the mortar until the wires are completely covered. In this situation, it would be in the best interest of the workers to correctly prepare the mortar, this is not the case for the rest of the systems; the thinner the mortar for PBC, Zitro, and Concrepal, the easier it is to spread over the panels.

Another important consideration when looking at the quality of the materials used in the construction of the houses is the quality of the steel used as the structural reinforcement for all of the systems except concrete block. Out of all of the alternative systems, Covintec is the only system that makes use of galvanized wire for its matrix. This is important, especially in a country where there is a great deal of humidity and precipitation. Even though the wire used for all of the systems is covered with concrete and mortar, rust can still be a major problem.

When considering the quality of the finished house, it is important to evaluate the resistance to seismic activity of each system. All of the systems, except for Covintec and Habicon, are constructed using very heavy materials that move in a serpentine motion during earthquakes; this causes the mortar between the panels and blocks to crack. This is not only an aesthetic problem, but it compromises the structural integrity of the house and costs a great deal of money to repair. The Habicon and Concrepal systems are yet to be proven in the real world, so it is difficult to anticipate how they will perform during earthquakes. Because the Covintec system is so light in comparison to the other systems and since it has a galvanized wire matrix, it can move with the forces of the earthquakes and return to its original state without cracking.

5.4 Environmental Concerns

The implementation of a new system for low cost housing may be beneficial to the Costa Rican population, but there are many environmental concerns with the changing of the concrete block system. The Covintec system uses polystyrene as a major component of their panels. This material is very difficult to properly disposed of, and although durable and structurally sound, when burned the polystyrene releases dioxins. The Habicon system also has materials that are of environmental concern. The implementation of this system would increase the number of pine trees logged in Costa Rica, and then this wood is treated with CCA, which is very harmful to the environment.

Concrete is used in each of the systems, though at varying amounts, and this is also an environmentally unfriendly material. This material uses up a great deal of energy in its production; not only does it use a significant amount of petroleum in its transport, it also takes energy to mix; energy that could be used elsewhere. The concrete block, PBC, Zitro, and Concrepal are all composed almost entirely of concrete; Covintec uses less, but Habicon uses the least amount of concrete in its construction.

5.5 Social Implications

The social aspect of this project was also very important. If a new system is to be implemented it must be social acceptable. The Costa Rican people have many concerns about what their houses are built with and it is difficult to convince them that something new is a good system.

In Costa Rica wood rots and becomes infested with insects easily. Because of this, there is little demand for wood in construction in the country. The Habicon system does use pressure treated wood, which should withstand the elements, but it is still socially unacceptable to use wood as a building material. This system could be very hard to implement, especially to low-income families.

The Covintec construction system also calls for social concern. When Oscar Arias was president of Costa Rica (1986-1990) he donated many houses to low-income families; these houses were built of Styrofoam. The Styrofoam was not put up correctly and became infested with rats, eventually causing almost all of the houses to fall apart. If the Covintec system is the best choice for Habitat, it will also be difficult to convince the Costa Rican society of the value of replacing the existing construction system.

PBC and Zitro are systems that are currently being used for construction in Costa Rica; since these systems are proven and Costa Rican society knows these systems, implementation would not be as difficult. The Concrepal system is very similar to the Zitro system, but is has yet to be proven over time; therefore, since it is not a proven system, implementation would be more difficult than for the other two systems.

5.6 Decision Matrix

A method of analysis decided upon to represent the data collected and to form recommendations for this project was a decision matrix. This matrix was constructed to form conclusions without bias to determine the best possible course of action for Habitat for Humanity. There were several steps that were necessary to form the decisions matrix, including: rating conceptual importance, ranking the categories that encompass the concepts, integrating the concepts within each category, selecting a concept based on the rating and ranking, and examining the results of the matrix.

The decision matrix was formed to weigh several concepts that describe the individual categories of each construction system, these categories include: cost of construction, building time, quality of materials, environmental disturbances, and social implications. Each of these categories for each construction system was weighted and then multiplied by the rank of importance of each concept. A total score for each concept was calculated, therefore creating a decision matrix that made it possible to determine the best system for Habitat for Humanity.

The first performed step to form this decision matrix was to decide upon the categories to be weighted. To decide upon a weighting system, four Habitat employees qualified in construction management, James Dolan, Wayne Nelson, Eduardo Blanco, and Fernando Chavarria, were asked to rate each of the categories on a scale of one to twenty; the higher the number the greater the importance. They were instructed not to confer with each other when deciding upon the weighting system. The individual weights are shown in Table 11.

TABLE 11. INDIVIDUAL WEIGHTS OF THE CATEGORIES

	James Dolan	**Fernando Chavarria**	**Wayne Nelson**	**Eduardo Blanco**
Categories	**Weight**	**Weight**	**Weight**	**Weight**
Cost	16	17	16	20
Time	12	13	12	15
Quality	20	18	20	20
Environmental	12	15	12	15
Social	18	17	18	10

After each individual provided the separate weights, they were asked to confer with each other and agree upon a weighting system that would best represent the needs of Habitat for Humanity. The reasoning for asking them to perform the weighting system individually was so they could think over all five categories; in theory, this helped the final scores from being geared more towards one person's opinions than another. The group weights for each category are shown in Table 12.

TABLE 12. CATEGORIES AND THEIR WEIGHTS

Categories	**Weight**
Quality	19
Cost	17
Social	17
Environmental	15
Time	13

Once the weights for each category were established, each concept had to be ranked for each system. This ranking was based on a scale from one to one hundred, referring to how sufficiently each concept satisfies each category. To rank these concepts fairly, each of the four members of the project group ranked each concept in relation to each category. After all members ranked the concepts and discussed their decision making process, the average rank was chosen as the final ranking.

The next step was to multiply the weight of each category with the rank of each concept to generate five separate weighted scores for each system. All of the weighted scores for each concept were summed to obtain a total score for each system. The system that generated the highest overall score was the one recommended to Habitat for Humanity. Table 13 is the full decision matrix.

TABLE 13. DECISION MATRICES FOR ALL SIX SYSTEMS

	System	Concrete Block	
Categories	**Weights**	**Rankings**	**Product**
Quality	19	72.50	1377.50
Cost	17	66.75	1134.75
Social	17	80.00	1360.00
Environmental	15	60.00	900.00
Time	13	65.00	845.00
		Total Score	**5617.25**

	System	PBC	
Categories	**Weights**	**Rankings**	**Product**
Quality	19	62.50	1187.50
Cost	17	54.75	930.75
Social	17	71.25	1211.25
Environmental	15	61.25	918.75
Time	13	53.75	698.75
		Total Score	**4947.00**

	System	Habicon	
Categories	**Weights**	**Rankings**	
Quality	19	65.00	1235.00
Cost	17	60.75	1032.75
Social	17	53.75	913.75
Environmental	15	58.75	881.25
Time	13	73.75	958.75
		Total Score	**5021.50**

	System	Zitro	
Categories	**Weights**	**Rankings**	
Quality	19	62.50	1187.50
Cost	17	45.00	765.00
Social	17	76.25	1296.25
Environmental	15	61.25	918.75
Time	13	52.50	682.50
		Total Score	**4850.00**

	System	Covintec	
Categories	**Weights**	**Rankings**	
Quality	19	76.25	1448.75
Cost	17	78.75	1338.75
Social	17	58.75	998.75
Environmental	15	53.75	806.25
Time	13	82.50	1072.50
		Total Score	**5665.00**

	System	Concrepal	
Categories	**Weights**	**Rankings**	
Quality	19	62.50	1187.50
Cost	17	55.00	935.00
Social	17	60.00	1020.00
Environmental	15	61.25	918.75
Time	13	53.75	698.75
		Total Score	**4760.00**

The total scores for each of the systems are displayed in table 14.

TABLE 14. FINAL SCORES

System	Score
Covintec	5665
Concrete Block	5617
Habicon	5022
PBC	4947
Zitro	4850
Concrepal	4760

As the table shows, Covintec came out to have the highest score, but it only came out to be forty-eight points higher than the concrete block system that Habitat is currently using. The only reason that Covintec was not much of an improvement over the concrete block system currently being used is because of the social acceptance issues. Covintec is 905 points higher than the lowest ranked system, Concrepal.

Chapter 6. Conclusions and Recommendations

This section of the report draws from analysis, data, methodology, literature review, and general hypotheses. All of the material collected and processed throughout the duration of this project has directly pointed to the following conclusions and recommendations. There were several categories that were examined to provide a basis for conclusion on which construction system was the best system for Habitat. These categories include cost estimation, quality control, time estimation, and environmental and social implications of the concrete block system, Covintec, Habicon, Zitro, PBC, and Concrepal. All advantages and disadvantages of each of these categories were discussed throughout this report and then analyzed. A decision matrix was formed with a weighting system that mathematically determined which system is best for Habitat, making it very difficult for personal bias to get in the way of conclusions.

The individual categorical rankings derived from the decision matrix were based on a scale from 1 to 20, where the higher the score, the better that category would be for Habitat for Humanity. After reviewing all of the rankings, the Covintec system received the highest mark of 5665.

Based on these mathematical findings, and careful analysis of all data, we have concluded that Covintec is the best possible system. Even though the difference between concrete block and Covintec is only forty-eight points, we would encourage Habitat to begin implementing this technology. This recommendation is in accord with all of the guidelines that Habitat provided for the research team. We realize that it might be difficult to get the community to accept the Covintec system, so it is recommended that an educational program be run with Hopsa and Habitat.

If there are still questions concerning the systems that we have studied, it is also recommended to Habitat that they build a house out of each system, with three purposes in mind: to allow Habitat and the Costa Rican society to observe the construction process, to train the families how to construct the system, and to allow the families to feel the strengths and weaknesses of the houses when finished. This would also make it easier to compare each of the systems to each other.

If there is still any concern on the implementation of a new system, Habitat can utilize the methodology presented in this project to further the research done. The methodology of this project was designed as a tool not only for this project, but also for future projects.

6.1 Future Projects

As a result of this project there will hopefully be a partnership established between Worcester Polytechnic Institute and Habitat for Humanity in Costa Rica. There are many opportunities for both institutions that could be embraced in the future. To help ensure that this is not overlooked, this section is dedicated to providing ideas on possible future projects with Habitat for Humanity.

This project quickly examined cost, time, quality, environmental, and social aspects before a recommendation for a new building system was made to Habitat. There is quite some concern within the Costa Rican affiliate of Habitat for Humanity about the social implications of implementing a new system. A project that would further benefit Habitat would be to carry out a societal feasibility study of Covintec and the other systems. This would involve extensive research on literature in Costa Rica pertaining to the materials being used and their acceptance, interviews of the low-income families that would live in the houses, and performing case studies of similar cultures that experienced the same housing changes. An in depth and quantitative study of the environmental impacts of each of the systems should also be done; CIVCO's methodology for environmental analyses would be a good place to begin the research.

Another project, possibly for mechanical or civil engineers, would be to test the structural integrity of Covintec and the five other systems. This would involve earthquake, harsh weather, break-in, and possibly even insect resistance testing. The division of the University of Costa Rica in which Juan Pastor and Alejandro Navas work, El Laboratorio Nacional de Materials y Modelos Estructurales, would be a good place to perform these tests since it is their area of expertise.

An additional study could be performed solely on the possibility of updating the roof structure from the current zinc sheeting to a new technology. Systems such as Covintec and Habicon have their own roof structures and warrant further investigation. A feasibility study and thorough cost analysis could be performed in order to determine the roof that is made of the best quality and has the lowest cost.

A civil engineering student could develop a successful project on the foundations that Habitat currently uses. Questions have been raised as to if the current foundations are dug too deep. A study could be conducted to see if the foundation could be smaller, yet retain the seismic standards that Habitat expects.

The study of septic systems is another issue that would benefit Habitat for Humanity. Although this project briefly looked at some alternatives, a project could be formed to perform a study on this topic in much greater detail. Centro de Investigaciones en Viviendo y Construcción (CIVCO) has developed several new systems that could prove useful to Habitat.

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Appendix A. Habitat for Humanity

Habitat for Humanity is a non-profit organization that builds houses for low-income families. Millard and Linda Fuller founded Habitat for Humanity in September of 1976. The purpose of this organization is to eliminate homelessness and poverty around the world. So far, Habitat for Humanity has built more than 85,000 houses in more than sixty countries around the world. These houses have provided more than 425,000 people with safe, decent, and affordable housing (http://www.habitat.org).

Habitat functions with the help of both volunteer labor and monetary and material donations. The donations can be assigned to certain project sites or sent to a specific affiliate. Habitat uses all of the donations to build and restore houses; the houses are then sold without profit and financed with zero interest loans. Habitat homeowners must participate in the construction of their own homes, place a down payment on the house, and pay monthly mortgage payments for seven to thirty years. Habitat uses the homeowners' monthly mortgage payments to finance the construction of more houses. Construction costs vary around the world, but the average Habitat house varies from approximately $4,000 in developing countries up to $38,000 in the United States (http://www.habitat.org). In Costa Rica Habitat for Humanity's houses range from $4,500 to $5,000.

One of the primary reasons that Habitat for Humanity has grown to the size that it is today is the support that former president Jimmy Carter and his wife have provided. In 1984, the Carters went to New York City to build their first Habitat house, and sixteen years later they are still building. Because of their involvement, national interest about the work being done by Habitat for Humanity increased, which consequently raised the number of volunteers and donations, thereby, increasing the number of new affiliates around the world.

Every year since 1984, Habitat for Humanity International has organized the Jimmy Carter Work Project (JCWP), and every year corporations across the world take this opportunity to show their appreciation to their communities by volunteering their time and giving donations. JCWP 2000 begins September 11th in New York City; the theme for this year's Jimmy Carter Work Project is "From New York to the New South, Breaking Down Barriers and Building Up Hope." They will be building twenty houses in Harlem and Brooklyn; one of the houses in Harlem will be Habitat's 100,000th constructed home (Habitat World, 2000: 11).

The International headquarters for Habitat for Humanity is located in Georgia; however, there are many independent and locally run nonprofit affiliate organizations scattered throughout the United States and the world. All of the affiliate offices are asked to give ten percent of their collected contributions to fund work in other countries. Each affiliate office is responsible for fund raising, building site selection, family selection and support, house construction, and mortgage financing. There are at least 1,900 active affiliates located in more than seventy countries across the world (http://www.habitat.org).

Each Habitat for Humanity affiliate office has a selection committee that determines which families are qualified to receive help from Habitat for Humanity. The families that are interested in receiving help from Habitat are put through a detailed selection process. The families first fill out a general application that provides Habitat with the number of family members, financial situation, and living situation. The cut off levels that disqualify families are different for each country and region. If the families show that they are in sufficient need, they move on to the next step: they fill out detailed descriptions of their monthly income, total savings, possessions, and debts. Next if the families are yet to be disqualified, Habitat officials come to inspect where the families are currently living. If the housing proves to be insufficient and the families pass all of the other qualifications, then the planning begins for the construction of the family's house (James Dolan, personal communication, 06/20/2000).

The selection committee also decides which of the housing candidates will have the next house that is built. The committee takes into consideration the family's housing needs, their eagerness to become a part of Habitat for Humanity, and their ability to make mortgage payments. Once a family is selected and all financial matters are settled, Habitat along with the family begin construction on the new house.

Habitat for Humanity International is controlled and managed by a paid board of directors that are from affiliate offices from all over the world. These directors create Habitat's policies and international goals. In order to become an international board member, an individual must have been a long-term dedicated volunteer who is willing to work to help overcome the problems of poverty housing around the world.

A volunteer board of directors runs each affiliate office. Citizens that are concerned about their community can form an affiliate office of Habitat for Humanity. This is accomplished by researching the community's housing needs and the availability of initial capital and then approaching Habitat International and addressing the problem of poverty and low income housing in their area. Finally the community needs to apply to Habitat for Humanity International to become an official Habitat affiliate.

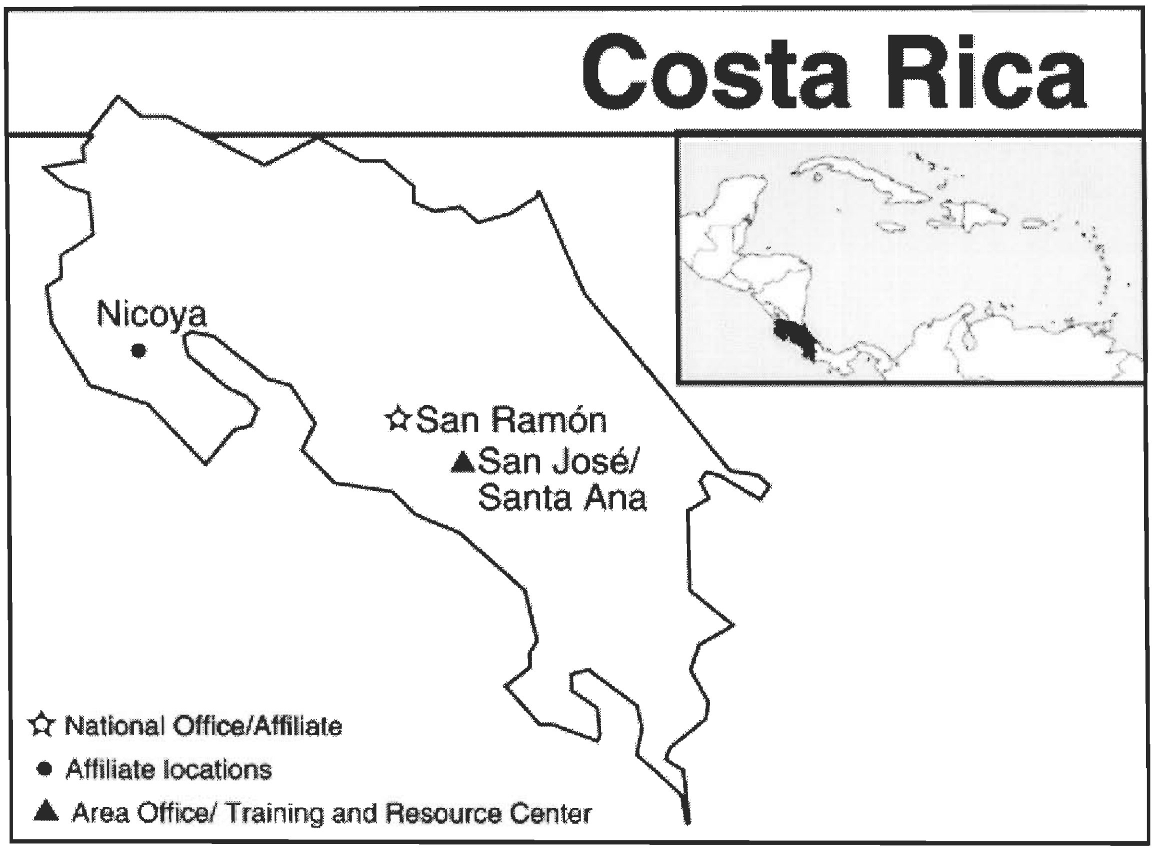
Habitat for Humanity is not a government agency, nor does it accept government funds for the construction of houses. However, Habitat tries to work along side local and national governments to help encourage them to assist in any way possible. A partnership with the government can help Habitat acquire land for building because the families must provide their own land for construction. The government can also provide houses for rehabilitation.

To combat the world's ecological problems, Habitat for Humanity aims to build houses that are resource and energy-efficient; therefore, the design of each house differs greatly from region to region and from country to country. For example, African houses are constructed with bricks made from fired clay and roof tiles that are made of cement or fired clay, where Latin American homes are generally built with concrete blocks and metal roofs. In the United States, houses are generally constructed with wood or vinyl siding to resemble most North American homes.

Habitat for Humanity in Costa Rica

"Rich coast," is the English translation of Costa Rica. Habitat for Humanity started working in Costa Rica in 1988 in the town of Scatters; by 1991 fifty houses were built. In the late eighties and early nineties the Costa Rican government also showed concern for low-income families. In 1991, the Costa Rican government created a "Bono" program, which gives land for building and or money to construct a house to families that apply. Because the Costa Ricans wanted free homes that they did not have to build themselves, Habitat lost its appeal and was forced to temporarily stop building. However in 1996, community leaders requested that Habitat return because the government program was having financial problems and homes were not being constructed fast enough. In December of 1996, construction in Costa Rica resumed. The current Habitat locations are shown in Figure 6.

FIGURE 6. THE LOCATION OF COSTA RICAN HABITAT FOR HUMANITY SITES



Appendix B. Interviews

16 May 2000: James Dolan

Our first interview for this project was conducted with our liaison James Dolan. Mr. Dolan is a consultant for Habitat for Humanity in Costa Rica. After introducing our school and ourselves, we discussed what we hoped to accomplish with this project, and the general methodology we were planning on using to complete this task.

Although Mr. Dolan liked our original ideas, he presented us with an alternative project that would be of much greater importance to Habitat for Humanity. He suggested that instead of our original plan to study new roofing materials and structures, we could investigate the feasibility of Habitat changing its construction system, maybe using a new prefabricated system. The way that Mr. Dolan suggested to get this accomplished is to first determine if the systems are cheaper than Habitat's current concrete block system. Then the construction time, quality, and social implications need to be considered.

Mr. Dolan referred us to Fernando Chavarria, the head Habitat for Humanity architect for Costa Rica and all of Latin America, because he would be the person to talk to about which systems to study and which could be most beneficial to Habitat for Humanity in Costa Rica. Mr. Dolan provided us with the plans and the material breakdown for the current Habitat house and the current costs of the materials that go into the Habitat houses. This information will allow us to begin to develop the cost analysis of the current Habitat house. We concluded by setting a date to speak with Mr. Dolan after we had talked with Sr. Chavarria.

17 May 2000: Fernando Chavarria

We interviewed Sr. Chavarria to discuss our project. We talked about our interview with James Dolan from the day before, and described the new idea for the project. We wanted to get his feedback on whether or not he thought that a project that focused on finding an alternative building system would benefit Habitat for Humanity.

Sr. Chavarria briefly talked about several building systems with us. After telling us that one of the systems that we should look into should be Covintec, a Panamanian prefabricated housing system, he asked us to also seriously look into CIVCO, a division of the Technological Institute of Costa Rica that studies the problem of low-income housing in Costa Rica. Sr. Chavarria wanted us to find out what kind of new research they were conducting on prefabricated systems, roofing tiles, and septic systems. He gave us some contact information for them.

For the remainder of the interview, he discussed the problem of septic contamination and septic systems in Costa Rica and many current and alternative types of septic systems, including the social aspects of each.

18 May 2000: Fernando Chavarria

At this interview, Fernando Chavarria described, in great detail, how Habitat currently builds their houses. Sr. Chavarria also gave us the preliminary information on alternate building systems: Covintec, Megablock, and Zitro. We finished the interview talking about basic pros and cons of each system. Sr. Chavarria stated that he wants to move Habitat for Humanity into the new millennium by implementing a "new" system. Megablock, Zitro, and some of the other systems, are old systems that would not help carrying Habitat into the future. He believed that Covintec and maybe CIVCO's Habicon system were be able to accomplish this; however, the perfect system that Sr. Chavarria was looking for was a system that would not leave Costa Rica technologically dependent on another country. He would like to find a system that could be produced in Costa Rica without importing any of the materials needed. This cannot be accomplished using Covintec but maybe Habicon.

20 May 2000: James Dolan

At this interview, we discussed our interviews with Sr. Chavarria and described to Mr. Dolan what we wanted to accomplish with this project. After we discussed all of our ideas, we refined the project goals to be more in accordance with what Habitat wanted to gain from this project.

20 May 2000: Manuel Granados

We discussed with Manuel Granados, the paid construction worker at a Habitat house site, how much time it takes to construct a Habitat house. He broke everything down by ten-hour days. With his help, we determined that a Habitat house takes from thirty to thirty-five days to build.

23 May 2000: Diego Estrada

We met with Diego Estrada, the Hopsa representative in San José, who provided a material and cost breakdown for a house very similar to the Habitat house that is being built in Esparsa using Covintec; this information helped us determine how much it would cost to build a Habitat house using the Covintec panels for the walls. Sr. Estrada also provided us with some of the general information on the how to construct a house using the Covintec system and photos of the houses in Matagalpa that are being built using Covintec panels.

Sr. Estrada showed us the mortar and staple guns that are used to put up and cover the panels. He informed us that the staple guns are approximately $30, and that the mortar guns are roughly $300 but an air compressor is also needed; however these initial costs quickly pay for themselves, and the guns could be purchased in the United States for less than the prices that he quoted.

26 May 2000: Instituto Technologico de Costa Rica

Rolando Fournier Zepeda, José Francisco Pacheco, Elias Rosales Escalante

We were referred to the Instituto Technologico de Costa Rica's professors in the CIVCO division by James Dolan, our liaison, and Fernando Chavarria, one of Habitat for Humanity's head architects, to interview them concerning micro fiber roof tiles and septic systems. Upon arriving at the university we met with Elias Rosales Escalante, a sanitary civil engineering professor, Rolando Fournier Zepeda, a professor of civil engineering, and José Francisco Pacheco, a professor of structural civil engineering. We talked with Fournier and Pacheco and later met with Elias Rosales Escalate for additional information about CIVCO's septic systems.

Sr. Zepeda and Sr. Pacheco explained to us that in Costa Rica there are over 150,000 people who are currently homeless, which translates to over 20 percent of the total population. Another 5 percent live in less than standard housing conditions. Professor Fournier stated that CIVCO was formed to find a solution to this problem, with their overall goal being to improve the quality of life for people in need by providing more families with safe and affordable housing.

CIVCO has developed several innovative building technologies ranging from new wall structures to new roofing tiles to new septic systems. They stated that their greatest achievement so far has been a newly designed pre-fabricated housing system called Habicon. It incorporates micro fiber concrete wall panels and roofing tiles with a wooden pine frame and metal connectors. CIVCO's Habicon system is aimed to combine the least amount of non Costa Rican resources as possible, by striving to use only materials that can be produced in locally in their country.

The Habicon house does not require the standard type of foundation. Instead, eighty-centimeter deep holes are drilled into the soil and filled with concrete. Wooden beams are attached to these pillars with the use of a vertical metal rod. Then, using the solid beams as a base, a pine frame is constructed to serve as the outline for the house with metal connectors being used to hold this frame together. Micro fiber concrete panels are then slid into the furrows found in the supporting wooden beams. These panels serve as both the wall and floor systems. The panels themselves consist of an internal non-galvanized wire grid encased by a mixture of concrete and micro fiber. After the panels are in place, mortar is used to caulk the separations between the panels. The finishing touch involves applying a layer of plaster over the entire surface of the structure, both inside and out. The finished wall is only one inch in thickness, but it can withstand a bullet fired from a thirty-eight-caliber pistol, the force of a fifty-kilogram weight swung into the panels, and fire.

An additional wooden frame, separate from the house frame, is constructed and mounted on the existing wall structure. The roofing tiles, made from the same micro – fiber concrete as the wall panels, are then attached to this frame by wires that are implanted into the tiles as they are being made. The tile's weight is 30 kilograms and the color of the tiles can be changed by the addition of ochre into the concrete.

According to the two professors, Habicon has been designed to reduce waste, building time, price and environmental disturbances. This enables Habicon, they say, to possess many advantages over other building systems. Professor Pacheco stated, "The people who are building the house learn how to produce the panels and tiles themselves." According Professor Zepeda, this reduces the total cost of the panels and tiles by 79 percent, due to the elimination of every cost except for the raw materials. The labor costs, the utilities costs a factory would need to produce tiles and panels, and fixed costs such as the costs of the necessary machines, are all neglected when the families produce the tiles and panels for themselves. It takes one day to make all the roof tiles, one day to make the wall panels and seven for them to dry. After all the materials for the house are produced, it takes fifteen days to construct the house using one skilled laborer and the three unskilled laborers.

A large benefit of the Habicon system is that it lowers the use of cement. One problem with cement is that over 50 percent of the cost is in the petroleum used to transport it. Because of difficulty in transportation, concrete is not easy to make in Costa Rica. Another problem with cement is that it requires materials like iron for reinforcement. Costa Rica itself has very little iron and is constantly forced to have to import its iron through Russia, Brazil, and several other countries. Because of the reduction in the amount needed, the overall cost of the house is reduced.

We found that the wood used for CIVCO's Habicon system comes from a Costa Rican wood plantation. This wood plantation has over 150 hectares of different species of trees. This program was started fifteen years ago and has been proven to be effective according to Sr. Zepeda. Professor Pacheco believes that this is beneficial because the wood does not have to be imported, unlike steel, which in turn creates jobs and income for Costa Ricans. In Costa Rica they have a lot of natural pine called "Pine Clevis." After the pinewood has been harvested, it is pressure treated with a mixture called CCA, a chemical mixture containing copper, chrome, and arsenic. This treatment theoretically adds at least fifty years to the life of the pinewood.

According to Professor Zepeda, the Habicon system also increases the area of the house by 10 percent. This is because the current Costa Rican houses are built using 12 centimeter thick concrete blocks, while Habicon uses only 1 inch thick panels. The floor space is further increased because the panels are attached to the outside of the wooden frame instead of the inside or middle of the frame.

The Habicon house has been proven to be more resistant to floods than a traditional house because it is built on top of concrete pillars that can be elevated up to 40 cm. José Francisco Pacheco stated that most of Costa Rica's terrain is hilly and the majority of houses need to be built on slanted land. This makes finding areas to build houses in Costa Rica a lot easier because they can be built in swampy areas and on land with up to a 20 degree slope. When digging a foundation, one compromises the strength of the soil, wastes a lot of time, and disturbs the natural vegetation. The Habicon system leaves the soil in its natural state thus allowing the house to avoid landslides from unstable soil.

Another advantage of the Habicon system is that it uses prefabricated elements. That means that there is less of a chance for error when assembling the house and that inexperienced laborers have the ability to use Habicon.

The major disadvantage of the Habicon system that Professor Zepeda mentioned was social acceptance. Typically, richer citizens build with blocks, and the underprivileged want the same type of construction because they recognize concrete block as quality. Another disadvantage of this system is that the internal metal grid is made of non-galvanized wire. Although the structure has a layer of plaster over all the panels and exposed wires, non-galvanized wire has a strong incidence of rust and severely compromises a structure's strength according to earlier interview with Fernando Chavarria.

During our interviews at CIVCO, we also learned that running water in homes is common in all of Costa Rica, so all or most of the communities are able to use septic tanks. All the septic tanks we were shown were made of fiberglass; however, Professor Zepeda and the rest of CIVCO is in the process of trying to engineer septic tanks that have thinner walls using micro concrete in order to improve strength and to be able to lower the costs. However, this new septic tank is not currently being used and is still in the testing stages.

In CIVCO's septic tanks, the tank is generally three times as long as it is wide. This is done because the distance between the entrance and exit of water flow need to be as far apart as possible to avoid contamination.

When deciding what kind of septic tank to use when constructing a home, one must take into account the climate of the region. Clay in the soil and rainfall play large factors in deciding what kind of system to use. If the soil is of high quality, meaning there is little clay in the soil and the building region has little to moderate rainfall, the simplest septic tank is used with an input from the house and pipe out into the soil. This is because the soil will be able to keep the fertilization and the rainfall will not wash away the soil. However if there is a lot of clay in the soil or a large amount of rainfall in the area, the soil will be unable to hold the fertilization. If a simple system were to be used, the land would omit strong odors and the ground would become very contaminated with fecal. In order to eliminate this problem, a filtration system needs to be added to the original septic tank. This filter is cylindrical in shape and the water is fed into the top of the filter. After water is filtered through this system, it is cleared of 97%-98% of impurities and solids. This allows the water to be used for other things for example gardening.

One problem with septic tanks mentioned by Sr. Pacheco was that the microorganisms in the septic tank itself are not able to breakdown metals. After several years of use, the bottom of the septic tank starts to fill up with these metal solids. Professor Zepeda and the rest of CIVCO have found a solution to this problem. In the bottom of the tank, a pipe can be inserted to connect the septic tank to a small collecting box. Because this box has a lower pressure than the septic tank, the solids move from the bottom of the septic tank into the box. This box is much easier and cheaper to dig up and empty then to pump out the entire septic tank every 2-5 years.

We only met with Professor Escalante for a brief period of time while we were at CIVCO. Sr. Chavarria gave us his name to talk to about different septic systems, however, in our interviews with Professors Pacheco and Fournier, all our questions were answered. Professor Escalante volunteered himself as a resource if any new questions presented themselves. He also gave us some printed information so we could have some written documentation on different styptic systems.

25 May 2000: James Dolan

Mr. Dolan informed us that houses made out of Styrofoam might not be something that we would be able to convince the Costa Rican people to accept because of a previous disastrous attempt at building cheep Styrofoam housing. According to him, when Oscar Arias was president from 1986 to 1990, he was very concerned with the amount of people in Costa Rica with insufficient housing, so he started building low cost housing using a Styrofoam system similar to Covintec. However, there was a problem: somehow rats managed to get past the mortar and ate into the Styrofoam walls of the houses, thereby destroying them. Mr. Dolan asked us to research this in order to determine if the same type of thing could happen with the Covintec houses, because if it could, then under no circumstances would Habitat for Humanity consider using the Covintec system to build their houses.

We informed Mr. Dolan that we already had a meeting scheduled with Diego Estrada, and we would investigate the matter further.

30 May 2000: Diego Estrada

The second time we went to talk with Diego Estrada, he showed us the versatility of the Covintec panel as a building system for a variety of buildings. We traveled to two sites that were currently building with these panels. The first site demonstrated Covintec being used to construct a large three-story building, while the second site showed Covintec being used to build low-income housing.

While in the car, we spoke to Diego Estrada about another building system we had heard was similar to Hopsa's Covintec panel called "Covintec Panel of Veracruz." Diego explained that in the 1980's the copyright owner of Covintec sold the name and product rights to a construction company in Mexico. Once this company had the license to Covintec, they decided to cut the cost of the panels by using a cheaper, more brittle Styrofoam and to not galvanize the steel used for the three-dimensional wire structure. The result was a cheaper panel, however, the quality was far beneath that of the Hopsa Covintec panel. Currently, the Mexican company still has the license to use the name of Covintec, and is able to sell the products for much cheaper because the manufacturing costs are less.

The Mexican company is Hopsa's largest competitor. The Costa Rican construction company that was building at the first site we visited near the Marriott in Jacó, first bought panels from the Mexican company. They found that the Styrofoam fell out of the panels and the wire mesh rusted. After the construction company observed this, they discarded the Mexican Covintec and decided to use Hopsa's higher quality Covintec.

The second site we visited was a low-cost house in Esparza. While there, we observed a 42 square meter house being constructed. The interior of the house was similar to that of a Habitat house, but Covintec was used for the interior and exterior walls and roof.

We also asked Sr. Estrada about the Styrofoam houses that were built by Oscar Arias. He had heard about them, and quickly explained why they did not work. They placed the Styrofoam panels on the foundation, like the Covintec system, but they put a boarder of wood around the bottom at the foundation. This wood rotted, and the rats were able to eat through the wood and get into the panels themselves. Sr. Estrada assured us that nothing like this could happen in the Covintec system, because the mortar that covers the panels meets the foundation. There is really no way that any insects or animals can get into the Styrofoam.

2 June 2000: José Pedro

José Pedro, the head of Habitat for Humanity in Costa Rica, informed us that we would probably have trouble convincing the Costa Rican people to use Covintec, because of the problems with the Styrofoam houses that President Oscar Arias built. But, we explained to him that had already gotten the explanation why the houses had been eaten by rats from Diego Estrada; we informed José Pedro that Diego Estrada assured us that the same thing would not occur with the current Covintec system.

2 June 2000: Maritza Rodriguez

After our meeting with James Dolan, we met with Maritza Rodriguez, a structural engineer who works for Habitat for Humanity and is familiar with the prefabricated systems. Mr. Dolan wanted to let her know about what the goal of this project and to let her know what we have found out to this point, because she is one of the people who need to be convinced that the system we recommend really is the best system to change to. Also, Mr. Dolan knew that she would be able to tell us what we need to include in the project in order to be able to convince the Costa Rican Habitat affiliates that a certain alternative system is better. We also needed to ask Sra. Rodriguez what size foundation a Covintec house needs.

As soon as Mr. Dolan explained to Sra. Rodriguez that we had been researching Covintec and Habicon, and that we had so far determined that both systems would save a lot of time, would work well in earthquakes, but were still more expensive, Sra. Rodriguez voiced her concerns.

Her first and major question was why are we only looking at Covintec and Habicon? Why not Superblock, PBC, or Zitro? They are all proven systems that are currently being used in Costa Rica. She said that if we wanted to be able to convince anyone that Covintec and Habicon were superior systems that should be implemented, then we needed to be able to either prove that they are better than all of the other systems or at least intelligently explain why we decided on Covintec and Habicon. Her second suggestion was that we should get some more opinions on the quality and structural strengths of the systems, because we really cannot take the word of the sales men, we need some outside sources.

Sra. Rodriguez provided us with an estimation of the foundation needed for a Covintec house. She suggested, after looking at a pamphlet of a system similar to

Hopsa's Covintec system, that the foundation should be approximately 20 centimeters by 15 centimeters.

6 June 2000: Ricardo Lincano

We interviewed Ricardo Lincano, one of Hopsa's structural civil engineers, to find out how much it would cost to build a Covintec house with the same dimensions as Habitat for Humanity's houses currently use. We were unsure of what the size of the foundation needed to be with a Covintec wall because we did not know the weight of a Covintec panel with the two layers of mortar on it. According to Ricardo Lincano the weight of a Covintec panel with mortar is 22 pounds.

Ricardo Lincano then looked at the blueprints of Habitat for Humanity's house. He calculated how many panels were needed for the entire house, how deep the foundation would need to be, and how many rods were required to support the wall. After finding the total amount of needed materials to build the walls and foundation of this house, Ricardo Lincano then calculated the total cost of these materials. The price was then added together along with the things that were kept the same for the Habitat's houses: plumbing, electrical, septic systems, interior divisions and the roof. This produced an estimated total cost of a Habitat for Humanity house using Covintec for the exterior walls.

9 June 2000: Fernando Chavarria

After our trip to CIVCO earlier in the week, we wanted to discuss with Fernando Chavarria what his impressions were, and why it is that we are only seriously looking at Covintec and Habicon instead of all of the other prefabricated systems that are available.

Sr. Chavarria had both good and bad impressions of CIVCO's Habicon system. The good qualities of Habicon that Sr. Chavarria noticed were that compared to the Styrofoam in Covintec, Habicon seems to be more ecologically friendly. Another benefit of Habicon is that it is very well ventilated and this helps combat the humidity that is a major problem in Costa Rica. In Costa Rica the soil is very clay rich, and as it becomes either more or less saturated with moisture it expands and contracts; this process causes foundations to crack, however, since Habicon uses pylons instead of the conventional foundation system the cracking does not occur. Another Habicon benefit is that houses can be constructed in very wet ground and on ground that is uneven or sloped up to 20 degrees; these are areas that would not be able to support a conventional foundation.

Others have already raised the problems that Sr. Chavarria sees with the Habicon system. One of his main concerns is the pressure treated wood. Not only is it treated with a poison but also the Costa Rican people see wood as something that should not be put into houses, because in the tropics all of the moisture causes wood to rot quickly and a large number of termites and other bugs swiftly eat unprotected wood. Another undesirable attribute that Sr. Chavarria noticed was that the Habicon house looks unstable and does not present an appearance of strength and stability, unlike the concrete-block house that looks like it could and will withstand everything and anything. Even though the system is designed to withstand seismic activity, the Habicon house does not look like it could withstand an earthquake; it looks like a house on stilts that would topple over in an earthquake.

We asked Sr. Chavarria to reiterate for us why he wanted us to research an alternative for the current concrete block system, and why he was interested in Covintec and Habicon instead of the other systems. He explained that first he wanted to look at prefabricated systems not because they are always better than traditional systems, but because they are alternatives that should be explored. Sr. Chavarria stated that the concrete-block system that Habitat is currently using is a guaranteed system that works well, but that does not mean that just because it works Habitat should not look for something better.

Prefabricated systems have several advantages over the traditional systems. First, a prefabricated system has a set budget; the quantities of the materials needed are known from the start and bought. The time for construction does not vary as much as it does with the traditional systems, so the salaries of the workers can be set. Prefabricated systems also keep a continuity in the construction unlike with the traditional system; if construction stops for the day, the concrete mixed the next day is not the same as the day before, so the blocks are not held together with the same strength or with mortar not as thick. This causes weak spots in the structure of the house; prefabricated systems help to keep this variation in quality and strength from happening.

After discussing prefabricated systems, Sr. Chavarria to discussed why he wanted to look at Covintec and Habicon instead of PBC and Zitro. His first reason was that PBC and Zitro are older systems that have not been improved upon. The second general reason for not looking at these two systems was that they are expensive when compared to other prefabricated systems. These systems take less time to construct and are designed to save money in the labor costs; however, since Habitat does not pay for most of its labor, this method would not save them any money. He also stated that though both of these systems can withstand earthquakes, the horizontal concrete panels for PBC and the vertical panels for Zitro, shift and the mortar between the panels crack and need to be fixed. Another aesthetic problem with the PBC system that many people find uncomfortable is the fact that this system makes use of columns that are always visible and cut into the living areas, making it difficult to arrange furniture.

14 June 2000: Professor Roberto Pietroforte

Roberto Pietroforte provided a considerable amount of information on prefabricated systems and the use of appropriate technology. Professor Pietroforte is an architect that currently practices as a professor of civil engineering at Worcester Polytechnic Institute. He stated the importance of implementing a system that was appropriate for Habitat for Humanity in Costa Rica. Appropriate technology is a technology that feeds the culture, economics, and skill of the users of a certain society; appropriate technology for one area may be extremely different than what is appropriate for another area.

Professor Pietroforte noted that the concrete block that is currently used by Habitat for Humanity is appropriate for the low-income society of Costa Rica. This system is appropriate for several reasons: low cost, low skill involved in construction, and there is no necessity for special equipment. This system is also advantageous because the construction of a concrete-block house is very labor intensive; in theory, the more labor intensive a construction process is, the more beneficial the process is to society because it creates work for low-income citizens.

This theory creates a paradox with the reasoning behind the implementation of a prefabricated construction system. Prefabricated systems decrease construction time and as a result decrease the amount of paid labor necessary. In Costa Rica, labor is very cheap so there tends to be little or no drive for mechanizing construction. If a technology demands workers, then jobs will be created; however, the use of prefabricated systems in Costa Rica will do the opposite.

Professor Pietroforte sees a large problem concerning the usage of a prefabricated system in Costa Rica. This problem revolves around marketing. Concrete blocks are used widely in Costa Rica and several manufacturers produce them locally; therefore, there is room for competitive pricing of the blocks. If a prefabricated construction manufacturer establishes business in Costa Rica, the general notion of the company is to gain clients by promoting low prices and then slowly raising these prices and obtaining a monopoly over the prefabricated market.

According to Professor Pietroforte, there are many parameters that must be weighed to correctly assess the necessity and the benefits of a prefabricated system. These parameters include: cost analysis, construction time, availability of the product, performance indicators such as thermal resistance, acoustics, resistance to moisture, longevity, and structural integrity, social implications, and environmental implications.

16 June 2000: Alejandro Navas

We visited the University of Costa Rica's Laboratorio Nacional de Materiales y Modelos Estructurales to interview Dr. Juan Pastor. Upon arrival, Sr. Pastor directed us to. Alejandro Navas. Sr. Navas is one of the head coordinators at the laboratory who has done extensive studies on prefabricated low-cost housing.

Sr. Navas provided us with a study that Dr. Juan Pastor did in 1989 that compares the cost, quality, and environmental impacts of several prefabricated systems. Although some of the systems that were analyzed are no longer in use, the process in which the conclusions and recommendations were obtained might be very useful to our group. Sr. Navas also provided additional names of Professors at the University that might be able to provide us with more information on additions prefabricated systems if we need it.

19 June 2000: Wayne Nelson

Wayne Nelson is a Habitat for Humanity International employee in Americas, Georgia. Mr. Nelson oversees many of the new building systems implemented across the world, so he is an expert in prefabricated systems used by Habitat for Humanity.

Mr. Nelson was interviewed by phone on June 19, 2000. Mr. Nelson is familiar with the Covintec system, and he provided a lot of useful information concerning the system. There are two different manufacturers that Habitat regularly approaches for polystyrene panels: Dow Chemical and Hopsa. The Dow Chemical polystyrene panels are blue in color and known as "X-treated polystyrene." This type of polystyrene can be expanded into the white polystyrene used in the Covintec panels, known as "EPS" or expanded polystyrene. One major difference between these two types of polystyrene is cost; the EPS is significantly cheaper than the X-treated polystyrene. Another major difference concerns fire retardation. The X-treated polystyrene holds flame where the EPS melts. This is beneficial to the EPS because if exposed to fire it will melt and not catch on fire and possibly spread to other elements of the house.

Mr. Nelson says there is some concern with the implementation of Covintec into Costa Rican society because the system is made of polystyrene. Mr. Nelson has been closely following the use of Covintec in Matagalpa, Nicaragua. A cultural acceptance study was performed in Matagalpa and the system gained approval from society; they were shown that the house was bullet proof and since the houses have been built there has been an earthquake and the houses were not damaged. Mr. Nelson believes that social acceptance should not be a problem because once the polystyrene is encased no one will notice the difference.

Mr. Nelson thinks that the Covintec system is structurally sound, but he believes that there is room for improvement in the system. In Tijuana, they use polystyrene panels from a company called In Steel, where the internal wire matrix is 12 gage instead of 14 gage, and the panels are 40 feet by 4 feet. Mr. Nelson thinks that Covintec can improve their system by producing a panel that is the length of the wall so there is less room for error in connecting the panels.

Mr. Nelson was then asked about his knowledge of micro fiber roof tiles and wall panels, similar to that of the Habicon system. Mr. Nelson has a lot of experience with roof tiles made of polypropylene concrete that is reinforced with plant fibers. He stated that generally these tiles have higher incidence of failure instead of success. The reasoning behind this is because the common workers make their own tiles, similar to the Habicon system, and quality cannot be controlled as strictly as it should be, specifically concerning high grade sand and how the tiles are cured; there is also a lot of waste production in this system. Mr. Nelson recounted a failure of micro fiber roof tiles in FIJI where the cost of the whole roof was $125 versus $500 for the traditional metal roofing, but the decreased quality of the tiles was not worth the savings.

Mr. Nelson also discussed pressure-treated wood. He is familiar with both CCA and CCB pressure treated pine and he knows from personal experience that the wood is very resistant to insect infestation; yet he is concerned with using wood in Costa Rica, and he wonders if the system could be advanced with the possible use of a metal frame instead of wood.

Mr. Nelson is very interested in the septic systems that CIVCO is proposing. He stated that the problem with human waste in third world countries is very prominent and the creation of a septic system that does not need to be pumped and where the metallic residue is flushed into another holding system is a good idea that he would like examined.

20 June 2000: James Dolan

We met with James Dolan at his office in San Ramon in order to have him go over the prices that we had determined for the Habitat house built with either Covintec or Habicon. We needed Mr. Dolan to help us find any mistakes made in the cost breakdowns. Mr. Dolan also helped us determine how much money would be saved on the salary of the paid construction worker if the house were built using Covintec. The Covintec system takes half the time to construct, so it saves half of the construction worker's fee. That reduced the price of a Habitat house built with Covintec to about $200 less than the current concrete block system that they are using.

After we discussed the details of our costs, Mr. Dolan informed us that for our project to be useful in convincing the affiliates to change to a different construction system we needed to include a section that explains why Covintec and Habicon were chosen as the alternatives. To be able to do this convincingly, we need to find out how much a Habitat house would be to construct using either Zitro or PBC, and then using

Fernando Chavarria's and our own reasoning we need to thoroughly explain why all the other prefabricated systems are inferior to Covintec and Habicon.

For our Appendix A, we needed more information on how Habitat chooses the families that receive aid. Mr. Dolan informed us that this varies from country to country, region to region, and affiliate to affiliate; however, the method stays fairly constant. The families fill out forms about their families, financial situation, and living conditions. After they pass this first level of screening, they fill out other forms where they have to describe in detail the their monthly income, total savings, possessions, and debts. Next, Habitat officials come to inspect where the families are currently living. If the housing proves to be unsuitable and the families pass all of the other qualifications, the planning begins for the construction of the family's house. Mr. Dolan provided us with copies of the forms that the families need to fill out and some of the cutoffs that the San Ramon affiliate has for the families it helps.

We asked Mr. Dolan to set the weighing on the analyses that we are doing so that we can use a decision matrix to decide which of the three systems is the best and should be recommended to Habitat. On a scale of one to twenty, Mr. Dolan rated cost a sixteen, quality a twenty, time a twelve, environment a twelve, and social acceptance an eighteen. We asked him to get a rating from Eduardo Blanco, the head of the San Ramon affiliate.

22 June 2000: Enrique Baz

We meet with Enrique Baz, the PBC representative, in San José for the first time on the twenty-second of June. He provided us with material about PBC and the current individual prices of each column and panel used by PBC. This information will help us determine how much it will cost to build a Habitat house using the PBC panels and columns. Enrique Baz also provided us with some of the general information on the how to construct a house using PBC.

Also while we were at his office, Enrique Baz showed us a real PBC panel and column and what they looked like dissected. After all of the information was exchanged, we set up a time the following week to get exact information of how many PBC panels, columns, and etc. are needed to build a house using Habitat's blueprints. Upon leaving the office we were swarmed with very happy customers telling us how great of a product PBC was.

23 June 2000: Flor Arauz

We meet with Flor Arauz, the Zitro representative, in San Pedro for the first time on the twenty-third of June. She provided us with material about Zitro and the current individual prices of each panel used by Zitro. This information will help us determine how much it will cost to build a Habitat house using Zitro panels. Flor Arauz also provided us with some of the general information on the how to construct a house using Zitro.

Also while we were at her office, Flor Arauz showed us a real Zitro panel and what it looked like dissected. We were also shown a house constructed of Zitro. After all of the information was exchanged, we set up a time the following week to get exact information of how many Zitro panels are needed to build a house using Habitat's blueprints.

23 June 2000: James Dolan

We called James Dolan called and he told us that a brand new prefab system was going to be presented to Habitat and told us that it was imperative for us to research this new system and include it in our report. We scheduled to meet James Dolan in Palmares to meet with this new company.

23 June 2000: Henry Mendez Mendez

We met with Henry Mendez Mendez, the Casas Prefabicadas Concrepal representative, in Palmares, with James Dolan for the first time on the twenty-third of May. Henry Mendez Mendez provided us with material about Concrepal and the current individual prices of each panel used by Concrepal. This information will help us determine how much it will cost to build a Habitat house using Concrepal panels. Henry Mendez Mendez also provided us with some of the general information on the how to construct a house using Concrepal panels. Also while we were at his office, Henry Mendez Mendez showed us a real Concrepal panel and what it looked like dissected. After all of the information was exchanged, Mr. Dolan told us that we needed we set up a time the following week to meet with Fernando Chavarria, and bring him to the company to see what his impressions of the prefab systems were. We made arrangements to get exact information of how many Concrepal panels are needed to build a house using Habitat's blueprints.

June 23, 2000: Klaus Stadthagen

Klaus Stadthagen is the Hopsa representative that is stationed in Nicaragua. He provided a considerable amount of information concerning overcoming social implications when implementing the Covintec system in Nicaragua. Mr. Stadthagen understands the concern in Costa Rica, and states that the problem was exactly the same in Matagalpa. To overcome this problem, Hopsa and Habitat set up an educational program, supplemented with videos and pictures, that showed that Covintec was faster, stronger, and had better thermal and acoustic insulation than the traditional system. Even after the program was run the families were concerned with having their house built out of polystyrene, so Hopsa donated the materials necessary to build a house. This was done with three purposes in mind: to allow the families to see the process of construction and how quick it is, to train the families how to construct the system, and to allow them to feel the strength of the house when finished. After the construction of this model house was finished, all sixty-five families that were about to start the construction of their homes chose to build with Covintec.

Mr. Stadthagen noted increased motivation in society once the new system was implemented. In Matagalpa, nine houses were constructed (before plastering) in a little over a week; this made the families feel that their housing problem was going to be solved quicker than they were expecting and therefore increased personal drive. He also noted that older and younger members of the families were able to get involved in construction because the panels weigh only twenty-five pounds before plastering; even though this is the same weight as the concrete blocks, the panels are much easier to handle.

June 26, 2000: Klaus Stadthagen

Mr. Stadthagen referred our group to the International Conference of Building Officials (ICBO) web site (www.icbo.org); the ICBO are the editors of the U.S. Uniform Building Code. On this site is a study done on the "Thermal IMPAC Panel," which is the Covintec panel.

Mr. Stadthagen also discussed environmental issues concerning the Covintec panel. He stated that the Covintec panel is very environmentally friendly, opposed to other traditional system. The polystyrene has proven to be "very, very safe to the environment, and is even used as an aggregate for soil treatment." He also stated that when the polystyrene is melted to install piping, no toxic gas is emitted.

Appendix C. CIVCO

CIVCO, the Centro de Investigacion en Vivienda y Construccion, or the Center for the Investigation of Life and Construction, is a research center dedicated to the development of new housing and construction technologies. CIVCO is a division of the School of Construction Engineering at the Technological Institute of Costa Rica (ITCR) located in Cartago; it was created in 1991 through a partnership and financial collaboration of ITCR, the Real Estate Mortgage House Bank (BANHVI), and the Danish agency for International Development (Danida) (http://www.itcr.ac.cr).

CIVCO works towards its goals through four main steps. The first step involves the investigation of new construction methods and materials. The second entails laboratory testing and research done on the new methods and materials in order to verify their quality. CIVCO then makes sure that these laboratory tested methods and materials are up to the current Costa Rican codes and regulations. The fourth step that CIVCO concentrates on is the investigation of the new materials and methods for the development and improvement of private construction, thereby emphasizing to the private sector the topics of social interest such as low-income housing. (http://www.itcr.ac.cr).

Septic Systems

According to Professor Escalante (05/26/2000), when deciding what kind of septic tank to use for a house, the climate and soil composition of the region must be taken into account. If the soil of a region has only small amounts of clay and little to moderate rainfall, the simplest septic tank can be used with an input from the house and an output pipe out into the ground. This is due to the fact that the soil will be able to absorb the fertilization.

However, if there is a lot of clay in the soil or a large amount of rainfall, the soil will be unable to soak up the fertilization. In this situation, a septic tank with a filter needs to be used. The filter used in this system is cylindrical in shape and the wastewater is fed into the bottom of the filter. The water is between 97 and 98 percent pure after it goes through the filtration system; this allows the water to be used for gardening or released into the soil.

Professor Pacheco (05/26/2000) and Fernando Chavarria (05/17/2000) both mentioned a problem with the current septic tanks. This problem is that the microorganisms that live in the septic tanks are not able to breakdown the mineral in the waste, so after several years of use the bottom of the septic tank starts to fill up with a hard layer of minerals. Because of this, the septic tanks must be pumped every two to five years. This is very expensive and many people cannot afford to get it done. The professors at CIVCO have found a solution to this problem. At the bottom of their septic tanks a pipe can be inserted and connected to a small collection box. This box has a lower pressure than the septic tank, so as the minerals settle to the bottom of the tank they are pulled into the box. This box is easier and cheaper to empty or replace than the pumping of the septic tank.

Appendix D. Photographs

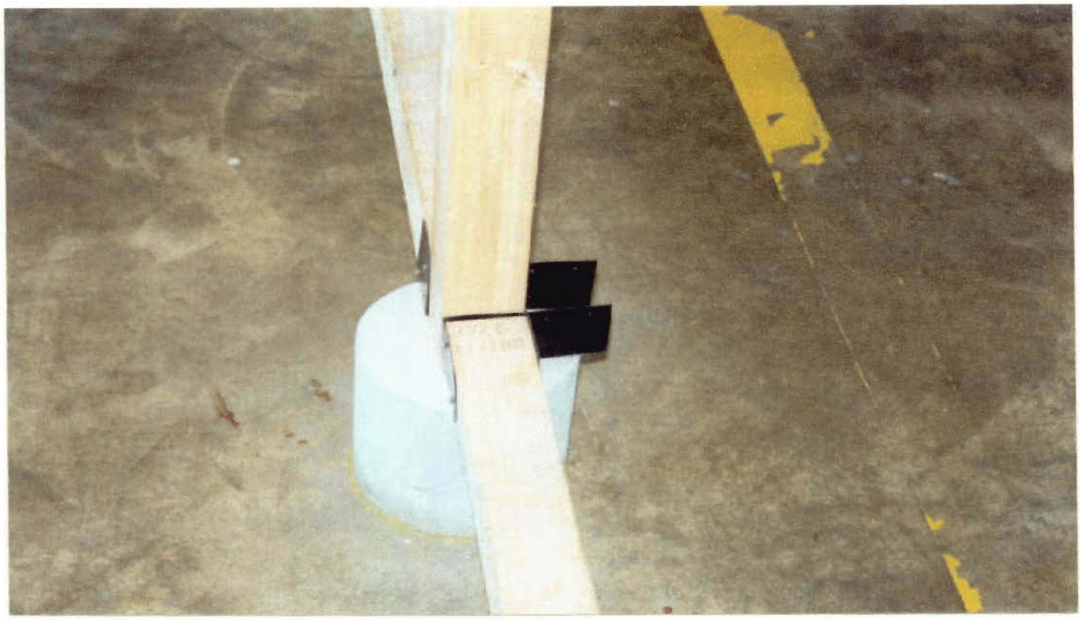
This section is dedicated to showing all visual representations of each building system.

HABITAT FOR HUMANITY'S CURRENT CONCRETE BLOCK SYSTEM

OUTSIDE VIEW OF A BLOCK HOUSE

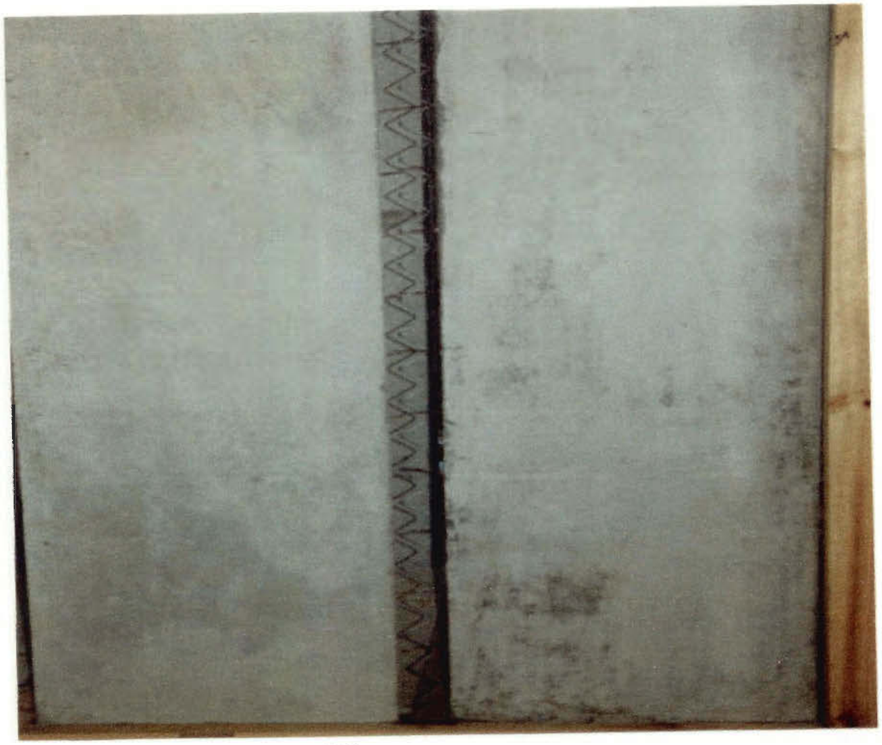
INSIDE VIEW OF A BLOCK HOUSE

Centro de Investigaciones en Viviendo y Construcción's Habicon System



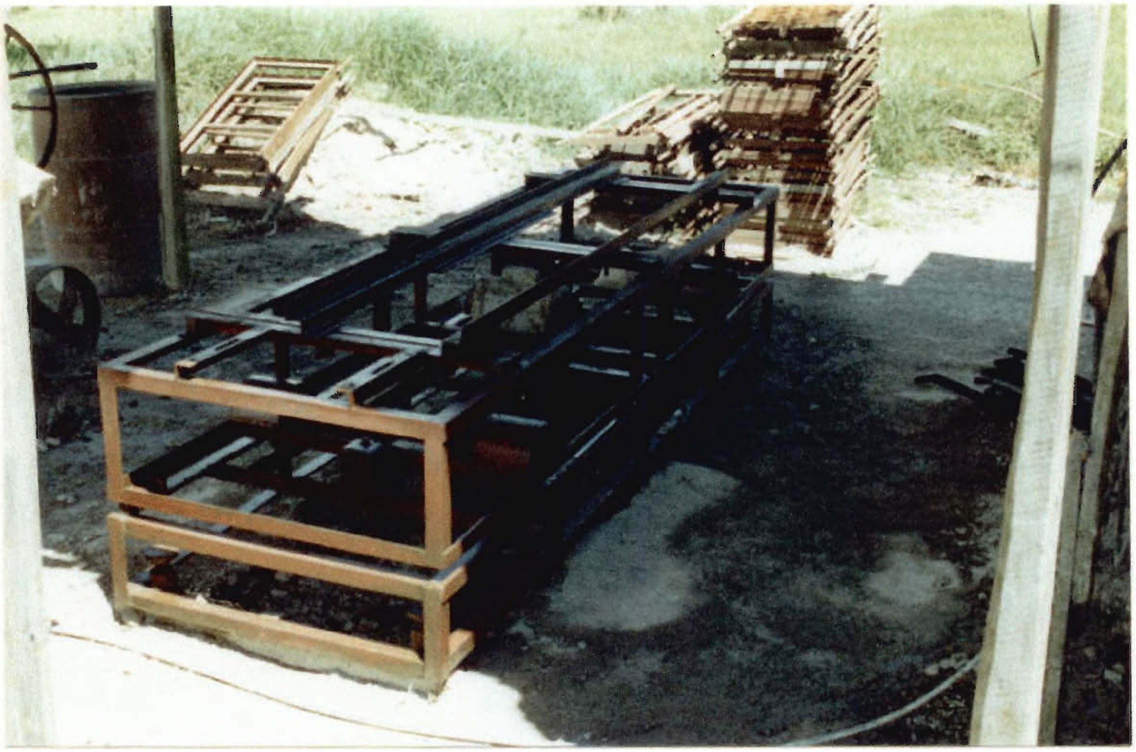
Pillar foundation with wooden frame and metal connectors

Habicon wall prior to final mortar



PANELS CONNECTED TO EACH OTHER

CEMENT MIXER USED FOR THE WALL PANELS AND ROOF TILES



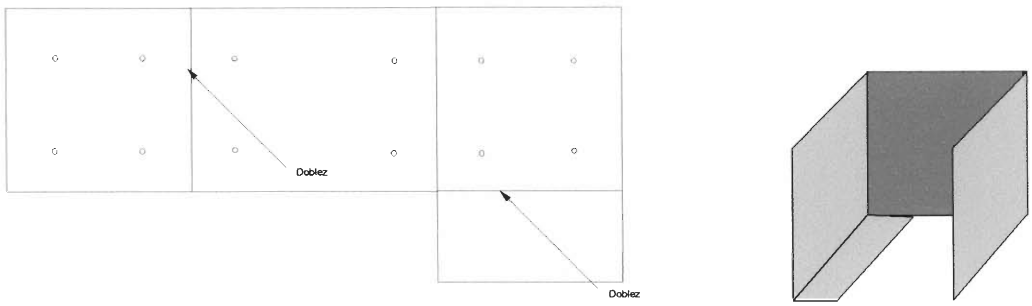
VIBRATING TABLE USED TO MAKE BOTH ROOF TILES AND WALL PANELS

MOLDS USED FOR VIBRATING TABLE

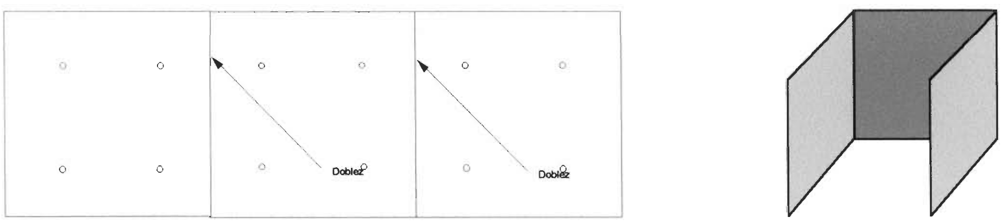
FINISHED HABICON PANELS

FINISHED MICRO FIBER ROOF TILES

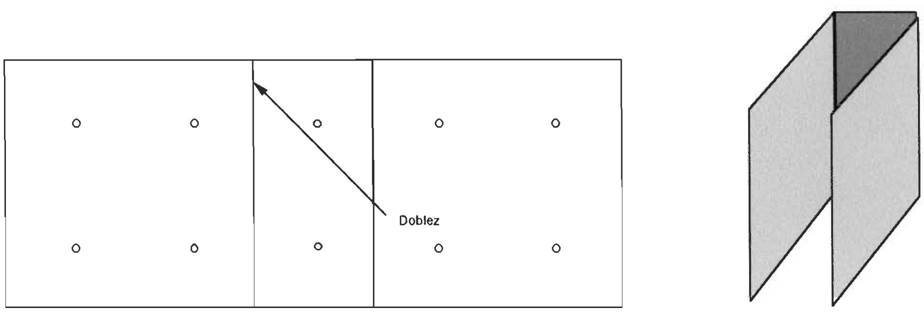
FINISHED HOUSE MADE ENTIRELY WITH THE HABICON SYSTEM



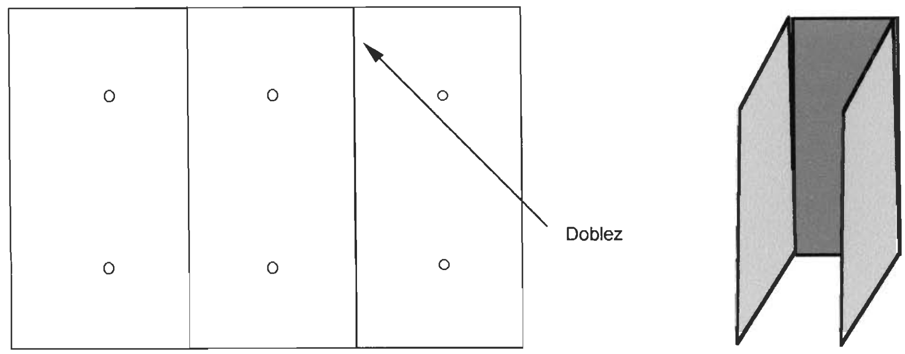
CONNECTOR COLUMN-BEAM



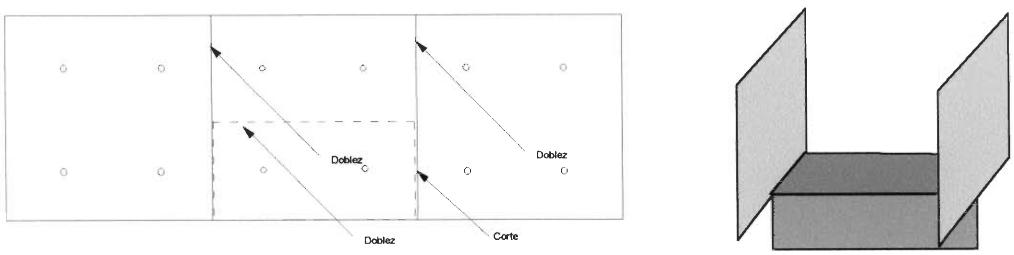
CONNECTOR SECONDARY COLUMN-BEAM



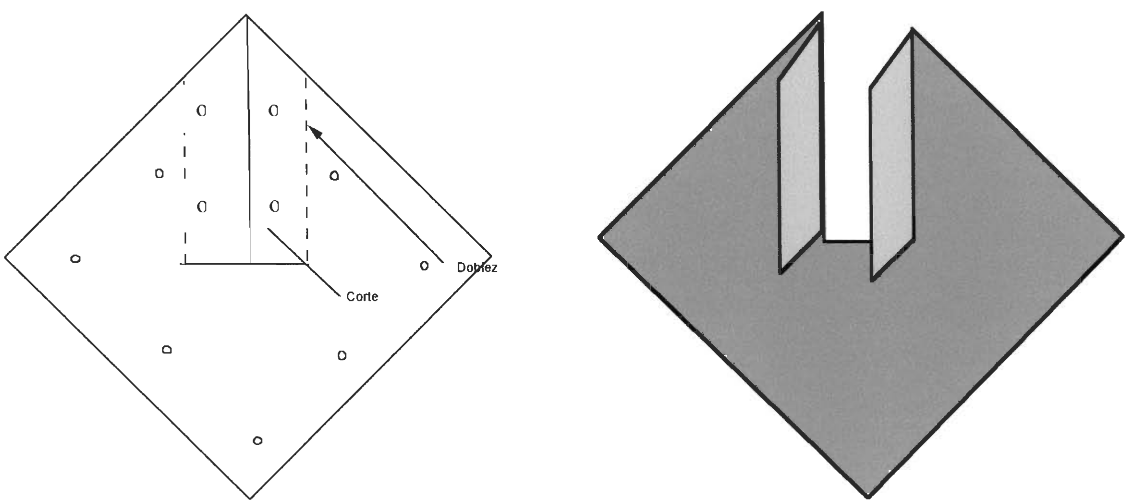
CONNECTOR MAIN ROOF BEAMS



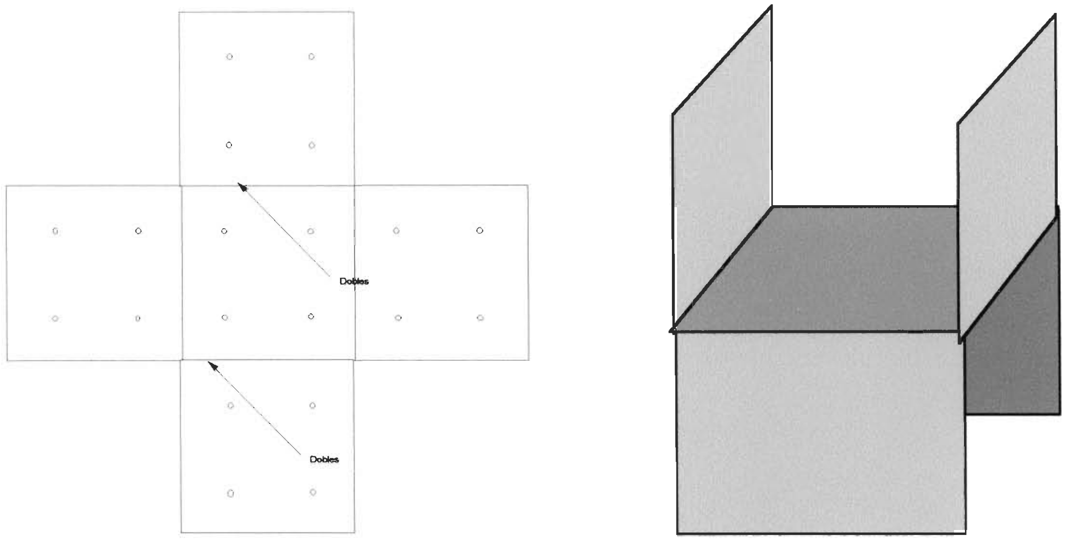
CONNECTOR SECONDARY ROOF BEAMS



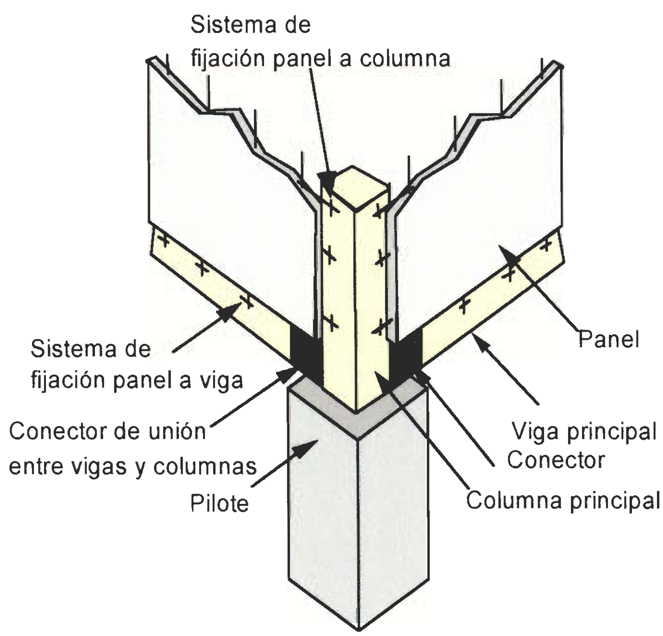
CONNECTOR BETWEEN BEAMS OR BEAM-COLUMN



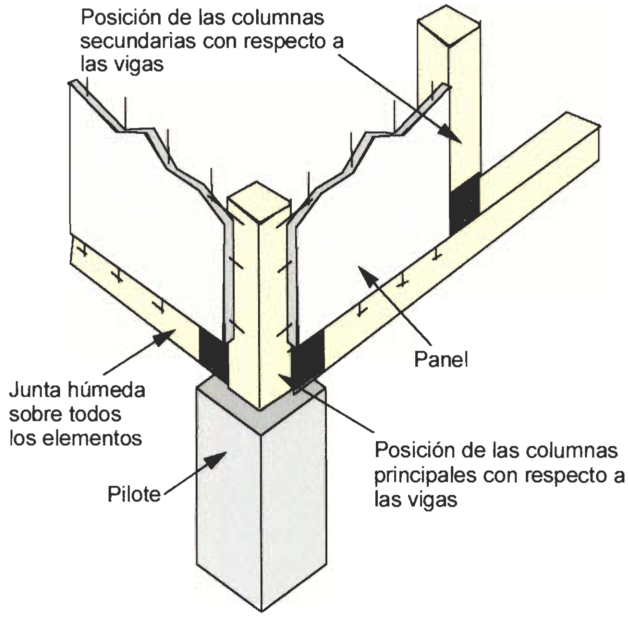
CONNECTOR BETWEEN BEAMS FOR ROOF



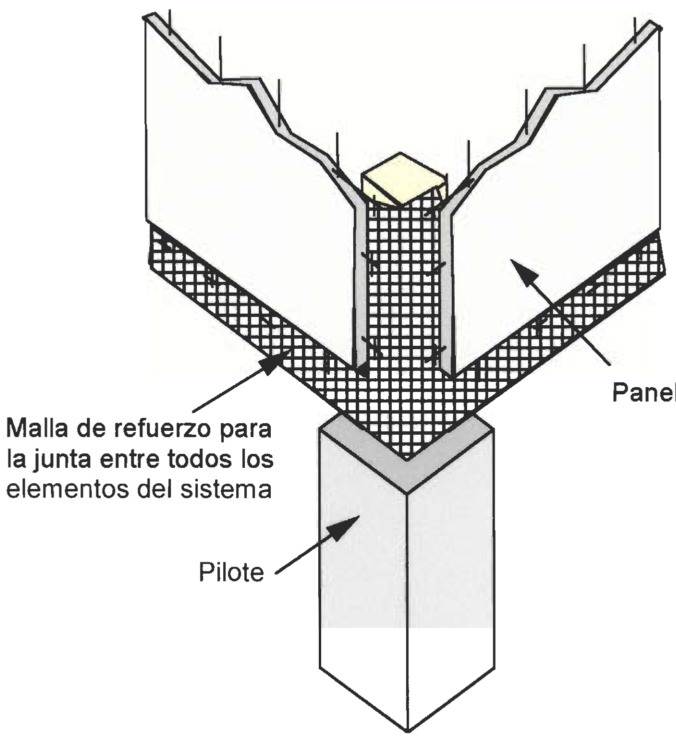
CONNECTOR COLUMN-COLUMN



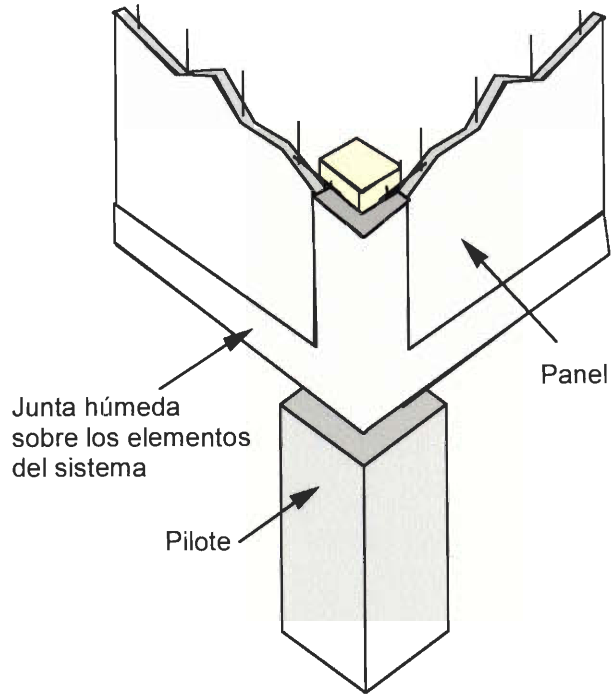
FOUNDATION DETAIL



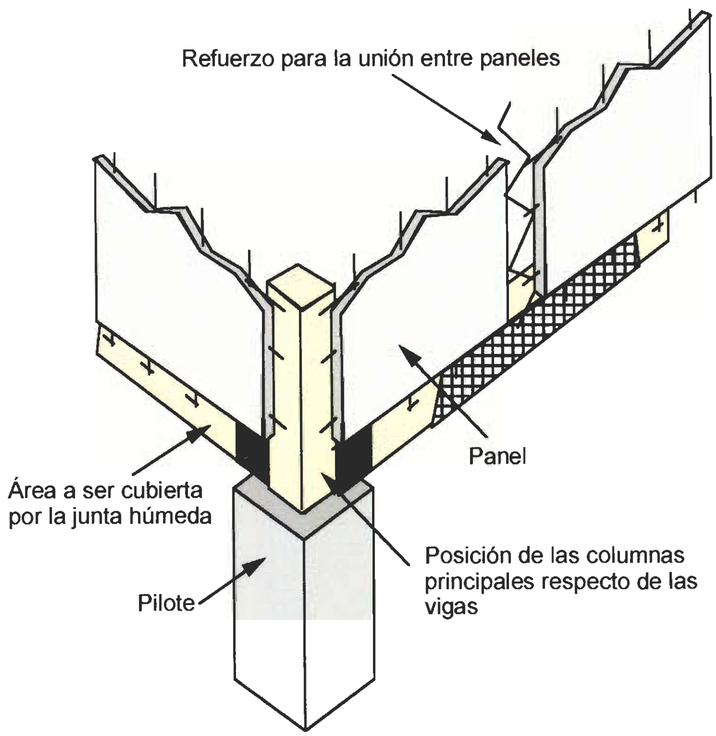
PRIMARY AND SECONDARY COLUMNS DETAIL



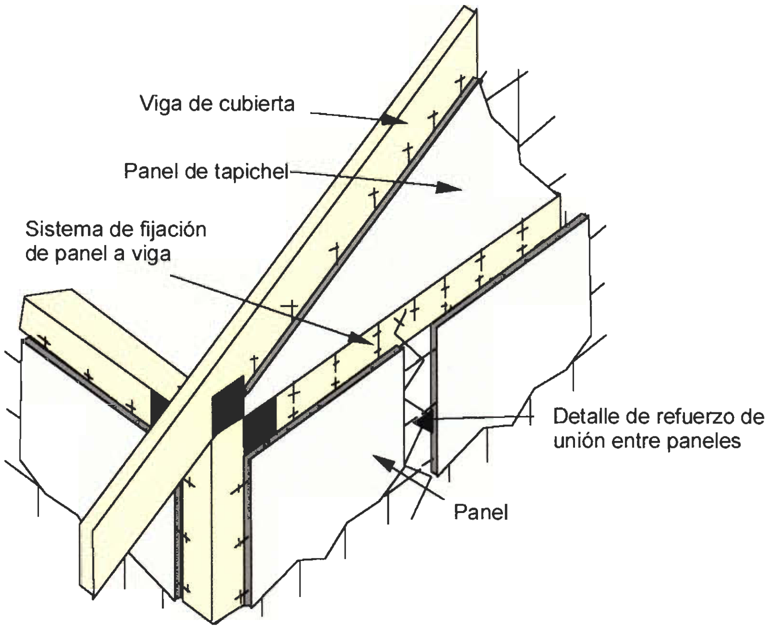
JOINT REINFORCEMENT DETAIL



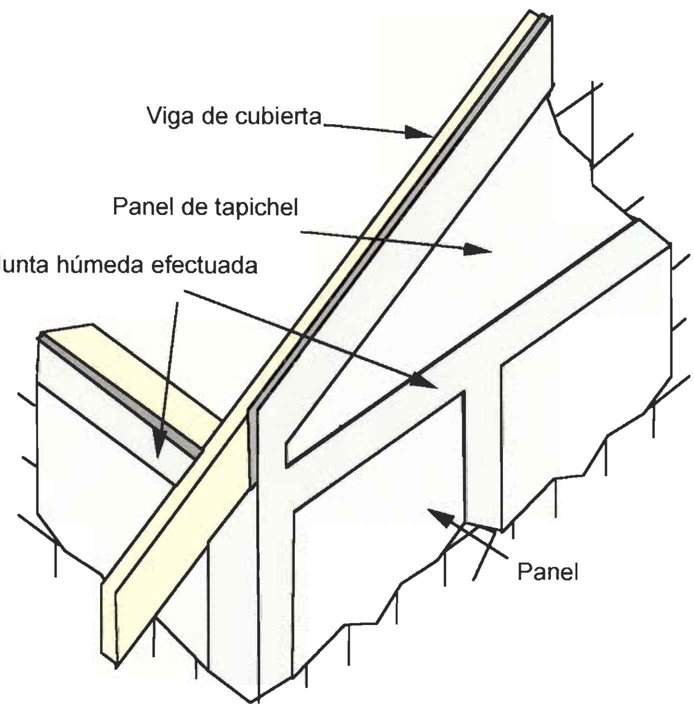
JOINTS FINAL RESULT



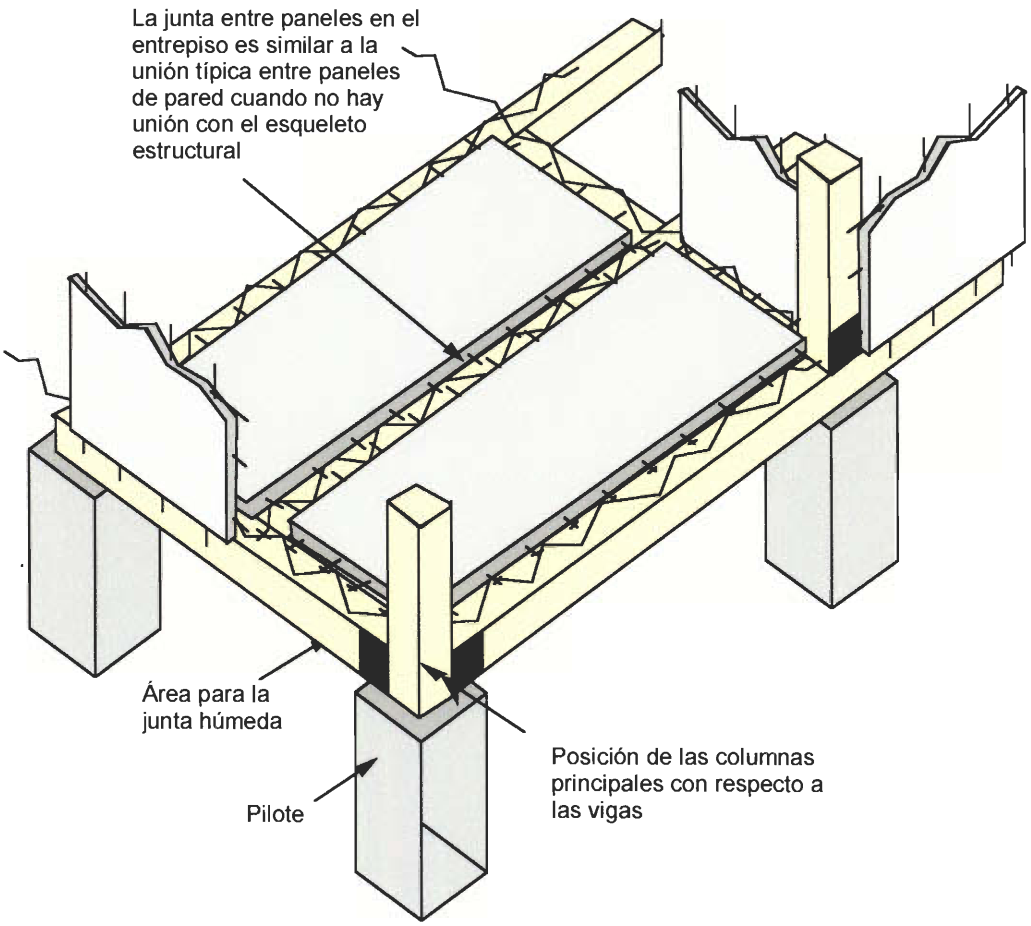
JOINT BETWEEN PANELS



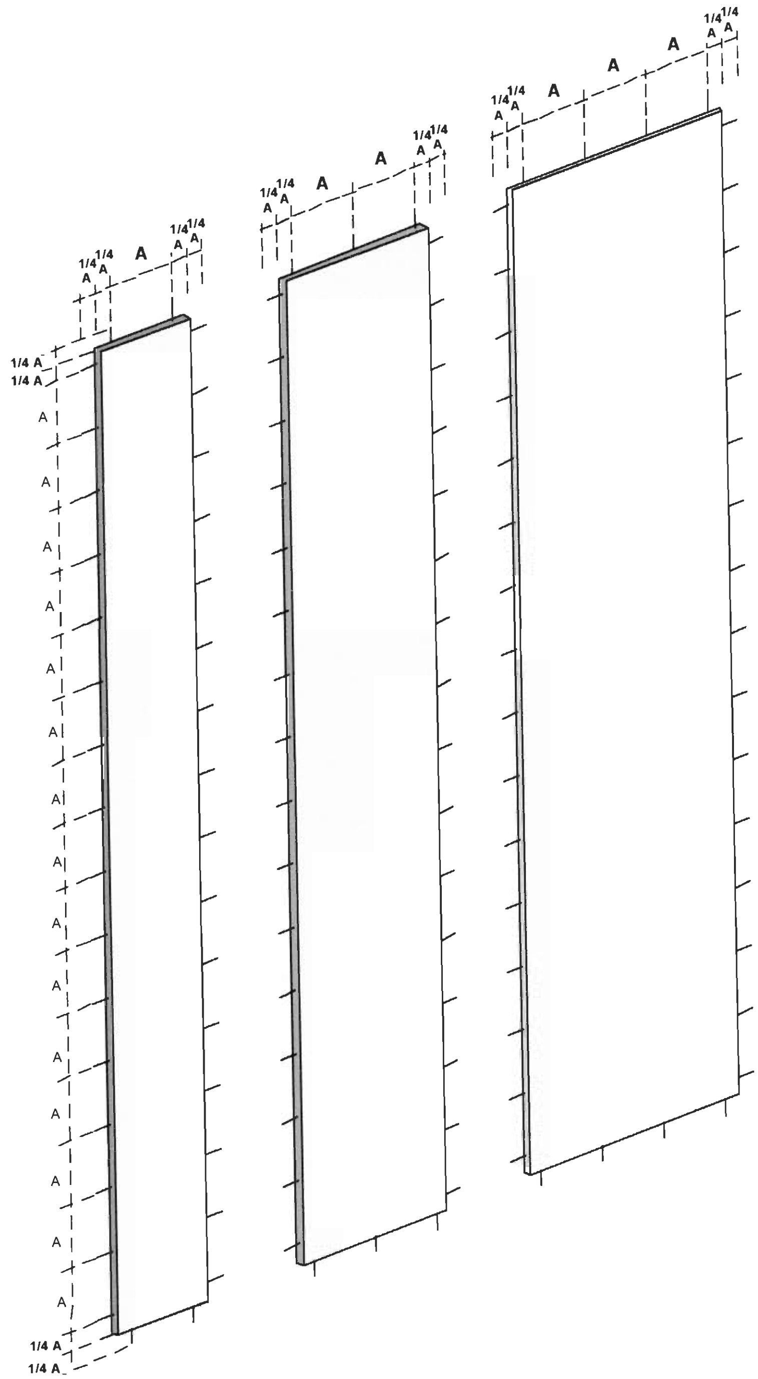
JOINT BETWEEN WALL PANELS AND ROOF PANELS



JOINTS WALL PANELS-ROOF PANELS

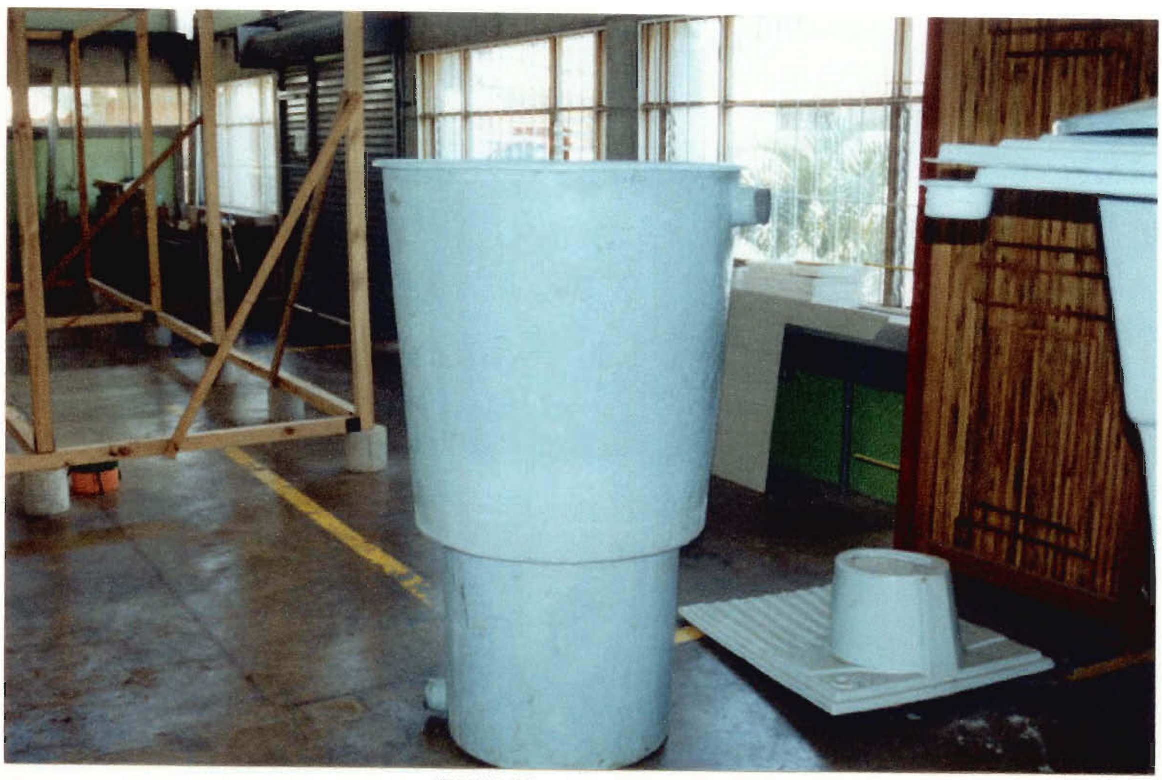


FLOOR PANEL DETAIL

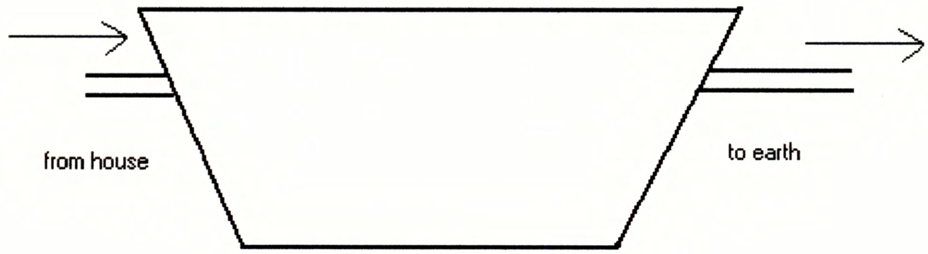


PANELS MODULATION DETAIL (A = MODULE)

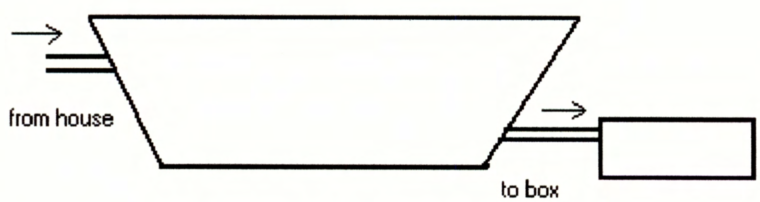
CIVCO'S SEPTIC TANK



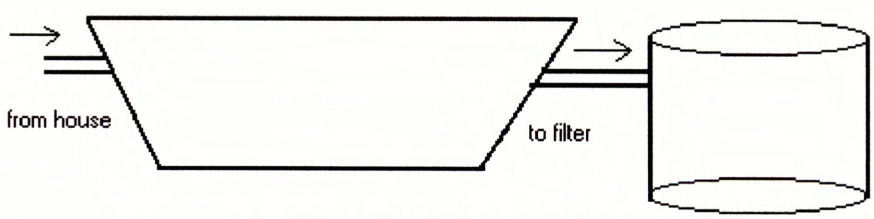
CIVCO'S SEPTIC FILTER



BASIC SEPTIC TANK

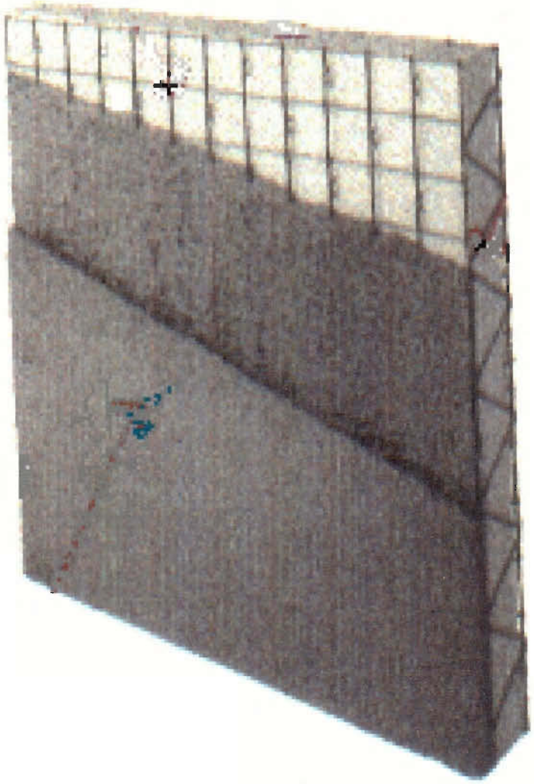


TANK TO BOX SEPTIC SYSTEM



TANK TO FILTER SEPTIC SYSTEM

HOPSA'S COVINTEC SYSTEM

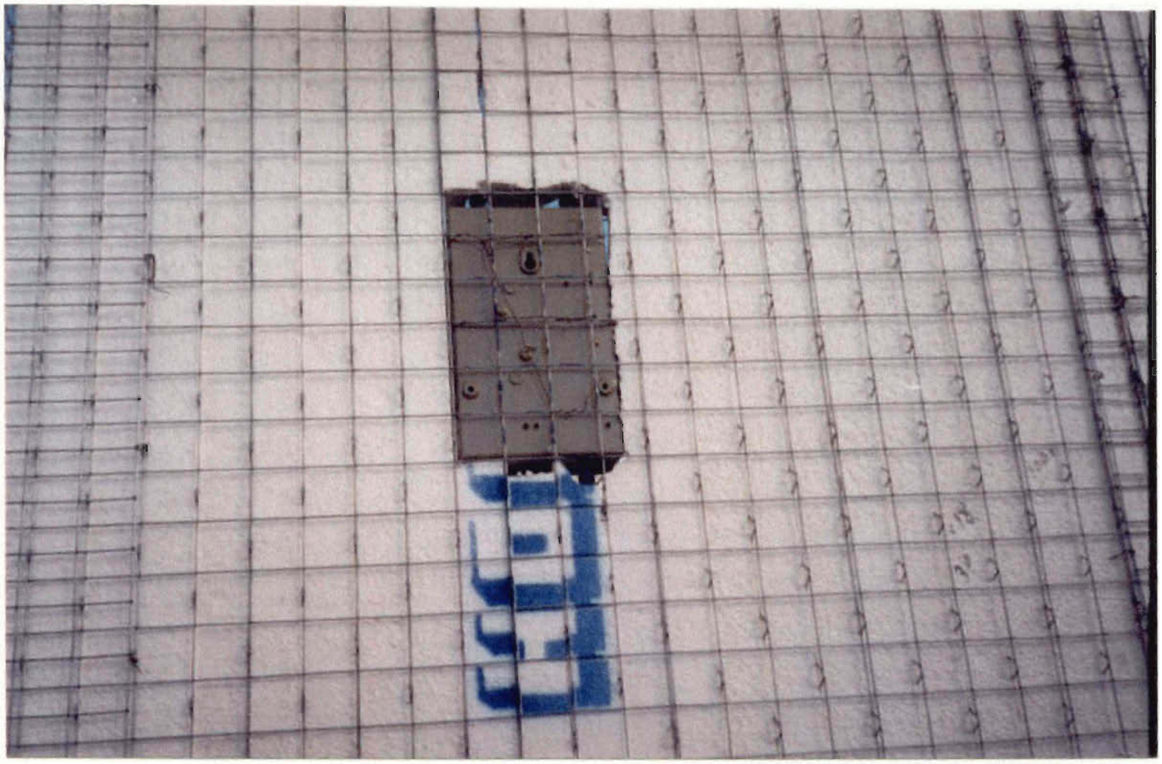


COVINTEC WALL PANEL SHOWING ALL THREE STAGES

WALL CONSTRUCTED WITH COVINTEC PANELS

WALL CONSTRUCTED USING COVINTEC PANELS

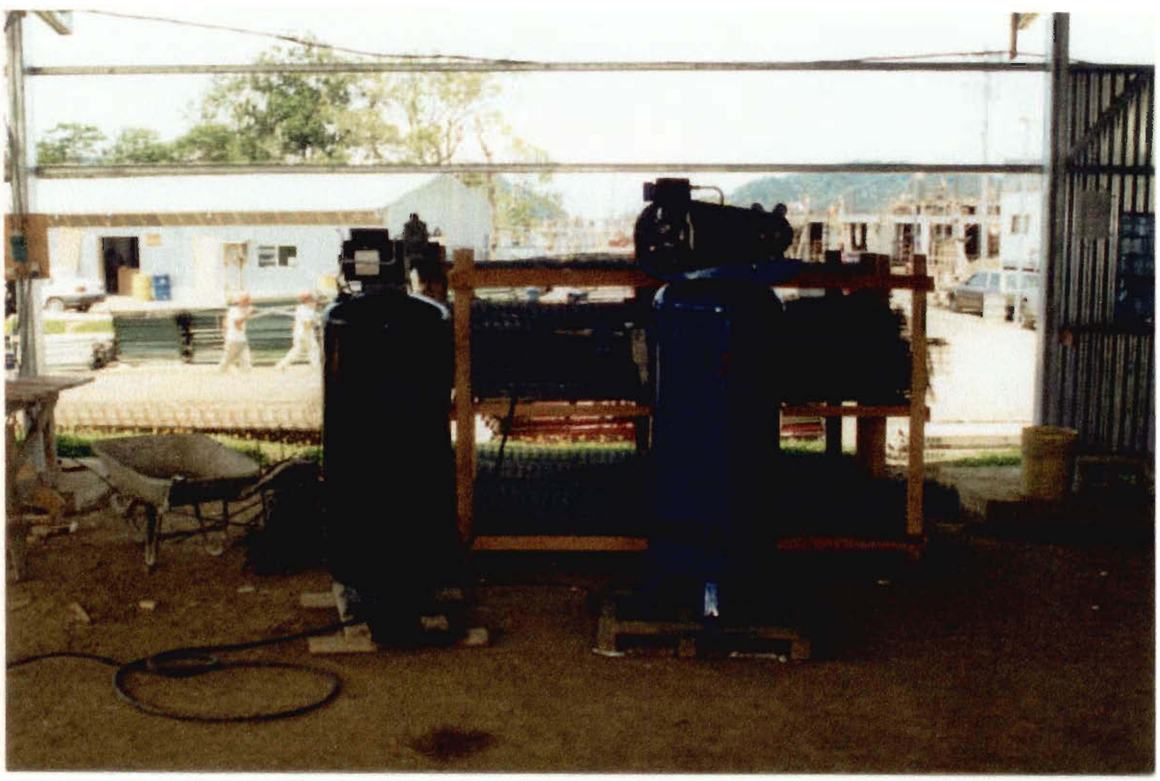
WALL BEING CONSTRUCTED WITH COVINTEC PANELS



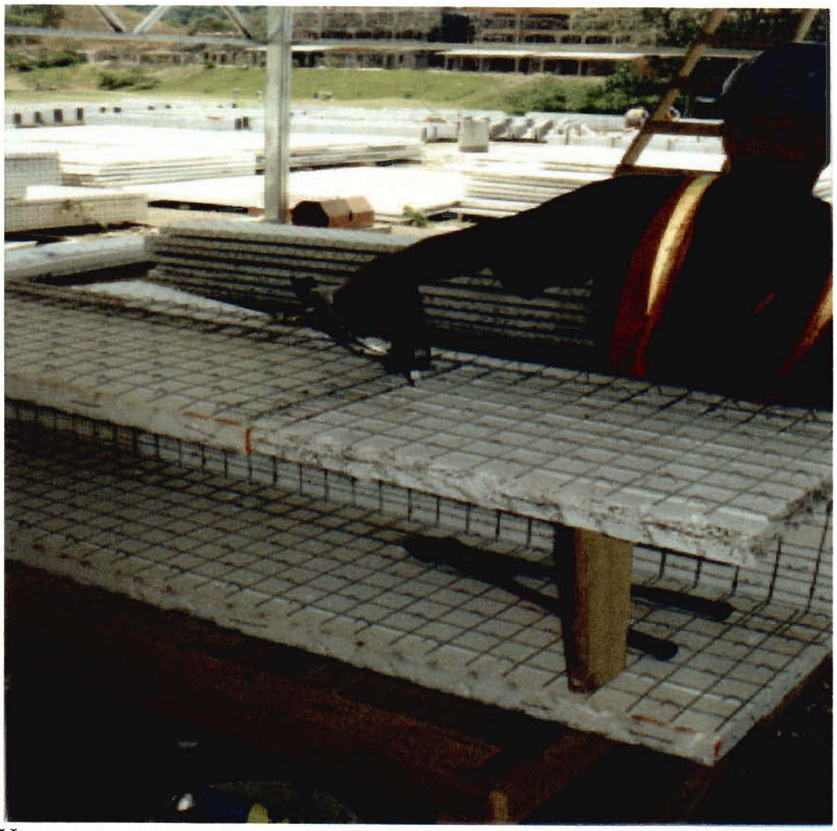
ELECTRIC BOX INSTALLED INTO A COVINTEC PANEL

FIRST LAYER OF MORTAR BEING APPLIED TO THE WALL

ROUGH MORTAR BEING APPLIED TO WALL USING MORTAR GUN



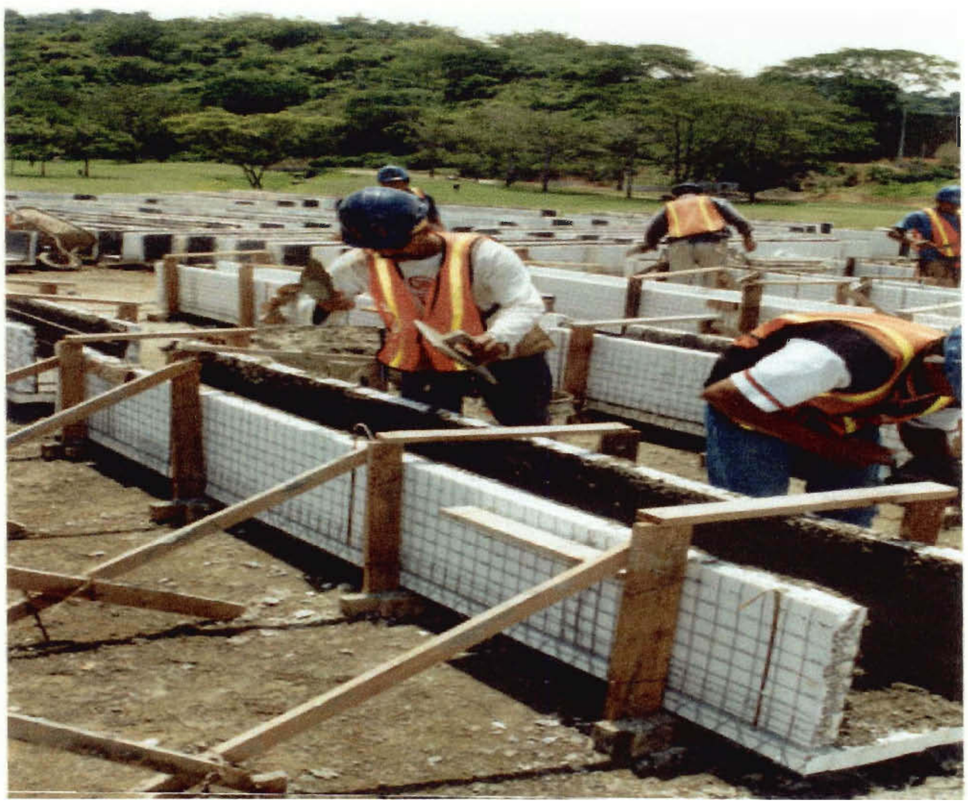
AIR PUMPS USED TO POWER STAPLE GUN FOR ATTACHING PANELS TOGETHER



WORKER ATTACHING TWO PANELS USING AIR POWERED STAPLE GUN

CEMENT MIXER USED FOR MIXING MORTAR

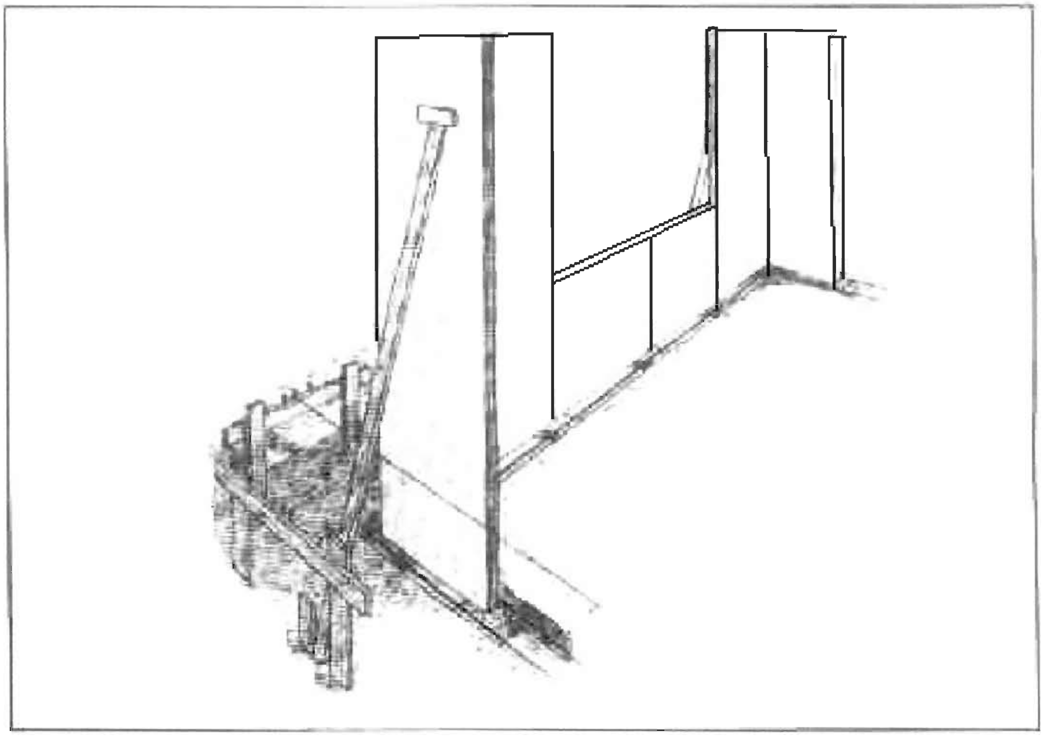
COVINTEC BEING USED IN A LARGE-SCALE OPERATION



FIRST LAYER OF MORTAR BEING APPLIED TO PANELS

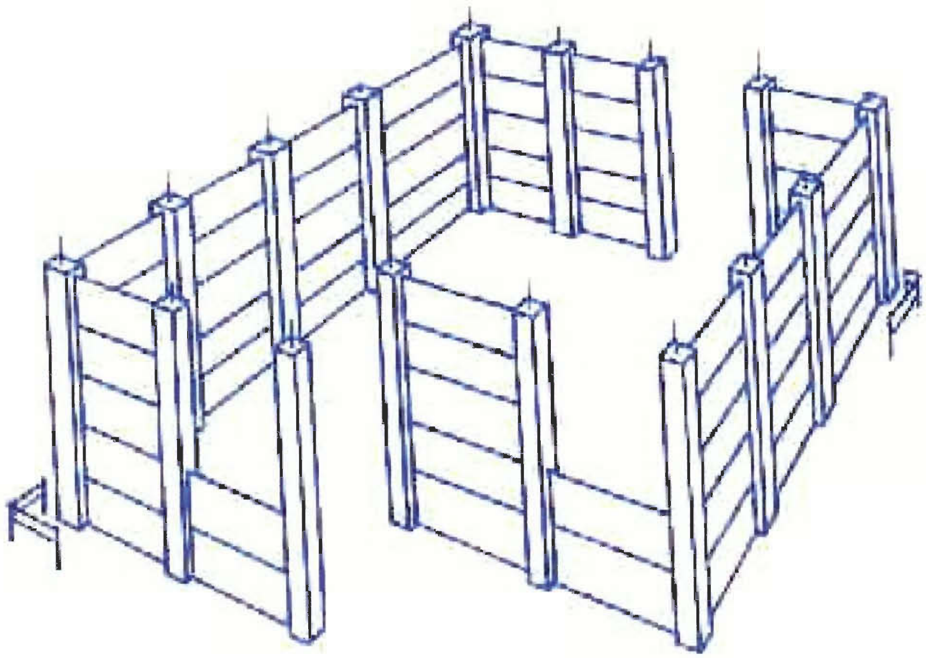
FINISHED HOUSE MADE WITH COVINTEC WALLS

ZITRO



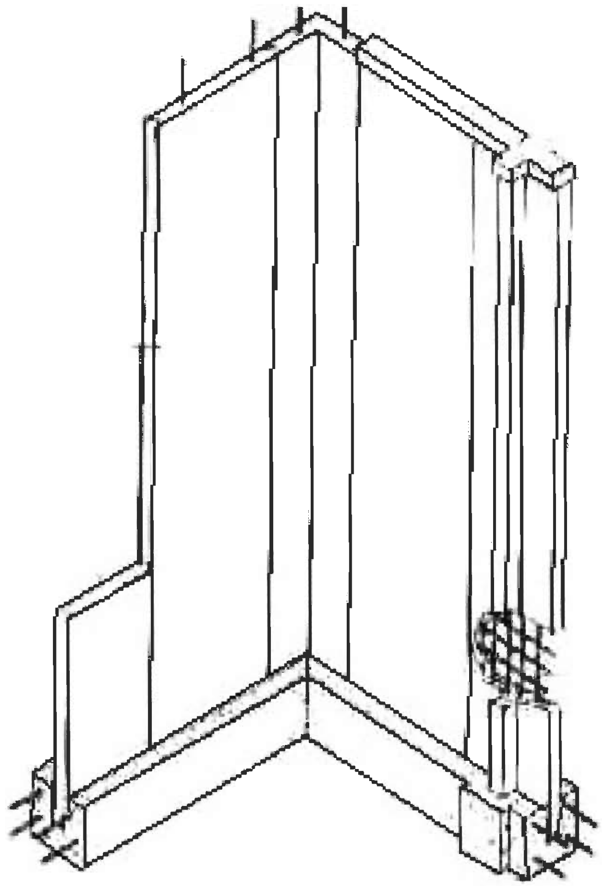
WALL MADE WITH THE ZITRO SYSTEM

PREFABRICADORA DE BALDOSAS Y COLUMNAS



MODEL OF A HOUSE BUILT WITH THE PBC SYSTEM

CASAS PREFABRICADAS' CONPREPAL SYSTEM



MODEL OF A CONPREPAL TILE

APPENDIX F. HABITAT HOUSE BUILT WITH CONCRETE BLOCK PAGE 165

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ciminto	*Cement*						
Madre De Trazo/Reglas 1x3x1	Woodline 1x3x1	Varas	90	¢90.00	$0.30	¢8,100.00	$26.64
Cuerda	String	Kilograms	1	¢350.00	$1.15	¢350.00	$1.15
Varilla	Rod, Srick 3/8	Per Unit	25	¢355.00	$1.17	¢8,875.00	$29.19
Varilla	Rod, Srick 1/4	Per Unit	15	¢166.20	$0.55	¢2,493.00	$8.20
Cemento	Cement	Per Unit	20	¢1,406.00	$4.63	¢28,120.00	$92.50
Arena Corriente	Ordinary Sand	Meters	2.5	¢4,000.00	$13.16	¢10,000.00	$32.89
Piedra 4ta	Stones 4ta	Meters	2.5	¢6,000.00	$19.74	¢15,000.00	$49.34
Alambre De Amarre	Wire Morning	Kilograms	4	¢218.00	$0.72	¢872.00	$2.87
Hojas De Segeta	Blades	Per Unit	3	¢245.21	$0.81	¢735.63	$2.42
2.5 Clavos	Nails 2.5	Kilograms	1	¢212.05	$0.70	¢212.05	$0.70
					Total	*¢74,757.68*	*$245.91*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Paredes	*Walls*						
Block 12x20x40	Blocks 12x20x40	Per Unit	1010	¢100.00	$0.33	¢101,000.00	$332.24
Varillas 3/8	Rods, Sticks 3/8	Per Unit	42	¢355.00	$1.17	¢14,910.00	$49.05
Varillas 1/4	Rods, Sticks 1/4	Per Unit	37	¢166.20	$0.55	¢6,149.40	$20.23
Reglas 1x3x3	Rulers 1x3x3	Meter	87	¢441.00	$1.45	¢38,367.00	$126.21
Arena Fina	Sand Finishing	Meter	5	¢5,600.00	$18.42	¢28,000.00	$92.11
Arena Corriente	Ordinary Sand	Meter	1.5	¢4,000.00	$13.16	¢6,000.00	$19.74
Piedra Cuarta	Stone Span	Meter	1.5	¢4,950.00	$16.28	¢7,425.00	$24.42
Cemento	Cement	Per Unit	38	¢1,406.00	$4.63	¢53,428.00	$175.75
1" Clavos	Nails 1"	Kilogram	2	¢343.00	$1.13	¢686.00	$2.26
2" Clavos Con Cab.	Nails with Cab. 2"	Kilogram	7	¢271.00	$0.89	¢1,897.00	$6.24
2.5" Clavos	Nails 2.5"	Kilogram	6	¢212.05	$0.70	¢1,272.30	$4.19
Fibrolit	Fiber	Per Unit	9	¢3,514.00	$11.56	¢31,626.00	$104.03
Alambre De Amarre	Wire Morning	Kilogram	3	¢218.00	$0.72	¢654.00	$2.15
Ceramica	Ceramics	Meter	1	¢3,100.00	$10.20	¢3,100.00	$10.20
Porcelana	Porcalin	Kilogram	1	¢398.00	$1.31	¢398.00	$1.31
					Total	*¢294,912.70*	*$970.11*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Viga Corona Y Tapichel	***Beams, Rafters, and Crowns***						
Varillas 1/4	Rods, Sticks 1/4	Per Unit	28	¢166.20	$0.55	¢4,653.60	$15.31
Varillas 3/8	Rods, Sticks 3/8	Per Unit	43	¢355.00	$1.17	¢15,265.00	$50.21
Arena Corriente	Ordinary Sand	Meter	2	¢4,000.00	$13.16	¢8,000.00	$26.32
Piedra Cuarta	Stone Span	Meter	2	¢4,950.00	$16.28	¢9,900.00	$32.57
Cemento	Cement	Per Unit	14	¢1,406.00	$4.63	¢19,684.00	$64.75
Tablas 1x12x4	Plank, Board 1x12x4	Per Unit	33	¢1,120.00	$3.68	¢36,960.00	$121.58
Madera 1x5x4 Cargador	Wood 1x5x4 Chamber	Meter	20	¢145.00	$0.48	¢2,900.00	$9.54
Alabre De Amarre	Wire Morning	Kilogram	6	¢218.00	$0.72	¢1,308.00	$4.30
2.5" Clavos	2.5" Nails	Kilogram	2	¢212.05	$0.70	¢424.10	$1.40
					Total	*¢99,094.70*	*$325.97*
Techo	*Roof*						
Zing 083x1.83 HG	Zinc 083x1.83 HG	Per Unit	17	¢998.00	$3.28	¢16,966.00	$55.81
Zing 083x3.66 HG	Zinc 083x3.66 HG	Per Unit	17	¢1,995.00	$6.56	¢33,915.00	$111.56
Perlig 2x4x6 HG	Metal Perlings 2x4x6	Per Unit	18	¢3,117.00	$10.25	¢56,106.00	$184.56
Tornillos Para Techo	Screws for Roof	Per Unit	225	¢9.00	$0.03	¢2,025.00	$6.66
Soldadura	Welding	Kilogram	2	¢800.00	$2.63	¢1,600.00	$5.26
Brocas 3/16 P/Hierro	Iron Bits 3/16	Per Unit	3	¢80.00	$0.26	¢240.00	$0.79
Tablillas 1/2x2	Planks, Boards	Meter	100	¢57.25	$0.19	¢5,725.00	$18.83
Clavos 1" Acero	Nails 1"	Per Unit	100	¢4.00	$0.01	¢400.00	$1.32
Tubo Industrial 1*2	Industrial Pipes	Meter	2	¢218.00	$0.72	¢436.00	$1.43
Botaguas 12" HG	Bolts 12"	Per Unit	12	¢490.00	$1.61	¢5,880.00	$19.34
Cumbreras 12" HG	?	Per Unit	4	¢476.00	$1.57	¢1,904.00	$6.26
Disco P/Hierro 9"	Iron Discs 9"	Per Unit	2	¢780.00	$2.57	¢1,560.00	$5.13
Spray Crinado	Crome Spray	Per Unit	1	¢1,110.00	$3.65	¢1,110.00	$3.65
Soldador	Welder		1	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*c141,867.00*	*$466.67*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Pisos	***Floor***						
Arena Corriente	Normal Sand	Meter	3	¢4,000.00	$13.16	¢52,631.58	$39.47
Arena Fina	Sand Finishing	Meter	1	¢5,600.00	$18.42	¢103,157.89	$18.42
Cemento	Cement	Per Unit	27	¢1,406.00	$4.63	¢6,502.75	$124.88
Ocre	?	Kilogram	8	¢683.00	$2.25	¢1,534.50	$17.97
					Total	*¢163,826.73*	*$200.74*
Plameria	***Pluming***						
Pegamento	Glue	Gallon	0.125	¢1,326.00	$4.36	¢165.75	$0.55
Tubos 1/2" PVC	Pipes 1/2" PVC	Per Unit	5	¢715.00	$2.35	¢3,575.00	$11.76
Codos 1/2" PVC Lisos	Elbow 1/2" PVC	Per Unit	10	¢44.00	$0.14	¢440.00	$1.45
Codos 1/2" PVC C/Rosca	Elbow 1/2" PVC	Per Unit	5	¢59.00	$0.19	¢295.00	$0.97
Teflon	Teflon	Per Unit	2	¢50.63	$0.17	¢101.26	$0.33
Tee 1/2" PVC	?	Per Unit	5	¢47.00	$0.15	¢235.00	$0.77
Adaptador Macho	Male Adapter	Per Unit	6	¢41.00	$0.13	¢246.00	$0.81
Tubos 2" PVC	Pipes 2" PVC	Per Unit	3	¢2,274.00	$7.48	¢6,822.00	$22.44
Tee 2" PVC	?	Per Unit	3	¢351.00	$1.15	¢1,053.00	$3.46
Codos 2" PVC	Elbow 2" PVC	Per Unit	6	¢260.00	$0.86	¢1,560.00	$5.13
Tubos 4" PVC	Pipe 4" PVC	Per Unit	3	¢6,326.00	$20.81	¢18,978.00	$62.43
Codos 4" PVC	Elbow 4" PVC	Per Unit	2	¢1,135.00	$3.73	¢2,270.00	$7.47
Tee 4" PVC	?	Per Unit	2	¢1,468.00	$4.83	¢2,936.00	$9.66
Llave De Paso 1/2"	Key of ?	Per Unit	1	¢784.10	$2.58	¢784.10	$2.58
Llave Para Bano	Bathroom Key	Per Unit	1	¢6,313.71	$20.77	¢6,313.71	$20.77
Llave De Chorro	Jetspurt Key	Per Unit	1	¢734.00	$2.41	¢734.00	$2.41
manguera 1 1/2"	Jetspurt Key ?	Per Unit	1	¢925.45	$3.04	¢925.45	$3.04
Asparcion Metalica	Metal Aspiration	Per Unit	1	¢1,330.00	$4.38	¢1,330.00	$4.38
Fregadero Nates	Sink	Per Unit	1	¢16,883.00	$55.54	¢16,883.00	$55.54
Inodoro economico	ordorless ecomic	Per Unit	1	¢14,850.35	$48.85	¢14,850.35	$48.85
Lavatorio	?	Per Unit	1	¢8,572.00	$28.20	¢8,572.00	$28.20
Tubos Abasto	Tubes for pipe	Per Unit	1	¢752.00	$2.47	¢752.00	$2.47
Pila Roja	Heating Battery	Per Unit	1	¢5,000.00	$16.45	¢5,000.00	$16.45
Parrilla De Desague	Drain Grill	Per Unit	1	¢412.90	$1.36	¢412.90	$1.36
Niple 12" Niquilado	Niple 12" ?	Per Unit	1	¢728.00	$2.39	¢728.00	$2.39
Niple 6" Niquilado	Niple 6" ?	Per Unit	2	¢446.12	$1.47	¢892.24	$2.94
Manguera 1 1/2"	Hosepipe 1 1/2"	Meter	2	¢465.00	$1.53	¢930.00	$3.06
Union 1/2" PVC	Joining PVC 1/2"	Per Unit	2	¢66.00	$0.22	¢132.00	$0.43
					Total	*¢97,916.76*	*$322.09*
Spanish	**Translation**	**Units**	**Quantity**	**Price Per Unit in Colones**	**Price per Unit in Dollars**	**Cost in Colones**	**Cost in Dollars**
Tanque Septico	***Septic Tank***						
Block 12*20*40	Block 12*20*40	Per Unit	120	¢100.00	$0.33	¢12,000.00	$39.47
Arena Fina	Finishing Sand	Meter	1	¢5,600.00	$18.42	¢5,600.00	$18.42
Arena Corriente	Normal Sand	Meter	1	¢4,000.00	$13.16	¢4,000.00	$13.16
Varillas De 3/8	Rod, Stick 3/8	Per Unit	10	¢355.00	$1.17	¢3,550.00	$11.68
Cemento	Cement	Per Unit	6	¢1,406.00	$4.63	¢8,436.00	$27.75
Alambre De Amarre	Wire Morning	Kilogram	1	¢218.00	$0.72	¢218.00	$0.72
Tubo Perforado Drenasep	Drainage pipe	Per Unit	1	¢3,640.00	$11.97	¢3,640.00	$11.97
Piedra	Uncut Stone	Meter	7	¢4,150.00	$13.65	¢29,050.00	$95.56
					Total	*¢66,494.00*	*$218.73*

Ventanas Y Puertas	*Windows and Doors*						
Regla 1*3 C/Cepillo	?	Meter	60	¢210.00	$0.69	¢12,600.00	$41.45
Venilla 1/2*1 Laurel	?	Meter	160	¢38.00	$0.13	¢6,080.00	$20.00
Regla 1*4 C/Cepillo	?	Meter	24	¢415.38	$1.37	¢9,969.12	$32.79
Tablilla 1/2*3 Laurel	Plank, Board	Meter	105	¢90.00	$0.30	¢9,450.00	$31.09
Clavos 1 1/4" Sin Cabeza	Nails without heads	Kilogram	0.25	¢282.20	$0.93	¢70.55	$0.23
Pegamento Blanco	White Glue	Gallon	0.125	¢625.70	$2.06	¢78.21	$0.26
Puerta Principal	Main Door	Per Unit	1	¢18,000.00	$59.21	¢18,000.00	$59.21
Vidrios Para Ventanas	Window Glass	Per Unit	6	¢5,000.00	$16.45	¢30,000.00	$98.68
Clavos 2" Sin Cabeza	Nails without heads	Kilogram	1.5	¢302.00	$0.99	¢453.00	$1.49
Clavos 2" Acero	Nails	Per Unit	100	¢5.00	$0.02	¢500.00	$1.64
Llavin Vera	Latch Key Glue	Per Unit	1	¢2,255.00	$7.42	¢2,255.00	$7.42
Visagras 3"	?	Pairs	3	¢325.00	$1.07	¢975.00	$3.21
Picaportes 3"	Doorlatch	Per Unit	2	¢166.10	$0.55	¢332.20	$1.09
Platinas 1*1/8	Slider	Per Unit	5	¢464.03	$1.53	¢2,320.15	$7.63
					Total	*¢93,083.23*	*$306.19*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Instalacion Electrica	***Electric Installation***						
Cajas Rectangulares	Rectangle Box	Per Unit	13	¢86.00	$0.28	¢1,118.00	$3.68
Cajas Octagonales	Octagonal Box	Per Unit	8	¢127.00	$0.42	¢1,016.00	$3.34
Conectores 1/2 PVC	Connectors 1/2 PVC	Per Unit	30	¢21.13	$0.07	¢633.90	$2.09
Tubos Conduit 1/2"	Pipe ?	Per Unit	35	¢308.00	$1.01	¢10,780.00	$35.46
Tubos Conduit 3/4"	Pipe ?	Per Unit	4	¢405.16	$1.33	¢1,620.64	$5.33
Tape 3M	3M Tape	Per Unit	1	¢915.40	$3.01	¢915.40	$3.01
Toma Corrente	Current Socket	Per Unit	7	¢683.00	$2.25	¢4,781.00	$15.73
Portalamparas	Socket	Per Unit	8	¢238.54	$0.78	¢1,908.32	$6.28
Apagadores Sencillos	Single ?	Per Unit	4	¢417.65	$1.37	¢1,670.60	$5.50
Apagadores Dobles	Double ?	Per Unit	2	¢555.40	$1.83	¢1,110.80	$3.65
Cable #12	Cable #12	Meters	200	¢61.00	$0.20	¢12,200.00	$40.13
Cable #10	Cable #10	Meters	20	¢102.00	$0.34	¢2,040.00	$6.71
Cable #6	Cable #6	Meters	65	¢253.00	$0.83	¢16,445.00	$54.10
Cuchilla Nec 2*100	?	Per Unit	1	¢3,430.10	$11.28	¢3,430.10	$11.28
Varilla Cooperwell	Rod, Stick ?	Per Unit	1	¢1,089.00	$3.58	¢1,089.00	$3.58
Union 3/4" Conduit	Joining Condoit 3/4"	Per Unit	2	¢39.00	$0.13	¢78.00	$0.26
Curvas 1/2" Conduit	Curved Condoit 1/2"	Per Unit	10	¢39.00	$0.13	¢390.00	$1.28
Curvas 3/4" Conduit	Curved Condoit 3/4"	Per Unit	4	¢61.18	$0.20	¢244.72	$0.81
Brek 40 AMP	?	Per Unit	1	¢1,520.00	$5.00	¢1,520.00	$5.00
Brek 30 AMP	?	Per Unit	1	¢1,282.00	$4.22	¢1,282.00	$4.22
Brek 15 AMP	?	Per Unit	2	¢1,106.00	$3.64	¢2,212.00	$7.28
Centro De Carga	Charge Center (Fusebox)	Per Unit	1	¢5,667.00	$18.64	¢5,667.00	$18.64
Instalacion Profecional	Professional Installation		1	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢86,152.48*	*$283.40*

Section	***Section***		***Quantity***	***Cost in Colones***	***Cost in Dollars***
Cimiento	*Cement*		*1*	*¢74,757.68*	*$245.91*
Paredes	*Walls*		*1*	*¢294,912.70*	*$970.11*
Viga Corona y Tapichel	*Beams, Rafters, and Crown*		*1*	*¢99,094.70*	*$325.97*
Techos	*Roof*		*1*	*¢141,867.00*	*$466.67*
Pisos	*Floors*		*1*	*¢163,826.73*	*$200.74*
Plomeria	*Pluming*		*1*	*¢97,916.76*	*$322.09*
Tanque Sectico	*Septic Tank*		*1*	*¢66,494.00*	*$218.73*
Ventanas y Puertas	*Windows and Doors*		*1*	*¢93,083.23*	*$306.19*
Instalacion Electrica	*Electric Installation*		*1*	*¢86,152.48*	*$283.40*
Thechos	*Roofer*		*1*	*¢12,000.00*	*$39.47*
Puertas	*Doors*		*1*	*¢18,000.00*	*$59.21*
Virdios	*Glass*		*1*	*¢28,000.00*	*$92.11*
Maestro de Obra	*Construction Supervisor*		*1*	*¢40,000.00*	*$131.58*
Costos Legales	*Legal Fees*		*1*	*¢74,250.00*	*$244.24*
Transporte	*Transportation*		*1*	*¢12,334.00*	*$40.57*
Albanil	*Mason*		*1*	*¢178,510.00*	*$587.20*
Gastos De Administracion	*Administration Fees*		*1*	*¢68,736.98*	*$226.11*
			Total Cost	*¢1,549,936.26*	*$4,760.31*

APPENDIX G. HABITAT *BUILT WITH Covintec*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ciminto	***Cement***						
Madre De Trazo/Reglas 1x3x1	Woodline 1x3x1	Varas	90	¢90.00	$0.30	¢8,100.00	$26.64
Cuerda	String	Kilograms	1	¢350.00	$1.15	¢350.00	$1.15
Varilla	Rod. Srick 3/8	Per Unit	36	¢355.00	$1.17	¢12,780.00	$42.04
Varilla	Rod. Srick 1/4	Per Unit	15	¢166.20	$0.55	¢2,493.00	$8.20
Cemento	Cement	Per Unit	12	¢1,406.00	$4.63	¢16,872.00	$55.50
Arena Corriente	Ordinary Sand	Meters	1	¢4,000.00	$13.16	¢4,000.00	$13.16
Piedra 4ta	Stones 4ta	Meters	1.3	¢6,000.00	$19.74	¢7,800.00	$25.66
Alambre De Amarre	Wire Morning	Kilograms	4	¢218.00	$0.72	¢872.00	$2.87
Hojas De Segeta	Blades	Per Unit	3	¢245.21	$0.81	¢735.63	$2.42
Clavos 2.5	Nails 2.5	Kilograms	1	¢212.05	$0.70	¢212.05	$0.70
					Total	*¢54,214.68*	*$178.34*
Materiles Covintec	***Covintec Materials***						
Panel COVINTEC 4'x8'x3"	Covintec Panels 4'x8'x3"	Per Unit	31.00	¢8,952.80	$29.45	¢277,536.80	$912.95
Malla Esquinera 6"x6"x8'	*Esquinera* Mesh 6"x6"x8'	Per Unit	12.00	¢820.80	$2.70	¢9,849.60	$32.40
Malla Union 4"x8'	Union Mesh 4"x8'	Per Unit	60.00	¢474.24	$1.56	¢28,454.40	$93.60
Sacos de Fibra	Fiber	Sacs	0	¢7,116.26	$23.41	¢0.00	$0.00
Arena Corriente	Ordinary Sand	Meter	6	¢4,000.00	$13.16	¢24,000.00	$78.95
Grapas de acero	Stainless Steel Staples	Pkg 12	3.00	¢3,237.60	$10.65	¢9,712.80	$31.95
Cemento	Cement	Per Unit	38	¢1,406.00	$4.63	¢53,428.00	$175.75
Fibrolit	Wall Devisions	Per Unit	9	¢3,514.00	$11.56	¢31,626.00	$104.03
	Wood Supprts	Per Unit	1	¢6,080.00	$20.00	¢6,080.00	$20.00
					Total	*¢440,687.60*	*$1,449.63*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Techo	***Roof***						
Zing 083x1.83 HG	Zinc 083x1.83 HG	Per Unit	17	¢998.00	$3.28	¢16,966.00	$55.81
Zing 083x3.66 HG	Zinc 083x3.66 HG	Per Unit	17	¢1,995.00	$6.56	¢33,915.00	$111.56
Perlig 2x4x6 HG	Metal Perlings 2x4x6	Per Unit	18	¢3,117.00	$10.25	¢56,106.00	$184.56
Tornillos Para Techo	Screws for Roof	Per Unit	225	¢9.00	$0.03	¢2,025.00	$6.66
Soldadura	Welding	Kilogram	2	¢800.00	$2.63	¢1,600.00	$5.26
Brocas 3/16 P/Hierro	Iron Bits 3/16	Per Unit	3	¢80.00	$0.26	¢240.00	$0.79
Tablillas 1/2x2	Planks, Boards	Meter	100	¢57.25	$0.19	¢5,725.00	$18.83
Clavos 1" Acero	Nails 1"	Per Unit	100	¢4.00	$0.01	¢400.00	$1.32
Tubo Industrial 1x2	Industrial Pipes	Meter	2	¢218.00	$0.72	¢436.00	$1.43
Botaguas 12" HG	Bolts 12"	Per Unit	12	¢490.00	$1.61	¢5,880.00	$19.34
Cumbreras 12" HG	*Roof Crown Cover*	Per Unit	4	¢476.00	$1.57	¢1,904.00	$6.26
Disco P/Hierro 9"	Iron Discs 9"	Per Unit	2	¢780.00	$2.57	¢1,560.00	$5.13
Spray Crinado	Crome Spray	Per Unit	1	¢1,110.00	$3.65	¢1,110.00	$3.65
Soldador	Welder		1	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢141,867.00*	*$466.67*

Pisos	***Floor***						
Arena Corriente	Normal Sand	Meter	3	¢4,000.00	$13.16	¢12,000.00	$39.47
Arena Fina	Sand Finishing	Meter	1	¢5,600.00	$18.42	¢5,600.00	$18.42
Cemento	Cement	Per Unit	27	¢1,406.00	$4.63	¢37,962.00	$124.88
Ocre	Ocher	Kilogram	8	¢683.00	$2.25	¢5,464.00	$17.97
					Total	¢61,026.00	$200.74

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Plameria	***Pluming***						
Pegamento	Glue	Gallon	0.125	¢1,326.00	$4.36	¢165.75	$0.55
Tubos 1/2" PVC	Pipes 1/2" PVC	Per Unit	5	¢715.00	$2.35	¢3,575.00	$11.76
Codos 1/2" PVC Lisos	Elbow 1/2" PVC	Per Unit	10	¢44.00	$0.14	¢440.00	$1.45
Codos 1/2" PVC C/Rosca	Elbow 1/2" PVC	Per Unit	5	¢59.00	$0.19	¢295.00	$0.97
Teflon	Teflon	Per Unit	2	¢50.63	$0.17	¢101.26	$0.33
Tee 1/2" PVC	1/2" PVC T Conection	Per Unit	5	¢47.00	$0.15	¢235.00	$0.77
Adaptador Macho	Male Adapter	Per Unit	6	¢41.00	$0.13	¢246.00	$0.81
Tubos 2" PVC	Pipes 2" PVC	Per Unit	3	¢2,274.00	$7.48	¢6,822.00	$22.44
Tee 2" PVC	2" PVC T Connection	Per Unit	3	¢351.00	$1.15	¢1,053.00	$3.46
Codos 2" PVC	Elbow 2" PVC	Per Unit	6	¢260.00	$0.86	¢1,560.00	$5.13
Tubos 4" PVC	Pipe 4" PVC	Per Unit	3	¢6,326.00	$20.81	¢18,978.00	$62.43
Codos 4" PVC	Elbow 4" PVC	Per Unit	2	¢1,135.00	$3.73	¢2,270.00	$7.47
Tee 4" PVC	4" PVC T Connection	Per Unit	2	¢1,468.00	$4.83	¢2,936.00	$9.66
Llave De Paso 1/2"	1/2" Step Key	Per Unit	1	¢784.10	$2.58	¢784.10	$2.58
Llave Para Bano	Bathroom Key	Per Unit	1	¢6,313.71	$20.77	¢6,313.71	$20.77
Llave De Chorro	Jetspurt Key	Per Unit	1	¢734.00	$2.41	¢734.00	$2.41
manguera 1 1/2"	?	Per Unit	1	¢925.45	$3.04	¢925.45	$3.04
Asparcion Metalica	Metal Aspiration	Per Unit	1	¢1,330.00	$4.38	¢1,330.00	$4.38
Fregadero Nates	Fiberglass Sink	Per Unit	1	¢16,883.00	$55.54	¢16,883.00	$55.54
Inodoro economico	ordorless ecomic	Per Unit	1	¢14,850.35	$48.85	¢14,850.35	$48.85
Lavatorio	Sink	Per Unit	1	¢8,572.00	$28.20	¢8,572.00	$28.20
Tubos Abasto	Tubes for pipe	Per Unit	1	¢752.00	$2.47	¢752.00	$2.47
Pila Roja	Heating Battery	Per Unit	1	¢5,000.00	$16.45	¢5,000.00	$16.45
Parrilla De Desague	Drain Grill	Per Unit	1	¢412.90	$1.36	¢412.90	$1.36
Niple 12" Niquilado	Niple 12" ?	Per Unit	1	¢728.00	$2.39	¢728.00	$2.39
Niple 6" Niquilado	Niple 6" ?	Per Unit	2	¢446.12	$1.47	¢892.24	$2.94
Manguera 1 1/2"	Hosepipe 1 1/2"	Meter	2	¢465.00	$1.53	¢930.00	$3.06
Union 1/2" PVC	Joining PVC 1/2"	Per Unit	2	¢66.00	$0.22	¢132.00	$0.43
					Total	*¢97,916.76*	*$322.09*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tanque Septico	***Septic Tank***						
Block 12x20x40	Block 12x20x40	Per Unit	120	¢100.00	$0.33	¢12,000.00	$39.47
Arena Fina	Finishing Sand	Meter	1	¢5,600.00	$18.42	¢5,600.00	$18.42
Arena Corriente	Normal Sand	Meter	1	¢4,000.00	$13.16	¢4,000.00	$13.16
Varillas De 3/8	Rod, Stick 3/8	Per Unit	10	¢355.00	$1.17	¢3,550.00	$11.68
Cemento	Cement	Per Unit	6	¢1,406.00	$4.63	¢8,436.00	$27.75
Alambre De Amarre	Wire Morning	Kilogram	1	¢218.00	$0.72	¢218.00	$0.72
Tubo Perforado Drenasep	Drainage pipe	Per Unit	1	¢3,640.00	$11.97	¢3,640.00	$11.97
Piedra	Uncut Stone	Meter	7	¢4,150.00	$13.65	¢29,050.00	$95.56
					Total	*¢66,494.00*	*$218.73*
Ventanas Y Puertas	***Windows and Doors***						
Regla 1x3 con Cepillo	1x3 Piece of Cepillo Wood	Meter	60	¢210.00	$0.69	¢12,600.00	$41.45
Venilla 1/2x1 Laurel	Piece of Wood that Keeps the Glass in Place	Meter	160	¢38.00	$0.13	¢6,080.00	$20.00
Regla 1x4 con Cepillo	1x4 Piece of Cepillo Wood	Meter	24	¢415.38	$1.37	¢9,969.12	$32.79
Tablilla 1/2x3 Laurel	1/2x3 Laurel Plank	Meter	105	¢90.00	$0.30	¢9,450.00	$31.09
Clavos 1 1/4" Sin Cabeza	1 1/4" Nails without heads	Kilogram	0.25	¢282.20	$0.93	¢70.55	$0.23
Pegamento Blanco	White Glue	Gallon	0.125	¢625.70	$2.06	¢78.21	$0.26
Puerta Principal	Main Door	Per Unit	1	¢18,000.00	$59.21	¢18,000.00	$59.21
Vidrios Para Ventanas	Window Glass	Per Unit	6	¢5,000.00	$16.45	¢30,000.00	$98.68
Clavos 2" Sin Cabeza	Nails without heads	Kilogram	1.5	¢302.00	$0.99	¢453.00	$1.49
Clavos 2" Acero	Nails	Per Unit	100	¢5.00	$0.02	¢500.00	$1.64
Llavin Vera	Latch Key Glue	Per Unit	1	¢2,255.00	$7.42	¢2,255.00	$7.42
Visagras 3"	3" Door Hinge	Pairs	3	¢325.00	$1.07	¢975.00	$3.21
Picaportes 3"	3" Doorlatch	Per Unit	2	¢166.10	$0.55	¢332.20	$1.09
Platinas 1x1/8	1x1/8 Slider	Per Unit	5	¢464.03	$1.53	¢2,320.15	$7.63
					Total	*¢93,083.23*	*$306.19*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Instalacion Electrica	***Electric Installation***						
Cajas Rectangulares	Rectangle Box	Per Unit	13	¢86.00	$0.28	¢1,118.00	$3.68
Cajas Octagonales	Octagonal Box	Per Unit	8	¢127.00	$0.42	¢1,016.00	$3.34
Conectores 1/2" PVC	1/2" PVC Connectors	Per Unit	30	¢21.13	$0.07	¢633.90	$2.09
Tubos Conduit 1/2"	1/2" Conduit Pipe	Per Unit	35	¢308.00	$1.01	¢10,780.00	$35.46
Tubos Conduit 3/4"	3/4" Conduit Pipe	Per Unit	4	¢405.16	$1.33	¢1,620.64	$5.33
Tape 3M	3M Tape	Per Unit	1	¢915.40	$3.01	¢915.40	$3.01
Toma Corrente	Current Socket	Per Unit	7	¢683.00	$2.25	¢4,781.00	$15.73
Portalamparas	Socket	Per Unit	8	¢238.54	$0.78	¢1,908.32	$6.28
Apagadores Sencillos	**Single ?**	Per Unit	4	¢417.65	$1.37	¢1,670.60	$5.50
Apagadores Dobles	**Double ?**	Per Unit	2	¢555.40	$1.83	¢1,110.80	$3.65
Cable #12	Cable #12	Meters	200	¢61.00	$0.20	¢12,200.00	$40.13
Cable #10	Cable #10	Meters	20	¢102.00	$0.34	¢2,040.00	$6.71
Cable #6	Cable #6	Meters	65	¢253.00	$0.83	¢16,445.00	$54.10
Cuchilla Nec 2x100	2x100 Main Power Switch	Per Unit	1	¢3,430.10	$11.28	¢3,430.10	$11.28
Varilla Cooperwell	**Rod, Stick ?**	Per Unit	1	¢1,089.00	$3.58	¢1,089.00	$3.58
Union 3/4" Conduit	Joining Condoit 3/4"	Per Unit	2	¢39.00	$0.13	¢78.00	$0.26
Curvas 1/2" Conduit	Curved Condoit 1/2"	Per Unit	10	¢39.00	$0.13	¢390.00	$1.28
Curvas 3/4" Conduit	Curved Condoit 3/4"	Per Unit	4	¢61.18	$0.20	¢244.72	$0.81
Brek 40 AMP	40 AMP Circuit Breaker Switch	Per Unit	1	¢1,520.00	$5.00	¢1,520.00	$5.00
Brek 30 AMP	30 AMP Circuit Breaker Switch	Per Unit	1	¢1,282.00	$4.22	¢1,282.00	$4.22
Brek 15 AMP	15 AMP Circuit Breaker Switch	Per Unit	2	¢1,106.00	$3.64	¢2,212.00	$7.28
Centro De Carga	Charge Center (Fusebox)	Per Unit	1	¢5,667.00	$18.64	¢5,667.00	$18.64
Instalacion Profecional	Professional Installation		1	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢86,152.48*	*$283.40*

Section	Section		Quantity	Cost in Colones	Cost in Dollars
Cimiento	*Cement*		*1*	*c54,214.68*	*$178.34*
Paredes	*Walls*		*1*	*c440,687.60*	*$1,449.63*
Techos	*Roof*		*1*	*c141,867.00*	*$466.67*
Pisos	*Floors*		*1*	*c61,026.00*	*$200.74*
Plomeria	*Pluming*		*1*	*c97,916.76*	*$322.09*
Tanque Sectico	*Septic Tank*		*1*	*c66,494.00*	*$218.73*
Ventanas y Puertas	*Windows and Doors*		*1*	*c93,083.23*	*$306.19*
Instalacion Electrica	*Electric Installation*		*1*	*c86,152.48*	*$283.40*
Thechos	*Roofer*		*1*	*c12,000.00*	*$39.47*
Puertas	*Doors*		*1*	*c18,000.00*	*$59.21*
Virdios	*Glass*		*1*	*c28,000.00*	*$92.11*
Maestro de Obra	*Construction Supervisor*		*1*	*c40,000.00*	*$131.58*
Costas Legal	*Legal Fees*		*1*	*c74,250.00*	*$244.24*
Transporte	*Transportation*		*1*	*c12,334.00*	*$40.57*
Albanil	*Mason*		*1*	*c89,255.00*	*$293.60*
Costas Mantentimiento	*Maintance*		*1*	*c4,560.00*	*$15.00*
Costas De Administracion	*Administration Fees*		*1*	*c68,736.98*	*$226.11*
			Total Cost	*c1,388,577.73*	*$4,567.69*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Trazado	***Tracing***						
Regla 1 x 3	Rulers 1 x 3	Varas	60 00	¢120.00	$0.39	¢7,200.00	$23 68
Clavos	Nails	Kilograms	2.00	¢220.00	$0 72	¢440.00	$1 45
Mano Obra- Operario	Worker	Hour	4 00	¢500.00	$1 64	¢2,000.00	$6 58
					Total	*c9,640.00*	*$31.71*
Cimientos	***Foundations***						
Pilotes	Piles	Per Unit	30 00	¢0 00	$0.00	¢0.00	$0 00
Pines Varilla #3	#3 Steel Bars	Per Unit	5 00	¢425 00	$1.40	¢2,125 00	$6 99
Concreto	Concrete	Meters Cubed	1.19	¢0 00	$0.00	¢0.00	$0.00
Cemento	Cement	Per Unit	7 13	¢1,475 00	$4 85	¢10,516 75	$34.59
Arena	Sand	Meters Cubed	0 53	¢3,500 00	$11.51	¢1,871 10	$6 15
Piedra	Stone	Meters Cubed	0 83	¢5,000.00	$16 45	¢4,150 00	$13.65
Alambre	Steel Wire	Meter	120.00	¢10.00	$0.03	¢1,200.00	$3 95
Formaleta	Temporal Support	Per Unit	15.00	¢300.00	$0.99	¢4,500.00	$14 80
Mano Obra- Operario	Skilled Labor	Hours	15 00	¢500.00	$1 64	¢7,500 00	$24 67
					Total	*c31,862.85*	*$104.81*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Entrepiso y Piso	***Floor***						
Viga Pared- 3 M	3 Meter Wall Beam	Per Unit	1.00	¢2,505.00	$8.24	¢2,505.00	$8.24
Viga Pared- 2.85 M	2.85 Meter Wall Beam	Per Unit	3.00	¢2,505.00	$8.24	¢7,515.00	$24.72
Viga Pared- 2.55 M	2.55 Meter Wall Beam	Per Unit	0.00	¢2,192.00	$7.21	¢0.00	$0.00
Viga Pared- 1.87 M	1.87 Meter Wall Beam	Per Unit	4.00	¢1,565.00	$5.15	¢6,260.00	$20.59
Viga Pared- 1.65 M	1.65 Meter Wall Beam	Per Unit	0.00	¢0.00	$0.00	¢0.00	$0.00
Viga Piso- 1.20 M	1.20 Meter Floor Beam	Per Unit	0.00	¢0.00	$0.00	¢0.00	$0.00
Viga Piso- 0.90 M	0.90 Meter Floor Beam	Per Unit	2.00	¢783.00	$2.58	¢1,566.00	$5.15
Viga Piso- 1.35 M	1.35 Meter Floor Beam	Per Unit	14.00	¢1,096.00	$3.61	¢15,344.00	$50.47
Viga Piso- 1.50 M	1.50 Meter Floor Beam	Per Unit	26.00	¢1,252.00	$4.12	¢32,552.00	$107.08
Viga Piso- 1.65 M	1.65 Meter Floor Beam	Per Unit	0.00	¢1,252.00	$4.12	¢0.00	$0.00
Panel E 60 x 150 cm	60 x 150 Centimeter E Panel	Per Unit	25.00	¢1,911.00	$6.29	¢47,775.00	$157.15
Panel E 60 x 135 cm	60 x 135 Centimeter E Panel	Per Unit	11.00	¢1,742.00	$5.73	¢19,162.00	$63.03
Panel E 60 x 90 cm	60 x 90 Centimeter E Panel	Per Unit	1.00	¢1,175.00	$3.87	¢1,175.00	$3.87
Panel E 60 x 60 cm	60 x 60 Centimeter E Panel	Per Unit	1.00	¢700.00	$2.30	¢700.00	$2.30
Panel E 60 x 180 cm	60 x 180 Centimeter E Panel	Per Unit	5.00	¢2,250.00	$7.40	¢11,250.00	$37.01
Panel E 45 x 150 cm	45 x 150 Centimeter E Panel	Per Unit	6.00	¢1,815.00	$5.97	¢10,890.00	$35.82
Panel E 75 x 150 cm	75 x 150 Centimeter E Panel	Per Unit	1.00	¢2,316.00	$7.62	¢2,316.00	$7.62
Panel E 75 x 90 cm	75 x 90 Centimeter E Panel	Per Unit	1.00	¢1,440.00	$4.74	¢1,440.00	$4.74
Panel E 45 x 135 cm	45 x 135 Centimeter E Panel	Per Unit	4.00	¢1,308.00	$4.30	¢5,232.00	$17.21
Panel E 75 x 135 cm	75 x135 Centimeter E Panel	Per Unit	1.00	¢2,150.00	$7.07	¢2,150.00	$7.07
Conector Silleta 2	2 Steel Connector	Per Unit	100.00	¢210.00	$0.69	¢21,000.00	$69.08
Clava Helicoidal	Helicoidal Nail	Per Unit	1200.00	¢1.50	$0.00	¢1,800.00	$5.92
Morter. JT-154ML	154 Milliliter Mortar Joints	Liter	240.00	¢25.00	$0.08	¢6,000.00	$19.74
Cedazo J Hum	Sierve Joints	Meters Squared	11.00	¢374.00	$1.23	¢4,114.00	$13.53
Mano Obra- Operario	Skilled Labor for Structure	Hour	10.00	¢500.00	$1.64	¢5,000.00	$16.45
					Total	*¢205,746.00*	*$676.80*
Afinado Pared	***Walls Finishing***						
Revestimiento	Coating	Per Unit	15.83	¢2,400.00	$7.89	¢37,992.00	$124.97
Rodillo	Roller	Per Unit	1.00	¢300.00	$0.99	¢300.00	$0.99
Rollo Cinta Autoadhesiva	Roll of Tape	Per Unit	2.50	¢3,200.00	$10.53	¢8,000.00	$26.32
Operario	Skilled Labor	Hour	25.00	¢500.00	$1.64	¢12,500.00	$41.12
					Total	*¢58,792.00*	*$193.39*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Parades	***Walls***						
Viga Pared- 3 M	3 Meter Wall Beam	Per Unit	4.00	¢2,505.00	$8.24	¢10,020.00	$32.96
Viga Pared- 2.85 M	2.85 Meter Wall Beam	Per Unit	12.00	¢2,505.00	$8.24	¢30,060.00	$98.88
Viga Pared- 2.55 M	2.55 Meter Wall Beam	Per Unit	4.00	¢2,192.00	$7.21	¢8,768.00	$28.84
Viga Pared- 1.87 M	1.87 Meter Wall Beam	Per Unit	11.00	¢1,565.00	$5.15	¢17,215.00	$56.63
Viga Pared- 1.65 M	1.65 Meter Wall Beam	Per Unit	2.00	¢1,252.00	$4.12	¢2,504.00	$8.24
Viga Pared- 1.50 M	1.50 Meter Wall Beam	Per Unit	5.00	¢1,252.00	$4.12	¢6,260.00	$20.59
Viga Pared- 1.35 M	1.35 Meter Wall Beam	Per Unit	4.00	¢1,096.00	$3.61	¢4,384.00	$14.42
Viga Pared- 1.20 M	1.20 Meter Wall Beam	Per Unit	9.00	¢939.00	$3.09	¢8,451.00	$27.80
Viga Pared- 1.05 M	1.05 Meter Wall Beam	Per Unit	3.00	¢939.00	$3.09	¢2,817.00	$9.27
Viga Pared- 0.90 M	0.90 Meter Wall Beam	Per Unit	4.00	¢782.00	$2.57	¢3,128.00	$10.29
Column T/1	T/1 Column	Per Unit	21.00	¢1,900.00	$6.25	¢39,900.00	$131.25
Column T/2	T/2 Column	Per Unit	4.00	¢1,900.00	$6.25	¢7,600.00	$25.00
Panel 60 x 240 cm	60 x 240 Centimeter Panel	Per Unit	40.00	¢2,895.00	$9.52	¢115,800.00	$380.92
Panel 45 x 240 cm	45 x 240 Centimeter Panel	Per Unit	14.00	¢2,318.00	$7.63	¢32,452.00	$106.75
Panel V 75 x 180 cm	75 x 180 Centimeter Panel V	Per Unit	2.00	¢2,798.00	$9.20	¢5,596.00	$18.41
Panel V 75 x 180 cm	75 x 180 Centimeter Panel V	Per Unit	1.00	¢2,317.00	$7.62	¢2,317.00	$7.62
Panel V 75 x 90 cm	75 x 90 Centimeter Panel V	Per Unit	1.00	¢1,440.00	$4.74	¢1,440.00	$4.74
Panel V 45 x 120 cm	45 x 120 Centimeter Panel V	Per Unit	2.00	¢1,129.00	$3.71	¢2,258.00	$7.43
Grapas	Clamps	Kilogram	10.00	¢300.00	$0.99	¢3,000.00	$9.87
Cedazo Para Juntas	Sieve Joint	Meter Squared	22.26	¢400.00	$1.32	¢8,904.00	$29.29
Mortero J Humeda	Joint Mortar	Liters	556.50	¢25.00	$0.08	¢13,912.50	$45.76
Aditivo Adherente	Adherent Additive	Liters	3.00	¢1,300.00	$4.28	¢3,900.00	$12.83
Conector Silleta T1	T1 Connector	Per Unit	66.00	¢233.00	$0.77	¢15,378.00	$50.59
Conector Silleta T2	T2 Connector	Per Unit	66.00	¢210.00	$0.69	¢13,860.00	$45.59
Clavo Helicoidal	Helicoidal Nails	Per Unit	1742.40	¢1.50	$0.00	¢2,613.60	$8.60
Pines Varilla #3	#3 Steel Bars	Per Unit	23.00	¢30.00	$0.10	¢690.00	$2.27
Mano Obra- Operorio	Skilled Labor- Structure	Hour	8.00	¢500.00	$1.64	¢4,000.00	$13.16
Mano Obra- Operorio Panel	Skilled Labor- Panels	Hour	20.00	¢500.00	$1.64	¢10,000.00	$32.89
Mano Obra- Operorio Junta	Skilled Labor- Joints	Hour	20.00	¢500.00	$1.64	¢10,000.00	$32.89
Acarreo	Transport	Trip	1.00	¢3,000.00	$9.87	¢3,000.00	$9.87
					Total	*¢390,228.10*	*$1,283.65*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Techo	***Roof***						
Zing 083x1.83 HG	Zinc 083x1.83 HG	Per Unit	17.00	¢998.00	$3.28	¢16,966.00	$55.81
Zing 083x3.66 HG	Zinc 083x3.66 HG	Per Unit	17.00	¢1,995.00	$6.56	¢33,915.00	$111.56
Perlig 2x4x6 HG	Metal Perlings 2x4x6	Per Unit	18.00	¢3,117.00	$10.25	¢56,106.00	$184.56
Tornillos Para Techo	Screws for Roof	Per Unit	225.00	¢9.00	$0.03	¢2,025.00	$6.66
Soldadura	Welding	Kilogram	2.00	¢800.00	$2.63	¢1,600.00	$5.26
Brocas 3/16 P/Hierro	Iron Bits 3/16	Per Unit	3.00	¢80.00	$0.26	¢240.00	$0.79
Tablillas 1/2x2	Planks, Boards	Meter	100.00	¢57.25	$0.19	¢5,725.00	$18.83
Clavos 1" Acero	Nails 1"	Per Unit	100.00	¢4.00	$0.01	¢400.00	$1.32
Tubo Industrial 1*2	Industrial Pipes	Meter	2.00	¢218.00	$0.72	¢436.00	$1.43
Botaguas 12" HG	Bolts 12"	Per Unit	12.00	¢490.00	$1.61	¢5,880.00	$19.34
Cumbreras 12" HG	?	Per Unit	4.00	¢476.00	$1.57	¢1,904.00	$6.26
Disco P/Hierro 9"	Iron Discs 9"	Per Unit	2.00	¢780.00	$2.57	¢1,560.00	$5.13
Spray Crinado	Crome Spray	Per Unit	1.00	¢1,110.00	$3.65	¢1,110.00	$3.65
Soldador	Welder		1.00	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢141,867.00*	*$466.67*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Plameria	***Pluming***						
Pegamento	Glue	Gallon	0.13	¢1,326.00	$4.36	¢165.75	$0.55
Tubos 1/2" PVC	Pipes 1/2" PVC	Per Unit	5.00	¢715.00	$2.35	¢3,575.00	$11.76
Codos 1/2" PVC Lisos	Elbow 1/2" PVC	Per Unit	10.00	¢44.00	$0.14	¢440.00	$1.45
Codos 1/2" PVC C/Rosca	Elbow 1/2" PVC	Per Unit	5.00	¢59.00	$0.19	¢295.00	$0.97
Teflon	Teflon	Per Unit	2.00	¢50.63	$0.17	¢101.26	$0.33
Tee 1/2" PVC	?	Per Unit	5.00	¢47.00	$0.15	¢235.00	$0.77
Adaptador Macho	Male Adapter	Per Unit	6.00	¢41.00	$0.13	¢246.00	$0.81
Tubos 2" PVC	Pipes 2" PVC	Per Unit	3.00	¢2,274.00	$7.48	¢6,822.00	$22.44
Tee 2" PVC	?	Per Unit	3.00	¢351.00	$1.15	¢1,053.00	$3.46
Codos 2" PVC	Elbow 2" PVC	Per Unit	6.00	¢260.00	$0.86	¢1,560.00	$5.13
Tubos 4" PVC	Pipe 4" PVC	Per Unit	3.00	¢6,326.00	$20.81	¢18,978.00	$62.43
Codos 4" PVC	Elbow 4" PVC	Per Unit	2.00	¢1,135.00	$3.73	¢2,270.00	$7.47
Tee 4" PVC	?	Per Unit	2.00	¢1,468.00	$4.83	¢2,936.00	$9.66
Llave De Paso 1/2"	Key of ?	Per Unit	1.00	¢784.10	$2.58	¢784.10	$2.58
Llave Para Bano	Bathroom Key	Per Unit	1.00	¢6,313.71	$20.77	¢6,313.71	$20.77
Llave De Chorro	Jetspurt Key	Per Unit	1.00	¢734.00	$2.41	¢734.00	$2.41
manguera 1 1/2"	Jetspurt Key ?	Per Unit	1.00	¢925.45	$3.04	¢925.45	$3.04
Asparcion Metalica	Metal Aspiration	Per Unit	1.00	¢1,330.00	$4.38	¢1,330.00	$4.38
Fregadero Nates	Sink	Per Unit	1.00	¢16,883.00	$55.54	¢16,883.00	$55.54
Inodoro economico	ordorless ecomic	Per Unit	1.00	¢14,850.35	$48.85	¢14,850.35	$48.85
Lavatorio	?	Per Unit	1.00	¢8,572.00	$28.20	¢8,572.00	$28.20
Tubos Abasto	Tubes for pipe	Per Unit	1.00	¢752.00	$2.47	¢752.00	$2.47
Pila Roja	Heating Battery	Per Unit	1.00	¢5,000.00	$16.45	¢5,000.00	$16.45
Parrilla De Desague	Drain Grill	Per Unit	1.00	¢412.90	$1.36	¢412.90	$1.36
Niple 12" Niquilado	Niple 12" ?	Per Unit	1.00	¢728.00	$2.39	¢728.00	$2.39
Niple 6" Niquilado	Niple 6" ?	Per Unit	2.00	¢446.12	$1.47	¢892.24	$2.94
Manguera 1 1/2"	Hosepipe 1 1/2"	Meter	2.00	¢465.00	$1.53	¢930.00	$3.06
Union 1/2" PVC	Joining PVC 1/2"	Per Unit	2.00	¢66.00	$0.22	¢132.00	$0.43
Mano Obra- Operorio	Skilled Labor	Hour	10.00	¢500.00	$1.64	¢5,000.00	$16.45
					Total	*¢97,916.76*	*$322.09*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tanque Septico	***Septic Tank***						
Block 12*20*40	Block 12*20*40	Per Unit	120.00	¢100.00	$0.33	¢12,000.00	$39.47
Arena Fina	Finishing Sand	Meter	1.00	¢5,600.00	$18.42	¢5,600.00	$18.42
Arena Corriente	Normal Sand	Meter	1.00	¢4,000.00	$13.16	¢4,000.00	$13.16
Varillas De 3/8	Rod, Stick 3/8	Per Unit	10.00	¢355.00	$1.17	¢3,550.00	$11.68
Cemento	Cement	Per Unit	6.00	¢1,406.00	$4.63	¢8,436.00	$27.75
Alambre De Amarre	Wire Morning	Kilogram	1.00	¢218.00	$0.72	¢218.00	$0.72
Tubo Perforado Drenasep	Drainage pipe	Per Unit	1.00	¢3,640.00	$11.97	¢3,640.00	$11.97
Piedra	Uncut Stone	Meter	7.00	¢4,150.00	$13.65	¢29,050.00	$95.56
Mano Obra- Operorio	Skilled Labor	Hour	20.00	¢500.00	$1.64	¢10,000.00	$32.89
					Total	*¢76,494.00*	*$251.63*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ventanas Y Puertas	***Windows and Doors***						
Regla 1*3 C/Cepillo	?	Meter	60.00	¢210.00	$0.69	¢12,600.00	$41.45
Venilla 1/2*1 Laurel	?	Meter	160.00	¢38.00	$0.13	¢6,080.00	$20.00
Regla 1*4 C/Cepillo	?	Meter	24.00	¢415.38	$1.37	¢9,969.12	$32.79
Tablilla 1/2*3 Laurel	Plank, Board	Meter	105.00	¢90.00	$0.30	¢9,450.00	$31.09
Clavos 1 1/4" Sin Cabeza	Nails without heads	Kilogram	0.25	¢282.20	$0.93	¢70.55	$0.23
Pegamento Blanco	White Glue	Gallon	0.13	¢625.70	$2.06	¢78.21	$0.26
Puerta Principal	Main Door	Per Unit	1.00	¢18,000.00	$59.21	¢18,000.00	$59.21
Vidrios Para Ventanas	Window Glass	Per Unit	6.00	¢5,000.00	$16.45	¢30,000.00	$98.68
Clavos 2" Sin Cabeza	Nails without heads	Kilogram	1.50	¢302.00	$0.99	¢453.00	$1.49
Clavos 2" Acero	Nails	Per Unit	100.00	¢5.00	$0.02	¢500.00	$1.64
Llavin Vera	Latch Key Glue	Per Unit	1.00	¢2,255.00	$7.42	¢2,255.00	$7.42
Visagras 3"	?	Pairs	3.00	¢325.00	$1.07	¢975.00	$3.21
Picaportes 3"	Doorlatch	Per Unit	2.00	¢166.10	$0.55	¢332.20	$1.09
Platinas 1*1/8	Slider	Per Unit	5.00	¢464.03	$1.53	¢2,320.15	$7.63
Mano Obra- Operorio	Skilled Labor	Hour	20.00	¢500.00	$1.64	¢10,000.00	$32.89
					Total	*¢103,083.23*	*$339.09*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Instalacion Electrica	***Electric Installation***						
Cajas Rectangulares	Rectangle Box	Per Unit	13.00	¢86.00	$0.28	¢1,118.00	$3.68
Cajas Octagonales	Octagonal Box	Per Unit	8.00	¢127.00	$0.42	¢1,016.00	$3.34
Conectores 1/2 PVC	Connectors 1/2 PVC	Per Unit	30.00	¢21.13	$0.07	¢633.90	$2.09
Tubos Conduit 1/2"	Pipe ?	Per Unit	35.00	¢308.00	$1.01	¢10,780.00	$35.46
Tubos Conduit 3/4"	Pipe ?	Per Unit	4.00	¢405.16	$1.33	¢1,620.64	$5.33
Tape 3M	3M Tape	Per Unit	1.00	¢915.40	$3.01	¢915.40	$3.01
Toma Corrente	Current Socket	Per Unit	7.00	¢683.00	$2.25	¢4,781.00	$15.73
Portalamparas	Socket	Per Unit	8.00	¢238.54	$0.78	¢1,908.32	$6.28
Apagadores Sencillos	Single ?	Per Unit	4.00	¢417.65	$1.37	¢1,670.60	$5.50
Apagadores Dobles	Double ?	Per Unit	2.00	¢555.40	$1.83	¢1,110.80	$3.65
Cable #12	Cable #12	Meters	200.00	¢61.00	$0.20	¢12,200.00	$40.13
Cable #10	Cable #10	Meters	20.00	¢102.00	$0.34	¢2,040.00	$6.71
Cable #6	Cable #6	Meters	65.00	¢253.00	$0.83	¢16,445.00	$54.10
Cuchilla Nec 2*100	?	Per Unit	1.00	¢3,430.10	$11.28	¢3,430.10	$11.28
Varilla Cooperwell	Rod, Stick ?	Per Unit	1.00	¢1,089.00	$3.58	¢1,089.00	$3.58
Union 3/4" Conduit	Joining Condoit 3/4"	Per Unit	2.00	¢39.00	$0.13	¢78.00	$0.26
Curvas 1/2" Conduit	Curved Condoit 1/2"	Per Unit	10.00	¢39.00	$0.13	¢390.00	$1.28
Curvas 3/4" Conduit	Curved Condoit 3/4"	Per Unit	4.00	¢61.18	$0.20	¢244.72	$0.81
Brek 40 AMP	?	Per Unit	1.00	¢1,520.00	$5.00	¢1,520.00	$5.00
Brek 30 AMP	?	Per Unit	1.00	¢1,282.00	$4.22	¢1,282.00	$4.22
Brek 15 AMP	?	Per Unit	2.00	¢1,106.00	$3.64	¢2,212.00	$7.28
Centro De Carga	Charge Center (Fusebox)	Per Unit	1.00	¢5,667.00	$18.64	¢5,667.00	$18.64
Instalacion Profecional	Professional Installation	Day	1.00	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢86,152.48*	*$283.40*

Section	*Section*		*Quantity*	*Cost in Colones*	*Cost in Dollars*
Trazado	*Tracing*		*1.00*	*¢9,640.00*	*$31.71*
Cimientos	*Foundations*		*1.00*	*¢31,862.85*	*$104.81*
Entrepiso y Piso	*Floor*		*1.00*	*¢205,746.00*	*$676.80*
Afinado Pared	*Walls Finnishing*		*1.00*	*¢58,792.00*	*$193.39*
Parades	*Walls*		*1.00*	*¢390,228.10*	*$1,283.65*
Techos	*Roof*		*1.00*	*¢141,867.00*	*$466.67*
Plomeria	*Pluming*		*1.00*	*¢102,916.76*	*$338.54*
Tanque Sectico	*Septic Tank*		*1.00*	*¢76,494.00*	*$251.63*
Ventanas y Puertas	*Windows and Doors*		*1.00*	*¢103,083.23*	*$339.09*
Instalacion Electrica	*Electric Installation*		*1.00*	*¢86,152.48*	*$283.40*
Thechos	*Roofer*		*1.00*	*¢12,000.00*	*$39.47*
Puertas	*Doors*		*1.00*	*¢18,000.00*	*$59.21*
Virdios	*Glass*		*1.00*	*¢28,000.00*	*$92.11*
Costos Legales	*Legal Fees*		*1.00*	*¢74,250.00*	*$244.24*
Transporte	*Transportation*		*1.00*	*¢12,334.00*	*$40.57*
Maestro de Obra	*Construction Supervisor*		*1.00*	*¢40,000.00*	*$131.58*
Gastos De Administracion	*Administration Fees*		*1.00*	*¢68,736.98*	*$226.11*
			Total Cost	*¢1,460,103.40*	*$4,802.97*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ciminto	*Foundation*						
Madre De Trazo/Reglas 1x3x1	Woodline 1x3x1	Varas	90.00	¢90.00	$0.30	¢8,100.00	$26.64
Cuerda	String	Kilograms	1.00	¢350.00	$1.15	¢350.00	$1.15
Hojas De Segeta	Blades	Per Unit	3.00	¢245.21	$0.81	¢735.63	$2.42
Concremix	Cement, sand, and stone mix	Per Unit	56.00	¢850.00	$2.80	¢47,600.00	$156.58
2.5 Clavos	Nails 2.5	Kilograms	1.00	¢212.05	$0.70	¢212.05	$0.70
					Total	*c56,997.68*	*$187.49*
Paredes	*Walls*						
Tile 190 x 50	Tile 190x 50cm	Per Unit	31.00	¢3,370.00	$11.09	¢104,470.00	$343.65
Tile 165 x 50	Tile 165x50cm	Per Unit	3.00	¢2,996.00	$9.86	¢8,988.00	$29.57
Tile 140 x 50	Tile 140x 50cm	Per Unit	20.00	¢2,515.00	$8.27	¢50,300.00	$165.46
Tile 127 x 50	Tile 127 x 50 cm	Per Unit	4.00	¢2,355.00	$7.75	¢9,420.00	$30.99
Tile 115 x 50	Tile 115 x 50 cm	Per Unit	12.00	¢2,065.00	$6.79	¢24,780.00	$81.51
Tile 65 x 50	Tile 65 x 50cm	Per Unit	13.00	¢1,225.00	$4.03	¢15,925.00	$52.38
Tile 40 x 50	Tile 40 x 50cm	Per Unit	40.00	¢880.00	$2.89	¢35,200.00	$115.79
Column C-Inter 330	Column C-Inter 330	Per Unit	3.00	¢6,020.00	$19.80	¢18,060.00	$59.41
Column C-Inter 330 Toma	Column C-Inter 330 Toma	Per Unit	10.00	¢6,690.00	$22.01	¢66,900.00	$220.07
Column C-Inter 330 Apag	Column C-Inter 330 Apag	Per Unit	3.00	¢6,690.00	$22.01	¢20,070.00	$66.02
Column C-Ducha 330	Comun C-Ducha 330	Per Unit	1.00	¢14,435.00	$47.48	¢14,435.00	$47.48
Column D-Esqui. 330	Column D-Esqui. 330	Per Unit	5.00	¢6,020.00	$19.80	¢30,100.00	$99.01
E- 3VERT 330	E- 3VERT 330	Per Unit	6.00	¢6,020.00	$19.80	¢36,120.00	$118.82
					Subtotal	¢434,768.00	$1,430.16
					Bulk Discount 25 %	-¢108,692.00	-$357.54
					13 % Import tax	¢56,519.84	$185.92
Fibrolit	Fiber	Per Unit	9.00	¢3,514.00	$11.56	¢31,626.00	$104.03
					Total	*c414,221.84*	*$1,362.57*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tapichel de Fibrolit y Perling	***Fibrolit Crown and Purlings***						
Fibrolit	Fibrolit	Sheet	4.00	¢3,514.00	$11.56	¢14,056.00	$46.24
Perlig 2x4x6 HG	Metal Purlings 2x4x6	Per Unit	18.00	¢3,117.00	$10.25	¢56,106.00	$184.56
Tomillas Gypsum		Per Unit	250.00	¢4.00	$0.01	¢1,000.00	$3.29
Soldadura	Welding Material	Kilogram	2.00	¢740.00	$2.43	¢1,480.00	$4.87
Soldador	Welder	Per Unit	1.00	¢15,000.00	$49.34	¢15,000.00	$49.34
					Total	*¢87,642.00*	*$288.30*
Techo	***Roof***						
Zing 083x1.83 HG	Zinc 083x1.83 HG	Per Unit	17.00	¢998.00	$3.28	¢16,966.00	$55.81
Zing 083x3.66 HG	Zinc 083x3.66 HG	Per Unit	17.00	¢1,995.00	$6.56	¢33,915.00	$111.56
Tomillos Para Techo	Screws for Roof	Per Unit	225.00	¢9.00	$0.03	¢2,025.00	$6.66
Soldadura	Welding	Kilogram	2.00	¢800.00	$2.63	¢1,600.00	$5.26
Brocas 3/16 P/Hierro	Iron Bits 3/16	Per Unit	3.00	¢80.00	$0.26	¢240.00	$0.79
Tablillas 1/2x2	Planks, Boards	Meter	100.00	¢57.25	$0.19	¢5,725.00	$18.83
Clavos 1" Acero	Nails 1"	Per Unit	100.00	¢4.00	$0.01	¢400.00	$1.32
Tubo Industrial 1*2	Industrial Pipes	Meter	2.00	¢218.00	$0.72	¢436.00	$1.43
Botaguas 12" HG	Bolts 12"	Per Unit	12.00	¢490.00	$1.61	¢5,880.00	$19.34
Cumbreras 12" HG	?	Per Unit	4.00	¢476.00	$1.57	¢1,904.00	$6.26
Disco P/Hierro 9"	Iron Discs 9"	Per Unit	2.00	¢780.00	$2.57	¢1,560.00	$5.13
Spray Crinado	Crome Spray	Per Unit	1.00	¢1,110.00	$3.65	¢1,110.00	$3.65
Soldador	Welder		1.00	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢85,761.00*	*$282.11*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Pisos	*Floor*						
Arena Corriente	Normal Sand	Meter	3.00	¢4,000.00	$13.16	¢12,000.00	$39.47
Arena Fina	Sand Finishing	Meter	1.00	¢5,600.00	$18.42	¢5,600.00	$18.42
Cemento	Cement	Per Unit	27.00	¢1,406.00	$4.63	¢37,962.00	$124.88
Ocre	Ocher	Kilogram	8.00	¢683.00	$2.25	¢5,464.00	$17.97
					Total	*¢61,026.00*	*$200.74*
Plameria	*Pluming*						
Pegamento	Glue	Gallon	0.13	¢1,326.00	$4.36	¢165.75	$0.55
Tubos 1/2" PVC	Pipes 1/2" PVC	Per Unit	5.00	¢715.00	$2.35	¢3,575.00	$11.76
Codos 1/2" PVC Lisos	Elbow 1/2" PVC	Per Unit	10.00	¢44.00	$0.14	¢440.00	$1.45
Codos 1/2" PVC C/Rosca	Elbow 1/2" PVC	Per Unit	5.00	¢59.00	$0.19	¢295.00	$0.97
Teflon	Teflon	Per Unit	2.00	¢50.63	$0.17	¢101.26	$0.33
Tee 1/2" PVC	?	Per Unit	5.00	¢47.00	$0.15	¢235.00	$0.77
Adaptador Macho	Male Adapter	Per Unit	6.00	¢41.00	$0.13	¢246.00	$0.81
Tubos 2" PVC	Pipes 2" PVC	Per Unit	3.00	¢2,274.00	$7.48	¢6,822.00	$22.44
Tee 2" PVC	?	Per Unit	3.00	¢351.00	$1.15	¢1,053.00	$3.46
Codos 2" PVC	Elbow 2" PVC	Per Unit	6.00	¢260.00	$0.86	¢1,560.00	$5.13
Tubos 4" PVC	Pipe 4" PVC	Per Unit	3.00	¢6,326.00	$20.81	¢18,978.00	$62.43
Codos 4" PVC	Elbow 4" PVC	Per Unit	2.00	¢1,135.00	$3.73	¢2,270.00	$7.47
Tee 4" PVC	?	Per Unit	2.00	¢1,468.00	$4.83	¢2,936.00	$9.66
Llave De Paso 1/2"	Key of ?	Per Unit	1.00	¢784.10	$2.58	¢784.10	$2.58
Llave Para Bano	Bathroom Key	Per Unit	1.00	¢6,313.71	$20.77	¢6,313.71	$20.77
Llave De Chorro	Jetspurt Key	Per Unit	1.00	¢734.00	$2.41	¢734.00	$2.41
manguera 1 1/2"	Jetspurt Key ?	Per Unit	1.00	¢925.45	$3.04	¢925.45	$3.04
Asparcion Metalica	Metal Aspiration	Per Unit	1.00	¢1,330.00	$4.38	¢1,330.00	$4.38
Fregadero Nates	Sink	Per Unit	1.00	¢16,883.00	$55.54	¢16,883.00	$55.54
Inodoro economico	ordorless ecomic	Per Unit	1.00	¢14,850.35	$48.85	¢14,850.35	$48.85
Lavatorio	?	Per Unit	1.00	¢8,572.00	$28.20	¢8,572.00	$28.20
Tubos Abasto	Tubes for pipe	Per Unit	1.00	¢752.00	$2.47	¢752.00	$2.47
Pila Roja	Heating Battery	Per Unit	1.00	¢5,000.00	$16.45	¢5,000.00	$16.45
Parrilla De Desague	Drain Grill	Per Unit	1.00	¢412.90	$1.36	¢412.90	$1.36
Niple 12" Niquilado	Niple 12" ?	Per Unit	1.00	¢728.00	$2.39	¢728.00	$2.39
Niple 6" Niquilado	Niple 6" ?	Per Unit	2.00	¢446.12	$1.47	¢892.24	$2.94
Manguera 1 1/2"	Hosepipe 1 1/2"	Meter	2.00	¢465.00	$1.53	¢930.00	$3.06
Union 1/2" PVC	Joining PVC 1/2"	Per Unit	2.00	¢66.00	$0.22	¢132.00	$0.43
					Total	*¢97,916.76*	*$322.09*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tanque Septico	***Septic Tank***						
Block 12*20*40	Block 12*20*40	Per Unit	120.00	¢100.00	$0.33	¢12,000.00	$39.47
Arena Fina	Finishing Sand	Meter	1.00	¢5,600.00	$18.42	¢5,600.00	$18.42
Arena Corriente	Normal Sand	Meter	1.00	¢4,000.00	$13.16	¢4,000.00	$13.16
Varillas De 3/8	Rod, Stick 3/8	Per Unit	10.00	¢355.00	$1.17	¢3,550.00	$11.68
Cemento	Cement	Per Unit	6.00	¢1,406.00	$4.63	¢8,436.00	$27.75
Alambre De Amarre	Wire Morning	Kilogram	1.00	¢218.00	$0.72	¢218.00	$0.72
Tubo Perforado Drenasep	Drainage pipe	Per Unit	1.00	¢3,640.00	$11.97	¢3,640.00	$11.97
Piedra	Uncut Stone	Meter	7.00	¢4,150.00	$13.65	¢29,050.00	$95.56
					Total	*¢66,494.00*	*$218.73*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ventanas Y Puertas	***Windows and Doors***						
Regla 1*3 C/Cepillo	?	Meter	60.00	¢210.00	$0.69	¢12,600.00	$41.45
Venilla 1/2*1 Laurel	?	Meter	160.00	¢38.00	$0.13	¢6,080.00	$20.00
Regla 1*4 C/Cepillo	?	Meter	24.00	¢415.38	$1.37	¢9,969.12	$32.79
Tablilla 1/2*3 Laurel	Plank, Board	Meter	105.00	¢90.00	$0.30	¢9,450.00	$31.09
Clavos 1 1/4" Sin Cabeza	Nails without heads	Kilogram	0.25	¢282.20	$0.93	¢70.55	$0.23
Pegamento Blanco	White Glue	Gallon	0.13	¢625.70	$2.06	¢78.21	$0.26
Puerta Principal	Main Door	Per Unit	1.00	¢18,000.00	$59.21	¢18,000.00	$59.21
Vidrios Para Ventanas	Window Glass	Per Unit	6.00	¢5,000.00	$16.45	¢30,000.00	$98.68
Clavos 2" Sin Cabeza	Nails without heads	Kilogram	1.50	¢302.00	$0.99	¢453.00	$1.49
Clavos 2" Acero	Nails	Per Unit	100.00	¢5.00	$0.02	¢500.00	$1.64
Llavin Vera	Latch Key Glue	Per Unit	1.00	¢2,255.00	$7.42	¢2,255.00	$7.42
Visagras 3"	?	Pairs	3.00	¢325.00	$1.07	¢975.00	$3.21
Picaportes 3"	Doorlatch	Per Unit	2.00	¢166.10	$0.55	¢332.20	$1.09
Platinas 1*1/8	Slider	Per Unit	5.00	¢464.03	$1.53	¢2,320.15	$7.63
					Total	*¢93,083.23*	*$306.19*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Instalacion Electrica	***Electric Installation***						
Cajas Rectangulares	Rectangle Box	Per Unit	13.00	¢86.00	$0.28	¢1,118.00	$3.68
Cajas Octagonales	Octagonal Box	Per Unit	8.00	¢127.00	$0.42	¢1,016.00	$3.34
Conectores 1/2 PVC	Connectors 1/2 PVC	Per Unit	30.00	¢21.13	$0.07	¢633.90	$2.09
Tape 3M	3M Tape	Per Unit	1.00	¢915.40	$3.01	¢915.40	$3.01
Toma Corrente	Current Socket	Per Unit	7.00	¢683.00	$2.25	¢4,781.00	$15.73
Portalamparas	Socket	Per Unit	8.00	¢238.54	$0.78	¢1,908.32	$6.28
Apagadores Sencillos	Single ?	Per Unit	4.00	¢417.65	$1.37	¢1,670.60	$5.50
Apagadores Dobles	Double ?	Per Unit	2.00	¢555.40	$1.83	¢1,110.80	$3.65
Cable #12	Cable #12	Meters	200.00	¢61.00	$0.20	¢12,200.00	$40.13
Cable #10	Cable #10	Meters	20.00	¢102.00	$0.34	¢2,040.00	$6.71
Cable #6	Cable #6	Meters	65.00	¢253.00	$0.83	¢16,445.00	$54.10
Cuchilla Nec 2*100	?	Per Unit	1.00	¢3,430.10	$11.28	¢3,430.10	$11.28
Varilla Cooperwell	Rod, Stick ?	Per Unit	1.00	¢1,089.00	$3.58	¢1,089.00	$3.58
Brek 40 AMP	?	Per Unit	1.00	¢1,520.00	$5.00	¢1,520.00	$5.00
Brek 30 AMP	?	Per Unit	1.00	¢1,282.00	$4.22	¢1,282.00	$4.22
Brek 15 AMP	?	Per Unit	2.00	¢1,106.00	$3.64	¢2,212.00	$7.28
Centro De Carga	Charge Center (Fusebox)	Per Unit	1.00	¢5,667.00	$18.64	¢5,667.00	$18.64
Instalacion Profecional	Professional Installation		1.00	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢73,039.12*	*$240.26*

Section	Section		Quantity	Cost in Colones	Cost in Dollars
Cimiento	Foundation		1.00	¢56,997.68	$187.49
Paredes	Walls		1.00	¢414,221.84	$1,362.57
Tapichel de Fibrolit y Perling	Fibrolit Crown and Purlings		1.00	¢87,642.00	$288.30
Techos	Roof		1.00	¢85,761.00	$282.11
Pisos	Floors		1.00	¢61,026.00	$200.74
Plomeria	Pluming		1.00	¢97,916.76	$322.09
Tanque Sectico	Septic Tank		1.00	¢66,494.00	$218.73
Ventanas y Puertas	Windows and Doors		1.00	¢93,083.23	$306.19
Instalacion Electrica	Electric Installation		1.00	¢73,039.12	$240.26
Thechos	Roofer		1.00	¢12,000.00	$39.47
Puertas	Doors		1.00	¢18,000.00	$59.21
Virdios	Glass		1.00	¢28,000.00	$92.11
Maestro de Obra	Construction Supervisor		1.00	¢40,000.00	$131.58
Costos Legales	Legal Fees		1.00	¢74,250.00	$244.24
Transporte	Transportation		1.00	¢12,334.00	$40.57
Albanil	Mason		1.00	¢225,000.00	$740.13
Gastos De Administracion	Administration Fees		1.00	¢68,736.98	$226.11
			Total Cost	¢1,514,502.61	$4,981.92

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ciminto	***Foundations***						
Cimiento	Foundation		1	¢92,037.66	$302.76	¢92,037.66	$302.76
Cemento	Cement		1	¢92,612.00	$304.64	¢92,612.00	$304.64
Agregados	Sand and Stones		1	¢146,160.00	$480.79	¢146,160.00	$480.79
					Total	*¢330,809.66*	*$1,088.19*
Paredes	***Walls***						
V-75		Per Unit	17	¢9,250.00	$30.43	¢157,250.00	$517.27
V-75 E		Per Unit	2	¢9,800.00	$32.24	¢19,600.00	$64.47
V-75 T		Per Unit	4	¢9,800.00	$32.24	¢39,200.00	$128.95
V-50		Per Unit	9	¢6,275.00	$20.64	¢56,475.00	$185.77
V-50 E		Per Unit	3	¢6,850.00	$22.53	¢20,550.00	$67.60
Vv-1		Per Unit	1	¢2,000.00	$6.58	¢2,000.00	$6.58
Vv-2		Per Unit	0	¢3,300.00	$10.86	¢0.00	$0.00
Vv-3		Per Unit	1	¢5,050.00	$16.61	¢5,050.00	$16.61
Vv-4		Per Unit	1	¢2,750.00	$9.05	¢2,750.00	$9.05
Vv-5		Per Unit	1	¢4,870.00	$16.02	¢4,870.00	$16.02
Vv-6		Per Unit	1	¢6,975.00	$22.94	¢6,975.00	$22.94
Vv-7		Per Unit	3	¢2,950.00	$9.70	¢8,850.00	$29.11
Vv-8		Per Unit	3	¢4,100.00	$13.49	¢12,300.00	$40.46
Tela Metalica		Per Unit	9	¢660.00	$2.17	¢5,940.00	$19.54
					Sub Total	*¢341,810.00*	*$1,124.38*
					13% Import Tax	*¢44,435.30*	*$146.17*
Fibrolit	Fiber	Per Unit	9	¢3,514.00	$11.56	¢31,626.00	$104.03
Acabado para Pared	Wall Painting Covering		1	¢75,897.00	$249.66	¢75,897.00	$249.66
					Total	*¢493,768.30*	*$1,624.24*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Techo	***Roof***						
Zing 083x1.83 HG	Zinc 083x1.83 HG	Per Unit	17	¢998.00	$3.28	¢16,966.00	$55.81
Zing 083x3.66 HG	Zinc 083x3.66 HG	Per Unit	17	¢1,995.00	$6.56	¢33,915.00	$111.56
Perlig 2x4x6 HG	Metal Perlings 2x4x6	Per Unit	18	¢3,117.00	$10.25	¢56,106.00	$184.56
Tornillos Para Techo	Screws for Roof	Per Unit	225	¢9.00	$0.03	¢2,025.00	$6.66
Soldadura	Welding	Kilogram	2	¢800.00	$2.63	¢1,600.00	$5.26
Brocas 3/16 P/Hierro	Iron Bits 3/16	Per Unit	3	¢80.00	$0.26	¢240.00	$0.79
Tablillas 1/2x2	Planks, Boards	Meter	100	¢57.25	$0.19	¢5,725.00	$18.83
Clavos 1" Acero	Nails 1"	Per Unit	100	¢4.00	$0.01	¢400.00	$1.32
Tubo Industrial 1*2	Industrial Pipes	Meter	2	¢218.00	$0.72	¢436.00	$1.43
Botaguas 12" HG	Bolts 12"	Per Unit	12	¢490.00	$1.61	¢5,880.00	$19.34
Cumbreras 12" HG	?	Per Unit	4	¢476.00	$1.57	¢1,904.00	$6.26
Disco P/Hierro 9"	Iron Discs 9"	Per Unit	2	¢780.00	$2.57	¢1,560.00	$5.13
Spray Crinado	Crome Spray	Per Unit	1	¢1,110.00	$3.65	¢1,110.00	$3.65
Soldador	Welder		1	¢14,000.00	$46.05	¢14,000.00	$46.05
Aleros, Precintas, Tapichel	Above the Window and Crown		1	¢35,246.00	$115.94	¢35,246.00	$115.94
					Total	*¢141,867.00*	*$582.61*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Pisos	***Floor***						
Arena Corriente	Normal Sand	Meter	3	¢4,000.00	$13.16	¢12,000.00	$39.47
Arena Fina	Sand Finishing	Meter	1	¢5,600.00	$18.42	¢5,600.00	$18.42
Cemento	Cement	Per Unit	27	¢1,406.00	$4.63	¢37,962.00	$124.88
Ocre	?	Kilogram	8	¢683.00	$2.25	¢5,464.00	$17.97
					Total	*¢61,026.00*	*$200.74*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Plameria	***Pluming***						
Pegamento	Glue	Gallon	0.125	¢1,326.00	$4.36	¢165.75	$0.55
Tubos 1/2" PVC	Pipes 1/2" PVC	Per Unit	5	¢715.00	$2.35	¢3,575.00	$11.76
Codos 1/2" PVC Lisos	Elbow 1/2" PVC	Per Unit	10	¢44.00	$0.14	¢440.00	$1.45
Codos 1/2" PVC C/Rosca	Elbow 1/2" PVC	Per Unit	5	¢59.00	$0.19	¢295.00	$0.97
Teflon	Teflon	Per Unit	2	¢50.63	$0.17	¢101.26	$0.33
Tee 1/2" PVC	?	Per Unit	5	¢47.00	$0.15	¢235.00	$0.77
Adaptador Macho	Male Adapter	Per Unit	6	¢41.00	$0.13	¢246.00	$0.81
Tubos 2" PVC	Pipes 2" PVC	Per Unit	3	¢2,274.00	$7.48	¢6,822.00	$22.44
Tee 2" PVC	?	Per Unit	3	¢351.00	$1.15	¢1,053.00	$3.46
Codos 2" PVC	Elbow 2" PVC	Per Unit	6	¢260.00	$0.86	¢1,560.00	$5.13
Tubos 4" PVC	Pipe 4" PVC	Per Unit	3	¢6,326.00	$20.81	¢18,978.00	$62.43
Codos 4" PVC	Elbow 4" PVC	Per Unit	2	¢1,135.00	$3.73	¢2,270.00	$7.47
Tee 4" PVC	?	Per Unit	2	¢1,468.00	$4.83	¢2,936.00	$9.66
Llave De Paso 1/2"	Key of ?	Per Unit	1	¢784.10	$2.58	¢784.10	$2.58
Llave Para Bano	Bathroom Key	Per Unit	1	¢6,313.71	$20.77	¢6,313.71	$20.77
Llave De Chorro	Jetspurt Key	Per Unit	1	¢734.00	$2.41	¢734.00	$2.41
manguera 1 1/2"	Jetspurt Key ?	Per Unit	1	¢925.45	$3.04	¢925.45	$3.04
Asparcion Metalica	Metal Aspiration	Per Unit	1	¢1,330.00	$4.38	¢1,330.00	$4.38
Fregadero Nates	Sink	Per Unit	1	¢16,883.00	$55.54	¢16,883.00	$55.54
Inodoro economico	ordorless ecomic	Per Unit	1	¢14,850.35	$48.85	¢14,850.35	$48.85
Lavatorio	?	Per Unit	1	¢8,572.00	$28.20	¢8,572.00	$28.20
Tubos Abasto	Tubes for pipe	Per Unit	1	¢752.00	$2.47	¢752.00	$2.47
Pila Roja	Heating Battery	Per Unit	1	¢5,000.00	$16.45	¢5,000.00	$16.45
Parrilla De Desague	Drain Grill	Per Unit	1	¢412.90	$1.36	¢412.90	$1.36
Niple 12" Niquilado	Niple 12" ?	Per Unit	1	¢728.00	$2.39	¢728.00	$2.39
Niple 6" Niquilado	Niple 6" ?	Per Unit	2	¢446.12	$1.47	¢892.24	$2.94
Manguera 1 1/2"	Hosepipe 1 1/2"	Meter	2	¢465.00	$1.53	¢930.00	$3.06
Union 1/2" PVC	Joining PVC 1/2"	Per Unit	2	¢66.00	$0.22	¢132.00	$0.43
					Total	*¢97,916.76*	*$322.09*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tanque Septico	***Septic Tank***						
Block 12*20*40	Block 12*20*40	Per Unit	120	¢100.00	$0.33	¢12,000.00	$39.47
Arena Fina	Finishing Sand	Meter	1	¢5,600.00	$18.42	¢5,600.00	$18.42
Arena Corriente	Normal Sand	Meter	1	¢4,000.00	$13.16	¢4,000.00	$13.16
Varillas De 3/8	Rod. Stick 3/8	Per Unit	10	¢355.00	$1.17	¢3,550.00	$11.68
Cemento	Cement	Per Unit	6	¢1,406.00	$4.63	¢8,436.00	$27.75
Alambre De Amarre	Wire Morning	Kilogram	1	¢218.00	$0.72	¢218.00	$0.72
Tubo Perforado Drenasep	Drainage pipe	Per Unit	1	¢3,640.00	$11.97	¢3,640.00	$11.97
Piedra	Uncut Stone	Meter	7	¢4,150.00	$13.65	¢29,050.00	$95.56
					Total	*¢66,494.00*	*$218.73*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ventanas Y Puertas	***Windows and Doors***						
Regla 1*3 C/Cepillo	?	Meter	60	¢210.00	$0.69	¢12,600.00	$41.45
Venilla 1/2*1 Laurel	?	Meter	160	¢38.00	$0.13	¢6,080.00	$20.00
Regla 1*4 C/Cepillo	?	Meter	24	¢415.38	$1.37	¢9,969.12	$32.79
Tablilla 1/2*3 Laurel	Plank, Board	Meter	105	¢90.00	$0.30	¢9,450.00	$31.09
Clavos 1 1/4" Sin Cabeza	Nails without heads	Kilogram	0.25	¢282.20	$0.93	¢70.55	$0.23
Pegamento Blanco	White Glue	Gallon	0.125	¢625.70	$2.06	¢78.21	$0.26
Puerta Principal	Main Door	Per Unit	1	¢18,000.00	$59.21	¢18,000.00	$59.21
Vidrios Para Ventanas	Window Glass	Per Unit	6	¢5,000.00	$16.45	¢30,000.00	$98.68
Clavos 2" Sin Cabeza	Nails without heads	Kilogram	1.5	¢302.00	$0.99	¢453.00	$1.49
Clavos 2" Acero	Nails	Per Unit	100	¢5.00	$0.02	¢500.00	$1.64
Llavin Vera	Latch Key Glue	Per Unit	1	¢2,255.00	$7.42	¢2,255.00	$7.42
Visagras 3"	?	Pairs	3	¢325.00	$1.07	¢975.00	$3.21
Picaportes 3"	Doorlatch	Per Unit	2	¢166.10	$0.55	¢332.20	$1.09
Platinas 1*1/8	Slider	Per Unit	5	¢464.03	$1.53	¢2,320.15	$7.63
					Total	*¢93,083.23*	*$306.19*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Instalacion Electrica	***Electric Installation***						
Cajas Rectangulares	Rectangle Box	Per Unit	13	¢86.00	$0.28	¢1,118.00	$3.68
Cajas Octagonales	Octagonal Box	Per Unit	8	¢127.00	$0.42	¢1,016.00	$3.34
Conectores 1/2 PVC	Connectors 1/2 PVC	Per Unit	30	¢21.13	$0.07	¢633.90	$2.09
Tape 3M	3M Tape	Per Unit	1	¢915.40	$3.01	¢915.40	$3.01
Toma Corrente	Current Socket	Per Unit	7	¢683.00	$2.25	¢4,781.00	$15.73
Portalamparas	Socket	Per Unit	8	¢238.54	$0.78	¢1,908.32	$6.28
Apagadores Sencillos	Single ?	Per Unit	4	¢417.65	$1.37	¢1,670.60	$5.50
Apagadores Dobles	Double ?	Per Unit	2	¢555.40	$1.83	¢1,110.80	$3.65
Cable #12	Cable #12	Meters	200	¢61.00	$0.20	¢12,200.00	$40.13
Cable #10	Cable #10	Meters	20	¢102.00	$0.34	¢2,040.00	$6.71
Cable #6	Cable #6	Meters	65	¢253.00	$0.83	¢16,445.00	$54.10
Cuchilla Nec 2*100	?	Per Unit	1	¢3,430.10	$11.28	¢3,430.10	$11.28
Varilla Cooperwell	Rod, Stick ?	Per Unit	1	¢1,089.00	$3.58	¢1,089.00	$3.58
Brek 40 AMP	?	Per Unit	1	¢1,520.00	$5.00	¢1,520.00	$5.00
Brek 30 AMP	?	Per Unit	1	¢1,282.00	$4.22	¢1,282.00	$4.22
Brek 15 AMP	?	Per Unit	2	¢1,106.00	$3.64	¢2,212.00	$7.28
Centro De Carga	Charge Center (Fusebox)	Per Unit	1	¢5,667.00	$18.64	¢5,667.00	$18.64
Instalacion Profecional	Professional Installation		1	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢73,039.12*	*$240.26*

Section	*Section*		*Quantity*	*Cost in Colones*	*Cost in Dollars*
Cimiento	*Foundations*		*1*	*c330,809.66*	*$1,088.19*
Paredes	*Walls*		*1*	*c493,768.30*	*$1,624.24*
Techos	*Roof*		*1*	*c177,113.00*	*$582.61*
Pisos	*Floors*		*1*	*c61,026.00*	*$200.74*
Plomeria	*Pluming*		*1*	*c97,916.76*	*$322.09*
Tanque Sectico	*Septic Tank*		*1*	*c66,494.00*	*$218.73*
Ventanas y Puertas	*Windows and Doors*		*1*	*c93,083.23*	*$306.19*
Instalacion Electrica	*Electric Installation*		*1*	*c73,039.12*	*$240.26*
Thechos	*Roofer*		*1*	*c12,000.00*	*$39.47*
Puertas	*Doors*		*1*	*c18,000.00*	*$59.21*
Virdios	*Glass*		*1*	*c28,000.00*	*$92.11*
Maestro de Obra	*Construction Supervisor*		*1*	*c40,000.00*	*$131.58*
Costos Legales	*Legal Fees*		*1*	*c74,250.00*	*$244.24*
Transporte	*Transportation*		*1*	*c12,334.00*	*$40.57*
Albanil	*Mason*		*1*	*c225,000.00*	*$740.13*
Gastos De Administracion	*Administration Fees*		*1*	*c68,736.98*	*$226.11*
			Total Cost	*c1,871,571.05*	*$6,156.48*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Arriostres	***Wood Supports***						
Reglas 1 x 3	1 x 3 Rulers	Per Unit	70.37	¢210.00	$0.69	¢14,777.70	$48.61
Clavos 2.5	2.5 Nails	Kilogram	9.43	¢212.05	$0.70	¢1,999.63	$6.58
					Total	*¢16,777.33*	*$55.19*
Trazo	***Tracing***						
Reglas 1 x 3	1 x 3 Rulers	Stick	49.12	¢143.00	$0.47	¢7,024.16	$23.11
Cuerda de Nylon	Nylon String	Per Unit	2.00	¢328.00	$1.08	¢656.00	$2.16
Clavos 2	2 Nails	Kilograms	0.27	¢208.00	$0.68	¢56.16	$0.18
Clavos 1	1 Nails	Kilograms	0.04	¢343.00	$1.13	¢13.72	$0.05
					Total	*¢7,750.04*	*$25.49*
Repello	***Plaster***						
Cemento	Cement	Sacos	10.12	¢1,406.00	$4.63	¢14,228.72	$46.81
Arena Fina	Fine Sand	Meters	1.90	¢6,328.00	$20.82	¢12,023.20	$39.55
Plasterbon	Plaster Bond	Gallons	2.11	¢4,389.00	$14.44	¢9,260.79	$30.46
Regla 1 x 2	1 x 2 Rulers	Sticks	116.04	¢99.00	$0.33	¢11,487.96	$37.79
					Total	*¢47,000.67*	$154.61
Ciminto	***Foundation***						
Alambre	Wire	Kilograms	5.41	¢218.00	$0.72	¢1,179.38	$3.88
Cemento	Cement	Per Unit	17.83	¢1,406.00	$4.63	¢25,068.98	$82.46
Arena Corriente	Ordinary Sand	Meters	1.11	¢4,000.00	$13.16	¢4,440.00	$14.61
Piedra 4ta	Stones 4ta	Meters	2.01	¢6,000.00	$19.74	¢12,060.00	$39.67
Lastre Compactado		Meters	1.43	¢3,000.00	$9.87	¢4,290.00	$14.11
Acero No. 3	#3 Steel	Per Unit	29.75	¢382.00	$1.26	¢11,364.50	$37.38
Acero No. 2	#2 Steel	Per Unit	19.06	¢176.00	$0.58	¢3,354.56	$11.03
					Total	*¢61,757.42*	*$203.15*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Paredes	***Walls***						
C-60-1	C-60-1	Per Unit	15.00	¢6,618.00	$21.77	¢99,270.00	$326.55
C-60-T	C-60-T	Per Unit	4.00	¢7,290.00	$23.98	¢29,160.00	$95.92
C-60-2	C-60-2	Per Unit	1.00	¢5,100.00	$16.78	¢5,100.00	$16.78
C-60-5	C-60-5	Per Unit	10.00	¢2,000.00	$6.58	¢20,000.00	$65.79
C-40-1	C-40-1	Per Unit	15.00	¢4,410.67	$14.51	¢66,160.05	$217.63
C-40-A	C-40-A	Per Unit	3.00	¢5,194.00	$17.09	¢15,582.00	$51.26
C-40-2	C-40-2	Per Unit	1.00	¢3,400.00	$11.18	¢3,400.00	$11.18
C-40-3	C-40-3	Per Unit	2.00	¢2,400.00	$7.89	¢4,800.00	$15.79
CL-1	CL-1	Per Unit	7.00	¢4,230.00	$13.91	¢29,610.00	$97.40
CT-2	CT-2	Per Unit	4.00	¢6,270.00	$20.63	¢25,080.00	$82.50
					Subtotal	¢298,162.05	$980.80
					20% Discount	-¢59,632.41	-$196.16
					13% Sales Tax	¢38,761.07	$127.50
Fibrolit	Fiber	Per Unit	9	¢3,514.00	$11.56	¢31,626.00	$104.03
					Total	*¢308,916.71*	*$1,016.17*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tapichel de Fibrolit y Perling	***Fibrolit Crown and Purlings***						
Fibrolit	Fibrolit	Sheet	4.00	¢3,514.00	$11.56	¢14,056.00	$46.24
Perlig 2x4x6 HG	Metal Purlings 2x4x6	Per Unit	18.00	¢3,117.00	$10.25	¢56,106.00	$184.56
Tornillas Gypsum		Per Unit	250.00	¢4.00	$0.01	¢1,000.00	$3.29
Soldadura	Welding Material	Kilogram	2.00	¢740.00	$2.43	¢1,480.00	$4.87
Soldador	Welder	Per Unit	1.00	¢15,000.00	$49.34	¢15,000.00	$49.34
					Total	*¢87,642.00*	*$288.30*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Solera	***Beam***						
Rt 1-16 (4 plg)		Per Unit	6.63	¢2,870.00	$9.44	¢19,028.10	$62.59
Acero No. 3	#3 Steel	Per Unit	4.82	¢382.00	$1.26	¢1,841.24	$6.06
Cemento	Cement	Sacs	1.49	¢1,406.00	$4.63	¢2,094.94	$6.89
Arena	Sand	Meters	0.09	¢4,000.00	$13.16	¢360.00	$1.18
Piedra	Stones	Meters	0.17	¢6,000.00	$19.74	¢1,020.00	$3.36
Soldedura	Welding Material	Bars	1.00	¢4,070.00	$13.39	¢4,070.00	$13.39
					Total	*¢28,414.28*	*$93.47*
Techo	***Roof***						
Zing 083x1.83 HG	Zinc 083x1.83 HG	Per Unit	17.00	¢998.00	$3.28	¢16,966.00	$55.81
Zing 083x3.66 HG	Zinc 083x3.66 HG	Per Unit	17.00	¢1,995.00	$6.56	¢33,915.00	$111.56
Tornillos Para Techo	Screws for Roof	Per Unit	225.00	¢9.00	$0.03	¢2,025.00	$6.66
Soldadura	Welding	Kilogram	2.00	¢800.00	$2.63	¢1,600.00	$5.26
Brocas 3/16 P/Hierro	Iron Bits 3/16	Per Unit	3.00	¢80.00	$0.26	¢240.00	$0.79
Tablillas 1/2x2	Planks, Boards	Meter	100.00	¢57.25	$0.19	¢5,725.00	$18.83
Clavos 1" Acero	Nails 1"	Per Unit	100.00	¢4.00	$0.01	¢400.00	$1.32
Tubo Industrial 1*2	Industrial Pipes	Meter	2.00	¢218.00	$0.72	¢436.00	$1.43
Botaguas 12" HG	Bolts 12"	Per Unit	12.00	¢490.00	$1.61	¢5,880.00	$19.34
Cumbreras 12" HG	?	Per Unit	4.00	¢476.00	$1.57	¢1,904.00	$6.26
Disco P/Hierro 9"	Iron Discs 9"	Per Unit	2.00	¢780.00	$2.57	¢1,560.00	$5.13
Spray Crinado	Crome Spray	Per Unit	1.00	¢1,110.00	$3.65	¢1,110.00	$3.65
Soldador	Welder		1.00	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢85,761.00*	*$282.11*
Pisos	***Floor***						
Arena Corriente	Normal Sand	Meter	3.00	¢4,000.00	$13.16	¢52,631.58	$39.47
Arena Fina	Sand Finishing	Meter	1.00	¢5,600.00	$18.42	¢103,157.89	$18.42
Cemento	Cement	Per Unit	27.00	¢1,406.00	$4.63	¢6,502.75	$124.88
Ocre	?	Kilogram	8.00	¢683.00	$2.25	¢1,534.50	$17.97
					Total	*¢163,826.73*	*$200.74*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Plameria	***Pluming***						
Pegamento	Glue	Gallon	0.13	¢1,326.00	$4.36	¢165.75	$0.55
Tubos 1/2" PVC	Pipes 1/2" PVC	Per Unit	5.00	¢715.00	$2.35	¢3,575.00	$11.76
Codos 1/2" PVC Lisos	Elbow 1/2" PVC	Per Unit	10.00	¢44.00	$0.14	¢440.00	$1.45
Codos 1/2" PVC C/Rosca	Elbow 1/2" PVC	Per Unit	5.00	¢59.00	$0.19	¢295.00	$0.97
Teflon	Teflon	Per Unit	2.00	¢50.63	$0.17	¢101.26	$0.33
Tee 1/2" PVC	?	Per Unit	5.00	¢47.00	$0.15	¢235.00	$0.77
Adaptador Macho	Male Adapter	Per Unit	6.00	¢41.00	$0.13	¢246.00	$0.81
Tubos 2" PVC	Pipes 2" PVC	Per Unit	3.00	¢2,274.00	$7.48	¢6,822.00	$22.44
Tee 2" PVC	?	Per Unit	3.00	¢351.00	$1.15	¢1,053.00	$3.46
Codos 2" PVC	Elbow 2" PVC	Per Unit	6.00	¢260.00	$0.86	¢1,560.00	$5.13
Tubos 4" PVC	Pipe 4" PVC	Per Unit	3.00	¢6,326.00	$20.81	¢18,978.00	$62.43
Codos 4" PVC	Elbow 4" PVC	Per Unit	2.00	¢1,135.00	$3.73	¢2,270.00	$7.47
Tee 4" PVC	?	Per Unit	2.00	¢1,468.00	$4.83	¢2,936.00	$9.66
Llave De Paso 1/2"	Key of ?	Per Unit	1.00	¢784.10	$2.58	¢784.10	$2.58
Llave Para Bano	Bathroom Key	Per Unit	1.00	¢6,313.71	$20.77	¢6,313.71	$20.77
Llave De Chorro	Jetspurt Key	Per Unit	1.00	¢734.00	$2.41	¢734.00	$2.41
manguera 1 1/2"	Jetspurt Key ?	Per Unit	1.00	¢925.45	$3.04	¢925.45	$3.04
Asparcion Metalica	Metal Aspiration	Per Unit	1.00	¢1,330.00	$4.38	¢1,330.00	$4.38
Fregadero Nates	Sink	Per Unit	1.00	¢16,883.00	$55.54	¢16,883.00	$55.54
Inodoro economico	ordorless ecomic	Per Unit	1.00	¢14,850.35	$48.85	¢14,850.35	$48.85
Lavatorio	?	Per Unit	1.00	¢8,572.00	$28.20	¢8,572.00	$28.20
Tubos Abasto	Tubes for pipe	Per Unit	1.00	¢752.00	$2.47	¢752.00	$2.47
Pila Roja	Heating Battery	Per Unit	1.00	¢5,000.00	$16.45	¢5,000.00	$16.45
Parrilla De Desague	Drain Grill	Per Unit	1.00	¢412.90	$1.36	¢412.90	$1.36
Niple 12" Niquilado	Niple 12" ?	Per Unit	1.00	¢728.00	$2.39	¢728.00	$2.39
Niple 6" Niquilado	Niple 6" ?	Per Unit	2.00	¢446.12	$1.47	¢892.24	$2.94
Manguera 1 1/2"	Hosepipe 1 1/2"	Meter	2.00	¢465.00	$1.53	¢930.00	$3.06
Union 1/2" PVC	Joining PVC 1/2"	Per Unit	2.00	¢66.00	$0.22	¢132.00	$0.43
					Total	*¢97,916.76*	*$322.09*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Tanque Septico	***Septic Tank***						
Block 12*20*40	Block 12*20*40	Per Unit	120.00	¢100.00	$0.33	¢12,000.00	$39.47
Arena Fina	Finishing Sand	Meter	1.00	¢5,600.00	$18.42	¢5,600.00	$18.42
Arena Corriente	Normal Sand	Meter	1.00	¢4,000.00	$13.16	¢4,000.00	$13.16
Varillas De 3/8	Rod, Stick 3/8	Per Unit	10.00	¢355.00	$1.17	¢3,550.00	$11.68
Cemento	Cement	Per Unit	6.00	¢1,406.00	$4.63	¢8,436.00	$27.75
Alambre De Amarre	Wire Morning	Kilogram	1.00	¢218.00	$0.72	¢218.00	$0.72
Tubo Perforado Drenasep	Drainage pipe	Per Unit	1.00	¢3,640.00	$11.97	¢3,640.00	$11.97
Piedra	Uncut Stone	Meter	7.00	¢4,150.00	$13.65	¢29,050.00	$95.56
					Total	*¢66,494.00*	*$218.73*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Ventanas Y Puertas	***Windows and Doors***						
Regla 1*3 C/Cepillo	?	Meter	60.00	¢210.00	$0.69	¢12,600.00	$41.45
Venilla 1/2*1 Laurel	?	Meter	160.00	¢38.00	$0.13	¢6,080.00	$20.00
Regla 1*4 C/Cepillo	?	Meter	24.00	¢415.38	$1.37	¢9,969.12	$32.79
Tablilla 1/2*3 Laurel	Plank, Board	Meter	105.00	¢90.00	$0.30	¢9,450.00	$31.09
Clavos 1 1/4" Sin Cabeza	Nails without heads	Kilogram	0.25	¢282.20	$0.93	¢70.55	$0.23
Pegamento Blanco	White Glue	Gallon	0.13	¢625.70	$2.06	¢78.21	$0.26
Puerta Principal	Main Door	Per Unit	1.00	¢18,000.00	$59.21	¢18,000.00	$59.21
Vidrios Para Ventanas	Window Glass	Per Unit	6.00	¢5,000.00	$16.45	¢30,000.00	$98.68
Clavos 2" Sin Cabeza	Nails without heads	Kilogram	1.50	¢302.00	$0.99	¢453.00	$1.49
Clavos 2" Acero	Nails	Per Unit	100.00	¢5.00	$0.02	¢500.00	$1.64
Llavin Vera	Latch Key Glue	Per Unit	1.00	¢2,255.00	$7.42	¢2,255.00	$7.42
Visagras 3"	?	Pairs	3.00	¢325.00	$1.07	¢975.00	$3.21
Picaportes 3"	Doorlatch	Per Unit	2.00	¢166.10	$0.55	¢332.20	$1.09
Platinas 1*1/8	Slider	Per Unit	5.00	¢464.03	$1.53	¢2,320.15	$7.63
					Total	*¢93,083.23*	*$306.19*

Spanish	Translation	Units	Quantity	Price Per Unit in Colones	Price per Unit in Dollars	Cost in Colones	Cost in Dollars
Instalacion Electrica	***Electric Installation***						
Cajas Rectangulares	Rectangle Box	Per Unit	13.00	¢86.00	$0.28	¢1,118.00	$3.68
Cajas Octagonales	Octagonal Box	Per Unit	8.00	¢127.00	$0.42	¢1,016.00	$3.34
Conectores 1/2 PVC	Connectors 1/2 PVC	Per Unit	30.00	¢21.13	$0.07	¢633.90	$2.09
Tape 3M	3M Tape	Per Unit	1.00	¢915.40	$3.01	¢915.40	$3.01
Toma Corrente	Current Socket	Per Unit	7.00	¢683.00	$2.25	¢4,781.00	$15.73
Portalamparas	Socket	Per Unit	8.00	¢238.54	$0.78	¢1,908.32	$6.28
Apagadores Sencillos	Single ?	Per Unit	4.00	¢417.65	$1.37	¢1,670.60	$5.50
Apagadores Dobles	Double ?	Per Unit	2.00	¢555.40	$1.83	¢1,110.80	$3.65
Cable #12	Cable #12	Meters	200.00	¢61.00	$0.20	¢12,200.00	$40.13
Cable #10	Cable #10	Meters	20.00	¢102.00	$0.34	¢2,040.00	$6.71
Cable #6	Cable #6	Meters	65.00	¢253.00	$0.83	¢16,445.00	$54.10
Cuchilla Nec 2*100	?	Per Unit	1.00	¢3,430.10	$11.28	¢3,430.10	$11.28
Varilla Cooperwell	Rod, Stick ?	Per Unit	1.00	¢1,089.00	$3.58	¢1,089.00	$3.58
Brek 40 AMP	?	Per Unit	1.00	¢1,520.00	$5.00	¢1,520.00	$5.00
Brek 30 AMP	?	Per Unit	1.00	¢1,282.00	$4.22	¢1,282.00	$4.22
Brek 15 AMP	?	Per Unit	2.00	¢1,106.00	$3.64	¢2,212.00	$7.28
Centro De Carga	Charge Center (Fusebox)	Per Unit	1.00	¢5,667.00	$18.64	¢5,667.00	$18.64
Instalacion Profecional	Professional Installation		1.00	¢14,000.00	$46.05	¢14,000.00	$46.05
					Total	*¢73,039.12*	*$240.26*

Section	*Section*		*Quantity*	*Cost in Colones*	*Cost in Dollars*
Arriostres	*Wood Supports*		*1.00*	*¢16,777.33*	*$55.19*
Trazo	*Tracing*		*1.00*	*¢7,750.04*	*$25.49*
Repello	*Plaster*		*1.00*	*¢47,000.67*	*$154.61*
Cimiento	*Foundation*		*1.00*	*¢61,757.42*	*$203.15*
Paredes	*Walls*		*1.00*	*¢308,196.71*	*$1,013.80*
Tapichel de Fibrolit y Perling	*Fibrolit Crown and Purlings*		*1.00*	*¢87,642.00*	*$288.30*
Solera	*Beam*		*1.00*	*¢28,414.28*	*$93.47*
Techos	*Roof*		*1.00*	*¢85,761.00*	*$282.11*
Pisos	*Floors*		*1.00*	*¢163,826.73*	*$538.90*
Plomeria	*Pluming*		*1.00*	*¢97,916.76*	*$322.09*
Tanque Sectico	*Septic Tank*		*1.00*	*¢66,494.00*	*$218.73*
Ventanas y Puertas	*Windows and Doors*		*1.00*	*¢93,083.23*	*$306.19*
Instalacion Electrica	*Electric Installation*		*1.00*	*¢73,039.12*	*$240.26*
Thechos	*Roofer*		*1.00*	*¢12,000.00*	*$39.47*
Puertas	*Doors*		*1.00*	*¢18,000.00*	*$59.21*
Virdios	*Glass*		*1.00*	*¢28,000.00*	*$92.11*
Maestro de Obra	*Construction Supervisor*		*1.00*	*¢40,000.00*	*$131.58*
Costos Legales	*Legal Fees*		*1.00*	*¢74,250.00*	*$244.24*
Transporte	*Transportation*		*1.00*	*¢12,334.00*	*$40.57*
Albanil	*Mason*		*1.00*	*¢225,000.00*	*$740.13*
Gastos De Administracion	*Administration Fees*		*1.00*	*¢68,736.98*	*$226.11*
			Total Cost	*¢1,615,980.27*	*$5,315.72*